SOUTHERN PERSPECTIVES on the RURAL ENERGY CRISIS

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R.S. GANAPATHY
PETER HAYES

Edited and Published By Nautilus, Inc.

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PHOTO CREDITS

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UNITS OF ENERGY

The two units of energy used in this paper are the kcal (one thousand calories; one calorie is the amount of energy required to raise the temperature of one cubic centimetre of pure water at standard temperature and pressure by one degree Centigrade) and the MJ (one million joules; a joule is the work of one newton-meter, also equal to 0.239 calories). One barrel of oil has about 6 billion joules. One kilogram of wood dryweight might have about 13 MJ, although this figure varies across the woods. One kilowatt-thermal [kW(t)] is a measure of power —one thousand joules/second. A conversion efficiency (ratio of electrical output to primary energy input) is required to measure the conversion of thermal energy to electrical energy [kW(e)]. A crude rule of thumb would be 30 to 40 percent. A power of one kw(e) applied for one hour produces energy of one kwh(e)-one kilowatt-hour (electrical). Similarly for thermal units.

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African village and overgrazing

About Nautilus:

Nautilus Inc. is a public-interest research and education group focussed on the interrelationship of energy, environment, and development. Our particular objective is to analyze and evaluate the development impacts of U.S. governmental and commercial policies on third world countries, especially in Asia-Pacific (and to determine impacts of these policies on the U.S.).

A key area of our concern is the export of U.S. nuclear technology to Asia. In 1979, *Pacific Research* published our study of a U.S.-Westinghouse nuclear export to the Philippines, "500 Mile Island." We are nearing completion of a book on the south Korean nuclear program—the most ambitious of any third world country —and the crucial role played by the U.S. Export-Import Bank in financing reactor-transfers (for more information, see page 48).

Nautilus frequently writes for popular magazines and journals, speaks to university students and citizen groups, and appears on radio programs.

Rice production, Philippines

Preface

Over two and a half billion people live in the villages of Asia, Africa, and Latin America. The daily struggle of these people to obtain energy is therefore an aspect of the global energy problem that affects more people than any other.

It took OPEC to bring energy to the center of global policy concerns. Belatedly for rural people in the Third World, attention is now being paid to the rural energy crisis. Villagers' vital energy statistics are being measured, their energy anatomy dissected, and their energy ills diagnosed.

In itself, information is harmless. But as the basis of the response to this crisis, information is also power. Villagers may use much of the anthropomorphic energy flows on the planet, but non-villagers—governments, international organisations, and transnational companies—clearly control most of the information about their energy plight. Villagers do not control the design of energy policies aimed at their energy problems. The gathering and interpretation of information about the energy dimension of their lives is therefore political.

It was to challenge some of the presuppositions about appropriate policy responses to the rural energy crisis—and thus some of the political ramifications of international policies aimed at redressing the crisis—that Nautilus decided to publish these essays. The essays are unabashedly provocative, and are designed to stimulate debate. They ask hard questions about the origins of the rural energy crisis, and while careful to supply pointers as to what might be done, the authors do not present easy solutions or short-cuts through the power-structure. Perhaps the most important point made by all the authors is that much of what is being done in the name of serving rural energy needs will actually make the situation worse for many of those most in need.

Most of what is being written on this problem emanates from international aid or development agencies, academic institutions, and consulting firms. The authors of these essays come from other quarters. Amulya Reddy's work with the Cell for the Application of Science and Technology to Rural Areas in central India is widely known for being a model of self-reliant work of the highest calibre. R.S. Ganapathy's work springs from an active interest in increasing citizen participation in international energy policies, especially at the UN. Peter Hayes, now a researcher with Nautilus, established the international network of *Soft Energy Notes*, aimed at transferring information—and sometimes warnings—about what is coming down the international energy pipeline to the third world.

Nautilus offers this publication in a spirit of debate, and we hope it will elicit dialogue. The authors' addresses appear at the beginning of each essay. Nautilus also solicits your comments and criticisms of this publication, and suggestions as to how it might be better next time.* The authors are responsible, of course, for the content of each essay.

Peter Hayes

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I. Energy Options for the Third World

Amulya Reddy[*]

1. INTRODUCTION

Third world countries differ from each other in many ways, but the most important difference which has been stresed since 1973 is that between oil-*exporting* and oil-*importing* developing countries. The former are considered to be "the blessed," and the latter, "the unfortunates." This is because most oil-exporting developing countries have the resource base of conventional energy to repeat the evolution of the energy consumption patterns of the industrialized countries; and therefore, their discussions on energy options can be restricted to considerations of various *paths* to western goals. It is not so with the oil-importing third world countries. In their case, energy options must imply choices with regard to *goals*, as well as *paths* to chosen goals. In this sense, their constraints (with respect to conventional energy sources) compel them to exercise an extra dimension of freedom—the freedom to choose what magnitude and structure of energy targets their societies shall strive for.

It follows that an essential part of any discussion of energy options for third world oil-importing countries must be directed towards the main options with regard to the magnitude and structure of energy targets.

2. THE MAGNITUDE AND STRUCTURE OF ENERGY TARGETS

The *magnitude* of a society's energy requirements depends, first, on its population—obviously, the larger the population, the greater will be its energy requirements, and second, on its per capita energy consumption—the larger the direct and indirect per capita energy consumption in a society, the greater will be the energy requirements of a society. It is important, however, to realize that these two factors of population and per capita energy consumption are not unrelated—invariably, the lower the per capita energy consumption, the greater is its need for muscle power, and therefore, the larger is its rate of population growth likely to be.

The choice of an energy goal hinges, therefore, on targets for population and for per capita energy consumption. Population planning is outside the scope of this paper, so attention will be restricted to per capita energy consumption, which in turn depends upon several factors.

The first factor is the degree of "affluence" of the society, usually expressed as the per capita GNP—the more the goods and services produced, distributed and consumed per person, the greater will be the per capita energy consumption, according to the well-known per capita energy consumption vs per capita GNP "correlation." The use of this "correlation" to define energy targets for developing countries involves two assumptions: (1) that these countries should follow the patterns of industrialization and energy utilization adopted by the developed countries, even though these patterns were historically determined by the low oil prices of the pre-1973 era, and (2) that the goal of third world countries should be the growth of GNP. Both these assumptions are questionable— the first may not be realizable, and the second may not be acceptable.

The second factor determining the per capita energy consumption is the "lifestyle" of the society as revealed by the composition of the GNP. This lifestyle comes into the energy picture because different products and services are associated with different energy consumption values. For example, a lifestyle based on individual transportation by automobiles requires more energy than one based on mass transportation

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by buses.

The third factor is the degree of centralization of production. The point is that the greater the average distance between the centers of production and of consumption, the larger becomes the energy which must be spent on processing, packaging, storage, transport and distribution. Centralized production for distant markets invariably requires more energy than decentralized production for local consumption.

The last factor which determines the per capita energy consumption concerns the technologies chosen for the production, distribution and consumption of goods and services. Here, the point is that different ways of producing, distributing and consuming goods and services are associated with different energies. For instance, most production technologies of the developed countries are energy-intensive, because these technologies were generated in countries which were able to obtain oil at low prices from the oil-exporting countries. Green revolution agriculture is a prime example of such an energy-intensive production technology. For perhaps similar reasons, a bias towards energy-intensive distribution or transport technologies can be observed in the industrialized countries, for example, goods transport by rail has given way to the energetically more expensive truck transport. Consumption technologies, too, are important because some ways of consuming goods and services consume more energies than others, for example, space heating by electricity costs more energy than the use of waste heat.

In addition to the magnitude of the energy target, the *structure* of the target is also important. There are four aspects to this structure. First, there is the distribution of the total energy requirements over different energy-consuming sectors, e.g., industry, agriculture, transportation, etc. Actually, it is much better to seek the task-wise distribution over various energy-consuming tasks, viz., low-, medium- and high-temperature heating, lighting, stationary and mobile motive power, electronic controls and communication, etc. Such a distribution indicates the category of energy-consuming tasks, and the magnitude of energy required for each category. This way of looking at the energy target is important because different categories of energy-consuming tasks are best satisfied by different energy forms—as will be elaborated later. The second aspect is the spatial distribution of energy requirements, in particular, the urban-rural distribution. The third aspect, and the one invariably neglected in energy discussions, concerns the distribution of energy in societies characterized by marked income disparities. The fourth aspect relates to the mix of energy sources—in most third world countries, the sources of energy used differ among the different income groups, mainly because different energy sources are usually associated with differing costs.

Thus, a definition of options with regard to energy targets for third world countries must be based on answers to a number of key questions:

Magnitude of the energy target

(i) What is the population corresponding to the target?

(ii) What per capita energy consumption will be attempted? i.e.,

(a) what extent of affluence, or per capita GNP?

(b) what type of lifestyle, or composition of GNP?

(c) what degree of centralization of production?

(d) what technologies of production, distribution and consumption?

Structure of the energy target

(i) What will be the break-up of the energy target according to sectors and categories of energy-consuming tasks?

(ii) What will be the spatial distribution of energy, e.g., between urban and rural areas?

(iii) What will be the energy distribution between various income groups in the stratified society?

(iv) What will be the mix of energy sources?

3. THE GROWTH OR KEEPING-UP-WITH-THE-JONESES OPTION

There are two distinctly different approaches to these questions and, therefore, to the definition of energy goals.

The first is a *more-of-the-same* approach based on a continuation of current trends of energy consumption, and hence, the assumptions and value-judgments underlying these trends. This approach leads to what may be called the *growth or keeping-up-with-the-Joneses option.*

In this context, one must not fail to note that most third world countries are in fact dual societies, with small, affluent, largely urban-based elites (10-20% of the population) and large masses of poverty-stricken people, most of whom live in rural areas. Further, the elites are heavily influenced by the life-styles of the developed countries and practice an outlook best described thus: "all that is rural is bad, all that is urban is better and all that is western is best!" This dual nature of society is clearly reflected in the energy consumption patterns.

The per capita energy consumption targets aimed at by decision-making elites are those based on attempting "to catch up with the west." This attempt is manifested as:

(a) the striving for continuously increasing values of per capita energy consumption, which are unquestioningly assumed to be the basis of per capita GNP, the growth of which has been the crucial socio-economic objective of most industrialized countries;

(b) the economic aim of emulating the composition of the GNP characteristic of the industrialized countries, and therefore generating the energy required to produce a similar bundle of goods and services;

(c) the belief that developing countries must necessarily follow the path of industrialization of the developed countries, in which centralized production for remote markets resulted in large energy expenditures on distribution, even though production for local consumption is traditional to the third world countries;

(d) the view that, in industrializing their economies, third world countries have no option except to adopt the package of production, distribution and consumption technologies adopted in the developed countries, even though these technologies were evolved to suit their specific historical circumstances of capital abundance, labor shortage and cheap energy.

In fact, these assumptions may not be tenable at all. Untempered pursuit of GNP *per se* only aggravates the inequalities of a dual society, and must, therefore, be abandoned as a socio-economic objective, and with it, the so-called "correlation" between per capita GNP and the per capita energy consumption. The composition of the GNP can be far more important than the magnitude of GNP in determining the quality of life, particularly for those below the poverty line—skyscraper office buildings (and the energy that goes into them) must be counted in the GNP (and the per capita energy consumption), even though they cannot easily substitute for low income housing. The switch from traditional decentralized production for local consumption to centralized production for distant markets invariably increases the energy bill due to energy costs for processing, storage, transport, and marketting, and at the same time prices the goods and services beyond the means of the poorest sections. Finally, the energy- and capital-intensity of the production, distribution and consumption technologies of the developed countries, along with their labor-saving character, make them intrinsically inappropriate for oil-importing developing countries, most of which are grappling with continuously increasing unemployment and desperate shortages of energy and capital.

Apart from all these considerations, it is fairly certain that if the entire populations of developing countries were to have the same per capita energy consumption as the developed countries, say the USA, then the energy demand would become too high to be sustained with the present pattern of usage of energy resources. For instance, on the basis of US per capita energy consumption figures, India alone would require about three times the total energy now consumed by the USA—a requirement which is 150 times the present production of commercial energy in India. Thus, energy resource limitations may make it impossible for third world countries to achieve the growth or "keeping-up-with-the-Joneses" option—the Joneses can use so much energy only because the Singhs use so much less. The more-of-the-same option for energy targets is just not feasible if the per capita energy consumption levels of the developed countries are used as norms.

The outlook is not any brighter with the structure of energy targets.

The sectoral distribution of commercial energy in many developing countries seems to be based on an emulation of the industrialized countries, even though third world countries are primarily agricultural, e.g., the comparison between USA and India.

TABLE 1. SECTORAL DISTRIBUTION OF COMMERCIAL ENERGY

Sector	Energy consumption India	(percentage) USA
Industry	39.1	30.3
Transport	32.3	25.2
Domestic	18.0	14.0
Agriculture	4.6	4.0
Miscellaneous	6.0	26.5

The spatial distribution of energy in developing countries is even more alarming (Table 2)—the urban-rural disparities in energy consumption show that commercial energy production hardly flows to rural areas, even though the bulk of the population lives there. The existence of these urban islands of energy affluence amidst vast oceans of rural energy deprivation is another characteristic of dual societies. They result from the energy supply system responding only to energy demands and ignoring energy needs which cannot be backed up with purchasing power.

TABLE 2. URBAN-RURAL DISTRIBUTION OF COMMERCIAL ENERGY IN THIRD WORLD INDUSTRIES

	Asia	Africa	Latin America
Rural share of commercial energy	23%	4%	23%
Rural poopulation	75%	91%	50%

Finally, there is a highly skewed distribution of energy between different strata in dual societies—a reflection of the skewing of incomes. The inequalities in energy consumption are not merely in the magnitude of energy consumption, but also in the forms of energy used. The point is that various types of energy—electricity, oil, coal, non-commercial energy (firewood, animal dung and agricultural wastes)—have differing costs, and the poorer the section of society, the cheaper the energy source it uses. And the poorest sections of third world countries survive on non-commercial energy. This non-commercial energy can be gathered at "zero" private cost, but there are very high-social environmental costs in the form of environmental degredation (deforestation, soil erosion and desertification) and lost social opportunities of diverting the labor now spent on gathering non-commercial fuels to socially productive activities. No wonder that developing countries rely to a great extent on non-commercial energy, which for example accounts for 50% and 90% of the total energy consumption in India and East Africa respectively.

Thus, energy targets based on the growth or keeping-up-with-the-Joneses option will only preserve and accentuate:

(a) the energy-deprivation of the agricultural sector,

(b) the urban-rural disparities in energy consumption,

(c) the highly skewed distribution of energy over the different income groups,

(d) the dependence of rural areas and the poorest sections on non-commercial energy.

These unwelcome features of current patterns of energy consumption in third world countries are an essential part of their dual societies. In this sense, the growth or keeping-up-with-the-Joneses option is an offspring of dual societies, and only serves to consolidate and acerbate the inequalities and injustices of such societies—it inhibits the development of third world countries.

4. THE DEVELOPMENT OPTION

An alternative approach to energy goals can be based on the development option, in which the energy sector is used as a mechanism for promoting development. The magnitude and structure of energy targets must therefore be chosen with this perspective.

Of course, much will depend upon the definition of development. In this context, the recent UN definition constitutes an excellent basis. According to this definition, development is viewed as a process which is primarily directed towards:

(a) the satisfaction of basic human needs (material and non-material), starting with the needs of the neediest, in order to achieve a reduction of inequalities between and within countries;

(b) endogenous self-reliance through social participation and control; and

(c) harmony with the environment.

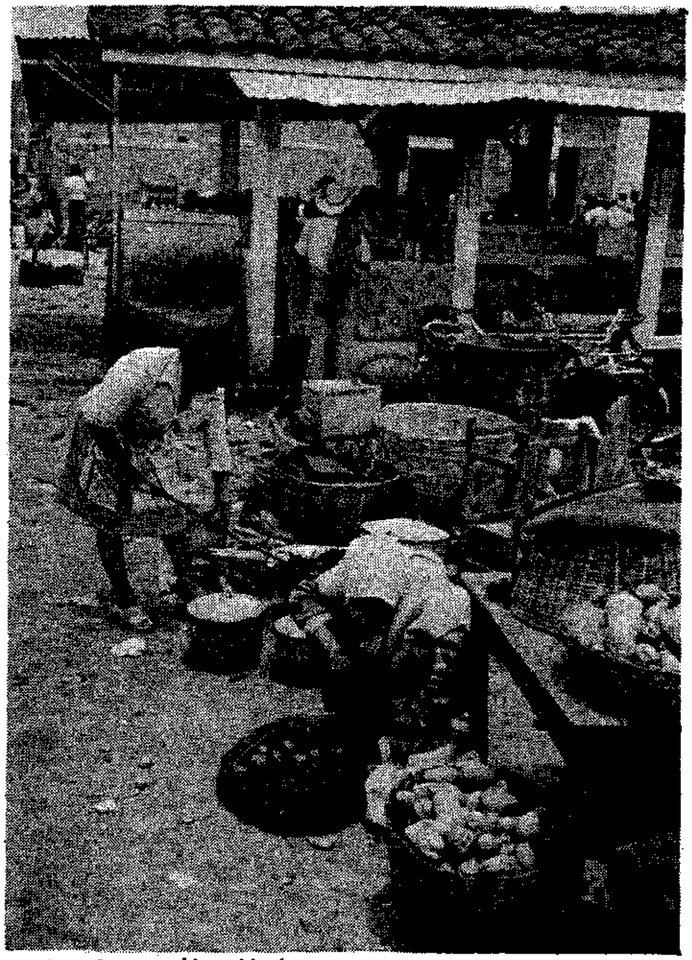
The commitment to development, rather than to growth *per se*, as a socio-economic objective has major implications with regard to energy targets for third world countries.

First, the viewpoint that growth of GNP should be a by-product, rather than basis of, development results in a liberation from a dependence on the "correlation" (between per capita energy consumption and per capita GNP) as a source of energy targets. Instead, per capita energy targets must be derived from development objectives, and in particular from the objective of satisfaction of basic human needs.

Second, the emphasis on development requires that the composition of the GNP, i.e., the product-mix, of third world countries be radically different from that in the developed countries. In particular, the basic needs of the neediest may have to be satisfied by simple life-styles. This requirement of simplicity *may* involve natural rather than energy-intensive synthetic fibers, renewable rather than depletable materials which have to be extracted at considerable energy expenditures, shared communal facilities (e.g., mass transportation systems) rather than energy-intensive luxuries for individual use (e.g., private automobiles).

Third, many cases of highly centralized production for massive markets have evolved at high energy costs only to satisfy the profit-seeking motives of large corporations, even though decentralized production for local consumption may be adequate for the satisfaction of basic needs. Industrialized food systems are an example. The change-over from production for small, local markets to production for nation-wide, or even world-wide markets, is inevitably associated with increasing off-the-farm energy expenditures on food processing, packaging, transport, distribution and storage. Today, this off-the-farm energy expenditure accounts for about 75% of the total energy consumption of the industrial food system of the USA. This energy price will have to be paid if third world countries "westernize" their agricultural sectors.

Fourth, a decision to avoid imitating the historically-conditioned path of industrialization of the developed countries means that the choice of technologies need not be restricted to their package of technologies. This widening of the choice has dramatic implications for the energy question. The point is that every technology is generated in response to certain ranges of factor prices, including the price of energy, and therefore, most technologies of the developed countries are very much the product of the



Market-place cooking, Mexico

pre-1973 low oil prices. Had the current oil prices prevailed over the past fifty years, it is almost certain that a radically different pattern of energy-saving technologies would have emerged in the industrialized countries. Today, the developed countries may not be able to dismantle their energy-intensive technologies, but the third world countries, precisely because they are in the very early stages of industrialization, can opt for available or generatable alternative energy-saving technologies. This would be a far wiser policy than importing and establishing western-type energy-intensive technologies and inevitably landing in a serious energy crisis from which they will have to extricate themselves painfully. The argument can be particularly well illustrated by the green revolution agriculture which is well-known to be a major sink for energy, rather than a source of energy, which is what one would expect from the phenomenon of photosynthesis.

All this means that the development approach to norms for per capita consumption is totally different from that based on keeping-up-with-the-Joneses. Unfortunately, hardly any research has been done in this new direction.

A significant step, however, was taken by Hafner (1979) who estimated the minimum per capita energy requirements for a North American to have a satisfactory life (Table 3). This minimum is about one-third the current US per capita energy consumption. But even this minimum is a high figure and can be reduced substantially. For instance, one can deduct the space heating component, which is about 10% of the 31,000 kcals per capita per day, because most third world countries are fortunately located in sun-drenched tropics. Thus, the per capita energy consumption figure gets reduced to 28,000 kcals per capita per day. But, still further reductions are possible by adopting (a) needs-oriented product-mixes, (b) where sensible and feasible, decentralized production for local consumption, and (c) alternative energy-saving technologies for production, distribution and consumption. The magnitudes of these reductions can only emerge from detailed research, but they may result in substantial reductions, perhaps even 50% to yield a per capita consumption figure of about 14,000 kcal per capita per day.

TABLE 3. MINIMUM ENERGY BUDGET FOR A SATISFACTORY LIFE IN USA

Basic Need	Energy requirement	percentage
Food	6,200 kcal/day	20
Housing	6,200 kcal/day	20
Clothing	2,065 kcal/day	6.7
Transportation	4,130 kcal/day	13.3
Leisure	12,400 kcal/day	40
Total	30,955 kcal/day	100

Source: Hafner, 1979.

Some such drastically reduced figure multiplied by the projected population will yield the energy target corresponding to the period for which the population projection has been made. Thereafter, it is a question of ensuring that the energy targets keep pace with the population growth. An important point to note with regard to the magnitude of development-based energy targets is that they are very much lower, and therefore more accessible and feasible, than the growth-oriented targets based on attempts to keep-up-with-the-Jonses.

In addition, the adoption of a development-oriented approach to energy targets has major implications with regard to the structure of these targets.

First, they demand substantial inter-sectoral shifts towards agriculture and agro-industries. The argument for such a shift is simple. In the context of growing unemployment, an employment-oriented strategy of development is unavoidable, and the sector which can generate the most employment in the predominantly agricultural third world countries is the agricultural and agro-related sector, particularly the processing, storage and marketting of agricultural produce and wastes. To ensure that the capital-output ratios in such agro-industries are sufficiently low, adequate inputs of inanimate energy may be essential—hence, more energy must flow to this sector.

Second, since the bulk of the third world population lives in rural areas, that is where the real energy needs of society are and that is where most of the energy must flow. Hence, the urban-rural disparities in energy consumption must be reduced drastically. This reduction is related to the whole question of energy supplies for third world *villages*, which therefore become the main focus of the development-based energy option.

Third, the inequalities in per capita energy consumption must also be reduced because the energy aspect of development objectives must mean satisfaction of basic energy needs, starting with the energy needs of the most energy-deprived. This means that the poorest sections in villages must be made the target population in development-oriented energy programs.

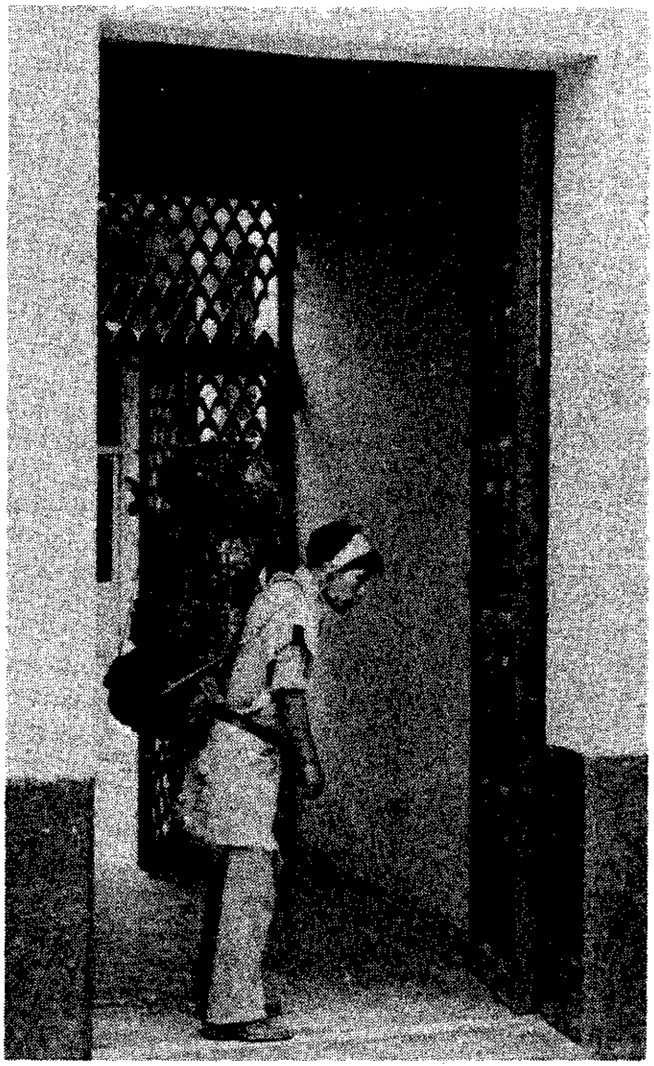
Fourth, the mix of energy sources for meeting rural energy needs must be altered to avoid the serious ecological consequences of the almost exclusive dependence of villages on non-commercial fuels.*

To summarize, the development option requires the following changes in the structure of energy targets: a biased energy flow towards the agricultural and agro-related sector, the villages in rural areas and the poorest sections in villages, and a shift away from environmentally unsound uses of non-commercial energy sources. These are major changes. In fact, they are in some senses more fundamental than a mere quantitative increase in the magnitude of the energy target, because the development option is incompatible with the continued existence of dual societies, whereas the growth option is a natural expression of dual societies. The beneficiaries of the two options are also different: whereas it is mainly the elites of developing countries who benefit from the growth option, it is the people, and in particular the poorest sections, who stand to gain by the development-oriented option. Further, there is a difference in the socio-economic implications of the two energy options: the growth option for energy is incompatible with socio-economic development, but the development option for energy is not inconsistent with economic growth. Notwithstanding all this, the development option raises a crucial question: what options are there for satisfying the energy needs of third world villages?

5. ENERGY NEEDS OF VILLAGES

The first step in answering this question is to define the magnitude and structure of energy needs of villages, but it is precisely this very step that poses problems. The difficulty is that a third world village is, in many senses, "an area of darkness" (to use the title of a well-known novel on India): literally, because there is a serious inadequacy of light which is a clear indication of the pitifully low levels of commercial-energy use, and metaphorically, because detailed information on energy consumption patterns in villages is lacking. However, empirical studies of the energy budgets of villages and of families below the poverty line are well underway, and the next year or two should witness the emergence of a clearer picture. Until then, the only choice is to fall back on "guesstimates" which, however, seem to tally with qualitative observations.

An idea of energy flows in villages can be obtained from an energy input-output matrix which reckons with all the energy sources as inputs and all the energy-consuming activities as outputs. Of course, such matrices may vary from village to village, province to province, country to country, and continent to continent. Thus, the energy input-output matrix shown in Table 4 for a typical Indian



Wood delivery, Mexico

*See Professor Reddy's treatment of these targets in Reddy (1981) also reported in *Soft Energy Notes, 4*, 1, pp. 13-15 (available from 124 Spear St., San Francisco, Ca. 94105, U.S.A.). [editor's note]

TABLE 4. ENERGY INPUT-OUTPUT MATRIX* FOR TYPICAL INDIAN VILLAGE (POPULATION $\leqslant$ 500)

Energy-consuming Activities (Outputs) x (10^3 kcals/day-capita^{-1})

Energy sources (Inputs)	Agriculture	Domestic Activities	Lighting	Transport	Manufacturing	Total
Human Labor	183.7	124.5	—	24.9	3.1	336.2
Bullock Power	420.8	—	—	80.9	—	501.7
Non-commercial energy	—	2110.7	—	—	233.5	2344.2
Oil	24.9	—	130.8	—	—	155.7
Coal	—	43.6	—	—	—	43.6
Electricity	46.7	—	18.7	—	—	65.4
Total	676.1	2278.8	149.5	—	236.6	3446.8

village with a population of 500* is presented only to underline the following essential features of the situation.**

(1) The main categories of energy sources are human labor, bullock power, non-commercial energy (firewood, dung and agricultural wastes) and commercial energy (oil, coal and electricity). The contribution of these energy sources is shown in Table 5.

TABLE 5. CONTRIBUTION OF VARIOUS ENERGY SOURCES TO VILLAGE ENERGY BUDGET

Energy Source	Percentage
Human labor	10
Bullock power	15
Non-commercial energy (firewood, dung, agro-wastes)	68
Oil	4
Coal	1
Electricity	2

The broad categories of energy-consuming activities are agriculture, domestic activities (livestock grazing and maintenance, fetching water, gathering non-comercial fuel, cooking, washing, carrying cooked food to farm workers, and other household tasks), lighting, pottery, brickmaking and metal work, and transportation and other activities. The division of the total energy input into these various energy-consuming activities is presented in Table 6.

TABLE 6. DISTRIBUTION OF VILLAGE ENERGY CONSUMPTION OVER VARIOUS ACTIVITIES

Activity	Percentage consumption
Domestic	66
Agriculture	20
Lighting	4
Transport	3
Manufacturing	7

(2) Human labor and bullock power must be included in the energy matrix; otherwise, the magnitude of energy used for agriculture will be highly misleading—55% and 84% of all human and bullock energy used in the village goes for agriculture, and these two *animate* sources of energy account for about 90% of the total energy used in agriculture. Even this 90% is only an average figure for India; in a large number of villages, particularly in backward areas, agriculture may not use any commercial energy at all.

(3) The dependence on non-commercial energy is striking—it accounts for about 70% of the total energy used in the village, but the figure goes up to 90% if only *in*animate sources are considered. Further, the bulk of this is used as non-commercial fuel for domestic cooking. Other domestic activities such as water heating and space heating (in some parts of India) and non-domestic uses in brick-making, etc., account for the remaining non-commercial energy.

(4) The magnitude of the per capita energy consumption is extremely low, about 750 kcals per capita per day, if only commercial energy is taken into account, but is quite high, about 7000 kcals per capita per day, if both non-commercial and animate sources are considered. Even if animate sources are ignored, the daily per capita energy consumption is around 5250 kcals, which is about one-third of the ultimate per capita energy consumption that third world countries should aim for, according to the development option (see Section 4).

(5) The magnitude of current per capita energy consumption levels in villages may not be too discouraging, but the productivity of this energy is another matter. The efficiencies of many of the devices which use animate and non-commercial energy are

*60% of India's 567,000 villages have a population of 500 and under.

**See Professor Reddy and coworkers' detailed empirical investigation of energy flows in Pura Village (Ravindranath *et al.*, 1978, and Reddy, 1978) reported in *Soft Energy Notes 2*, July 1979, pp. 53-54. [editor's note] extremely low. For instance, the traditional Indian cooking stove has an efficiency of only about 10%, and therefore results in a serious wastage of the non-commercial fuels used for cooking.

(6) Similarly, approximately 40% of the total human labor is spent on domestic activities and actually consists of child-hours and woman-hours. *At least* 10 hours per day have to be spent by each household, particularly the poorest ones, to carry out the major activities of cooking, fetching water, gathering firewood and grazing the livestock—traditionally the first two activities are women's occupations, and the latter two are often carried out by males. The poorest families cannot hire labor; hence, the simplest way for them to cope with the domestic workload is for the mother (who does the cooking) to be assisted by a daughter (who fetches drinking water) and by one or two sons, who graze livestock, gather firewood, and carry the father's food to the fields.

(7) In the absence of labor-saving devices and/or hired labor, these household energy needs become work schedules and time budgets for the members of the family, and these schedules and budgets can be achieved only when there are at least two or three children to help the parents. Thus, a family below the poverty line can survive in the face of demanding domestic energy needs only by having two or three children whose first cost in these income strata is "zero." Such energy consideration are unfortunately completely ignored by population planners.

(8) The vital role of children as an energy source has an impact on education too. Since the contribution of children is essential for the balancing of a poor family's energy budget, it follows that such families cannot forego these crucial energy contributions in return for a questionable type of education in a village school. In other words, a landless laborer's intuitive grasp of cost-benefit analysis and of the opportunity cost of a child's labor is vastly superior to that of educational policy-makers.

(9) In the case of agriculture, the energy needs are now being met primarily by human and bullock energy. The human contribution in the typical village energy budget corresponds to about 160 males each working for 1800 hours per year (180 ten-hour days), and about 35 females each working for about 1000 hours per year (125 eight-hour days). The bullock contribution to the village agriculture corresponds to about 56 bullocks each working for about 1200 hours per year. The annual input into the village agricultural activity is as shown in Table 7. This input is wholly directed towards (a) water lifting and pumping, (b) traction and (c) miscellaneous other uses of mechanical energy such as sowing, etc. (Of course, the human beings also play roles of decision-making and guidance.)

TABLE 7. CONTRIBUTION OF ANIMATE ENERGY SOURCES TO AGRICULTURE IN TYPICAL 500-POPULATION VILLAGE

Source	Number	Hours/Year	Annual total
Male labour	160	1800	288,000 man hours
Female labour	35	1000	35,000 woman hours
Bullock power	56	1200	67,200 bullock hours

(10) Finally, the matrix permits the definition of some overall targets. For instance, the total energy consumed in all the activities is of the order of 3.5 million kcals per day, or 4000 kWht per day, which corresponds at the usual 60% load factor to a supply of 280 kW of power. Further, the break-up of energy consumption according to end-uses is as shown in Table 8. It can be seen that the most demanding end-use of energy is cooking which is based on medium-temperature heating, followed by stationary and mobile mechanical power for water lifting and pumping, traction, etc.

TABLE 8. APPROXIMATE ENERGY CONSUMPTION ACCORDING TO END-USE

End-use	Percentage
Heating (cooking, water heating, brick-making, metal-work, etc.	70
Stationary Mechanical work (including ploughing, etc.)	27
Transport	3

Having described the main features of an indicative energy input-output matrix for a typical village, a fundamental question arises: does such a matrix facilitate the achievement of development objectives? Several aspects of the village energy budget must be considered in order to derive an answer.

First, the predominance of non-commercial energy, and of animal and human labor implies that there are few ways of increasing the production of energy. Increases in the human population will only lead—as has happened—to increases in energy needs; in fact, the gap between needs and supplies will only grow. Larger bullock populations will result in greater need for fodder, and for pasture land at the expense of crop land. An increase in non-commercial energy, particularly firewood, cannot be achieved by leaving forests to natural forces, which is largely the case at present.

Second, energy supply systems in villages neither satisfy basic human needs nor correspond to a reduction of inequalities between rural and urban areas and between various income groups within the villages. The extremely low inputs of *in*animate energy into the agricultural systems impede the increase of production of food. At the same time, the limitations on land availability and the lack of energy to create new industrial activities imply a saturation in the growth of employment. These two factors —low agricultural productivity and restricted growth of employment opportunities—coupled with an increasing population result in less food to buy and less work to earn the money to buy this food, i.e., decreasing satisfaction of the basic need for food. The basic need of shelter is not adequately fulfilled, particularly with respect to services such as the supply of water and cooking fuel. Community health is threatened by polluted water and the absence of sanitation—90% of the rural population in India is said to suffer from intestinal parasites, which are estimated to consume about 15% of the already low per capita daily intake of 2000 calories of food. Attempts to solve the water and sanitation problems require further inputs of energy. As long as the poorest families have to depend on the labor inputs of children, their basic need for education cannot be satisfied. The generation of employment is very much dependent on the increased supply of energy to new agro-industrial activities, but the difficulty of increasing energy supplies within the framework of the current energy supply patterns constitutes a major obstacle. Above all, village life in third world countries may seem idyllic to city dwellers, but the real picture is different: the manual work constituting the human energy input is dull, back-breaking, often degrading, and erodes the quality of life whch gets progressively worse, particularly for the poorest families. This is mainly because what little commercial energy flows into the village can be bought only by those with purchasing power—hence, the richer sections utilize commercial energy to become richer and therefore inequalities are increased.

Third, the self-reliance of villages becomes increasingly undermined as the inability to increase energy supplies inhibits the satisfaction of basic needs. As the village becomes more and more dependent on imports of essential commodities (including food in many cases), its ability to control its destiny is diminished, and the debilitating dependence on the metropolis increases.

Finally, the virtually exclusive reliance on non-commercial energy implies the absolute necessity of ecologically sound practices with regard to the vegetative energy resource base. But what is taking place in most third world countries is a devastation of the very forests which supply the bulk of village energy needs. Hence, the current energy supply system in villages will progressively deteriorate because it is inherently un-sustainable in the face of rising populations.

The conclusion is clear—*the energy budgets of villages in third world countries are inconsistent with development*, and radical changes in the magnitudes and structures, both on the supply and demand side, are essential to meet development objectives.

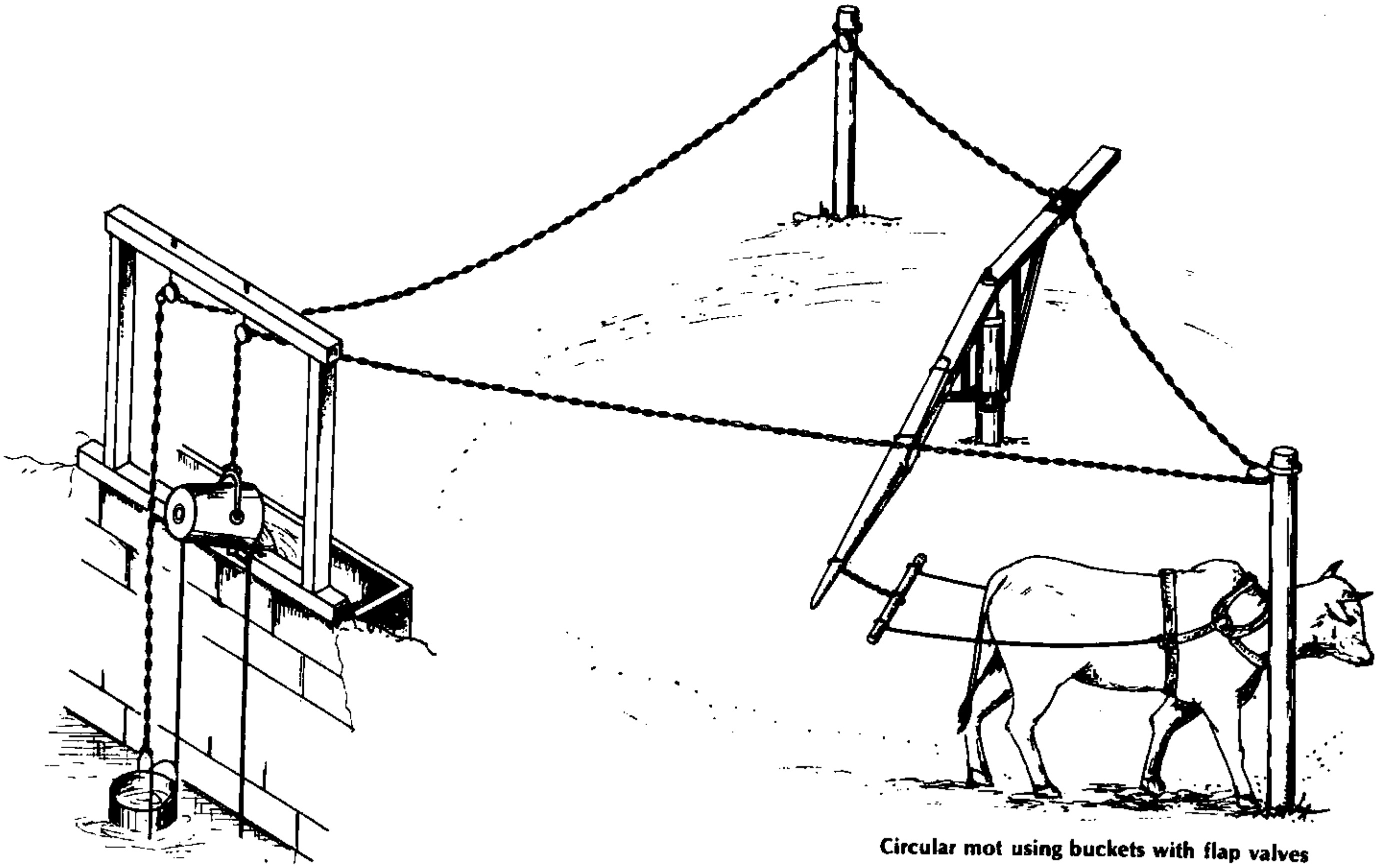
6. MEETING VILLAGE ENERGY NEEDS

The response of most third world countries to the challenge of meeting village energy needs has been based on an energy-analogue of the "trickle-down" theory of GNP growth. Just as the pursuit of GNP has been sought to be justified with the argument that the benefit of growth will gradually "trickle down" to the poor, there is an implicit view that the erection of large-scale, centralized power stations will result in their energy "trickling down" to the villages. But, the energy of such plants which does reach the villages is indeed a mere trickle of less than 20%.

There are many reasons for this reluctance of centrally-produced energy flow to villages. An obvious reason is that the decision-making elites in most third world countries are mainly urban-based, and quite naturally, they make first claims on centrally-generated power. But an oft-quoted reason is that villages cannot generate sufficient demand backed up by purchasing power—however, this is only another way of stating the obvious truth that there is only a small percentage of rich persons in villages. In any case, the weak demand leads to very low load (utilization) factors ranging 1 to 14%, which render the energy supply uneconomical. Another important economic obstacles to energy supplies to rural centers is the high cost of conveying energy from centralized plants to distant villages. The costs of transmission lines (about $150 per kW for $850 per km) are a great deterrent to connecting villages to grids. In addition, there are transmission losses (as much as about 20%) which aggravate the problem.

The result of all this is that rural electrification from centralized sources in the third world is rarely a success story. In India, for example, only 11% of the 350,000 villages with an under-500 population have been electrified—and will be electrified in the next decade or so—even though 25% of India's 600 millions live there. And even when they are electrified, they are only supplied with about 100 kWhe per day, which is equivalent to about 400-500 kWht per day, i.e., about 10% of current energy consumption. In fact, this 10% is consumed by the rich who constitute approximately 10% of the rural population.

Above all, rural electrification from centralized power stations comes nowhere near satisfying the largest and most important energy need in villages, viz., energy for cooking. In fact, it is this need which must be the touchstone of any scheme for energizing villages. The crucial question is: does the proposed



Circular mot using buckets with flap valves

scheme meet the energy needs for cooking in the villages?

Thus, what may be called the *centralized option* for meeting the energy needs of villages must be pronounced a failure. In fact, even when the touchstone of cooking energy needs is ignored—as is the practice in most third world countries—the centralized option has not been successful. Seen in this perspective, arguments in favor of particular technologies of centralized energy production, e.g., nuclear power stations, are irrelevant to the basic issue of providing power to villages, because the failure under discussion originates from the very approach of centralization, and not from the particular technologies for centralization. The depletable nature of fuels used in central power stations (other than hydroelectric), as well as the environmental impact of energy production in such stations, are of course important additional issues which have been treated elsewhere.

Inevitably, therefore, attention must be turned to another path to the achievement of energy targets. This is what may be termed the *decentralized, renewable sources option*, i.e., the use of renewable sources for the village-scale* decentralized production of energy to meet most village needs.

It is obviously an advantage to attempt a smooth, continuous, so-called "reversible" transition from current energy production and consumption patterns in villages to a future pattern of decentralized energy production based on renewable energy sources. Otherwise, the possibility of irreversible damage done to the fabric of village life may distort development objectives and lead to the rejection of the option. In other words, the energy path (or means) is just as important as the energy goal (or end). Hence, abrupt changes and major perturbations in energy production and consumption patterns are sought to be avoided by designing a time evolution of the energy input-output matrix from its present form to a future form. For this reason, large-scale imports of fossil fuels, e.g., diesel, for the local generation of electricity are not considered.

The starting point, therefore, must be the fact that human beings, cattle and non-commercial fuels supply the bulk of the energy needs of villages in third world countries. An energy program, such as the uncritical mechanization of agriculture, which leads to wholesale redundancy of human labor, may benefit the proprietors of the machines, but will only increase farm unemployment and mass migration to the cities, unless there is a simultaneous generation of employment opportunities in the village. Similarly, the sudden displacement of bullock power from the village scene may prove to be disadvantageous for several reasons. First, bullock power does not depend on depletable fossil fuel sources. Second, cows and bulls play an intricate role in an agrarian

*The term "village-scale" is meant to include the scale of a cluster of, say ten, villages.

economy by serving in several economic categories—(1) consumer goods (they can be eaten as beef), (2) machines for producing consumer goods (milk), (3) equipment yielding intermediate goods (dung which yields biogas energy and fertilizer) and services (traction), and (4) "mother machines" (cattle reproduce cattle). Cattle are therefore a crucial part of agricultural ecosystems entering in many ways into the flows of matter and energy. Besides, the monetary investment in bullocks is too large, viz., about $3.8 billion in India, to warrant a rapid phasing out. Finally, however ecologically unwelcome the dependence of non-commercial energy may be, the fact is that the "zero-cost" end-use appliances, viz., mud and cooking stoves, have been evolved to use this fuel. Hence, alternative fuels will bypass the poorest families unless these fuels can be used with appliances which are within their means.

Nevertheless, major improvements can be effected in the productivity of human and animal labor and in the efficiency with which non-commercial energy is used.

Continued reliance on human labor would be putting back the clock of history only if the arduousness, drudgery and low productivity of labor are preserved in their traditional and pristine form. It is possible, however, to turn the critical and creative attention of modern science and engineering on every one of the productive activities involving human effort, and thus achieve the twin objectives of lightening the burden while increasing per capita productivity. The *modus operandi* for attaining this target has to be based on exploiting the mechanical advantage of what are known in physics as simple machines—levers, pulleys, wheels, cranks, gears, etc.—which do not require inputs of harnessed energy. The research, design and development work could well be inspired by the spirit and physics underlying the well-known statement of Archimedes: "Give me a long enough lever, and I will lift the earth!"

One has only to observe the effort by a teen-age village girl in rope-drawing or hand-pumping water from a deep well to realize that there is tremendous scope in simple inexpensive designs for alleviating human burdens while enhancing efficiency. A similar challenge arises with a large number of agricultural operations—weeding, sowing, planting, harvesting—which are today being carried out with human labor, but are strenuous, tedious, literally back-breaking, and above all, characterized by low productivity.

One of the most important possibilities in this mission of finding better* ways of using human energy is *pedal power*** involving the principles and parts of bicycles and bicycle mechanisms, e.g., pedals, sprockets, chains, axles, wheels, etc. There are two main categories of pedal power possibilities:

(1) *stationary* applications, e.g., water-pumps, winches, electrical generators, refrigerators, winnowers, corn grinders, mechanical power take-offs, hydraulic pumps, etc., and

(2) *transport* applications, e.g., bicycle-drawn trailers, cycle rickshaws for passenger transport, pedal rovers for unprepared terrains, wheelbarrows, etc.

Above all, an extensive rise of pedal power will significantly augment the effectiveness of a massive source of energy in the rural energy scheme, viz., human energy, *without* demanding large inputs of harnessed commercial and non-commercial energy.

Similarly, the productivity of bullock power can also be enhanced by creative engineering on the devices which transform this animate energy source into desired end-uses.

With regard to cooking with non-commercial fuels, simple designs for mud cooking stoves permit a doubling or trebling of the efficiency with which the heat produced by the combustion of these fuels is utilized for the chemical changes involved in cooking. This means that the same quantity of non-commercial fuel used in the village can satisfy double or treble the current cooking energy needs, or that the current energy needs can be satisfied with a half or third of the current fuel consumption.

All this pertains to more efficient utilization of currently used energy sources—they come under the category of "conservation measures." But the real thrust of the decentralized, renewable-sources option for meeting village energy needs is the emphasis on energy production technologies which have not been hitherto exploited in villages:

(1) biogas energy produced by the anaerobic fermentation of cattle, poultry, human and agricultural wastes;

(2) "energy forests" in which fast-growing trees are specifically grown as sources of firewood and/or charcoal;

(3) solar energy;

(4) wind energy; and

(5) micro-hydroelectric plants.

The temptation will be to carry over urban thinking and attempt to convert all these sources into electricity and thus integrate them into all-electric systems with transmission lines and electrical end-use equipment. The temptation is increased because an all-electric system is well established in the developed countries and most of the technologies and end-use

*Better from the point of view of the particular human being who is laboring as well as from the point of view of his society.

**Pedal power is environmentally very sound—it is non-polluting, not based on continuous use of depletable energy resources, and can be "cycled and recycled."

equipment are either available off-the-shelf or are almost there. But there are also serious disadvantages: the capital costs of end-use equipment are almost certain to exclude families below the poverty line (compare electric cookers with mud stoves). In addition, totally different domestic life-styles are suddenly demanded by an all-electric system.

Further, the system can suffer from substantial efficiency losses which occur in two ways. First, there are the losses whch are associated with energy conversions from one form to another. For example, going from biogas to electricity may only yield 25% conversion of energy, so that direct use of biogas for cooking may be far more efficient than converting biogas to electricity which is then used for cooking. Second, energy comes in various grades; electricity and mechanical motion correspond to the highest grade of energy, in contrast to waste heat which is the lowest grade; and fossil fuels (coal and oil) are of intermediate grade. (Solar energy is very special because its grade depends upon how much it is concentrated—unconcentrated it is very low grade, but it becomes very high grade when concentrated.) The grading of energy sources leads to a simple thumb-rule: "Don't use a higher grade energy source than the task deserves." For example, it is unwise to use high-grade electricity for medium-temperature heating which is what is required in cooking.

All this means that so-called all-electric rural energy centers are not such a good idea, however "modern" they may sound. Nevertheless, it is very likely that no single alternative energy technology, neither biogas nor "energy forests" nor wind nor sun, can meet all the energy needs of villages. There will have to be a *mix* or combination of energy sources without conversion into a single form, e.g., electricity. It is here that the compactness of villages may be turned into an advantage because it lowers distribution costs. Energy sources can be matched, through appropriate devices, to energy-consuming tasks, and separate supplies can be considered, e.g., for cooking, pipeline distribution of biogas, or fuel from an energy forest, and for lighting, low-tension electric lines. Some indication of possible appropriate devices is presented in Table 9.

It is important not to exclude the use of electricity and electrical appliances and equipment from villages. In some situations, e.g., lighting, communication, water pumping, their advantages are too obvious to cite. Where the electricity will come from is another matter. It may prove convenient to generate it in the village itself. It is also possible for a cluster of villages to have a tower-top focussing solar collectors driving an electricity generator, or a run-of-the-

TABLE 9. MATCHING SOURCES AND DEVICES TO TASKS

Energy-consuming task	Possible appropriate devices/equipment
Cooking	Stoves for non-commercial fuels, Biogas stoves, solar cookers
Water lifting and pumping	Windmills, biogas-based Humphrey pumps, solar-powered pumps, animal- and pedal-powered pumps, handpumps, electric pumps
Water purification	Solar distillation, filters
Water heating	Waste heat from cooking stoves, solar water-heaters
Drying of agricultural produce	Solar dryers
Space heating/cooling	Solar airconditioning (Skytherm process)
Refrigeration	Pedal-powered refrigerators, "dry ice" (solid carbon dioxide from biogas)
Grinders, mills, winnowers and crushers	Windmills, animal- and pedal-powered devices, electric mills
Heating in small-scale chemical and metallurgical industries	Equipment based on combusion of non-commercial fuels or biogas, and solar heating devices
Lighting	Electricity, windmills and biogas generators, solar collectors (when they become sufficiently inexpensive)
Mechanical power	Windmills, biogas engines, animal- and pedal-power, electric motors
Mobile power	Biogas engines, pedal-power, animal-power

river micro-hydroelectric plant. Or it may prove economical for villages near electric grids to obtain more than a "trickle" of electrical energy. The point is that electricity may have to form an essential part of the mix of energy sources, and the "trickle" of energy from centralized power stations must neither be vetoed nor ignored.

A detailed scenario for the decentralized, renewable-source option for meeting village energy needs is neither possible nor advisable, because the details would vary too much with the precise nature and structure of the energy needs and the availability of energy sources. Further, the time-variation of the changes in energy supplies and needs will vary from village to village. The scenario will also vary with developments in technology. Finally, even for the micro-world of third world villages, all the techniques of energy planning have not yet been fashioned. This then is the real challenge—to envisage their energy futures and to implement these visions. One point is clear—if third world villages are to be the peripherals to growth, their futures, as well as those of the people in them, are bleak, but if they are made the core of development, their futures are bright.

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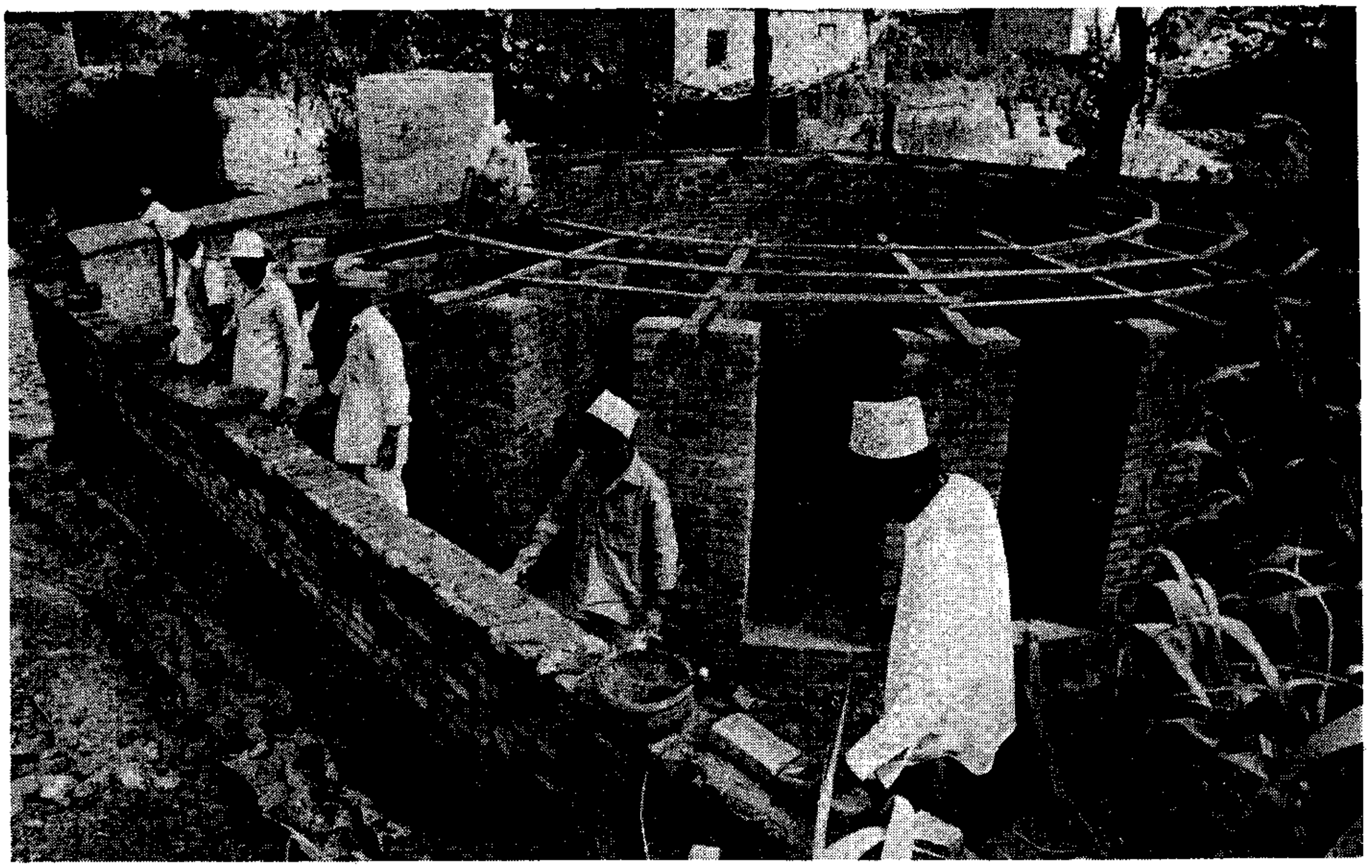
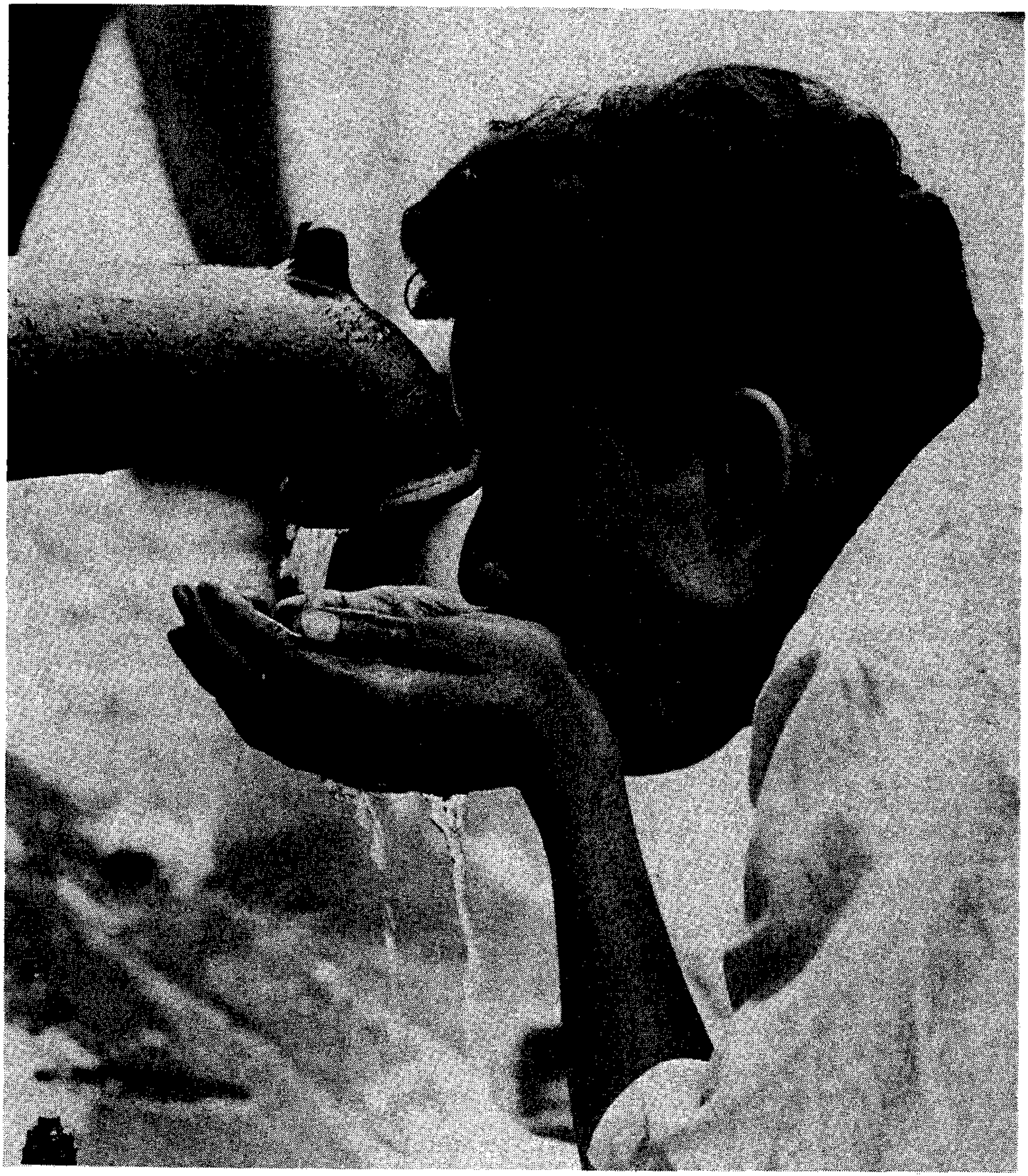


Biogas, Nepal



II. RURAL ENERGY AND DEVELOPMENT: A STRATEGIC PLANNING ANALYSIS

R.S. Ganapathy*

1. INTRODUCTION

Traditionally, development efforts have focused on urban, industrial areas and not on rural areas, where over 2.5 billion people live. Rural problems have now entered a critical stage. They are manifestations of underlying crisis, of poverty, hunger and underdevelopment. In this paper, an analysis of rural energy problems will be made in the broad development context. Approaches to rural energy planning will be discussed and policy options to deal with the rural energy crisis will be developed, with particular reference to renewable energy sources.

2. THE DEVELOPMENT CONTEXT

To define the rural energy crisis, we need to understand its context of development. Here I propose to review the three basic development theories which attempt to understand and interpret the rural energy scene. The *Modernization* perspective views development as a linear, universal process going through several stages ranging from agricultural to post-industrial society, all governed by economic rationality. North and South, in this view, represent two different stages in the same process of general development. With modernization, it is possible to move from any stage to a higher one. The *Dependency* perspective views development as an historical process of sustaining polarity (but not duality), based on unequal relations of interdependence among countries. The affluence of the North is dialectically related to the poverty of the South and its underdevelopment. The third perspective of *Self-Reliance* considers meaningful development to be contextual, decentralized and non-linear, oriented towards ecological sustainability and resource conservation, determined and pursued autonomously. Meeting basic human needs, it is participatory and empowers people to be autonomously in control of their lives. These different perspectives have different basic assumptions about human nature, social problems and goals and the processes of change. They inform the rural energy debate in different ways.

In addition to these theoretical perspectives, we need to identify emerging world trends as part of the development context. The meaning of rural energy can only be understood, as I have suggested, in a particular context. Such understanding is crucial in developing policies and solutions. The emerging world picture is characterized by three dominant features:

(a) Increasing interdependence due to world trade, communication flows and interrelated, interacting problems arising out of the finiteness of the ecosystem and natural resources.

(b) Science and technology are now perceived not as neutral activities but as normative and contextual. They are powerful instruments of socio-economic transformation. They are part of the problem we face as well as part of the solution.

(c) Inequalities from within and among nations have grown considerably worse during the last few decades. While growth is desirable, "more" may not necessarily be better for all.

Given these conditions, it would be useful to outline the objectives of rural development in the Third World as a synthesis of the three perspectives described earlier. While contextual conditions differ considerably, the following four goals will be relevant for most countries (Weisskopf, 1980). Goals must be derived from the interaction among competing perspectives rather than from a single perspective.

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(i) *Growth* in (a) industrial and agricultural production, (b) savings-investment rate and (c) per capita consumption.

(ii) *Equity.* (a) Meeting minimum basic needs for everyone in food, healthcare, clothing, housing, education, etc. (b) Reduction in inequalities (wealth-income, rural-urban and interregional) and in economic and social stratification and organizational hierarchy. (c) Macroeconomic policies to redistribute income and resources. (d) Equalization of access to social power: productive assets, finance, information, knowledge and skills and political and social organization (Friedmann, 1979).

(iii) *Self-Reliance.* (a) Self-sufficiency: diversified production capacity to meet local needs, with minimal imports. (b) Economic autonomy: indigenous control of economic activities at various levels (national, regional, local) and minimum reliance on external institutions, finance, technology and expertise. (c) Democratic control of production.

(iv) *Employment.* Full employment (everyone can find a productive and meaningful job).

As one can surmise, these objectives are not always consistent and there are trade-offs between them. The objectives of rural development are objectives of the *overall development strategy* itself. The relative emphasis on each of these elements depends on the contextual conditions, as we shall see later. We will also derive the rural energy objectives from these. Rural energy strategies ought to satisfy rural development objectives. Rural energy is both a spatial and functional manifestation of development. The spatial and functional elements are dialectically related, reciprocally determining one another. If a rural community wants to achieve these developmental objectives, it must decide on a balance among them and solve questions of efficiency and equity, production and distribution, self-reliance and interdependence, employment and automation, simultaneously. *The experience of many countries since 1945 indicates that lopsided attention to or primacy of one objective over others leads to uneven, restricted, dependent, unequal and marginal development.* Yet as we shall see shortly, such tendencies persist.

In reviewing the context of rural energy, we must note the role of the Appropriate Technology (AT) movement. Recognizing the political bias of technology, the AT movement, starting from Schumacher (*Small is Beautiful*) and others, has promoted the *self-reliance* perspective of development theory. This is defined as (i) technology by the people (ii) holistic (iii) location-specific and (iv) futuristic. It is usually employed with three related but distinct meanings: (a) meeting basic human needs (b) using local resources (c) enhancing the autonomy and direction of people over their affairs both individually and collectively (Bookchin, 1979). The choice of rural energy technologies will be influenced by the combination of such meanings one employs. The AT movement and the ecological movement have overlapping interests in advocating the development of renewable energy sources.

Finally, we need to comment on several studies, reports and United Nations efforts that have a bearing on the rural energy question. In the late 60's, when it was found that the Modernization paradigm was not working effectively and the problems of the world's poor had worsened, several significant events took place. The Pearson Commission in 1969 brought out its report on international developments (*Partners in Development*). The Club of Rome brought out several reports, the most important on development being Jan Tinbergen's *Reshaping the International Order* in 1976. Another key U.N.-sponsored study was Wassiley Leontief's *The Future of World Economy* in 1977. The Dag Hammarskjold Foundation brought out *What Now? Another Development* in 1975. Articulating the concept of Basic Needs, ILO published in 1976 *Employment, Growth and Basic Needs*. The OECD Interfutures Group brought out *Facing the Future* in 1979. Finally, the World Bank brought out the *World Development Report* in 1979 and 1980.

The United Nations itself organized several international conferences, starting with the 1972 Conference on Human Environment. Throughout the 70's, conferences (on Food, Population, Women, Water, Desertification, Science and Technology, and Technical Cooperation) took place which had the cumulative impact of changing world consciousness about the holistic nature of world problems characterized by multiple, mutual, and simultaneous causal interaction. Reflecting the growing strength of the Third World in the United Nations, in 1974 the UN General Assembly adopted a resolution for a declaration and programme of action on the establishment of a New International Economic Order. Formally recognizing the conflicts of interest between North and South in an expanding one world economy (not just several national economies linked by external interactions), it also cited the unequal exchange between the global Center and the global Periphery. In 1980, the Brandt Commission presented its report, *North-South: A Program for Survival*, calling for massive transfer of resources, agreement on international energy strategy, an end to mass hunger and structural reform in international institutions. Finally, in its Special Session, the UN adopted the International Development Strategy (IDS) for the Third Development Decade (United Nations 1980). The Strategy document has a number of noteworthy proposals and guidelines. Both the IDS and the Brandt Commission assume that there are mutual interests for North and South (Brandt

Marginal settlement, Asia

Commission 1980). The recovery of the World economy by increased production in the North and massive transfer of resources to the South to buy exports from the North is identified as critical. Trade expansion, more aid, more growth, new international division of labor and integration of Third World countries into an international economic system primarily fuelled by capitalism and the market economy, is the projected scenario for the future by the IDS and the Brandt Commission.

While no specific strategies are proposed for rural energy, the IDS analyzes the energy problem in terms of four crises: (a) a supply crisis (gap between demand and supply) requiring assistance to expand supply through exploration and imports, with special assistance to create substitute fuels, (b) a balance of payments crisis due to oil imports, calling for more aid/loans, (c) a technical problem calling for new R&D, technology transfer, easier access to Northern technology, investment by the private sector, new information systems and exchange, training and development, and new inputs for improving energy efficiency and productivity, and (d) the disadvantages of the "target" poor, who lack skills, infrastructure, credit, inputs and technology. The latter problem can be faced by channeling aid and resources through the existing institutions in a "service delivery" framework. The IDS formulation of the rural energy problem and solutions follow this framework. Having outlined the broad context in which Rural Energy will be debated, we will now return to the nature of the rural energy crisis. The critique of the above formulation of the rural energy problem will be discussed in a subsequent section.

3. THE NATURE OF THE RURAL ENERGY PROBLEM.

Energy has been ample in rural areas all over the world for millenia. The harmony between rural people, their economic and household activities and nature, which provides renewable energy, continued during untold centuries except for occasional disruptions by famines, earthquakes and other disasters. Rural energy is and continues to be primarily solar energy, available through photosynthetic conversion of crops (food and fodder), fuelwood, animal dung and crop residues. Over 80% of rural energy in the Third World is derived from wood and animal wastes and is primarily used for cooking and agriculture (Makhijani, 1978). Energy is needed for water heating, cooking, space heating/cooling, irrigation, fertilizers, crop drying, grinding, food processing and fabricating materials needed for construction, tools, pots/pans, etc. and local services (schools, trades, hospitals, etc.) (Howe, 1980, Brown and Hoe, 1978). Energy stability is part of the rural life style in the Third World. Most of the energy used is noncommercial and produced by people themselves to meet their own needs. Rural energy, in other words, is not a commodity exchanged through a market, but a *use value* (Illich, 1978). Recognition of this characteristic is central to the task of rural energy planning and assessment. Although energy is a basic necessity to meet human needs, there is no direct correlation between the quantity of energy used and human well-being. Again, energy is a use-value, not easily subject to quantification and cross-contextual comparison.*

Over the last 100 years or so, the population (human and animal)-energy-agriculture equilibrium has slowly deteriorated. Now it faces disruption, degradation and ultimate collapse. Overcultivation and overgrazing have resulted in waterlogged and saline soils and in spreading deserts. The search for cultivable lands has sent subsistence farmers into forests and slope areas, resulting in deforestation, soil erosion and disrupted hydrological cycles. Flooding and landslides have increased in frequency. Clearing for wood has destroyed the wildlife habitat, reducing the diversity of species. The shortage of fuelwood has become an alarming problem, forcing people to spend more time in wood collection and less time cooking meals, affecting their nutritional, economic and family stability. The introduction of commercial energy for cash crops has generated the need for cash to purchase fuel which was formerly available free. The demand for commercial firewood and charcoal in urban areas, the higher prices of kerosene after the 1973 oil price increase, the increasing demand for energy from rural industries and agricultural production, higher population, and competing demands (forest cover to control erosion, food, fodder, fuel and timber) for forest products have all generated the rural energy "crisis" (U.S. AID, 1979). *The crisis is not a product of unbridled nature but of the social use of nature.* It can be understood only as an *interaction* of natural, technological and social factors. Energy cannot be addressed as an isolated natural or technical problem but only in an overall developmental context, which is a historical and socio-structural phenomenon.

As we can see, the formulation of the rural energy problem is critical. Depending on the formulation, different solutions and policies emerge. The formulation again, can be technical, economic, political, environmental or a combination of these. The effective way to understand it is to formulate the problem in systemic, holistic terms. Manifestations of underdevelopment in rural areas can thus be seen as historical, socio-structural transformations. Colonialism has led to commercial agriculture, landlessness and marginalization, urban migration and unemployment. Commercialization of firewood has led to the loss of access to a major fuel source (firewood) and to the alienation of rural poor from their means of production, including energy. Environmental overloading has led to increased pressure on dung as fuel, causing its loss as a nutrient and increasing the share of the family budget for fuel (over 30% in many parts of Africa), lowering the quality of rural life. All these represent an unfolding historical reality that is complex and defies easy frontal attack and simplistic solutions.

A particular aspect of this "development crisis" (for rural energy is only a manifestation of the underlying, pervasive development crisis) requires social analysis—the role of women. The rural energy crisis in the Third World can be described as the women's crisis (Wisner, 1980). Women are closely connected with energy generation and use in rural areas. They do much agricultural work, repair houses, collect firewood, draw water, cook, go to the mills for grinding cereals and bear the bulk of managing the family (particularly if the husband is away in towns, estates or mines). Tinker (1980) estimated recently that women in Africa spend close to 12 hours a day for cooking, firewood collection and water-drawing. They have to travel further and further to collect firewood. Many cook only one meal a day (in Upper Volta), or use quick-cooking cereals (in Senegal, rice replaced the more nutritional millet), because energy is so expensive. They boil water less often, jeopardizing the family's nutritional health (Tinker, 1980). In the worsening crisis, they are forced to have more children who can help them handle this crushing burden. Development, as it has taken place, has inequitably affected women. It has reduced women's power and has stimulated men's access to money linked to outside opportunities. With the loss of control over energy, women become increasingly dependent, alienated and frustrated. This grim picture of women is symbolic of the rural energy crisis. The nature and pervasiveness of the crisis suggests that we need to look for systemic solutions rather than develop quick "supply" or technical fixes. We will examine later how we can develop comprehensive, strategic policy options.

To get an appreciation of the magnitude of the problem, let us look at some statistical estimates (Howe, 1980, National Academy of Science, 1976). In 1975, the estimated total energy consumption in all the developing countries was 36 MBODE (millions of barrels of oil equivalent per day), consisting of roughly 50% noncommercial energy and 50% commercial. By one estimate, 28,000 kcals per day per person is the minimum energy needed to provide a decent standard of living (food, water, clothing,

*For example, wood-fires can simultaneously or sequentially deliver all of the following services: economic (fermentation of drinks for domestic use or sale, food preparation); ecological (pest-control in organic construction materials or direct protection); cultural (taste preferences); social (gathering place, boundary definitions); and religious (spirit location).

shelter, education, and health). (Current U.S. per capita energy consumption is 282,000 kcals per day per person.) Thus, the Third World countries would need a total energy of 95 MBODE for a higher expected population in 2000. The Overseas Development Council study (Howe, 1980) estimates that noncommercial energy can increase only marginally from its 1975 production, since environmental stress upon supply is great and the efficiency/productivity of noncommercial energy is quite low. Hence, commercial energy has to supply the rest of the requirements to the order of 75 MBODE. Present *world* consumption of all energy is only 57 MBODE. We will examine later the implications and analysis of such a forecast.

4. CONVENTIONAL SOLUTIONS TO THE RURAL ENERGY PROBLEM

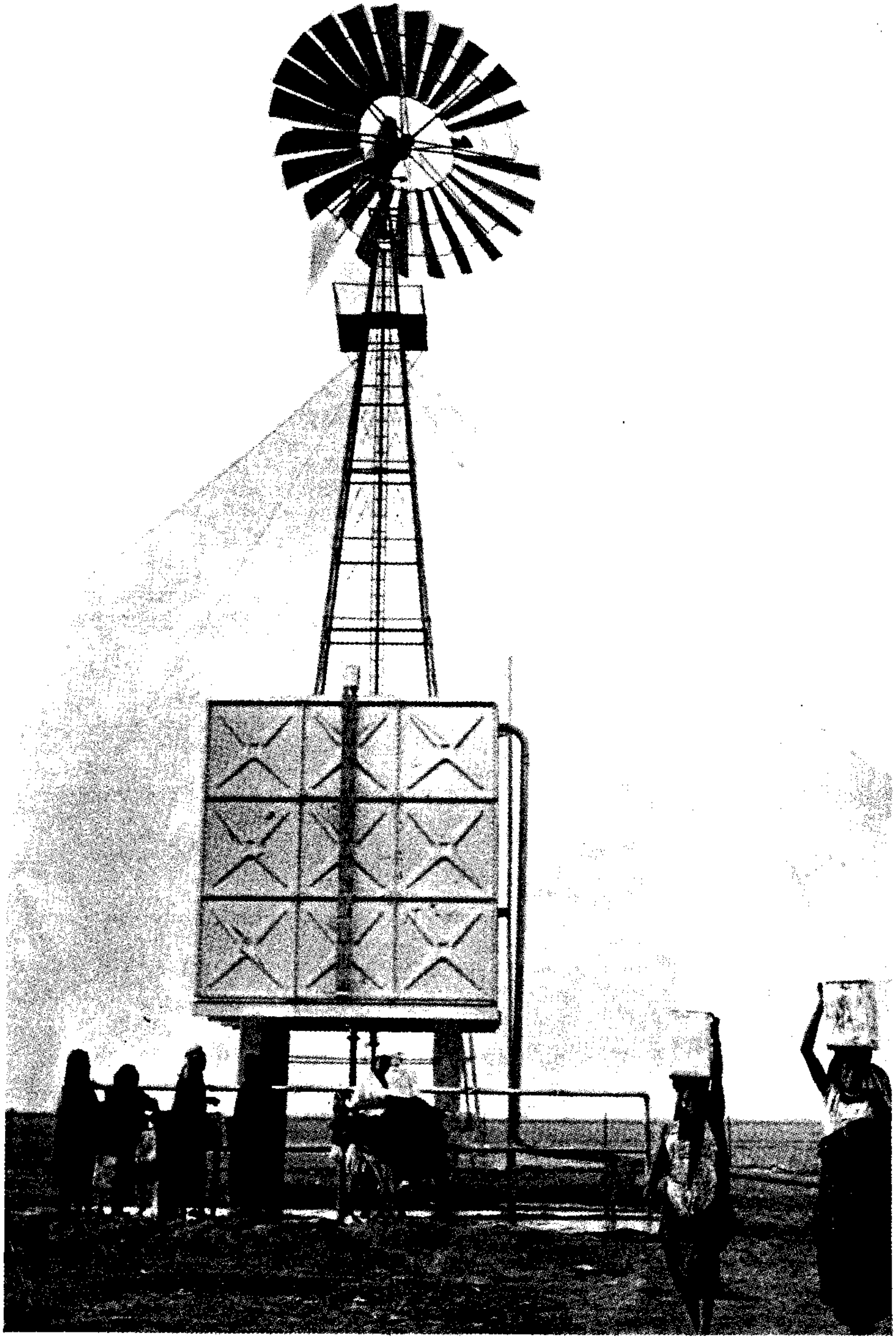
It was mentioned earlier that the solution to the rural energy problem depends on the problem-formulation. We have enough research studies and analyses in social sciences to show that problem-formulation is a function of interests, ideologies and theoretical perspectives and not a 'neutral,' 'objective' or 'scientific' exercise. Reality has multiple dimensions. One needs multiple perspectives to gain real insight into it (Feyerabend, 1975). The ancient Hindu philosophical doctrine of "Syadvada" is similar to this approach. It states that every proposition is true only up to a point. Ultimately, one needs *multiple perspectives* to develop insight into reality. Thus we need to encourage a dialectic of multiple images of the problem. We need also to remember that the only meaning these images have are contextually grounded and not universal or context-free.

During the last 35 years or so, in many post-independence Third World countries, rural electrification was promoted as the solution to meet rural energy demand (Smith, 1980). Electricity was perceived as a symbol of modernization and progress, and the decision to electrify villages was primarily made by engineers and bureaucrats aided by foreign experts and advisors. Electricity was beyond the purchasing power of most of the rural poor. It was not a suitable form of energy for cooking, agriculture, fertilizer or pumping, without an expensive capital outlay which is beyond the reach of most rural people. It was culturally unacceptable and disruptive of family and kinship norms. It was very expensive to extend transmission to remote areas where the load densities were very low. It was centralized and hence alienated rural women from their means of production, making them vulnerable to the commercial economy even when it was subsidized heavily. The technical innovation of electrical energy has both a factor and social bias. It was capital-intensive (a factor bias) and it also benefited the already privileged and rich classes, resulting in more inequality in rural societies. The rich farmers, rural industrialists and business people increased their profitability considerably, turning the rural poor, in the process of land tenure consolidation, into landless, marginalized victims of "progress." In addition, the rural victims were blamed for being "conservative" or insufficiently motivated to adapt to innovation. We see similar experiences in the Green Revolution in the Third World. While it increased production of food grain, it was systematically biased in favor of energy-intensive agricultural practices and the rich. The spatial and class bias of innovations and the crisis they create in the long run are well documented (Lipton, 1977; Cecelski, 1979; Friedmann, 1979; Soja, 1980; Yapa, 1980; Wisner, 1980).

Given this abuse of innovations, let us review some of the solutions proposed to solve the rural energy problem. There have been a large number of studies and reports on this question. It is useful to categorize the major recommendations of these studies and to summarize them. The categories found most useful are: (i) Supply-oriented solutions; (ii) Efficiency/Productivity-oriented (primarily technological) solutions; and (iii) Appropriate Technology solutions. These categories are not mutually exclusive.

(i) *Supply-oriented solutions.* (a) Increase the kerosene supply through modified refining and cross-subsidy by taxing gasoline, etc. (Howe, 1980). (b) Community or commercial woodlots (UNIDO, 1979 and Tinker, 1980). (c) Increase the supply of charcoal and firewood (Gamser, 1980 and UNEP, 1979). (d) Supply solar cookers, solar crop dryers, water heaters, solar cells (supplying electricity) and solar distillation stills and substitute active and passive solar space heating devices for existing fuels (Howe, 1980; Makhijani, 1978; National Academy of Sciences, 1976). (e) Increase biomass production and supply through biogas, pyrolysis (charcoal), bio-alcohol (ethanol and methanol as transport fuel) and crop residues. (f) New mini- and micro-hydro schemes: water wheels to generate power as well as to provide energy for irrigation, grain milling and sugarcane crushing (UNIDO, 1979). (g) Windmills to provide mechanical energy in appropriate locations (UNIDO, 1979).

(ii) *Efficiency/Productivity-oriented solutions.* (a) Redesigning of agricultural implements (UNEP, 1979). (b) Improved cooking stoves (Lorena) which increase energy efficiency by almost 300% (Brown and Howe, 1978). (c) Recovery of energy from waste materials (National Academy of Science, 1976). (d) Improving the productivity of factors of production to reduce energy consumption (soil enrichment, use of fertilizers, intercropping, improving animal draft power, etc.) (FAO, 1978). (e) Promotion of



Agroforestry (production of timber, food, fuel and cash crops) to maximize energy productivity (FAO, 1978). (f) Use of diesel pumps to increase output/energy input. (g) Integrated Renewable Energy Development (for example, solar collector waste heat used in a methane plant which generates gas, when combined with wind energy, can provide mechanical energy for pumps and heating, as well as fertilizers) (Brookhaven, 1976 and Hayes, 1977). (h) Training and skill development (UNIDO, 1979). (i) Conservation technologies that improve on open fire cooking, charcoal kilns, vehicles (Reddy, 1977).

(iii) *Appropriate Technology Solutions* are primarily focused on maximizing utilization of local resources and ecological sustainability. They usually involve some community participation and democratic control and sometimes emphasize production to meet basic needs and cultural acceptability. However, they tend to be primarily technology-oriented, focusing on micro- or site-specific viability. A whole range of renewable energy technologies described under earlier categories will fit the AT bill (Makhijani, 1978 and Howe, 1980). Often, they tend to focus on hardware, have a target population and a service delivery/innovation diffusion approach (Lovins, 1977).

In addition to these categories of solutions, there are several other energy policies proposed at the national and international levels which deal with oil and synthetic fuels, nuclear power, coal, etc. While these issues are relevant to the broader North-South dialogue and to complex global problems as well as to rural energy through their impact on surplus flows, interfuel and interregional substitution and the political economy of global trade and financial relations, these are not discussed in this paper. But the issues are relevant, since now 20% of the world's population is consuming 75% of its energy production. Setting the same standards of consumption for the other 80% of world's population would obviously be unsustainable (Rifkin, 1980). As we are quickly reaching the ecological limits of certain types of energy usage, building an equitable international order would necessarily mean reduction of consumption in the North. The notion of continuous economic and energy growth and adjustment by price/market mechanisms is a dangerous bias that IDS and Brandt Commission postulate as the basis for their policies.

5. ASSESSMENT OF IMPACTS OF CONVENTIONAL SOLUTIONS

Before critiquing these solutions (purportedly apolitical, transcontextual, technical, and instrumental) and developing alternative strategies, it is important to review how the impacts of these solutions are assessed conventionally. The "supply" solutions and "efficiency" solutions are normally evaluated according to technical feasibility and market rationality. Social and environmental impacts of technological choices are identified but unsatisfactorily integrated in the social policy process. Non-economic effects are often unquantifiable and cannot be converted into monetary terms. The criteria for AT solutions were described earlier. Additional criteria based on the four objectives of rural development were discussed earlier in Section 2. Structural simplicity, worker control, local self-reliance, capacity for meeting a perceived local need, social and cultural acceptability, and integration with the status quo are sometimes cited. But too often these criteria turn out to be rhetorical. Experimentation and demonstration of technologies in different ecological, resource and social settings are often emphasized to accumulate physical evidence about the operation of these technologies. Institutional capacity and incidence of ownership, use, maintenance and benefit of technologies are also assessed (Howe, 1980 and Gamser, 1980). Assessment usually includes plans for diffusion or delivery of technology to the ultimate users by a variety of marketting methods.

We must reiterate here that rural energy has physical and social dimensions. Let us briefly assess the physical aspects of alternative energy sources whose significance and meaning can only become evident in a social context.

(a) The spatial distribution of solar, biomass and wind energy resources is much wider than the occurrence of fossil fuel resources, giving rise to decentralized development possibilities (Hoare, 1979).

(b) The scale and complexity of rural energy sources are both human and "low," facilitating individual and collective autonomy (Illich, 1978) and minimizing alienation of rural people from their means of production.

(c) Empirical data about the incidence, availability and variability of renewable energy in rural areas are extremely poor. Many regions of the world have not been surveyed about their resource potential (Gamser, 1980, FAO, 1978).

(d) The supply and demand for renewable sources may not be spatially close. Moreover, at the present level of technology, certain types of uses are more preferable for certain types of sources. For example, solar sources generate more power where heating demands are low (e.g. tropical areas) and biomass is relatively poorly suited to urban demand (it occurs in remote areas).

(e) The supply and demand of renewable sources vary in time (diurnally and seasonally). Wind and solar are typical examples.

(f) Predictability of supply of these sources is not very reliable. Hence storage of energy from these sources becomes critical.

(g) Most of therenewable sources need substantial surface area. The relationship between catchment area and energy yield is site-dependent. Some renewable sources (e.g. fuelwood plantations) may preclude other land uses.

(h) Some renewable sources permit multipurpose development schemes. Biomass, for example, permits joint development of food, fuel, woodlands for recreation, wildlife care, soil husbandry and sewage disposal. Agroforestry is another possibility.

(i) Production of most renewable sources is relatively innocuous and clean, but the risk and the temporal range of effects of their large-scale development is not known fully. Large biomass production may cause pollution or soil erosion. Burning of crop residues may cause pollution.

(j) Social impacts vary with the renewable sources. Legal rights to wind and sun, land ownership, tree and forage rights, are some new questions that might arise. Housing must have a community orientation to facilitate the use of solar power.

The impacts, as we can see, vary temporally and spatially, and planning for rural energy can be done only in a site-specific manner.

6. RURAL ENERGY PLANNING: A CRITIQUE

Rural energy conditions in the Third World and the existing responses can be described in the words of observes of the Austro-Hungarian empire: "The situation is desperate but not critical!" We have briefly reviewed the approach of the Brandt Commission and the UN International Development Strategy regarding planning for rural energy. There have been other studies (Brown and Howe, 1978 and National Academy of Science, 1976) on rural energy needs, as we have briefly noted. Let us now summarize the characteristics of rural energy planning, as found in these studies.

(a) Most of the planning approaches are dominated by an epistemology of instrumental rationality. The restriction of knowledge to the effort to control, manipulate and shape events is very common. Often there is a fact-value, ends-means separation, denying distinctive interests of people in favor of a general public interest. The latter implies the illusion of neutral, context-free knowledge, in the attempt to construct a comprehensive theory/model or master plan which specifies *all* the variables and their relationships. The social nature of planning knowledge is denied in favor of technical, depoliticized knowledge. This is a mechanistic view of human responses, neglecting historical and structural conditions ("how things come to be as they are") (Frieire, 1978). The "supply" or "efficiency"-oriented solutions we discussed earlier are key examples of instrumental-rational planning.

(b) Inducing change in the rural energy system is not some mechanical master-plan activity of spelling out in accurate detail a complex of forces operating at a given moment. It does not construct a course of action that respects these forces, then presses a button that starts the process towards its final outcome. While radical change entails a clear understanding of the forces operating to produce change, it also involves continual choices and a human, collective openness to the moment. It involves freedom as well as necessity (Mishra, 1979). In the words of Jean-Paul Sartre, "the future is not to be predicted but a project to be accomplished." The need for multiple images of the problem was stressed earlier. Rural energy planning efforts have so far generated only the empirical-scientific image of the crisis, which denies the validity of any other perspective.

(c) Legitimacy in rural energy planning (for that matter even in national energy planning) is created by exclusive appeal to expert, quantitative knowledge and disciplinary authority (for example, econometric models, historical trends, forecasting, etc.). The present mode of planning is repressive in the sense that it is elite-dominated, uses manipulative management techniques, views people as subjects to be manipulated or as things to be controlled, as *passive objects* to whom services are to be delivered (Illich, 1978). Public consensus, argument, criticism, debate, participation, and democratic control in rural energy decision-making are denied or only rhetorically conceded. It treats the dispossessed people as deficient/unfortunate clients to whom energy has to be delivered. The estimate of 28,000 kcal per day per person is a good example of this approach. Denying a contextual meaning of energy, it confuses a biological energy need with an historically-determined energy need.

(d) The majority of energy planning exercises are guilty of decontextualizing energy. Rural energy is simultaneously physical (spatial, material) and social (use value). The Marxian concept of "mode of production" is useful here. It is a dialectical combination of the forces of production (human-nature relationship: appropriating nature) and social relations of production (human-human relationship: appropriating surplus) (Mishra, 1979). Production and distribution of energy, rural and urban interaction, efficiency and equity have mutual causation relationships that must be considered together, in a holistic manner. Our comment above, that technologies are never neutral but have a factor and social bias (for example, rural electrification, green revolution), exemplifies the use of the concept of modes of production. Renewable energy planning solutions (supply or technology oriented), proposing *diffusion* strategies (technology transfer, education, extension, marketing) completely ignore the social context and reify rural energy.

(e) In spite of the historical-structural nature of the rural energy crisis, energy planning often proposes ahistorical and incremental solutions. In asking the question "how" ever more rigorously, the "why" is ignored.

(f) The hidden interests and ideology behind rural energy planning are never explicated. A few examples of bias: the growth ideology (Thurow, 1980); the "preservation of status quo" ideology (World Bank, 1980); the market ideology (Brandt Commission, 1980); the ("everybody stands to benefit equally") mutual interest syndrome; the ideology of international trade (rather than one world-economy which is undergoing dynamic transformation) (Wallerstein, 1979); the ideology of stage theories of development (agriculture to manufacture to post-industrial) and the corresponding international division of labor (United Nations, 1980) and the ideology of professionalism (knowledge is objective and experts are the best people to know it) (McKnight, 1980). All these biases are typical of energy planning exercises which seek to determine in aggregate terms energy need, as well as techniques for its supply and delivery (National Research Council, 1980).

(g) Noncommercial energy, which is dominant in rural areas of the Third World, is the opposite of commercial energy (a social product, privately appropriated in an unequal exchange through a market). Because market price is the only measure of worth of commercial energy, integration into the international, market-oriented capitalist economic system is considered desirable. Thus rural energy will be mostly supplied by the market, at some future point in time. In fact, in many studies, non-commercial, use-value energy is considered "backward!" We have historical evidence of the negative impacts of the encroachment of the market through colonial agricultural policies which favored cash crops instead of food. For example, World Bank guidelines for many rural projects indicate the need for "marketable surplus" rather than non-market satisfaction of a basic need (World Bank, 1980; Lappé, 1980). Planning analysis for rural energy is almost always undertaken to estimate profitability, savings-investment ratios, etc. (United Nations, 1980). Environmental degradation (Singh, 1976), deskilling of labor due to technical and social division of labor (Irvine, 1979), dependency and loss of autonomy over energy sources (Wisner, 1980) and continuing immiseration because of surplus appropriation in unequal exchange (Griffin and Rehan, 1979) are either ignored or treated as externalities in the dominant economic analysis. "Willingness to pay" or "equivalent price in a market if it exists" are phrases sometimes used to monetize the so-called "intangible" factors, even though we know that market prices are usually distorted, do not reflect the true costs to society, and are conceptually irrelevant to non-market exchange.

(h) Forecasts and models tend to express specific political and ideological interests and are not neutral. Thus the images of fabulous wealth and material consumption conjured up by Herman Kahn or Soviet futurologists presuppose and justify a world order serving the needs of U.S. economic domination or Soviet hegemony. Malthusian scenarios of the Club of Rome have been related to the concern of European multinational corporations to ensure stability in prices and supplies of resources. Very few forecasts or models have sympathy with the interests of the Third World poor. However, the Bariloche Model of Herrera *et al* showed, in contrast to the gloomy forecasts of the "Limits to Growth" model, that in a more equitable world order, basic needs of all can be met. Such an exercise is yet to be done for rural energy in the Third World. Forecasting practices which treat people as only reacting passively to changes beyond their control (Argonne, 1980)—as mere *objects of history*—need to be replaced by concepts of people assuming responsibility for the democratic formulation and planning of energy goals (becoming active subjects of their history). Forecasts legitimate the social order and as such may tell us more about the present than about the future. As Marx *might* have said: "The energy planners have only quantified the rural energy scene; what counts is our success in changing it."

(i) Technological determinism pervades current energy planning. If we understand that energy is a historical product of a capitalist world-economy, then we can see why renewables have not developed. There was no profit or growth in renewable energy until recently. Consider the sudden interest of major oil companies and other multinationals in forming solar subsidiaries. Energy technologies are not neutral, good or bad in themselves, but reflect the social order in which they operate. In a more equitable, democratic, decentralized society, renewables will flourish—not the other way around. We cannot, then, speak of *energy* under capitalism but of *capitalist energy*. In fact, so long as capitalist relations dominate and persist, global development of renewable energy will be very slow. The rural energy crisis is in its present shape not because the rural areas have been left out of progress but because they form the other side of metropolitan and Northern "progress." Thus the premise of conventional energy planning of duality is not correct. The more meaningful explanation is one of polarity. The rural energy crisis is not one of underconsumption and demand sufficiency but of overproduction and accumulation (Irvine, 1979).

Uneven rural development (in the sense of spatial concentration of productive forces through unequal exchange) stems from the very nature of capitalist production. Urban agglomeration and rural underdevelopment within the South as well as underdevelopment on a world scale are manifestations of this historical process—unequal exchange and capital accumulation through surplus transfer. Rural energy crises provide a precondition for capital accumulation and are also a consequence of it. As commercialization increases through production of cash crops, timber and charcoal to meet the market demand in urban areas, rural poor need cash to buy food and fuel they formerly produced or collected without cash. They must then seek urban employment or become agricultural laborers. When the ecological limits of carrying capacity are exceeded, the energy crisis becomes acute, as it has in several parts of Africa and Asia. As the crisis becomes an interlocking one, the need for state intervention becomes clear. To defuse the crisis and stabilize capitalist relations, many Third World governments, within their limited resources, try to subsidize (by tax policy, grants or accelerated depreciation) rural energy. Or they try to increase rural energy supplies through rationing or increased public expenditure on research and development, infrastructure, or public works programs. Such a state response is a structural requirement of the capitalist rural energy crisis affecting rural areas.

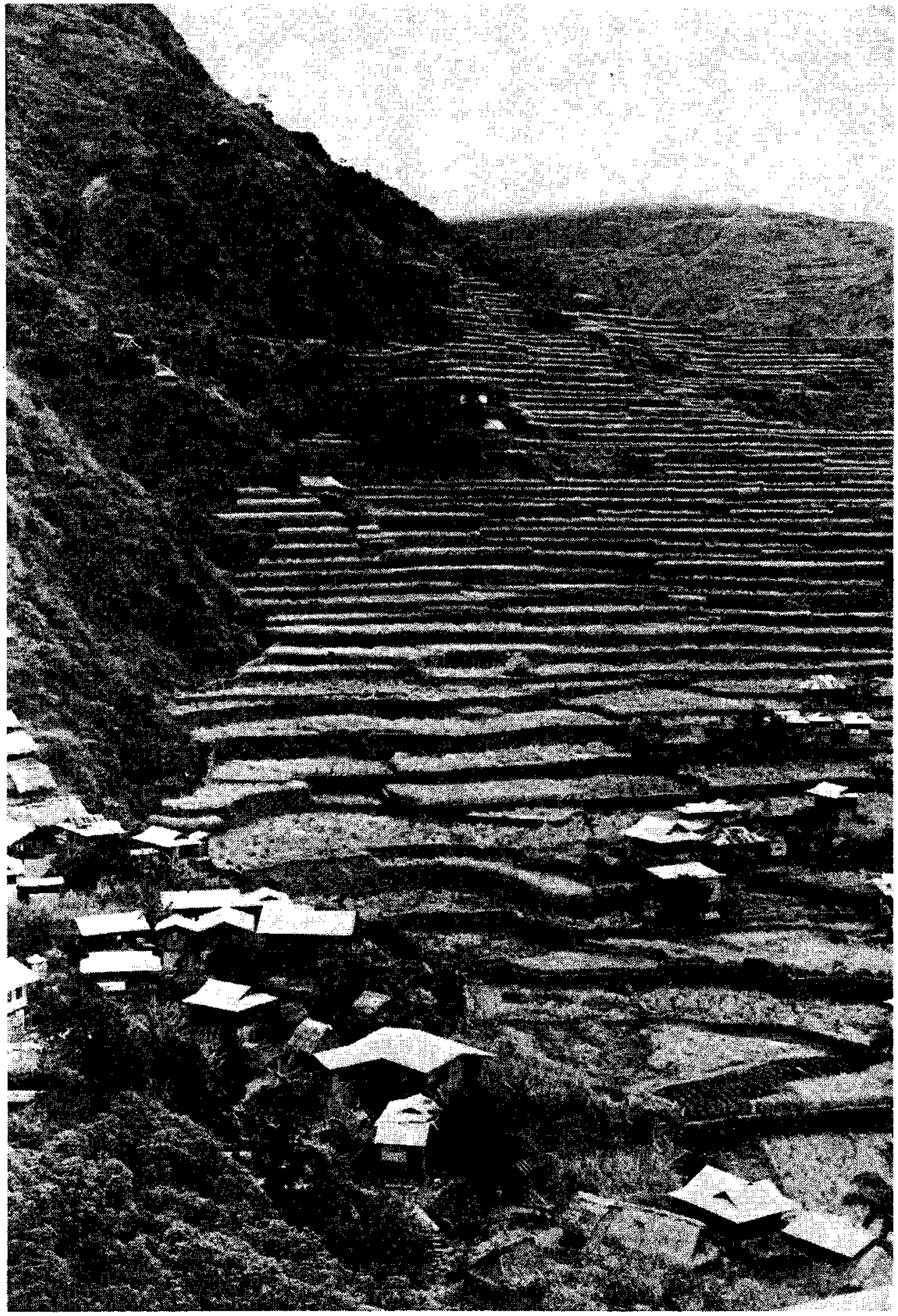
7. A STRATEGIC PLANNING FRAMEWORK FOR RURAL ENERGY

Since the early seventies, a factor of increasing importance in the development of global consensus has been the recognition that our problems are systemic in nature. In a finite ecosystem, dealing with crises and problems is impossible without benefitting some and hurting others. This is what Lester Thurow calls the zero-sum society. Yet the illusion of infinite growth and benefit for all continues to be encouraged, as we see in IDS and World Bank reports and in the Brandt Commission Study. A series of plans and policies which are basically incremental have been proposed. The structure and themes of UN Conferences during the seventies, while they attempted global consciousness-raising through issues like food, population, water, environment, etc., lent strength to this reductionist, partial and incrementalist view of development. The Chinese delegation to the 1972 UN Enviroment Conference recognized this when they said that the problems of economic development were logically and causally prior to problems of environmental quality (*Peking Review*, June 25, 1972). Aid approaches which address false premises, allow false promises to obscure causes and effects, or obscure the systemic and interrelated nature of renewable energy simply serve to perpetuate the problem rather than produce solutions. What is needed is fundamental structural change, not just the removal of some obstacles, bottlenecks or constraints. The first principle of strategic planning for rural energy ought to be systemic interdependence.

Second, since equity and autonomy in social relations of production (property, distribution of surplus, income and wealth, etc.) is an important objective, democratic and decentralized control over resources (Wisner, 1980) or social power (Friedmann and Weaver, 1979) for the poor is an essential condition. New technologies must be implemented without negative impacts on equality. Democratic control over energy resources is not just one among many issues but *central* to any meaningful development. It creates a context in which people have fewer children, reduces the burden of women, increases production, and protects the environment. Hence, empowering people by reducing their dependency on external forces is a central purpose of strategic planning for rural energy. Such autonomous development is what the Dag Hammarskjold Foundation calls "endogenous" development (Dag Hammarskjold Foundation, 1976).

Third, unequal center-periphery relations have over a long period created a spatial distortion in energy, resulting in the appropriation of energy and capital accumulation in the center (either in the urban areas or in Northern countries). This historical process was caused by the commodification of energy and labor. A conscious objective of the planning effort is to correct this distortion in favor of the rural (spatial) and the poor (class). The growing alliance between nationalists (in the post-colonial period) and socialists (advocating a major role for the state/public sector) provides a possibility for such an orientation in rural energy planning. Allocation of development expenditure for rural areas, economic diversification, distribution of energy-related facilities, policies ensuring fair rural-urban terms of trade, and the just promotion of the flow of resources, skilled personnel and production activities in rural areas are all necessary to support rural energy.

Fourth, the interpenetration of the exchange economy (based on markets) into a largely use-value oriented rural economy is a crucial problem. Commercial agriculture leading to marginalization and unemployment, the diversion of forestry for commercial uses, and the growing need for cash to buy consumer goods and basic needs—all these are manifestations of the market. In planning for self-reliant rural energy, care must be taken to restrict the scope of the market in rural areas to selected sectors, there-



Philippines rice terraces

by minimizing the impact of capital accumulation, environmental degradation, overproduction and falling profit crisis. All programs having a major community impact must be publicly owned and controlled. There should also be administrative control of resource allocation. The market may have a limited role in producing personal, consumer goods or in highly specialized areas.

The fifth condition for rural energy planning is a strong role for government (national and local): to mobilize resources on a large scale (public enterprise, tax policy), to implement policies through a strong yet decentralized administration and to influence and involve people widely through education, media and local citizens groups. Only such a government can effectively determine policies for incentives, regulation, enforcement, public expenditure and institution building. Such an administration can be decentralized spatially with functional coordination at the center (Weisskopf, 1980).

Sixth, promotion of collective institutions and behavior is critical for rural energy planning. Shared experience, cooperative effort, participatory decision-making, equality in status, the decentralization of authority, and an absence of domination by precapitalist and capitalist elites all exemplify this collective institutional strategy. In rural energy, this might mean collective production brigades (teams), community ownership of all energy resources and trade/marketting.

Seventh, maximization of employment and production labor must be a key macro-economic policy. Promotion of appropriate rural energy technologies, decentralized human scale development, the fair use of labor which is in abundant supply and the minimization of alienation are the goals of a full employment policy.

Eighth, motivation for work should go beyond material incentives. A guarantee of minimum basic needs to provide security, minimum wage differentials, and stress on collective gain seem important if we want to avoid current problems. Reduction of the social division of labor (mental-manual splits, excessive specialization, labor-management divisions) while accepting a technical division of labor for productivity reasons, is necessary.

Ninth, mass education and human resource development are vital. Distributing modest skills over a larger number of people rather than providing an elitist education is desirable. This would limit dependence on experts/professionals, promote equity, be less expensive and more conducive to growth.

The tenth condition for effective planning would be the limitation of foreign/external influence in terms of trade, finance, aid and technology. No foreign domination or continuing economic power should be allowed. When it is absolutely necessary to meet rural energy needs, selective foreign technical assistance or collaboration may be useful (Weisskopf, 1980).

The likelihood of satisfying these ten conditions depends on the following historical and structural factors which may not be obtainable in all Third World rural societies: (a) medium to large scale area and population, diversity of resources, and cultural, religious, tribal or ethnic unity; (b) traditional (tribal or otherwise) collectivism in ownership of land/resources (Mazrui, 1980); (c) experience of mass education, skill-diversity and a diversified industrial and agricultural base; and (d) minimized integration into the national and international marketting systems. Some of these conditions can be altered over time but others cannot. Together, they constitute a limiting boundary within which the ten planning conditions may be met.

8. POLICY OPTIONS FOR RURAL ENERGY

Rural energy policies and the strategic, structural conditions described above have a dialectical (mutual causation) relationship, within specific contexts. The structural conditions have a primacy in this relationship, though not deterministically. Let us now examine a series of policy options in rural energy.

From our analysis of rural energy so far, it is obvious that the major locus of policy responses will be at local and national levels. Very few policy initiatives need to be at a regional and international level. Such an approach is derived from the strategic focus on self-reliance from democratic control over energy resources, from production for use-value and from the autonomy of people over their affairs. The objectives of rural development listed earlier in this paper can only be reached by concerted local action. What are some of the initiatives that can be taken? While the following list appears arbitrary, it is actually derived from a careful application of the foregoing analysis. Because the structural issues are primary, the specific solutions must necessarily change from context to context.

(a) Rural energy strategies need to be a part of an integrated rural development strategy. No separate programs exclusively for rural or renewable energy need to be started.

(b) Market efficiency must be accorded much less importance as a criterion for rural energy development. Hence cost/benefit analysis, market surplus, commercial viability, etc. will not be the criteria for project selection in this area. Rather, welfare maximization and basic need satisfaction as interpreted by the rural poor themselves will be the criteria for choice of technology and programs.

(c) Technologies, however benign, "soft," or humanscale, when introduced into societies with unequal power relations, will exacerbate those inequalities, benefitting the rich over the poor, and urban over rural areas. Hence development, transfer or use of rural energy technology must be very carefully designed from the specific interest of the rural poor (for example, Lorena cookstoves). In a period of economic stagnation and in an ecosystem where physical limits are transgressed, these benefits to the rural poor initially will mean a reduction in the power of the rich and urban classes. This conflict of interests (rural-urban, rich-poor, timber-firewood, energy-agriculture) and the zero-sum nature of technological impact has to be made explicit.

(d) The rural communities *do* need assistance in building a secure energy future. However, such assistance has to be catalytic and facilitative rather than creating dependency. The role of experts or professionals would be minimal. Assistance needs to be in capacity-building for problem solving, interpretation of technical data and identification of needs and opportunities. The consultant-expert should never assume primacy in decision making.

(e) While decentralized planning should be encouraged, coordination at the national level will be necessary. Interregional problems and intersectoral (agriculture, health or transportation) problems interface with a miscellany of competing problems: e.g. international markets, regulation, environmental protection standards enforcement, information exchange, financing experimental and demonstration projects, the building of a data base and resource inventory of forests, rural energy sources and providing needed rural extension and training services. Balancing these tasks would be the job of the national government.

(f) Promotion of village utilities on a cooperative or democratic basis to provide fuel, water supply and sanitation to the villages is vital. One estimate indicates that a village of 1000 people (200 families) with an investment of US $12,000 can organize a utility and repay the money in seven years with a 12% interest rate. Each family gets needed water, fuelwood, an improved cookstove and community sanitation. In exchange it contributes 35 manhours of work per week (each family spends more than that now on wood-gathering alone) in community agriculture, utility (biogas) maintenance or community woodlot maintenance (Makhijani, 1978). Such a program reduces the need for a market/cash economy. It promotes collective ownership and institutions and meets the basic needs in rural areas. Such models need to be encouraged.

(g) Community utility facilities can fail! Broken pumps and unused community water wells are quite common in South Asia. The causes of failure are usually social, not technical. The villages are "delivered" these services with installation effected without the villagers' participation; and/or the government was expected to make repairs (UNIDO, 1979). The construction of community tubewells in Bangladesh led to their monopolization by the village rich (Lappé, 1980). Community control and participation at every stage is the critical factor. Villagers have been using renewable energy for centuries. We do not need to *prove* its viability. The task is to prevent the capitalist market system from interfering with and commercializing rural energy, and to enhance the capacity of villagers to be self-reliant. Real, meaningful, productive innovations in design of the technology, size, and fabrication of materials will emerge from the village.If we stop blaming the villagers for destroying the ecosystem, when the culprit is the commercial market system, we will not then formulate the rural energy problem as a supply-gap or technology crisis. Facilitating community participation and restricting commercial penetration of the rural energy field must go together as policies.

(h) Education and training are critical to develop endogenous strategies in rural energy. The rural poor, as Paolo Frieire says, are "hosts" of their oppression. Elaborating their condition as the "culture of silence," he sees them as submerged in a situation in which they do not possess a capacity for critical self-reflection. They have no capacity to see that their situation can be changed as a result of their own action. They are passive, fatalistic, dependent, and adaptive to almost whatever occurs. The liberation from this "culture of silence" is the task of education (Frieire, 1978). Non-formal education (use of media, popular participation, continuing education, group extension and political mobilization) is far more important in this regard than formal education. The latter only streams the poor towards specialized manual jobs and thus reinforces class structure. It also creates dropouts, unemployed, and loss of confidence. Unfortunately, formal education has more prestige and funding than informal education. National policy can change this to some extent. Frieire's own work in northeastern Brazil and in Guinea Bissau is a classic example in this regard (Simmons, 1980).

(i) While there is increasing recognition that energy and development problems are endogenous and contextual and cross-national comparisons of indicators meaningless and misleading, many policies are still formulated to "close the gap" between the North and South. Gap-closing is a misformulation of the problem. Though dissemination of information and case studies (rather than econometric-statistical models) are helpful, rural energy performance ultimately depends on local resources, skills, leadership and contextual factors. Such performance cannot be evaluated by appeal to some extrasystemic standard. The design of a survey or mere appeal to theory (Schmalessee, 1980, Brunner, 1980) promises little success in "filling the gap."

(j) The complex system of subsidies, tax incentives and public expenditure in favor of urban, non-renewable energy use needs to be ended. We recall the example of input subsidies and price support for the growing of energy-intensive cash crops. Success was temporary, and it concealed the risk and vulnerability of farmers to fluctuations in the international market (Payer, 1980). In selected instances, however, output/production subsidies to meet basic needs may be justified.

(k) Information systems and exchange are often touted as the solutions to the rural energy problems (UN Conference, 1980). The key assumption here is that more information will lead to better decisions and consensus. Unfortunately, this is not necessarily the case. The privileged elite in a community will fight and resist community control over energy resources if they feel it threatens their interests. Information availability to all may actually *increase* conflict in this case. The nature of information technology is both determined by and reproduces the social relations of power. Many of the information systems that are proposed (UNISIST, AGRIS, INRES) are highly complex, centralized, computer-based and deskilling. Many Third World user groups do not have the capacity to utilize such systems. High technology information systems lead to privatization and control of individuals, thus destroying the sense of community. The information overload in some areas has reached such a point that we need an intermediary class of "information professionals" to help users. We are back again to the initial problem: loss of democratic control and alienation.

There is no high correlation between information availability and effectiveness in performance. Often information systems become reified and assume a momentum of their own, supported by the data processing industry. The success of biogas in China was not based on an extensive information system but on communal organization. Information as a resource is comparable to finance about 40 years ago. The knowledge of finance has become mystically complex now and is proposed as an end in itself. Observe that the Third World energy problem is posed as a balance of payments problem, requiring increased loans and aid from the IMF/World Bank. Mystifying terms like "debt exposure," "leverage," "coverage," and "service" are being used, as if sovereign countries exist only to service debts! Hence information systems and exchange should be carefully designed. They should be simple enough to be used by the rural poor communities, a stringent test which most high-flying information systems fail.

(l) Use of renewable energy may require non-renewable materials for manufacture, transportation, installation, operation and repair. Third World rural societies ought to reject any aid that supplies such systems if they create a new dependency. As aid policies usually do not employ life-cycle costing, the dependencies are systematically hidden.

(m) The problem of small countries is very acute. We mentioned earlier, in laying out a framework, that size is an important condition for the purpose of national self-reliance. In rural energy, collective self-reliance seems to be a prerequisite to build up an endogenous capacity. The prospects for such collective self-reliance appear dim if one reviews the experience of past few years. Comparing information, case studies, and networking at the grass roots appear to be possibilities worth supporting. Significantly, they are also *simpler* techniques.

(n) Only through democratic control can responsive institutional capability to analyze and plan for energy be built (Nelkin and Pollak, 1979). Such a capacity would also improve access to bases of social power for the rural poor. This process will also result in a number of related changes: removal of the burden upon women and children, increasing the efficiency of production, satisfaction of basic needs, improvement of health, protection of the environment, and rational land use.

(o) At the national level, we have argued for structural change, not merely removal of this obstacle or that constraint while maintaining the *status quo*. Structural change, however, is very difficult, usually long-term, and it cannot be accomplished quickly except by social revolutions like those of China, North Vietnam, Cuba and Mozambique. The prospect for a social revolution in the interest of the rural poor in many Third World countries appears remote. Hence we need some transitional strategies while continuing to move slowly towards a structural change. The international capitalist system is very strong, making it difficult to engage in selective delinking and self-reliant development. Transitional strategies would include:

- "The better, the better." To the extent that rural energy planning improves the material situation of the poor, it is progressive, even if it legitimizes the system in the short run. The issue is whet-er a particular program or policy *actually* provides the poor with energy. Incremental programs like village utilities and community wood lots *may* achieve this.
- "The more, the better." Rural poor are better served by government planning which is bureaucratized, even if this is in the interest of social capital, than by the unplanned outcome of the market forces.
- Expansion of planning and a welfare state should be encouraged. State capitalism in many Third World countries often represents a marked

improvement over market capitalism from the perspective of the rural poor. The larger the public sector, the greater the possibilities of benefits to rural poor, including energy supplies, subsidies and alleviation of crises (Fainstein, 1979).

We have so far discussed the policy options at the national level. We will now discuss the policy options at the international level. Is international action possible to solve the problems in rural energy? Is rural energy a relevant agenda for the North-South dialogue? Is international resource transfer helpful? Can the UN system play any role in alleviating the rural energy crisis? The answer to these questions is a qualified "yes." Let us now look at the policy options in the international area.

(i) We have argued that rural energy policy can promote self-reliance and achieve growth, equity, and employment for the rural areas. Such an approach would mean selective territorial or spatial closure and selective delinking from the international system. It would imply profound changes, such as switching back from cash crops to food crops, and organizing agriculture for local use rather than for exchange. It would mean community control of energy resources and virtual elimination of commercial interests. International action does not have a large role to play in this process, but it could prevent interference through the power of capital, technology and mass media. After nearly 300 years of global expansion of the capitalist mode of production, it is actually amazing that rural energy remains largely noncommercial and renewable even today. It shows the resilience of pre-capitalist modes of production and the limitations placed upon the interpenetration of capitalism. Expansion and accumulation are imperative necessities of capitalism. The current recession is a contradiction it is struggling to overcome. *International action to restrict the impact of capitalism upon the commercialization of energy would be beneficial.* The multinational corporations and OECD governments would certainly be opposed to such an approach. It is possible that the privileged classes in Third World countries would also oppose it. In a more positive respect, international action is possible for information sharing, collaborative research and development, and emergency relief to a limited extent.

(ii) The negative impacts of foreign aid (both bilateral and multilateral) are too well known to do more than summarize them. From a variety of sectors and a number of countries, there is increasing evidence of their damage. (a) Aid increases dependency by "tying" purchases. (b) Aid serves the interests of the donor and promotes the business of exports. (c) It distorts development priorities by shifting even domestic resources away from food to export crops or from necessities to luxury goods. It adopts a diffusion approach that assumes passive recipients/consumers. (d) It promotes the illusion that external resources are critical to development. (e) It assumes that growth is inevitable. (f) It postpones needed domestic reforms in land tenure, property ownership, choice of technology and means of production by alleviating or defusing crises. (g) It is spent mainly to build infrastructure for capitalist expansion. (h) By insisting that the aided project generate marketable surplus, it introduces and promotes capitalist relations of production (Payer, 1980).

The export emphasis of serving the metropolitan countries makes wage restraint necessary to make the products competitive in the international market. The World Bank, for example, in its agriculture projects, encourages production of cash crops, rigidly specifies inputs, harvesting and delivery and considers noncommercial activity of any kind backward and to be eliminated. The World Bank's heavy involvement in rural electrification and its impacts are well known. Recently the Bank has become somewhat more cautious and broad-minded, and is funding renewable energy and "basic needs" projects as well. But the basic dogma of market rationality continues. Recently the Bank set up an affiliate for energy finance. Predictably, its focus will be on fossil-fuel exploration, increasing the supply of conventional fuels, and technology transfer. It has proposed to start an international renewable energy program under its leadership, by which a network of institutions all over the world will conduct research, develop technologies and transfer them to national agencies (World Bank, 1980). In the nineteen-sixties, it was the network of agricultural institutions supported by the World Bank that started the green revolution with its disastrous consequences (Payer, 1980). In the nineteen-eighties, the Bank is likely to create the same dependency and inequality through rural energy programs.

Admittedly, there is a need for research, experimentation, demonstration and improvement in renewable energy technology. But this has to be done by Third World countries themselves, along with necessary changes in the social context. Massive aid, such as the Brandt Commission advocates, is not only *not* needed but is harmful. The kind of aid that might be effective is for information dissemination, capacity-building, networking through private voluntary organizations and support for emergencies. In rural energy, the role of inter-governmental aid ought to be very limited. Currently it is estimated that about $300 million is available through all sources for renewable energy aid. It should probably be reduced and be made more selective. The Volunteers for International Technical Assistance (VITA) (Washington, D.C.) and the International Development Research Centre in Canada have provided aid of this kind and are considered relatively effective. There is a need to emulate such examples and not attempt to set up another bilateral/international program in renewable energy. Any such program will resemble others. Its own survival, expansion and delivery personnel will become the program's purpose rather than helping the rural poor. Traditional advocates of aid (Ashworth, 1980) requesting more resources for testing, technology transfer, research and development, and data collection, have not adequately understood the structural impacts of these problems.

(iii) The role of the UN system in rural energy development is yet to be articulated clearly. We have already criticized the role of the World Bank. During the last few years, particularly after the 1974 declaration on NIEO, North-South dialogues have not been very productive. The UN Conferences over the 70's have increased our appreciation of the concepts of world problems and global political-economy (Ruggee, 1980, Union of International Associations, 1976). The expansion of the knowledge base and collective consciousness at the global level has been facilitated by the UN Conferences. For example, environmental quality after the 1972 Stockholm Conference and Basic Needs after the 1976 ILO Conference are two areas in which there were significant changes. UNEP's work in building global integrated environmental information and monitoring systems has been outstanding, in spite of the resistance of many governments to any form of socioeconomic monitoring and data collection and the consequent castration of system capabilities. The institutional mechanisms of the UN have been criticized and found inadequate. Profound measures like changing the structure of international economic relations implied by declarations of a "new International Economic Order" (NIEO) or the Cocoyoc Declaration, which take into account equity and ecological considerations, often amount to rhetoric. To that extent the UN's role can be said to be governed by the forces of the *status quo*, and in turn can affect only marginal changes in them.

UN conferences have been criticized as being ritualistic, bureaucratic and technocratic. They are often trapped in the "lowest common denominator" syndrome where bland, pious statements that can satisfy everyone must be made. It is rare to find in UN documents or resolutions systemic views of the problems, or multiple, conflicting images of issues capable of generating meaningful dialogue and negotiations over values, assumptions and interests. A recent suggestion (Brandt Commission, 1980) is that since UN conferences are not effective in North-South dialogue, a small summit of select leaders can be held to resolve issues. Then it can take the packaged recommendations to the UN General Assembly for approval. In fact, a summit of this kind is planned for 1981. Such an approach is elitist and undemocratic and is fashioned after the Trilateral Commission or the North-South Round Table. Building a collective, shared understanding of the complex of global problems as well as of specific problems like rural energy in that broader context, is a difficult and long-range although extremely necessary task. A few leaders, however powerful they may be, cannot get together and negotiate the solutions. As Paolo Frieire put it, "In the process of enlightenment, there are only participants." UN conferences might be ineffective but the alternative summit idea is even worse. We need to find more democratic means of securing consensus and making progress.

(iv) The South proposals on NIEO are: removal of tariff barriers, export income stabilization, recipient control on transfer of technology, and debt relief. Even in the unlikely event that all these proposals are accepted by the North, the rural energy crisis will not be solved. (The chances of acceptance are very low in this era of long recession). Price stability and better terms of trade are important but will not solve the problems of food production and internal inequity in distribution of food. Nonprotectionist trade policies will encourage market penetration, driving down wages due to international competition. Increasing commercialization can only disrupt and destroy most of the communal rural energy. Unrestricted technology transfer will increase future dependence and inhibit indigenous capacity building. Debt relief will only be temporary, postponing problems to the future (Magdoff, 1978).

(v) The role of private, voluntary organizations and groups in shaping the kind of rural energy policy we have outlined is significant. Many of them are decentralized, grassroots, cooperative, non-profit, public-interest and educational in nature. In the restoration of a renewable energy society in the rural areas and in helping others in the transition to a renewable future, they can be very important. They should plan to play a more productive role in energy development. The *can* change reality in rural energy. Through publications, critique, consciousness-raising, education, lobbying and rural mobilization they can affect national and international policies.

9. CONCLUSION

We set out to plan strategically for rural energy. The analysis shows that rural energy is not a simple problem that has a direct one-dimensional answer. Its systemic relationships require a systemic response as well as an understanding of the historical and structural processes at work. This systemic planning is inherently normative and political in nature. It is not a solely technical exercise. In our uncertain, complex world, rural energy systems appear fragile, and to be undergoing irreversible, inevitable change. This is not the case. It is possible to change the situation from bottom-up in a framework of non-deterministic, bounded choice. This analysis is meant to be a contribution to the task.

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Reforestation of sand dunes, Chang-Go-Tai, PRC

III. SOCIAL STRUCTURE AND RURAL ENERGY TECHNOLOGY

Peter Hayes¶

1. INTRODUCTION

The previous two essays introduced important principles for social and technical analysis of rural energy issues. This paper examines three detailed reports of rural energy in Bangladesh, Zambia, and Nepal. Drawing on these and other examples, alternative theories of the adoption—or blockage—of new rural energy technologies are reviewed. The paper concludes with an interpretation of the significance of these observations for project planning and practice.*

2. THE SOCIAL ORGANISATION OF RURAL ENERGY SYSTEMS

A. Energy Flows in a Bangladesh Village

How can development projects direct more energy toward the Third World rural poor? The conventional answer is to introduce new technologies and land management practices that make a village energy system more efficient. A study by John Briscoe points out that this approach "assumes some type of homogenous, harmonious, and cooperative village social structure" in which those who own the means of energy production share the energy produced with those who own no energy sources.[1] Briscoe's examination of village energy use in Bangladesh reveals the flaws in this assumption and explores their implication for development policy.

The subject of Briscoe's study was the Bangladeshi village of Ulipur, a settlement of about 96 families located near a canal one mile west of the Dhanu, a major branch of the Meghna River. The region is densely populated, with 2300 people per square mile (888/km^2) inhabiting numerous small, residential clusters or *baris*. The hamlets that dot the countryside sit atop man-made, earthen mounds that become islands when the rivers flood their banks during the summer monsoons.

Ethnic, religious and economic cleavages divide Ulipur into two unequal districts. Roughly one-sixth of the villagers are landless Hindus who subsist primarily through fishing and who own no energy resources. The bulk of the villagers, as in the rest of Bangladesh, are Muslims, themselves spread across a poor-rich spectrum.

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*This paper addresses only the rural dimension of potential biomass energy technologies. Biomass energy production in urban areas is of course a significant, albeit largely neglected, technological option. See I. Wade, "Urban Self-Reliance in the Developing Countries, Strategies for the Future," Urban Resource Systems, 783 Buena Vista West, San Francisco, Ca. 94117, U.S.A. 1981.

TABLE 1.

THE OWNERSHIP OF FUEL-PRODUCING ASSETS (per family)

	Hindu Fishermen	Landless	Muslims: Poor	Medium	Rich
(No. families)	(8)	(14)	(11)	(8)	(8)
LAND: (decimels)					
Median	0	8.5	66.0	126.5	242.0
Mean	0.7	9.5	65.2	135.1	295.8
TREES:					
Median	0	6.0	8.0	16.0	182.0
Mean	2.0	11.1	12.2	17.5	209.0
CATTLE:					
Median	0	0	0	1.0	4.0
Mean	0	0.3	1.3	1.3	2.6

Source: Briscoe, p. 31a.

The Muslims, especially a small rich strata, control the available agricultural land, and with it most of the local energy resources. Making up 16 percent of the village families, the rich Muslims own 55 percent of the land, 79 percent of the trees, and 42 percent of the cattle (see Table 1 for ownership detail).

Briscoe's study involved a 50 percent sample of these two populations. Every two weeks, for more than eight months, he and a research collaborator collected information on household energy consumption and production: cattle fodder and dung output, human and animal labor inputs, crop residue use, and fuel storage. Table 2 summarizes the village's use of fuels.

The production system in Ulipur is frugal and complex. Village crops, such as the deep water *amon* ride paddy, follow multiple resource use pathways, and serve a variety of economic needs. In addition to rice grains for human food, the *amon* paddy produces rice husks often used as fuel or as animal feed. The *kher*, or upper, tender straw, is primarily a source of fodder, but occasionally fills in as fuel or even as compost. And the *nara*, or coarse lower straw, shows great versatility with uses as fuel, compost, animal fodder and construction material (in that order) predominating.

Village technologies, however, enforce an inefficient use of energy. Bullocks, for example, return as useful work only 3 percent of the energy they consume in fodder. Crops (at the "farm-gate") contain only twice the amount of energy needed to produce them, slightly worse than U.S. energy-intensive agriculture. Cooking is also highly technically inefficient relative to modern technologies.

These aggregate data conceal a pattern of energy use and resource ownership in Ulipur that is quite non-uniform (see Table 3). Hindus and Muslims obtain their fuels from spatially distinct sectors,

TABLE 2.

ANNUAL FUEL USE IN ULIPUR

Fuel types	MJ/person-year^{-1}	% Total
Crop residues		
Nara (coarse straw from deep water paddy)	2,648.5	38.3
Top straw from deep water paddy	96.2	1.4
Straw from other paddy	138.1	2.0
Grain husks	368.2	5.3
Jute sticks	133.9	1.9
Sesamum plant	200.8	2.9
Mustard plant	121.3	1.8
Chili plant	25.1	0.4
Residues from non-village lands	355.6	5.2
Total residues	4,087.8	59.2
Animal residues		
Cow dung	192.5	2.8
Firewood		
Village trees	698.7	10.1
Riverborne wood	301.3	4.4
Purchased from bazaar	355.6	5.2
Total Firewood	1,355.6	19.6
Other fuels		
Doinshah (sesbania cannibina)	338.9	4.9
Bamboo	251.0	3.6
Water hyacinth	113.0	1.6
Leaves and other sources	569.0	8.2
Total other fuels	1,271.9	18.4
TOTAL FUEL USE	6,907.8	100.0

Source: Briscoe, p. 9b.

TABLE 3.

FUEL USE BY DIFFERENT CLASSES DURING THE STUDY PERIOD

% of Total Consumption for:

	Hindu Fishermen	Muslims: Landless	Poor	Medium	Rich
1. Sesamum plant	0.3	0.0	1.5	10.3	10.2
2. *Hanza kuta* [1]	1.2	3.2	10.7	8.6	16.6
3. Grain Husks	2.7	4.1	6.9	12.7	17.3
4. *Ghoita* [2]	0.0	1.3	5.3	3.2	4.7
5. Jute-sticks	0.5	1.5	0.9	0.7	4.5
6. *Doinshah*	1.4	7.5	5.3	9.3	7.5
7. *Nara* [3]	25.0	38.4	26.0	33.2	19.2
8. *Lakri* [4]	46.9	26.8	31.1	9.0	10.8
9. Bamboo	16.6	3.1	1.2	4.8	1.5
10. Water hyacinth	0.0	4.8	1.7	1.8	1.8

Source: Briscoe, P. 33a

1. Courtyard crop residues
2. Cow-dung fuel
3. Course rice straw
4. River-borne wood

Note: Population shares may be derived from Table 1.

the Muslims from within the village, the Hindus from elsewhere; the types of fuels used in cooking vary among Muslims of different economic class, and the ownership of the assets that produce fuels—the trees, the cropped lands, and the cattle—is highly concentrated.

Briscoe asserts, therefore, that the village energy system must be explained in terms of Ulipur's social and economic organization. And, "to understand how villagers of different classes will meet their fuel needs in the future," he writes, "it is essential to understand how the present forms of social organization have evolved and how they appear to be changing." [2]

Disintegration and Disparity

Briscoe begins a social analysis of Ulipur by reviewing the quasi-fuedal system of patron privilege and responsibility which has endured throughout the Indian subcontinent for almost two centuries. Under this type of system, poor individuals look to the patron-client relationship to reduce their risks, stabilize their incomes, and provide a buffer beween themselves and the bureaucracy. Social pressures on all classes enforce the traditional reciprocity that perpetuates the feudal hierarchy.

Briscoe demonstrates, however, that this social order is disintegrating in Bangladesh as the Green Revolution and modern management practices, along with population growth and increasing foreign aid, displace traditional agriculture. Under these new land use patterns, resources available to the poor by convention are becoming scarce. And many villagers are being forced from their traditional subsistence niche into the insecurities of the market economy in "the rapid and final stages of a change to capitalist production relationships in Bangladesh agriculture." [3]

The trends are worsening: "The number of landless people will continue to grow as landholdings become more concentrated, migrant labor working for cash contracts is likely to displace much village labor, the real wages of agricultural laborers will fall, relations between families will become more strictly economic, and class cleavages will become more pronounced" (pp. 42-43).

The cash- and land-poor in Bangladesh have extremely limited access to the new technology, since they cannot afford its high-priced inputs, such as seed stocks and agrochemicals. Mechanization, at the same time, reduces the demand for agricultural labor, and these two factors together cause real income among the rural poor to fall. The rural rich, in contrast, enjoy increased income, both from local farming and through external employment in professional and technical fields.

As economic disparities between the classes mount, their relative bargaining stances change, and the customary balance of reciprocity is upset. Social changes within the village erode the position of the rural poor from two sides: the beneficence of their former patrons falls off sharply, leaving the poor politically powerless, and competition among the poor classes over resources that were previously slack—the uncleared land, the common pasturage, the crop residues that provided fuel—is on the rise.

These changes have had a major effect on the patterns of energy use in Ulipur. In the traditional patron-client society, the movement of goods and services had a large "vertical" component, reflecting the reciprocal relationship between economic classes. But in Ulipur, Briscoe notes, most transactions have become "horizontal:" landowners now prefer to pass over the extremely poor and to rent to solvent tenants; they extend wage labor to members of their own class when employment is scarce;

and they distribute less crop residues to the poor who are pressed into consuming more expensive fuels. The only resource which still follows traditional, vertical lines of distribution is the coarse *nara* rice straw, partly because there is still a surplus beyond the demands of the rich and powerful in the village, and partly because the distant location of a substantial part of this material makes pilferage by the poor and powerless almost impossible to prevent.

Poverty and Fuelwood Scarcity

Fuelwood is in short supply in Ulipur, as in many parts of the developing world, because of absolute shortages compounded by distributional inequities. Although rich peasants own 80 percent of the fuelwood and fruit trees, they take only 10.8 percent of their fuel supply from this resource. Poor Muslims, on the other hand, depend on fuelwood for 31.1 percent of their supply because the agricultural residues they once collected freely now circulate almost exclusively in transactions among wealthy families.

The landless Hindus have therefore been forced to find money to purchase necessities like cooking fuel which they previously supplied themselves (p. 21). The Hindus live in such crowded conditions that there is little space to dry or store residues or water hyacinths collected from the river (p. 29). The net result is "not that the poor use fuel more efficiently, but that they are forced to go to greater lengths (including stealing and buying fuel with money that could be used for food) to acquire the fuel necessary to cook their food" (p. 33).

The poor Muslims' tenuous claim to fuels generated on the land of middle and rich Muslims is also weakening. "The sadness," writes Briscoe, "which the poor Muslims display in private at the fate of the Hindu community is tinged by the knowledge that their own fate is unlikely to be much different" (p. 21).*

The primary proximate cause of the scarcity of fuelwood and other energy resources faced by the poor is massive population increase. In the last century, the inhabitants of Ulipur have increased by 350 percent, while production of foodgrains and fuel resources has remained essentially the same. Since cooking technology is unaltered, fuel requirements have risen with the size of the population. As other resources are substituted, organic materials once recycled into the land or fed to animals are now being diverted into the cooking energy supply. "The consequences," Briscoe asserts, "are that the animals are unable to plough as well and the fertility of the soil is reduced, meaning that crop yields continue to fall."

Population growth may have taken up much of the slack in village resources, but recent social transformations have concentrated the scarcity at the society's lowest economic levels, where privation can least ably be borne. By denying marginal groups access to their previous fuel supplies, the village social system forces them into the market, where they fall outside the protection of traditional feudal class relationships.

If Ulipur is to produce sufficient food and fuel for all its present population, and not just the local elites, some form of agricultural modernization is essential. Village farmers with sizable landholdings, who have access to credit and the other inputs required by high intensity cultivation, can switch to high-yielding rice varieties. Unfortunately, the crop residues left by such strains are much smaller than with traditional agriculture. No slack remains to distribute to the poor, and in contemporary village culture, there is no longer any social incentive to share the shrinking resource.

High-Yielding Varieties [HYVs]

High-Yielding Varieties (HYVs) in Ulipur have not been widely adopted—yet even low-level use results in dire consequences for the poor in Bangladesh. In an earlier study, Tyers analyzed the effects of the shift in Bangladesh to HYVs on the parboiling of rice (wherein paddy rice is soaked, and heated or steamed, then dried and milled, gelatinizing and hardening the kernel and improving milling, taste, and nutrition).

Tyers constructed a model of food production, incorporating differential growth rates of foodgrain, livestock food, and crop wastes for cooking as well as economic and technological trends. In the two optimistic runs of the model, foodstuffs grow at 4.4 and 3.8 percent per year while fuels grow at 3.3 and 2.9 percent per year, respectively. In both cases, minimal per capita cooking energy (1.2 MJ/d) is available in the ecosystem. In both cases, livestock growth is restricted to 0.6 percent per year. However, if livestock increases at the same rate as population, increasing fodder demand on the crop wastes, then cooking energy demands cannot be met by traditional sources and cash would have to be diverted to commercial energy. The cash costs of obtaining minimum nutrition would then increase from $42.86/y (for 168 kg of grain) to $50.29/y (to buy grain plus fuel; 1978 figures).

The determining variables of this complex interaction in Tyers' model are the supply of artificial

*Briscoe does not examine nutrient and energy flows in relation to ethnic and sexual divisions in the village. His analysis of exchange implies, however, that ethnic divisions are becoming less important with the emergence of class differentiation within the Muslim community, reducing the economic privileges received by poor Muslims relative to the hardships imposed upon Hindus due to their ethnicity. Gender appears to be an organizing principle in energy production and consumption within classes and ethnic groups; its relevance to class determination of energy and nutrient flows is unclear. Class and ethnic changes may in turn have affected the sexual division of labor in the energy system, but Briscoe does not deal with this.

fertilizer (to boost productivity), oil prices, livestock growth rates, and the quantitatively obscure relationship between livestock-powered land preparation and livestock fodder demand.

Tyers admits that margins of error may easily swamp the precise ratios on which his results are based. But he insists that the risk of declining per capita fuel availability be considered in adopting high-yielding crops and emphasizes the model's heuristic value.

Given the present population density and resource pressure in Ulipur—and throughout Bangladesh—increasing agricultural output is crucial. But, under present social and economic organization, conventional agricultural development is disastrous for the majority of the population. It is a contradiction of modernization that the plight of the poor is given as the rationale for development programs which often end up serving the rich and the powerful. "By failing to distinguish between the effects of absolute pressure of people on resources and the effect of differential access to these resources, [they] provide a rationale for using public funds to subsidize the rural rich" (p. 46).

Wealth, Power, and Energy Policies

Briscoe provides an important critique of the conventional energy policies for rural areas prescribed by the Bangladesh Energy Study and others (village fuelwood lots on wasteland and expanding fuelwood seed distribution, biogas plants). As he puts it,

> The great attraction of these "apolitical" prescriptions is that they hold out the promise of a solution to the problems of underdevelopment in Bangladesh while leaving domestic and international political and economic structures intact. For the aid agencies and foreign "experts" such an analysis provides a cogent rationale for their presence and influence in Bangladesh; for the elite who run the Government of Bangladesh it promises more of the foreign aid on which their political survival and personal well-being depend; and for powerful peasants . . . it promises a further increase in their power and wealth (p. 47).

Since significant redistribution of wealth in Bangladesh is not likely in the near future, Briscoe concludes that conventional development holds little promise for the rural poor. Reformist programs such as organizations designed to funnel information and expertise directly to the poor, enabling them to develop new energy resources or use more efficiently those that are presently available, are more attractive in principle. Providing inexpensive solar dryers, for example, could make water hyacinths available as a cooking fuel to mainly Hindus of Ulipur, whose crowded quarters lack space needed for drying this potential resource. But, as Briscoe notes, "the major obstacle to the success of such programs . . . [is] not technical but political. Because organized groups of poor people threaten the privileges of wealth and power of the dominant classes of society, these groups are suppressed and thus rare" (p. 50). Furthermore, use of "cooperatives" for distribution of dryers would likely benefit the rich rather than the poor, as Ulipur's "landless" subcommittee of the *Swarnivas* program is chaired by a member of the largest landholding family.

Another possibility would be to design a rural energy program specifically for the rural working women who collect the fuel, make the chulah stoves, and receive payment in fuel for labor performed. However, if the project is to avoid co-option by the elite city women who normally represent women to foreign development agencies, poor village women would have to *plan and execute* the project (p. 49, my emphasis).

Despite the published availability of these conclusions,[5] we find that aid organizations have continued to ignore them—presumably because of their unpalatable nature. One consultant's report[6] to the Asian Development Bank on Bangladeshi energy recently reiterated precisely those technological fixes which Briscoe demonstrates so painstakingly will assuredly be vitiated by the prevailing distribution of social and political power—introduction of firewood seedlings in private and public land, more efficient stoves and rice cookers, and commercial production of firewood.

B. Charcoal Production in Zambia

Over 90 percent of Zambian roundwood consumption in 1975 was for charcoal and fuelwood production.[7] Charcoal is therefore an important sector for energy planning. Milhayi's little-known study of the charcoal industry[8] presents an excellent analysis of issues generally ignored in the conventional literature on charcoal.[9]

Charcoal burners in Zambia use flat, mild-steel, traditional axes, usually made from old car springs, to fell trees by clearcutting. One producer fells and cuts about one cord of wood a day. The wood is not debarked to remove impurity but is gathered in piles of 1-10 cords. Logs of up to 50 kg are moved manually and covered with turf. Such a kiln may burn for 12-16 days, although the dire economic situation of producers often compels them to conduct an inefficient "fast" burning. Combined with un-sorted wood sizes and high water content of fresh wood, fast burning results in a reduction of carbonized product and low-quality charcoal. Yields of only 8 percent of the original wood charge are achieved versus efficiencies of 20 to 30 percent in steel and brick kilns.*

After it is cooled, raked, and bagged by the producer and family, the charcoal is then transported by truck for a fixed fee to copper smelters and refineries and, for a variable fee, to urban markets. The variable fee, between 20 and 50 percent of the retail selling price, is "fixed with a single goal in mind: to get the maximum out of the burner desiring transport. The transport operators are individuals; they do not have any kind of organization, neither do they have any agreement in regard to the charges. But in general transport is in short supply and for the burner who is in need of selling his charcoal and obtaining cash within a limited period, there is hardly any choice but to pay the transport fee demanded."

Charcoal is retailed from the roadside (5 percent), by bicycle direct delivery (20 percent), and from established market outlets (75 percent). "The majority of burners lead a hand-to-mouth existence, do not cultivate any lands aside from perhaps a small garden, and have to purchase all necessary supplies for themselves and their families." Without an early sale, they would "suffer from extreme deprivations." Producers are thus forced to sell to traders for immediate sale to obtain survival cash.

Uhart points out that charcoal merchants are generally dominant over producers throughout Africa. "[Charcoal] is usually marketted through a chain of small middlemen who deal in charcoal and fuelwood. Between the producers (charcoal makers) and the consumers there come into the picture wholesalers who buy these commodities up from producers, transport it, and sell it to the retailers; these wholesalers hold a very [crucial place] in the commercial circuit and it is they who make the greatest profit. [They also] give loans to charcoal makers either in cash or in kind (tools, food, etc.)."[10]

Resistance to Technological Change

There are about 2,200 full-time and 4,000 part-time illegal charcoal burners in Zambia. They are almost all rural migrants, mostly 20-35 years old with families. Two-thirds are illiterate, and virtually all are impoverished without material assets or reserves to cover emergencies or to move onto another occupation. Many imbibe intoxicants at work to relieve muscular pain. The work involves many hazards and many are injured or suffer from eye inflammation, bruises, and cuts without medical aid. Work sites have poor hygiene, and often have no water available. Workers eat one meal daily, and sometimes a snack of roasted corn. The mice and birds captured with slingshot do not relieve the malnutrition of the majority. Milhayi sums up these dismal conditions:

> Standards of living and conditions of life for the average burner are depressing. Any visitor to the area would realize this upon seeing the people wearing ragged clothing, smeared by dust, coal powder and sweat, and "cured" by the acrid smoke of the burning clamps. The men are soon worn out by the hard work toiling under the hot sun or rain, depending on the season. Without outside assistance there is practically no chance of significant improvement in their way of life but so far neither the government nor any other authority or organisation has made any consistent and meaningful efforts to improve the lot of the charcoal burners."

Milhayi says that there is no evidence that the government-sponsored charcoal producers cooperative (ZUPCPCS) "has benefited the charcoal burners." The cooperative has not provided alternative transport or marketing services, nor promotion (overproduction is a problem); it is widely distrusted by the burners; and has worsened drastic environmental effects, including the degradation of the forest, increased sheet-wash and erosion, and laterization.

Finally, he argues that a technological transformation of production under prevailing social relationships of production would disadvantage the already marginal burners:

> A significant increase in the efficiency of conversion by using modern techniques, while highly desirable for the economics of forest exploitation, would result in some disadvantages for the burners. It would most likely lead to a reduction in price (due to increased supply) if the same number of burners would be operating or it would lead to the decrease in the number of burners (or both).¶ Pres-

*Roscoe Ward provided these latter two efficiencies.

¶ This double effect of lower prices and fewer producers may occur despite the fact that, as Russell de Lucia points out, lower prices may elicit greater demand and thereby production of charcoal. Most likely, the most desperately marginal producers would be driven out by the rationalization process, leaving the expanded market to big producers with access to credit, markets, etc. However, the resistance of the producers is unlikely to be heeded due to their marginal status. More important is the likelihood that the merchants will object to the economic upgrading of producers who would thereby become less susceptible to super-exploitation as described by Milhayi.

TABLE 4. GROWING STOCK, ANNUAL INCREMENT, AND DEADWOOD BY SETTLEMENT GROUPS [in 10^3 kg]

Settlement Group	Forest Area (ha)	Growing Stock: Timber	Growing Stock: Small Trees and Branches	Growing Stock: Total	Annual Increment: Timber	Annual Increment: Small Trees and Branches	Annual Increment: Total	Deadwood	Fuelwood Supply Potential
North	81	4,967	2,581	7,548	138.3	144.5	282.8	226.5	509 3
West	33	1,852	816	2,668	52.8	43.5	96.3	80.0	176.3
Middle	117	10,262	2,710	12,972	280.8	158.7	439.5	389.1	828.6
South	97	7,637	2,722	10,359	208.4	138.3	346.7	310.7	657 4
TOTAL	328	24,718	8,829	33,547	680.3	485.0	1,165.4	1,006 3	2,171.6

Source: Bajracharya

ently, the occupation of charcoal burning, despite the very hard work involved, secures a marginal existence only, due partly to the high transport charges to the market. For anybody displaced from this employment the only alternative appears to be to return to the village. However, this proposition, as a rule, is rejected by burners. Thus a reduction in the numbers would only add to the impoverished, disenfranchised, unemployed poor already crowding the slums of the major cities and towns. For this reason, some projected, large-scale charcoal producing schemes using mechanized equipment and kilns, should be approached with caution.

Technological change involving significant injections of capital would likely also undercut the merchant oligopoly over wholesaling which permits them to drive down the price paid to producers by exploiting their precarious existence. Merchants would thus find it in their self-interest to oppose the capitalizing of the industry and to perpetuate the existing low-productivity techniques.

Charcoal production in Zambia is a clear example of the crucial role played by the social relations of production—in this case, the political capability of merchants to restrict producer access to markets and the apparent disinterest of industrial capital in the charcoal industry—in the blockage of technological change. (The competing opportunities for industrial capital which divert it away from displacing merchant capital and transforming artisan charcoal production require further investigation.) Plainly, any technological fix which does not take into account these political and economic factors has a high probability of failure.

C. Deforestation and Fuelwood Shortages in Nepal

It is widely believed that a fuelwood crisis, driven by population and ecological variables, afflicts Nepal. Over-use of the forests for fuelwood is posited to be the origin of extensive deforestation. Bajracharya undertook to demonstrate that this is an almost exact inversion of the actual situation. [11] Instead, he suggests, a food deficit has resulted in an expanded demand for agricultural land, which has led in turn to deforestation and thereby a fuelwood shortage.

Bajracharya studied the Nepali settlement of Pangma. The settlement is bounded in the north and west by hill ridges, and on the east by a stream. Pangma is a unit of interdependent settlement clusters that are self-contained in a small ecological unit (p. 3.4). The population of 3002 cover an area of 1,300 odd hectares, of which 57 percent is arable, 22 percent is forest, and the remainder is grassland, scrub, and pathways. Thirty percent of the inhabitants are indigenous Rais, and the rest are found in four groups (Gurungs, 27 percent, Brahmins and Chhetries, 23 percent, Sherpas, 7 percent, and minority castes and occupations, 13 percent). The main economic activities are agriculture and occasional seasonal wage employment (porterage, and civil and military service) (p. 3.7).

Overall, he finds that the fuelwood needs of Pangma can be met by 328 ha. of forest and 96 ha. of woodland (including branches, small trees, and treetops neglected by conventional foresters although not by villagers!). However, aggregate figures are misleading as the spatial distribution of supply and demand are not uniform. As can be seen in Tables 4 and 5, fuelwood supply and demand calculated for each region show deficits in the north and the west of Pangma, whereas the middle and south have an excess supply. In Table 6, he demonstrates that the north and west also have insufficient food supply. The agricultural land supply may be expanded by mortgaging, cropsharing, purchasing, and clearing new land. He shows that the north and west benefit least by the first three avenues, leaving open only the final option: "It is clear that the clusters in the North and the West are facing the greatest problems of food deficit. The levels of consumption are low for many households; the availability of arable land is limited;

TABLE 5. ANNUAL FUELWOOD DEMAND FROM FORESTS ACCORDING TO SETTLEMENT GROUPS [in 000 kg]

Settlement Groups	Number of Households	Gathered dāurā	Treefell dāurā	Total
North	143	444.6	106.9	551.5
West	58	155.1	20.4	175.5
Middle	199	464.6	226.0	690.6
South	182	315.8	114.7	430.5
TOTAL	582	1,380.1	468.0	1,848.1

purchasing power is limited; and even possibilities of obtaining land through cropsharing or mortgaging arrangements are limited." (p. 3.40). They are consequently forced to employ slash-and-burn technique to produce maize and millet—a fact reflected in their food consumption. Bajracharya concludes in summary:

> The pressures from food shortages and hence to expand agricultural land by clearing forest areas has a much greater influence on deforestation than those arising from extraction of fuelwood. This finding is supported by the observation that the people of Pangma are much more preoccupied with means of increasing their food supply than conserving their fuel demand. Furthermore, in areas where a larger number of households enjoy adequate food supply, aggregate fuelwood consumption exceeds wood increment. Our conclusion is that the constraints of agricultural land and low crop yields are the primary influences on deforestation. *As a consequence fuelwood supply may be curtailed to a point where demand will exacerbate deforestation*. (p. 3.47) (my emphasis)

Consequently, in Pangma at least, technological solutions "that seek to introduce substitutes for fuelwood or increase its efficiency will have only limited success" as long as food needs remain unfulfilled.

TABLE 6. AVERAGE ANNUAL PER CAPITA GRAIN BALANCE BY SETTLEMENT GROUPS [kg]

	All Grains	Rice	Millet	Maize
North	+17	-15	+20	+12
West	+11	-21	+31	+ 1
Middle	+30	- 5	+ 9	+26
South	+38	- 3	+32	+ 9
Panchayat Average	+27	- 9	+21	+15

Note: + = surplus
- = deficit

Source: Bajracharya

The Survival Dilemma

Conceptual, technologically feasible solutions to the crisis of food productivity in Nepal certainly exist—for example, a plan calling for small-hydro power plants integrated with small-scale ammonia fertilizer production by electrolytic fixation has been spelt out in some detail.[12] Yet the forces which have led to deforestation seem to preclude this solution.

Makhijani gives us some idea as to what lies behind this decline in food productivity and land availability for the north and west population clusters of Pangma:

(1) The 1964 land reform converted land into a commodity and abolished traditional land tenure, with a consequent loss of land for the indigneous Rai population;

(ii) Rais and Gurungs returning from service with the British army often found their families indebted and had to sell their land;

(iii) Commodities from the international market out-competed and destroyed the local cotton-growing and cottage textile industry, narrowing the economic base and pitching lower-ranking social groups into unemployment and poverty.[13]

Thus the encroachment of the international market, combined with the pressures of the traditional institutions (for example, usury) divested the Rais and Gurungs of land. Fuelwood problems are an effect of a multiple causation grounded in capitalist and tribal-traditional combinations of productive elements. Technological changes addressed to the energy dimension of the Nepali villager's survival dilemma are therefore likely to fail before the competitive thrust for the biomass resource which results from the articulation of the natural economy with the world market.

3. ANALYTICAL FRAMEWORKS

The bulk of the development literature on rural energy is built on *neoclassical economic* theory. Examination of the content, thrust, and applicability of this theory to rural energy is therefore incumbent. In contrast, *political-economic* theory places rural energy in a structural context, and suggests constraints on the possible success of rural energy projects.

Developed for different purposes, neoclassical and political-economic theories generate different and often conflicting conclusions about social receptivity to and the import of technological changes. This section examines each theory and their application to rural energy problems.

A. Conventional Wisdom

To explain technological change, a neo-classical model poses a production function for peasant subsistence, subject to multiple constraints. Subsistence households exchanging goods and services are assumed to compete vigorously with each other in pursuit of self-interest.[14] The rural producer will introduce technological changes (new tools, new land) as long as they provide greater economic benefits than other means of increasing consumption (for example, working longer, increasing family size and thereby the consumer/producer ratio). At the point when a new equilibrium is achieved (where the marginal costs of obtaining consumption are greater than the subjective benefits gained)[15] adoption of new technology stops. Put simply, peasant producers will introduce new technologies while that is easier and cheaper than other ways of increasing consumption.

In neoclassical theory, market exchange based on marginal costs allocates potential energy resources such as biomass to optimal economic use. This market allocation of resources at competitive prices is thought to shift the "social utility function" upwards to the "Pareto" benefit of all—the theoretical basis of the popular notion of "trickledown."[16]

While a full-blown neoclassical theory of technological diffusion could be borrowed from other contexts and applied to biomass,[17] there are no detailed applications or investigations of rural energy technology using this theory. However, the general thrust of neoclassical theory would explain the observed failures to deploy new rural energy technologies by pointing to market "distortions" and would likely recommend palliative and gradual adjustments such as more information, more technical extension services, cooperative training, improved administration, and provision of complementary inputs.[18] Faced with an obdurate social structure which resists new technologies as in Bangladesh, another conventional response is to design programs "to correct for maldistributive impacts" by avoiding or minimizing them.[19] This entails making eclectic and *ad hoc* adjustments to the theory to incorporate observable peasant behaviour.[20]

The neoclassical theory of competition and technological change rests on an assumption of socially harmonious results from pitting individuals against each other in exchange. A slack in village resource availability which can be incorporated in and shared through economic growth is also assumed. Assuming that economic growth is a non-conflictual process, aid agencies constantly urge the creation of village cooperatives as the vehicle for technological diffusion.[21] For example, a recent U.S. Agency for International Development Study clearly states this typically implicit presupposition of village harmony by defining a "village" as:

- a fairly stable small-scale, localized group of people
- sharing basic values and belief
- with a clearly defined set of social institutions
- *who are relatively homogenous and unstratified* [my emphasis]
- being somewhat isolated from urban centers, and
- having a recognized and effective authority (the "take me to your leader" syndrome).[22]

Using the market-oriented approach of neoclassical theory, rural energy planners and managers usually devote themselves to calculating financial rates of return.[23] Externalities are sometimes included in the cost-benefit calculus. However, only positive indirect benefits are typically included, while non-financial negative social externalities are often neglected in the rush to justify a project.[24]

As noted above, there is, to my knowledge, no rigourous or detailed examination of the applicability and relevance of the assumptions (individualism, transitive preferences, harmony, etc.) lying behind neoclassical theory to any specific rural energy system.[25] Thus there is an extraordinary disjuncture between empirical field reports and the neoclassical assumptions which are the dominant theoretical bases of rural energy policy formulations.[26]

B. Unconventional Wisdom

A political-economic theory focusses on social-structural determinants of technological change.¶ Of particular relevance to rural energy is the political-economic analysis of the blockage of technological change. Before analysing types of technological blockage, however, it is necessary to define the basic concepts of social-structural analysis.

Social Relations of Production

According to political economists, three elements of production are always present in any class society: producers, non-producers, and the material wherewithal to produce (biomass, tools, skills, etc.). Relationships between producers and non-producers—who form two fundamental classes—may revolve around either possession or ownership of productive resources. How the three productive elements are combined in these two social relationships

¶ Other analytical frameworks departing from neo-classical assumptions abound:[27] "technological underdevelopment" theorists, for example, who argue that dual economies misallocate land, labor, and capital resources and skew technological choice to "inappropriate technology;"[28] "moral economists" who argue that technological change systematically favors the rich and increases risk and insecurity for the poor peasantry who are at the mercy of the vagaries of the market;[29] and political-economists of the UNCTAD persuasion who present Third World energy problems as being tied up with patents and a new dependency in the rural sector on First World renewable energy technologies.[30] Due to space limitations, we merely note these approaches in passing.

defines a *mode of production*. In the feudal mode of production, for example, peasant-producers possessed land subject to the legal ownership of the lord or king non-producers. In capitalist societies, most producers possess no material resources apart from their capacity to work and to consume; non-producer capitalists possess *and* own the productive resources.

Feudal, capitalist, and other modes of production may co-exist in the same society, but invariably one achieves dominance, reconstituting the others to ensure the reproduction of the dominant mode.

In both feudal and capitalist societies, the non-producing class has faced the problem of assured access to producers' surplus and labor. This access, the cornerstone of a class society, is maintained by the exercise of class power economically, politically, and/or ideologically. In a capitalist mode of production, class power is expressed economically as market purchasing power; politically, through direct intervention and regulation by public or private agents (by enclosure and physical possession of the resource and consolidation of legal ownership, etc.); and ideologically, through religious and cultural forms of persuasion which reinforce political and economic power and limit the need to resort to military power. Military coercion, an important subset of political means of control, is invariably ignored in partial analyses of development and rural energy problems.*

Conflicts between producing and non-producing classes over possession and ownership of productive resources (or of relative shares) are endemic to capitalist societies. The outcome of these struggles is determined by the relative political, economic, and ideological power of each class. Class conflict results in reproduction, adjustment, or total transformation of the dominant social relations of production.[34]

Blockage of Technology Change

Technological blockage is defined as the exercise of power by a resource end-user to prevent uses of resources required for a technological change. The extension of credit, for example, required by small farmers to deploy technical innovations in agriculture, is often blocked by large landholders who monopolize the credit resource for their own benefit.

In contrast to the neo-classical assumption of socially harmonious adoption of technology, political-economic theory presupposes fundamental conflict between different end-users—that is, between classes. Social structures such as class, race, ethnicity, and sex, and the overall organization of production, distribution, and consumption determine the parameters and content of a "local" problem such as rural energy—and the possibility and probability of a solution. These concerns depart from the individualistic and micro-economic focus of neo-classical theory—as does the consequent historical emphasis of political-economic theory.

Finally, unlike the neo-classical treatment of energy as a generalized technical-economic product, political-economic theory always emphasizes the social specificity of energy products. Thus charcoal is not simply charcoal, but the social product of quite different relations between competing classes. It can be the product of urban or provincial merchants who monopolize markets and provide usurious credit to producer/sellers (as in Zambia), or who direct teams of wage laborers employing artisanal techniques (as in Mexico).[35] Charcoal can be the product of marginal, self-employed tribal producer-retailers who use wood from their own fields, bought rights, or common land (as in Southern Sudan).[36] It can be the product of independent capitalist farmers selling direct to individual manufacturers and foreign merchants (as in the Philippines).[37]

The social relations of production which determine differential class access to resources needed for a technological change—and therefore the types of technology blockage—are quite different in each of the cases sketched in Section 2. In the Zambian example, dispossessed peasants occupy state-owned forests to produce charcoal in a pre-capitalist organization of production. These producers are dominated by capitalist charcoal merchants with an interest in maintaining the primitive techniques of charcoal production. The charcoal producers remain subordinate to the merchants' economic power in part because the Zambian Government ensures the political impotence of their cooperative. Zambian charcoal merchants will have little interest in transforming the technical conditions of production as long as they can squeeze profits out of a disorganized, fragmented, and helpless workforce.

In Bangladesh, few remnants of the pre-capitalist mode survive the development of capitalist relations of production. Briscoe described clearly a situation in which rich Muslims coerce economically the mostly dispossessed poor Mulsims and Hindus, a relationship which also militates against technological

*Social conflicts often result in the militarization of rural areas. Thus we find in contemporary Kampuchea that the Pol Pot forces control the forests. One Kampuchean was reported to state recently, "The people need wood to cook food. But the wood is in the forests—and so are the enemy.' 31 A similar insurgency problem exists for fuelwood plantations in the Philippines.[32]
A common response by the military to political challenges of the status quo is "strategic denial" of the forests. The effects of British, Japanese, Kuomintang, and U.S. "scorch-and-burn" policies have only been overcome with much time and reforestation efforts in Malaysia, China and Korea.[33] The effects of the strategic resettlements and wholesale forest destruction by defoliation, napalm bombing, and clearfelling in Indochina will take much longer to repair.

changes which might ameliorate the rural energy crisis.

In Nepal as in Zambia, the availability of an environmental frontier (the valley hill-sides) to which dispossessed households could flee permits the reproduction of pre-capitalist modes under the dominance of the capitalist mode. As this shortage is the ultimate outcome of the penetration locally of global economic forces, the problem cannot be addressed with technological fixes.

These differences in class structure and modes of production portend a dismal future for rural energy aid. For where capitalist planning and project criteria are most relevant, that is, in a capitalist mode, capitalist class relations will ensure that the rich will reap the benefits, possibly at the cost of the poor. Where capitalist wage relations are absent, that is, in pre-capitalist modes, non-capitalist planning and project criteria are required—but are unlikely to emerge given the dominance of the capitalist mode over pre-capitalist remnants.

4. CONCLUSION

These examples demonstrate some of the types of technology blockage engendered by different social relations of production. Many other examples of politically, economically, or ideologically determined blockage of technology change could be cited.

While this paper dwells on the linkage of the micro-phenomenon with macro-structures, it should not be concluded that the only means of achieving technological change is for a global realignment of the social relationships of production to occur. At least two short-run strategies short of whole-sale transformation are potentially feasible.

The first approach is the wide-spread, pragmatic "bet-on-the-strong" approach to technological diffusion. This approach recognizes the distributional consequences of technological change, but argues that these are necessary human costs for a longer-term goal. The goal driving the technological intervention in this case can be humane (buttressed by a belief that relative equality will improve in the long-run, a belief battered by two decades of trends in the opposite direction). Or it can be simply a technocratic commitment to the deployment of a new technology regardless of the social cost.

The second approach is explicitly normative, arguing that technological development should be pursued if it contributes to:

(i) satisfaction of basic human needs (material and non-material), starting with the needs of the neediest;

(ii) endogenous self-reliance through social participation and control;

(iii) harmony with the environment. [38]

According to this perspective, a technological change should be pursued if it can meet these criteria or an acceptable set of trade-offs between them and has a low risk of co-option by the rich. However, the rarity of such events in the literature may reflect the persistence of social structures which vitiate such initiatives—and/or the values of technologists! A guiding light in this field is the work of ASTRA (Cell for the Application of Science and Technology to Rural Areas) which has demonstrated the commercial feasibility of a large biogas plant fulfilling all three criteria in the village of Pura, India. [39]

While such work lays the foundation for broader, long-run political change in the villages, the social structures described in the Zambian, Nepali, and Bangladeshi examples above will frustrate the generalization of the ASTRA model (not every village has access to an ASTRA!). Precisely because of these limitations, such an approach, while necessary, is insufficient in itself to achieve broad changes in the social receptivity to energy-technology innovations in third world countries. In the long run, far-reaching political strategies (which are beyond the scope of this paper) are needed to create social contexts in which the benefits of technology change can be embraced.

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14. A good example of this approach is S.L. Popkin, *The Rational Peasant. The Political Economy of Rural Society in Vietnam*, U.C. Press, California, 1979.
15. Most eloquently stated by A. Chayanov, *On the Theory of Peasant Economy*, ed. D. Thorner, Illinois, 1966. p.6.
16. Growth may be associated with increases in relative inequality: while the rich may get richer faster than the poor, no one should become poorer in this model.
17. Especially the Green Revolution—for example, J. Roumasset, *Rice and Risk*, North Holland, New York, 1976 and J. Roumasset *et al*, *Risk, Uncertainty, and Agricultural Development*, Agricultural Development Council, New York, 1979.
18. See such a list, for example, in J. Spears, "The Changing Emphasis in World Bank Forestry Lending: A Summary of Recent Experiences and Problem Areas," paper FRIC 14-13, Eight Forestry Congress, Jakarta. October 1978, p. 11.

19. R. de Lucia and H.D. Jacoby, "LDC Energy Planning: A Study of Bangladesh," (draft mimeo), Cambridge, Massachusetts, 1980, p. 4-51.

20. For examples of incorporation of such failures and observed peasant behaviour, see T.W. Schultz' works or the econometric analyses of C.H. Gotsch, for example, "Technology Prices and Incomes in West Pakistan Agriculture: Some Observations on the Green Revolution," Economic Development Report No. 199, Center of International Affairs, Harvard University, Massachusetts, U.S.A. 1971.

21. For example, J. Parikh, "Mobilization and Impacts of Biogas Technologies," *Energy*, volume 2, no. 4 December 1977. The potency of this belief in the cooperative form is also revealed in its uncritical application to explain project results. For example, H. Gregersen states that "A major intangible benefit of the fuelwood component would be its contribution to the strengthening of village institutions.... Fuelwood plantations, while technologically simple, give a very tangible demonstration to the villagers of the benefits of cooperative action," And elsewhere, "The most important single [success] factor of all is the fact that under the Korean "Samaeul" movement the villagers are fully committed to the scheme." (in "Village Fuelwood Plantations in Korea," FAO Forestry Paper 17, Supplement 1, Case Study 2, FAO, Rome 1979, p. 15, and "Appraisal of Village Fuelwood Plantations in Korea: A Component of an Integrated Rural Development Project," UM/FAO/SIDA Project TF INT-257 (SWE), Case Study 2, College of Forestry, University of Minnesota, June 1977. p. 24.) This uncritical view may be contrasted with Aksel and Larson's observation of the same project that "The [Village] Forest Associations are meant to be voluntary member organizations, but in reality they are top-down government controlled organizations with 'compulsory' membership and membership fees, . . . " a fact reflected in the unpopularity of Village Forest Associations among Korean peasants because of "negative past experience with Forestry work, unpaid labor and low incomes." (in "Report on the Establishment of Forest Management Cooperatives," German Agency for Technical Cooperation, Eschborn FRG, 1978, pp. 13, 36-37.). Korean anthropologist Kyung Soo-Chun casts similar doubt on "fairy-tale" versions of Korean reafforestation in "Economic Development and Energy Policy in South Korea: Macro and Micro Perspectives," (draft mimeo), Anthropology Department, University of Minnesota, November 1979.

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23. For example, World Bank, "Philippines: Appraisal of the Smallholder Treefarming and Forestry Project," Report 169a-PH, November 1977, pp. 16-22 and Annex 7. See also D. French, "The Economics of Renewable Energy Systems for Developing Countries," Washington DC, 1979, for an overview of neo-classical cost-benefit analysis in project evaluation.

24. See Gregerson, *op cit*, 1977, p. 15. Gregerson includes the strengthening of government-imposed institutions as an "indirect benefit" and neglects the project's debilitating effect on traditional village institutions on the debit side.

25. There are many economic analyses using the concepts of opportunity costs and optimal allocation and the conceptual apparatus of welfare economics—for example, R. Bhatia and N. Niamir, "Renewable Energy Sources, The Community BioGas Plant," (mimeo) Department of City and Regional Planning. Harvard University, 1979). However, even these tools are misapplied by some authors to some situations; for example, the valuation of non-marketted fuels in terms of substitute commercial fuels is highly misleading since such an option is not usually the substitute which would be chosen by the peasant, who would use a lower-grade non-commercial fuel instead. Such microeconomic studies cannot substitute for detailed empirical analyses of social and economic conditions is specific rural systems. R. De Lucia and R. Bhatia in "Economics of Renewable Energy Technologies in the Rural Third World A Review," (mimeo) Metasystems Inc., Cambridge, Massachussetts, October 1980, present a detailed listing of the conceptual paradoxes and dilemmas faced by the neoclassical analyst in rural energy technologies (pp. 7-13). This laudable effort does not demonstrate the applicability of the tools—only the difficulty entailed by their application.

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