ENVIRONMENT AND DEVELOPMENT

REGIONAL SEMINAR ON ALTERNATIVE PATTERNS OF DEVELOPMENT AND LIFE-STYLES IN ASIA AND THE PACIFIC

14-18 August 1979
Bangkok

E/ESCAP/DP/EDRS/8

ENGLISH

United Nations
Economic and Social Commission
for Asia and the Pacific
(ESCAP)

United Nations
Environment Programme
(UNEP)

"Not only additional constraints but also new development possibilities are at the heart of environmental considerations"

ECONOMIC AND SOCIAL COMMISSION FOR ASIA AND THE PACIFIC

UNITED NATIONS ENVIRONMENT PROGRAMME

Symbol number: DP/EDRS/8

Distribution: Limited

12 July 1979

ORIGINAL : ENGLISH

ENVIRONMENT AND DEVELOPMENT:
REGIONAL SEMINAR ON ALTERNATIVE PATTERNS OF DEVELOPMENT
AND LIFE-STYLES IN ASIA AND THE PACIFIC

TOPIC PAPER

ECONOMICS AND SOCIOLOGY OF ALTERNATIVE ENERGY SOURCES

BY

ARJUN MAKHIJANI

This paper was prepared by Arjun Makhijani of India. The views expressed in it are those of the author and do not necessarily reflect those of the United Nations or the Government of India.

ACKNOWLEDGEMENTS

I would like to thank the United Nations Environment Programme and the Economic and Social Commission for Asia and the Pacific for having given me the opportunity to prepare this paper for the UNEP/ESCAP Regional Seminar on Environment and Development: Alternative Patterns of Development and Life-styles in Asia and the Pacific, 14-18 August 1979. During the course of my work, Uttam Dabholkar of UNEP and Ian McDougall and Stephen Browne of ESCAP sent me many useful materials and gave me many useful suggestions, for which I thank them. Mr. R. Bhatia wrote a helpful review of the first draft. I am also grateful to Deepak Bajracharya and Amulya Reddy for having shared with me some of the data which they and their colleagues have gathered in their respective projects, even though these projects are not yet complete. Finally, I thank Annie Makhijani and Sharad Naik who typed the two drafts of this paper.

ABSTRACT

This paper is addressed to the question of approaches to energy use and sustainable satisfaction of energy needs in the poor countries of Asia and the Pacific in the over-all context of a search for alternative patterns of development and life-styles. As regards available technological options which are ecologically sound, the author touches upon various promising, but as yet inadequately explored, alternatives in respect of energy required for agricultural production, for cooking, for lighting, heating and transportation. Specifically he analyses the social, economic and ecological aspects of alternatives such as clover-cover farming, drop irrigation, family and community biogas plants, fuelwood plantations including village woodlots, solar energy in its various forms and small-scale hydroelectricity.

The author's principal thesis is that the perspective for alternative energy sources in particular and alternative development patterns in general in the region has to be derived from the initial conditions of poverty and the social and economic inequities prevailing in the rural areas of the poor countries. Consequently, solutions in terms of alternatives have to be carefully developed keeping in view the social, economic, cultural and ecological aspects of the problem. Only in this way, would it be possible to effect sustainable improvements in the quality of life. Ecologically sound alternatives *per se* do not guarantee that pressing problems of poverty, destitution, oppression and inequities of development - or lack of it - will be necessarily ameliorated. On the other hand, it is possible to identify and adopt concrete integrated approaches to energy development and social and economic change (e.g. land reform, participation of people in decision making and management) which would help realize ecologically sound, socially just and self-reliant development in the region.

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Contents

I. INTRODUCTION

In studying energy use, it is necessary to pay close attention to what people do in everyday life and why they do it. The use of time and the use of energy are, as we shall see, intimately related. The principle seems obvious; all the more reason that we should ask ourselves why it has so rarely guided study. With some exceptions, it is only in the last half-a-dozen years or so that fuelwood, crop residues and dung, which are the most important domestic fuels in most of the countries of the ESCAP region have been included in energy statistics. But the most important single source of energy for most people of the region - food for draft animals - has yet to find a place in most energy studies and in the statistics of energy production and use.[1/]

Apart from domestic work, agriculture is, of course, the single most important economic activity of most of the people of the region, and draft animals are the single most important source of power for agriculture. In some countries of the region, the power of draft animals far exceeds electrical generating capacities, as indeed it does in many, if not most, villages of the entire region. In Nepal, as an extreme example, the installed capacity of electricity generation was 60,000 kilowatts[2/] in 1975; the combined power of its, bullocks and buffaloes was 40 times as large, or roughly 2.5 million kilowatts.[3/]

Table 1 shows rough estimates of energy production and use in many of the developing countries of the ESCAP region. In the countries which have more industry, the "commercial" fuels - coal, oil, electricity, natural gas predominate in the total, but even in most of these, "non-commercial"

/Table 1.

1/ I exclude food for human beings and human work from energy production and use because such an approach is reductionist - that is, it represents human beings as machines or draft animals.

2/ Department of Economic and Social Affairs, World Energy Supplies 1971-1975, Statistical Papers Series J, No. 20, United Nations, New York 1977, table 18.

3/ Economic and Social Policy Department, Production Yearbook 1972 Vol. 26, Food and Agriculture Organization of the United Nations, Rome, 1973, table 95. I have taken two thirds of the cattle and buffaloes to be draft animals. The power of each animal is assumed to be 0.4 kilowatts. See Makhijani and Poole, Energy and Agriculture in the Third World (Cambridge, Ballingers Publishing Co., 1975), p. 140.

Table 1. Rough estimates of annual energy production and use in the ESCAP region in 1975

(units of 10^{15} joules/year[a/])

Country or area \ Source	Coal[b/]		Petroleum[c/b/]		Natural gas[c/]		Hydro & nuclear[c/]		Sub-total[c/]	
	Production	Use	Production	Use	Production	Use	Production	Use	Production	Use
Afghanistan	5.7	5.7	0.3	17.5	118	4.4	2.7	2.7	127	30.3
Bangladesh	-	10.2	-	34.4	18.9	18.9	1.8	1.8	20.8	65.4
Brunei	-	-	384	3.5	255	39.0	-	-	639	42.5
Burma	0.45	2.1	42.1	43.4	0.6	0.6	1.7	1.7	44.9	47.9
China	14,100	14,100	3,500	2,770	140	140	140	140	17,900	17,100
Dem. Kampuchea	-	-	-	3.9	-	-	-	-	-	3.9
Hong Kong	-	0.4	-	134.2	-	-	-	-	-	135
India	2,900	2,900	360	900	36	36	130	130	3,440	3,960
Indonesia	6	7	2,830	460	250	250	7	7	3,090	730
Iran	35	35	11,900	790	880	490	20	20	12,800	1,340
Japan	570	2,400	30	8,850	110	390	410	410	1,120	12,100
Korea, Rep. of	528	551	-	522	-	-	6	6	534	1,080
Laos	-	-	-	5.9	-	-	0.9	0.3	0.9	6.2
Mongolia	30.4	30.4	-	16.9	-	-	-	-	30.4	47.3
Malaysia[d/]	-	-	206	189	-	6	4	4	210	200
Nepal	-	0.15	-	3.4	-	-	0.36	0.36	0.36	3.9
Pakistan	23	25	17	154	186	186	20	20	246	185
Philippines	3	4	-	398	-	-	14	14	17	416
Singapore	-	-	-	145	-	-	-	-	-	145
Sri Lanka	-	-	-	49	-	-	4.1	4.1	4.1	53.1
Thailand	4	5	0.3	342	-	-	9.4	10	13.7	357
Viet Nam	127	80	-	140	-	-	3	3	130	250

/Table 1 (continued)

Table 1 (continued)

Country or area \ Source	Fuelwood Use[e/]	Food for draft animal Use[f/]	Sub-total Use[g/]	Total Use
Afghanistan	42	110	152	182
Bangladesh	95	530	625	690
Brunei	4.4	0.4*	4.8*	47.3*
Burma	110	140	250	298
China	820	2,300	3,120	20,200
Dem. Kampuchea	23	n.a.	n.a.	n.a.
Hong Kong	neg.	neg.	neg.	135
India	680	4,700	5,380	9,340
Indonesia	670	190	860	1,590
Iran	12	170	182	1,520
Japan	9	neg.	9	12,100
Korea , Rep. of	44	25	69	1,150
Laos	17	28	45	51.2
Mongolia	8	90	98	145
Malaysia	33	13	46	246
Nepal	52	200	252	256
Pakistan	51	690	741	1,130
Philippines	130	140	270	686
Singapore	-	neg.	neg.	145
Sri Lanka	25	50	75	128
Thailand	98	220	318	675
Viet Nam	160	120	280	410

/Table 1 (continued)

Table 1 (continued)

Notes: a/ 1 million tons coal equivalent equals approximately 30 x 10^{15} Joules. Numbers may not precisely add up to the totals shown because of rounding.

b/ Includes liquified natural gas.

c/ Source: World Energy Supplies, 1971-1975, Statistical Papers Series J, No. 20 (United Nations, New York, 1977), table 2.

d/ Includes Sabah and Sarawak.

e/ Ibid., table 24, 1 cu m wood = 0.6 metric ton
= 10 billion Joules.

It takes about 1 ton of fuelwood to prepare 1 cu m of charcoal. These data are, most likely, very rough estimates.

f/ One "standard" or "effective" draft animal is assumed to consume about 30 billion Joules of energy per year in some mix of feed, fodder and grazing. See Makhijani and Poole, op. cit., p. 140. Data for draft animals from the Food and Agriculture Organization of the United Nations, Production Yearbook, vol. 26 (Rome), pp. 184-188. The data are for 1972, but draft animal population doesn't change very fast, usually considerably slower than population growth. The draft animals included are mules, asses, horses, cattle, buffaloes and camels. There are, unfortunately, no data on elephants. The Food and Agricultural Organization data show all animals. I have taken two thirds of the total to be draft animals for underdeveloped countries.

g/ These sub-totals are underestimates for most countries since the various crop residues used directly as fuel are not included. Neither is dung from animals other than draft animals. The dung of draft animals does not need to be explicitly included as it is already implicit in the draft animal food intake.

/energy

energy sources are important because they are the main funds for the rural poor and a significant proportion of the urban poor.[4/] Actually the terminology "non-commercial" fuels is highly misleading, since in many areas a large proportion of fuelwood is traded. In India, for instance, this proportion is about one fourth. Cattle are commodities and hence, implicitly, so is the food they consume. They are rented out and some fodder too is traded. A large proportion of cattle feed comes from grazing land which is thus one of the most important contributors to energy production. While common land used mostly for grazing, is usually not a commodity, the various possible uses of common land can be, and often are, an important source of conflict in village life.

Table 2 shows energy use per person in most countries of the ESCAP region. The differences in energy use per person are not as large as these which are based only on the "commercial" fuels, because some "commercial" fuels use merely substitutes for "non-commercial" energy. We find, however, a peculiarity when we compute the energy required per unit of Gross National Product. This is lower for the more industrialized countries. In Japan it is about 30 million joules per (1970) United States dollar in Malaysia, Thailand, Sri Lanka and the Philippines, the figure is 70 to 80, and in Afghanistan and Bangladesh it is about 130. Thus, energy appears to be put to more productive use in industrialized countries, in direct analogy with the more efficient use of energy in green revolution agriculture when compared with traditional agriculture (see chapter III). The inference is that the technical efficiency which the poor manage to extract from the energy they use is much less than that which the more affluent can extract. We can expect that this was caused by the lack of access to the resources of society, specifically to investment and to the control of property, a point we shall explore at some length in this paper.

Even more generally, the energy inputs into agriculture per unit of output are comparatively large. As a result export of agricultural goods and import of industrial goods constitutes a vast net export of expensive energy, primarily draft animal energy.

For instance, it takes 10 to 30 billion joules to produce a ton of paddy[5/] worth about \$ 100. Thus one dollar export earning means an export of 0.1 to 0.3 billion joules of energy. Manufactured goods containing a

/Table 2.

4/ The statistics shown understate "non-commercial" energy use since the crop residues used directly as fuel are excluded. I have these statistics for India, but have excluded them from the table for reasons of comparability of the data.

5/ Makhijani and Poole, *op. cit.*, note 3, table 2-23.

Table 2. Rough estimates of energy use per person in the ESCAP region in 1975, in billion joules and in per cent a/ and energy/GNP ratios

Country or area	Commercial energy		Non-commercial		Total
	Use	Per cent	Use	Per cent	use
Afghanistan	1.8	14	11.0	85	12.8
Bangladesh	0.8	8	9.0	92	9.8
Brunei	330.0	89	40.0 b/	11	370.0 b/
Burma	1.6	16	8.3	84	9.9
China	19.0	85	3.4	15	22.4
Dem. Kampuchea	0.5		n.a.		n.a.
Sri Lanka	3.6	40	5.4	60	9.0
Hong Kong	34.0		n.a.		n.a.
India	6.6		7.8	54	14.4
Indonesia	5.5	45	6.6	55	12.1
Iran	40.0	88	5.4	12	45.4
Japan	110.0	100	0.1	-	110.1
Korea, Rep. of	31.0	94	2.0	6	33.0
Laos	2.0	12	15.0	88	17.0
Mongolia	34.0	33	70.0	67	104.0
Malaysia	20.0	90	2.3	10	22.3
Nepal	0.3	1	21.0	99	21.3
Pakistan	5.4	33	11.0	67	16.4
Philippines	10.0	60	6.7	40	16.7
Singapore	64.0		-		64.0
Thailand	9.0	53	8.0	47	17.0
Viet Nam	4.5	43	6.0	57	10.5

Notes: a/ Compiled from table 1 using population statistics from International Bank for Reconstruction and Development, World Bank Atlas - Population: Per Capita Product and Growth Rates (Washington, D.C., 1972).

b/ Very approximate.

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large proportion of steel require about 70 billion joules/ton.[6/] Thus the import of an automobile weighing a ton and costing $ 4,000 means an import of about 0.02 billion joules of energy per dollar spent which is five to fifteen times less than the energy exported.

The difference is even greater in the case of electronics goods, armaments etc. This is clearly a part of the more general problem of terms of trade, in which there is the net export of a vast amount of labour.[7/]

Inequality is, of course, not confined to the international sphere. If anything, the inequalities between the rich and poor within the develope-ing countries are much larger than those between the rich of various countries, though the proportion of the rich varies.

Careful consideration of all energy sources has led us to some basic questions which force us to reevaluate our entire approach to examining the problems of energy policy. Why do the poor not get enough work out of the energy they use? Why does the pattern of energy use show similar features to other, broader, social inequalities. Why must some people give up more energy and time in exchange for less? Are the inequalities and peculiarities of energy use one expression of social structure? What, after all, are the fundamental aspects of energy use in society? We can hardly proceed to examine alternative energy sources until we have briefly considered the reasons why the pattern of today's energy use is the way it is.

II. ENERGY NEEDS

Energy, except for food and sunshine, is not a need in itself, but is needed to satisfy other human needs for clothing, shelter, warmth, water, light, physical and mental health, meaningful and productive work and personal mobility. Therefore, when we speak of "energy needs" it is merely shorthand for "the energy needed to produce and justly distribute the wherewithal to meet human needs". Since neither human needs nor the ways in which we use energy are fixed, there can be no once-and-for-all determination of energy needs.

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6/ M. Fels and M. Munsen, "Energy thrift in urban transportation: options for the future", in The Energy Conservation Papers, ed. Williams, Ballinger, Cambridge, Mass., 1975; appendix C.

7/ See Rammanohar Lohia, "Economics after Marx", in Marx, Gandhi and Socialism (Hyderabad, Nava Hind Publications, 1963), pp. 1-90.

We must, from the outset, distinguish between energy needs, energy demand and energy use. Energy demand is that part of energy which appears as a commodity in the economic system. Since only those who have the money to corner supplies determine the demand for energy, demand has only a tenuous and grossly distorted relationship to evergy needs. Energy use includes, besides energy demand, the fuel which people collect for their own consumption which may or may not meet their needs.

A crucial distinction between energy use and energy needs is that use is reckoned in terms of the energy input - that is, the energy value of the fuel; energy needs must be figured in terms of the energy needed to fulfil human needs - that is, the energy output as applied to the task at hand and the relation of that task to the fulfilment of human needs.

There are further essential distinctions between energy needs and energy use. There are many tasks essential to meeting human needs that are not done. Simultaneously, there are a number of socially unnecessary indulgences which cause an excess of energy use over needs. But these uses of energy which are unnecessary and even harmful from the point of view of human needs - that is, from an ethical and ecological point of view - are an integral part of local, national and international social structures. Therefore, the waste which results from energy use is the result of specific technological, economic, social and political conditions. If our judgements are to be historically and ethically sound, we must seek the reasons for this simultaneous existence of penury and prodigality in energy use in the history of these conditions, which includes the desires and motives of various groups of people for the future. Therefore, translating energy needs into magnitudes of energy use is not a simple empirical matter, but one which necessarily involves value judgements and interpretation.

Within a society, energy use is largely determined by the requirements of the dominating classes to fulfil their own desires and to maintain and expand their control over society. The dominated classes are forced to make do as best they can. These efforts usually fall far short of meeting their needs, particularly in developing countries, precisely because they have little command over the resources of society.

When the wealthy and the powerful decide on the building of prestige projects, the sales and purchases of armaments, the construction of air-conditioned palaces, the imports of luxury goods, they also decide

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what kinds of investments will be made, how many people will be employed and what they shall produce. Those workers who are organized can at least struggle for a share in such economic growth, though in many countries even such trade union organization is forbidden. This process deliberately leaves out the majority of the people - the poor peasants and agricultural workers, most women, the temporary and unorganized workers, the unemployed - who are severely constrained in the extent of the demands they can make on the commodities that are produced or imported; their effect on the mix of production is thereby very limited.[8/9/] For energy use this means that they are forced to rely primarily on gathering fuel, or recouping it as a by-product of some other activity such as agriculture or dairy farming.

For the same reasons, the oppressed are forced to rely on traditional techniques. While these are usually well adapted to local conditions and to such local resources to which the poor have access, they are often quite inefficient from the technical standpoint. This is because the oppressed have been shut out from the process of innovation and the learning that goes with it. The base of innovation in local craftsmanship and artisanary crippled by colonialism has not been allowed to reemerge with any strength in the developing countries. Indeed such a reemergence would pose a threat to the "professionals and their establishments [who] have appropriated and monopolized innovation and developed a vested interest in it."[10/]

Such an unjust social structure not only determines energy demand and severely constrains energy use, but it also implies a magnitude of energy needs which is generally far in excess of that implied by an equitable distribution of resources. When the gap between the rich and the poor remains or grows with economic growth,[11/] then the very needs escalate so rapidly as to make their satisfaction impossible. Indeed, the entire structure of human needs and desires becomes warped. In the United States of America automobiles became a necessity after the Second World War

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8/ S.L. Shetty, "Structural retrogression in the Indian economy since the mid-1960s", Economic and Political Weekly, vol. XIII, Nos. 6 & 7 (Bombay, February 1978), pp. 185-244.

9/ Arjun Makhijani, "Structural retrogression in the Indian economy: a comment", Economic and Political Weekly, vol. XIII, No. 45, (Bombay, 11 November 1978), pp. 1865-1868.

10/ A.K.N. Reddy, "Mere popularization of science or democratization of innovation?", paper presented to the All India Convention of People's Science Movements (Trivandrum, 10-12 November 1978), p. 2.

11/ This judgement of increasing inequalities cannot be made on a national basis alone; international inequalities are also of the essence.

due to suburbanization (in which the United States Government's housing policy, automobile lobby pressures and racial discrimination each played a part), to the neglect of public transportation (often deliberate), and so on. Further, repressed sexuality and status found a new outlet in the automobile. When the "technology was transferred" to the developing countries, it was primarily these latter aspects that went with the private car. In Bombay, for example, private cars proliferate though there exists a reasonably good public transportation system, and though for many car owners even taking taxis would be cheaper. It is not only the elite that possess these desires, for there are booming sales of all manner of luxury goods (including cars) to workers freshly returned from West Asia. Are we to deny these workers the prerogative of having automobiles on the pretext that oil or some other resource is running out, even while the elite proceed with their unrestrained profligacy? I think that this is an ethically untenable position. Since energy needs depend on the ideological approach of the dominating classes (and the constraints on that approach at any time) we must, if we wish to chart an ethically and ecologically sound alternative, begin by questioning that ideology.

Civilized society has had, from the time of the Egyptian Pharoahs to the present day, what one may call the "brute force" approach to energy use. With the division of work into mental and manual labour, the thinkers of Egypt looked upon the slaves as nothing but raw, if nimble, energy to move and place stones into pyramidal shapes. Steam power, the internal combustion engine and electric power seemed to hold the promise of liberation from physical drudgery by substituting inanimate energy for human labour. They have, in part, accomplished that.[12/] But the "brute force" approach remains. Whether in industry, in transport, in commerce, in agriculture or at home we use enormous amounts of energy to do even the simplest things. Today the environmental and social problems and the mental drudgery of this approach are apparent. In fact, its ethics and ecological philosophy are quite compatible: the ethics demand the subjugation and alienation of people; the ecological philosophy demands the subjugation of nature to the will of man. Man stands outside nature and above it. Man must batter nature into submission to accomplish his ends. This expression "the will of man" more closely examined reveals that it is not the will of people in general, but the desires of the ruling classes.

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12/ However, one must not exaggerate the extent of this accomplishment. A good deal of the physical drudgery has simply been transferred to the factories, mines and fields of the developing countries particularly from Western Europe, North America and Japan. This has been so since the days of mercantile imperialism. See Rammanohar Lohia, op. cit.

There is, of course, no question of a return to primitive life, or even to its philosophy. That too had, in part, the same approach, though the ancients were technologically and organizationally constrained to use much less energy. Today we have the problem of decreasing the physical drudgery of the ancient techniques, the alienation of the modern and the violence of both.

There is a little recognized feature of energy[13/] which we must understand if we are to evolve a different approach. Energy is being constantly degraded - that is, it is irretrievably "used up".[14/] There is one other physical entity which has the same property: time. Both energy and time proceed unidirectionally.[15/] But time for human beings has yet another property which derives from human consciousness. We are conscious of our past, of life, of death. We have desires in the present for the future; these desires are in turn conditioned by our (past) experience and knowledge. Thus human time possesses a dual characteristic - one physical and unidirectional; the other human (i.e. the result of the process of socialization of the individual) and bidirectional - it brings the past and future into the present.

One aspect of the use of energy is that it is an effort to overcome the unidirectionality of time which decrees birth, life and death. The harnessing of solar energy in agriculture, the enhancement of human work by the domestication of cattle and the gradual subjugation of some people to others (at first it was the subjugation of women to men[16/] and of most people to magicians and sorcerers who became priests and rulers)[17/] developed with the recognition that energy, including the labour of others, is a partial substitute for time. A ruling class ideology of unrestrained consumption, of warped and unlimited wants, of violence and domination was, and is, an essential aspect of the appropriation of the time and lives

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13/ I use the term "energy" in the sense of "capacity to do work".

14/ More precisely, entropy - a concept of randomness - is constantly increasing, according to the second law of thermodynamics. Energy is conserved but its capacity to do work is used up.

15/ This applies to time scales small compared to the "life" of the universe. It is not possible at present to formulate a clear account of the characteristics of energy and time on cosmological time scales. Different cosmological theories imply quite different properties of energy and time. However, this controversy does not affect the present discussion much.

16/ Kathleen Gough, "The origin of the family", in ed. Reiter, Toward an Anthropology of Women (New York, Monthly Review Press, 1973).

17/ Archibald Robertson, The Origins of Christianity (New York, International Publishers, 1962).

of others. It should not be so surprising then that dealing with only one aspect of the problem by mechanization, and that too partially, has not given us the direction that we need. If wants are unlimited, how can we get rid of inequality, domination and violence?

Lost in the morass is the question - what do we want the time for? Much of the time of the dominating classes is spent in planning and effecting the perpetuation of their domination. Even the nature of their technology traps them. For example, if one takes account of the time spent in a car, the time spent to earn the money to buy and repair it, buy the gasoline etc., as Ivan Illich has suggested, the average speed of the United States automibile works out to roughly 10 miles per hour.18/ This is a direction that produces slavery and physical drudgery for many and alienation for all.

The ideological ingredients of an alternative approach are implicit in this critique. So far as energy is concerned, the use of "brute force" can be made quite unnecessary. It is already provided by the sun. The natural energy flow to and from the earth is enormous. It is, therefore, largely a matter of channelling a part of this energy intelligently and creatively rather than converting it in large amounts to some other form and continuing the present ways of using energy. This latter is simply a substitution of one energy source for another and does not get to the heart of the problem. The former implies the use of small quantities of energy to direct a part of the natural flows of energy. It requires that we radically rethink both our ways of using energy and our ways of using materials.

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18/ The problem is actually considerably more complicated. The question is often not one of average speed, but of the possible speed at the time the contraption is wanted or needed. Many of these are manipulated and created wants, of course, but the speed of the ambulance when a heart attack or shock victim is to be transported to the hospital is crucial; though it is true that we would probably not need ambulances as much if we understood more about our bodies and health. So far as the average speed is concerned, the figure is somewhat too high if we remember it is in part the small earnings and unemployment of some that enables others to afford automobiles.

The ecological philosophy implied by such an approach to energy use is one of harmony with nature. This is not the harmony of nature which obtains from evolutionary adjustments of plants and animals, but one which is deliberately created through an understanding of nature and of ourselves. The base of knowledge for such a project has emerged slowly over the last hundred years or so in our understanding of physical processes of cells, of biology, of ecology, of consciousness, of society, though it is still far from adequate.

If this knowledge is to give humanity fresh inspiration, it will have to be incorporated into social and political movements that begin with a clear and sober historical assessment of the dangers and possibilities which we have. There will undoubtedly be mechanization of some things in the very process of changing the mechanical structure of civilization. What we must be clear about is that we speak of a process of change in which the ecological and social violence is reduced, rather than a wondrous utopia in which we will all find ourselves one fine day. What is crucial is how we mechanize, who controls the process, how it can be made consistent with meaningful and productive work for all with a just distribution of goods, and with increasing human creativity, co-operation and freedom.

This view should not be confused with the elitist and technocratic "appropriate technology" that is being promoted by many well-intentioned and not-so-well-intentioned institutions and intellectuals. Nothing but further perpetuation of domination and injustice can be achieved unless the process of change and innovation is controlled by the people and forms an integral part of their struggle against oppression. It is an authoritarian prevention of the satisfaction of the needs of the poor that would assign to them some politically convenient heap of "intermediate" technologies. That would be a strategy of underdevelopment - a continuation of what we have had till now. It is true that creative use of energy sources such as biogas and wood should be part of a process of development, along with moderate use of fossil fuels, but it is not only the techniques which produce development, but also the social context in which these techniques are used.

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III. AGRICULTURE

Agriculture consumes as well as produces energy. Solar energy is fixed in crops which serve as food[19/] and fuel. Crop residues and various other kinds of energy are, in turn, used in agriculture. Most of the energy used in agriculture is for ploughing, irrigation, the manufacture of fertilizers and pesticides and crop processing.

The crop residues fed to draft animals supply almost all the energy input to traditional agriculture.[20/] In India[21/] the 150 million or so draft animals consume about 4,000 x 10^{12} Joules of energy which is about equal to India's entire consumption of "commercial" energy (coal, oil, hydropower etc.). Possibly 60 per cent of this comes from grazing and almost all the rest from crop residues.[22/] Draft animals provide the power for ploughing, for puddling (in wet paddy cultivation) and for irrigation. In addition some 15 per cent of the draft animals are also used for powering India's 12 million bullock carts.[23/] They are also used for crop processing activities such as threshing and sugarcane crushing.

In spite of this large energy use, many peasants face acute shortages of draft power. Many poor peasants do not own draft animals so they must hire them, often at exorbitant rates. In many parts of the Deccan plateau, where the soil is hard, the power requirements for proper ploughing are 2 to 3 kilowatts - that means 3 or 4 pairs of bullocks. Most peasants own at most

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19/ I include food in the category "human needs" rather than in "energy needs".

20/ Some (natural) wind energy is used to separate chaff from grain; likewise sunshine is used to dry grain. Solar energy also supplies the fertilizer, directly through nitrogen fixing bacteria and algae and indirectly through manure.

21/ Most of the information I have on agricultural energy use pertains to India. However, most of the observations on energy use are qualitatively valid for most countries of the ESCAP region, since most agricultural practices in the region are also found in one or another part of India.

22/ Arjun Makhijani and Alan Poole, op. cit., p. 17, pp. 107-111.

23/ A.K.N. Reddy, "Technological alternatives and the energy crisis", Economic and Political Weekly, vol. XII, Nos. 33 and 34; Special Number 1977; p. 1469.

one pair and as a result, much land is left fallow, and the yields on cultivated land are reduced. These shortages are made more acute by the erratic rainfall which puts a premium on ploughing immediately after the rains, for the land dries up quickly and becomes hard. Some farmers use cattle to power Persian wheels for irrigation. Where the water table is close to the surface as in Bangladesh and West Bengal manual irrigation (i.e. irrigation with human labour) from ponds commonly supplements the rains.

Energy use in "green revolution" agriculture is, of course, considerably different. It requires about 80 billion Joules to fix one ton of nitrogen in urea using natural gas as feedstock and twice that much using coal. 100 kg/hectare is a usual nitrogen requirement for high yielding varieties of wheat and rice. In addition mechanical irrigation requires 0.5 to 5 billion Joules of energy output per crop per hectare [24/] - that is, about 2.5 to 25 billion Joules of fuel such as diesel or electricity (about 20 per cent efficient) or about 10 to 100 billion Joules of crop residues if draft animals are used. Widespread use of draft animals for irrigating crops is thus out of the question, except as a supplement to rain. Tractors require about 5 to 10 billion Joules of diesel per hectare for ploughing and harvesting, though it must be remembered that much, if not most, of the ploughing and harvesting even in green revolution agriculture is done by traditional techniques.

While agriculture with high yielding seed varieties requires from 10 to 30 billion Joules of energy per hectare (today supplied by various combinations of oil and electricity), it also produces substantially larger quantities of food and crop residues because high yielding seeds fix more solar energy. In traditional wheat culture the energy input is 20 to 30 billion Joules per hectare and the output (food plus crop residues) amounts to about 40 billion Joules - that is, about 0.2 per cent of the incident solar energy is fixed in the crop. On an irrigated and well fertilized field the input goes up to about 50 billion Joules per hectare, and the output to 120 billion Joules - that is, about 0.6 per cent of the incident solar energy is fixed in the crop.[25/]

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24/ The amount of energy output required varies according to the depth of the water table and other geological features, the type of delivery system of water and quantity of water required.

25/ Assuming an average insolation of 200 watts/m^2 over a season of 120 days. If only one crop per year is cultivated, as is common, the annual efficiency of traditional agriculture drops to 0.07 per cent. Multiple cropping, made possible by irrigation, can raise the efficiency of agriculture to about 2 per cent. The latter is about the efficiency of irrigated sugarcane cultivation. See Makhijani and Poole, ibid., pp. 82-87.

It would be simplistic and superficial to regard these vast differences in efficiency as being caused principally by technical factors such as new seed varieties. For example, high yielding wheat seeds had been available for two decades before they were used in India on any significant scale. It is rather the different patterns of control of agricultural land (and, secondarily, other assets such as bullocks, wells etc.) that determines whether new seed varieties can be successfully adopted. In those parts of India where landlordism, usury (interest rates vary from a low of 100 per cent per year to several thousand per cent per year), and slavery[26/] are common, the rich have little interest in increasing production through investment because their surplus is derived primarily through trade, moneylending and various other forms of extortion. The poor peasants and tenants cannot afford to take to new techniques when interest rates are so high and where institutions are controlled by interests closely allied to landlords, usurers and rich traders. It is for these very same reasons that traditional agriculture in these regions is unproductive.

It is largely in the regions where there were a large number of owner-cultivators (many of whom use hired labour) and where, as in Punjab, a good deal of the infrastructure such as irrigation considerably predated the introduction of new seed varieties that these could be used successfully.[27/] In these regions, agricultural production has increased a good deal and has become much more market oriented. Incomes within these regions have increased, but so have inequalities.[28/] The regional inequalities have become greater, indicating that the dominant and influential classes in the agriculturally productive regions are growing richer partly at the expense

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26/ Slavery is more usually referred to as "bonded labour". A recent survey found that there are about 3 million slaves in India's rural areas, according to the Gandhi Peace Foundation of New Delhi.

27/ The picture is, of course, considerably more complex than this. The social, political, cultural and economic causes which lead to significant changes generally have a long history in which many subtle factors play a vital part. There are, for example, some areas where slavery, landlordism, usury and high yielding varieties exist together.

28/ Biplab Dasgupta, "India's Green Revolution", Economic and Political Weekly, Vol. XII, Nos. 6 and 7, pp. 241-260.

of the poorer classes and regions.[29/] The use of fertilizer in India is concentrated in less than 10 per cent of India's 400 districts and there are large inequalities even within districts. Market orientation has made wheat, paddy, cotton and sugarcane cultivation more profitable, so that the cultivation of pulses, which are nitrogen-fixing (leguminous) crops and the primary source of protein for the poor, has declined. Of course, this is not an ecologically sound practice and necessitates greater use of chemical fertilizer. Neither is it very ethical for it deprives the poor of protein.

This is not a very promising social or economic context for alternate energy sources to make a contribution to a different and equitable pattern of development. In the landlord-usurer dominated areas, these techniques are not likely to find much application for the same reasons that the new seed varieties were not adopted there. Even if they are used in a few areas, they are certain to benefit the wealthy and powerful and help them to further entrench their dominance, unless there are strong organizations of the oppressed that can get and maintain their just shares of society's wealth. So far, this has not been the case as is indicated by the fact that the proportion of India's people who are poor is according to some sources, increasing in spite of economic growth.[30/]

In such areas where new agricultural techniques were widely adopted, it is quite probable that the richer peasants can use alternative energy sources for agriculture. For example, methane obtained by purifying **biogas** can be compressed in high pressure cylinders (about 200 kg/cm^2) and used for supplying power to irrigation pumps and tractors. Similar systems using natural gas as fuel for automobiles and trucks have been in use in many countries for some years (see chapter V). The cost of compressed gas would be approximately Rs 45 (= $US 5.6) per billion Joules which is comparable to the current cost of diesel in India.[31/] Undoubtedly some trials and pilot projects would be necessary to sort out some of the technical problems.

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29/ Shetty, op. cit., p. 202.
30/ Shetty, ibid., pp. 209-214.
31/ 1 billion Joules approximately equals 28 litres of diesel. See Arjun Makhijani, "Energy policy for rural India", Economic and Political Weekly, vol. XII, Nos. 33-34 (Bombay, August 1977), table 2, p. 1455.

Such an approach would help those peasants who have successfully used new seed varieties and mechanized agriculture. There are serious shortages of electricity in many parts of India, and sometimes even of diesel. It would also help reduce the use of chemical fertilizers and enhance soil fertility. Biogas plants also provide many more jobs for a given output of energy and fertilizers than corresponding centralized approaches.32/ Even with all this, this scheme would neatly fit into the existing pattern of increasing inequalities.

Since the rich peasants own more land and cattle, they would have the greatest use of the output; they would be the ones to control the plant and equipment, as they control the co-operatives today. Those who own a little land may benefit some, but the pressures on them to sell their land could be increased in various ways (by denying them fuel at critical times, for example). The landless may actually suffer since cow dung is a vital cooking fuel in many green revolution areas. The plant sizes and quantities of fuel required for biogas programme to make a dent in diesel use would be very large - half or more of the present cow dung production. Cow dung would probably become monetized and monopolized by the relatively wealthy. Therefore, unless some provision is made for cooking fuel, such as supplying biogas at a nominal charge, it would certainly hurt the interests of the poor in those areas where cow dung is used for cooking. Providing bio-gas for cooking at a nominal charge would roughly double the cost of the methane for agricultural use, making it uncompetitive with diesel. Perhaps the most damaging consequence of such a programme based primarily on the dissemination of a technique is that it would, like the green revolution and for the same reasons, exacerbate regional inequalities. The result of such a process is already quite familiar - deepening poverty in most of the country with pockets of relative prosperity (within which, increasing inequalities).

The technique is itself more ecologically desirable than the ones being used at present. As such it should be developed. But if its use is to help alleviate the pressing problems of poverty, it will have to be implemented in the context of the priorities of the oppressed - that is to say, in the context of a process by which the oppressed are able to acquire a substantial control over society's resources.33/

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32/ C.R. Prasad, K. Krishna Prasad, and A.K.N. Reddy, "Bio-gas plants; prospects, problems and tasks", Economic and Political Weekly (Bombay, August 1974).

33/ As this is a more general problem, I will address it in the final chapter.

All of the techniques described thus far require relatively large amounts of energy. They are "brute force" techniques, which make a very limited use of the natural flows of energy in conjunction with relatively large amounts of fuel.[34/] Today's ploughing, irrigation and fertilization of land are based on empirical techniques invented thousands of years ago, and though the sources of energy for all three have changed (in some places, at any rate), the approach has not. We turn over enormous quantities of earth to loosen and aerate it, using enormous effort. Is it possible to direct the natural flow of solar energy to accomplish some of these tasks?

An experimental method of cultivation developed at the Institute of Tropical Agriculture, Ibadan, Nigeria seems to have the desired ability of channelling solar energy.[35/] A crop of corn was planted in rows amidst a permanent ground cover of clover.[36/] The ground cover of clover serves several functions: the nitrogen-fixing bacteria which inhabit the roots supply fertilizer to the crop while aerating the soil; the dew drops that form on the leaves provide water for irrigation; and the ground cover keeps the field weed-free. This channelling of solar energy via the clover plant eliminates many major energy using features of present day agriculture, thus reducing energy needs as well. Sowing (together with application of phosphorous and potassium fertilizers), insect-pest control and crop processing (harvesting, winnowing and threshing) would be the remaining needed agricultural operations, of which the first two require rather minimal amounts of energy. The energy requirements for making land suitable for agriculture would also probably be considerably reduced since the method does not require level land.

If this method of agriculture proves to be workable, it would seem to conform well to non-violent ecological philosophy, particularly if it can be integrated with biological pest control. However, the practical merit of the technique is determined by social considerations.

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34/ I include the use of crop residues for draft animals as "fuel use".

35/ Ray Wijewardene, Lecture at Habitat Forum, Vancouver, June 1976.

36/ In its present form this method is not applicable to wet paddy cultivation.

In most places in India, at any rate, it is likely to have perilous consequences for the poor. First, it reduces labour requirements considerably. For example, the labour requirements of irrigated high yielding wheat in Punjab, in which bullocks are used for ploughing and threshing and a pump-set for irrigation, are approximately as follows:37/

Person-day/hectare	
1) Ploughing and seeding	12
2) Irrigation and bunding	16
3) Pest control, weeding and fertilizer application	30
4) Harvesting, winnowing and threshing (for a yield of 2200 kg/ha)	55
Total	113

By eliminating most of the work required for the first three operations, the clover-cover method (presuming it is technically feasible) would reduce the work per hectare by roughly 45 per cent. The reduction in the case of traditional varieties would be somewhat less, since the over-all labour requirements are lower. About one fourth of the peasants in India have no land whatever and they rely on agricultural labour for income. They would be very hard hit by widespread adoption of this technique. Most poor peasants, perhaps about 50 per cent, also do agricultural work for wages and their income would also be reduced. Tenants would probably also become more insecure and may suffer a reduction in their share of the output (which is low as it is) because of the reduced work requirements. All in all, where there are large numbers of agricultural workers (full-time or part time) or tenants, the clover-cover method may have disastrous effects for them unless, of course, land is redistributed first.

Where land is equitably distributed or commonly owned, the method could be socially and ecologically beneficial (if it proves technically feasible). In hill areas, it would reduce the enormous amount of work needed for terracing and soil conservation and hence perhaps help make the task of soil and water conservation somewhat more compatible with the need for agricultural land (e.g., the case study of Pangma village, in IV below). In such areas it could also help poor peasants by reducing the need for them to own or hire draft cattle.

/Another

37/ Raj Krishna, "Measurement of the direct and indirect employment effects of agricultural growth with technical change" (manuscript), table 1.

Another method of channelling solar energy applies to horticulture. Vegetable cultivation and seedling nurseries normally require enormous amounts of irrigation water. The earthen pot irrigation method can decrease water requirements by perhaps a factor of ten. Unglazed baked earthen pots of the variety commonly made by village potters are buried, up to their necks, in the field. The warm earth gradually sucks up the water out of pot and the water reaches the roots with a minimum of waste. Since the water is drawn primarily by the heat of the earth, losses by downward seepage are also minimized. "Experiments in India have grown melons and pumpkins with very little water (less than 2 cm ha for the entire 88-day growing period). Very little evaporation occurred because there was no standing or surface water".38/ This is a technique which, by channelling solar energy to stretch water supplies by an order of magnitude, holds great promise, not only in arid and semi-arid areas, but in other areas as well.

Besides its ecological advantages, earthen pot horticulture is at once labour-intensive and productive. It can also help revitalize a cottage industry pottery. But, as with every technique, its progressive possibilities will depend on the social context in which it is put to use, and on who controls it. If it is used to open up new areas to vegetable production, marketing will definitely be a problem unless the reduced costs (made possible by lower water and labour requirements) are kept out of the hands of usurers and traders and passed on to consumers. Vegetable consumption in India, as in most underdeveloped countries, is very low and the elasticity of demand for them is probably relatively high.39/ However, most of the profits from vegetable growing go to the big traders who market the vegetables in towns and cities, the demand for them being limited in the villages. Data collected in Pen Taluka in Maharashtra, for instance, show that rural vegetable growers get only 10 to 20 per cent of the retail price of vegetables in Bombay which is only 100 km away.40/ The technique can do nothing but reduce jobs in plantations unless the demand constraint is mitigated by a reduction in market prices with a simultaneous increase in the remuneration of the worker-grower. With these prerequisites it could also help in towns and cities where shortage of water sometimes hampers vegetable cultivation.

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37/ National Academy of Sciences, More Water for Arid Lands (Washington,D.C. 1974) p. 110.

39/ Economic Survey of India, quoted in Economic and Political Weekly, vol. VII, No. 31-33, Special Number 1972, p. 1453.

40/ Ajit Kondvidar, National Institute of Bank Management, personal communication, November 1978.

The use of solar dryers for paddy, fish, timber etc. is perhaps the mose commonly discussed example of the principle of channelling solar energy. These devices use natural convection and require no fans. They do require some investment as compared to the present methods of drying in the open sun, but it is claimed, probably with some justice, that the added cost is easily offset by the savings due to reduction of losses incurred by exposing the goods to the hazards of rats, the weather and so on.

Solar drying has not yet found wide acceptance, possibly, because the technique is new and unfamiliar. Some technical problems may also need to be ironed out since the dryer capacity and the drying chamber design must be tailored to the specific situation. The fact that an investment is required will inhibit the poorer people from adopting it, even if effective extension disseminates the knowledge, particularly because the job of drying fish or paddy is done primarily by women. Men are often more reluctant to make investments in areas that lighten the burden of women's work. Finally there is, once more, the question of priorities. New techniques such as solar dryers attract attention only when they are set in the context of the pressing problems such as jobs, wages, land, education, security etc. which people face. If not, techniques such as those discussed in this chapter will either find little acceptance or they will reinforce inequalities and underdevelopment.

IV. ENERGY AT HOME

The sun provides, via trees and crop residues, most, but not all, the energy that rural people and large proportions of town-dwellers use at home. Wood is far and away the most important fuel for cooking and heating. In most places it is used directly, but in many towns and even villages, for example in Thailand, it is converted to charcoal before use. Where wood is scarce, it is supplemented with crop residues (e.g. cotton sicks, bagasse, palm leaves, coconut shells), cattle dung, and in a few areas, coal. Kerosene is the most important lighting fuel for the poor; in the towns it is an important cooking fuel as well. We will deal in turn with the needs for cooking fuel and keeping warm, and then with lighting.

There are substantial regional variations in the use of fuel for cooking and heating. In India, the use amounts to an equivalent of about one **kilogramme** of wood per day, of which about two thirds is provided by wood

/and

and the rest by crop residues and cattle dung.41/ The pattern of use varies from one area to the next and depends on the availability of wood. This does not fulfil the needs of the poor for keeping warm, particularly as they cannot afford adequate clothing and bedding. A rough survey indicated the annual use of fuelwood in Nepal to be about 550 kg per person.42/ I have two sets of very different data for Thailand. A Thai Government publication43/ states the fuelwood consumption in 1976 to be 960,314 cubic metres and that of charcoal 180,079 cubic metres - that is a total fuelwood use of roughly 800,000 tons. This seems to be an underestimate by at least an order of magnitude since the vast majority of Thailand's 41 million people use fuelwood, either directly or as charcoal. Possibly the figures indicate the sales of these goods, rather than the amounts used. Openshaw's data, reportedly collected from the Thailand Public Work Department, show a total domestic fuelwood consumption (in 1970) of 44 million cubic metres44/ or about 27 million tons. This amounts to about 800 kg per person per year which seems to be on the high side. Perhaps, as in the hill areas of Nepal, a high rate of fuelwood use is associated more with the need for agricultural land than with the need for fuel (see below).

It is commonly assumed that fuelwood use is causing deforestation; some even go so far as to assume that it is the primary cause of deforestation.45/ This conclusion is based on superficial observation and faulty reasoning, however, a temporal correlation - that is, the simultaneous existence of fuelwood use and deforestation - does not establish causation. Causation can only be established by a careful study of the social process in which both fuelwood use and deforestation are taking place. So far as the author knows, no published energy studies have attempted this. Energy studies have presumed causation upon noting correlation, and that too usually out of the context of social and political processes. There are substantial indications that this is an erroneous conclusion.

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41/ National Council on Applied Economic Research (NCAER), Domestic Fuels in Rural India (New Delhi, 1965), table 8, p. 79.

42/ Nepal - The Energy Sector, Kathmandu, 1976, pp. 7-14.

43/ Thailand Energy Situation 1976, National Energy Administration, Bangkok, table 2.

44/ K. Openshaw, "Projections of wood use in Thailand", unpublished Report to the Public Works Department, Thailand, Midlothian, Great Britain, 1973, table A4-W4, p. 92.

45/ Eric Eckholm, The Other Energy Crisis: Firewood (Washington D.C., World-watch Institute, 1976).

The first thing to note is that, as a rule, the poor do not cut whole trees for fuel, much less clear entire areas. Most fuelwood consists of twigs and small branches. Moreover, a great deal of this does not come from the forests but rather from trees planted near people's homes, on field bunds, village common lands and roadsides. It is not possible at present, for lack of information, to establish over-all magnitudes of the fuelwood that comes from forests. In India, at any rate, this is likely to be much less than the total fuelwood use of 120 million tons or so, Measurements in a village in Karnataka made by the ASTRA team of the Indian Institute of Science[46/] indicate that fully 90 per cent of the fuelwood supply is in twigs and small branches.

Population growth also seems to be a relatively minor factor. The increase in deforestation has been sudden and faster than population growth. Moreover, people usually do not clear entire areas of forest because of fuelwood needs. The devastation of forests in many regions, where forests have been entirely or largely wiped out, clearly points to other causes.

Large scale commercial clear-cutting for timber and fuelwood by governments and private contractors is one of the causes. The timber and fuelwood business is very profitable for those who control the forests. Governments and contractors have so far been loath to give up even a small part of their immense profits to undertake sound reforestation of the areas they cut.

> "In six countries says the report /of the Asian Development Bank/ - Afghanistan, Bangladesh, Sabah (sic), Pakistan, Thailand and the Philippines - it appears that this annual increment of commercial species is being overcut.
>
> "The fastest rates of growth in production since 1960 have been in Malaysia, particularly Sabah (600 per cent), Indonesia (400 per cent) and the Philippines (100 per cent). This growth is directly related to the rapid development of the Japanese market for imported logs."[47/]

Politics also plays a considerable role in deforestation. Destruction of the forests in Viet Nam was a deliberate aim of United States policy. Earlier, in Malaysia, it was equally a deliberate policy of the British to deprive the Malaysian Races Liberation Front of their sources

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46/ A.K.N. Reddy, Convenor, Application of Science and Technology to Rural Areas, Indian Institute of Science, personal communication, November 1978. Prof. Reddy has kindly given me some preliminary information on the ASTRA programme findings whose data have not yet been compiled.

47/ Daniel Nelson, "Asia must plant more trees", Financial Times, April 1979.

of food. The people were herded into large hamlets under military control as part of what was known as "operation starvation".

Such destruction has also been a feature of many of the struggles within the ESCAP region after the colonialists left. In these wars, mostly between post-colonial governments and tribal peoples in vast parts of the ESCAP region, deliberate destruction of forests has been one of the principal aims of napalming and bombing. Simultaneously, land was made into a commodity in many of these areas. Monetization of land and agriculture is thoroughly incompatible with the shifting cultivation which tribal peoples have practised for centuries. While this is not the place to discuss the political merits of the various positions involved, no discussion of deforestation can ignore the fact that these practices of many governments have been among the fundamental causes of deforestation in many parts of the ESCAP region.

Other kinds of "war efforts" have caused deforestation. In India, the British drastically accelerated deforestation by reckless contracting out of forest lands during the World Wars, and by encouraging the use of wood instead of coal. They also distributed forest lands that had been cleared by contractors to intermediaries or cultivators in order to increase food production, intended primarily for export. Similarly after the 1962 India-China war, the Government of India encouraged cultivation of forest land.

Long before that the British had destroyed the economy of rural artisans and craftsmen of the Indian sub-continent.[48/] By the latter half of the nineteenth century this process caused one famine every two years according to one source.[49/] The impoverished artisans and craftsmen were forced, for the most part, to look for a living by agricultural labour. The demands of agricultural workers and poor peasants for land have, for the most part, not been met even after Independence. Where they have organized and rebelled, governments instead of redistributing land, have sometimes handed out grazing and forest land to some of the people. Land is a primary need of millions of the poor and if governments cannot find the resolution to redistribute it where there are great inequalities, ecologically sound policy, the needs of the poor and political expendiency will be at odds and none of the problems satisfactorily addressed.

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48/ R. Mukherjee, The Rise and Fall of the East India Company, (New York, Monthly Review Press, 1974), Chapter 5.

49/ B. Mishra, Famines in India, Chapters 1 and 2.

There are some places where deforestation appears more closely related to fuelwood use. But even here the first or even second impressions are misleading. As an example a preliminary analysis is given below of the findings of Deepak Bajracharya who lived for more than one year in a village called Pangma in Nepal trying to understand the problems of the people and the place of energy problems in that context.50/

Notes on Pangma village, Nepal

Pangma is a village of 3,700 people in the hills of eastern Nepal. Most of its 1,420 hectares of land are used for agriculture - paddy on the terraced fields, and coarse grains on the hill slopes that have been freshly cleared for forest and not yet terraced. Pangma also has 100 hectares or so of grazing land and about 200 hectares of forest. There is a larger but more inaccessible area of forest outside the village boundary. The terrain is difficult and there are no roads, only foot trails. Within Pangma the elevation varies between 600 and 2000 metres above sea level.

Many communities live in Pangma - Rais, Gurungs, Sherpas, Chhetris etc. Most of these groups (except Brahmins and Chhetris) retain the communal closeness that characterizes tribal societies. They are (generally) endogamous. They also retain many tribal customs and rituals. Each community has one or more hamlets in the village. Almost all of the 600 families have some land and cultivate it. Most families hold between 1/2 and $2\frac{1}{2}$ hectares of land. These are not large differences, but the inequalities have been increasing particularly during the last 15 years. The inequalities in income are much larger than the inequalities in land holdings. About 20 per cent of the families (among whom the Sherpas figure in disproportionately large numbers) are very poor and regularly do not have enough to eat.

Besides agriculture, a few families weave cloth (Rais) some work wool (Gurungs), some work as porters (mainly for shopkeepers and tourists). There are 15 shopkeepers and about 25 teachers, clerks etc. A few men among the Gurungs and Rais are still recruited for military service by the British and Indian armies. There are also a few artisans, particularly blacksmiths.

/Wood

50/ I stress that this is a preliminary analysis of part of an enormous body of information which Bajracharya was kind enough to share with me, and with which he he is now preparing a Ph.D. dissertation to be submitted to the Science Policy Research Unit, University of Sussex, Brighton, England. He is not responsible for the opinions expressed here and may or may not agree with them..

Wood serves for cooking and heating and kerosene for lighting. Poor families use wood fires to supplement expensive kerosene as a source of light. Cattle dung is used as manure. Cattle and human work provide the power for agriculture and human work for transport (there are no bullock-cartable roads). Pangma, like almost all hill villages in Nepal, has no electricity. Wood is fetched primarily from the village forest. In the months before the rainy season, the men join the women in wood gathering, for the people must stock up dry wood for the busy rainy season.

The people of Pangma use large quantities of fuelwood - about $1\frac{1}{2}$ tons per person per year - or about 5,500 tons per year for the whole village. The per capita use of fuel depends more on family size (higher for smaller families) and on altitude (higher for higher altitudes) than on factors such as income because wood is not a commercialised commodity in Pangma (in contrast to the Kathmandu valley). The rate of fuelwood use is apparently much higher than the average use of about 800 kilogrammes per person per year in the hill regions of Nepal.[51/] Though this latter figure is based on a very rough survey and a biased sample, the difference is large enough to require explanation.

Most people in Pangma use open stoves for cooking and heating. To keep warm in the winter they sleep around the fire and quite close to it which sometimes causes accidents. Technically, this is an inefficient way to burn fuel. The problem, therefore, seems to be quite straightforward. The energy data would seem to confirm the prognosis of the Malthusian energy literati that population growth (about 2 per cent per year in rural Nepal) and inefficient use of fuelwood are the principal causes of the deforestation that is taking place in Pangma (and elsewhere). Such a conclusion provides automatic reinforcement of the prejudice of the elite that the poor know neither efficient techniques nor how many children to have, nor how to tend the forests. A deeper and more empathetic look at the problems of the people reveals these views to be quite superficial and incorrect.

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51/ Nepal - The Energy Sector, op. cit.

To take the "technical" problem first. The chulo which is a more efficient cooking stove than an open fire, is used by the Brahmins in Pangma. The Brahmins (who use the open fire only for heating) and the other communities have lived together and learned from each other for many generations. Yet the other communities have not adopted the chulo and continue to use an open fire both for cooking and heating. It is immediately evident that, so far as cooking is concerned, the problem is not one of ignorance of more efficient technique. They know the technique but do not use it.

The people who do not use chulos believe that the open fires contain the pitri devata which can be roughly translated as the "family spirit". There is a special, and fixed, place in the house for this fire and, besides being the hearth, it is the spot where sacrifices are made during religious festivals.

Such religious and social customs are usually transformed under pressure of economic necessity. For example, in England where burial is becoming more and more expensive, many people now cremate the dead, but many others are willing to make considerable economic sacrifices to bury theirs. In Pangma, however, economic necessity works in quite the contrary direction. It appears, on the basis of a preliminary analysis of the data, that one of the reasons for the high fuelwood use in Pangma is because people need land for agriculture.

A number of factors have caused this need to grow suddenly during the last fifteen years or so. First there was the "land reform" of 1964 which abolished the traditional system of land tenure (the Kipattiya system). As a result many people lost control over much of their land. Land settlements were made by bureaucrats even before a survey had been done, and the land was made into a commodity.

At about the same time, soldiers recruited by the British (primarily Rais and Gurungs) in large numbers in the early 1950s began to return. Some brought back considerable amounts of money (by local standards) while others had been robbed or tricked out of theirs on the way home. Many returned

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to find their families in debt.[52/] Much money went to pay off the loans (interest rates run to about 10 per cent per month) and sometimes land had to be sold. Thus many of the Rai families who owned forest land began to clear it for cultivation. Some ex-soldiers bought land from others who were in debt.

Additional pressure on the land has been created by the almost total destruction of the local cottage textile industry and cotton growing by thread and cloth imported from India. Fifteen to twenty years ago, making thread and cloth occupied at least one person in every Rai family for $3\frac{1}{2}$ to 4 months. Cotton was grown on some marginal lands in Pangma, but was mostly brought from nearby Tumlingtar. The loss of this source of income and increasing monetization of the economy left many Rais with no option but to clear some more forest. They have somehow to earn enough money to buy such necessities as salt, kerosene, spices and cloth.

Bringing more land under cultivation created the need for more draft animals and hence the need for more grazing land. Probably, increasing monetization of the economy and growing inequalities further increase pressure on the poor families, often in debt, to sell off their land.

The base of the economy has, during the last two decades, narrowed down to one activity - agriculture. The poverty of those who have little or no land - many Sherpa families, for example - is worsening. Unemployment has increased and many young people migrate out of the area and the country into India, particularly Assam, in search of jobs.

Even this rough sketch shows the great complexity of the fuelwood problem which has technical, economic, social, ritual and ecological aspects. It is not a problem amenable to legalistic solutions such as passing laws which prohibit or limit cutting. The bureaucracy would multiply and apply legal and illegal sanctions quite arbitrarily and the principal result would be an increase in corruption. There is considerable experience of this in India, particularly in tribal areas.

The people of Pangma need more employment both on and off the land. Agriculture needs to be improved and intensified. There is a great deal of room for this, for local inequalities are not yet so great as to obviate a change of direction. The hill areas of Nepal have plenty of water and

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52/ In those days there was no way for soldiers to remit money home while they were abroad.

an enormous potential for microhydro projects to pump it. Hydraulic energy need not be converted to electricity. It can be transmitted by wire rope for distances up to almost one kilometre. The Amish people of Pennsylvania have been using this technique together with wooden water wheels for a long time.53/

Within such a context of an improving economy and decreasing inequalities with innovation suited to local conditions and amenable to local control (in contrast say, to the package microhydroelectric plants which Nepal reportedly plans to import from Europe at $US 3,500/KW), it is conceivable, and even likely, that people would begin to use chulas for cooking and perhaps even more efficient devices (such as the Kang stoves of China or the Republic of Korea) for heating. In such a case 200 hectares of forest land, planted with suitable varieties of trees, could meet at least the present level of cooking and heating needs, if not more. However, the present direction of increasing inequalities and deteriorating economy is quite the contrary of what is needed.

To return to the more general problem of cooking and heating fuel, the efficiency of the traditional stoves (chulos in Nepal, Chula or sigri in India, Pakistan and Bangladesh) is, technically speaking, quite low. It is about 1 per cent or so for boiling water or cooking rice and about 2 per cent to 3 per cent for baking.54/ The efficiency of the Kang stove used in the Republic of Korea and China is probably higher since the waste heat from cooking is used for heating.

Increasing the efficiency of cooking and heating (by the use of waste heat) by better stove design seems possible because the usual constraint, that traditional ways require mostly labour power which the poor have and efficient ways require money which they do not have (as for example in the case of solar dryers or electric lights), is not as severe in cooking stoves. In India many have designed more efficient stoves using local materials and traditional techniques but these have made no headway. I suspect that lack of effective extension or higher first cost are not fundamental causes of this failure (as illustrated in detail by the Pangma case study above).

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53/ Volunteers in Technical Assistance, Village Technology Handbook (Mt. Rainier, Maryland, 1973), pp. 117-122.

54/ These efficiencies have been estimated using the second law of thermodynamics.

The fact that women collect the wood and cook and face the smokey fire from the traditional stove may have more to do with the failure. Rural women have little contact with the world of men outside the village; nor do they have much say in how the household income is spent. Effective extension is difficult under these circumstances. Perhaps extension would be more fruitful among users of fuelwood in towns and cities.

There is some evidence that there are technical flaws in the design of the "improved" stove - "smokeless chula"55/ that has been offered as an alternative to the traditional ones. According to A.K.N. Reddy,56/ preliminary results of test conducted by the ASTRA team of the Indian Institute of Science indicate that there are two objections to the present design of the "smokeless chula". First, it is not more efficient than a one burner traditional chula. The efficiency of the smokeless chula is substantially greater only when there are two or more burners, since the "waste heat" from the first burner is used to cook or to heat water. Hence some rethinking regarding stove design appears necessary. It also seems that the smoke from traditional stoves keeps straw roofs free of pests, which, if true, would render the present design unsuitable for a majority of rural people.

Besides improving the efficiency of traditional stoves, there are other ways of reducing the use of fuelwood for cooking. However, numerous problems must be solved before they can be of much use. Present designs of solar cookers are either very costly, or require cooking outdoors, or both. All designs cost much more than the traditional chula. Daytime cooking also interferes with other work. Unless new techniques are invented which meet the requirements of very low cost and indoor cooking at convenient times, the prospects for widespread use of solar cooking are not promising.

Biogas is another possible substitute for fuelwood. In China, the use of biogas for cooking has increased dramatically in the last few years to the point that about 7 million household biogas plants are now reportedly in operation.57/ In the rest of the ESCAP region, the use of

/biogas

55/ In this stove, the wood burner is at one end; the hot gases pass under two or more "burners" where cooking and water heating are done before going out of the chimney. See Hyderabad Engineering Research Laboratories, "Smokeless 'Herl' Chula" (Hyderabad, Government Press, 1956).

56/ A.K.N. Reddy, op. cit.

57/ Committee on Natural Resources, "Draft report of the Committee on Natural Resources on its fifth session" (Bangkok, Economic and Social Commission for Asia and the Pacific, 6 November 1978), p. 19.

biogas is still quite limited, there being about 100,000 household plants principally in India and the Republic of Korea. It is not an easy matter to sort out the causes of the failure of the biogas programme to take hold in most countries and of the sudden success in China. It is evidently bound up with the social, political and economic upheavals which have taken place in China almost continuously since the beginning of this century and more particularly with those of the past two decades. Among the principal immediate reasons seem to be:58/

(a) A cheap design, which uses family labour and mostly local materials; 59/

(b) Cheap stoves and lamps;

(c) The great amount of work it takes to gather fuelwood;60/

(d) Effective extension and local organizations that reach everyone. There are vast numbers of trained technicians (over 100,000 in Szechwan alone);

(e) Pigs owned by every family (pig manure is especially good for biogas plants).

These immediate reasons for the rapid success are intimately related to social factors such as the struggle for women's rights both at home and at work, the local control of the innovation process, relatively equitable distribution of society's resources and so on. Perhaps, the traditions of careful husbanding of manurial resources and vegetable gardening have also been a strong factor.

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58/ Vaclav Smil, "Intermediate technology in China", World Development, vol. 4, Nos. 10/11, 1976, pp. 933-934.

59/ The cost exclusive of labour, and possibly of the extension services and technical training, is reportedly 40 yuan - roughtly equivalent to 200 Indian rupees or 400 (Thai) baht. If a cost is imputed to the family labour, though it is not clear whether it is correct to do so in the Chinese context, the total cost may be substantially higher and more comparable to the costs of plants in, say, the Republic of Korea and Thailand, but still much less than that in India.

60/ I have not come across any quantitative data on this for China. In India, my own limited observation is that, in wood-scarce areas, about one person-day per family per day is needed to gather wood; more usually it is one person-day every three to five days.

Many of these conditions do not obtain in other countries of the region. In the developing countries where the economic prospects of the poor are stagnant or declining, the creation of a social atmosphere where people experiment with new techniques and take them up if they work is difficult. Indeed, most dominant social forces work in quite the contrary direction. S.K. Subramaniam, who did a survey of biogas plants in Asia, excluding the socialist countries, concluded as follows:

> "The general picture seems reasonably clear - although it may vary a little between different countries in the region. Essentially, it has been the richer strata of rural society who have installed bio-gas plants. A host of factors hav- made it difficult, unattractive or impossible for relatively poor people to use bio-gas plants". 61/

Note that in spite of the great differences in climatic and geographical factors, average incomes, costs of biogas plants (varying from $US75 to $600 for family size plants) and the types of extension methods used in non-socialist Asia, there is hardly any difference in the stark central fact - the beneficiaries are almost exclusively from "the richer strata". But even among the rich the success has been meagre. Indeed in many places, the rate of abandonment of biogas plants is very high. In the Republic or Korea, only "about 30 per cent of the installed digestors are stated to be in use". 62/ In Pakistan too, "a very large portion" of the plants were "shut down", according to Ghulam Kibria, who feels that the subsidies given by the government were largely responsible for the failure. 63/ But S.K. Subramaniam observed that when the government of the Republic of Korea discontinued its subsidies, this "drastically affected the further installation programme. In the very year of removal of subsidy (1974), not even a single plant was constructed". 64/

/Outside

61/ S.K. Subramaniam, Biogas System in Asia (New Delhi, Management Development Institute, 1977), pp. 88-89.

62/ Ibid., p. 100.

63/ Ghulam Kibria, "Progress of biogas technology in Pakistan" (Bangkok, Economic and Social Commission for Asia and the Pacific (ESCAP), May 1978)(mimeo.).

64/ S.K. Subramaniam, op. cit., p. 116.

Outside the socialist countries, therefore, a large number of biogas plants have been abandoned. Even the most ambitious biogas programme - that announced by the Indian Government - has a small over-all target of 100,000 family size plants. This is an implicit recognition that even the rural rich are not interested in the programme though it is heavily subsidized, for the number of their families is at least an order of magnitude greater. So far as the vast majority of rural people are concerned they do not own the 4 to 5 cattle needed for a household plant. The programme is hardly of interest to them, except that it may deprive them of cow dung.

A number of reasons, usually technical, are cited for the marked lack of success of these various biogas programmes. There are no doubt a number of technical problems. For example, the Indian Khadi and Village Industries design, which uses a steel gas holder, is very costly (about 3,000 rupees for a plant rated at 3 metric metres of biogas per day) and does not produce anywhere near the rated capacity in the winter. Sharp fall in winter gas production is, in fact, a common problem. The required capacities have to be much larger than average fuel use. Many of these problems can, no doubt be sorted out. The Pakistan Government has, for example, been experimenting with the cheaper Chinese design, and a number of other governments, including the Indian, are also beginning to do so. Reduced cost cannot, however, solve the problem of ownership of cattle. Neither can it solve the problem of extension. Extension in rural areas is only strong in "green revolution" areas and there it is addressed to the rural rich. Significantly, the biogas programme has been modestly successful in reaching the rich only in such areas - as for example in Haryana and the sugar belt in western Maharashtra.

It is sometimes suggested that forming co-operatives may solve the problem of extension.[65/] This can only happen where serious local conflict over basic issues such as land and wages is absent. If co-operatives have been instruments in China's successful biogas programme, as Kibria notes, then it is because these issues have long before been solved. Where they have not, co-operatives either do not function or reach only a small minority.

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65/ For example, see Ghulam Kibria, op. cit.

The problem of the high cost of biogas can possibly be more easily resolved with the use of community biogas plants. It would also be cheaper (per unit of biogas) to install a heating system to solve the problem of low winter gas production.66/ The question of equity will be more vexing. In places where there are conflicts over basic issues, or where social and economic inequalities are great, it is doubtful that such plants could be operated and maintained at all. More likely, they would either be monopolized by the rich, or rust and rot as much of the equipment in similar efforts does today. In fact, where economic exploitation or other forms of social oppression, such as untouchability, exist, how can the question of a "community" gas plant arise at all? "Community" implies a harmony of interest. This does not exist, and could not exist, where the oppressed live under constant threat of violence, threats which are real and are frequently carried out. Examples are rife in the history of the ESCAP region: Indonesia in 1965; Marathwada (a region of Maharashtra) in 1978. While the scale of violence in Marathwada 1978 or Indonesia 1965 was unusual, its intencity was not; and the threat is ever present. So long as it is, harmony cannot be created by building a large gas plant and labelling it a "community" plant. If it is to benefit the oppressed, then they must control it, and take the decision to build it and use it in the context of their own priorities. Where a harmony of interest already exists, it should be possible to implement a programme of building community biogas plants with a reasonable expectation of success.

Community biogas plants may also have some application for institutional uses (dormitories, government institutions etc.), or as neighbourhood plants for towns and cities. Such plants can be built in dairies, piggeries, poultry farms etc. and some pilot units are in operation in the region (Maya farms plant in the Philippines, and the Kaoturha Grass Krishi Kendra plant in Indore, India).67/ Since much or most of the garbage in towns is wet garbage (food wastes), it may also be possible to use treated garbage to generate gas in neighbourhood plants in towns. I do not know of any experiments or evaluation of such a possibility so I cannot comment on its feasibility. In any case, in towns where the raw materials are available, or can be made available, neighbourhood biogas plants to provide fuel for cooking, and perhaps for small industry, are of considerable interest, since they would be a substitute for expensive wood or kerosene.

/Keeping

66/ The ESCAP Committee on Natural Resources reports that community biogas plants have recently been built in China and are being used. (See Committee on Natural Resources, op. cit.) There are also a number of experimental projects in many parts of the region. See Subramaniam, op. cit. chapter II.

67/ Subramaniam, op. cit. p. 18 and pp. 33-36.

Keeping warm is more a matter of adequate clothing, bedding and housing in much of the ESCAP region, except in mountainous areas and the northern latitudes. It is primarily poverty that prevents satisfaction of this need, as can be judged from the fact that in most of the region even the rich do not use heating systems. On the contrary, it is the poor who, ill-housed and poorly clad, need fuel for heating, while the rich (with warmer clothes and housing) can get by with none at all. In the mountainous and northern regions the <u>kang</u> stove (called <u>ondol</u> in the Republic of Korea) seems to be the most efficient among the traditional techniques and can perhaps be adapted by people in other cold areas.

The Office of Rural Development of the Republic of Korea is considering the possible adaptation of the <u>ondol</u> system to run off biogas.[68]

Passive heating and cooling systems can channel the sun's energy to meet the need for keeping warm. Essentially, they change the rhythm with which the sun's heat reaches the interior and with which the house reradiates heat. Traditional construction in some places (e.g. Iran) uses this principle. The wonderful houses in the tribal areas of Midnapur district of West Bengal are built with mud, bamboo, straw and gravel in a way that automatically regulates interior temperature. But in recent years the availability of bamboo for house construction has declined. (The reasons are probably as complicated as those for deforestation.) The bamboo serves as reinforcement and, according to Laurie Baker,[69] when enough of it is not used, the houses become prone to collapse. People have begun using bricks and mortar when they can afford it. Possibly, the example of the rich in the village, who adopt the ways of the city as a matter of status, also does damage to the local skills and positive aspects of local traditions.

There will be one adverse effect of reducing the use of fuelwood if specific steps are not taken to prevent it. Though wood is referred to as "non-commercial" energy source, a large proportion of fuelwood use is, in fact part of the monetary sector. Almost all fuelwood is a commercial commodity in the Kathmandu valley, for instance. This is also true of many towns and cities all over the ESCAP region. According to a survey of the National Council for Applied Economic Research, 23 per cent of the fuelwood

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68/ <u>Ibid</u>, p. 26.

69/ Laurie Baker, <u>Lecture at All India Convention of People's Science Movements</u> (Trivandrum, 10-12 November 1978).

used in India was monetized in 1962.70/ The figure is probably slightly higher today. Most of this wood is gathered by poor people who carry headloads of it to the towns or large villages. (In addition, some wood is also taken by contractors and governments to the cities for sale in trucks.) One person can collect and sell between 10 and 25 kilogrammes of wood a day. This means that collecting and selling fuelwood is a primary occupation for somewhere between 5 and 10 million people in India who are among the poorest and most oppressed people in the country. A substantial reduction in the use of commercial fuelwood would hit them hard, and perhaps even create other undesirable effects such as a reduction in agricultural wages. Reforestation and other public works programmes which pay an adequate minimum and regular wage must be implemented on a wide scale simultaneously with programmes to increase the efficiency of fuelwood use, if these adverse effects are to be avoided. The question of implementing such public works schemes is, however, problematic.71/

Apart from large scale reforestation schemes, the possibility of increasing fuelwood supply by planting village wood lots has also been mooted although this seems, in most cases, a dubious proportion.72/ There is little unused land near villages and what is often termed "waste land" is generally used for grazing which is essential for agricultural operations. In fact, in many places, forest is cleared for want of agricultural and grazing land, so that no scheme to reestablish a wood on such land might be acceptable. However, it is possible that cultivation of fodder crops such as alfalfa and clover would reduce the need for grazing land, so that some of it could become available for wood lots. Since this requires the monetization of local fodder production and since the rich own most of the cattle, such a scheme would face and give rise to essentially the same problems as use of high yielding seeds discussed earlier. Further, wood lots would be established on common land. Where there are strong social and economic inequalities, such a scheme cannot succeed. Even guarding the seedlings and mature trees would become enormously expensive. One can see,

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70/ NCAER, ibid., table 12, p. 82.

71/ See Alamgir, "Programmes of environmental improvement at the community level: Bangladesh, Indonesia and the Republic of Korea" (Bangkok, ESCAP, 1979). This is another background paper for the UNEP/ESCAP Regional Seminar on Environment and Development.

72/ Arjun Makhijani, "Energy policy for the rural third world", (International Institute for Environment and Development, September 1976), pp. 33-39.

often enough, luxuriant private forest adjacent to bare public lands. It is not that no land is available for planting trees. There are few places like Kerala where every bit of land is carefully husbanded, and a close look at a village's resources often reveals many spots for tree planting and other uses. But creating a tradition of fine husbandry is a very complicated matter; certainly it cannot be done by making speeches, planting some trees on ceremonial occasions, by making saplings available to villagers, or even by having them planted.

This is a rather bleak picture. But people can organize to save and regenerate their forests. We may give two examples from India of such movements, both of which have long roots in history.

The Chipko movement[73/] in India began in 1920s with the people's struggle for forest rights "which culminated in May 1930 at Tiladi in erst while Tehri when 16 persons died in military firing. Throughout Uttarkhand (a region of Uttar Pradesh, in India) today, Tiladi is a symbol of what people are prepared to face".[74/] The movement was revived about seven years ago in order to resist the continuing devastation of Himalayan forests, particularly in the Alaknanda catchment area. It has made some gains in resisting green felling, but are far from complete success. The struggle to prevent green felling and to implement a forestry programme oriented to meeting people's needs continues. The following is the programme of the movement:

> "(1) Stop all green fellings in the hills. Manage hill forests as protection forest (not commercial forests as today); (2) Mass plantation with priority to (i) food (nuts, oilseeds, fruit trees), (ii) fodder (even in conifer areas for mixed forests), (iii) fuel, (iv) fertilizers, (v) fibre and (3) the whole programme should be chalked out and implementation entrusted to the people".[75/]

While the people of Uttarkhand are "sticking to their trees" to save them from the axe, the people of Jharkhand are axing some of the government planted teak (sag) tree monoculture in order to save their sal forests:

/"Teak

73/ The word chipko is the imperative of the Hindustani verb "chipakna", which means to stick to (something). The movement is called chipko because people "stick" themselves to the trees to prevent them from being cut.

74/ Sumi Krishna Chauhan, "Forest people's rights axed", Hindustan Times, 16 April 1979.

75/ Letter of Sunderlal Bahuguna to the Indian Council of Agricultural Research, described in "Patel assails UP forest policy", Hindustan Times, 28 January 1979.

"Teak wood has destroyed our life, so we must destroy teak", say the Adivasis simply. Their reasoning is simple: other trees like "sal" and "mohua" which yield them a vast variety of produce have been cut down to make room for teak which also does not allow anything to grow under it. The (Bihar) forest department has also deprived them of other rights, like picking "datuns" (to clean teeth) and gathering grass. Except during the brief harvesting period, the tribals depend on the forest for their sustenance; they even worship "sal". And, as Mora Munda, a proud lynx-eyed tribal leadman adds: "When the rain washes off "sagwan" (teak) plantations, it turns yellow (he implies it is polluted). With half the jungle cutdown in some areas to grow "sagwan", elephants and other wild animals maraud our fields.

"In protest, the Adivasis have started felling teak trees in five blocks which has forced the Bihar Government to post CRP /Central Reserve Police/ units in the troubled areas. Inevitably, there have been violent clashes, with the tribals at the receiving end".76/

These movements are examples of what I consider "appropriate actual projects" in the context of which human needs can be met in an ecologically sound way - if the efforts of the people who are struggling to reestablish some control over their forests are successful.77/

Kerosene is the principal lighting fuel in South Asia. Most people use small wick lamps; those who can afford it use hurricane lanterns and mantle lamps (the last particularly in towns and cities). Deepak Bajracharya's data (referred to earlier) shows that one litre of kerosene provides about 70 hours of rather dim light. In Pangma, the average use is about 1.5 litres per month per family and varies between a minimum of 0.8 litres and 3.2 litres. This is approximately equal to an average of 3 litres per person per year. In India, where kerosene is much less expensive78/ the use is about 4.5 litres per person per year;79/ in the Republic of Korea it is about the same.80/ If Bajracharya's figures are typical of Nepal, and the data

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76/ Darryl D'Monte, "Bihar Adivasis determined to recover land", Times of India, 6 March 1979, p. 1 and p. 5.

77/ There are also examples from other countries of villages managing self-sustaining forest plantations e.g. the village fuelwood plantations of the Republic of Korea and the "forest villages" of Thailand.

78/ The cost of kerosene in the hill areas of Nepal is very high (6 1/2 Nepali rupees per litre) because of the high cost of transport. In India, it costs about 1 1/2 Indian rupees per litre, or about Rs 2 Nepali.

79/ NCEAR, op. cit., table 8, p. 78 and table 15, p. 88.

80/ Subramaniam, op. cit., p. 22.

from other countries indicate that they are, then use of kerosene for lighting constitutes about one third of Nepal's entire oil consumption; for India the figure is about 7 per cent; for the Republic of Korea about 1 per cent. Hence, in the poorer countries, kerosene for lighting is one of the largest uses of oil, and an important item in the household budget of the poor.

Wich lamps are an inefficient source of light, with an efficiency of roughly 1/4 lumen per thermal watt; mantle lamps are about 5 times and electric incandescent lamps are 10 to 20 times more efficient.81/ Fluorescent lamps are about 5 times as efficient as incandescent lamps. These vast differences of efficiency mean that the poor get very little light for their money. Those who use electricity, that is the relatively well-off, get a much better bargain, lumen for lumen. The poor pay more for their light because they cannot afford mantle lamps or an electricity connexion; so they try to get by with a small wick lamp or two because it is the only thing which does not demand that they spend a large amount of money at once.82/

It is possible to increase the efficiency of lighting and to conserve oil and foreign exchange by providing everyone with an electric connexion for lighting. This seems socially and individually economical.

Most of the cost of an electric connexion is due to the cost of the meter. This can be dispensed with when the only requirement is a couple of points for lights. It is cheaper and equally effective to base rates on the number of bulbs or electrified rooms. This was the rate method during the 1930s of the Tennessee Valley Authority when it embarked on its ambitious and successful rural electrification programme.83/ Forty watts or so of lighting, for example would provide much better lighting than the poor have now.

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81/ Efficient Use of Energy, Report of the Summer Study on Technical Aspects of Energy Utilization, American Physical Society, Janua8y 1975, table 3.4.

82/ This is not the only instance where the poor get a bad bargain because of their poverty. We have already seen this in the case of keeping warm where the poor are compelled to use fuel and the relatively well-off can get by with warm clothes. This is also true for those who buy fuelwood for cooking. In India fuelwood costs a minimum of Rs 200 up to Rs 400 per family per year, while cooking with liquified petroleum gas (LPG) costs about Rs 200 per year. The catch is that LPG is available only in the cities, to those who know the procedures and can lay out Rs 400 as deposit, etc. The scarce, cheap fuels go to the wealthy, according to this law of this market.

83/ Jim Cudworth, Chief, Rate Branch, Tennessee Valley Authority, Chattanooga, Tennessee, personal communication, August 1978.

The costs in India per rural house (with a thatched roof) are about as follows:

		Rupees	($US)
1)	30 watts of generating capacity, transmission and distribution84/	120	(15.0)
2)	1 square metre tiles for the roof	20	(2.5)
3)	Wiring to and in the house	150	(18.8)
	Total investment	290	(36.3)

The fuel cost is about Rs 0.10 per kWhe (including transmission and distribution losses). The monthly household use of electricity would be about 5 kWhe,85/ so that a monthly charge of Rs 3 per house which requires 40 watts or so would cover all the costs of electrification, including 7 per cent on capital and 3 per cent depreciation. This is approximately equal to the current expenditure on kerosene for lighting and is considerably better than the heavy subsidies to the rural rich electricity consumers, which characterize today's rural electrification programmes. All that is required is that connexion charges be abolished and internal and external wiring be provided.

The over-all investment required for the 100 million or so houses now using kerosene for lighting in India would be around Rs 30 billion. This is no doubt a large sum. But the over-all investment required to find, produce, refine and transport kerosene is also very large. In the United States, the capital costs of producing, refining and transporting oil amount to $US 12,000 to $US 16,000 (in 1970 dollars) per barrel per day capacity.86/ In today's dollars this would amount to $US 25,000 to $US 30,000. These figures which exclude the costs or exploration, are high, the more so in countries without the capacity to undertake such exploration (and often, production) since large premiums and royalties must be paid to multinational

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84/ I have used a diversity factor of 3/4. The diversity may be greater since much or most of the load on rural electrification systems is from irrigation and rural industries which are primarily day time loads. The cost of rural electrification excluding the connexion and meter is about Rs 4,000/kw.

85/ Fluorescent lamps will probably not be suitable for rural lighting because of severe voltage fluctuations in the supply. I have assumed an average use of 4 hours per day.

86/ J. Hass et al., Financing the Energy Industry (Cambridge, Massachusetts, Ballinger Publishing Co., 1974), chapter 3.

corporations for these activities. The costs of transporting kerosene in small amounts to rural areas are also likely to be considerably higher than the pipeline transport of the United States. If seems reasonable to take a total capital cost therefore of about $US 50,000 per barrel per day capacity for all phases of the programme. Thus producing capital cost of Rs 18 billion can be imputed to the 45,000 barrels per day of kerosene that are consumed for lighting in India. The added capital cost in a programme phased over 10 years would be only Rs 2.20 per person per year, or less than 1 per cent of the development outlay of the government. This is surely not a large sum considering that everyone would be provided with light.

The over-all increase in the use of electricity in India, were lighting to be provided to everyone, would be 6,000 million kWhe, or only about 7 per cent of the expansion in generation planned over the next six or seven years. Note that the over-all energy use with electric lighting (6,000 million kWhe) is equivalent to 8o to 90 quadrillion Joules of fuel per year, a substantial reduction over the present kerosene use for lighting of about 120 quadrillion Joules per year. It seems to be a scheme that could be implemented even with many of the institutional and social constraints which would hamper other energy projects. As such it merits serious consideration.

V. ENERGY FOR OTHER USES: OIL, NATURAL GAS AND BIOGAS

Finding substitutes for oil has been one of the principal motives in the search for "alternative energy sources". The very expression "alternative energy sources" betrays this motive. But alternative to what? Since wood is already one of the principal fuels today and solar energy is a prime source, via wood, crops, crop residues and grazing land, "alternate" can only be to fossil fuels, particularly oil. This is a rather distorted and narrow view, mainly suited to those who are now using enormous quantities of oil and want to save it for themselves. For developing countries, it is, or should be, a secondary consideration that derives from broader policy issues such as those we have illustrated in the cases of the use of kerosene and electricity for lighting, and the use of biogas and diesel in agricultural operations.

/The

The world is not about to run out of oil - a thesis eminently illustrated by the "discovery" of significant quantities of oil in many countries in the last five years and rather enormous quantities in some, notably Mexico and China. Besides, there are a number of resources such as oil from shale and coal, and in part, natural gas and biogas, which are direct substitutes for oil. It is certainly desirable to moderate the use of resources and we have already stressed this. However, given the great inequalities in their use, this is a message primarily for the immoderate, and a philosophy that could be adopted by the oppressed in their struggle for a greater share and control over the world's resources. Whether this means the use of greater or smaller quantities of oil or any other resources will depend on the specifics of the situation. It may be necessary, for example, to build more fertilizer factories while embarking on biogas and organic fertilizer programmes; to use more oil for buses and trains while coverting others to cleaner and cheaper sources of fuel, and indeed changing the entire way we think about transportation systems.

Large scale transportation[87/] is a particularly difficult area of energy policy in most countries of the ESCAP region because of the almost exclusive use of oil (apart from some use of coal in railways). Given the current substantial requirements for kerosene for cooking and lighting, the pressure on the middle distillates (diesel and kerosene) is very great. Simultaneously, natural gas is flared in large, even enormous, quantities in many countries of the region.

Natural gas, and hence methane obtained by purifying biogas, can substitute for petrol or diesel in transportation. Such a scheme could help conserve a vital natural resource, and help a good deal in easing foreign exchange constraints in countries such as Bangladesh and Pakistan which have proven natural gas reserves in large amounts compared to present petroleum use, but no proven crude oil reserves as yet. Bangladesh for instance has natural gas reserves of about 300 billion cubic metres[88/] which is about 300 times the annual imports of petroleum in 1975.[89/] Current use of natural gas, however, is very small - less than one billion cubic metres in 1975.[90/]

/Natural

87/ I exclude such modes of transport as bullock carts, bicycles, walking and so on.

88/ E.B. Roth, "New uses of natural gas in Pakistan and Bangladesh", unpublished manuscript.

89/ World Energy Supplies 1971-1975, United Nations, Series J, No. 20, New York 1977, table 6, p. 67.

90/ World Energy Supplies, ibid., table 15, p. 152.

Natural gas compressed to about 200 kg/cm^2 is used for fleets of trucks and taxis in many parts of the world. The refuelling is accomplished either by replacement of the high pressure cylinders, which takes a few minutes, or by refilling the cylinders without removing them from the vehicle which takes considerably longer. Our rough calculations using specific operating data for the buses operated by the Bombay Electric Supply and Transport (tables 3a and 3b below) indicate that it would be economical to use natural gas by converting existing diesel buses to use a mixture of 85 per cent natural gas and 15 per cent diesel, or to purchase gas engine buses (converted petrol engines) for additions to the fleet.

Such schemes need serious study as most countries in the region have natural gas reserves.91/ Natural gas burns much more cleanly than diesel and is quite likely to prove more economical. It may even be economical to lay gas pipelines on routes with heavy truck traffic so that the rather severe limitations on range (roughly 80 kilometres) between refuellings can be overcome.

The use of natural gas in transport would also facilitate the transition to using biogas for transport, since purified biogas and natural gas have essentially the same composition. Sewage gas was used for transportation in a number of countries, principally during the Second World War. Two trucks were operated for about 2 years during 1942-1944 in Bombay with gas from the municipal sewage treatment plant at Dadar.92/ Similar uses were common in Europe during the same period, but given up after the War presumably because of the cheap oil obtained from the Middle East.

Gas from sewage treatment plants and other kinds of biogas plants in cities cannot meet the requirements of industry and transport, at least given the present structure of use of raw materials and space in the cities. There is, however, another source of biogas which could supply more than adequate quantities of fuel, were it to prove technically feasible. The

/Table 32.

91/ Committee on Natural Resources, op. cit., pp. 3-4.

92/ Joshi, Municipal Sewage Treatment Plant, Dadar, Bombay, personal communication, November 1978.

Table 3a. Comparison of annual costs for 30 buses operating in Bombay: diesel vs. compressed natural gas a/

(Rs in million)

Item	Diesel			Compressed natural gas b/		
	Rupee cost	Foreign ex. cost ($US)	Total	Rupee cost	Foreign ex. cost ($US)	Total
Fuel	0.6	0.5	1.1	0.6 c/	0	0.6
Added interest and depreciation	0	0	0	0.04	0.04	0.08 d/
Added operating and maintenance cost	0	0	0	0.1	0	0.1
Total	0.6	0.5	1.1	0.74	0.04	0.78

Notes: a/ Each Bombay bus consumes about 80 litres of diesel per day costing about Rs 100. This can be replaced by 95 mm of natural gas. All costs are in 1975 rupees and US dollars. Conversion rate: Rs 8 = $US 1.

b/ Natural gas compressed to 200 kg/m^2.

c/ Price of natural gas taken as Rs 0.65/mm (about $US 2.25/1,000 cu ft).

d/ The added capital costs are: 4 cylinders (200 kg/m^2) costing $US 200 each per bus. One compressor of 2.1 cu m/minute capacity costing $US 15,000 for every 30 buses. Source: Roy Nourse, Canadian Western Natural Gas Company, Calgary, Alberta, Canada, personal communications, June 1975. This company markets gas for fleet use. Construction costs per natural gas filling station taken as Rs 200,000. Interest and depreciation at 15 per cent per year. New buses operating on natural gas are assumed to cost the same as new diesel buses, which is a conservative assumption.

4/ Includes Rs 0.06 million for compressor fuel.

/Table 3b.

Table 3b. Comparison of annual costs for 30 buses operating in Bombay: diesel vs. mixture of natural gas and diesel[a]

(Rs in million)

Item	Diesel			85 per cent compressed natural gas + 15 per cent diesel		
	Rupee cost	Foreign ex. cost ($US)	Total	Rupee cost	Foreign ex. cost ($US)	Total
Fuel	0.6	0.5	1.1	0.6	0.1	0.7[b]
Interest and depreciation	0	0	0	0.04	0.09	0.13
Added operating and maintenance cost	0	0	0	0.1	0	0.1
Total	0.6	0.5	1.1	0.74	0.19	0.93

Notes: a/ This table compares the cost of existing diesel buses with existing buses converted to run on a mixture of natural gas (85 per cent) and diesel (15 per cent). Cost of conversion per bus is $US 1,000. Other capital costs are shown in table 3a.

b/ Cost of 85 per cent compressed natural gas about Rs 0.51 million and of 15 per cent diesel about Rs 0.19 million.

/vegetation

vegetation which grows in tropical and subtropical bogs are the most efficient photo-synthetic converters of solar energy.[93/] The amounts of biogas produced annually in tropical and subtropical bogs is quite enormous - about 15 billion tons,[94/] which is approximately equal to the world's energy use today, excluding wood and crop residues. Most of these bogs are in the developing countries. Such biogas plants would probably not provide a source of organic fertilizers since the nutrients in the sludge must be returned to the bogs if their productivity and balance is to be maintained. There may be other requirements, such as limits on possible rates of sustainable production, which can only be determined by further study.

Since biogas is akin to natural gas, it can have a vast variety of applications in industry. In addition, it can also be used to produce carbon dioxide, as Reddy has suggested.[95/] Its use today is essentially limited by the technical problems which face the generation of biogas on a relatively large scale. At the Maya farms in the Philippines, biogas has been used, on an experimental basis, for a large variety of operations such as canning, industrial cooking, running petrol engines and refrigerators and generating electricity.[96/] A large variety of small scale industries can be run and many new uses can be invested.[97/] But running medium or large scale industry on biogas must await the possibility of the production of biogas on a large enough scale (such as biogas from tropical bogs). Using biogas to substitute for or complement natural gas, oil and coal in industry is, in general, an ecologically sounder course, can also help create more jobs and permit of a much greater flexibility in the scale of both fuel and industrial production when compared with the production of petroleum and natural gas. Like natural gas, biogas can also be used as

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93/ Alan Poole and Robert Williams, "Prospects for photosynthetic energy", The Bulletin of the Atomic Scientists, May 1976, table 1.

94/ Ibid, pp. 57-58.

95/ Reddy, "Technological alternatives to the energy crisis", op. cit., pp. 1486-1989.

96/ Subramanian, op. cit., p. 34.

97/ Reddy, op. cit.

a fuel in total energy systems. But it is not possible to evaluate the possibilities for specific industries as yet due to a paucity of experience and, hence, of reliable information.

I have used various examples not so much to make any definitive assessment of the suitability of various schemes for transport and industry - such conclusions would be premature, since these are largely untested schemes - but rather to illustrate that, in the process of development, the same fuels can be both substitutes and complements. Any rigid views on which fuels are more desirable as such are, in most cases, likely to distort the more primary commitment to meeting human needs and even to ecological sanity.98/

/VI.

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98/ There are exceptions. Nuclear power, for example, must be foreclosed - and everywhere - if we are serious about not foreclosing the wellbeing of future generations, to say nothing about achieving harmony with nature.

VI. SOME GENERAL CONSIDERATIONS

In almost all countries a large proportion of investments made are in the energy sector. In developing countries electricity alone accounts for 15 per cent to 20 per cent of total investment. Electricity is one of the most capital-intensive industries and creates very few jobs per unit of investment, though production and maintenance of employment are, in many vital sectors, critically dependent on electricity supply. Possible substantial contributions of solar energy (direct and indirect) to energy supply have to be viewed in the context of over-all problems of energy supply, use and need.

Solar energy is usually discussed with an overwhelming emphasis on its possible contribution to electricity supply. The potential being enormous, commentators accustomed to brute force techniques of energy use are carried away by the prospects, particularly as the use of solar energy seems to serve a number of other objectives (ecological soundness, reduction in oil use and so on). However, the generation and use of solar energy in developing countries faces a number of problems:

a) Its capital costs are high. Even if the capital costs can be brought down several-fold to $500 or $500 per peak kilowatt, the high cost of energy storage (e.g., conversion to hydrogen or storage in batteries) still renders solar electricity uneconomical, particularly in those countries which have got fossil fuel and hydroenergy resources. Unless a cheap energy storage technique can be coupled to a suitable generation system, the maximum utilization of installed capacity cannot exceed 30 per cent in the best of situations. More likely, it will be under 20 per cent. With such a poor use of capacity, the costs of electricity would be very high.

b) It will be difficult to match agricultural loads, which occur in relatively sharp peaks during energy supply, without additional energy storage, or stand-by generators that use other fuels. This will further increase costs.

c) Decentralization of solar electricity generation will be very difficult. Timely maintenance, spare parts and technical skills would all be serious problems at the village level. Given the sensitivity of agricultural operations to timing, unavailability of electricity at the needed time could cause a reversion to earlier techniques. Since foreign exchange and outside skills (in most cases provided by governments) would be needed for parts and repairs, the usual bureaucratic delays would aggravate these problems.

/d)

d) Large scale manufacture of solar cells and other equipment will probably be required given the conversion techniques that are most intensively being researched. Most developing countries will not be able to undertake it and these techniques are likely to remain firmly in the hands of a few companies and countries, in the same way that oil exploration or drug manufacture are today.

e) There are likely to be severe ecological problems with some of the techniques being contemplated. Cadmium sulphide cells are, for example, one of the types being seriously researched. Cadmium is very poisonous and water pollution from cadmium manufacture could cause damage to human life and health and also wipe out fisheries.

Given these problems, it will be difficult to decentralize solar electricity generators, even if they become as economical as fossil fuel or hydro-power stations. Unless special steps are taken to the contrary, the benefits of electrification, solar or non-solar, will flow as they do today primarily to the urban people (disproportionately to the urban rich) and the rural rich. In India, hardly 10 per cent of rural people use electricity, and local and regional inequalities are great. In some other countries, such as Nepal, the proportion is much smaller.

If solar cells can be made cheap enough (e.g. about $US 200/peak kw), then it may be possible to use them to provide electricity to one-shift industries without any provision for storage. Where reliable supply is more essential, biogas, natural gas or oil generated electricity could supplement solar electricity thus obviating the need for storage.

In terms of their potential for contributing to energy supply, a number of solar energy schemes may be more promising than solar electricity, and possibly considerably less expensive. We have already referred to biogas from tropical and subtropical bogs. Solar heaters could provide low and medium grade heat for industrial processes. Synergistic schemes which produce various combinations of food, industrial raw materials, fertilizers and fuels (such as water hyacinth plantations in sewage treatment ponds, combined with fish culture and pig and poultry keeping) can be made ecologically sound and have technical promise, though any assessment of their economics is difficult at this stage.

Two important advantages of many biogas and some solar electricity schemes are that the time between the decision to build capacity and the start up time can be short and that they can be built in relatively small units without significant sacrifice of economies of scale. Capital intensive projects with large capacity plants and long maturity periods have been one of the main factors in the existence of idle capacity in many industries with shortages in others:

> "There is a further fundamental problem with capital intensive projects with long maturity periods. The uncertainty of the demand projections on which basic investments are made increases greatly with the maturity period. This creates serious problems and structural vulnerability, when the proportion of the fixed cost in the total cost of the product is large. If the demand is below that anticipated, then the price must be pushed up to recover the cost or make a profit. Thus we get subsidies, or underutilization of capacity and high prices, and sometimes all three together.
>
> "It is as unpleasant when one is confronted with a chronic and serious shortage at the end of a long term project. Shortages have plagued a vital sector of the Indian economy-electric power. First, this contributes to underutilization of capacity in other industries and hence to the problems enumerated above. Second, other long term projects in sectors with unused capacity tie up money and reduce the flexibility for moving resources to the areas which need them." 99/

This is a problem which afflicts even the electricity sector in the United States of America, once thought capable of absorbing the largest units without difficulty. Careful analysis shows that even here smaller plants with smaller lead time make more sense.100/ Relatively small plants also enhance power system reliability. For a given system reliability, far less capacity is required if it is added in small increments rather than large, and thus large savings in capital costs can be realized.101/

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99/ Makhijani, "Energy policy for rural India", op. cit., see footnote 31, p. 1866.

100/ Edward Kahn, et al., Investment Planning in the Energy Sector (Berkeley, California, Lawrence Berkeley Laboratory, 1 March 1976).

101/ What is "small" depends, of course, on the size of the power system as a whole. In the largest power systems (20,000 megawatts and more), 400 megawatts is indicated as the largest practical size. In a study of the PJM interconnection in the eastern United States of America, Kahn concluded that every three megawatts of nuclear capacity in 1,100 megawatt units could be replaced by only two megawatts of coal capacity in 375 megawatt units, for the same reliability. See Edward Kahn, "The impact of nuclear generators on system electric power system reliability", Testimony before the Environment, Energy and Natural Resources Sub-committee of the Committee on Government Operations, United States House of Representatives, 19 September 1977.

We have tried to illustrate the great range of social, ecological and economic questions which must be considered for making sound and equitable energy policy. We have also recommended some projects such as provision of electric lighting to all and the use of natural gas and bio-gas for transportation. So far as techniques are concerned, there is a considerable amount of testing and development to be done in areas such as the exploration of tropical and subtropical bogs. Many crucial techniques are being ignored, possibly because the technological orientation of the research so far has taken its cues from the wealthy countries, and because social considerations, particularly at the local level, are not yet a systematic part of the process of deciding what techniques should or should not be developed. We do not think that the proper priorities for research can be developed, to say nothing of programmes that mitigate oppression, unless the desires of the oppressed are systematically taken into account.

To develop a direction of decreasing social and ecological violence and of greater social justice, we have to learn to ask some fundamental questions about what constitutes development. What, for instance, are "basic" human needs? Are there needs that are not basic? Specifically, does "basic" imply only physical and biological criteria such as so many litres of water per day? Are not control over one's life and human rights also a part of basic human needs? If so, then what is one to do about the facts of oppression, of domination, enslavement and violence which is perpetrated routinely upon the majority of the peoples of many countries in the region? Who will determine the priorities of the development process? Can an ecologically sound and socially just policy be formulated without integrally considering these questions? What can one say then about the failures of the past, the increasing violence and inequalities?

A specific energy policy for a country or even for the ESCAP region can only be formulated in the light of the answers to such fundamental questions. The problem of justly distributing the benefits of energy use is severe in most developing countries. It is essentially a question of a lack of control of resources by the people who need them. Grossly unjust societies have deep cleavages down to the village level which makes it difficult or impossible to implement programmes top-down that will benefit the poor. This can be reversed only when the poor have organizational strength to assert and achieve their demands. Only thus can they control the process by which priorities are made and programmes formulated and

/implemented.

implemented. Within the context of such organization, a great many programmes, including those for the development of alternative energy sources can become gradually feasible. This is not only a question of the dominant social and economic groups yielding at the national, city or village levels. We have seen in the case of cooking fuels that these problems extend even to the milieu of the family.

In developing countries, that is, in most countries of the ESCAP region, even militant trade union organization of agricultural and other workers, particularly in rural areas, can help redirect energy policy toward a sounder course, because higher income will mean more demand for fuel, which the political and economic system will be hard put to meet without including fuels such as wood and biogas in its planning and production.
