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Manila, November 12-16, 1979

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Objectives of Conference*

In recent years rising costs and intermittent shortages of energy have become barriers to development in Asian countries. These energy problems have directly and indirectly affected programs to increase food production, improve health and education, and enhance employment and income distribution. Energy trends and possible future energy choices also have major environmental implications, relating to both the production and use of conventional and nonconventional fuels and the use of traditional fuels such as firewood.

AID, along with other bilateral and multilateral donors, has only recently begun to provide assistance to Asian countries in energy-resource development and President Carter and Secretary Vance have pledged to intensify U.S. assistance in this area. AID needs to consider how it can best utilize its funds to assist Asian LDCs meet their energy problems.

This conference has two objectives:

(1) To learn more about energy problems and their environmental and forestry implications in Asian countries

(2) To discuss and make preliminary recommendations as to what AID's role should be in assisting Asian developing countries ameliorate their energy problems.

To pursue these objectives, the conference is divided into two sections. The first two days are presentations and papers to review energy and related environmental problems in Asian countries. The second two days will be divided into work groups to consider and make initial recommendations on AID's role as a donor organization.

* This sheet was given to participants prior to the opening of the conference.

Summary of Conference

The Asia Bureau Conference focused on Asian energy problems and policies and their related forestry and environmental aspects. The role of energy in development was addressed from a variety of perspectives -- international, regional, national, functional and sectoral. Working groups examined the energy situation and options in specific countries and considered what role AID could play in supporting energy planning and programs in these countries.

The main conclusions of the conference were:

(1) The firewood crisis is reaching a critical point in a number of countries and AID should place increased emphasis on augmenting fuelwood supplies and developing suitable energy alternatives for rural areas.

(2) The significance of the oil crisis for overall agricultural and industrial development in Asia cannot be ignored by AID. Technical assistance in promoting the conservation and development of conventional as well as renewable and traditional energy sources may be an appropriate area for AID in specific countries.

(3) The energy problem bridges rural and urban concerns, as the process of urbanization places demands on rural resources, especially wood and charcoal, and as the expansion of agricultural production and rural-based industries increases demands for conventional fuels. Technical assistance in energy planning and technology development, while primarily directed to rural sector activities, should <u>not</u> be limited therefore, but should seek to identify the critical links between sectors and to support sustainable national energy strategies that can meet the needs of both sectors.

(4) The energy implications of non-energy projects should be addressed more thoroughly in project development.

(5) AID needs to expand the capabilities of its missions in the energy area. A central training course should be established for AID personnel in energy issues and the inclusion of energy specialists on mission staffs should be considered by missions with plans for major energy activities in the future.

(6) Substantial opportunities exist for AID to increase collaborative activities with other donors in energy assistance, particularly with the Government of Japan and the Asian Development Bank, both of whom sent representatives to the conference.

(7) This type of problem-oriented regional conference, involving experts, host country specialists, mission and AID officials, and representatives of other donor agencies, is an effective vehicle for developing sound Agency policy, especially in a new and fast-moving field like energy.

These conclusions emerged from four days of meetings that began with John H. Sullivan's opening remarks, in which he stressed that the expanded agricultural and industrial production necessary to meet basic human needs in Asia will require increasing supplies of energy. He called for a transition to an energy economy substantially less dependent on oil and for a concerted international effort to increase the efficiency of energy use, expand and diversify world oil production and reserves, and develop and commercialize alternative energy technologies.

Overview of Major Issues

Day one was devoted to presentations and discussion of key economic, social, and environmental issues related to the nature, determinants, and consequences of the present and future energy situation in Asia.

John O'Leary, former Deputy Secretary of the Department of Energy and Herman Franssen, Director of DOE's Office of International Market Analysis, established the current and likely future parameters of the international energy system. Mr. O'Leary noted the tremendous existent pressures on oil supplies and price due to the restrictive production policies of the major oil producing countries in the face of rapid worldwide inflation and oil resource depletion. Dr. Franssen highlighted the possible negative consequences of economic recession in the industrial countries on demand for LDC products and on levels of foreign assistance.

Dr. Roger Revelle examined energy resources, uses, and needs in Asia from a regional perspective, giving special emphasis to the issues of biomass potential, rural electrification and research priorities. He calculated that the substantial increase in the incomes of people in Asia necessary to achieve a leveling-off of population growth in the next fifty years will require more than a doubling of food, fiber, and energy consumption.

A national energy policy perspective was provided by Mr. Gabriel Itchon, Deputy Minister of Energy for the Philippines. Mr. Itchon outlined the dramatic impact of world oil prices on the Philippines' external trade balance and the aggressive policy measures being taken by the Philippine government to diversify import supplies and develop domestic sources of petroleum, geothermal, coal, biomass for liquid fuels and for power generation,

large and small/mini hydro, and one nuclear power plant. By encouraging foreign private investment, the Philippines has been successful in discovering offshore petroleum deposits. Production began in 1979 and Mr. Itchon expected production to reach 60,000 barrels per day in the near future.

Within this context, Dr. Soemarwoto, Director of the Institute for Ecology in Bandung, Indonesia; Dr. Tinker, Director of the Equity Policy Center; and Mr. Eckholm, formerly with the Worldwatch Institute and presently with the U.S. Department of State, discussed the environmental, social, and institutional dimensions of rural energy use in Asia. Dr. Soemarwoto described the results of research in Indonesia on the 'home garden,' which is the main source of firewood supplies for the rural population, and how this "agro-forestry system," which also functions as a source of vegetable and a protection of the soil, has taken on increasing importance in sustaining large Japanese families as population pressures reduce rice land holdings. Dr. Tinker stressed the key role of women in Asian societies in collecting wood and residues and in cooking and other tasks. This fact needs to be recognized in designing rural surveys and assessing the impacts of technology interventions. She raised the key question of "who pays for the higher cost of energy within the family?"

Erik Eckholm provided a link between the discussion of household energy and the formulation of national policy. He argued that national energy sector plans are generally inadequate in their attention to rural energy needs and to the supply of firewood and "non-commercial" energy. Strategies involving village woodlots and community participation in afforestation efforts were suggested and successful examples from India, South Korea, and China were presented.

Current Energy Planning

Panel discussions were held on energy policy in the industrial and agricultural sectors. Dr. Satish Chandran from the Indian Planning Commission analyzed India's problem of maintaining a reasonable rate of industrial development in the face of the serious global energy problem, which threatens to deprive Third World countries of even their small share of oil supplies and to push up the prices beyond their reach. Thailand, as noted by Dr. Prida Wibulswas of the King Mongkut Institute of Technology, is also highly dependent on oil imports for its urban/industrial development. He described present efforts to substitute natural gas and lignite in the power sector and expressed the view that nuclear energy had a role to play in meeting Thailand's future electricity requirements. Mr. Galano from the Philippine Ministry of Energy presented a paper by Gary Makasiar, Acting

Chief of Planning Services for the Philippine Ministry of Energy, on selected issues in the development of an industrial/urban energy strategy in the Philippines, especially time-of-use and marginal cost pricing in the power sector and mass transit planning.

Mr. Senadhipathy, Secretary of the Ceylon Electricity Board and Dr. Khattak, Director of the Institute of Forestry in Pakistan, discussed energy planning in the agricultural/rural sector. The Government of Sri Lanka has launched an ambitious village electrification program based on hydro power development and Mr. Senadhipathy stressed the importance of channeling electricity into productive uses, e.g., agro-based industries involving tea, rubber, cocoa, paddy and sugar cane, ice plants for fisheries, saw mills, brick and tile manufacture. Dr. Khattak focused on the problem of deforestation and soil depletion and the potential for implementing fast growing varieties. He stressed the problem of developing a cadre of trained specialists.

National Energy Problems and AID's Role

Intensive workshop discussions were held on individual countries. The reports are included in this volume along with background papers prepared by each mission and AID Washington. Each group considered two countries and the extent to which their problems and potential solutions were similar. Some common problems that emerged from the four groups included:

(1) the escalating cost and uncertain availability of imported petroleum;

(2) the depletion of firewood and traditional sources of energy and the serious environmental and human consequences;

(3) the limited or unexplored energy resource base;

(4) the cost and lead times involved in developing and implementing indigenous energy alternatives.

Possible short- and long-term actions to deal with specific country problems were formulated, including strategies to expand supplies of conventional, renewable and on-conventional and traditional energy; accelerate research, development, and demonstration of new energy technologies and end-use devices; promote conservation in both the urban and rural sectors; and to develop the human and institutional capabilities needed to plan and implement effective national energy programs.

Discussion of AID's role in supporting such actions elicited recommendations for an expanded effort in the energy sector in most countries. No specific budgetary implications were developed at this stage nor were the cost/benefits of possible energy projects weighed against other mission priorities.

Opening Remarks

John H. Sullivan*

Good morning and welcome to what should be an exciting and productive week of discussions on one of the central problems facing Asia and the world today -- energy and its related forestry and environmental aspects. It is a central concern because the expanded agricultural and industrial production necessary to meet basic human needs will require increasing supplies of energy. It is problematic since rising energy consumption and prices and decreasing petroleum and firewood availability are constraining production, contributing to deforestation and environmental degradation, and fueling inflation in the prices for food and other commodities and services essential to the survival of the poor. For example, I have been informed that some recent increases in malnutrition can be linked to oil-induced price increases for food in several Asian countries.

The seriousness of the energy problem is compounded by the apparent lack of viable short-term solutions and the continued inability of the OECD, OPEC, and oil-importing developing countries to reach a political accommodations which would help assure a long-term solution.

A general concensus, is however, developing on the need for a transition to an energy economy substantially less dependent on oil. The nature of this transition and whether it can be achieved without major political upheavals are as yet unclear.

The urgency of the transition calls for increased and concerted efforts to (a) conserve energy and increase the efficiency of its use; (b) expand and diversify world oil production and reserves; (c) develop and commercialize alternative energy technologies.

The United States has and is supporting expanded bilateral and multilateral programs to assist developing countries in these areas. Notably in January 1979, the United States voted for an expanded $3 billion, five-year program of World Bank lending for petroleum and coal development. A U.S. initiative at the 1978 Bonn Economic Summit has led to intensified bilateral assistance programs by OECD members in renewable energy technologies. The AID program in this latter area has grown from a couple million dollars in 1976 to a proposed level of over $40 million in FY 81. In the FY 80 authorization bill, Congress has directed AID to carry out surveys of petroleum and conventional energy resources. The President and

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I. Overview of Major Issues

Congress have also directed AID to devote increased effort to the related problems of deforestation and environmental degradation. And with the creation of IDCA, energy is being further emphasized as a prime focus of overall U.S. international development policy.

This conference therefore comes at a critical juncture in U.S. and international energy policy and program development. It offers an opportunity for us to assess this growth in energy programs and the assumptions and motivations underlying it as well as to reflect in an imaginative way on the directions and role AID should pursue in helping developing Asian countries undertake their collective and individual energy transitions.

The problem is immense and certain choices are essential if AID is to maximize its limited resources at a time of severe constraints to incremental funding and staffing in the Agency.

Finally, the conference represents a unique experiment in Asia Bureau policy formulation, bringing together individuals from AID Missions, AID/Washington, Asian countries, other donor agencies, U.S. government departments, and private organizations. Its success in clarifying the importance of the energy problem and its related forestry and environmental dimensions and in suggesting a well-reasoned course of possible action by AID depends on the active participation of each of you. I look forward to working with you in this endeavor.

Thank you.

The World Energy Outlook for the 1980's

John O'Leary*

There is one internationally traded commodity in the energy business that is of real significance, that's oil. There is a certain amount of international trade in coal but most of the coal is produced and consumed in a fairly close geographic relationship. We find some trade, for example, in metallurgical coal between the United States and Europe and Asia but I don't expect that we are going to see an enormous amount of trade in coal flourishing during the 1980's. Similarly some gas is traded, mostly by pipeline. Iran, for example, up until recently, sold a good bit of gas to the Soviet Union. We received in the United States a good bit of gas from Mexico, and there is a little bit of trade in LNG. But I don't expect that we'll see massive trade in LNG. Very important commercially but not strategic in the sense of being important to the energy future of countries during the 1980's. There is, of course, international trade in uranium but that is such a small part of the fission industry that I think it's fair to regard that as relatively trivial in the great scheme of things internationally.

Oil is really the commodity to watch if you're thinking about trade in this business and particularly as oil prices go up. And I'm sure that you've observed this during the period 1973-74. It's not long until coal prices go up too, and uranium prices as well. For example, although many of us have noted that the price of oil on the international market went up from less than, say, $2.00 in 1973 into the range of $10.00 by very early 1974, few of us recall that the price of uranium during that same period roughly went up from about seven dollars a pound for yellow cake to about $42.00 -- again a factor of about six. The thing to note is that oil price availability will condition the entire energy market over the next decade. This may change in the next century but I think that during the 80's and probably during the 90's we're going to continue this enormous reliance on oil.

Now let me just briefly sketch out for you where the oil is and what we can expect over the next five to ten years. Right now the world as a whole produces and, of course, uses, about 60 million barrels of oil a day. I can recall when I first came into this business that it was about 20 million barrels a day and it's gone up by a factor of three in the last, let's say, 30 years. Ten of that 60 is in the Soviet Union and Eastern Europe -- maybe a little bit more than ten. Ten of it, roughly, is in the U.S. Ten more is in the remaining non-OPEC producers in the world. Now that would be Canada, Australia, a good bit of production in Mexico, some production in China and in scattered developing countries.

Now between the U.S., the U.S.S.R., and the other small OPEC producers (and I should have added the North Sea to that list) we

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we have about half of the world's supply of oil. Most of that stays where it is produced; it isn't traded. Soviet oil, for example, is consumed within the block. Our oil is consumed within the United States. A little bit goes to Mexico, a little bit to Canada; most of it just isn't traded very far. But similarly the oil produced from Mexico is for the most part today consumed in Mexico. Most of the oil produced in China is consumed there. Most of the oil produced in the North Sea is consumed by the nations about the North Sea.

Now the other half of world oil production -- 30 million barrels a day (it fluctuates - it might be 31 or 32 million at the moment) -- is produced by the nations that comprise OPEC. Let's take a further sub-division. About 20 of that is produced in the area of the Persian Gulf and about 10 is produced by the non-Persian Gulf producers of oil. They would be Algeria, Nigeria, Venezuela, Indonesia, with a few other smaller contributors.

If we take a look over the next five or ten years, I think that this is what we're going to find.

For one reason or another those countries that have substantial production today that are the non-Persian Gulf members of OPEC are probably not going to be able to find new oil reserves sufficient to support expansion of production.

That is to say that 10 million barrels a day that they produce now will remain constant or more probably fall a little bit as we get into the 1980's. I would suspect that for example, we won't see it below 8 million barrels a day by 1985. But we might very well see it in the 8 - 9 million barrel a day range. I would be very much surprised if we would see a significant expansion over the period of time.

Now does that mean that those nations don't have the capacity to expand? No, not at all. In Venezuela, in Algeria and the others that I've mentioned over time I think that there will be enormous finds of oil. But for one reason or another, during the next decade they won't be able to bring the resources together; they won't be able to provide the priorities that are necessary to permit the investment that in turn will permit an expansion of production. Their production will stay about even or decline a little bit for the next several years.

Now how about the other big chunk of OPEC, the Persian Gulf producers; they are the ones with the tremendous reserves. In the United States, for example, we support 10 million barrels a day capacity with about 30 billion barrels of reserves. Saudi Arabia is producing about the amount we produce, that is 9½ million barrels a day at the moment, and they have 117 billion barrels of reserves -- three, almost four times the reserves level of the United States. We find, similarly, very large reserves in Kuwait, the United Arab

Emirates and in Iraq. There are also very large reserves in Iran.

Now let me tell you what I think is going to happen to those producers in the immediate vicinity of the Persian Gulf within the next five to ten years. With the exception of Iraq and with the possible exception of emerging Egypt, which might surprise us over the next five to ten years in terms of new oil production, I think we're not going to find substantial expansion in production. The situation there is pretty well typified by Saudi Arabia. You have a very small population at five to seven million people. Some people have estimated as few as three million people in Saudi Arabia and already they are generating more income than they can effectively use. I've heard endless scholars who have studied the Saudi position say that the Saudis can get along very nicely on the proceeds from three to five million barrels a day at today's prices. And, of course, they're producing 9½ million barrels a day. Now in that sort of a situation we can not expect that Saudi Arabia will put money into the addition to capacity and the very large investment that would be required to permit them to further produce what is in their view useless revenues. What they are finding now is that they are producing about double the amount necessary to drive their economy, putting their surplus into American and European banks and watching it whither as the inflation cuts its buying power. And I think that we simply won't find that sort of a proposition, sufficiently attractive to the Saudis, or Kuwaits, or the Iraquis or the United Emirates leadership.

Consequently, I really don't think that we're going to see those producers increasing their production significantly beyond today's 20 million barrels, despite the fact that everyone who studied the matter would concur in the fact that they could. Until last year the official U.S. estimates had production from that part of the world running from today's 20 million barrels a day up to 30 million barrels a day and even higher during the course of the 1980's. I think in this post-Iranian world that we're living in today, that that's not in the cards.

Now, the summation of all this is about as follows: we're going to find outside of OPEC increased production -- the Mexicans, for example, have found some very fine oil fields in the Reforma region down in the Gulf of Mexico. China appears on the verge of a major expansion in production. But as we look at the situation in Mexico, with 70 million people today and 100 million people by the end of the century, it's unlikely that they will really emerge as major exporters during the remainder of the century. It seems to me that in the mid-to-late 1980's, they may have some export surplus; but as their own economy expands and their capacity to use fuel expands with it, I think that they're going to be hard put really to meet their own requirements. Similarly, China is now exporting small amounts of oil, primarily to Japan; and as you look at the current levels of consumption and the aspirations of the

Chinese people, it seems to me unrealistic to think of China emerging as a massive exporter during the remainder of the century. I think that they're going to have to work very hard to stay even. And to meet their own requirements alone through the 80's and 90's. Consequently, I think we're going to find ourselves 10 years, 14 or even 20 years from now still depending, for the internationally traded segment of the oil economy, on all those countries that now comprise OPEC. And what I'm telling you today is this, I don't think that their production is going to expand as the OPEC nations themselves expand. Probably their exports are actually going to go down a little bit over the next 5, 10, 15 years. Or at least that is the sort of world that we should plan today. It may be that something much more positive will develop; but if you look at it coolly, and analytically, I think that you can't count on anything much brighter than the picture that I outlined for you.

Now what does that mean? It means that the price of oil, which I will remind you again was $2.00 in 1973 and then went to $10.00 and is now at the official selling price basis around $20 or $22 and heading for $30, will probably, in very short order, go to a formal $30.00. I would expect that either this winter or next, that it would head toward $40.00 within the next three to four years. And again in today's dollars -- that takes the inflation out of it. I think that the view of the Saudis, for example, who have been one of the tempering factors in world oil prices, is that they made a mistake in trying to hold the real price of oil down during the period four or five years after the embargo. That simply encouraged too much consumption in the United States and some other nations. And from now on out, I suspect that even the Saudis will be pushing for some real increases in the price of crude. And, of course, the Saudi influence has waned. When a number of the OPEC countries that need the money (that would be the ones essentially some distance from the Persian Gulf with large populations, e.g., Indonesia in your part of the world) are producing less than their capacity, the Saudis can, of course, hurt their markets by expanding production. That was the case in 1976-77. But now when everyone is producing essentially all that they can and the world is willing to snap up any additional oil that comes on the market, that Saudi leverage has disappeared and I believe that their tempering capacity on world market prices for oil has disappeared with it.

I think, in short, that what we're going to see is every year, year in and year out, increases in the real price of oil.

Now, what does that say to the world? It says to the nations of the North, the industrial nations of the North, that they can bid against each other and against the rest of the world for that limited supply; and of course that's what behind today's activity in the spot market, driving up the price (there was a transaction reported just last week of Iranian crude at $45.00 a barrel). We'll probably see more of that over time. The spot market for crude used

to represent a year, year and a half, ago, just a tiny fraction of the amount of oil that was traded in international commerce. Today, according to some authorities, it's as much as 10%; and other authorities claim as much as 20%. And the price is in excess of $30.00. That means that the bidding has already begun. And indeed that bidding is going to be the pushing factor or pulling factor on the increase in the official selling price that I project for this winter and again for the coming year.

So I think what we're seeing then is that the bidding has already begun. The Japanese are to a degree bidding against the United States, the United States against Western Europe, and all of the Northern industrial nations against the less developed nations of the South. Now, what's the sort of end result of this process? Well when you take a look at the potential in the North, you find that really there are a great many more alternatives. For example, it takes a big market to support a nuclear plant. Many of the developing nations of the Southern Hemisphere just don't have a big enough market at the moment to permit them to look at the nuclear energy. One of the things that we're finding in the United States is that we're going away from nuclear energy and in the course of that we're dooming ourselves to increased dependence upon oil.

We have coal in the Northern Hemisphere -- very large volumes of coal. And in Western Europe and North America, we can use that coal; but we're not doing that; we're not doing that at anything near the rate that we could if we were to put our minds to it. What we're doing is using oil.

Now what's the consequence? In the Southern Hemisphere, we don't have the coal and you don't have the nuclear option because your markets are simply not large enough. Oil is the proper fuel. And what's going to happen to that oil, because of bidding from the North, is that it is going to get more and more expensive and a higher and higher proportion of the surplus of the nations of the South will be devoted to paying their oil import bill. That, I think is among the most serious consequences of the run up on oil prices.

Let me contrast for a minute the situation of the last ten years and that of the next ten. During the past ten years the run-up in the world price of crude took place in the presence of sustained and chronic surpluses. At the time of the Iranian crisis, for example, the world was able to muddle through because there was about 4½ million barrels a day of capacity that could pick up the swing that was created by the disappearance for the first quarter of 1979 of Iran as an oil supplier.

That surplus is gone now and I think that that means that there will be a worse decade ahead than the decade just behind us. If we can have the enormous run up in prices that we had in the last ten years in the presence of chronic surpluses, think of the impacts that

we can have on price availability over the next ten years in the absence of those surpluses. That I think is the single most important aspect of the 80's petroleum market -- that is the disappearance of the surplus that characterized the 70's and indeed the 50's and 60's as well. That surplus has disappeared and probably for good. And what that means to me is that prices are going to go up and up and up and the bidding of the industrialized nations is going to become ever more severe for the small amount of oil that is going into their own tanks and away from the countries of the Southern Hemisphere that would like to use it.

Now there's another aspect to this that we ought to touch on before I finish. And that is the opportunity that this presents to countries in the Southern Hemisphere for development of their own oil resources. It's evident to me that we haven't done anything approaching a decent job of exploration even on reconnaissance basis on the areas that the countries control that are sitting at this conference. I'm pleased to see that the World Bank has come forward with a program of about a half billion dollars annually which they intend to expand to a billion or a billion and a half to assist financing for exploration and development of petroleum.

It seems to me that that's the key to the future for many of the countries that are involved in this conference today -- to find within their own boundaries sufficient oil to meet their urgent requirements for the next ten to fifteen years.

The World Energy Outlook

Dr. Herman Franssen *

The energy outlook I shall present today is an outlook from the perspective of the developed consuming nations. You will hear a great deal more from other participants in the workshop on energy policy from the perspective of the developing nations. But our expertise in my office is primarily in the area of the major consumer nations' perspective on world energy development. As you may recall, we are frequently castigated for the fact that the United States consumes about one-third of the world's energy. But we should be reminded that the United States' share of energy consumption is not much different from our share in world gross national product. Subsequently, there is a very good explanation for the high use of energy. Moreover, in the United States we always were a low-cost energy economy and in the past there was really no need to make a major effort to reduce energy consumption. It's only in recent years, due to the environmental movement and limitations on the production of conventional oil and natural gas, that we can see a limit to the use of energy in our country and in the industrial countries and that major efforts are underway to reduce energy inputs in our economic process.

To give one example, in the period prior to 1974 the energy/GNP ratio in the United States was about 1 to 1, which means that for every additional unit of gross national product produced, we needed 1 unit of additional energy; and that was expressed in British Thermal Units. Following the Arab oil embargo and the quadrupling of the price of oil, the energy/GNP ratio has been reduced to almost 50% of what it was prior to 1974. So today, for every additional unit of GNP added, we consume only half a unit of additional energy, be it oil, gas or other sources of energy. And to a lesser extent, the same is true for other developed countries. In the developing countries where the major effort is underway to begin the industrial process, one cannot expect such an improvement in that energy/GNP ration; in fact, in many countries we expect a deterioration in that ratio as nations move from basically agricultural states to industrial states.

Following the quadrupling of the price of oil in 1974, the GNP growth rates in the industrial countries declined dramatically, particularly in Western Europe and to a lesser extent in Japan. The United States did better than any of the 3 major blocs; we had, particularly from 1975 through the early part of 1979, reasonably high economic growth rates and we were able to reduce the consumption of energy. On the production side, we have not performed well. The production of oil and natural gas in the United States has declined somewhat since 1974. In production of coal, the big promise of the early 1970's, we haven't done very well at all. The only area that has undergone rapid growth is nuclear power and that's one of the energy sources which is in trouble right now in the United States. In Europe, the Europeans had the good fortune of finding North Sea oil in the middle of the 1960's and they began to produce that oil in the middle 1970's. Production is likely to grow for some time to come. As a result of the high

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prices and somewhat more production of domestic oil in the OECD countries in general, the net demand for OPEC oil has remained practically unchaged since 1974. There have been years where it was a little higher and years where it was a little lower than the average. But the average has been somewhere around 30 million barrels a day for that period of the past 5 years. And the willingness of OPEC countries to produce at that rate or to produce at even slightly higher rates was there until the Iranian revolution of November-December of last year. There was a substantial surplus capacity of oil in world markets and that surplus capacity kept prices down. In real terms in 1974 dollars, the price of oil declined by maybe as much as 2.5-3% between 1974 and January of 1979.

So OPEC countries, in fact, reduced their balance of payments surpluses as a result of the lower earnings per barrel of oil produced. And, in spite of their higher price for imported oil, our imports for oil grew -- and in fact, continued to grow throughout the period from 1974 through 1978. The major reason was not that we had very rapid growth in consumption of oil, as such. Consumption of oil increased only gradually. The major reason for the increase in oil imports in the United States, was a net decrease in domestic production of oil and a decrease of natural gas prodution. Imported oil served as a substitute for domestic oil and domestic gas.

The decline in consumption of oil in the past 5 years has been primarily caused by the reduction in economic growth rates. And that is, of course, not the kind of offsetting mechanism that we'd like to see continue in the future because that would mean higher unemployment, lower economic growth rates and higher inflation. When we go back to the most recent developments following the Iranian revolution of November of last year, we find that the industrial nations were caught by surprise. The major oil companies reduced their stocks in 1978 because nobody really expected a major increase in the price of oil for some time to come and nobody thought of the possibility of major reductions in production by any one or any number of OPEC countries. And as a result, when the Iranian revolution occurred and production gradually declined to zero in December of last year, all of a sudden the industrial world was caught by surprise. On top of that phenonmenon of the Iranian revolution and fairly low stocks at the end of 1978, Europe, in particular,was caught by a very severe winter; and the combination of the very severe winter the fairly low stocks, and the Iranian supply interruption resulted in an unusually high reduction of free world oil stocks in the first quarter of this year. The perceptions in industrial circles were that this was likely to continue for some time to come; because nobody knew when and whether Iran would come back to a particular level of production.

So traders, worried as they were over not being able to get the supplies that they needed for their refineries and for third party sales, began purchasing crude oil on the spot market, the so-called Rotterdam market, and they began bidding up the available

crude. When that happened, spot prices went $10-15 above the official OPEC price. The OPEC countries became increasingly impatient and several of them began to add surcharges to the official price they had decided on in December 1978. So by June of this year, when OPEC supply had returned to normal, in fact higher than normal, levels and the spot market prices continued to be substantially higher than the official prices plus the surcharges that OPEC countries have added, OPEC decided to substantially increase the price. By the beginning of July after the second OPEC meeting, the price of oil, the average price of oil, was about 60% over and above what it was in December of 1978.

No one would have expected an immediate reduction in demand, although the members of the International Energy Agency in Paris and the Big Six of the Tokyo Summit, had decided to reduce consumption of oil by 5%. When the final figures come in, it is unlikely that, with the exception of the United States, any country within the International Energy Agency will have, in fact, reduced consumption by 5% over and above what they had previously projected. So consumption is down somewhat, indeed; but not to the extent needed to bring some balance in the market.

What we have now is a situation, in which the OPEC countries are producing almost all out, with very few exceptions, producing very close to maximum sustainable capacity. Some of the exceptions are Iran, which could produce probably at least a million barrels a day more than it is currently producing, and a few others could produce a couple of hundred thousand barrels a day more. But more or less OPEC is producing at full capacity.

We have to separate out what we mean by demand. Demand means actual consumption plus stock build-up. And actual consumption of oil, particularly in the second part of this year, has leveled off -- in fact has declined in the United States and some other major consuming nations. But, for a number of reasons, stock build up from the second quarter of this year on, has been very heavy. Part of the reason is that we were caught with very low stocks in the first quarter of this year.

But there are a number of other reasons. The great uncertainties related to future supply of oil have led to a situation where the major oil companies do not want to get caught by surprise again. So they are building up stocks almost to the maximum level throughout this year. And another reason for the major stock build-up is that, prior to this year, the major oil companies not only controlled somewhere around 70% of the oil in trade; but much of the oil they traded did not end up in their own refineries but was sold to private companies and national oil companies in other countries. This has changed, OPEC countries and non-OPEC oil producers are increasingly dealing directly with national oil companies and small, private oil companies in consumer countries. So, instead of the major oil companies holding stocks for the companies that they used to deal with in the past, we now have a much larger number of private and national oil companies in consumer countries

building up stocks. And in the aggregate, the safety margin, that all these companies want to build up, is much higher than the safety margin that the major oil companies used to hold for all of these companies and countries together.

One can compare it a little bit with the banking system. When all of us put savings in a particular bank, the bank provides many more loans on the basis of the savings than the actual volume of savings put in. And the reason is that the bank doesn't think that all of the people that put in the savings are going to call on these savings at the same time. This is why the major companies could hold a certain volume of stocks expecting that some may draw on them but others would not. But, now when you have so many individual actors in this game, each one of these actors wants to have their own safety margin. So you can expect for some time to come that stock build-up will continue around the world, adding to the tightening of the market and adding to potential pressure on prices.

It seems that, as a result of this continuing growth in demand, that prices are not likely to be stabilized for the rest of the year. We have already seen that in recent weeks, Kuwait, Libya, and a number of other countries have again increased oil prices and some of them over and above the selling price agreed upon at the most recent June OPEC meeting. So it's quite likely that in December, when the OPEC countries meet again in Caracas, they'll decide on another price increase. How high this is going to be is really a speculative matter. We don't know whether they are going to set a new ceiling price or whether they are going to have a ceiling price at all; but they are likely to bring the floor price up above what it is today. And we may continue to have surcharges, particularly for higher grades of crude.

In the end, we may have a crude oil price by the end of 1979, which may not be very far removed, from twice the price that we had in December of 1978. The net result of that is, of course, for the entire industrial world and for the non-oil producing developing countries that they are going to be faced with very serious balance of payments troubles again, like they did in the period immediately following 1973-74. There is going to be increasing inflationary pressures on their economies. Monetary authorities are likely to meet those pressures by clamping down on inflation and subsequently reducing economic growth rates. And that in turn will lead to more unemployment. So it almost looks as if we are back to a kind of a repetition of the period that we had following the 73-74 embargo.

It is very difficult, if not impossible, to project whether we are actually going to see a repetition of that earlier situation or whether the recession or era of low growth is going to be less significant than it was after the first major oil supply interruption. One could argue that, everything else being equal, we then could expect, as Tahir of the Saudi Arabian National Oil Company has suggested, to have a mini-glut next year-- not, if everything else were indeed equal, We could have a mini-glut because we do

expect that in the non-OPEC countries, oil production is likely to increase by about a million barrels a day, which is about 5%. And most of that increase will be in North Sea and Mexico, with the remainder coming from non-OPEC developing countries. And if oil demand in the world doesn't change, or increases by maybe one half a percentage point, then any demand could be met from additional non-OPEC supplies.

The big uncertainty, however, is what OPEC supply is likely to be in 1980? We very well know that the situation in Iran is increasingly uncertain. The current revolutionary struggle could result in periods of no oil production at all; and there will be periods where production is likely to be at the full level of close to 4 million barrels a day. And in between there may be periods of production going up, production going down, and production entirely disappearing. Now that's a very great uncertainty in the market. Aside from that, we have a country such as Kuwait which would like to reduce production and in the Kuwaitis case quite significantly.

Kuwait currently produces about 2 million barrels per day and they would like to reduce that by about 25%. And the main reason is long-term conservation. They have only X much oil in the ground and they would like to conserve that for future generations. And a more short-term reason is that the country is running such vast balance of payments surpluses, that they really don't know what to do with it. Kuwait is a nation of only 1 million people. And that little nation is running a balance of payments surplus of 12 billion dollars in 1979 alone. And if they were to continue to produce at current levels, with the higher prices, their current account surpluses would be even higher next year. And what to do with all these surpluses? They can invest them in United States Treasury Bonds or in the Euro-Currency market; but given the uncertainties on the rate of inflation, that is not necessarily the very best investment. And direct investment takes an awful lot of expertise, and sometimes runs into political opposition in the consumer countries.

Unfortunately, for us and to some extent for Kuwait, if they reduce production, and if other OPEC countries are going to reduce production, there may be additional pressure on oil prices. Prices, in spite of the projected low-economic growth rates next year, may still continue to rise. The net result would be that Kuwait, with less production, would still earn as much money as they would at the higher rate of production. So it's very understandable for Kuwait to take this kind of an action but it is deplorable if one looks at it from the consumer side of the world. Other countries may do the same thing but we don't know. Iran may reduce production; Libya may reduce production; and a number of other countries may reduce production. Saudi Arabia would like to reduce its output from the current 9½ million barrels per day to their long-term projected 8½ million barrels per day.

The net result of all of this is that in 1979 the industrial countries and the developing countries are going to run very substantial deficits on their balance of payments. And for the industrial countries that means they are going to suffer from higher inflation rates. Higher inflation is likely to be translated into lower economic growth rates, when the monetary authorities attempt to reduce the rate of inflation. The lower economic growth rates in turn, will lead to less trade and to more unemployment. The developing countries, which in the previous period (1974-78), found ways to finance the additional burden that high oil prices brought with them are going to have growing difficulties financing their already very high external debts. Are the private banks going to be able to finance the additional oil purchases? If not, then many developing countries will have to forgo some of their oil purchases, unless OPEC and the industrial countries will off - set their purchases by direct or international or multinational aid. And under low economic growth rates in the industrial countries, one cannot really expect a growth in their aid.

So the situation for the next 2 years at least doesn't look very good. Going beyond that, the world oil market continues to be uncertain. We see an increase of a couple million barrels a day of oil production in the non-OPEC countries, particularly in the North Sea, Mexico, and a number of developing countries outside of the OPEC group. But that increase will not be enough to bring about or to make possible a moderate growth rate in world oil demand of even 2 percent. And 2% growth in oil demand is only ½ of what we were accustomed to in the period prior to 1973. In other words, in order for world oil demand to grow at 2-3% there needs to be (1) a great deal more production from non-OPEC sources, (2) production in North America will have to stabilize if not increase, and (3) the Soviet Bloc -- the centrally planned economies -- have to stay out of the world market. And all this is not at all sure. We think it's quite possible that the Soviet Bloc and in particular Eastern Europe, will become a net importer of oil. We believe that it is quite possible that North American, with the exception of Mexico's oil production is not likely to grow. And if OPEC, as it intends to, will not increase production by very much, you are going to see a growing tightness in the market that will translate into even higher prices than we have today. These higher prices in turn will lead to more inflation, lower growth rates, and more unemployment.

And how to get out of this vicious circle? To get out of this vicious circle, we in the industrial nations need time. Time for transition. Time for transition from the overreliance on imported oil to a combination of conservation, changes that can be brought about with both changes in lifestyles and more efficient use of oil in the industrial process. And it can be brought about by substituting other sources of energy for oil. But all that takes time. We need at least a decade to bring about this transition. And within that decade, we need fairly high economic growth rates to muster the capital that is needed to make a transition -- to put

that capital into alternative energy systems, into various methods to increase the efficiency of energy use in general and of oil use in particular.

If we don't have fairly reasonable economic growth rates, the transition cannot be brought about; or it will take a much longer period of time. We would be faced with a prolonged situation of very low economic growth rates. These low growth rates in turn are likely to have a major effect on the developing countries. And it is within this larger context, as the way we look at the world market, that I think that is is important for you to address the specifics of developing country demand and supply of energy during the rest of this conference.

Future Energy Resources and Use in Asia
The Needs for Research and Development

Roger Revelle *

INTRODUCTION

The 15 largest countries of South and East Asia contain half the Earth's population, but only 14% of its inhabited land area and about a fourth of the cultivated land (see Table 1). Because of their large populations and relatively small cultivated areas, the densities of population on cultivated land are very high - averaging more than five persons per cultivated hectare, compared to about 1.3 persons in the United States. Although these countries were originally heavily forested, the need for agricultural land to feed growing populations has resulted in a reduction of the forest area to only 11% of the world total 1/. Population sizes and land areas range from 900 million people living on 960 million hectares in China, to 17 million people on 3.6 million hectares in Taiwan, and 13 million people on 14 million hectares in Nepal. Population densities on cultivated land vary by a factor of 12.

Energy Resources of the Asian Countries

Energy resources relative to population are even more variable from country to country. These resources are shown in Table 2 in a common unit - millions of metric tons of coal equivalent (one million metric tons of coal equivalent contains 27.8 trillion BTUs or 7 trillion kcal, close to 1000 megawatt years, or 10^{-3} terawatts). For the non-renewable fossil fuels (coal, lignite, petroleum, natural gas liquids, and natural gas), Table 2 gives the total known or estimated resources. It should be noted that, in general, the location and extent of these resources have been inadequately explored, and no more than guesses can be made concerning the fraction that could be recovered or the costs of recovery. For the potential "renewable" resources (hydropower and thermal energy in forest biomass) estimated maximum annual yields have been multiplied by 100 to give some measure of comparability with the total fossil fuel resources. The potential sustainable annual yield from the forests is taken as 22% of the estimated net annual primary production 2/. This is several times larger than the yields now being obtained.

The People's Republic of China has by far the largest energy resources, both in total and per capita 3/. Its fossil fuels and potential hydro power correspond to 868 tons of coal equivalent per person and make up about 13% of the estimated world total. Outside of China, the Asian countries, with 30% of the world's population, are endowed with only a little more than 2% of the world's fossil fuel and hydropower resources. Even this small fraction is unevenly distributed among the different countries. India, Japan,

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TABLE 1

Population, Agricultural land, and Forests in 15 South and East Asian Countries

Country	Population millions	Total Area million ha	Agricultural Area irrigated(1)	total million ha	Forests million ha	Population Cultiv ha caput	Density forest ha caput
Bangladesh	85	14.4	1.2	9.1	1.5 (2)	.11	.02
Burma	32	67.8	0.8	18.9	39.0	.59	1.22
China	900	959.7	76.0	127.0	111.8	.14	.12
India	638	328.0	31.6	165.0	65.8	.26	.10
Indonesia	137	190.4	6.9	18.1	121.8	.13	.89
Japan	116	37.2	2.6	5.3	24.5	.05	.21
Korea	37	9,8	0.8	2.4	6.6	.06	.18
Malaysia	13	33.0	0.3	3.5	23.5	.26	1.81
Nepal	13	14.1	0.2	2.0	4.5	.15	.32
Pakistan	77	80.4	14.0	19.4	2.6	.25	.03
Philippines	46	30.0	1.2	11.1	13.9	.24	.30
Sri Lanka	14	6.6	0.5	2.0	1.3 (2)	.18	.09
Taiwan	17	3.6	NA	0.9 (3)	NA	.05	-
Thailand	45	54.4	2.5	13.9	16.0 (2)	.31	.36
Viet Nam	50	33.0	0.6	5.3	13.5	.11	.27
TOTAL	2,220	1,862.4	139.2	403.1	446.3	.18	.18
% of estimated world total	50	14		27	11		
% of world total Less China	30	7		19	8		

Notes:
(1) Irrigated area around 1970
(2) see text
(3) author's estimate

Sources: Population and total land areas: Asian Development Bank, 1979

Land Use: FAO Production Yearbook, 1974 Table 1, except where noted.

TABLE 2

Estimated Fossil Fuel, Hydropower and Forest Energy Resources in South and East Asian Countries
in millions of metric tons of coal equivalent

Countries	Coal and Lignite (1)	Petroleum & Natural Gas Liquids	Natural Gas	Hydro(2)	Forests(3)	Total	Total per caput metric tons/person total	less forests
Bangladesh	1,187	--	290	10	270	1,753	20	17
Burma	N/A	12	N/A	N/A	6,920	6,932	217	?
China	719,000	17,300	26,500	18,000	19,850	800,650	890	868
India	85,800	3,000	9,800	730	11,680	110,010	172	154
Indonesia	2,520	2,300	N/A	410	21,620	26,850	196	38
Japan	8,760	11	150	7,950	4,350	21,221	182	145
Korea	1,515	--	N/A	615	1,170	3,300	89	58
Malaysia	N/A	630	N/A	4,915	4,170	9,715	747	426
Nepal	--	--	--	400	800	1,200	92	31
Pakistan	650	42	690	470	460	2,312	30	24
Philippines	920 (4)	400 (4)	N/A	240	2,470	4,030	88	34
Sri Lanka	--	--	--	45	230	275	20	3
Taiwan	450	2.5	--	1,280	N/A	1,733	102	102
Thailand	235	0.4	190	825	2,840	4,090	91	28
Viet Nam	12	N/A	N/A	335	2,400	2,747	55	7
TOTAL	821,049	23,687	37,620	36,225	79,230	996,818	449	413
%of estimated world total	16.2	5.3	10.9	30.7	12.4	16.5		
% world total, less China	2.0	1.4	3.2	15.4	9.3	3.2		

Notes:

(1) Total known resources of coal and lignite; economically recoverable resources may be less than _____.

(2) Hydropower resources taken as 100 times potential annual production of electric energy, converted to coal equivalents, assuming one equivalent ton of coal = 3×10^{10} joules.

Notes (Table 2 - con't)

(3) Forest resources taken as 100 times potential annual yield (= 22% of estimated net annual primary production of 8.07 metric tons of coal equivalent/hectare).

(4) Solid fuel and petroleum resources from data in: Republic of the Philippines, Ministry of Energy, "Ten-Year Energy Program, 1979-1988." The Philippines also have significant geothermal resources. The planned electric generating capacity for geothermal sources may be nearly 1900 megawatts by 1988, equivalent to annual combistion of 6 million metric tons of coal equivalent.

Sources:

Coal and lignites from Wrold Energy Conference, Coal Resources (IPC Science and Technology Press, Guildford, England, 1978)

Petroleum, Natural Gas, and Hydropower resources from Survey of Energy Resources 1978 (IPC Science and Technology Press, Guildford, England, 1978) supplemented by Oil and Gas Journal, December 5, 1978, pp. 102-103; Nehring, Richard, Giant Oil Fields and World Oil Resources, Report R-2284-CIA (Rand Corporation, Santa Monica, Calif.: 1978); Parent, Joseph D. and Henry R. Linden, A Survey of U.S. and Total World Production, Proved Reserves and Remaining Recoverable Resources of Fossil Fuels and Uranium as of December 30, 1975 (Chicago: Institute of Gas Technology, 1977).

Malaysia, and Taiwan possess more than 100 tons of coal equivalent per person. So far as is known, the remaining 10 countries have much less than 100 coal equivalent tons of these resources per person, ranging from 58 for Korea to 3 for Sri Lanka - clustering around 30 tons for Bangladesh, Indonesia, Nepal, Pakistan, the Philippines, Thailand, and Viet Nam. On a per capita basis, Burma, Indonesia, Malaysia, Nepal the Philippines and Thailand have fairly extensive forest resources, with potential sustainable yields of between 0.5 and 8 tons of coal equivalent per person per year. Potential sustainable forest yields in the other countries are smaller, varying from 0.48 tons per person per year in Viet Nam down to .06 tons in Pakistan and .03 tons in Bangladesh.

Present and Future Uses of Energy in Asia

Most available statistics on energy use refer only to so-called "commercial" energy, that is, energy from fossil fuel and hydroelectric installations. But for the poor countries of Asia, the figures on commercial energy are misleading. On the average, total energy use is about twice the quantity of commercial energy. The major part of the difference is made up of biomass fuels - wood, charcoal, agricultural residues, and cattle dung - and a significant fraction is accounted for by energy expended in human and animal labor. As may be seen in Table 4, estimated use of biomass fuels, plus human and animal labor corresponds to around 200 to 400 kg of coal equivalent per capita per year. Most of this non-commercial energy is devoted to cooking and other household uses. The fraction of energy used in agriculture, but not the absolute quantity, is much higher than in the industrialized or "developed" countries.

In the past, the proportion of commercial energy has increased with time and economic growth. This increase resulted chiefly from the growth of the industrial and transportation sectors, and partly because convenient commercial sources were substituted for traditional ones as incomes rose and people migrated to cities and towns from the countryside.

The population of East and South Asia, outside of Japan, in the first quarter of the Twenty-first Century is likely to be around 4000 million people - about twice what it is today. To achieve a levelling-off of population growth in the next 50 years, the incomes of most people in these countries must rise substantially, and if this happens, it is likely that the proportions of the populations living in cities and towns will also about double. Demands for food, fibers, and energy should be much more than twice those of today.

Haefele 4/ has estimated that per capita energy consumption in the developing countries of Asia, Africa, and Latin America would increase between three and five times over the next 50 years,

provided normal expectations of economic and social development are realized. His conclusion is confirmed if we examine future energy needs in rural areas of Asia, which will probably contain about 2 billion people by the end of the first quarter of the Twenty-first century. 2/

To produce the needed food supplies for their own countries - approximately 1.7 billion tons of food grain equivalent, with an energy content equal to that in 800 million tons of coal - the energy required for irrigation, fertilizer production, and operation of farm tools and machinery would correspond to 350 million tons of coal equivalent. Thermal energy used in rural households would total 230 million tons, and transportation of agricultural harvests, rural industrial harvests, rural industrial products, farm inputs, and human beings could use up to 800 million tons of coal equivalent. Energy expenditures in rural industry would be between 400 and 800 million tons. Household lighting could add one kwh/person/day or 80 million tons.

The maximum estimated rural energy use, not counting human energy in manual labor or thermal energy used to generate electric power, would be equal to 2.3 billion tons of coal equivalent. This is 28% of the entire world consumption of energy at the present time, and twice present use in South and East Asia, outside Japan. Per capita use would correspond to 1.1 tons of coal equivalent. It would be expected that rural incomes would still be considerably lower than those of the urban population and, consequently, because of the close relationship between incomes and energy, urban energy use per capita would be between 1 and 2 tons of coal equivalent, say a total of 3 billion tons. Thus, the overall energy demand would be close to 5 billion tons of coal equivalent - four and a half times present energy use.

For China, with its vast coal deposits and large reserves of petroleum and natural gas, such an increase in energy use would not be constrained by the availability of fuel resources, though large capital investments and considerable development of energy technology would be required. India and Malaysia could turn to their coal and hydropower reserves, respectively, provided they could find the needed capital and technology. India has a sufficiently large and diverse science and technology establishment to be able greatly to expand its use of nuclear fission energy, in addition to developing its fossil fuel and hydropower resources. But for the poorer developing countries of Asia, presently-known energy resources could not sustain the large increase required for economic and social development. These countries will either need to find and develop new energy resources within their own borders (including economical methods of conservation) or depend on large-scale imports of fossil fuels. For the first alternative, long-range research and development will be an essential pre-requisite. The second alternative is, of necessity, being followed on a short-range basis, with potentially disasterous results.

Overall trade balances and petroleum imports of the developing-market-economy Asian countries in 1972-73, just before the first rapid rise in petroleum prices, and in 1978, before the recent 250% increase, are shown in Tables 3a and 3b. The comparative figures reflect the world-wide inflation of commodity prices, the strenuous efforts of the Asian countries to increase their exports, and their significant economic growth as well as the effects of the quintupling of petroleum prices during these six years.

TABLE 3a

Trade Balances and Petroleum Imports for Developing Market Economy
East and South Asian Countries - 1972-73
(millions of US dollars)

Country	Total Imports	Petroleum Imports value	Petroleum Imports % imports	Debt Service	Exports	Exports less imports and Debt Service
Bangladesh	875	24	2.7	9	415	-475
India	3,210	264	8.2	652	3,325	-535
Indonesia	2,730	44	1.6	211	3,300	360
Korea	4,240	296	7.0	617	4,115	-742
Malaysia	2,510	156	6.2	85	3,315	720
Nepal	95	13	13.2	0.5	29	-66
Pakistan	980	65	6.6	187	1,130	-37
Philippines	1,800	188	10.4	214	2,465	451
Sri Lanka	430	38	8.8	55	425	-60
Taiwan	3,796	100	2.6	180	5,140	1,168
Thailand	2,050	226	11.0	55	2,110	5
TOTAL	22,712	1,414	6.2	2,266	25,769	790

Source: Asian Development Bank. Annual Report, 1979

TABLE 3b

Trade Balances and Petroleum Imports for Developing Market Economy East and South Asian Countries - 1978
(Millions of US dollars)

Country	GNP	Imports	Petroleum Imports value	Petroleum Imports % of imports	External Debt Service	Exports	Exports less imports and Debt Service
Bangladesh	7,590	1,555	175	11.2	94	550	-1,100
India	112,665	7,400	1,900	25.7	913	6,400	-1,913
Indonesia	48,530	6,650	580	8.7	1,388	11,200	3,162
Korea	39,000	14,970	2,312	15.4	1,795	17,100	335
Malaysia	14,545	5,920	627	10.6	705	8,000	1,375
Nepal	1,585	225	21	9.3	2.2	81	-146
Pakistan	17,525	3,325	495	14.9	316	1,840	-1,800
Philippines	23,080	5,140	1,030	20.0	646	4,715	-1,070
Sri Lanka	2,72-	935	142	15.2	89	970	-54
Taiwan	23,935	11,050	1,590	14.4	633	14,380	2,695
Thailand	21,790	5,355	1,125	21.0	171	5,015	-510
TOTAL	312,955	62,525	9,997 (1)	16.0	6,752	70,251	974
% OF WORLD TOTAL		4.7	3.0 (2)			5.5	

Notes:

(1) volume of petroleum imports = 87.7 millions metric tons
(2) volume of total world crude oil production = 2,903 million metric tons

Source: Asian Development Bank 1979 Annual Report - Statistical Tables (Bangkok 1979)

Tata Services Limited, Statistical Outline of India, 1980 (Bombay, 1980)

The only countries with improved trade balances between 1972-73 and 1978 were Indonesia - which is a large-scale exporter of its own low-sulphur oil and an importer of small quantities of petroleum products and low-grade crude - and the most rapidly developing countries of Korea, Taiwan and Malaysia. Trade balances (including external debt services) markedly worsened in the remaining seven countries. Bangladesh, Pakistan, the Philippines, and Thailand were especially hard hit, in terms of the ratio of the trade deficit to gross national product. India also experienced a marked deterioration in its balance of trade in commodities, but this was more than made up for by remittances from Indian citizens employed in the Middle Eastern oil countries.

The total petroleum imports by the Asian countries represent only about 3% of the world oil production; thus, they plan a minor role in the worldwide competition for petroleum and petroleum products. Nevertheless, the ratio of the money value of oil imports to total imports rose from an average of slightly more than 6% in 1972-73 to 16% in 1978, ranging from nearly 26% in India and 21% in Thailand to between 8.7% and 11% in Bangladesh, Indonesia, Malaysia, and Nepal. Indonesia and Malaysia are sulf-sufficient in petroleum, while uses of all forms of commercial energy in Nepal and Bangladesh are very low.

The probable impact of the sharp rise in import prices of petroleum and petroleum prices in 1979-80 can be easily visualized in the case of Thailand 5/. With no change in the volume of oil imports (about 20 million tons of coal equivalent in 1978), or in the value of exports and imports other than petroleum, the oil import bill could be close to $2.7 billion in 1980, about 40% of the value of all imports. The trade deficit, plus services on external debt, could be more than $2 billion, on the order of 10% of GNP.

Under these circumstances, Thailand's recent rapid rate of industrial growth is likely to slow down drastically. Not only will growth be affected by rising energy costs, but the prices of the equipment and commodities Thailand must buy to increase its industrial production will almost certainly rise, in large part because of rising energy costs in the supplying countries. At the same time, the need to channel a larger proportion of resources into oil imports may diminish the country's ability to procure other supplies and make needed capital investments. Agricultural development will be adversely affected by the rising costs of transporting inputs and harvests and of manufacturing nitrogen fertilizer from oil products or natural gas.

If economic growth, including a continually increasing volume of exports, could be maintained without a corresponding rise in the volume of imports of crude oil and petroleum products, Thailand's situation would gradually improve over the next decade. But growth of industry and agriculture will almost certainly require increasing use of energy in these two sectors and in transportation of goods, as well.

The dilemma might be partially resolved by early development and use of Thailand's estimated resources of coal, lignite, and natural gas, which, according to Table 2, comprise 425 million metric tons of coal equivalent. But these resources, even if it were possible to substitute them for present oil imports, would be exhausted in 21 years. Thailand's hydropower resources could provide an annual energy supply equal to the thermal energy in 8.25 million tons of coal equivalent. But most of the unutilized hydro potential cannot be exploited quickly. It is largely dependent on power development of the Mekong River, and at present, its development faces severe political problems. In principle, the forested area

of Thailand, which, according to Table 2, has a potential annual energy yield of 28.4 million metric tons of coal equivalent, could meet a larger fraction of the country's energy needs than at present. But this would require a considerable increase in the sustainable annual yield of wood.

Thailand urgently needs to find new energy resources, to learn to utilize its limited energy supplies more efficiently in all sectors of the economy, and to practice vigorous energy conservation. Each of these activities will involve extensive applied research and development.

TABLE 4

Approximate Energy Use Per Capita in Five Asian Countries

Energy Source	China 1977	Bangladesh 1978	India 1978	Sri Lanka 1975	Thailand 1977
	kg of coal equivalent/person				
Commercial Coal and Liquite	427	4	115	0.7	7
Oil		23	51	82.0	310
Natural Gas		17	3		
Hydro Power & Nuclear		2	8	8.5	33
TOTAL	427	46	177	91.2	343
Non Commercial Firewood and Charcoal	57	46	238	163	370
Other Biomass	103	187			41
Human Labor	43	33	44		
Animal Labor		17	111		
TOTAL	203	283	393	163	411
Total, Commercial and Non Commercial	630	329	570	254	754

Sources:

China: Smil, V., "China;s energetics: A system analysis", Chinese Economy Post Mao, Washington, D.C., Joint Economic Committee, Congress of the United States, 1979.

Bangladesh: Briscoe, J., "Energy use and social structure in a Bangladesh village:, Population and Development Review Vol. 5, No. 4, pp 615-641, New York, Population Counsel, 1979.

India: Desai, A.V., The Impact of the Rise in Oil Prices on India, Center for Development Studies, Ulloor, Trivandrum, May 1979.

Sri Lanka: Senadhipathy, D.G., Energy Consumption Aspects and the Rural Sector, Asia Bureau Conference on Energy, Forestry, and Environment, Manila, 1979.

Thailand: U.S.A.I.D. Mission, Thailand, Annex III to Project Paper for Renewable Non-Conventional Energy Project, U.S.A.I.D. Bangkok, 1979.

Energy Research and Development in the Asian Countries

It is well-recognized that intensive research and development are needed in all countries to enable the world to make the transition from an oil-based energy economy to a new order based on other forms of energy. Because their resources and problems differ in many fundamental ways from those of the developed countries, the poor nations of Asia, Africa and Latin America need to undertake research and development programs with a special thrust and emphasis. This is particularly true of the oil-importing countries of South and Southeast Asia, with their extreme poverty and high, and rapidly growing, population densities.

We can conveniently classify energy research and development in six broad areas: Production, Conversion, Transportation, Storage, Conservation, and Economic and Social Issues. These categories are not exclusive; research and development in any one of them is likely to spill over into others.

Energy Production

The two most important energy production problems in Asia are to find and develop reserves of petroleum, natural gas, and other energy resources, and to increase energy yields from trees.

Systematic exploration for deposits of petroleum and natural gas, using modern geophysical and geochemical tools and drilling methods, and the geological concepts of plate tectonics, has not been undertaken on a sufficiently large scale in any Asian country. Such exploration is costly and risky and requires highly-qualified technical personnel. In the past, the Asian countries have not been able to allocate the necessary capital, and they have lacked the trained specialists. Their needs for oil and natural gas have been relatively small and could be met by low-cost imports. But the needs are rapidly increasing, and the ten-fold rise in petroleum prices during the last seven years gravely jeapordizes their economies. A systematic search for oil and gas deposits in the offshore areas on the Continental shelves and slopes appears to be especially promising. Significant results have already been obtained. Thailand has discovered a large natural gas field in the Gulf of Thailand 6/ The Philippines are now producing petroleum from an off-shore field

near Palawan 7/, and India is obtaining several million tons of oil a year from the "Bombay High" southwest of Bombay 8/.

Surveys of other kinds of potential energy resources are also needed, especially the possibilities for wind, small-scale hydropower, and geothermal energy.

The technology for extracting power from the wind is rapidly developing. But all windmills are bound to have two characteristics: the power produced varies with the cube of the wind velocity; and no power will be produced at all below a certain threshhold wind speed 9/. Stong, steady winds are most likely near the seacoast; hence, a country like Sri Lanka, which has a relatively long seacoast compared to its area, may be able to meet a significant fraction of its energy demands by installing windmills 10/. As surveys in Thailand show 11/, there may also be large areas in the interior of a country where the winds are sufficiently strong and steady to provide a useful source of energy, at least to pump water for irrigation. In general, climatological data on the frequency distribution of wind speeds are not now adequate in the Asian countries to form a basis for extensive investment in wind machines.

Equally lacking are sufficient data on the annual variations in flow of small and medium-size streams in hilly regions where micro- or mini-hydroelectric generators might be installed. Such generators depend on diversion of a small quantity of water from a stream into a channel where the water can be carried nearly parallel to a contour until it can be dropped through a penstock which will provide sufficient head. To minimize costs of the "Civil works", a high head (on the order of 100 meters) and a small volume of flow (a fraction of a cubic foot per second) are desirable. In both Nepal and Thailand, it has been estimated that at least 500 mw of firm, year-round power could be generated in this fashion 2/, 11/. Extensive possibilities also exist in Sri Lanka, the Philippines, and the hilly regions of Pakistan and India.

A search for sources of geothermal energy has been notably successful in the Philippines 7/. The planned electric generating capacity from geothermal sources may be nearly 1900 mw in 1988, equivalent to annual combustion of 6 million metric tons of coal equivalent. Geothermal energy resources in Indonesia could also be extensive.

Wherever fuel wood is available in less-developed countries, wood is the "poor man's oil" 12/. It is the principal source of energy for cooking and other domestic uses in Sri Lanka 10/, Nepal 2/, and Thailand 11/ , and probably in the Philippines, and it is an important fuel in the rural areas of all Asian countries 8/, 12/. In most of these countries, the forests are being rapidly destroyed as populations grow - not only because of the growing needs for fuel wood but also because of destructive logging for timber, clearing of land for settled agriculture, and shortening of the rotation cycle for "slash-and-burn" agriculture.

In the Chittagong Hill tracts in the southeastern part of Bangladesh, about 40 percent (870,000 hectares) of the total forested area of the country is being rapidly destroyed by illicit timbering and by shifting cultivators who have reduced the traditional ten-year "slash-and-burn" rotation to three years 14/. In the Hills of Nepal, the 3.4 million hectares of forested land are being depleted for fuel and cattle feed at an annual rate of more than 3 percent. This could lead to total depletion within 30 years 2/. Between 1963 and 1971 in Thailand, the total land area covered by healthy forests was appreently reduced from 53 percent to 39 percent of the area of the country 15/. It is estimated that the forested area is now probably less than 30 percent - probably about 16 million hectares. In Sri Lanka, the forest cover has been reduced since 1956 from 44 percent to about 20 percent of the total alnd area by a combination of land-clearing for settled agriculture, slash-and-burn agriculture with progressively shorter rotation times, and illegal exploitation of trees for construction and household and industrial fuels (chiefly in manufacturing tea, ceramics. brick and tobacco 16/. Sri Lanka's major development program - the accelerated Mahaweli River Development scheme - will reduce the forest cover still further to 16 to 17 percent of the total land area, or about 1 million hectares. In India, actual or potentially-usable forests are said to cover around 66 million hectares, mainly in mountainous regions, and in four states that have less than 20 percent of the population. The forests are being cut down faster than they can grow, partly to make room for new farmlands and partly for use as fuel. In consequence, the upland areas are subjected to destructive erosion, which results, in turn, in rapid silting of irrigation and power reservoirs and destructive floods in downstream areas 17/.

The yield of wood [illegible] her timber or fuel from the natural forests of South and [illegible] sia is extremely low. Estimates for Thailand indicate th[illegible] .02 percent of the incoming solar energy is photosyn[illegible] verted into wood 11/ that can be used for fuel and ti[illegible] tainable-yield basis. In Nepal, the efficiency of ph[illegible] solar energy conversion into fuelwood and animal forate is [illegible] bout .03 percent 2/. The "Sal" forests of India are said to take 80 years or more to mature.

Intensive tree-planting programs are urgently needed to provide fuelwood for cooking and other domestic uses in rural areas. In the long run, wood might also prove to be a partial substitute for fossil fuels as a source of energy for generation of electricity and other industrial uses. Because of the pressures on land use for agriculture, the areas planted in trees must be kept as small as possible, and this will require a very considerable increase in the yields per unit area of useful products from trees.

Higher yields can be obtained from several varieties of fast-growing trees that have been discovered in different parts of the world in recent years. One of the these, the Hawaiian Giant", or

Salvador variety of evergreen tropical legume, Leucaena leucocephala, is especially well-suited to humid and semi-humid lowland tropics 18/. In dense plantations in the Philippines, this tall, virtually branchless tree, which can grow to a height of 20 meters in six to eight years, has produced 12 to more than 50 tons of wood/hectare/year. At 25 tons/hectare, about 17 percent of the incoming solar energy is converted into the chemical energy of wood.

Leucaena is able to withstand long dry seasons and to tolerate a wide array of soil conditions, owing to its deep, aggressive root system that reaches far below the soil's surface for water and nutrients. In energy plantations, it could be continuously renewable source of fuel because the stumps readily re-grow or coppice, and thus "defy the woodcutter". However, it does not grow well in acid soils high in alumina or at elevations above 500 meters, and the young trees must be protected against grazing animals which eagerly browse on the protein-rich foliage 19/. It is being widely-introduced in Sri Lanka as a garden tree for rural households 10/. In the Philippines, where it is called the Giant Ipil-Ipil, an energy plantation of several thousand hectares of Leucaena is planned for electrical power generation 2/, and a Japanese steel company has planted over 5,000 hectares as a source of smelting charcoal 20/. The tree has been introduced in Thailand during the last five to seven years; it is also popular in Indonesia 21/.

Other fast-growing trees for fuel production include Acacia auriculiformis, Acacia albida, Casuarina equisetifolia, Caliandra callothyrsus, Eucalyptus camaldulensis, and Eucalyptus spp 19/.

Much research, development, and demonstration should be undertaken in each of the Asian countries to determine the species that are best suited to local climatic, soil, topographic, and social environments, and the most productive and feasible cultural practices, including spacing, length of rotation, weeding and irrigation, and methods of protection against fire and browsing animals. An important research problem is study of the ecological characteristics of the beneficial mycorrhiza fungi which infect the root-hairs of the trees and transfer phosphorous and other nutrients from the soil to the roots 18/. The adaptability of the mycorrhiza to transplantation may determine the range of environments in which a particular tree species can be productively grown.

Wherever sufficient village land is available, it may be possible to establish managed "community woodlots" using one or more varieties of fast-growing trees. This is being attempted on a trial basis in the different regions of Thailand, where the average household uses up to five tons of fuelwood per year 11/. Assuming an annual yield of 15 tons/hectare, 133 hectares would be required per average family, or about 30 hectares for a village of 100 families. Annual costs have been estimated at $72/hectare, or $4.80 per ton of wood, compared to a price of $6.25 per ton recorded in urban and rural areas of northeast Thailand.

To provide the fuelwood requirement for the present Thai population of 44 million would require 2 million hectares, assuming an annual yield of 15 tons of wood per hectare. As Table 1 shows, this is 14 percent of the present cultivated area of Thailand. It is unlikely that the rural people would be willing to devote such a large percentage of cultivated area to wood production when the average value of their rice crop is nearly $400 per hectare, with rice selling at $325/ton.

In Indonesia, Bangladesh, and Sri Lanka, trees for fuelwood and livestock forage are grown together with vegetables, spices, and fruits in home gardens - small plots surrounding the homestead. The plants grown in these areas have a complex, three-dimensional ecology in which the tallest trees partially shade lower trees and bushes and crops grown near the ground. Falling leaves and litter from the upper canopy are beneficial to the smaller plants. Research needs to be done on the most suitable fast-growing trees which can be introduced into these micro-ecosystems. For example, introduction of Calliandra callothyrsus, which is a good producer of fuelwood, would not be desirable in many home gardens - at least in Indonesia 21/. This bushy tree branches profusely from near its base and needs full sunlight, even though it is only 2-3 meters tall. Consequently, taller trees would have to be removed, and cassava, coffee, taro, citronella and other low-growing plants would be displaced by the profuse coppicing of Calliandra. On the other hand, Leucaena might be well suited because it can tolerate moderate shade, does not excessively shadow lower plants, and its dropping leaves provide abundant nitrogen.

With the severe pressure on agricultural land in the crowded Asian countries, it will be essential to increase the yields of wood from forested areas that are not suited for agriculture because of steep slopes, irregular topography, rocky, thin soil, or other reasons. The average net primary production (photosynthetic production minus respiration) of Asian forests is believed to be about seven tons of organic carbon/hectare/year 22/, with an energy content of 5.6×10^7 kcal. Thus, the forests convert about 0.37% of the incoming solar radiation into chemical energy of organic matter. Yet, as we have seen, less than 5 percent of this quantity is being recovered for human use. Most of the net primary production is in the form of leaves and roots, but it is estimated that about 22% could be recovered on a sustainable basis as wood, useful for fuel and other purposes, in forests under intensive silviculture 2/. In the tropics, this will undoubtedly require replanting of forested areas with those species of fast-growing trees that are most appropriate for each local environment. Such a transformation of the Asian forests will require a broad, sophisticated research and development program based on tree genetics (including somatic-cell genetics) and physiology, as well as on practical field experimentation. An international forest research center similar to the International Rice Research Institute at Los Banos in the Philippines, established in a south Asian country by a consortium of multilateral

and bilateral donors, could provide the focus for this urgently-needed program of accelerated forest research.

Another long-range international research program related to energy production should also be considered. The Asian countries possess a relatively large share of the world's hydroelectric potential, but geologic and hydrologic conditions make the costs of development very high. One of the reasons is that the rivers flowing from the great Asian mountains carry some of the highest sediment concentrations in the world. Consequently, reservoirs for power and irrigation silt up very rapidly. It is expected that the reservoir behind the world's largest dam, Tarbela Dam in Pakistan, with an initial live-storage capacity of 12 billion cubic meters, will be completely filled by sediment in the next 40 years. Some hydraulic engineers have suggested that it should be possible to design a non-silting dam, that is, a dam through which river-borne sediments would in some fashion be sluiced out instead of accumulating in the reservoir. This possibility deserves analytical and model studies and field trials on a pilot basis.

Energy Conversion

Many research and development problems in energy conversion are especially urgent in the Asian poor countries, although they are not unique to those countries. These include problems of converting wood to charcoal, pyrolysis of organic wastes, wood combustion, the microbiology of anerobic production of methane from human, animal, and vegetable wastes, small-scale hydroelectric power generation, nitrogen fixation, uses of solar energy for water heating and crop and wood drying, and integrated use of different energy sources. Other problems, such as the microbiology of alcohol production, lowering the costs of photovoltaic conversion of solar energy, improving efficiency of electricity generation from fossil fuels, solar space-heating and cooling and thermal electricity generation, and co-generation of electricity, steam, and process heat, are important for both developed and developing countries. Attaining a range of solutions may be facilitated by cooperative research between groups of scientists and technicians in different countries. A third set of problems is for the time being of primary concern to the rich countries because of the requirements for very large investments of capital and technical personnel. These include conversion of coal, oil shale, and tar sands to liquid fuels and safe management of nuclear power.

Wherever it can be obtained at sufficiently low cost in the poor countries, charcoal is preferred over wood as a domestic fuel. Presently used charcoal braziers in Thailand have an "efficiency" of 15 - 20 percent, that is, 15 - 20 percent of the heat energy of combustion is actually utilized in boiling rice or frying other foods, whereas wood stoves are only 5 - 10 percent efficient. Because of its high energy density, transportation costs for charcoal are much less than for wood with an equivalent energy content, and

it is generally considered that with transportation distances of more than 80 km. charcoal is a more economical fuel. Charcoal burns without generating much smoke, and consquently it is preferred over wood and other biomass fuels in urban areas 10/.

In Thailand, charcoal is made from rice husks and from the wood of the mangrove forests in South Thailand. Coconut husks are also used in Sri Lanka 15/. Charcoal can be made from sawmill wastes, which make up to 60 percent of the total quantity of harvested timber and from logging residues. It has been estimated that as much as 40 percent of the mass of harvested trees is now left to rot in the forests (and even more in clear-cut areas) 10/.

Highly efficient charcoal kilns consume 3 to 3.5 tons of wood to produce a ton of charcoal; 50 - 60 percent of the heat energy in the wood is converted into energy in charcoal. With the methods presently used in the Asian countries, only about 30 percent of the wood energy is converted. Adaptive research is needed to produce charcoal kilns for small-scale family or village operation, using wood, or rice or coconut husks, and for larger-scale conversion of logging and saw mill wastes. A 30% increase in conversion efficiency appears feasible Charcoal from rice and coconut husks can be briquetted for more economical transportation and easier final use 10/.

Equipment for pyrolysis of rice hulls and straw has been developed in Indonesia. This can handle about one ton of feedstock per day to produce .25 tons of charcoal, .15 tons of pyrolytic oil, and usable quantities of gas. For a small rice mill, handling three or four tons of paddy per day, the operation can be highly profitable, with an estimated annual rate of return on investment of 50% or more 10/. Most of the energy in the feedstock is captured in the pyrolytic products. The potential for adaptation of a device of this sort for use in the villages and small towns of other Asian countries should be explored. Presumably, saw mill sawdust and finely-ground chips from logging operations could also be used as inputs.

The combustion efficiency of wood is low in the Asian countries, in part because the wood is not dry when it is burned. Perhaps as much as 15% of the energy of combustion goes to driving off water as steam. Where wood can be used for electric power generation, higher temperatures of burning and more efficient heat exchangers are desirable to increase thermodynamic efficiency from the presently estimated level of about 18 percent 2/. Research and development are needed on methods of wood-drying, controlling the oxygen supply in combustion, and improving heat exchange.

So-called biogas digesters for bacterial production of methane from human, animal and vegetable wastes are widely used in China 22/ and are being actively promoted in several other Asian countries. While there are many technical and social problems associated with these devices, including lower costs and greater reliability of

construction and the determination of appropriate sizes for community use, there is also a set of basic microbiological problems. Microorganisms are needed that can function effectively over a range of temperatures from 5 - 45°C and can utilize a high ratio of crop wastes to animal and human feces. Research should be undertaken to develop more useful strains of methane-producing anerobic bacteria. This is one of a large number of problems for research in applied microbiology that could be undertaken in the less-developed countries at relatively low capital costs for equipment and facilities. 23/

Research on microbial production of ethanol as a vehicle fuel in the Asian countries, with their high population densities on cultivated lands, needs to be directed toward utilization of organic materials that do not compete with human food production. The situation in these countries is radically different from that of Brazil 24/, in which the present population density on potentially-arable land is about .7 hectares per person, compared to an average of .18 hectares for South and East Asia. In Brazil, annual production of 26 million tons of ethanol from sugar cane is planned by 1990, at which time it is comtemplated that alcohol could be substituted completely for gasoline and deisel oil. At an assumed yield of 60 tons of sugar cane/hectare, the recovery of 70 liters of ethanol/ton, eight million hectares - nearly 12% of Brazil's potentially arable land - will be needed for production of sugar cane. The estimated capital cost will be $15 - 30 billion 2/. Even so, less than a liter of gasoline equivalent per person per day will be available in this large country in which transportation over long distances is essential for socio-economic development.

The aim of microbiological research and development for ethanol production in the Asian countries should be toward developing organisms and chemical engineering processes that can convert the cellulose and lignins of agricultural residues and other plants to ethanol, leaving a protein-rich by-product that can be utilized as an animal feed. A second objective should be to minimize the water content of the fermentation product in order to reduce the energy required for distillation 25/.

Small-scale, "run-of-the-river" hydroelectric power generation represents a considerable potential energy resource in several Asian countries. Experience in the United States and elsewhere shows that the total capital costs for turbines, generators, and "civil works" can be as low as $1,000 - 2,000 per kw for plants generating 3 - 20 kw 2/. But there remain serious problems of operation and maintenance of the equipment and acceptance and use of the electric power in the hill villages of South and Southeast Asia, with their low levels of mechanical skills and traditional life-styles.

The high proportion of potential hydro-power to other energy resources in several Asian countries, as shown in Table 2, suggests that efforts should be directed toward the conversion of electrical

energy to nitrogen fertilizer. In Norway, this is accomplished by electrolytic generation of hydrogen from water, followed by catalytic combination of the hydrogen with atmospheric nitrogen to produce ammonia. The process can be carried out in relatively small-scale plants which produce on the order of ten tons of nitrogen a day at a daily energy cost of about 175 mwh, but it is uneconomical at much lower production levels. For micro-hydro plants generating 10 - 20 kw, recourse may be had to the almost-forgotten electric arc process 26/. Air is passed through a chamber fitted with electrodes which generate an electric arc that converts part of the nitrogen and oxygen to nitrogen oxide. The air is then passed through a water bath containing calcium carbonate and the nitrogen oxide is captured as calcium nitrate, which can be precipitated and utilized directly as nitrogen fertilizer. The process is relatively inefficient, consuming 25,000 - 50,000 kwh per ton of nitrogen in fertilizer. But its simplicity and feasibility for small-scale operations appear to make it appropriate for village or small-town production, particularly in the isolated hill areas of Asian countries. 2/ Research is needed to reduce the energy requirement per ton of nitrogen and to develop simple, easily-maintained and operated equipment for village use.

Sun-drying of crops in the open air has always been practiced by farmers. It is particularly difficult during the monsoon season in Asia because of intermittent and unpredictable rainfall and almost continuous cloudiness. A large fraction of the nutrients in the grasses that grow during the monsoon in village pastures of the Nepalese Hills is lost because hay cannot be dried 2/

Solar drying can be improved in a variety of ways, at different scales of volume and costs. In Bangladesh, for example, rice is spread out on the earthen surface of homestead compounds. Covering the surface with an impermeable material and providing drainage would greatly speed up the drying process and thereby reduce losses. Small, flat-plate, plastic-covered solar "tent" dryers for rice, costing $10 - 20, have been used in Thailand 10/. These are said to reduce losses of rice from spoilage, insects, and birds by 5% - 15% and to result in a product which has both longer storage life and better milling characteristics, owing to its low moisture content. The farmer has more flexibility in timing the marketing of his crop, and he can expect a higher price because of its better quality. Dryers of this type can also be used effectively for vegetables, fruits, and fish. Larger batch and continuous-flow solar dryers, with capacities of one to several tons, have been designed and built in Thailand. These can be utilized for crop drying and in such small-scale rural industries as tobacco-curing, drying of export-grade lumber, and noodle-making. Solar drying is also potentially applicable to distillation of water for salt harvesting.

Technical research and development is needed for two purposes: 1) to reduce the cost and increase the effectiveness of solar dryers

for specific functions; 2) to design equipment that could be constructed by village and small-town craftsmen, using locally-available or inexpensively-transported materials.

To raise the incomes and improve the welfare of Asian peoples, more energy must be used in agriculture, industry, and transportation. Yet some energy sources such as petroleum products are rapidly becoming scarce, while others such as hydroelectric potential exist in limited quantity or, as in the case of forests, are being destroyed. One way to improve the situation is to utilize the different forms of energy in optimum combinations. Scarce, expensive forms should be used only for those functions for which they possess a market comparative advantage, and more abundant sources for those functions where they are economically practical. In many cases, a modest increase in the use of one form of energy can result in a much larger increase in the supply of other forms. For example, application of more nitrogen fertilizer in the farmlands of Bangladesh would provide not only more food but also a larger supply of rice, straw, and other crop residues needed for cooking 27/. The nitrogen fertilizer is the product of the conversion of fossil fuel energy, usually natural gas or naphtha. About 15 x 10^6 kcal are required to produce a ton of nitrogen in fertilizer. The energy content of the additional straw and rice husks produced by applying this amount of nitrogen can be at least 45 x 10^6 kcal. In the Hills of Nepal, use of electrical energy generated in micro-hydro plants to pump water for irrigation and to produce nitrogen fertilizer would make it possible to grow two high-yeilding crops per year on land that is best suited for cultivation. The land thereby released from agricultural uses could be utilized for a community woodlot planted in fast-growing trees. With a relatively low sustainable annual yield of five tons of firewood/hectare, the energy content of the wood would be more than twice the electrical energy utilized. 2/

Energy is required for many purposes in the rural areas of Asian countries: in agriculture for chemical fertilizers, lifting water for irrigation, cultivation of the fields, and crop-drying; domestically, for lighting, cooking, water- and space-heating; in transportation, for moving purchased inputs and harvests between farms and markets; and, in rural industries for shaft-power, steam, and processed heat. In any specific time and place, different forms of energy will have comparative advantages for these different uses. At present, manufacture of nitrogen fertilizer requires either fossil fuel hydro-carbons or electrical energy. Water-lifting commonly utilizes animal power, electric motors, or diesel-fueled engines, although pumps powered by windmills, biogas, or photovoltaic devices may be more widely used in the future. Traction for farm machinery is provided by livestock or by diesel-powered tractors. The sun's energy is mainly used for crop-drying, but heaters using fossil fuels, wood, or charcoal are often employed for specialty crops such as tobacco. Kerosene is commonly, and electricity sometimes, utilized for lighting. Cooking and water- and space- heating

depend mainly on fuel wood, charcoal, crop residues, and livestock dung, the latter, sometimes, as in China, converted to biogas. Energy for transportation, which in the past came largely from animal power, is becoming more and more dependent on trucks and tractors powered by liquid petroleum products. Shaft-power for rural industry has in the past often utilized an internal combustion engine as a prime mover, but central-station electric power is becoming more widely used. Industrial process heat in rural areas is usually produced from wood or charcoal and sometimes from coal or bottled natural gas.

The rapid and continuing rise in the prices of petroleum products has given considerable impetus to attempts to substitute other forms of energy for that of petroleum fuels in as many as possible of the uses described above. As research and development on alternative sources proceeds, this may become more and more practicable. One of the tasks of national energy planners, now and in the future, will be to assess the benefits and costs of utilizing these alternative sources for different energy functions. To accomplish this successfully, all available energy sources and all energy uses within a particular geographical area must be considered as part of an interacting system in which goods and services are produced on a sustainable basis to meet human needs.

Energy Transportation and Storage

The problem of energy transportation arises for two reasons: 1) Most commercial energy sources are highly localized in coal mines, oil fields and refineries, and hydroelectric power dams, while energy users are widely dispersed; and 2) Fuelwood, the principal traditional energy source often can be found only at a distance from the places where it is needed. Among the rural poor, much human energy and, commonly, the entire working time of one family member are expended in collecting and carrying it. For both commercial and traditional energy sources, the transportation problem is basically the same - to reduce the costs in energy and other resources of moving energy from the point of production to the point of use. If coal, with its relatively low energy-density and inconvenience for many uses, is to be more widely utilized in the future, the problems of energy transportation will become more urgent in the developed countries, and will be closely related to questions of conversion of the energy in coal to electricity or to liquid or gaseous fuels. It can be expected that the needed engineering research and development will be carried out in these countries, with results that should be directly transferable to the poor ones. In the case of fuelwood, we have already discussed conversion to charcoal as a method of mitigating the transportation problem and the difficulty of establishing local wood sources in agricultural areas. It is hard to see how other kinds of research and development on transportation of non-commercial energy could be helpful.

Better and less-expensive processes for energy storage at high-energy densities represent the principal problem in developing solar energy and in widening uses of electricity for vehicle transportation. A diverse series of processes has been proposed, ranging from electrolytic production of hydrogen and storage of hydrates or hydrides to inertial storage in large, high-speed flywheels. New types of chemical batteries and storage of hot water in large stratified ponds are other suggestions.

Energy Conservation

In contrast to problems of energy transportation and storage, questions of energy conservation are urgent in the Asian countries, and many are specific to those countries. Both short- and long-term benefits of large magnitude can be expected from research and development. The problems include developing use of more energy-efficient stoves, fuel-saving motor vehicles, forest conservation, use of energy-saving materials, reduced use of fossil fuels in nitrogen-fixation, and lower energy costs in lifting water for irrigation.

Fuel for cooking is just as essential as food in the Asian countries, and in many areas the costs are comparable. In rural areas, more energy is used for cooking than for any other purpose. One reason is the gross energy inefficiency of the cooking stoves. It is estimated that only 5 - 10 percent of the heat energy in wood and agricultural resideus used as fuel is actually utilized in cooking rice 16/. Inefficiencies arise from several sources. In many cases, the heat from combustion is not confined and only a small fraction is transferred to the cooking pot. The fire must be started before cooking begins, and it continues after cooking is completed. Means to control the air supply are lacking, and often the air/fuel ratio is insufficient to maintain complete combustion so that considerable quantitites of carbon monoxide are produced.

Many improved cook-stoves have been designed in different parts of the world. Five of these have been described by Goldemberg and Brown 28/: The Indian Hyderabad smokeless Chulah; the improved Egyptian rural stove; the Ghana smokeless stove; the Indonesian Singer stove; and the Guatemalan Lorena cook-stove. All are useable either indoors or out, have multiple cooking holes, burn a variety of fuels, offer air-intake control, and are capable of 15 - 20 percent efficiency in rural households. All of them can be user-built from local materials at very low cost. If they are universally substituted for traditional stoves, domestic energy use could be reduced by perhaps 50 percent.

Improved stoves for rural household use have been available for some time, yet they are not widely used. One major research and development question is to find out why this is so 29/. It has been suggested, for example, that the large quantities of smoke produced by presently-used stoves are valuable for controlling insects

and rodents in the thatched roofs of village houses, and are useful in curing meat and other foodstuffs. On the other hand, rural housewives exposed to the smoke frequently suffer from bronchitis, emphysema, and even lung cancer and partial blindness 25/. Perceptive studies need to be made of cooking practices and of housewives' attitudes. Cooking is one of the most tradition-bound of human activities, and in many Asian countries, the interests of women have been largely neglected by government agencies.

In Thailand, cooking is done over both open wood fires and charcoal braziers. The latter are much more energy-efficient but even here, considerable room for improvement exists. Research and development needs to be undertaken on energy-efficient designs 10/.

Following the onset of the oil crisis in India, a major effort has been made to promote the use of mopeds and scooters for personal transportation in urban areas. Local transportation is one of the main users of energy in Indian metropolitan areas and is of less importance in small and medium-sized towns. The thrust of urbanization policy in India's sixth Five-Year Plan is therefore an attempt to slow down the rate of growth of the largest cities and to increase the growth of smaller cities and towns 30/. This will, of course, have many benefits for rural development, as well as conserving petroleum products. In the Philippine city of Manila, small "minibuses" and "jeepneys" appear to be a principal mode of personal transportation 31/. Studies should be made to determine whether these are more or less energy-efficient per passenger mile than one- or two- person motor scooters. Bangkok, which has some of the worst traffic jams in the world, would clearly benefit in several ways from a reduction in the use of personal automobiles.

One of the main causes for the rapid destruction of forests in Bangladesh, Thailand, Sri Lanka, and probably in the Philippines, northeastern India, and the other islands of Indonesia, is the increase in both area and intensity of slash-and-burn agriculture that has come with rapid population growth. New areas have been invaded by peasants using this method of farming, and in many places, the fallow period between cropping seasons has been cut to only a few years, resulting in a vicious circle of decreasing yields and every-shorter fallowing times.

Wherever the environment is suitable for growth of a fast-growing leguminous tree such as Leucaena, it should be possible to substitute settled farming for slash-and-burn agriculture. Half of each farmer's plot could be planted in these trees and the other half in row-crops such as maise or upland rice. Lopped, leafy branches from the trees can be placed between the rows, or stripped leaves can be mulched into the soil. Leucaena leaves contain about 500 kg of nitrogen/hectare, 32/ and perhaps 40 percent of this can be transferred to the cropped soil. Thus, a farmer possessing two hectares could grow two high-yielding crops on a permanent basis on half of his land, with only a minimum of purchased inputs, provided

water is available during both growing seasons. The weight of the harvest would be more than equivalent to that obtained from a single crop on two hectares. This proposed farming method should be further studied and field-tested.

Six bags of Leucaena leaves are said to contain as much nitrogen as one bag of ammonium sulfate produced from fossil fuels. Thus, wherever sufficient land is available, it should be possible to substitute the nitrogen fixed by these leguminous trees for nitrogen produced from fossil fuels. Experience in the Indian state of Tamilnadu demonstrates that a variety of blu-green algae, Azolla, grown in wet rice paddies, can also fix sufficient nitrogen to permit elimination of chemical nitrogen fertilizer.

Artificial fibers and synthetic rubber produced from petrochemicals require an energy utilization of more than 40,000 thermal kw hours/ton - equivalent to the energy in nearly four tons of petroleum 33/. Significant energy savings could be obtained on a world-wide basis by substituting natural fibers and rubber for these synthetic materials. Research and development to increase the yields and quality of these natural materials and their range of uses can therefore be thought of as an important contribution to energy conservation. Metals used in building construction usually have high energy costs per ton, ranging from 13,000 thermal kwh for steel to 91,000 kwh for new aluminum 33/. The energy costs per ton for cement and bricks are an order of magnitude smaller. Minimizing the proportion of metal in building construction might, therefore, conserve fossil-fuel energy. This question needs to be examined by careful economic and engineering analysis.

Significant quantities of energy are used in lifting water for irrigation - on the order of $.5 \times 10^6$ kcal per cropped hectare for water pumped from an average depth of 10 meters. This is equivalent to the energy in 50 kg of oil. The amount of energy required varies directly with the depth of pumping. To meet the future food requirements of the Asian countries, it will be necessary to crop 750 million hectares, hence, the magnitude of the annual energy requirement for lifting water could be equal to the energy content of 25 - 50 million metric tons of petroleum. Careful water management to maintain a shallow water table by properly balancing pumping and ground-water recharge could significantly reduce this energy demand.

The Need for Biological Research

Throughout the above discussion, I have emphasized the need and promise of biological research - to increase forest yields and reduce forest losses through research in forestry and agro-forestry, to maximize production of household gardens through better understanding of their ecology; to increase the production and widen the uses of natural fibers and rubber; and, to obtain more useful microorganisms for production of methanol and ethanol, nitrogen fixation,

and mycorrhizal symbiosis with trees 23/. These potential applications of biology to the solution of energy problems in the Asian countries give an added dimension to their already recognized importance in agriculture, food preservation, nutrition, health, and birth control.

Relative to research in physics and chemistry, the Asian countries have a comparative advantage in biological research. It is relatively inexpensive, requiring neither huge research establishments nor massive, highly-complex equipment. It is in many ways a "new" science - a science of the future. Most discoveries in biology remain to be made. Hence, developed countries have less of a head start than in physics and chemistry. At the same time, biological research is a most primising field for international scientific cooperation.

Social and Economic Issues

Many social and economic issues have already been discussed. They cannot realistically be separated from the "technical" issues of energy production, conversion, and conservation. But one set of socio-economic research issues deserves special mention: those concerning problems of rural electrification.

In the Asian region, agricultural modernization is - and will be - essential to provide enough food for growing populations, but it cannot provide sufficient employment for rapidly growing rural labor fouces. In order to diminish rural poverty, new non-farming jobs must be created. Considerable employment can be provided by development of small-scale rural industries, based on processing and adding value to agricultural products and on meeting local needs for consumer and capital goods.

Rural employment is not an end in itself, but rather a means to attain greater equalization of incomes; to enhance human dignity based on the freedom that comes from self-reliance; and to raise average incomes through fuller use of human resources. Empirical evidence indicates that equalization of incomes acts as a powerful force toward the stabilization of population size.

Because of its flexibility and ease of use, electrical energy is probably more satisfactory than any other form to provide shaft-power for rural industries. Many industries suitable for rural areas also require process heat and/or process steam, as well as shaft-power. In most cases, these can probably be obtained more economically by direct combustion of fuels rather than by electric heating.

Rural industries have sprung up spontaneously in some small cities of the Indian subcontinent, and these have been helped by government or private agencies. Jobs in ferro-crete construction,

kraft paper manufacturing, diamond cutting and polishing, rug weaving, making of dry foods such as "papar" and production of brown sugar, are among the industries established by rural development agencies. Some have been created at an average capital cost of $500 per worker.

Although rural electrification may often be a necessary condition for the establishment of small industries in rural areas, experience shows it is far from a sufficient condition. Other factors that are likely to be important are: 1) the actual or potential existence of adequate transportation facilities to and from markets and sources of raw materials; 2) availability of an adequate supply of other forms of energy needed for a particular industry or industrial complex; 3) sufficient investment capital, either in the form of credit or savings; 4) the presence of trained technicians and of managers familiar with problems of marketing, cost accounting, personnel management, and business operation; 5) the existence of a market town or small city in which a complex of mutually-supporting industries can be established; and 6) the availability, skills, discipline, and comparative costs of labor in the rural areas vs. the labor force in large cities.

Important policy questions emerge in considering rural electrification. How much primary and secondary employment, what increases in incomes, and what multiplier effects can be expected from rural industrialization based on electrification? How can the load factors on electrical transmission grids from central station power systems be raised? What kind of public-sector intervention (e.g., credit for investments, technical training, road-building, construction of storage and market facilities, subsidies for other necessary forms of energy for certain industries) should supplement electrification in order to stimulate rural industrialization? What factors need to be taken into account in appraising benefit/cost ratios? What types of data are needed for formal project evaluation?

REFERENCES

1. Food and Agricultural Organization of the United Nations, FAO Yearbook of Forest Products, FAO, Rome (1979).

2. Revelle, R., "Energy Sources for Rural Development", Energy Vol. 4, No. 5, pp 969-988, October 1975.

3. Landsburg, Hans H. (Chairman of Study Group): Energy: The Next Twenty Years, (Ballinger, Cambridge, Massachusetts, 1979), p. 247.

4. Haefele, W., "Global Perspectives and Options for Long-range Energy Strategies," Energy, Vol. 4, No. 5, pp. 733-744.

5. Wright, Jesse W. and Sarunya Chaloryoo, 1979 Oil Price Increases and Their Economic Costs to Thailand, (USAID, Thailand, November 8, 1979).

6. Wibulswas, P., Thailand Energy Issues, (AID Asia Bureau Conference on Energy, Forestry, and Environment, Manila, November 1979).

7. Desai, Ashok V., The Impact of the Rise in Oil Prices on India, (Working Paper No. 91, Centre for Development Studies, Ulloor, Trivandrum, May 1979).

8. Tewari, S.K., "Economics of Wind Energy Use for Irrigation in India," Science 202, 481 (1978).

9. Republic of the Philippines, Minestry of Energy, Ten Year Energy Program, 1979 - 1988, Manik. 1979.

10. Senadmipathy, D.G., Energy Consumption Aspects and the Rural Sector - Country Paper of Sri Lanka, (AID Asia Bureau Conference on Energy, Forestry and Environment, Manila, November 1979).

11. USAID Mission to Thailand, "Annex XI, XII and XIII to Project Paper for Renewable Nonconventional Energy Project" (USAID Bangkok, July 1979).

12. McKhijani, A., and A. Poule, Energy and Agriculture in the Third World, (Ballinger, Cambridge, Mass., 1975).

13. Islam, Nural, personal communication, Bangladesh Scientific and Technical University, Dacca, Bangladesh, November 1978.

14. USAID Mission to Bangladesh, "Considerations from Bangladesh", (USAID Manila Conference, November 1979).

15. deBacker, M., and K. Openshaw, Present and Future Forest Policy Goals: A Timber Trends Study, 1970-2000, FAO Report to the Government of Thailand, 1972.

16. Ericsson, John R., Energy, Environment and Forestry in Sri Lanka: Some Major Issues, (AID Asia Bureau Conference on Energy, Forestry, and Environment, Manila, November 1979).

17. Revelle, Roger, "Energy Use in Rural India," Science, 192, pp. 969-975. (1976).

18. Revelle, Roger, "Flying Beans, Botanical Whales, Jack's Beanstalk, and Other Marvels," in The National Research Council in 1978, Washington, D.C., National Academy of Sciences, April 1978.

19. USAID Mission, Sri Lanka, Project Proposal for the Establishment of Fuelwood Plantations within and in Close Proximity to the Mahaweli Basin Development, (AID, Colombo, 1978).

20. Knowland, William, Letter to Mr. Peter B. Martin, (Institute of Current World Affairs, Hanover, New Hampshire, August 1979).

21. Soemarwoto, Otto "Ecological and Environmental Impacts of Energy Use in Asian Developing Countries, with Particular Reference to Indonesia," Institute of Ecology, Bandung, 1979.

22. Whittaker, R. H., and G. E. Likens, "The Biosphere and Man," in Primary Production of the Biosphere, H. Lieth and R. H. Whittaker, editors, (Springer Verlag, New York, 1975).

23. Advisory Committee on Technology Innovations, National Research Council, Microbial Processes: Promising Techniques for Developing Countries, Washington, D.C. National Academy of Sciences, page 112, 1979.

24. Goldemberg, J., "Global Options for Short-Range Alternative Energy Strategies," Energy, Vol. 4, No. 5, pp. 733-744.

25. International Project for Soft Energy Paths, Soft Energy Notes VIII, Vol. II, December 1979, (Friends of the Earth Foundation, San Francisco, December 1979), pp. 77 - 102

26. Trehane, R.W., Moles, M.R., Bruce and Cl.K. McKibben, A Nitrogen Fertilizer Generator for Farm Use, (C.F. Kettering Research Laboratory Technical Note, Yellow Springs, Ohio, April, 1978).

27. Briscoe, John, Energy Use and Social Structure in a Bangladesh Village, in Population and Development Review. (Vol. 5, No. 4) pp/ 615 - 41, 1979.

28. Goldemberg, J. and R.I. Brown, Cooking Stoves: The State of the Art, (Institute of Physics, University of Sao Paulo, 1978).

29. Tinker, Irene, Socio-economic Considerations for Energy Programs, (AID Asia Bureau Conference on Energy, Forestry and Environment, Manila, 1979).

30. Chandran,T.R. Satish, "Energy and Industrial Development -- The Indian Experience," (AID Asia Bureau Conference on Energy, Forestry and Environment, Manila, November 1979)

31. Makasiar, Gary S., "Energy and Industrial/Urban Development", (AID Asia Bureau Conference on Energy, Forestry and Environment, Manila, November 1979).

32. Philippine Counsel for Agricultural Resources Research, ed., National Academy of Sciences, Leucaena, Promising Forage and Tree Crop for the Tropics, Washington, D.C., pp 55-56, 1977.

33. Chapman, P.F., "Energy Cost of Materials," Energy Policy, March, 1975.

34. Smil, V., "China's energetics: a system analysis,"in Chinese Economy Post Mao, Joint Economic Committee, Congress of the United States, Washington, D.C., Government Printing Office, 1978.

35. Smil, Vaclav, Renewable Small-Scale Energetics in China, (International Soft Energy Path Conference, Rome, Italy, May 1979).

Energy Issues in the Philippines [1]

Gabriel Itchon *

Until 1979, when commercial oil production began from the NIDO field offshore Palawan Island, the Philippines was totally dependent on imported oil. Since 1973, rising oil prices have resulted in the deterioration of the Philippines trade balance from a positive $665 million in 1973 to a deficit of $270 million in 1978. The oil import bill is estimated at $1.5 billion for 1979.

In response to higher oil import costs and supply uncertainties, the Philippines government established a Ministry of Energy to coordinate energy development and conservation. A program to develop indigenous energy resources was launched, including geothermal, coal, nuclear, hydro, petroleum and solar. Over 500 MW of geothermal capacity has been developed since 1973 and a 450 MW coal-fired plant is planned. A 600 MW nuclear power plant is under construction, although the nuclear option is not being pursued further due to international problems. Recently, the government has initiated efforts to make alcohol from sugar cane and to develop wood burning power plants.

We are, however, "racing against time." The capital investments required for energy development are large and the lead-times long. The Philippines welcomes foreign assistance in energy, in such areas as training, technology, and rural electrification.

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1. Synopsis of remarks by rapporteur.

Ecological and Environmental Impacts of Energy Use In Asian Developing Countries, with Particular Reference to Indonesia

Otto Soemarwoto

ABSTRACT

An ecosystem, like any system, obeys the natural law in that it tends to change spontaneously from a more orderly state to a disorderly one. Therefore, maintenance has to be performed which acts like a pump to remove disorder from the system. Since maintenance is work, energy is required to maintain the orderly state of a system. Energy is also required for growth and development. Consequently, an ecosystem must have a continuous supply of energy in order to exist, grow and develop.

Deforestation is a serious problem in Indonesia. In Java, it is caused by high population densities, which exceed the carrying capacity of the environment. Outside Java, although the population densities are low, forests are also decimated and changed into alang-alang (Imperta cylindrica) wastelands, because of the low carrying capacity due to the low soil fertility and shifting cultivation. Logging is another causal factor of the creation of alang-alang fields. Because of deforestation, soil erosion, floods in the wet season and water shortage in the dry season are occurring extensively. The ecosystem is changing from order to disorder. Energy subsidies are needed to counteract the trend.

Unlike many countries in Africa, Nepal and elsewhere, the primary cause of deforestation in Indonesia is not fuelwood, but the need for more food energy. However, there are indications that there is a shortage of fuelwood. Because of its high price and the need for additional investment for stoves, kerosene cannot substitute for fuelwood in the rural areas.

To increase the production of fuelwood, intensification of the integrated agroforestry systems of homegarden, kebun and talun has a better chance of success than the introduction of new systems which emphasize fuelwood production only.

Biogas as a source of energy for the rural areas presents serious social-economic problems. But it can become an important source of energy for dairy, pig, cattle and poultry farms which produce large quantities of organic matter. Biogas from waterhyacinth is a promising source of energy.

Alcohol from biomass and pyrolysis deserves to be studied. Oil from plants, e.g., Euphorbia, however, is still too speculative.

Indonesia has a large potential of hydroelectric power. The construction of dams has a large environmental impact. In densely populated areas, such as Java, the social impact is very large, since thousands of people are displaced by the reservoir. Adequate mitigating measures have to be taken, since otherwise these displaced people will aggravate the problem of deforestation. Part of the generated electric energy should also be used as an energy subsidy to the river basin ecosystem to create job opportunities in the non-agricultural sectors, in order to relieve the population pressure on land to enable the afforestation program to succeed.

INTRODUCTION

The interaction of living organisms with their environment forms an ecological system which is called an ecosystem. A system consists of components which work together as a unit. For example, an engine is a system. When all parts of the engine work well and are tuned correctly, it runs smoothly and orderly. But when a part does not work well, the engine runs erratically. An engine needs maintenance. Without it, it runs down and goes into a disorderly state. Therefore, maintenance is work to remove disorder from a system. There is a universal law which states that in the real world any system tends to change spontaneously from order to disorder and that consequently any system requires a continuous supply of energy for maintenance work in order to remain in an orderly state.

An ecosystem also consists of components. They are grouped into respectively the living or biotic and non-living or a-biotic parts. Human beings, animals, plants and micro-organisms belong to the first group, and water, air, soil and other non-living matter to the second one.

Ecosystems are also subject to the above cited universal law. In natural ecosystems, such as forests, the source of energy is the sun. In the process of photosynthesis solar energy is fixed by the green plants, and converted to chemical energy in the biomass, where it flows to the other components of the ecosystem through the food chain. Hence green plants are called producers, and human beings and animals consumers. Energy is utilized in the metabolic processes of the living organisms of the ecosystem for their growth, development and maintenance. Without, or with insufficient energy supply to an ecosystem, its growth and development will cease and it will run down and change into a disorderly state. Metabolism acts as a pump to remove disorder from the system.

In man-made ecosystems. such as cities, the sources of energy are fossil fuels, hydroelectricity and nuclear energy in addition to energy in the biomass of plants, i.e., food and fuelwood. Energy which is acquired from outside an ecosystem is called energy subsidy and the ecosystem a subsidized ecosystem. (Odum, 1974). A city for example, is a subsidized ecosystem, while an isolated village, which obtains all of its energy needs from within the ecosystem, is a non-subsidized one.

Unlike other organisms, human beings use energy not only by burning fuels within the body by way of metabolism, but also by burning them outside the body by using machines. Therefore, we may distinguish repsectively internal and external metabolism (Margalef, 1974). Of course, the fuels in the two kinds of metabolism are different. In internal metabolism the fuel is food, primarily

carbohydrates. In external metabolism the fuels are firewood, oil, coal, electricity and nuclear energy. The average energy consumed per capita in internal metabolism in the developed countries (DC's) is about 1.5 times that in the less developed countries (LDC's). But the corresponding figure for external metabolism is 25 or more. The energy subsidies of the DC's are enormous. The LDC's have much lower energy subsidies, and many villages in the LDC's are non-subsidized ecosystems. This low level of energy consumption seems to be unsatisfactory for growth and development. Hence in many instances we find environmental degradation hand in hand with stagnant growth and development. These are especially found in the rural areas. But in the urban areas the more intensive use of energy has increasingly become a major cause of problems of environmental quality.

Since the problem of deforestation is specifically related to the rural areas, the following discussion is focused on the areas.

Environmental Impact of Insufficient Energy Supply in the Rural Areas

An area of definite acreage has a limited capacity as to the numbers of animals which can be supported in that area. This limit of capacity is called the carrying capacity. When this limit is exceeded the animals will suffer from shortage of food. They become weak and are easily attacked by predators and diseases, and will cause environmental degradation because of trampling and over-grazing. In the management of grazing lands and nature reserves, the attempt is to keep the number of animals at the optimum carrying capacity which will produce healthy animals without damage to the environment.

The concept of carrying capacity has also been applied to human populations, specifically agrarian communities. There are obvious differences since human beings, unlike animals, can improve their technology a d obtain energy subsidies so that more yield can be obtained from a unit land area and therefore more people can be supported. But for indicative purposes the concept of carrying capacity can be useful.

Many studies have been carried out on carrying capacity for human beings. Basically carrying capacity is determined by the land area available for cultivation, its yield and the energy requirement of the people. As mentioned earlier, the energy need of human beings includes not only food, but also fuels for their external metabolism. An example is Allan's formula (1949), which is based on his studies in Rhodesia. In a slightly modified form it reads:

$$K = \frac{Cp}{100 \times Ca \times L}$$, in which

K = carrying capacity in number of people per unit area (square mile or square km)

Cp= percentage of cultivable land

Ca= the land area needed per person per year (hectare or acre per person), and

L = the land use factor. This letter is expressed as:

$$L = \frac{R}{U} + 1, \text{ in which}$$

R = number of successive years the land is rested, and

U = the number of successive years the land is cultivated.

The longer the land is rested relative to the length of time of cultivation, the larger the value of L and therefore the lower the value of K.

From this formula we can see that when population density increases, the value of K has to increase, unless the people migrate or exercise other means of reducing population density. Migration is indeed one of the reactions of human communities to increasing population densities. Other means of reducing population density are, among others, war and infanticide, or it can also happen by natural means, e.g., disease. To increase the value of K, one or a combination of the following can happen: increase of Cp, decrease of Ca and decrease of L.

A decrease of Ca requires that the yield per unit area has to be increased, which in turn requires improvement of technology. Therefore, it can only happen in more advanced societies. The most common reactions of primitive societies to increasing population density is to increase Cp, i.e., bringing more land into cultivation, and in the case of shifting cultivation to decrease L by shortening the shifting cultivation cycle. Both reactions are disasterous to forests. In the rice growing areas, where the people have better education, CA is reduced by improved technology consisting of the cultivation of high yielding varieties, better soil management and applications of fertilizers, improved irrigation and pest control. Improved irrigation also reduces the value of L, since it facilitates the growing of rice the whole year round without a fallow period in the dry season.

Outside Java, shifting cultivation is still practiced extensively. In these areas the reaction to population growth is to reduce the value of L by shortening the cycle of shifting cultivation, to the extent that the forests do not have sufficient time to regenerate. Traditionally the shifting cultivators also maintain a piece of grassland near their settlements to attract animals which they hunt. This problem is intensified by development projects,

such as logging and transmigration, which take large areas from the shifting cultivators. In effect they reduce the Cp value which forces the people to further reduce the value of L. On the other hand development projects also make areas, which were formerly inaccessible to the shifting cultivators, available to them. However, since these formerly inaccessible areas are outside their traditional right, they seem to work opportunistically without careful selection whether the plot they cut is suitable for cultivation. These combined factors have resulted in the creation of millions of hectares of alang-alang (Imperta cylindrica Beauv.) wastelands. It is estimated that the area of alang-alang fields grows with about 200,000 ha annually. But no one knows the exact figure. It should be possible to arrive at a more reliable figure by using multidata satellite imageries.

In Java we can see all three kinds of reactions to population density operating. The Bimas (mass guidance of farmers) program has increased rice production at an average annual rate of about 3.24% (Birowo et al, 1978). Thus the Ca value is declining, which has been made possible by the massive energy subsidies in the Bimas package, notably high yielding varieties, fertilizers and pesticides.

In some parts of Java, particularly in West Java, shifting cultivation is still practiced. This is locally known as huma. But population density does not allow it to have a long fallow period. As a result the forests are continuously decreasing. In its place we find only weeds, especially alang-alang and Chromo lena odorata.

The population density of Java is high, averaging almost 500 people per square kilometer. Accordingly the population pressure on forests is high. As most everywhere in Java we can observe hills and mountain slopes which are denuded of forests, and the cultivation of crops on steep slopes. When irrigation water is available the people inevitably grow rice for which purpose they build terraces to regulate the water. Under such conditions, it will not cause soil erosion. But when irrigation water is not available, upland crops are grown, in many cases without or with inadequate soil conservation measures. Soil erosion soon sets in, soil fertility declines and yield decreases. As a result, carrying capacity decreases and the pressure to extend the area for cultivation further increases, initiating a vicious cycle of deforestation and decreasing carrying capacity at an increasing rate. Studies of Landsat imageries show that deforestation is indeed proceeding at a rapid rate. In the Citarum river basin in West Java, for example, about 30% of the dense forest area was damaged in the period between 1970 and 1972 (Soemarwoto et al, 1967). The extensive deforestation has changed the basin characteristics: the ratio of rainfall to discharge increased from 0.47 in the period 1919 - 1933 to 0.52 in the period 1970 - 1975 and ratio of wet season discharge to the dry season discharge increased from 3.0 in the period between 1923 - 1940 to 4.1 in 1966 - 1976. The sediment load of the river also increased from 3.5 ppt in 1970 to 21.5 ppt in 1977 (Institute of

of Ecology, 1979). To arrest the vicious cycle, energy subsidies are needed, partly to decrease Ca and partly to create employment for the people in the non-agricultural sector so that the population pressure on the forests can be relieved.

Recently the need for fuel wood has become the cause celebre of deforestation. Although fuelwood is a causal factor of deforestation in Indonesia, it is certainly not the only one. A more important causal factor is the need to produce more food energy to satisfy the growing population. This can be deduced from the fact that to produce food, clear cutting of the forest is practiced. On the other hand to obtain fuelwood dead twigs are collected from the forest floor, branches cut from living trees and dead or fallen trees are chopped. Although it is true that living trees are also cut, it is never done by clear cutting one or more hectares of a forest. But considerable damage is done to saplings and shrubs. Even so in comparison to food production, the collection of fuelwood is relatively less damaging to the forest. This is not to suggest to neglect the fuelwood problem. But it is useful to put it in proper proportion in order to enable us to look for suitable solutions. Overemphasizing the fuelwood problem could lead us to take measures which would reduce production of food and other needs which in turn would exaggerate the problem of deforestation.

Sources and Problems of Fuels

Indonesia is still predominantly agrarian. Therefore non-commercial uses of fuels, primarily for household purposes are still important. The fuels used are biomass (wood and other plant organic materials), kerosene and electricity. In the rural areas biomass is the primary source of fuel energy, because it is readily available and its use does not need much investment. Kerosene and electricity are mostly used in cities. For example, in our studies in the Saguling catchment area in West Java the consumption of kerosene decreases and biomass use increases with the distance from cities, as shown in Figure 1 (Karyono, et al, 1979). In the rural areas kerosene is almost exclusively used for lighting. Since about 80% of the Indonesian population lives in the rural areas, a large percentage of the population use kerosene for lighting. However, in cities kerosene is mostly used for cooking and most of the total consumption of kerosene is for cooking as shown in Table 1 (Hadi et al, 1979). This table also shows that kerosene is primarily used for household purposes and that sales and consumption steadily increased from 1969 to 1978. Even so, according to the same source, the ratio of consumption of fuelwood to kerosene increased from 7.6 in 1969 to 21.4 in 1978. Therefore, more and more fuelwood was consumed relative to kerosene. Table 2 summarizes the proportions of the population using the various kinds of energy sources for their household (Martono, 1974). Fuelwood and kerosene were used by the majority of the people. Gas, LPG, and electricity were used by a very small percentage of the people only. We can safely assume that this situation has not changed much.

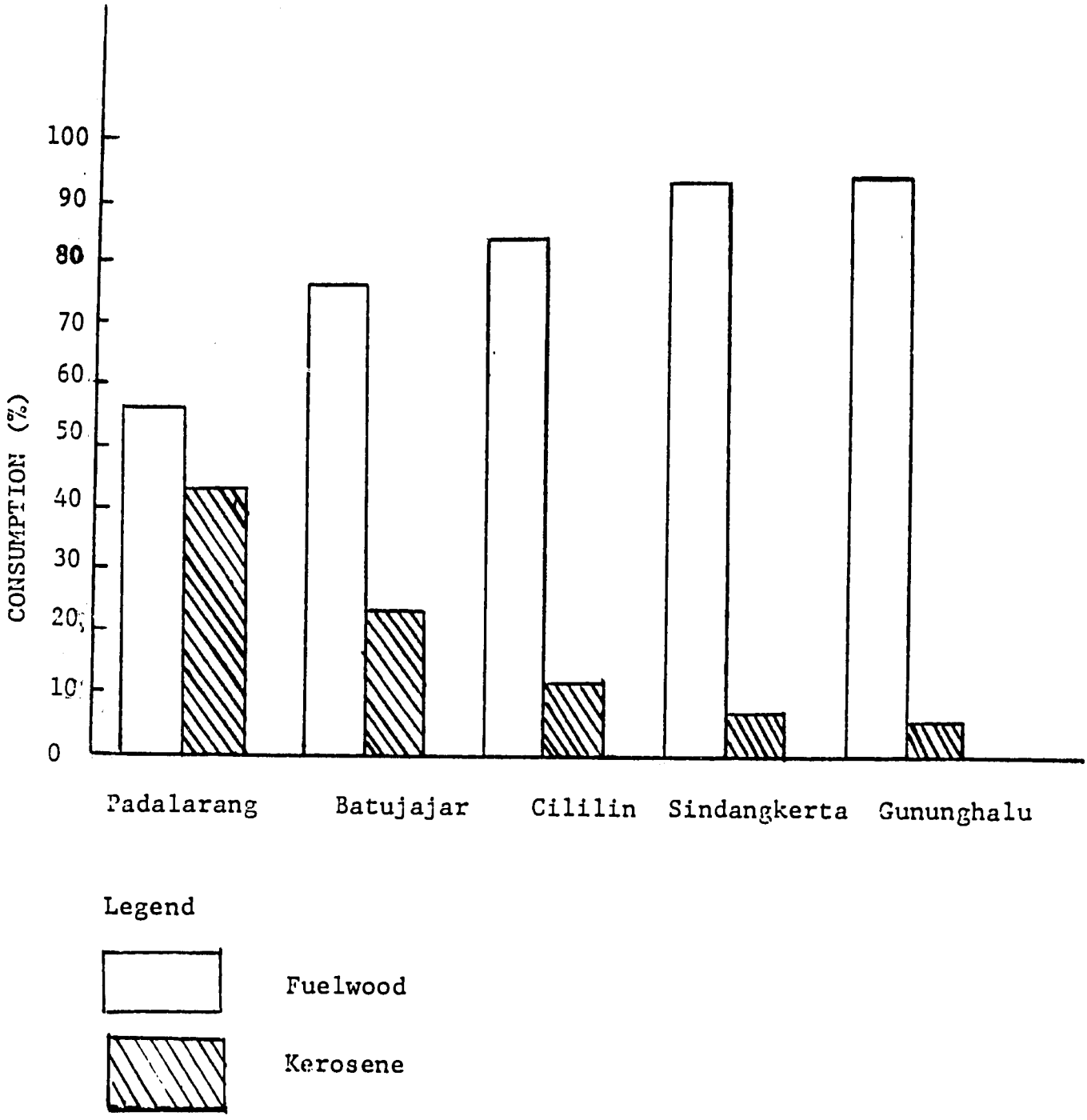


Figure 1

With increasing distances from Bandung, the consumption of fuelwood increases and of kerosene decreases. Padalarang is closest to Bandung and Gununghalu farthest (After Karjono et. al., 1979).

TABLE 1

Consumption of Kerosene Between 1969-1978

Year	Total sale of kerosene (kiloliter)	Consumption of kerosene by household (kiloliter)	Consumption of kerosene for cooking (kiloliter)
1969	2,700,067	2,160,053	1,728,042
1970	2,732,195	2,185,756	1,748,604
1971	2,817,548	2,254,034	1,803,230
1972	3,306,580	2,615,264	2,116,211
1973	3,681,977	2,945,581	2,356,464
1974	4,258,050	3,406,440	2,725,152
1975	4,882,663	3,906,130	3,124,904
1976	5,302,722	4,242,177	3,393,741
1977	5,895,330	4,716,264	3,773,011
1978	6,426,000	5,140,800	4,112,640

After Hadi et al, 1979

TABLE 2

Estimated Use of Different Energy Sources for Household Purposes (% of Population)

	Fuel-wood	Char-coal	Kero-sene	LPG	Gas	Elec-tricity	Batte-ries
1. Cooking	± 80	<1	20	0.2	0.16	<1	
2. Lighting			95	<1	<1	5	<1
3. Ironing		25				5	
4. Entertainment (radio, TV)						5	20
5. Household utensils						<1	
6. AC, fan, etc.						<1	

After Martono, 1974.

Biomass

Fuelwood. As mentioned earlier biomass is the primary source of fuel energy in the rural areas, where the majority of the people are living. Almost anything which can be burnt is used, for example, wood, twigs, leaves and straw. For simplicity's sake these are grouped under the term fuelwood, unless otherwise noted. Hadi et al, 1979, reported higher per capita fuelwood consumption in rural areas than in large cities and urban areas. Furthermore, in the period between 1971 - 1978, consumption in cities and urban areas did not change, or even slightly decreased, while in the rural areas it increased two-fold. A doubling time of seven years means that wood consumption in the rural areas is growing at an annual rate of about 10%. It was also noted by Kamarudin (1977) that there was a very significant negative correlation between the income of a household and its fuelwood consumption, i.e., the lower the income, the higher the fuelwood consumption, since less of other kinds of energy sources were used. Thus economic factors play a role in the consumption of fuelwood in addition to its ready availability. For their daily need poor village people can gather twigs, dry leaves, straw, etc., for which they do not have to invest any monetary cost, but only their time and labor. This work is done many times by older women and children, i.e., those who are in the unproductive age bracket, so that the time and labor allocation for this work does not affect the income of the family. But when the wood is intended for sale, collection is usually done by men and women of the productive age bracket, since the wood is of better quality for which harder work is needed to chop and carry it. Another economic aspect is, that cooking with wood or other plant organic matter can be done with very simple stoves which do not require much monetary investment either. A few stones on which to place the cooking pot suffice as the simplest stove. Of course its efficiency is low. Table 3 shows the estimated costs of different energy sources for cooking (Martono, 1974).

TABLE 3

Estimated Costs of Different Energy Sources for Cooking

	Fuel-wood	Kero-sene	Gas	Lpg	Electri-city
1. Stove, cheapest model (Rp)	0	500	2000	8,500	5,000
2. Other investments/ LPG bottle (Rp)	0	-	-	7,500	-
3. Burning efficiency (%)	17	30-50	65	60	76 (34% of primary energy)
4. Cost of fuel, 700 keal/cap/day, (Rp)	0-8.75	4	5.18	5.70	10.60

After Martono, 1974)

Based on statistical data Sayogya (1978) reported that between 1970 and 1976 the number of the poorest people in the rural areas was increasing, both percentage-wise as well as in absolute numbers. If the trend as reported by Sayogya continues and together with the price increase of kerosene, we can expect that fuelwood consumption will continue to rise, not only because of population growth but also because of economic factors. This expectation agrees with the earlier mentioned data of Hadi et al, i.e., an increase in the ratio of consumption of fuelwood to kerosene.

Because of the large masses of people living in the rural areas, the total non-industrial consumption of wood is also high. It was estimated that in 1975 total wood production was 128,700,000 m^3 and total non-industrial wood consumption was 112,404,000 m^3 or about 90% of total wood production (Wiersum, 1977).

Production and consumption of fuelwood in Java and outside Java in the period between 1969 and 1978 are presented in Figure 2. Up to 1975 Java had a surplus of production over consumption, but thereafter there was a deficit which continued to rise until in 1978 it reached about 24 million m^3. Outside Java, however, there was a surplus, although it decreased from almost 50 million m^3, in 1969 to about 35 million m^3 in 1978. Theoretically the surplus of outside Java could cover the deficit of Java, but the cost, both money and energy-wise, may not make it worthwhile. In any case the increasing deficit of Java on the one hand and the decreasing surplus of the outer island would not make such arrangement a longlasting one. Extrapolation of the curves, and the deficit in Java and the surplus in the outer islands indicates that in the year 1979 there would probably be no more net surplus nationwide (Figure 3).

The annual rate of growth of consumption in Java is 10.7% and outside Java 11.1%. These are much higher than the population growth rate. Therefore factors other than population growth must have been in operation in pushing the growth of consumption of fuelwood so rapidly. One seems to be the economic factor as discussed earlier, i.e., that more people were reverting from kerosene to fuelwood than vice versa. As mentioned earlier the ratio of consumption of fuelwood and wastes to kerosene was increasing rapidly. Another factor could be the rapid process of industrialization. But Hadi et al (1979) presented data that fuelwood and wastes consumption in industries increased only slightly between 1969 to 1978, i.e., from about 10 million m^3 to about 12 million m^3. In the same period consumption of fuelwood for transportation decreased from 165,314 m^3 to 93,148 m^3, because the steam locomotives were being replaced by diesel ones. Therefore, the rapid rate of increase of consumption must have occurred in the household sector. Indeed, using Hadi's data the rate of increase of consumption in the household sector was about 10%. It is difficult to account for this high rate.

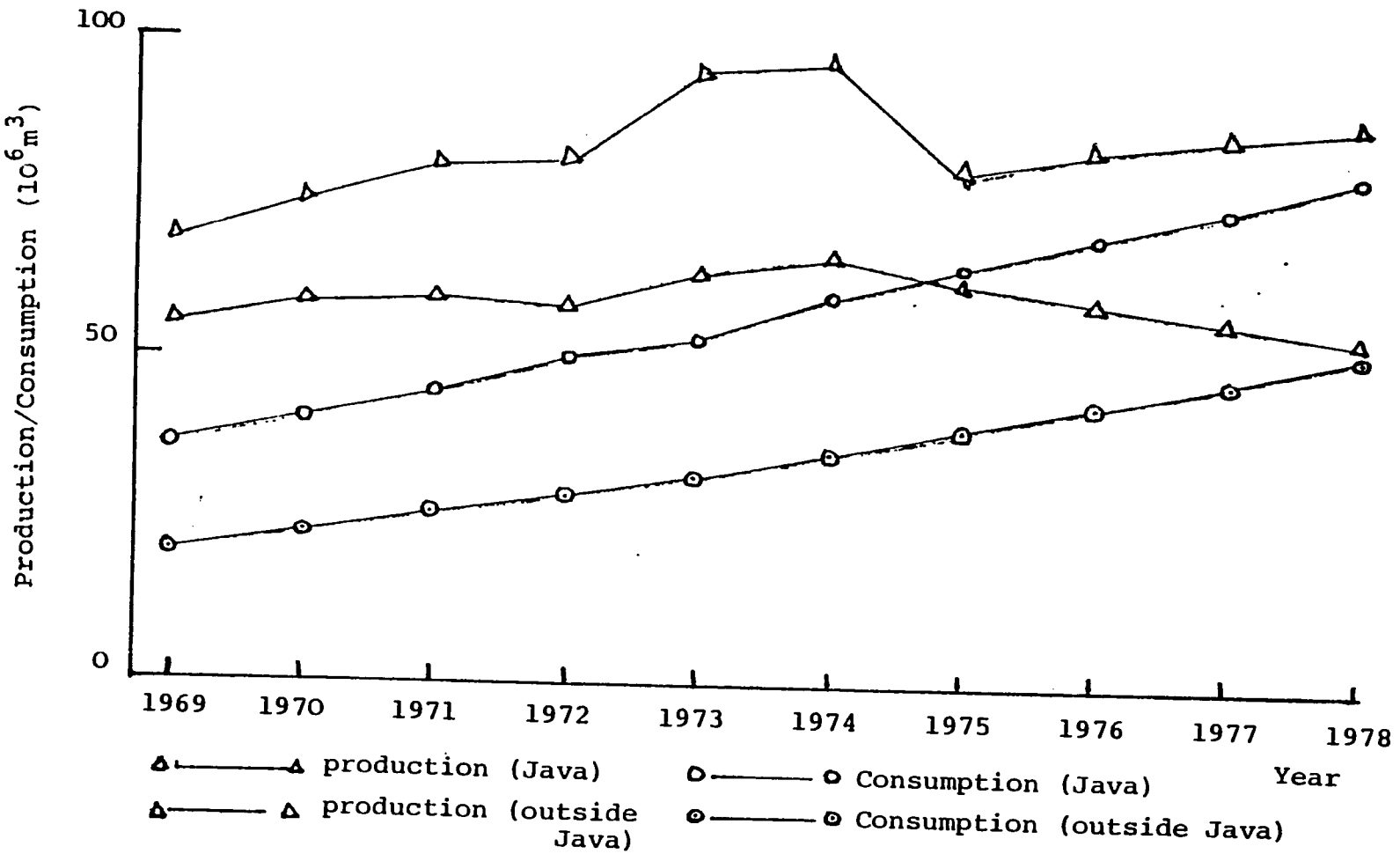


Figure 2. Trends of production and consumption of fuelwood in Java and outside Java. Graphs prepared on the basis of the data of Hadi et al (1979)

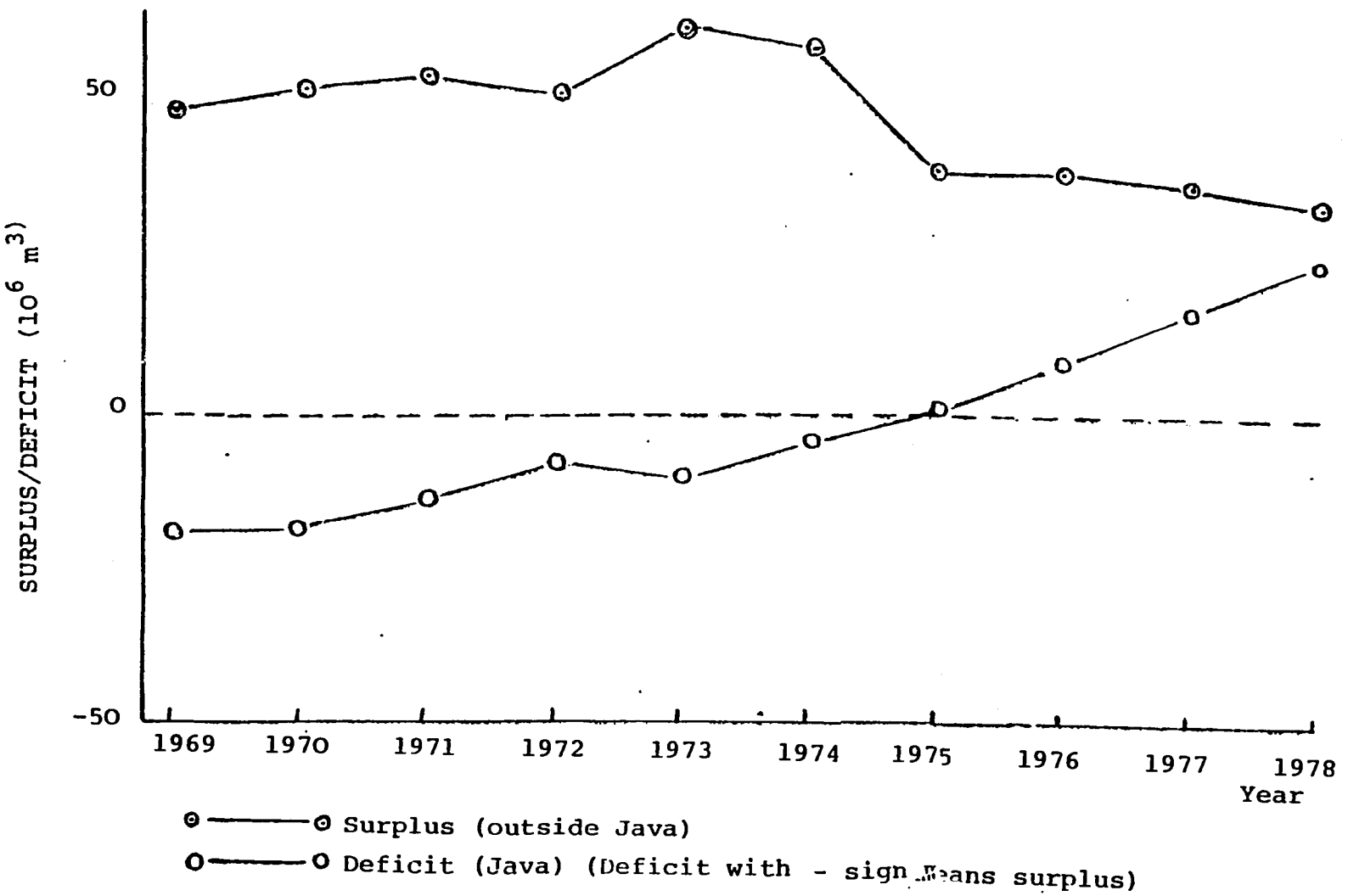


Figure 3. Trend of surplus and deficit of fuelwood in Indonesia. Graphs prepared on the basis of the data of Hadi et al (1979)

The Directorate General of Forestry (1970) estimated that fuelwood consumption in West Java in the period between 1965-1969 remained approximately constant of about 3 million m^3. This was assumed on the basis that although there was a population growth, more people were using kerosene. In the projection of FAO (cited by Silitonga, 1974), the annual per capita consumption in Indonesia could decrease from 0.718 m^3 in 1970 to 0.300 m^3 in 1985 and total consumption would decrease from 86,919,000 m^3 to 61,000,000 m^3 in 1970. These estimates were made before the oil crisis of 1973 and the subsequent increases of oil price.

Data of fuelwood and fuelwastes consumption are difficult to obtain. Villagers switch from one kind of fuel to the other depending on the supply. After a harvest of corn, for example, people will use dried stalks as their fuel. In the rest of the year, when the supply of corn stalks is low, people may use wood and twigs, leaves and other organic matter which are very difficult to quantify or may escape observation at all. A survey over a large area with a short observation time at each sample site will only reveal an instantaneous picture of a type of fuelwood consumption which does not necessarily apply for the whole year. Ernst (1970) concluded from her study in Upper Volta, West Africa, that estimates of global yearly wood consumption based on daily measurements may be grossly overestimated for the rural sector, since people were using millet stalks for half the year. Oekan (1979) reported that in his study village near Bandung the people in the upper level used less agricultural wastes than those in the middle and lower levels, as shown in Table 4.

TABLE 4

Sources of Fuelwood in Salamungkal Village Near Bandung

Status of household	Source of Fuelwood (%)		
	Forest	Homegarden kebun & talun	Agricultural wastes
Upper level	31.2	62.4	6.4
Middle and Lower level	73.6	10.2	16.2

(After Oekan 1979)

The reason for this was that the former group had more land in the form of homegarden, kebun and talun. Therefore, beside seasonal variation, fuelwood consumption also varies with the economic status of the people. Because of these variations and the difficulties to quantify, under or overreporting can easily occur.

Therefore, it is not surprising that estimates, particularly when projected over a long period, vary widely.

In former times much fuelwood was sold from the villages to the cities. This is decreasing, because city people are increasingly using kerosene. Those who do not use kerosene, are mostly using fuelwastes, for example, from construction works and discarded crates. These are mostly the urban poor.

In the villages most fuelwood are produced by the people themselves. Wiersum (1976) reported that in a rural area in Central Java only 6% of all local fuelwood consumption was purchased. Our studies in the Citarum river basin show that only 13% of the households in the villages bought fuelwood, and the rest obtained it by collection from the homegarden, kebun (mixed garden), talun (see below) or elsewhere. Those who bought fuelwood, did it only for part of their needs. Clearly most fuelwood was obtained from collecting it and not from buying.

The homegarden, kebun and talun can supply up to about 60% to 90% of the fuelwood need of the villagers (Wiersum, 1979). The rest comes from agricultural estates (tea, quinine, rubber and others), and forests. Oekan's data (Table 4) shows that the people in the lower strata obtained more fuelwood from the forests than those in the higher strata. However, Oekan conducted his studies in a village which was located near a forest. In villages, which are far from forests, it was not observed that the people went to the forests to collect wood. Therefore they must have fulfilled their fuel needs from their homegarden, kebun and talun, and by using agricultural and other wastes. Nevertheless Oekan's data is important, since it shows that efforts to save the forests must be directed toward the village poor.

Wiersum (1977) estimated that 43 - 81% of all fuelwood production was obtained from homegardens. A homegarden is a piece of land on which a house is built. It is usually planted with a mixture of perennials and annuals of different heights, from those creeping on the ground to those of more than 20 m high, so that typically the space is occupied with layers of plant stories. As many as 50 to 60 species can be found in a homegarden. In Cibakung, a small hamlet about 60 km West of Gandung, we found more than 200 species in the homegardens.

The homegarden has the following functions: 1) social, 2) aesthetic, 3) subsistence and commercial production, 4) soil conservation and 5) genetic resources conservation. (Soemarwoto and Soemarwoto, 1979).

Land is an important property in villages. It is not only a source of income, but also a social status symbol and has mystical values as a link of the villagers to his ancestors and relatives who have died. Someone who does not have a homegarden and who has

to build his house on someone else's homegarden is considered to have a low social status. Part of the garden, usually in front of the house is not cultivated and kept clear. In West Java it is called the buruan and in Central Java polataran. Children play and adults congregate here to exchange news and experience of the day or just to gossip. Therefore, it forms an important place of the village socialization processes.

Most homegardens are not fenced and neighbors are free to enter or to pass through. Neighbors are welcome to use the bathroom or well. For religious rituals or medicinal purposes certain plants or plant parts can be asked from a neighbor and can be obtained free. Poorer people are allowed to collect dead branches, twigs and other waste products for their fuel.

Generally the farther a village is located from a city and the less accessible it is, the more pronounced are the social and subsistence production functions, and the less important are the aesthetic and commercial production functions. The subsistence production function also includes fuelwood supply for the owner's own consumption.

Many reports have shown the importance of the homegarden as a source of income, carbohydrates, proteins, vitamins and minerals (for example Ochse and Terra, 1937; Donaesastro, 1972; Harijadi, 1975; Stoler, 1975).

In the neighborhood of large cities, such as Jakarta, Bandung, Semarang and Surabaya, commercial production is important. Usually it consists of fruits, e.g., rambutan (Nepheleum lappaceum), daku (Lansium domesticum), darian (Durio zibethinus), mandarin, guava and manggosteen. Nowadays cloves have also become important as a source of income in many villages.

The layered structure of the plants in the homegarden can effectively protect the soil against rains and sunshine. Figure 4 shows a profile of a sample homegarden. From these figures we can discern how canopies are structured in the homegarden. The effectiveness of the protection of the canopies against soil erosion can be appreciated from the fact that in the Upper Solo river basin in Central Java, which is suffering from severe soil erosion, the homegardens are still productive.

Soil fertility is also maintained by an effective recycling system. In fact the people do not have the concept of waste. A waste product of a process is used as a resource for another production process. For example, wastes of animals are composted and used as fertilizers. Some are also thrown into the fish pond and are directly eaten by fish or via plankton. The mud of the fishpond is mixed with animal wastes and composted.

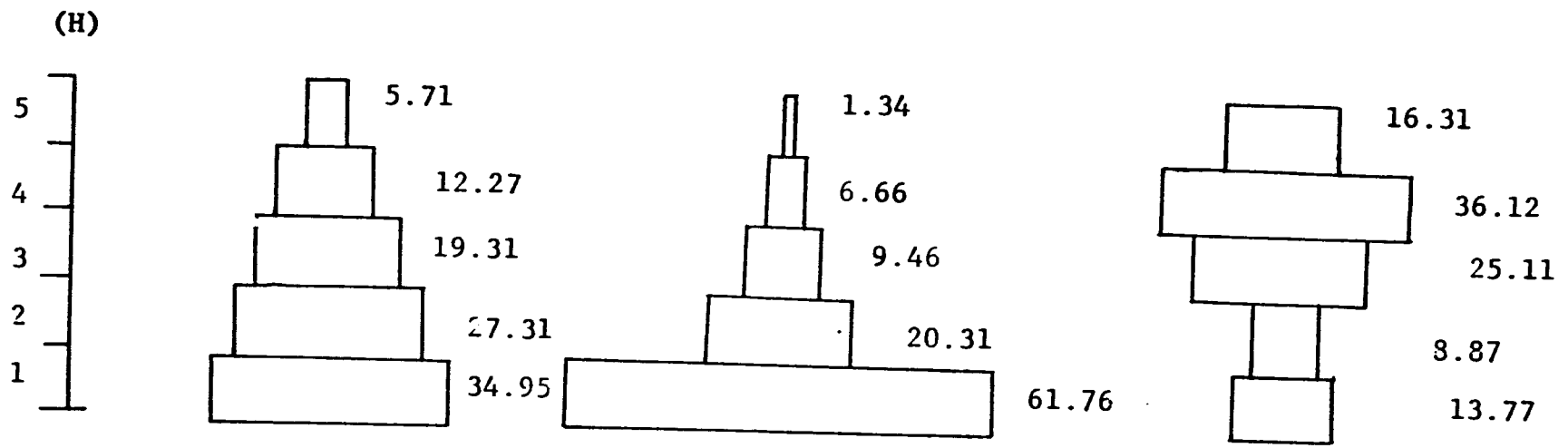
The many plant species form a rich genetic resource, particularly when we consider that most species are represented by many

varieties. For example the people in the Citarum river basin distinguish about 40 varieties of banana.

Kebun and talun are almost similar and in some places the people do not separate them. They can be designated as two stages in an agricultural cycle of five or more years. A talun is dominated by perennials and few annuals are found underneath the tree canopies. The perennials usually consist of a mixture of species. But sometimes it may be a monoculture, such as bamboo, in which case it is called a bambu talun. Every five or more years the trees are harvested by clear cutting. Food crops are grown and seedlings of the perennials are planted. As the trees grow taller and the canopies are closing, less and less annual food crops are grown. While the mixture of perennials and annuals exists, it is called a kabun. When no more annuals are grown, the kebun has become a talun again. Since the talun has more trees it is a more important source of wood for fuel and for building material, but less important as a source for food. The harvested trees are usually sold. Therefore a talun has an important commercial production function.

The practice of the kebun-talun cycle differs from place to place. For example, in Purwakarta, about 100 km Northwest of Bandung, the bamboo talun is permanent. The people harvest the bamboo by selected cutting. In Ciwidey, about 30 km southwest of Bandung, the bambu talun resembles a shifting cultivation system. A small piece of about 200 m2 is clear cut and planted with a legume. After several crops it is reverted to bamboo and another piece is clear cut for the legume crop. Table 5 shows the protective effect of kebuns and taluns against soil erosion. Clearly their soil protective function is excellent and compares well with forests.

Since the homegardens, kebuns and taluns can supply 60-90% of the fuelwood need of the villagers, it is logical that the solution of the fuelwood problem must first be sought in these traditional agro-ecosystems. From the brief discussion of these traditional agro-ecosystems, it is clear that the village people integrate their fuelwood need with their other needs. Accordingly fuelwood is not an isolated problem and cannot be considered singly. The integrated nature is more clearly demonstrated in the diagram of plant association in the homegarden as shown in Figure 6 (Karyono, 1978). In this figure taro serves as an important center of association. Connected with it are among others, cassava, hot pepper, terong (Solanum melongena), rambutan, coffee, roay (Dolichos lablab), papaya, avocado, citronella and suren (Toona sureni). Taro and cassava are food crops, hot pepper and citronella are spice crops, terong and roay are vegetables, rambutan, papaya and avocado are grown for their fruits, coffee is a drink, and suren produces fuelwood. The produce can be consumed by the owner or sold and stalks of cassava and the dead branches of the trees and shrubs can, of course, be used as fuelwood. There seems to be a plan, although not explicitly expressed, by which the villagers try to fulfill their daily needs and income.



Layer: 1:H < 1 M

2:1 ≤ H < 2 M

3:2 ≤ H < 5 M

4:5 ≤ H < 10 M

5: H ≥ 10 M

Figure 4: Distribution of percentages of number of individuals (A), number of species (B), and area of canopies (B) of homegarden plants in the layers of canopy (H) showing the layered structure of the homegarden (After Karjono, et. al., 1978).

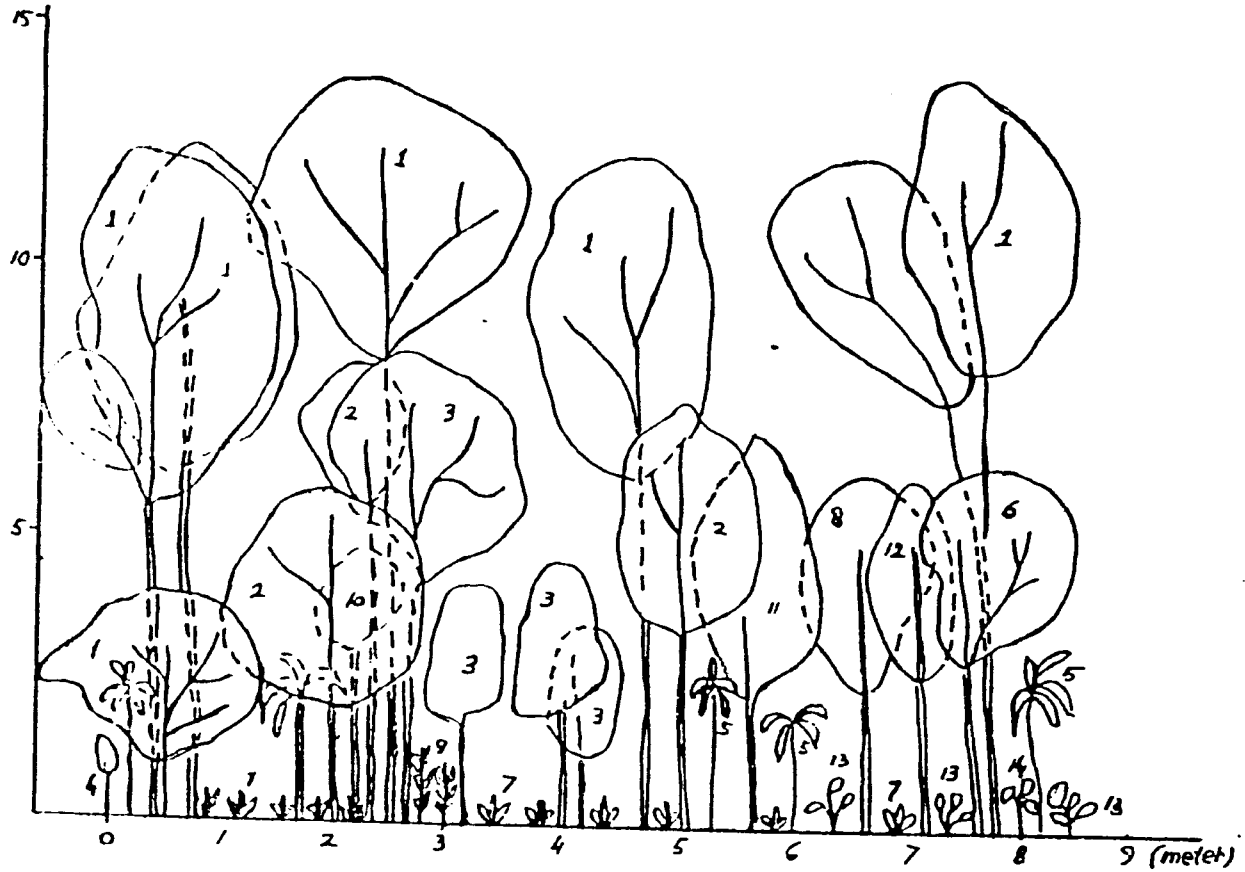


Figure 5. An example of a profile of a homegarden. Note the layered structure (After Karjono, et. al., 1977).

Legend:
1. Albizia falcataria
2. Artocarpus heterophylla
3. Sandoricum koetjape
4. Mangifera indica
5. Musa paradisiaca
6. Psidium quajava
7. Ananas comosus
8. Pithecelebium dulce
9. Alpinia galanga
10 Annona muricata
11 Durio zibethinus
12 Nenhellium lapacceum
13 Alocasia indica
14. Marantha arundingocae

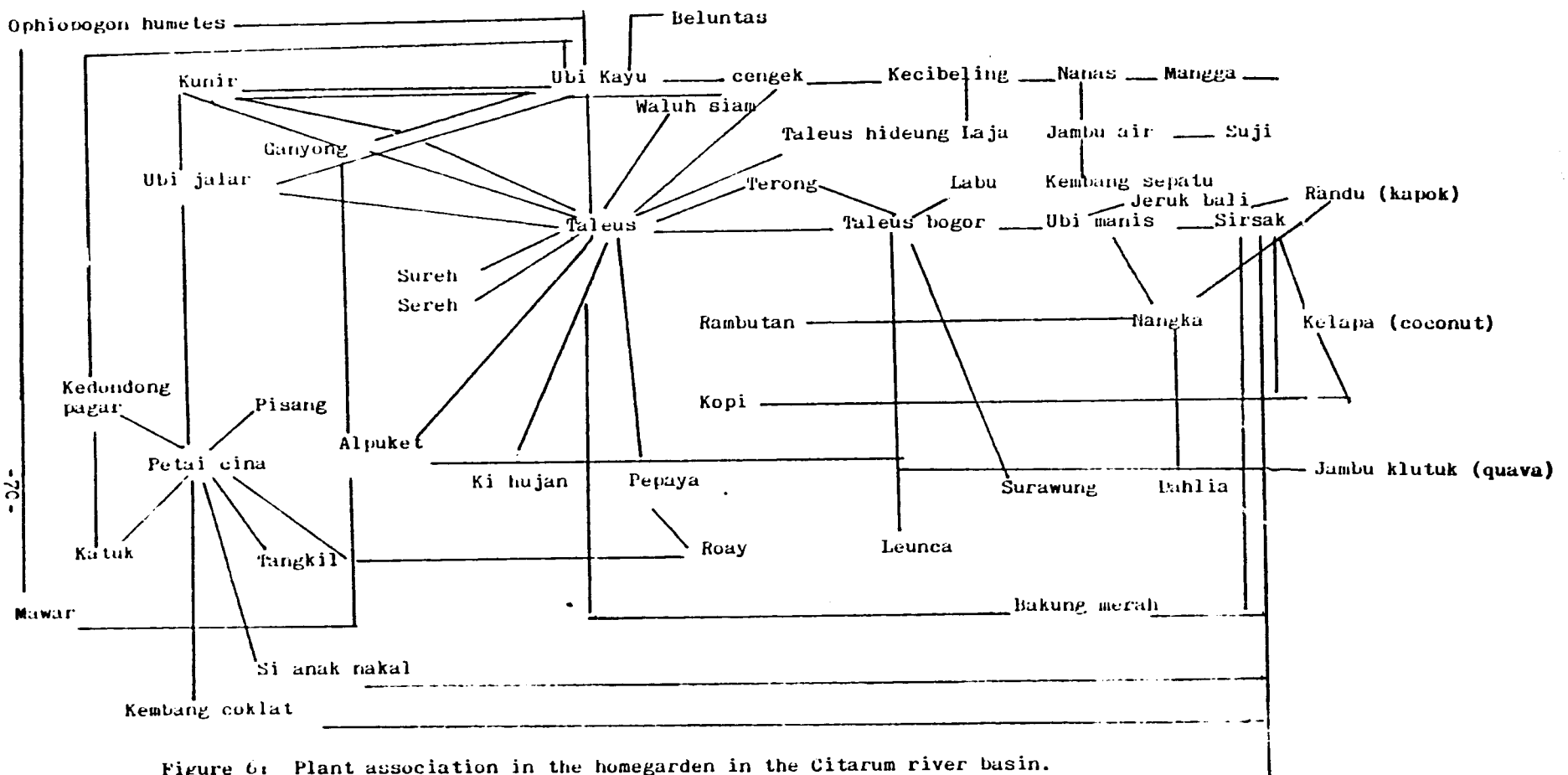


Figure 6: Plant association in the homegarden in the Citarum river basin.
(After Karyono et al. 1978)

TABLE 5

Effect of Various Vegetation Types on Soil Erosion
the Jatiluhur-lake Catchment Area

No.	Vegetation Type	Slope Gradient(0)	Erosion
1.	Belukar + bambu	14	No erosion
2.	Dalbergia forest	30	Slight erosion
3.	Dalbergia forest	10	No erosion
4.	Young belukar	23	No erosion
5.	Young belukar	30	Slight erosion
6.	Secondary forest	15	Slight erosion
7.	Secondary forest	40	No erosion
8.	Kebun	0	No erosion
9.	Kebun	10	No erosion
10.	Kebun	15	Slight erosion
11.	Kebun banana	33	Slight erosion
12.	Talun	0	No erosion
13.	Talun	5	No erosion
14.	Talun	10	No erosion
15.	Talun	30	Slight erosion
16.	Talun bambu	15	No erosion
17.	Talun bambu	20	No erosion

(After Soedarto, 1979)

Legend of Figure 6

Local Name	Scientific Name	Function
1. Alpuket (Avocado)	Persea americana	fruit/commercial
2. Bakung merah	Hippaestrum puniceum	ornamental
3. Beluntas	Pluchea indica	vegetable/hedge
4. Cengek (hot pepper)	Capsicum	vegetable/spice
5. Dahlia	Dahlia rosea	ornamental
6. Ganyong	Canna edulis	food
7. Jambu air	Syzygium aqueum	fruit/commercial
8. Jambu klutuk (guava)	Psidium guajava	fruit
9. Jeruk bali	Citrus grandis	fruit
10. Katuk	Sauropus androgynus	vegetable
11. Kecibeling	Sericocalyx crispus	medicinal
12. Kedondong pagar	Polyscias fruticosa	ornamental/veg.
13. Kelapa)Coconut)	Cocos nucifera	vegetable/comm.
14. Kebang coklat	Zephyranthes rosea	ornamental
15. Kembang sepatu (Hibiscus)	Hibiscus sp.	ornamental
16. Ki hujan	Samanea saman	fuelwood
17. Kopi	Coffea arabica	commercial
18. Dunir	Curcuma domestica	spice/medicinal
19. Labu	-	-

Legend of Figure 6 (continued)

Local Name	Scientific Name	Function
20. Laja	Languas galanga	spice/medicinal
21. Lempuyang	Zingiber odoriferum	medicinal
22. Leunca	Solanum nigrum	vegetable
23. Mangga (Mango)	Mangifera indica	fruit/commercial
24. Mawar (rose)	Rosa hybride	ornamental
25. Nanas (Pinapple)	Annas Comonas	fruit/commercial
26. Nangka (jackfruit)	Artocarpus heterophylia	fruit/vegetable
27. -	Ophiogon hermetes	-
28. Papaya (papaya)	Carica papaya	fruit/vegetable
29. Petai cina (ipil-ipil)	Leucaena leucocephala	vegetable/fuel-wood
30. Pisang (banana)	Musa paradisiaca	fruit/commercial
31. Rambutan	Nephelium lappaceum	fruit/commercial
32. Randu (kapok)	Ceiba pentandra	commercial
33. Roay	Dolichos lablab	vegetable
34. Sereh	Cymbopogon citratus	spice
35. Si anak nakal	Durante erecta	ornamental
36. Sirsak	Anona muricata	fruit/commercial
37. Sarawung	Ocium basilicum	vegetable
38. Suren	Toona sureni	fuelwood
39. Taleus	Xanthosoma sp	food
40. Taleus bogor	Colocasia esculenta	food
41. Taleus hideung	Xanthosoma nigrum	food
42. Tangkil	Gnetum gnemon	vegetable/comm.
43. Terong	Solanum melongena	vegetable
44. Ubi jalar	Iplmoea batatas	food
45. Ubi kayu	Manihot esculenta	food
46. Ubi manis	Dioscorea alata	food
47. Waluh siam	Sechium edule	vegetable

Suppose that in this type of garden Caliandra callothyrus, which is a good producer of fuelwood, is promoted and that the village is isolated. Caliandra branches profusely from near its base, and accordingly it can effectively cover the soil. The height of the plant is about 2 to 3 meters. It grows well in full sunlight. The consequences of its promotion are that the taller trees have to be eliminated or at least reduced in number in order that Caliandra can get sufficient light, which means that the higher strata of the space of the homegarden cannot be fully utilized. In our example these are rambutan, avocado and suren. Cassava and coffee which are of about the same height of Caliandra will be displaced, taro, citronella and roay will also be displaced by the profuse coppicing of Caliandra, so that they will be eliminated or reduced. Therefore, the introduction of Caliandra will greatly alter the structure of the homegarden and hence also its functions. Since in our example the village is an isolated one, there will be no market for the wood of Caliandra. Accordingly, the villagers will not gain benefits from it, but on the contrary they will suffer.

If the planting of Caliandra is made compulsory, as often happens in the regreening program, the villager may have to grow his complementary food crops elsewhere, perhaps by cutting in forests.

This example should, of course, not be interpreted that we should refrain from changing the homegarden to improve its productivity. We should try to do it, but with an understanding of its structure and functions. Under the condition of our example, ipil-ipil (Leucaena leucacephala) would suit better than Caliandra, since it has a growth form similar to suren, but has a better quality wood, faster growth, can tolerate moderate shading and does not excessively shade the lower plants. In other words the ipil-ipil fits into the niche of suren in the homegarden. Therefore, the promotion of ipil-ipil would increase fuelwood production without interfering with the production of food, fruits, spices and vegetables. In fact, in the example, ipil-ipil, or petai cina in the local language, is grown and also serves as a center of association. In this case introduction of improved varieties would be very appropriate to increase wood production.

In villages near cities or industrial centers, Caliandra can be beneficial since there is a ready market for the wood and at the same time it can serve as ornamental plants.

Similar considerations should be made when we wish to increase fuelwood production in the kebun and talun.

Since the homegardens, kebuns and taluns, are still very little studied, there are many opportunities for improving them. Selection of the existing plant and animal varieties for superior forms, followed by a breeding program, should enable us to increase production substantially, not only of fuelwood, but also of food and income, and by understanding their functions, soil conservation would be taken care of at the same time. If we learn from the lessons of Bimas, measures can also be taken to prevent the creation of social problems arising from increased production.

The improvement of traditional agro-forestry systems has a better chance of success than the introduction of new systems, since the former ones are already known to the people and they are already embedded in their culture. Since the villages are undergoing dynamic social-economic changes as a result of the modernization process, the functions of these traditional agro-forestry systems will also change. Emphasis will shift from one function to the other and some functions may even disappear. These changes will affect the structure.

We can expect that commercial production will become more important with time. Industrialization will advance and commercial fuelwood consumption will accordingly increase. Even now in certain places commercial fuelwood consumption is already important, for example in the lime kiln areas and brick factories. Many lime

kiln areas are denuded. Under such conditions special fuelwood plantations are needed. Several promising tree species are Caliandra, ipil-ipil, Sesbania grandiflora, Acacia auricauliformis and albizia falcataria. Further studies have to be carried out to enable us to anticipate what changes are likely to occur in the future and what impact these changes will have on the traditional agro-forestry systems. Experiments will also have to be carried out to search for new or modified systems which can meet the new needs but which do not adversely affect the vital function of the conservation of soil and genetic resources.

Another aspect of the fuelwood problem is the low cooking efficiency of stoves. Efforts are being carried out to introduce better stoves (Singer, 1961). Although these improvements do not need much money, some tens of rupiah still mean much for people who earn a few hundred rupiahs per year. But at least for part of the population these improvements are within their reach.

Drying, of course, is the most simple way of increasing the burning efficiency of fuelwood. In the dry season this does not present problems. But in the wet season good drying usually cannot be done.

It should be bourne in mind that the village stove is not only for cooking. The heat is also used to dry agricultural products which are placed above the stove and the smoke from the fire acts as preservative. In improving stoves these functions should be considered.

Still another aspect is the development of alternative energy sources of biomass.

Alternative Sources of Energy from Biomass. Recently much attention has been given to alternative sources of energy from biomass. These are biogas, alcohol, products from pyrolytic conversion of biomass and oil from plants. There is now a flood of literature dealing with these subjects. The author does not wish to review the literature, but will limit himself to discussing the problems as they relate to Indonesian conditions.

As far as rural energy is concerned, all these alternative sources share the weakness that they require high initial investments relative to the income of the villagers.

Biogas. Among the alternative energy sources mentioned above, biogas is the closest to its application. The technology is well known, although it seems there is still much room for its improvement. Active groups in this field are among others Dian Desa (Village Light) in Yogyakarta, the Institute of Technology of Bandung (ITB) in Bandung, and the Institute of Ecology of Padjadjaran University in Bandung. They all have digesters in operation. Both Dian Desa and ITB use cow dung mixed with other organic matter as

as the raw material and the Institute of Ecology uses water-hyacinths.

Dian Desa has an 8 m^3 digester in operation in a village near Yogyakarta. The digester is placed in the garden of the village head, using the dung of his cows as the raw material. It is operating well, but when the author visited this place the gas was not used. The reason was not clear. The village head told him that it was easier to use wood. This could not be true, since the gas was piped to the kitchen and it would be much easier to cook with gas than with wood. However, it could be that there were cultural reasons for not using the gas, perhaps because it was produced from cow dung and hence considered dirty. Another reason could be climatic. The village is located at the foothills of Mt. Merapi and at nights the temperature is chilly. Cooking by wood will also heat the room which does not happen when gas is used. When asked by the author whether the villagers would build digesters, he said that they could not afford to do so.

ITB also uses cow dung as the raw material. There are several operating units in dairy farms. For these farms, which produce large quantities of organic matter, e.g., pig, poultry, and cattle farms, biogas can become an important source of energy. At the same time it will also become a means to combat pollution by recycling the organic wastes. But it is questionable that the villagers will adopt it for their daily use. First, the cost of a digester to serve a family of five will at least cost Rp. 100,000.00 ($1 US = Rp. 625,00). In our recent study in the Saguling catchment area the average monthly income of a family was about Rp. 27,500.00. The daily wage of a laborer is in the neighborhood of Rp. 300. The World Bank (1978) reported that the GNP of Indonesia in 1976 was $280., i.e., Rp. 156,250. These figures show that the installment of a biogas digester is beyond the means of the average villager, unless a subsidy is given to them by the government. The cost would be enormous but if it could reduce the consumption of kerosene, which is being subsidized by the government, it could still be worthwhile. However, even with subsidies to build the digester, the second problem would remain unsolved, i.e., to have sufficient cow dung to run the digester. It has been estimated that a family of five will need 3 - 5 cows to get enough biogas for the family's daily need of fuel. A villager who has that many cows would be considered rich and only a few people belong to this group. Therefore, the problem of a biogas digester run on cow dung or other animal waste is more a socio-economic problem than a technical one. Because of this difficulty the Institute of Ecology searches for other raw materials.

Waterhyacinth (Eichhornia crassipes) is a noxious weed in many lakes, reservoirs, rivers and other water bodies. It causes a lot of damage, since it obstructs navigation, increases water loss several fold due to its high rate of evaporation, reduces reservoir storage capacity, interferes with tourism and reduces fish yield.

It is very difficult to control because of its high rate of growth. But the high rate of growth also means that it is capable of fixing solar energy at a high rate. Therefore, eradication of waterhyacinth actually means that energy is used to destroy an ecosystem with high energy content. Ecologically this cannot be justified, particularly at a time of rising energy scarcity and prices. It would be much better to extract the energy from the biomass of waterhyacinth. At the same time it would have the effect of controlling the waterhyacinth by harvesting it regularly. Methane fermentation, which produces biogas, would serve this purpose.

Experiments were initiated in Lake Curug, which is suffering from aquatic weeds. The lake is about 750 ha large. About 135 ha are covered with a mixture of aquatic weeds, of which about 45 ha consist of waterhyacinth. In situ experiments showed that the growth rate was 1.9% per day and the biomass of leaves and petioles was about 580 g dry-weight/m^2. Therefore, in the lake there were 261 tons dry-weight of biomass and the daily growth increment was 4.96 tons or about 5 tons.

The daily growth rate of 1.9% and biomass of 580 g/m^2 at Curug lake were lower than reported growth rates of between 5% and 10% per day and biomass of 1.5 kg/m^2 (Mitchell, 1974). This could be because the waterhyacinth was growing in a mixture of waterfern (Salvinia sp) and Hydrilla. Observation showed that in places with a dense growth of Hydrilla, the growth of waterhyacinth was very poor. Apparently Hydrilla has an inhibiting effect on the growth of water hyacinth, presumably by allelopathic substances.

Field experiments using a digester of 1000 liters showed that 620 liters of biogas could be produced per kg dry-weight of leaves and petioles of waterhyacinth. When whole plants were used, i.e., including roots and stems, only 330 liters of biogas could be produced. It should be noted here that chopped waterhyacinth was used without drying. This is an advantage, since waterhyacinth contains 90% water and drying would need much energy and time.

NASA reported a production of biogas of 370 liters per kg dry-weight of waterhyacinth (National Academy of Sciences, 1976), thus lower than the Institute of Ecology. However, the methane content of biogas produced by NASA was 69%, while by the Institute of Ecology was 52%. When computed on the basis of 69% methane, the production of biogas by the Institute of Ecology was 467 liters per kg dry-weight. Since the daily growth increment was 5 tons, it could produce $5 \times 10^3 \times 467$ liters = 2335 kiloliters. According to Fry and Merril (1973), the fuel requirement for cooking was 383 liters per person. Therefore, the biogas produced from the daily growth increment of waterhyacinth at Lake Curug would be sufficient for about 6000 persons or about 1200 households. If the lake authority would be willing to use the money, which would be used to eradicate the weeds, for the building of biogas digesters, the

villagers in the surroundings of the lake could control the waterhyacinth by producing biogas. Naturally training and extension would be needed.

Waterhyacinth farming could also be attempted. In ponds the growth should be better than in Lake Curug. At least a daily growth rate of 5% should be possible. By systematic harvesting and recycling the sludge from the digester as fertilizer the growth rate should be even better. Assuming a daily growth rate of 5% and biomass of 1 kg dry-weight/m^2, the production of biogas will be 233.5 kiloliters/ha from the daily growth increment. This will be sufficient for the daily fuel need for cooking of 600 people or 120 households. Therefore, per household will need 83 m^2 or about 100 m^2 to satisfy its daily fuel need for cooking. The waterhyacinth can be grown together with fish in a fishpond larger than 100 m^2.

The average farm in Indonesia is about 0.5 ha. If 5% of the farm is used as a pond, i.e., 250 m^2, waterhyacinth farming mixed with fish seems to be more feasible for biogas production than using animal waste as the raw material for rural energy supply. Naturally, this applies only for regions where water is adequately available, such as West Java. Many villages in West Java already grow waterhyacinth in small quantities for the purpose of clearing the water of ponds, which they use for bathing and other household purposes. But to build the digester the villagers will need a subsidy.

An important aspect to be considered is that waterhyacinth can serve as habitat of the mosquito Mansonia uniformis which acts as a factor of bancroftian filariasis. Therefore, before we promote waterhyacinth farming we must be sure that it does not create a health hazard.

Alcohol. Alcohol can be used to fuel engines by mixing it with gasoline, the socalled gasohol, or it can be converted to gasoline.

Fermentation of alcohol has been carried out traditionally by the people for a long time using many kinds of raw material, e.g., cassava, rice and juice tapped from inflorescences of palm trees. In most cases fermented cassava and rice are eaten as a snack. Distillation of alcohol is done very little. Accordingly, not much alcoholic drinks are prepared and alcoholism is not a problem. If large scale production of alcohol for fuel is going to be carried out, careful consideration should be given for the prevention of alcoholism. The majority of the people are Moslems. Islam forbids the people to drink alcoholic drinks. Unfortunately there is no guarantee that the people will strictly obey the religious law, if alcohol is freely available. The danger is particularly great, when many small scale stills are introduced in the villages. If for technical reasons or otherwise, alcohol is produced in large plants, control will be easier.

Since rice is the principle staple food, it will be out of the question to use it to produce alcohol as an energy source. About 55% of the total calories consumed is derived from rice and rice bran, 11% from corn and 8% from cassava. About 50% of the total proteins consumed is derived from rice and rice bran, 14% from corn and 3% from cassava (Birowo, et.al., 1978). These figures clearly show the importance of rice. Rice also has to be imported in large quantities every year. Likewise, cane sugar cannot be used, since there is a short supply of it. But corn, cassava, sweet potato and sagu offer possibilities to be used as raw materials for alcohol production.

In the period between 1970 and 1976, in Java consumption of corn, cassava, sweet potato decreased, but outside Java consumption of cassava and sweet potato increased. At the national level, in the period between 1969 and 1977, production of corn on the average increased and cassava decreased, but there were large yearly fluctuations (Birowo, et.al., 1978). Although national figures are important, we should bear in mind that corn and particularly cassava, are the foods of the poor people. Should alcohol production become a reality and put a large demand on these commodities, their price would increase. This would give an opportunity for the farmers to earn additional income, if proper measure would be taken to insure that the benefits of higher prices would indeed come into the hands of the farmers. Otherwise the higher demand for corn and cassava would bring them into more difficulties, due to competition for this food resource.

Price increases will stimulate people to produce more corn and cassava. Intensification of these commodities has been attempted by the introduction of high yielding varieties in combination with a credit system for fertilizers and pesticides, but it is still at a low level of activity. Increase in acreage of corn and cassava has also happened as a result of impoverishment, which interacts with soil erosion. Corn and cassava are commonly grown by the farmers on marginal lands which are not suitable for rice, for example, when irrigation is not available, and as mentioned earlier, with inadequate or without soil conservation measures, simply because the people are too poor and cannot afford to take up such measures. It is known that generally people will switch from upland rice to corn when soil fertility has declined and finally to cassava as their last resort, when soil erosion has become severe. For example, in the Gunung Kidul area south of Yogyakarta in Central Java, when soil erosion is a serious problem, the landuse pattern has changed. Between 1920 and 1959 the acreage of rice decreased from 6100 ha to 5900 ha, but the acreage of corn increased from 7100 ha to 20500 ha and of cassava from 7700 ha to 57000 ha. Since the total area of cultivation has increased, it must have occurred at the expense of the forests. Indeed deforestation in the Gunung Kidul area has been going at a fast rate. Here we see an example of the downhill spiral or vicious cycle of increasing population density, deforestation and soil erosion. Therefore,

if the higher demand for cassava could not benefit the poorest people, but on the other hand would act as a competitor for corn and cassava as food resources of the poor people, the production of alcohol from these commodities would cause impoverishment of the rural poor and would aggravate the soil erosion problem.

Therefore, production of alcohol from corn and cassava should not only consider the technical and macro-economic aspects, but should also include planning for mitigation of the potential negative impacts of alcoholism and soil erosion. The latter is related to efforts of better equitable distribution of benefits of development which has been recognized as one of the cornerstones of Repelita III.

Sagu (Metroxylon sagu) forests are found in large quantities in Indonesia, such as Irian Jaya, Kalimantan and Sumatra, but no one knows how large these forests are. Studies with satellite images should enable us to obtain a reliable estimate of their extent. The sagu area in the Moluccas is estimated to be 5000,000 ha, and in Irian Jaya about 7 million ha (Johannes, 1978). According to Johannes, Sambas estimated that the flour harvest would be 10 tons/ha/year. The potential production of the extensive sagu forests would be tremendous. Others, however, have estimated the yield at only one third of Sambas. Although sagu is the staple food of people in the sagu growing area, the population density in those areas is low, while the sagu forests are extensive. Therefore, there should be no danger for competition between sagu for food or the local people and for alcohol production. The trunks of the sagu trees can be used to fuel the stills. However, there are several problems.

The knowledge about the sagu palm is still limited. Its growth requirements, growth rate and productivity are not quite known yet. Accordingly it is still difficult to design a harvesting method which can assure sustainable yields. The questions of what will happen when a large piece of sagu forest is clear cut or how much damage will selective cutting do to seedlings and saplings need to be answered before large scale operation is attempted. Sagu is growing in areas which are not easily accessible. Its harvest and processing, therefore, is still difficult and will need large capital investments for infrastructure. But these investments will also be useful for the development of the remote areas although it is a question whether these investments will be economically feasible, since these areas are sparsely inhabited and seemingly without great economic resources.

Nipah (Nipa frusticans) is another plant which has often been mentioned as a potential source of energy. The sap from the inflorescence can be fermented into alcohol. The knowledge about Nipah is even less than about sagu. According to Johannes its production potential is about 3 tons sugar per hectare per year. Nipah is growing in marshes which are not easily accessible. The

tapping of the inflorescences will require much labor, but many Nipah areas are sparsely populated. Large scale exploitation, therefore, will offer many problems.

Pyrolysis. Pyrolysis is a process by which organic matter is broken down by heat producing char, gas and oil, which can be used as fuel for cooking or other purposes. The oil can also be used as a preservative of wood. The raw material can be waste products of rice hullers, copra industry, saw mills, city wastes and organic matter of weeds, e.g., alang-alang and waterhyacinth. Therefore, it has the advantage that wastes and organic matter which are now not being utilized and pollute the environment or are a nuisance can be turned into a valuable resource.

Johannes (1979) reported that pyrolysis of one gram of dry alang-alang produced 31.74% char, 0.67% methanol, 1.77% acetic acid, 1.25% tar and 37.5 cm^3 flamable gas. Methanol can also be produced from char which can be further processed into gasoline. Theoretically 7 tons of gasoline can be produced from 6 tons of char. Since 28.5 tons (dry-weight) of alang-alang can be harvested from 1 ha of alang-alang field, Johannes theorized that the present producion of oil of Indonesia of 81.5 million tons per year, could be produced from 7.8 millions ha alang-alang, which is about 50% of the estimated alang-alang wasteland. However, the yield of 28.5 tons/ha of alang-alang seems to be on the high side. Surjani (1970) reported a yield of only 11.5 ton/ha. Furthermore, it is known that alang-alang can not tolerate periodic cuttings. In fact, one of the control methods of alang-alang is to cut it at regular intervals. It can be expected that a sufficiently long period between cuttings will be required. Alang-alang also impoverishes the soil, but when the soil is improved it cannot compete with other plants. Consequently weed problems may be serious in fertilized alang-alang fields. Therefore, to manage alang-alang fields for a sustainable yield will not be an easy task.

The use of wastes seems to have a promising future. According to Imanuddin (1979), the pyrolytic reactor of ITB, using rice husks, yields 10% oil, 30% char, and gas. The char is powdery. To use it as fuel, it has to be processed into pellets with the aid of the waste of the tapioca processing. However, the ash content of the char is high, i.e., 40 - 50%, which lowers its heating value. To use the oil as fuel, it needs a pressurized stove. The gas can be used with simple burners.

Pyrolysis may become an important source of energy for industries which produce large quantities of wastes and for cities to get rid of their organic wastes. But at present it is still at the experimental stage and we have to wait for more concrete results, before we can evaluate it.

Oil From Plants. It has been reported that oil can be produced from plants, especially Euphorbia. There are many species of

Euphorbia growing in Indonesia. This field, however, is still very speculative. Much basic research is still required to get a clearer picture of its potentialities.

Environmental Impact of Hydroelectric Power. The total installed capacity of electricity in Indonesia at the end of the Second Five Year Development Plan, i.e., in April 1979, was 2292 MW, and the total installed capacity of hydro-electricity was only 450 MW at the end of the fiscal year 1977/1978 (Surjono, 1979). The population of Indonesia in 1979 was about 130 million. Therefore at the end of the Second Five Year Development Plan, the available electricity was $\frac{2292 \times 10^6}{130 \times 10^6} = 17.5$ watts/capita. The contribution of hydro-electricity was $\frac{450 \times 10^6}{130 \times 10^6} = 3.5$ watts/ capita. Clearly the supply of electricity, especially of hydro-electricity, is still very low relative to the population number.

According to Notodihardjo and Putuhena (1979) the potential of hydro-electricity in Indonesia has been estimated at about 17,575 MW. This estimate was based on rainfall and topographical maps. It is lower than the State Electricity Company's estimate of 31,000 MW. The target is to have an installed capacity of hydro-electricity of 4000 MW in the year 2000. Since at that time the population will be about 250 million, the contribution of hydro-electricity will be

$\frac{4000 \times 10^6}{250 \times 10^6} = 16$ watts/capita, i.e., almost 5 times its present contribution.

The generation of hydro-electricity can be by run-off river storage or pumped storage method. In Indonesia it is usually done by the storage method by building a dam in a river which creates a reservoir. Rarely is a dam built for the sole purpose of the generation of electricity. More usually it is built for a multipurpose function, e.g., generation of electricity, irrigation, flood control, fisheries and recreation, although not all functions are of equal importance. For example, the Jatiluhur dam near Bandung has the primary functions of irrigation and flood control. Electricity is secondary albeit still important. Fisheries and recreation, however, are considered to be byproducts, and up to this time, they are not well developed. The Saguling dam, which is now being planned upstream of the Jatiluhur dam is an exception. Its function is the generation of electricity, although it will also be useful to increase the supply of water for Jakarta. Recreation, which may be developed later, will just be a byproduct. The impact of a dam has to be considered in relation to its functions.

A river basin can be considered as an ecosystem with natural boundaries which consist of mountain tops and ridges. In Figure 7

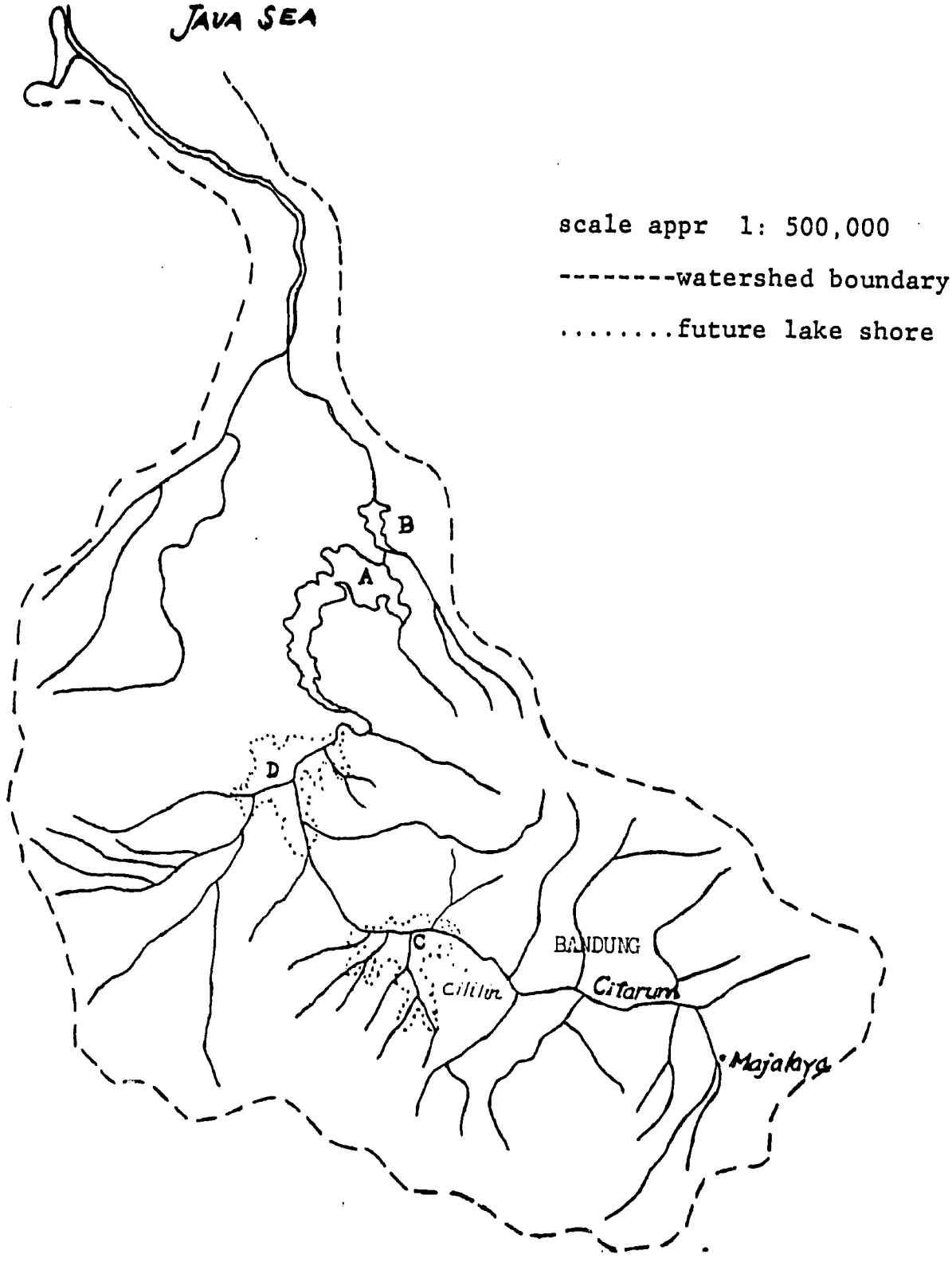


Figure 7: The Citarum basin ecosystem. The compon
consist of rive, city, village, farmland and
forest.

is shown the Citarum river basin as an example of a river basin ecosystem. In this basin a large dam, i.e., the Jatiluhur dam, and a small one, i.e., the Curug dam, have been built. Two more dams are being planned, respectively the Saguling and the Cirata dams. From this figure it is clear that the dams and the reservoirs have become components of the ecosystem. They impact on and are being impacted by the other components, which are cities, villages, forests and farmfields. Schematically the Citarum basin ecosystem can be presented as shown in Figure 8.

The components city, village and farmfield, are man-made and man's activities predominate in these components. The components river and forest are more or less natural.

Of course, the components vary from place to place. In many parts of Sumatra, Kalimantan and Irian Jaya, for example, the components may only consist of forest and river, because the population density in those places is very low and some river basins are not inhabited at all.

Because of the interactions between the components within an ecosystem we may expect that when a dam is built in a river the impact is not limited to the river, but potentially it will extend to the other components. Whether or not the impact will actually occur in any one of the other components depends on many factors, such as the size of the reservoir created by the dam, the distance of the components to the dam and topography. Conversely we may also expect an impact of every one of the components on the dam. Such an ecosystem approach is useful as a tool for identifying potential impacts.

Let us consider the Saguling dam as concrete example. It is being planned upstream of the Jatiluhur dam in the Citarum river (see Figure 7). In the first phase 750 MW of electricity will be generated and in the final phase 1400 MW. The dam will create a reservoir of about 5000 ha, which will inundate villages and farmfields. The major city in the basin is Bandung with a population of about 1.5 million. It has many industries in its environs. All cities and the majority of industries do not have waste treatment plants. Population density in the Upper Citarum basin is high. Many subdistricts have population densities above 1000 people km^2. Because of this high population density and since most people are farmers, the population pressure on the forest is high. Hence deforestation is proceeding at a fast rate (Soemarwoto et.al. 1976). Intensive agriculture of rice, vegetables, tea and quinine is practiced with fertilizers and pesticides.

The inundation of villages and farmfields will be the most important environmental impact of the dam, since in the densely populated area it will affect thousands of people. Many more people, who depend on the transportation, processing and trade of agricultural products of the area, will lose their jobs. These people

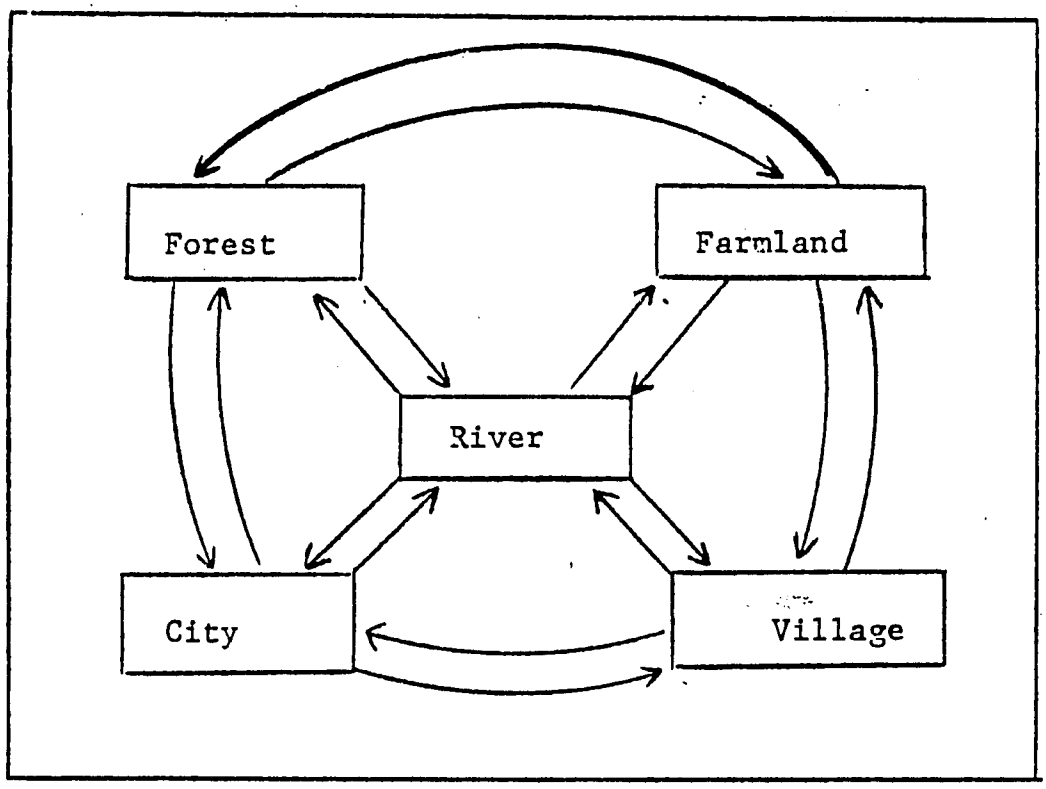


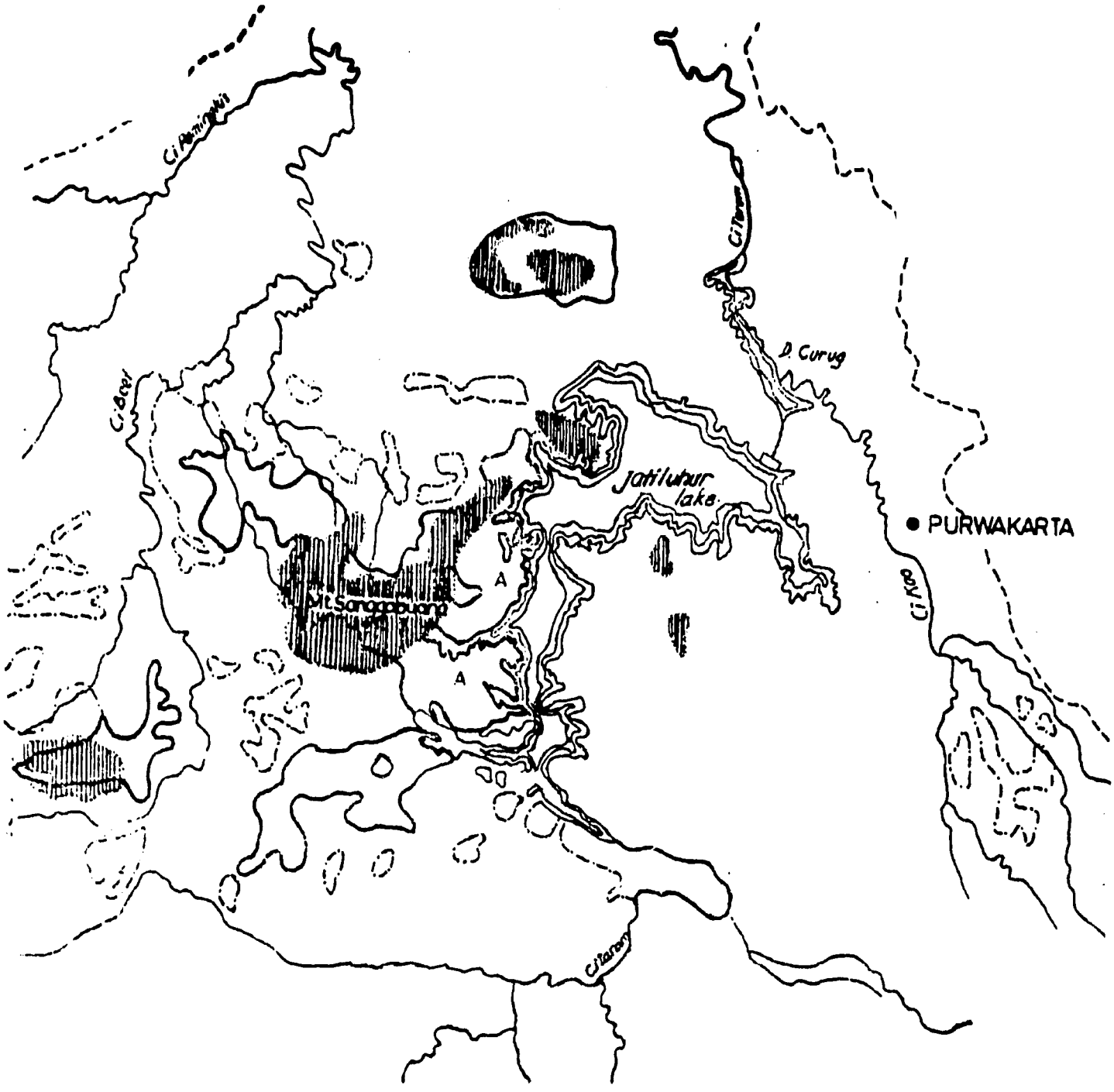
Figure 8: A schematic presentation of the Citarum basin ecosystem, showing the interactions of the five components, river, city, village, farmland and forest.

are traditional, and strongly attached to each other and their villages, which they consider the land of their ancestors. Therefore they are very reluctant to be relocated, or if they had to, they would prefer to move to the neighboring villages, where they have relatives. If they are transmigrated to other islands, we may expect that at least some of them will return. In other similar projects, it was assumed that those who choose to remain would become fishermen. However, experience in Jatiluhur shows that they remained as farmers. Because of inundation, the Cp value in the Allan formula decreased. Under conditions of high population density, which is being increased by the movement of people from the inundated areas, a reaction of the people will be to increase the Cp value by cutting forests for cultivation. This was indeed observed in Jatiluhur. Comparison of the landuse map before inundation and satellite imageries which were taken after the creation of the lake shows that large patches of forests disappeared in the Western slope of the lake (Figure 9).

Inundation of farmfield and roads will also disrupt the market system. In the Saguling area three market systems can be identified, one centered in Cihampelas, a second one centered in Rancapanggung and a third one centered in Gununghalu. The Cihampelas market complex will most probably collapse because of the loss of its producing area by inundation. The Rancapanggung and Gununghalu market systems will be relatively little affected by the reservoir. But because of inundation of the access road to these areas, they will become isolated and unless a new road is built their market activities will certainly decline. Because of the collapse of the Cihampelas market and the decline of the two other markets, many people will lose their jobs. These will either move to cities to look for employment or revert to farming by cutting forests on the mountain slopes. In the first instance they will add to the problems of urbanization and in the second instance they will accelerate deforestation process. Since the basin is already undergoing serious deforestation, accelerating it will cause excessive sedimentation of the lake. In fact our calculations have shown that the average annual rate of erosion of the Citarum is already as high as 3.35 mm. Serious efforts are needed to control deforestation and soil erosion, if the reservoir is expected to last according to plan.

Three mitigating measures have been identified and proposed. These are summarized in Figure 10. We have set a criterion that a viable alternative should be one which can offer an improved standard of living above the poverty line for the affected people.

The first alternative is transmigration. As already mentioned most people are reluctant to be transmigrated. Therefore, only few people will choose this alternative. Many reports have s that the benefits of transmigration are not fully materializ yet and many transmigrants have not been able to rise above subsistence level (e.g., Suratman and Guinnes 1977; Suratman et 1977). A major difficulty is that most soils outside Java are



LEGEND

Dense forest areas according to LANDSAT-I (1972)

Dense forest areas according to land-use map (1970)

Shrub forest according to land-use map.

Figure 9: Deforestation at the western shore of the Jatiluhur lake (A) after creation of the reservoir, due to the reaction of the people to the decrease of farmland by inundation.

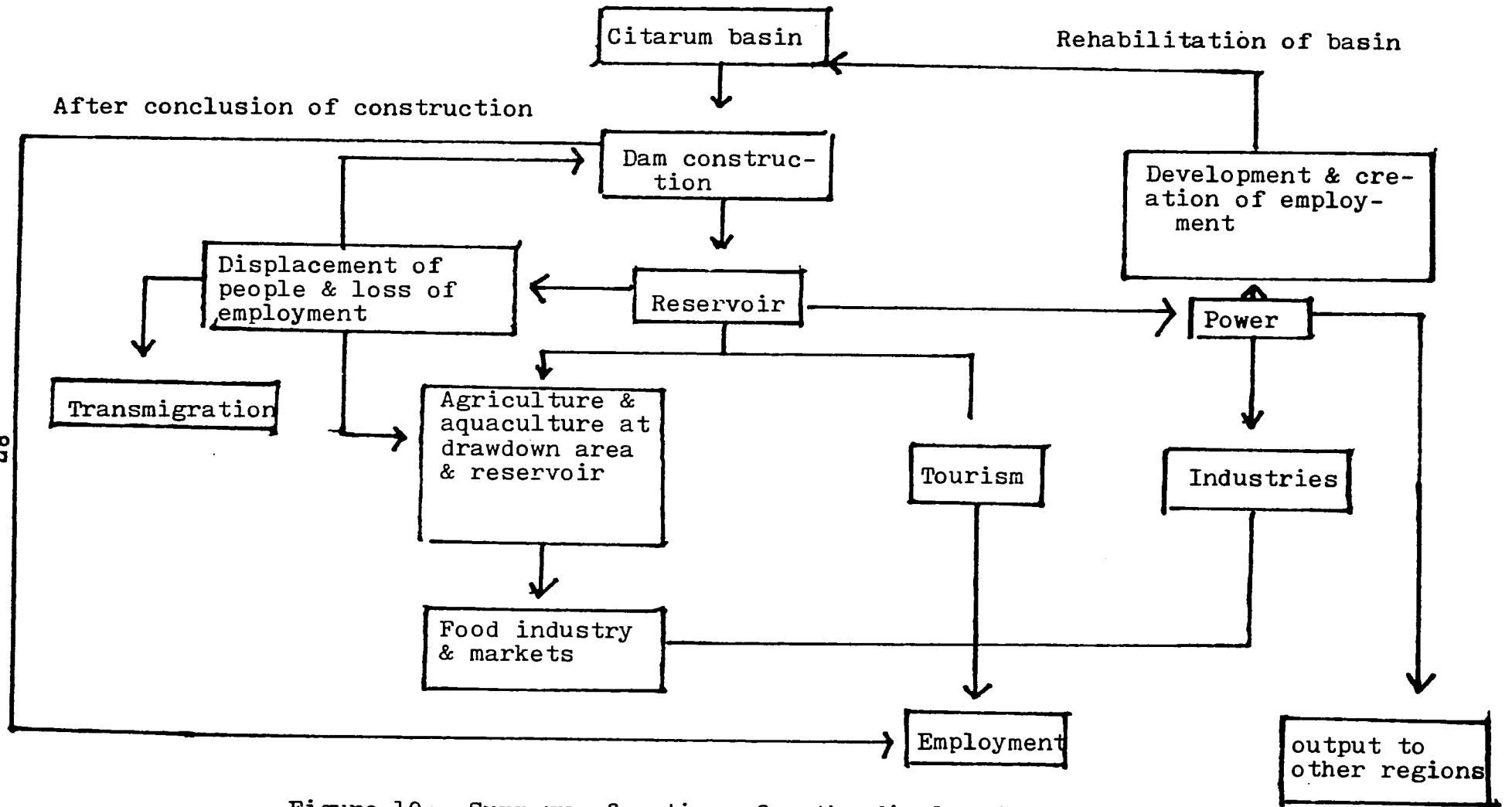


Figure 10: Summary of options for the displaced people and those who would lose their jobs as a result of the Saguling reservoir. Explanation in text.

non-volcanic and of low fertility. Irrigation is mostly absent or the areas for transmigration are located in the tidal swamps. The technology to cultivate these soils is not quite known yet. Therefore, transmigration should not be based on agriculture only, but should be coupled to non-agricultural economic activities. Training of transmigrants, before leaving, will be required.

The second alternative is to channel the people to construction work. Since a few people have skills, they will have a hard time to compete for jobs, if they are left on their own. Accordingly they need to be trained and deliberate planning to absorb them in the construction work has to be made. Otherwise, most of the jobs will go to migrant workers from elsehwere as has happened in other development projects. In addition the people also have to undergo a training in order that they can successfully adapt to the way of living of a construction worker, which is quite different from that of a farmer.

Since the construction work is only of a limited duration, plans also have to be made for channeling them to jobs of the secondary development resulting from the dam construction, among others, tourism and manufacturing industries.

The third alternative is to develop agri- and aqua-culture in the drawdown area and the reservoir. We do not have experience in that field yet. But aquaculture in fishponds and in combination with wet rice is a wellknown technique in the area. Some small scale experiments with cage culture of fish and fresh water shrimps (Macrobrachium rosenbergii) were carried out at Jatiluhur lake and Curug lake with promising results. It should be possible to further develop the techniques to be applied at a large scale in the Saguling reservoir. In any case training for the people will have to be carried out.

Development of the drawdown area is a must. Without it these areas will be occupied by illegal tenants in no time, because the population pressure on land in this region is high and the shoreline mostly has a gentle slope.

Local resettlement for construction workers and development of agri- and aqua-culture in the drawdown areas and the lake will be preferred by the people. It offers new opportunities for a higher standard of living. Of course, many problems still have to be worked out.

It is also proposed to use part of the generated electric energy for development in the Upper Citarum basin to create new job opportunities in the non-agricultural sectors, in order to relieve the population pressure on the forests and thereby to enable the reforestation and afforestation program to succeed. With the success of the regreening and afforestation program, soil erosion will be arrested and eventually the basin can be rehabilitated.

These ideas, which have been accepted as inputs in the planning of the new dam, show that the construction of a dam can become an asset for the people and the region, instead of a liability.

Although conditions differ from place to place, the principles can be applied elsewhere.

The cities will also have their impact on the reservoir. Untreated wastes of cities which are located short distances from the lake will cause pollution and also eutrophication. From the experience in Jatiluhur Lake and Curug Lake it is most likely that eutrophication will in turn cause blooms of aquatic weeds and the blue-green alga microcyctis. The aquatic weeds will in all likelihood include the dreaded waterhyacinth, since in our survey this weed was found in large masses in several places near Bandung.

From a literature survey, Pieterse and Dhahiyat et.al. (1979) reported that Mansonia uniformis, a vector of bancroftian filariasis, is known to depend on Pistia stratiotes, waterhyacinth and other floating plants for their larvae. Therefore, it is possible that aquatic weeds can become a source of bancroftian finariasis. Other mosquitoes are also known to inhabit vegetated swampy areas (Table 6). These areas may be formed in the drawdown areas, for example as a result of sedimentation which obstructs the flow of rivers. Such pools were observed in Jatiluhur. In this respect it is important to note that Jatiluhur had a high incidence of malaria when compared to other subdistricts in the Citarum basin, although there is no proof that the higher incidence was caused by the lake. Because of this potential hazard, disease vectors need to be monitored in order to detect any threat as early as possible.

Other damages which are caused by aquatic weeds include decrease of reservoir storage capacity, increased evapotranspiration, interference with navigation, reduced fisheries yield and decline of aesthetic values. Therefore, constant watch has to be kept on the aquatic weeds.

It is most probable that it will be impossible to eradicate them. But it should be feasible to control them to keep their population below the economic damage threshold. A promising method is an integration of manual, chemical and biological control, with the utilization of the macrophytic weeds for cattle and poultry feed, handicraft, compost and production of biogas. Small scale experiments have shown that the grasscarp and the utilization of the weeds can become an effective means of control.

Downstream effects of dams may be expected. A positive one is that the river flow can be controlled, so that the difference between the maximum flow in the wet season and minimum flow in the dry season can be minimized. Accordingly the frequency as well as the magnitude of floods and shortages of water can be reduced, which perennial irrigation can be developed.

TABLE 6

Species of Mosquitoes Which Colonize Vegetated Swampy Areas and the Disease(s) They Transmit

Species	Disease(s)
Anopheles maculatus	malaria
A. aconitus	malaria
A. subpictus	malaria
A. sincrisis	malaria
A. nugirinus	malaria
A. venhuisi	malaria
A. barbirostris	malaria and bancroftian filariasis
A. togoi	bancroftian filariasis
Culex bitaeniorhynchus	bancroftian filariasis
C. tritaeniorhynchus	Japanese encephalitis
C. vishormi	Japanese encephalitis
C. farigans	dengue haemorrhagic fever and bancroftian filariasis
Mansonia uniformis	bancroftian filariasis

after Pieterse et.a., 1979

Most of the sediments will be entrapped in the reservoir. Therefore, the rate of sedimentation in the river and in irrigation canals downstream of the dam will be reduced. This also has a positive effect on flood control. The Cimanuk, for example, has a high rate of sedimentation which causes reduction of the volume of the river course. This increases the likelihood of floods. To counteract it, dikes are built along the riverbanks which have to be increased in height continuously to keep pace with the growth of the riverbed. It has now reached the stage that in the lower reaches of the river it is flowing at a higher elevation than cities, villages and farmfields. Accordingly when a part of the dike is damaged, a disasterous flood occurs. If a dam were built upstream, the rate of sedimentation would be reduced and the riverflow could be regulated to control floods.

On the other hand, the reduction of sediment load in the water will increase riverbed and bank erosion and changes in the river course may occur, which will cause damages to farms, villages and other properties. Foundations of engineering structures may be endangered. The lesser sediment load will inhibit delta formation along the shoreline, which will increase erosion of the shore by waves and currents of the sea. This, however, has not been observed in Indonesia, specifically in Java, since the tributaries downstream of the dam still contribute sufficiently to the sediment load of the mainstream.

Indonesia is also lucky that schistosomiasis is not found in the country except in a small pocket in Central Sulawesi. Therefore, the extension of irrigation as a result of the construction of dams does not create health hazards. However, malaria may increase, if no adequate control measures are taken.

So far, salination of farmlands has also not been observed, presumably due to the high rainfall and relatively short dry season in most parts of the country. This problem may arise in the eastern parts of the country, when extensive irrigation programs are carried out, since in those areas rainfall is low, with long dry seasons.

REFERENCES

1. Allan, W., 1949. Studies in African land usage in Northern Rhodesia, 85 pp. Oxford University Press, Cape Town.

2. Birowo, A. T., W. Sugiarto and H.Tedjckoesoemo, 1978. Supply and demand of food in Indonesia, 52 pp. (mimeographed). Paper presented at the National Workshop of Food and Nutrition, Bogor, (Indonesian with English summary).

3. Danoesastro, H., 1972. Utilization of homegarden. Directorate General of Agriculture, Jakarta (Indonesian).

4. Directorate General of Forestry, 1970. A survey report on the trend of fuelwood need in West Java, 19 pp. Directorate General of Forestry, Jakarta (Indonesian)

5. Ernst, E., 1978. Fuel consumption among rural families in Upper Volta, West Africa, 9 pp. Eighth World Forestry Congress, Jakarta.

6. Hadi, S., Buharman, Boen Purnama and Hartojo, 1979. Consumption of fuelwood and agricultural wastes in Indonesia (Progress Report). Workshop on Energy, Jakarta.

7. Haeruman, H., 1979. Consumption and supply of energy in the rural areas in relation to the quality of the human environment in West Java, 3 pp. Faculty of Forestry, Institute of Agriculture Bogor. (mimeographed, Indonesia).

8. Harijadi, M. M. and Sri Setiati, 1975. Potential contribution of homegarden to nutrition intervention program in Indonesia, 20 pp. (mimeographed). Paper presented at the Seminar on Food and Nutrition, Yogyakarta.

9. Imanuddin, 1979. Pyrolysis of rice husks as a cheap source of energy, Kompas, 20 September 1979.

10. Institute of Ecology, 1979. Environmental impact of the Saguling Dam, Vol. IIA. Report to Perusahaan Listrik Negara. Institute of Ecology, Bandung.

11. Johannes, H., 1978. Energy farming. Agro-Ekonomika 9(9): 3-14 (Indonesian).

12. Johannes, H., 1979. Gasoline from alang-alang, 4 pp. (Mimeographed, Indonesian).

13. Karjono, L. Christanty, Oekan and O. Soemarwoto, 1979. The role of homegarden, kebun and talun as a source of fuelwood in the rural areas of the Citarum basin. Workshop on Energy Conservation, Jakarta (Indonesian).

14. Karjono, Iskandar, J., O. Soekotjo, Prihono, H. Ismawan, H. Y. Hadikusumah and A. Ramlan, 1978. Homegarden structure in the Citarum River Basin, West Java. Seminar of Ecology of Homegarden, Institute of Ecology, Bandung (mimeographed Indonesian).

15. Komarundin, M., 1977. Research about the fuelwood consumption in Babakan Village, Kebupaten Bogor. Master's thesis, Faculty of Forestry, Bogor (Indonesian).

16. Margalef, R., 1968. Ecological theory and prediction in the study of the interaction between man and the rest of the biosphere. In: Oekologi und Labenschutz in internationalen Sichy, 307 - 363, ed. H. Sioli. Verlag Rombach, Freiburg.

17. Marjono, N., and F. Patuhena, 1979. The place of water energy in the development of water resources and its contribution toward meeting the national energy need. Workshop on Energy, Jakarta (Indonesian, mimeographed).

18. Martono, A., 1974. Some thoughts on policies for energy consumption for household purposes. National Energy Seminar (indonesian).

19. Mitchell, D.C., 1974. Aquatic vegetation, its use and control, UNESCO, Paris.

20. National Academy of Sciences, 1977. Making aquatic weeds useful: Some perspectives for developing countries. Washington, D.C.

21. Ochse, J. J. and G. J. A. Terra, 1937. The economic aspect of the Koetowinangun Report". Landbouw 13: 54.

22. Odum, H. T., 1971. Environment, power and society, 331 pp. Wiley Interscience, New York.

23. Oekan, S. Studies on food-ecology in Pasch, West Java. Master's thesis (in preparation).

24. Sayogya, 1978. Poverty in the midst of development Pustaka 2: 8 - 13 (Indonesian).

25. Silitonga, T., 1974. The role of fuelwood and charcoal to fulfill the energy need in Indonesia. National Seminar on Energy, Jakarta. (Indonesian).

26. Soedarto, H.A., Ramlan, R. Priatma, Adang Sujana, Agussyadi, 1979. Problems of vegitation in the Jatiluhur catchment area, 38 pp. Seminar on erosion of the Jatiluhur catchment area (Indonesian, mimeographed).

27. Soemarwoto,O., Supriyo Ambar and M. H. Khan, 1976. Dense forest areas in the Citarum river basin. Ecology and Development 4, 10 pp. Institute of Ecology, Bandung (Indonesian with English summary).

28. Soemarwoto, O., and Soemarwoto, 1979. The village homegarden: a traditional integrated system of man-plants-animals.

29. Soerjono, 1979. Development of hydroelectricity: Experience in Indonesia. (Indonesian, mimeographed).

30. Stoler, A., 1975. Garden use and household consumption pattern in a Javanese Village, 91 pp. (mimeographed). Department of Anthropology, Columbia University.

31. Wiersum, K. F., 1977. Fuelwood in Indonesia, future prospects for a traditional energy source, 12 pp. Institute of Ecology, Bandung (mimeographed).

32. World Bank. 1976. World Bank Atlas. Population, per capita product and growth rates. Washington, D.C.

Socio-Economic Considerations for Household and Rural Energy Programs: Notes on Field Trips to India and the Philippines

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The Asia Bureau of USAID held a Conference on Energy, Environment and Forestry in Manila in November 1979. I prepared a short paper on "Socio-Economic Considerations for Energy Programs" as the basis for discussion at the second plenary session. To test and refine the points made in the paper, I visited poor rural and urban communities in India and the Philippines. The following notes set my impressions of these field trips in the context of the earlier draft paper.

The rapid rise of oil prices has put pressure on energy supply all along the spectrum from household to advanced industrial use. Because the substitution of more efficient energy for animal and human muscle power is the essence of modernization, the end of the cheap fossil fuel era requires a reconsideration of most of the basic assumptions upon which current development plans are based. But like the proverbial complaint that the right hand does not know what the left hand is doing, development schemes dependent upon the availability of cheap energy continue to be funded by sections of the aid assistance community while at the same time other sections fund pilot projects in energy conservation and renewable resources. Such mutually contradictory policies impact on the present and future availability of fuel for total national consumption.

Clearly following high energy models of development exacerbates the shortages of fuel at the other end of the consumption spectrum among users in household and in informal sector industries. Strategies to address the fuel crisis at the small user end of the spectrum are a vital part of any development plan, particularly in the least developed countries where as much as fifty percent of the total fuel usage is for household or homecraft activities. As prices for oil, kerosene, and electricity increase, substitutions occur along the entire use spectrum. A detailed study in the Sudan noted that over the decade 1966-67 the price of kerosene increased eight times, compared to a tripling of charcoal price and a doubling for firewood. Much of this study is concerned with the increased desertification of the area, especially the widespread disregard of traditional conservation practices of not cutting young trees or those standing alone, and of completely ignoring personal rights in trees so that investment in or protection of trees becomes useless. 1/

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Urban poor are hit even harder with fuel scarcity. As much as one-third of the family's budget may go for fuel in the Sahelian countries. One study states that "to obtain the same amount of useable energy which can be purchased in the US for about $1.30, a charcoal-burning family in Addis Ababa may have to spend about $8.00." 2/

As fuel prices climb, the impact on the poor will be twofold:

- cooking and eating patterns will change, with likely negative nutritional impact;

- human and animal energy will be substituted for more efficient sources wherever possible.

The combination of reduced nutrition and greater daily drudgery reverses hopes for basic improvement in the quality of life among the poor, and anticipates social unrest as deterioration becomes increasingly critical.

A major problem in addressing fuel needs of the household and informal industry is the lack of either current data anywhere along the fast changing energy consumption spectrum. Data are particularly fragmentary at the household level since renewable resource use was considered, until recently, as a measure of underdevelopment to be replaced as soon as economically feasible by rural electricity supplied from oil-based or macro-hydro plants. A World Bank survey suggests that today only twelve percent of the rural populations in the less developed countries have access to electricity, but no one knows how many of the poor in those areas actually have access to electricity. At the present rate of increase, access will be doubled to twenty-five percent of rural areas by the year 2000. Any predictions for future energy use or availability in the present unstable crisis situation are extremely fragile. Thus, in most countries, strategies for responding to the energy crisis appear to be responses to the perceived points of the levels of fuel criticality both by government planners and by the poor.

Fuel Criticality in India and the Philippines

India and the Philippines provide distinct contrasts in the perception held by decision-makers and by the poor as to the energy crisis. In India the deforestation around villages is obvious; rights-of-way often have no trees; twigs and leaves are gathered and often sold. In the Philippines the emphasis is on conventional solutions of rural energy; little concern is given by the government to non-commercial fuels.

Fuelwood

India's concern for the availability and use of non-commercial or non-modern sector fuels goes back at least two decades. Fire wood, dung, and agricultural wastes account for 60 to 70 percent

of total household fuel usage in most urban households and 85 to 90 percent for rural households, according to a 1963-64 survey. Overall, non-commercial fuels continue to account for more than half of the total fuel consumption, perhaps 60 percent, according to a 1970-71 survey. The composition of these non-commercial resources is estimated as: firewood 65%, dungcakes 15%, wastes 20%. The bulk of this fuel is used for cooking, though there is some use for other domestic needs such as space heating or hot water, and some consumption for small industry such as brick-making. 3/

The Self Employed Women's Association, SEWA, of Ahmedabad, has formed a support group of "firewood pickers". Women make up one-third of the firewood pickers who get daily permits to collect wood on Girnar mountain. The toll on a headload of firewood is ten paise. The women start at daybreak, walk about an hour beyond the toll gates to collect wood: they may not cut certain trees or any greenwood. By the time they tie up the gathered wood and take it to town to sell, it is ten in the evening. The average monthly income for these women is rupees 120. They do better if they sell directly to customers, but many sell wholesale. 4/

A.K.N. Reddy of the Indian Institute of Science in Bangalore emphasizes that if animate energy -- animal and human -- is added to total energy use in a village, then the non-commercial energy falls from 90 to 70 percent. Indeed,

> the percentage of human labor and bullock power used in the village for agriculture is 55 percent and 84 percent respectively. And these two energy sources account for about 90 percent of the total energy used in agriculture. 5/

Reddy emphasizes that this animate energy should be made more efficient by judicious use of mechanical means rather than by "uncritical mechanization" that only benefits the owners of the machines while creating widescale unemployment. The great need among the poor is for cooking fuel, with some attention to energy for small, labor-intensive industry.

In India, people clearly recognize the growing crisis as fuel for cooking becomes increasingly scarce. Carpenters making wheels for bullock carts near Bardole in Gujerat complain that rising costs of wood are jeapordizing their livelihood. Only women dare poach in Bihar forests; the rangers would surely shoot men. Population pressure is causing widespread cutting of forest areas which results in increasing erosion. Sweepers in the streets of New Delhi collect and sell leaves swept up outside offices.

In contrast, in the Philippines, coconut shells smolder where they are burned as waste. The government has concentrated its energy programs in the commercial sector, seeking to replace imported oil by developing indigenous energy resources of geothermal,

coal, uranium, and some oil. Forests are being rapidly depleted; in the past decade, the amount of the country under forests has fallen from 55 percent in 1968 to 43 percent in 1978. Yet this deforestation does not seem of great concern to the government, nor has the process been carefully studied. In most countries forest cutting and settlement appears to be more a function of population pressure for agricultural land than it is of fuel shortage. But in the Philippines, Professor A.V. Revilla, Jr., in his lecture on "Critical Issues in Forest Resources Management in the Philippines", seems to relate deforestation to cutting for fuelwood. 6/

The widespread availability of fuelwoods -- coconut husks as they are or as charcoal, bark from commercially logged trees, and sawdust -- suggests that, at the present time, the poor do not perceive a fuel crisis. While prices are going up, they are not out of line. In one slum area of Manila, San Andreas, residents reported that firewood sellers no longer came through the muddy streets hawking their wares; today one must go out on the major paved thoroughfares to buy. In Piape, a long settled squatter area of Davao, no such concern existed. Costs were going up, but charcoal and firewood seemed to be selling for about the same cost per cooked meal. In an area where a working couple might at best make up to ten pesos a day, somewhat more than one peso might go for fuel to cook three meals for a large family. Three sticks of firewood or bark cost thirty centavos, up recently from twenty-five. That amount would cook one meal on the local stove. A plastic bag of charcoal sold for one peso ten centavos and would certainly last for one day.

Cooking was done on a single device: a cement cooker for charcoal costs between ten and twelve pesos while the clam-shell clay pot, good for wood or charcoal, sells for seven. Custom, rather than price, seemed to indicate who used which fuel: Tagalog use charcoal and Vasayan use wood, according to my informants. The lower status Bajao who live along the sand spit use only a three-stone tripod. Fuel costs were less in this squatter settlement on a marsh than the cost of water, for drinking and for washing. While many families trapped rain water for bathing, or bought from those who did, all bought trucked spring water to drink. Estimated daily water costs for a large family were one-and-one-half pesos.

In a low-income area of Cebu City, a large bag of sawdust costs only two pesos and lasts for two months, said one woman who used LPG as well. Now that the logging factories are using more of their own sawdust, it is becoming scarce. Three pieces of firewood there cost fifty centavos, for Cebu lacks the forests of Mindanao.

Stoves

In all of the Philippines, cooking is done on a table at waist height. In a Muslim village, the table and cooker were inside; in

a Cebu low-income area the LPG cooker, used for speed during the week when the children had to get to school and the mother to work, was inside, but the sawdust cooker was portable. All homes in the newly built, low-income schemes had a sheltered space behind the house for the "dirty kitchen". Except for the LPG cooker, all of the stoves observed were single units.

Mario Chanco is experimenting with an adapted loreno stove for the Philippines. In the Earthman (Vol. 1, No. 1, Dec. 1979), of which he is the editor, Chanco reports on finding a traditional mud stove called the "tungko" and using the design for the adapted loreno stoves. While at least one hundred stoves have been adopted in the hilly region outside Manila, there is some indication that most users are teachers and other professionals. The stoves are built on the ground and have three openings. Considering that most women seem to cook at waist level and on one pot, I wonder about the adaptation. Since the original lorena stoves are higher, the squatting variety could easily be raised.

In India, at Bardoli, where the Council of Scientific and Industrial Research held a rural development workshop, there was considerable interest in flat plate solar cookers, which I would describe as a solar oven. Made at the Agricultural Tools Research Center under the direction of Mohan Parikh, the ovens both bake and boil. Reports were that over one hundred cookers had been sold in the locality. Because the ovens can boil water, they are well adapted to the cooking of pulses, a major part of the diet.

Bio-gas

The Bardoli center uses several bio-gas units for its cooking needs. Parikh has a small unit for his houshold use. The center, a social service center organized along Gandhian lines, concluded that the general appraisal of bio-gas converters is that they are being adopted by the better-off, despite or because of governmental subsidies.

> The government has been promoting small family-size plants with a capacity of 60-100 cft of gas per day. These are mainly gobar gas plants requiring cowdung of at least 3 cattle. The unit cost of a plant of this size is a little over Rs 3000. Costwise this scheme cannot be extended to a significant majority of the rural population. At best, it can only cater to the cattle-owning upper-income stratum of the rural population which accounts for not more than 8 to 10 percent of the total rural population. In fact, it was found in a recent survey in Gujerat, one of the most successful states in gobar gas scheme, that the average landholding size of the gobar-gas plant owners was as high as 26 acres. 7/

Although Parikh connected his lavatory to the converter, Moulik found in his survey that 73 percent of his respondents did not make such connections. 8/ Thus, one of the advantages of bio-gas, its health aspect, is not incorporated in most India models.

Ramesh Bhatia confirms this observation in his case study of a village in Uttar Pradesh. There the community bio-gas plant was to serve landless as well as landed. The only incentive to collect dung was to receive equivalent amounts of the slurry. Street lighting was the free pay-off for the village, while each home received cooking gas and gas for two lamps of 100 candle power. Apparently the villagers felt they were only replacing one form of cooking fuel with another, one which required longer walking by the women. The result from better fertilizers was not quickly apparent to them. The cost of the plant seemed therefore only an added expense. Bhatia argues that soft coke is a cheaper solution for cooking, since few villagers actually used the gas for lighting. 9/

Both Bhatia and Moulik suggest that bio-gas is better suited to use for irrigation pumping or small industry such as flour milling. Satish Chandran, talking of energy planning needs, emphasizes the demand for energy by the "unregistered" industrial sector, which uses both commercial and non-commercial fuels and calls for increased efficiency in this sector. 10/ Such use for bio-gas makes clear the answers to many social questions about who benefits when a bio-gas plant is set up. What happens when "free goods" acquire monetary value? Bio-gas converters are one of the components in the Vecchhi Intensive Area Scheme in Valod, Gujerat; they have 150 plants, both individual and institutional. Rusting and cracking of containers is a major problem; they await non-metal containers and improved technology.

Despite the generally unenthusiastic view of bio-gas among experts, social service workers see much value in the process. For example, water hyacinths clog many rivers in Assam; they can be fed as is into bio-gas converters. Devaki Jain, Director of the Institute of Social Studies in New Delhi, is trying to get a scheme set up whereby women would be paid for cutting the hyacinths; gas would be sold commercially. CSIR has promised technical assistance.

The most remarkable example of bio-gas being used by a small industry was at Maya Farms, outside Manila. The original reason for starting digesters was to reduce the smell of this pig farm. Once Dr. Felix Maramba undertook the challenge, he developed the most impressive interplay of elements: gas pumps warm water with an automobile engine; water warmed while cooling the engine is used in the meat processing. Slurry becomes part of the animals' feed. Water from the digesters flows to a fish pond where tipalia swim. Ducks feed on the algae in the pond, and also eat fly larvae. Ducks are canned along with the pig products for sale in Manila. Every type of converter is being tried: Chinese, Taiwanese, Indian; batch and continuous feed, large scale, and for a household.

Maramba has set up a farmer on one corner of the land to see if small farms are not even more efficient in raising pigs. "Mortality is nil", he boasts, "because the pigs are the children to the couple!" In ten months the farmer liquidated his debts for the ten pigs. He gets fish from his own pond to eat or sell; his wife likes the clean methane flame.

The Philippine Business for Social Progress has helped many barrios set up bio-gas plants under the Laguna Rural Development Project. All were attached to small pig farms. Once the PBSP pulls out of the active management this year, the scheme will be tested to see if the barrio support is sufficient for the plants to continue.

Electricity

Two years ago a dam was put in above Valod. Today about half the villages in the district have electricity. Allu Shah emphasized that service was so unpredictable and uneven that few dared to use electricity for any industry. Indeed, the intermittent character of most electrical service in both India and the Philippines needs to be stressed. A Peace Corps volunteer in an emboidery plant on Luzon spoke of the difficulties the women had in delivering goods on time when so often the electricity was off. Many larger shops have a diesel engine as back-up, adding to capital costs. Davao had been having citywide "brownouts" of up to twelve hours a day for over three months. Many energy dependent industries had failed. Others had workers come whenever the service was on.

When the electricity worked, most of the squatter areas of Davao had lights. Since September 1979 the government decided that squatters would no longer be eligible for a connection. The result is that many homes use power from one meter, perhaps adding to the danger of fire. Connections cost 200 pesos; one fish cooperative bought the connection and a TV set; charges for watching the TV have paid for both investments. In Piape the cost of a kilowatt had just gone up from 63 centavos to 80. Estimated cost for lighting for a house for a month was about two-and-a-half pesos.

Social Forestry

In the Philippines fast-growing trees, particularly the giant ipil-ipil, are being widely planted. It is almost a magic tree, according to Rev. Masterson of SEARSOLIN, the Southeast Asia Rural Social Leadership Institute, at the college of Agriculture of Xavier University in Cagayan de Oro, Mindanao. Trainees and students are replanting badly eroded hills with the tree and using the wood to make charcoal.

In Cebu, the idea of the "magic meter" began as part of a nutrition program: edible plants that could grow in a small area

would improve the diet. Now, as part of the house garden, people are being urged to plant firewood trees. In India many house trees are considered sacred and so may not be cut. Neither forest planting nor putting trees along rights-of-ways will be successful unless ownership or use rights in the trees can be established. As fuelwood prices increase, especially in India, efforts to set up community woodlots or to encourage planting of trees on public lands will increase and should be carefully followed. 11/

The Voluntary Fund for the Decade of Women of the UN is funding several woodlot projects. One in Thailand lists the program impact targets as:

> Village women and families, who will be trained in woodlot production and conservation, given seeds or seedlings, provided with subsidies in cash or kind or loans during the period of planting and nurturing of the trees; assisted with development of energy-saving improved traditional cooking stoves; supported in launching small-scale forest-related industries.

Issues raised by energy programs:

1. Who are the users? At the UNIDO International Forum on Appropriate Industrial Technology, which met in New Delhi in November 1978, the working group on Energy for Rural Requirements concluded:

> It is the women of the developing world who are most concerned with the problems of energy supply and use, because it is they who do the cooking and in most countries, gather the fuel. Furthermore, it is usually the women who draw and carry the water for domestic use. Thus, although action programmes undertaken to meet the energy problems of rural areas must involve people at the village level during planning and implementation, their impact on women must be taken into account and indeed, should not be planned or implemented without the significant involvement of women at both the planning level and the village level. 12/

Women need to be consulted not only about their use of fuel in what kind of stoves, but also their daily tasks and their time budgets must be considered when planning bio-gas plants that depend upon dung collection or developing schemes to plant trees. Will the improved fuel source compensate for the time spent?

2. Who benefits? Despite governmental subsidies, both bio-gas and electricity tend to be used only by the better-off in the rural areas of India. In the Philippines, however, electricity

rates are so low that most poor seem to buy if the line is nearby. Can the government of the Philippines coutinue such subsidies?

Do the poor benefit from electrified industries in rural or urban areas? Does the unreliability of electrical power have cost implications not always counted? Mechanical devices for pumping water or for household tasks may greatly reduce time spent by women, especially in these daily tasks. Small mechanical or solar- or diesel-driven mills, for example, can benefit the present grinders, women, or can reward the small entrepreneur who had credit enough to pay for the technology. Because women often lack money to pay for grinding, whether in Upper Volta or in Indonesia, they may continue to pound grain for their own consumption, thus reducing the utility of the new technology. Rubber roller mills in Indonesia actually produce more edible rice than hand-pounding methods so, from a productivity point of view, they should be used. Women would be the beneficiaries. Different institutional arrangements, such as cooperatively owned mills, might have altered that situation.

Community bio-gas plants raise many issues of beneficiaries. Bhatia stresses the point that immediacy is also part of the perception of benefits. Delayed gratification may seem to be no gratification, so that planners must build in strong incentives for changed behavior.

It is important to note that the further that energy production gets from the user, the less direct are the impacts. Changing from wood to charcoal will immediately reduce the amount of smoke in the home, and may reduce the time of the women and children collecting the wood and wastes to burn. Assuming available money to buy the more expensive fuel, charcoal would seem to be an improvement. But actual costs need to be carefully plotted.

Erosion of mountain tops which fill drainage canals may affect villagers other than those who benefitted from the wood cut. In tropical areas, the reduced water catchment area may have little immediate impact on persons living in the mountains, but the water table at sea-level may be reduced by the rapid run-off, and floods are likely to occur.

Environmental impacts of coal mining, large dams, or nuclear burning seldom directly affect the users of the energy, yet all must be considered in final energy accounting.

3. Who controls? Proponents of solar energy argue that its very technological base fosters decentralization as opposed to the centralization of authoritarian control implicit in large and dangerous nuclear plants. Small electrical grids, while not providing sharing across the country, may be less prone to breakdown, and more responsive to in- and out-usage which is likely to be part of any increased use of wind or water power. This view is contested by

Wallace E. Tyner and John Adams 13/ who argue completely on economic grounds. Even if their figures of cost are not out of date, their assumption that electricity will be available is surprising, considering how slowly the grid has been extended throughout India.

4. Efficiency. Much emphasis is placed on the inefficiency of firewood for cooking. It is argued that LDC cooks use three to five times as much energy to make a meal. These statistics were gathered in such diverse places as Indonesia and Upper Volta. But what are we measuring? This issue was addressed in the insightful report to the World Bank on "Household Energy Use and Supply by the Urban and Rural Poor in Developing Countries" done by Resources for the Future. Energy efficiency must be related to the tasks the energy is expected to perform.

> For the urban and rural poor these are habitually summed up as "cooking and lighting" of which cooking is estimated to account for about 90 percent. Even such a rudimentary breakdown is, however, misleading. Lighting may not exist as a separate energy task for large numbers of the developing world whose working day is geared to hours of daylight. And if artificial light is needed it might be provided with sources of energy which have not been included here, such as candles, vegetable oil lamps or flashlights. Furthermore, light, space, heat, and protection against animals and insects may also be provided by open fires used for cooking. Dying embers are used for a succession of energy-using tasks requiring less high-quality heat -- heating of water for washing, ironing, and so forth -- in very much the same process of matching quality of energy supply to energy-using tasks which is urged in developed countries. The overall efficiency of a system as rudimentary as an open fire may be higher than the low levels assumed if only cooking is considered. 14/

Do we know that cooking is 90 percent of use? Revelle refers to estimates of 40 to 50 percent of rural energy going for cooking. 15/ One household survey in the Gambia found cooking only accounted for 53 percent of the energy use while water heating used 36 percent and ironing 8 percent. 16/ Also, what are the different patterns of usage between urban and rural areas? Present information suggests that urban poor use less energy, probably due to higher costs, less need for using fire as protection, and more concentrated cooking.

Further, efficiency is not merely the amount of heat per amount of fuel. If you need high heat to fry a chapati, the heat available after the frying is complete is not useful and cannot become a substitute. One observer in Upper Volta argues that the reason the women continue to use the three stone method is because it is

is more efficient. First, the women do not need to chop the wood for use with the stones as they would for a stove -- remember, African women work as long as 80 hours per week; nor do they have easy access to money to pay someone else to chop the wood. Second, the heat can easily be adjusted by dampening one stick, something more difficult in the alternate stoves. Finally, as soon as the food is cooked, the sticks can be doused, to await the next meal.

5. Single problems. The energy issue is in some ways the entire problem of modernization. While we are all increasingly aware of the interrelatedness of social change, it is easier to retreat into sectoral descriptions of problems. Thus, pumping for irrigation falls within the agricultural sector while well-water and pumping may be health. The result is narrowed vision and often greater use of energy.

Concern for land degradation caused by overcutting of wood is likely to be located in environment offices. While environmentalists worry about the land, foresters plant trees, and the people seek the harvest. Thus, few forestry projects deal seriously either with village woodlots or with multiple tree usage: berries, nuts, medical uses, etc. Land ownership, tree rights, forage rights, are all involved in planning for increased production of fuelwood.

6. Single solutions. Much of the literature focuses on one solution or another: new stoves, improved charcoal burning, solar cookers. Yet anyone familiar with food preparation knows that different methods are used to cook different foods. In the US we use ranges, ovens, grills, toasters. So the women in the LDCs use a variety of implements with which to cook: dung or firewood for hot heat, kerosene in a primus for slower heat. Ovens are often village-owned or communally. In Basaisa, Egypt, the oven was one of the first things converted to solar heating.

Not only should a spectrum of energy sources by considered for cooking, but other household or industrial uses might come from a variety of sources. Solar water heating is one of the most developed uses for solar heat; solar dryers, solar water pumps, solar water purifiers, may all precede solar cookers.

My concern with the Philippine version of the lorena stove is the suggestion that somehow it is the solution. The need to squat would seem inconsistent with observed cooking patterns; the making of several cooking holes surely reduces the efficiency if only one hole is used.

7. Nutritional impact. The increasing cost of fuel has already caused a change in consumption of energy, often altering food patterns. In Guatemala Indians in the high plateau have stopped cooking beans as often because they require longer cooking. The food substituted is lower in protein and has resulted in visibly lower nutritional levels. In Upper Volta women used to cook

millet twice a day, then once a day. Now many cook only every other day or so; in between they feed their families on flour mixed with water. In the Senegal there is a switch from millet to rice because it does not take as long to cook. But the rice of favor is polished, even though traditionally rice was parboiled. Since the latter rice is more nutritious, a village enterprise might be made of "Uncle Ben-ing" rice in large quantities and selling it to the housewives. Is this a proto-type for pre-cooking other staples, improving nutrition while reducing total energy used?

Conclusion

What is clear when trying to identify the socio-economic issues relating to household and homecraft energy needs is how interrelated they are. Control, benefit, use are all intertwined. But an important distinction needs to be made between fuel for cooking and energy for relieving human or animal effort. This latter energy is substitution; higher fuel costs could mean more animate energy; it could also mean more efficient, larger scale solutions. The balance between who benefits and who controls is vital when considering such alternatives.

Cooking, on the other hand, has tended to be a smaller effort in most advanced countries. Recently in the US there has been a rise in meals eaten out. But large-scale food preparation is the exception. Therefore, the issues of who controls the firewood or the methane for cooking seem to require a different level of concern.

Many questions were raised on this field trip which might well be answered only by studies or projects. No single new or renewable energy source will solve all the problems of energy needs today. More information on the impact of the present choices will aid us all in technological selection.

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REFERENCES

1. Hammer-Digernes, Turi, "Wood for Fuel, Energy Crisis Implying Desertification, the Case of Bara, Sudan", Thesis, University of Bergen, Norway.

2. USAID, Environmental and Natural Resource Management in Developing Countries, A Report to Congress, Washington, D.C., Feb. 1979, Vol. 1, p. 13.

3. For official GOI statistics, refer to Kirit S. Parikh, Second India Studies: Energy, New Delhi, Macmillan, 1976. For details on rural use see Basic Statistics Relating to the Indian Economy, Vol, I: All India, Center for Monitoring the Indian Economy, Bombay, 1976. Also see Harrison S. Brown and Kirk R. Smith, "Energy in Asia and the Pacific", Annual Review of Energy, Vol. 5, 1980.

4. Information from a pamphlet "Firewood Pickers of Girnar" by A. N. Buch and Ela R. Bhatt, SEWA, Ahmedabad.

5. A. K. N. Reddy, "Energy Options for the Third World", Bulletin of the Atomic Scientists, May 1978, p. 29.

6. As quoted in Carol S. Harlow, "Phillipine Energy Issues", prepared for the USAID Asia Bureau Conference on Energy, Environment and Forestry, Nov. 1979.

7. "Bio-gas System: Alternative Technology for Meeting Rural Energy Needs in India?" a paper read by T. K. Moulik at the Second Seminar on Management Research, held at the Indian Institute of Management, Ahmedabad, Jan. 1978. He refers also to his study: T. K. Moulik and U. K. Srivastava, Bio-gas Plants at the Village Level: Problems and Prospects in Gujerat, CMA Monograph No. 59, Indian Institute of Management, Ahmedabad, 1970.

8. T. K. Moulik, Uma Kant Srivastava, Prakash M, Shingi, Bio-Gas System in India: A Socio-Economic Evaluation, Indian Institute of Management, Ahmedabad.

9. Ramesh Bhatia, "Energy and Rural Development", draft paper prepared for the NAS International Workshop on Energy Survey Methodologies, Jekyll Island, Georgia, January 1980, pp. 18-20.

10. T. R. Satish Chandran, "Energy and Industrial Development - The Indian Experience", a paper read at the USAID Asia Bureau Conference on Energy, Environment and Forestry, Manila. November 1979.

11. For a discussion of reforestation and improved forest usage in a poor tribal taluka, see B. M. Desai, Ranjit Gupta, T. K. Moulik, V. S. Vyas, CMA Monograph No. 63, Rural Development for Rural Poor: Dharampur Project, Vol II, Indian Institute of Management, July 1976.

12. UNIDO, Draft Report, Chapter XI, pp. 71-72.

13. Wallace E. Tyner and John Adams, "Rural Electrification in India: Bio-gas Versus Large-Scale Power", Asian Survey, August 1977.

14. Joy Dunkerley, William Ramsay, Elizabeth Cecelski, Emmanuel Mbi, "Household Energy Use and Supply by the Urban and Rural Poor in Developing Countries", report to the World Bank, by Resources for the Future, October 1978.

15. Pimental, D., et al., "Energy Needs, Uses and Resources in the Food Systems of Developing Countries", report of a workshop held at the College of Agricultural and Life Sciences, Ithaca, Cornell University, December 1977.

16. op. cit.

Strategies for Dealing with the Firewood Problem

(Summary of Remarks)

Erik Eckholm*

Despite recent publicity and the initiation of new programs by aid agencies and governments, the firewood problem remains under-attended. The problems and potentials of traditional fuels are usually not fully included in national energy-sector studies and plans. Responsibility for dealing with firewood issues is frequently tucked away in forestry or agricultural ministries, while energy ministries concern themselves with oil, coal, and nuclear power. Funding for improving the traditional energy sector generally is miniscule considering the severity of the problems, the proportion of national populations adversely affected, and the long-term consequences of uncontrolled deforestation and dung-burning for agriculture and natural-resource bases.

A first step toward dealing with the firewood crisis, then, is to give it the bureaucratic and financial priority it deserves. Trends in and prospects for traditional fuels need to be fully integrated into comprehensive national energy and forestry plans. Even successful firewood-production schemes have often been pursued in isolation from broader energy strategies.

Sensitive economic analysis, taking into account social acceptability and impacts, is required of alternative measures for meeting household fuel needs. Biogas plants often turn out to face greater economic and social obstacles than first appear; further experimentation with biogas, and promotion where appropriate, are called for. Despite the cultural obstacles, experimentation with solar cookers and heaters in real-life situations is also warranted.

In any case, major expansions of tree planting for firewood and charcoal production are required in almost every country. The needs include large plantations to supply urban areas, village woodlots, farm forestry, and fuel production in home gardens.

In many cases, there are no strong technical or economic reasons why villages cannot grow much, if not all, of their firewood needs. Most villages have unused communal or privately held lands that could sustain tree growth, and knowledge of fast-growing tree species is spreading fast. The main obstacles to successful firewood production are usually bureaucratic and sociological.

One common problem is related to the nature of existing forestry departments, and to the nature of the forester's traditional role. Foresters have usually seen their job as administering, exploiting, and protecting forest reserves. Foresters are often perceived by the rural populace as enemies, and are associated with the denial of access to needed goods rather than with assistance in producing

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them. Foresters need to, in effect, move outside the forests and help communities create new forest resources on their own lands.

As the history of failed projects teaches, public participation in planning, implementation, and sharing of benefits is important to the success of village woodlots. Donated labor helps reduce costs, while public support is essential if saplings are to be protected. Often traditional forms of social cooperation exist that can serve as a basis for new cooperative forestry schemes. Recent community forestry successes in South Korea and the Indian State of Gujarat show that a community-based approach can work in quite different cultural and political environments.

Where they have not already done so, Forest Departments should consider the creation of new extension branches, or community forestry divisions. Officers should be carefully chosen for their ability to work with people. As projects begin, the rapid provision of concrete benefits to the local populace helps gain needed support The inclusion of fodder production in woodlots is one possible means of producing quick, visible returns.

The potential for integrating wood production with agriculture (e.g., agroforestry, shelterbelts, farm woodlots, etc.) deserves greater attention. The possibilities for productive, as opposed to ornamental, forestry within urban areas also need wider investigation.

The major potential for wood conservation through use of more efficient cooking stoves is the subject of much talk but little action. Numerous inexpensive stove designs are available and more are being developed all the time; means of disseminating them widely and rapidly must be devised. Rural development programs of all sorts should include extension work on the demonstrations of efficient cooking stoves.

Planting for the Future: Forestry for Human Needs*

Erik Eckholm**

The challenge facing world forestry is not just to halt deforestation and to plant enough trees to satisfy commercial and environmental needs. From a social perspective, top priority must also be given to meeting the elementary forest and wood needs of the poorest one-third of humanity. And with forest products, as with food, merely growing more produce is not necessarily sufficient to eliminate deprivation. Who does the producing and how the benefits are distributed are equally crucial considerations.

Today, new notions about the purpose and practice of forestry are percolating through Third World forestry circles and international aid agencies. In essence, some foresters are beginning to see the necessity of taking forestry outside the forests - of involving people throughout the countryside in growing trees to meet their own requirements as well as to protect the land off which they live. Forestry carried out by deprived people themselves can vastly augment global forest resources even as it directly benefits those in greatest need. But community forestry, as it is becoming known, will not materialize on the needed scale without major changes in the way foresters conduct their business.

Traditionally, and not surprisingly, most national forest departments have concerned themselves almost exclusively with the areas officially designated as "forest". Foresters have applied what silvicultural knowledge and economic management they could to these wooded reserves, and have maintained guard forces to protect the trees from wood poaching by fuel-starved peasants and unscrupulous merchants. Consistent with this spatially narrow vision, the bulk of official forestry investment in poor countries has been devoted to large-scale timber exploitation for industrial, urban, and export markets. Where forests are especially rich they have often been given over to multinational firms for cutting and export.

Meanwhile, the small-scale, spatially diffused forestry needs of the rural majority - fire wood for cooking and heating, poles for construction, fodder for livestock, and trees throughout the countryside for the protection of soils and the production of foods and other goods - have often been virtually ignored. As Jack Westoby, a long-time social critic of international forestry, puts it, "In precious few countries have the energies of the foresters been bent upon helping the peasant to develop the kind of forestry that would serve his material welfare." 1/

Unfortunately, in forestry, as in more general economic development, the fruits of large-scale, centralized investments seldom trickle down to the poor. Past patterns of forestry development have brought little benefit to the half of humanity inhabiting

* Taken from Worldwatch Paper #26, February 1979, pp. 33-39.
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rural villages. As practiced to date, forestry has often accentuated rather than narrowed the gaping social divisions that exist within most Third World countries. Similar perceptions about the parallel failures of many industrial and agricultural projects to benefit the poor have become commonplace among more enlightened economists. Now the rhetoric of the forestry profession, which has never been part of the mainstream development establishment in any case, is catching up. Perhaps not coincidentally, the infusion of a socio-economic consciousness into foresters' thinking is occurring just as the importance of trees to economic development is finally beginning to be appreciated by economists.

Even without the inspiration provided by the recent conversion of many economists to people-oriented development, foresters would have been drawn toward people-oriented forestry by the sheer pressure of events. Reports of the social and ecological manifestations of past myopia - of spreading firewood and timber scarcity, of deepening soil erosion and falling soil fertility, of record floodwaters running rampantly off denuded hills - are now common fare in Third World newspapers and are creeping into the professional journals. Even the achievement of the foresters' traditional objective, the sound management of forest reserves, is being visibly undermined, for where acute wood scarcity prevails and protection of woodlands from the desperate and the greedy is all but impossible.

The elements of community-based forestry strategies that could help reverse these dire trends can be spelled out easily enough; in theory, probably no country lacks the physical resources to meet its most urgent rural forestry needs. Villages virtually everywhere have unused or misused lands on which fast-growing woodlots can be planted. In watersheds, the raising of crops, trees and livestock can be integrated in new ways that protect soils as they provide extra benefits for people. Agro-forestry systems can give shifting cultivators a stable, productive life. Idle lands along roads and canals and around fields can be planted to trees that produce food, fodder, timber, traditional medicines, and assorted industrial raw materials as well as a more hospitable environment. Cheap, efficient cooking stoves can be disseminated that cut family wood-fuel needs in half. Participatory forestry, with the profits if not the products widely shared, can even to adapted to industrial wood production - as in the Philippines, where small-holder farmers are supplying timber to the paper industry; and in Oakland, California, where a citizens' group plans to grow marketable tree products on vacant city lots.

Although the list of potential community forestry activities can be extended, the problem is not so much what to do as how to do it. To an outsider, prompting rural communities to grow some badly needed trees may not seem like such a tall order. But as the experience of countries such as China and South Korea that have already implemented participatory forestry on a wide scale demonstrates, actually doing so requires radical changes in the attitudes

and activities of governments and aid agencies, and reforms in villagers' social organization and land use.

Foresters, like development planners generally, are used to running things from above. What contact they have had with villagers has usually been in their roles as policemen, denying destitute people access to protected lands and wood. Antagonism between peasants and forestry officials is commonplace throughout the Third World; tales of murdered forest guards are not rare.

Yet if experience and common sense tell us anything, it is that community forestry cannot be imposed from above and carried out in the face of a hostile population. New forms of land use impinge upon, and are influenced by, the daily activities of everyone. When the local people are not active participants in and supporters of a project, saplings have a way of disappearing overnight. With fodder usually as scarce as firewood, uncontrolled goats or cattle can quickly ruin a new plantation even when disgruntled peasants, facing the alternative of a lengthy hike to collect fuel, don't covertly cut the saplings themselves.

Community involvement, then, is not just an ideologically appealing goal; it is a practical necessity if rural forest needs are to be met. A recent effort to establish 500 hectares of village woodlots in Niger, for example, failed because "as fast as the trees were planted, the village people either pulled them out or allowed uncontrolled grazing to take place." This debacle occurred, concluded John Spears, because villagers "had not been involved in formulating the project and because they perceived the village woodlot area as a traditional grazing ground." Likewise, an effort to preserve some natural forest within a resettlement area in Colombia failed "because the settlers themselves regarded the area as being better suited to agriculture than forestry and they forcibly occupied the protected forest area". 2/

Popular participation is important for economic reasons too, for in most countries the costs of the needed plantings and upkeep would be prohibitive if local residents did not pitch in generously with their labor. The high cost of plantation development in Brazil, which has chosen to subsidize commercial plantations by large landowners and corporations rather than to pursue community forestry, stands as a warning on both economic and social grounds to other developing countries, most of which are far poorer than Brazil. Since 1967, three million hectares of plantations, mostly fast-growing eucalypti and pines destined for pulp mills, have been established. A valuable resource has been created but at an extraordinary price: tax subsidies have averaged $500 to $820 a hectare, with the public subsidy over 11 years totaling $1.8 billion. "Despite relatively cheap labor," writes U. N. economist H. K. Muthoo, the plantation program has involved "one of the highest costs in the world of creating man-made forests." The program has widened

socioeconomic inequality too: 92 percent of the plantations are over 100 hectares in size, and the bulk of them are in the country's richest regions. 3/

For bureaucrats accustomed to giving orders, and to worrying more about science than sociology, the necessary handing down of authority to the people can be as personally painful as it is institutionally difficult. Several speakers before the October 1978 World Forestry Congress, whose theme was "Forests for People", stressed the need for reforms in the structure of the forestry profession itself. In what amounted to an admission of the profession's past neglect, Eduard Saouma, Director-General of the FAO, said that knowledge about community-based forestry "is still in its infancy." It "introduces problems which are far removed from your traditional training," he challenged the 2,000 delegates in Jakarta. "Above all, it means dealing with people and the priorities they give to their various needs." Along similar lines, Charles Lankester, chief forester with the U.N. Development Programme, observed that "foresters have preached at the people too much, now we are realizing that we must work through the people instead." 4/

Pushed by economic necessity and pulled by the spread of egalitarian ideas, some governments and aid agencies are beginning to change their forestry plans. The FAO has initiated, with the financial support of the Swedish Government, a major program of research and education under the theme of "forests for local community development." The World Bank, the world's largest aid giver, has in a recent forestry sector policy paper announced its intention to multiply its support for such activities as village woodlots, farm forestry, and environmental rehabilitation. A new International Council for Research on Agro-Forestry, directed by the noted forester K. F. S. King, has been set up, mainly with Canadian aid money, in Nairobi. The U.S. Congress has directed the Agency for International Development to give new attention to forestry in its rural development programs, while AID and the U.S. State Department have together sponsored an unprecedented strategy conference on tropical forestry problems. Top foresters and even national political leaders all over the world are beginning to talk of the need to integrate forestry into rural development in new ways. 5/

Welcome as it is, this belated shift in attitudes among national officials and aid agencies provides no guarantee that community forestry will take off with the required speed. In the words of Jack Westoby, making trees serve people "is not simply a matter of gearing the development establishment towards new objectives." Government bureaucracies everywhere are notorious for their resistance to retooling, particularly when the proposed changes seem to involve a loss of customary authority and elite status. Forest departments - or other agencies if foresters cannot adapt - need to provide "barefoot foresters" who will worry less about the elegance of silviculture and more about how peasants' cows will be fed, how cooking stoves might be redesigned to conserve firewood, and how

small farmers whose economic horizons extend only to the next harvest can be persuaded voluntarily to plant trees for the future. Furthermore, the needs and potential contributions of women - as gatherers and users of wood and as possible growers of wood - have been badly neglected virtually everywhere.

Perhaps the greatest impediments of all to community forestry are the local social and economic institutions that, in many poor countries, perpetuate the rigid stratification of social classes and the severe exploitation of those on the bottom. Community forestry is not a technology; it is a process of social change that requires the continuous participation of whole communities in planning and problem-solving. It requires people to shift from an individualistic to a cooperative state of mind in spheres of life where communalism has not usually been the norm, at least in recent history. People must willingly give up land-use practices and privileges to which they have long been accustomed. Such a process of cooperative behavioral change, never easy to bring about anyway, is especially unlikely where grossly unequal land tenure and marketing systems insure that a powerful minority will capture nearly all the benefits of any economic gains.

Initiating community forestry, then, can require grappling with all the interlocking social, economic, and political problems that add up to underdevelopment. At the same time, the process of creative community action that successful village forestry requires is the essence of what real development is all about: communities learning to solve problems, to create better lives for their members, to become more self-reliant. Ironically enough, forestry, long the neglected stepchild of economic studies, could in some countries turn out to be the catalyst of meaningful development.

REFERENCES

1. Jack C. Westoby, "Forest Industries for Socio-Economic Development," presented to the Eighth World Forestry Congress, Jakarta, October 16-28, 1978.

2. Spears, "Changing Emphasis in World Bank Forestry Lending".

3. M. K. Muthoo, "Socio-Economic Impact of Brazil's Man-Made Forestry Programme," mimeographed, Brasilia, undated.

4. Saouma, "Statement by the Director-General"; Lankester quote from oral statement during conference.

5. FAO Forestry Department, Forestry for Local Community Development (Rome, 1978); FAO Forestry Department, Forestry for Rural Communities (Rome, 1978); World Bank, Forestry: Sector Policy Paper; S. Jacob Scherr, "Amendments to the Foreign Assistance Act concerning Environmental Natural Resources," memorandum, Natural Resources Defense Council, Washington, D.C., September 25, 1978; Proceedings of the U.S. Strategy Conference on Tropical Deforestation (Washington, D.C., U.S. State Department/Agency for International Development, October 1978).

II. Current Energy Planning

Energy and Industrial Development - The Indian Experience

T.R. Satish Chandran *

Introduction

Though India's economy is still predominently argricultural, the process of industrial development which had its origin from around the beginning of the century, received a large impetus during the last three decades since the country's attainment of independence. The successive Five Year Plans under which India's economic development has been regulated have laid emphasis, right from the outset, on a balanced growth of the economy. The industrial sector (mining and manufacturing) presently accounts for about a fifth of the GDP. In a situation characterized by pressure of population of land, a large domestic market, availability of skilled manpower and the need to generate additional employment, it becomes imperative to maintain a reasonable rate of industrial development. In the last thirty years, substantial capabilities have been built up in heavy and basic industries which are needed to sustain further industrial advancement. Indeed, the attainment of virtual self-sufficiency in food and the steady improvement in the country's balance of payments in the recent years, have created favourable conditions for stepping up the pace of industrialization which could, in turn, accelerate overall economic growth and raise the levels of income of large segments of population which are currently below the poverty line. Unfortunately, this has synchronized with the emergence of a global energy problem, which threatens to deprive the Third World countries of even their small share of oil supplies and to push up the prices beyond their reach. Countries like India are, therefore, faced with the difficult problem of maintaining a reasonable rate of industrial development in an increasingly difficult energy situation.

Trend of Energy Consumption in the Industries Sector

The industries sector accounts for the largest share of commercial energy consumption in India (commercial energy includes coal, oil and electricity). A notable feature of this sector is that it comprises two distinct parts - one generally referred to as the 'registered' sector consisting of factories registered under the Factories Act and the other the "unregistered' sector, which includes not only unregistered industrial establishments but also a very large number of household industries. The role of the unregistered sector is by no means unimportant, as it contributes as much as a third of the total value added in industries.

The registered sector of industry is almost wholly dependent on commercial fuels, sugar being a notable exception. The unregistered sector depends on large quantities of non-commercial fuels, i.e., firewood, agricultural and animal waste, and animal and human power, but it also consumes significant quantities of commercial energy. The data on energy consumption in the unregistered sector are, however, scanty and unreliable. This limitation should, there-

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fore, be always kept in view while looking at published data on industrial energy consumption.

The share of industry in commercial energy consumption has varied between about 37% and 41% during the last twenty-five years. Viewed fuel-wise, this sector consumes almost three-fourths of the total coal produced (excluding coal used for power generation) and about two-thirds of the electricity generated in the country, but its share of oil consumption is relatively small. The table below sets out the manner in which the share of this sector has changed over the years.

Table I

Share of the Industries Sector in the Consumption of Commercial Energy
(In percentages)

	1953-54	1960-61	1965-66	1970-71	1975-76	1978-79
Coal	48.1	47.1	58.1	60.5	71.9	73.4
Oil	15.3	16.5	11.8	11.2	6.4	6.4
Electricity	65.8	68.7	74.0	70.7	65.6	63.8
Total Commercial Energy	37.3	39.2	41.4	38.7	40.3	38.5

Tables II and III below set out the consumption of commercial energy in industries and its rate of growth:

Table II

Consumption of Commercial Energy in Industries Sector
(In MTCR)*

Energy form	1953-54	1960-61	1965-66	1970-71	1975-76	1978-79
Coal	13.80	20.90	30.10	31.07	51.01	50.50
Oil	3.65	7.23	8.09	10.90	7.55	9.00
Electricity	5.00	11.60	22.62	34.35	43.35	53.90
Total Commercial Energy	22.45	39.73	60.81	76.32	101.91	113.40

* See next page

* **MTCR stands for million tonnes of coal replacement. In India, the coal replacement measure is generally used, as it better reflects efficiencies of energy use. The conversion factors are as below: -**

Original Unit	Equivalent MTCR
1 Million tonnes coals	1.0
1 Million tonnes of oil	6.5
1 TWH	1.0
1 Million tonnes of firewood	0.95
1 Million tonnes of animal dung	0.40
1 Million tonnes of vegetable waste	0.95

In comparison with the coal equivalent measure, the coal replacement measure overestimates the use of oil and electricity.

Table III

Rate of Growth of Commercial Energy Consumption in Industrial Sector
(Averge % per year)

Period	Rate of growth of value added in industries	Rate of growth per year of consumption of			
		Coal	Oil	Electricity	Total commercial energy
1953-60	2.92	6.1	10.2	12.8	8.5
1960-65	7.30	7.6	2.3	14.3	8.9
1965-70	3.51	0.7	6.2	8.7	4.6
1970-75	3.27	10.4	-8.0	4.8	6.0
1953-75	4.12	6.1	3.4	10.3	7.1

The total commercial energy consumption increased at the rate of about 7.1 percent in the period 1953-75; the rate of growth has slightly declined since then. Of the three forms of commercial energy,

electricity registered the fastest rate of growth, though here again there is a deceleration in the successive sub periods.

The composition of fuel consumption in the industries sector in the years 1960-61 and 1978-79 is given below in Table IV:

Table IV

Relative Shares of Coal, Oil & Electricity
(In Percentages)

	1960-61	1978-79
Coal	52.6	44.6
Oil	18.2	7.9
Electricity	29.2	47.5
Total	100.0	100.0

It will be seen that the share of electricity has expanded at the expense of oil and coal, though coal continues to be an important industrial fuel.

As mentioned earlier, the full picture regarding noncommercial energy consumption is not available. Among the noncommercial fuels used in industry, bagasse is the most prominent. It is estimated that in 1975-76, about 42 million tons of bagasse were utilized as fuel, not only in the organized sugar industry, but also in small units in the unregistered sector producing country sugar (khandsari and jaggery). In terms of coal replacement, a rough estimate of the total quantity of the noncommercial fuels used that year in industry was 47.5 million tons, of which over three fourths were derived from bagasse. The use of bagasse, it may be noted incidentally, does not put any pressure on firewood demand.

Intensity of Energy

Defining the intensity of energy use as the ratio of the quantity of commercial energy used per unit of value added, the total commercial energy consumed in million tons of coal replacement per billion rupees of value added in industry has been as follows:

1960-61	..	1.86
1965-66	..	1.99
1970-71	..	2.11
1975-76	..	2.40

The industrial sector shows a clear trend of becoming increasingly energy-intensive. The main reason, as will be apparent from Table V below, is the rise in the intensity of electricity consumption:

Table V

Intensity of Electricity Consumption in Industry

Item	1960-61	1965-66	1970-71	1975-76
1. Value added in industry in billion rupees	21.38	30.41	36.14	42.46
2. Electricity consumption in Twh.	11.60	22.62	31.35	43.35
3. Intensity of electricity of consumption	0.54	0.74	0.95	1.02

It will be apparent from the above table that while the intensity of electricity consumption has been rising continuously, the rate of growth of intensity has been steadily declining. This pattern is consistent with international experience. In the initial stages of industrialization, the share of primary metal industries is high and these industries are invariably large consumers of electricity. There is also a switch-over by industries from other fuels to electricity when the intial spread of electricity takes place. In contrast to electricity, the intensity of coal and oil (combined) use in industry shows a surprizing stability. The increased use of these fuels in place of non-commercial fuels in the decentralized sector of indusry, is apparently balanced by savings resulting from improvement in technology and use of more efficient fuel burning equipment (e.g. boilers).

The intensity of electricity consumption can also be looked at from the angle of energy consumed per unit of output. The following Table VI sets out the data for a few selected categories of industries:

Table VI

Electricity Consumption Per Unit of Production

Item	1960-61	1965-66	1970-71	1975-76
1. Aluminum (Gwh per thousand tonnes)	24.5	25.2	20.2	19.7
2. Iron & Steel (Gwh per thousand tonnes)	0.2	0.1	0.2	0.2
3. Cotton textiles (Gwh per thousand metres)	0.3	0.4	0.4	0.6
4. Fertilization (Gwh per thousand tonnes)	3.2	5.3	2.4	2.4
5. Cement (Gwh per million tonnes)	117.0	98.1	95.2	102.0
6. Paper (Gwh per thousand tonnes)	1.5	1.2	1.2	1.5

The aluminum and fertilizer industries display a clear improvement in energy efficiency. The increase in consumption of electricity in cement is readily explained by the rise in the proportion of "wet process" cement as compared with "dry process" cement. (The dry process is more efficient, if the total energy consumption is considered). Higher electricity consumption in the paper industry and cotton textiles could be due to the increase in the share of superior qualities of paper or cloth, but a deeper study would be needed to pinpoint the precise reasons.

Exercises have been carried out to make a comparative analysis of the intensity of electricity use in specific industries in India with similar industries abroad, but these do not turn out to be fruitful. The main reason is that on account of variations in the structure of the industry, product mix, etc., comparisons at an aggregate level do not bring out the correct picture. To give an example, Indian steel plants are far more 'integrated' than their counterparts in Europe or USA in the sense that, starting from iron ore and raw coal, almost all the processes right upto the rolling of finished sections are carried out in each of the major steel plants. The consumption of energy per ton of steel in India therefore looks high in comparison with, say, a Japanese steel plant, but this does not reflect the relative energy efficiency.

However, an industry-wise analysis of energy consumption in India does bring out the fact that there are wide variations in specific electricity consumption among units producing similar products which indicates that there is considerable potential for improving the efficiency of energy use in many industries.

Policy Approach

Since 1973, the need to formulate a cohesive energy policy has been recognized in India and the broad outlines of such policy have also been accepted. One of the basic features of this policy is that coal would be the main source of primary energy in the coming few decades and that the use of oil would be minimized. Thus, since the last several years, no new industry is permitted based on the use of oil as fuel, unless there are compulsions from the technological, environmental or other angles. Existing industries using oil from steam or heat generation are being encouraged to switch over to coal wherever feasible. An organization called the Petroleum Conservation Research Association has been established to provide assistance to the users in achieving efficiency and economy in the utilization of petroleum products. Some headway has been made and it is estimated that savings of furnace oil worth about Rs 95 million have been achieved through various measures. A look at TAbles II and IV clearly brings out how the burning of oil as fuel in industry has been kept strictly under check.

With the continuous spiralling of oil prices and its all-round impact on the economy, a re-examination of the energy policy to be adopted in the country is currently under way. The salient features of the approach to be followed are already clear and, in respect of the industries sector, they can be summarized as follows:

a) A further impetus would have to be given to the substitution of oil by coal in industry. As this would call for investment in new eqiupment, fiscal incentives would have to be offered.

b) The progress in introducing co-generation in Indian industries has not been significant so far. While this is being already practiced on a wide scale in the sugar industry and to a substantial extent in steel and fertilizer, this is not yet an accepted practice in other industries such as textiles, where there are possibilities for combined generation of heat and power. Here again, incentives for such capital investment as might be needed to encourage energy conservation through co-generation, will need to be considered.

c) As mentioned earlier, there is considerable evidence to show that within the same category of industries, the energy used per unit of production varies widely between efficient and inefficient units. In general, fuel efficiency does not receive adequate attention in the small scale and decentralized sector of industry which play an important role on the Indian industrial scene. Standards of fuel efficiency would have to be evolved and mechanisms for monitoring the use of energy in industry would have to be easy in a country in which the number of industrial units, big and small, run into millions, but a beginning could be made with specific industries.

Apart from achieving a better efficiency of energy utilization in the industries themselves, similar steps would have to be taken in regard to energy consuming end products produced by the industrial sector. To give an example, a recent survey of agricultural pump sets disclosed that the efficiency of many of the makes of such sets was abnormally low, on account of mis-match between the motor and the pump and lack of quality control in the process of manufacture. It is necessary, therefore, to draw up energy consumption norms for various kinds of equipment and for introducing appropriate certification and regulatory measures. Simultaneously, assistance would have to be given to the small manufacturers to improve their designs.

d) It is well known that the ratio of energy used to output varies with the level of utilization of rated capacity in most of the industries. While utilization of industrial capacity is dependent on a variety of factors, its importance from the energy angle needs to be appreciated and kept in view while taking decisions in regard to the creation of additional capacities.

e) In certain industries, options regarding process technology are available. In exercising the option, consideration has so far been given mainly to such aspects as capital cost, extent of foreign exchange required, employment generation, etc. Hereafter, energy would also have to be treated as one of the factors to be reckoned with in the selection of technology.

f) While fixing the targets of production for energy intensive industries like steel, aluminum, caustic soda, etc., their impact from the energy angle would

have to be kept in view. While no country could afford to be excessively vulnerable to the vagaries of international trade in regard to basic and essential commodities and the capacity of the country to import depends on its situation in regard to balance of payments, the cost-benefit of expanding capacity in power intensive industries would have to be carefully evaluated and the possibility of producing exportable commodities with less energy intensive technologies would have to be considered.

g) While improvement of efficiency in the production and utilization of energy is important, there are limits to which this can be carried out. A more basic question is whether it is possible for a country like India to adopt a strategy which makes future industrial growth less energy intensive. Even in the normal course, it is reasonable to expect that industries such as steel, aluminum, copper, etc. would grow at a lower pace than in the past, while technology-oriented industries like electronics, maching tools, etc. which require lower energy input per unit of value added would grow at a relatively faster rate. But can something more be done to bring down the intensity of energy use in industry? For the first time, the Sixth Five Year Plan of India (1978-83) seeks to achieve a deliberate shift from capital intensive to employment oriented technologies and decentralization of production, wherever feasible. The data of the Annual Survey of Industries indicate that there is significant correlation between capital-output ratios and energy-output ratios and a similar correlation between captial-employment ratios and energy-employment ratios. The new policy of Government should therefore result in a lowering of the energy intensity. But there are a number of activities which are essential and in which large scale energy intensive units, e.g. steel plants, oil refineries, etc., do represent an optimal route from the energy conservation point of view also. It is not also as if small scale operation always results in energy economy. Then again, the range of products for which appropriate technologies are available, is not too wide. There is also the unavoidable trend of substitution of non-commercial by commercial energy. These will act as countervailing factors against reduction in energy intensity. It will therefore take a great deal of effort and considerable time before a signficant reduction in energy intensity in industrial consumption can be achieved.

To sum up, energy conservation in industry through improvement of efficiency of energy utilization has to be as much a vital component of a developing country's energy policy as that of an industrialized country. The fact that the industrial sector comprises not only modern large scale industries but a multitude of small and household industries undoubtedly poses formidable problems in organizing any kind of a program which seeks to bring about technological improvements or enforce energy standards. The provision of supportive technical services to assist the small manufacturers to improve their designs and processes and exercise better control over the quality of materials inputs, is as important as regulatory action or fiscal measures to encourage efficient use of energy and to penalize energy wastage. In theory, developing countries embarking on the process of industrialization could profit from the experience of the Western industrial world and avoid an energy-intensive growth path. But the limited availability of alternative technologies and the time and investment needed to develop such technologies would inevitably mean that at least in the short and medium term, the pattern of growth would not be radically different. The rural-agricultural character of the economy of a country like India will not, however, undergo a basic change. Therefore, if the country is to solve its long-term energy problems, the highest priority would have to be given to rural development, especially the growth of cottage, village and small-scale industries which can operate on the 'low-quality' energy inputs that renewable energy sources can provide.

Energy and Urban Development

While almost 80% of India's population still lives in the villages, there has been a steady process of urbanization. During the decade 1961-71, while the overall population grew by 24.7% urban population grew by 37.9%. A somewhat disturbing feature of the urbanization process has been the faster rate of growth of the large and metropolitan cities as compared to small and medium towns. The table below illustrates this trend:-

Table VII

Growth Rate of Cities and Towns

Town Classification	Proportion of population in each size class to total urban population.		Growth Rate	
	1961	1971	1951-61	1961 71
Class I (1 million & above population)	48.37	52.41	+44.47	+49.35
Class II (50,000 to 99,999)	11.89	12.15	+39.26	+40.86
Class III (20,000 to 49,999)	18.53	17.36	+40.14	+29.10
Class IV (10,000 to 19,999)	13.03	12.04	+18.23	+27.30
Class V (5,000 to 9,999)	7.23	5.24	-30.07	- 0.09
Class VI (less than 5,000)	0.95	0.80	-62.30	+16.18

As in most other countries, the processes of urbanization and industrialization have gone hand in hand. Thus, large urban agglomerations are also areas of industrial concentration. The relatively larger scope for employment in urban areas is considered to be the main propelling force for the inflow of people into cities and towns from the rural areas.

The relationship between energy requirement and urbanization is not susceptible to easy quantification. Leaving aside the requirement of energy for industry which can be considered to be invariant to location, the additional demand for energy in the urban areas arises in India primarily for transportation. Unlike Western cities, the amount of energy needed for operating lifts, air-conditioning etc. is still relatively small in most Indian cites. The National Sample Surveys indicate that the per capita consumption of energy in the household sector is of the same order in both rural and urban areas, though, no doubt, the fuel mix is somewhat different (as is to be expected, the proportion of commercial fuels is higher in the urban areas). If even after excluding energy consumption in industry and urban transportation, the per capita energy consumption in urban areas is higher than in the rural areas, this is essentially on account of the fact that a higher level of services like water supply, roads, health and education facilities is available in towns and cities compared with the villages. In case the same standard of services were to be provided in the rural areas, the energy consumption would, in fact, go higher.

Since the main cause for higher energy intensity in the urban areas is local transportation, the strategy should be to divert urban growth from the metropolitan areas to small and medium towns. The thrust of the urbanization policy in the Sixth Five Year Plan is, therefore, to slow down the rate of growth of the metropolitan cities and increase the rate of growth of the small and medium towns. It is proposed to do this by giving greater emphasis to the provision of infra-structural and other facilities to the small towns and to equip them to act as growth and service centers for the rural hinterland. For this purpose, increased investments are proposed in these towns in housing, water supply, communication facilities (e.g., post offices, telephones and telegraphs). Likewise, facilities for higher education, medical care and recreation will be augmented. Simultaneously, measures such as restriction on setting up new industries and commercial establishments in large cities and incentives to shift industries to new urban centers, will be taken to restrict the growth of population in the larger urban conglomerates.

Thailand Energy Issues

Prida Wibulswas*

Abstract

Status of the present sources of energy for Thailand comprising petroleum, hydro power, lignite, bagasse and firewood, are reviewed. Problems of electricity generation are mentioned. Alternative sources of energy consisting of natural gas, coal, oil shale, small-scale hydro power, solar energy, wind energy and bio-energy conversion including forestry, are discussed. Actions to overcome the energy problems of Thailand are suggested.

Introduction (1,2)/

With no major conventional energy source of her own, Thailand has to obtain more than 80% of her energy requirement from imported crude oil and its products whose values represent over 25% of the national spending on imported goods. Since the energy consumption of the country increases at a rate of about 10% annually and the price of petroleum continues to rise rapidly, our deficit in trade balance will soon be so large that the country may go bankrupt.

Another fundamental energy problem of Thailand is the inequity of energy distribution among various economic and regional group. It is estimated that Bangkok with 13% of the country's total population consumes more than 60% of the total energy used in the country.

Present Energy Sources and Problems

1. Petroleum (1,2)/

Petroleum products are used in the following proportions: 42% for transportation, 21% for manufacturing industry, 15% for electricity generation and 22% for domestic and other uses. Though petroleum products satisfy about 82% of the total energy requirement , only about 0.1% of the total consumption of crude oil is met by domestic production. A number of survey and exploration have not shown any deposit with commercial viability.

2. Hydro-power (1,3)/

About 10% of the national energy consumption is met by hydro-power which is used mainly for generation by electricity. The present power generated by hydro-electric plants is just over 900 MW. There are now only a few major sites at which hydro-power may be economically developed. The most primising site with respect to generating capacity is unfortunately located on the Maekong River which flows through five countries having different political systems. Realization of the project on the Maekong is therefore very remote.

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3. Lignite (1.4)/

About 2% of the national energy consumption is contributed by lignite which is used mainly for generation of electricity. More 700 million tons of lignite reserves in the country have been estimated, but less than a half of the total reserves may be exploited economically. The use of lignite has been limited mainly by the fact that mining and burning of lignite create serious environmental deterioration.

4. Bagasse (1,2)/

At present, bagasse is used mainly in sugar industry. It accounts for about 7% of the total energy consumption of the country.

5. Firewoods (1,2)/

Firewoods and charcoal are two main sources of domestic fuel. According to an offical estimation, firewoods and charcoal satisfy just about 7% of the national energy consumption. However, as firewoods may be gathered non-commercially in most parts of the country, its actual consumption may be much higher than the estimated figure.

Generation of Electricity

Generation of electricity deserves a special attention since electricity is the most convenient form of energy to be distributed and used. The present generating capacity is about 2,800 MW which are obtained from different primary sources as follows: 38% from hydro-power, 5% from lignite and 57% from petroleum products. Hence, more than a half of the generating capacity depend upon the imported petroleum.

As most developing countries, consumption of electricity increases at a rapid rate of about 15% per annum. Additional generating capacity is now limited by the primary sources of energy which have already been discussed.

At present, about 65% of the total amount of electricity generated is consumed in Bangkok and electricity is available to only 20% of the total population. It means that 81% percent of about 50,000 villages in rural areas do not have electricity. To remedy this situation, the government has approved the rural electrification project of the Provincial Electricity Authority which hopes to provide electricity to 90-95% of the rural popluation within 15 years.

Alternative Sources of Energy

It is now obvious that the most serious energy problem of Thailand is the increasing gap between the growth rates in consumption and in domestic production of energy. To solve the problem in the long run, alternative sources of energy have to be developed. The possible alternative sources are as follows.

1. Natural Gas

The proven reserves of natural gas under the bed of the gulf of Thailand are over 6.6×10^{12} cubic feet. The Petroleum Authority of Thailand has planned to use about 150×10^6 cubic feet per day for generation of electricity in 1981 and about 350×10^6 cubic feet per day as fuel and raw material for industries in a later stage.

In conjunction with the above plan, the Electricity Generating Authority of Thailand is constructing a 860 MW power plant fired by natural gas. A sponge iron plant and a soda plant which will use natural gas as fuel and raw manterial are also being planned.

2. Coal

Though domestic reserves of lignite are limited, coal reserves are still abundant in this region of the world such as in Australia, Indonesia, etc. More extensive uses of domestic lignite and imported coal are being considered for generation of electricity and process heat for industries. However, the industrial plants have to be located in sparsely populated areas where a higher degree of pollution from burning of coal may be tolerated. Alternatively, distillation of coal to produce coke may also be considered, though it will involve a large capital investment.

3. Oil Shale

Some 2500 million tons of oil shale reserves have been estimated. Limited samples have been analysed and found to give 7-10% oil yield.

As the extraction of oil shale at present is very costly and produces serious environmental problems, the oil shale technology still needs a great deal of research and development before its utilization is realized.

4. Small-Scale Hydro Power (2)/

As already mentioned, suitable sited for large scale hydroelectric plants are now very limited, but potential still seems to exist for small scale hydro power plants on a number of river systems in the north and northeastern parts of Thailand. Micro hydro power plants having outputs from 0-100 kW, and mimi hydro power plants having outputs from 100-5000 kW, will be more suitable for rural areas where power requirements are not so large. However, a more in-depth survey of the river systems for their hydro power potential is still needed.

5. Solar Energy (5,6)/

Solar energy is attractive because it is renewable and free from pollution. Thailand is endowed with fairly good solar radiation whose daily average value is about 17 MJ/sq.m.d. A number of educational institutes and government agencies have been engaged in solar neergy research and development in the last five years.

Solar water heaters using flat plate collectors are now produced in Thailand by a few local manufacturers. They are used mainly in hotels, hospitals, clinics, etc. Solar water heating also has potential to be

used in a number of industries such as food processing, textile, paints, etc. Nevertheless, due to a high capital cost and a long pay-back period, popularisation of solar water heating will be difficult unless some incentives such as tax rebate, government subsidy, etc., are provided, and/or more efficient collectors are developed.

Portable solar dryers and low-cost stationary solar dryers have been locally developed for cash crops and grain drying. However, further developments are still needed for dryers requiring precise temperature and humidity controls and for large-scale co-operative dryers.

A large amount of electricity is now used for running air-conditioning units in Bangkok. Solar heated air conditioning systems will save electricity for more benefitial uses such as in industry. Nevertheless, further development to lower the initial cost of the system is still required.

Solar-generated electricity, either by photovoltaic cells or by solar thermal electric power system, seems feasible for remote areas where connection to national electricity grid will be too costly. In Thailand, research, development and feasibility studies are being done on both methods of generation. However, a great deal of effort involving high technology, is still required before solar electric generation is locally practical.

6. Wind Energy (5)/

Lifting of water and generation of electricity by wind seem viable along the coastal areas and in the Gulf of Thailand where wind speeds are high enough. There exists at least one local firm which produces multi-blade wind turbines for water pumping.

Two wind electric power systems, using a horizontal axis turbine and a vertical axis turbine, are being developed by two technological institutes to generate about 1 kWe for rural application. Indigenous technology for small systems is this field appears to be possible.

Institutions engaged in various R & D activities on solar and wind energy are shown in Table 1.

7. Bio-Energy Conversion (5,6)/

Since 1960, bio-gas plants have been introduced to rural areas of Thailand by the department of health as a means to eliminate health problems arising from manure of domestic animals. In the fiscal year 1979, more than 100 bio-gas plants will be installed in various parts of the country.

If the bio-gas is to be used as an alternative source of energy, a number of problems have to be solved such as insufficient manure to feed digesters, high construction cost, leakage of the gas holder, etc. Further research and development are needed on the use of vegetation as a substitution for manure and on continuously operating digesters.

With the availability of sugar canes and cassava in Thailand, interest in the production of ethanol as a motor-fuel has recently been aroused. It has been estimated that if a mixture of 80% gasoline and 20% ethanol is used as the fuel for motor cars, Thailand will be able to save U.S. $65 million in foreigh exchnage annually. However, a thorough feasibility study has to be made before a large ethanol plant is set up in the country.

8. Nuclear Power (2,3)/

Even with additions of a new power plant using domestic natural gas and of a few large hydro-electric plants, the consumption of electricity will exceed the generating capacity by 1990.

As it is unlikely that other alternative sources of energy will be able to provide large generating capacity as required, nuclear power seems to be a logical alternative since its technology is well proven.

Electricity Generating Authourity of Thailand has planned to construct a 600 MW nuclear plant on the eastern coast of Thailand. The project was submitted to the government for approval in 1977. It is anticipated that the project will be further postponed due to public sentiment on safety operation of the nuclear plant.

In connection with the above project, the analyses of environmental impacts such as biological fouling, thermal diffusion, etc., which started in 1975, will be completed in 1979. Neveryheless, the government will have to take a decisive action on nuclear power soon, otherwise shortage of electricity will result in 1990.

Forestry (2)/

Forests contribute not only the nations economy in terns of raw material and fuel, but also affects its climate and water resources. Though forests are renewable, they are being depleted fast in Thailand. Surveys conducted in 1963 and in 1971 showed that total land area covered by healthy forests in Thailand had been reduced from 53% to 39% of the total land of the country. It is now estimated that the area covered by forests is less than 30% of the total area.

The depletion of forests in Thailand arises from two main causes. First, many farmers cut down forests to obtain new fertile agricultural land. Secondly, increasing population leads to greater demands for timber for housing and fuel.

If this trend of forest depletion should continue, uncalculable and perhaps irreversible harmful effects on Thailand's watersheds and climate may result. At present, government agencies and logging companies are responsible for replanting trees. However, the rate of replanting has been lagging far behind the rate of deforestation. One of the main reason is the wide spread of illegal log poaching.

One method to solve the problem of deforestation is to grow fast-maturing and disease-resistant trees, such as leucaena which has been reported to have a trunk of one foot within six years. Leucaena

was introduced to Thailand in 1976 and a large plantation of leucaena now exists in the country.

Conclusions

The main solution to the energy problems of Thailand is to select suitable alternative sources of energy. Within the next ten years, nuclear power and coal are the most viable alternatives if the public can be convinced to accept some pollution effects which may be lessened in the long run by new technology. As for other alternatives, solar energy and bio-energy conversion look very promising, but a great deal of research and development are necessary before their large-scale applications are realized.

External assistance will be one of the main factors which will help accelerate the applications of the alternative sources of energy. The assistance should be in the forms of short-term and long-term training of technical personnel, R & D equipment, information and expert services. The training of technical personnel is considered to be the most valuable components of the external assistance, since well-trained technical personnel will enable Thailand to help herself in the long run.

References

1. Energy resources and fuels, the fourth national economic and social development plan (1977-1981), Section 4, National Economics and Social Development Board, Bangkok..

2. Energy, Thai national paper for UNSTD conference, Para 122, National Economics and Social Development Board, Bangkok, 1978.

3. Annual report, Electricity Generating Authority of Thailand, 1978.

4. Programme and problem of electrification in PEA responsible area, Provincial Electricity Authority, Workshop on energy and rural development, National Research Council Thailand, Pataya, 1978.

5. Status of research and development of solar energy in Thailand, Country report of Thailand, The first ASEAN meeting on non-conventional energy research, National Research Council, Bangkok, 1979.

6. ASEAN proposal on co-operation programme on non-conventional energy research, The first ASEAN meeting on non-conventional energy, National Research Council, Banfkok, 1979.

Table 1 Solar Energy R & D in Thailand

R & D Activities	R & D Institutions
Water heating	King Mongkut Institute of Technology Thonburi, National Energy Administration, Solar Industrial Co. Ltd., Soltech Co. Ltd.
Drying	Asial Institute of Technology, Chulalongkorn University, King Mongkut Institute of Technology Thonburi & North Bangkok, Prince of Songkla University.
Distillation	Asian Institute of Technology, King Mongkut Institute of Technology Thonburi, Department of Science.
Cooking	King Mongkut Institute of Technology Thonburi, National Energy Administration
Refrigeration & Air conditioning	Asian Institute of Technology, Chulalongkorn University, King Mongkut Institute of Technology Thonburi, National Energy Administration.
Pumping	Asian Institute of Technology, National Energy Administration.
Thermal Power	King Mongkut Institute of Technology Thonburi, Chulalongkorn University, Electricity Generating Authorities of Thailand.
Photovoltaics	Chulalongkorn University, King Mongkut Institute of Technology Thonburi, & Ladkrabang.
Wind Power	Chulalongkorn University, King Mongdut Institute of Technology Thonburi, National Energy Administration, Prince of Songkla University, Usa Industrial Co. Ltd.
Bio-energy conversion	Department of Public Health, Thailand Institute of Science and Technology, Chulalongkorn University, King Mongkut Institute of Technology Thonburi, Department of Agricultural Technology

Energy and Industrial/Urban Development

Gary S. Makasiar *

> Since development is far from being achieved at present, the need is not as generally imagined to accelerate economic growth -- which could even be dangerous -- but to change the nature of the development process.
>
> - Dudley Sears

Introduction

The great interest in the development of "backward" countries is a fairly recent phenomenon. Poverty has been with mankind for a long time but the awareness that something can be done about it on a national level is relatively new. This awareness is greatly due to the exposure of the underdeveloped countries to the economic achievements of the industrialized world. The rapid development of some countries and their standard of living proved that poverty was not, after all, the unavoidable and normal condition of mankind. The contrast between the standard of living in the economically "advanced" and the "backward" countries led to an interest in the way it can be done.

In the Economic History of World Population, Cippola argued that the more successfully man can use his own energy output to control and put to use other forms of energy, the more he acquires control over his environment and achieves goals other than those strictly related to animal existence. 1/ He then adds what is certainly obvious but does not suffer from repetition -- that fundamental to the utilization of non-muscular energy is the problem of transforming it into the needed form at a selected time and place and at a convenient cost. 2/

Thus, oil, relatively cheaper than other sources of energy, at the same time possessing advantages of being easier and cheaper to transport, has for several decades ruled supreme over alternative forms of energy. Most developing countries, including the Philippines, entered upon a more total dependence on imported oil by founding its efforts to industrialize almost exclusively on oil as a thoroughly inexpensive and easily used imported source of energy. And for as long as uninterrupted supply of "cheap" imported oil was available, the energy requirements for rapid industrialization was taken for granted.

Events in recent years have led to the realization that world reserves of fossil fuels are slowly nearing depletion with foreseeable scenarios of supply shortages and high prices. The energy crisis has created public demand at the national as well as local level for energy supply systems that are energy conserving, safe, environmentally acceptable, reliable and "price stable".

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This is especially true in the urban areas, where its effects are so critically observed. Urbanization, it should be noted, brings about centralization and/or concentration in industry and energy systems. This in turn brings in pollution (environmental problems) precisely because of scale-economics and the reality of concentration and centralized systems in urban areas. Thus, the urban environment, because of its high population and energy demand densities, offers a significant opportunity for the application of a variety of energy-related technologies in an energy-conserving, cost-effective manner. Due to the recent sharp increases in petroleum fuel costs with the expectation of further price increases in the foreseeable future, there is a growing interest in the technologies which are: (a) energy-conserving and (b) which use renewable energy sources, such as solar or less scarce fuels such as geothermal, coal or nuclear.

The relationship between economic growth and energy has a reciprocal effect. Like a two-way mechanism, "cause and effect" are inter-related. Whether GNP pushes up energy consumption or energy use causes increased GNP is an interesting and important question.

Toward a General Energy Equilibrium Analysis

The Growth-Energy Interaction

The task of development initially consists in creating a surplus, which is investible, by minimizing the cost of conversion of raw materials to goods and services. In a related study, the amount of energy consumed measured in barrels-of-oil equivalent was analyzed as a function of gross national product (at constant 1972 prices) and energy price index (EPI) with 1972 as the base year. The regression results are expressed in the following specification:

$$\log C = 1.79038 + \underset{(17.11)}{1.52349} \log \overline{GNP} - \underset{(5.06)}{0.35038} \log \overline{P}$$

$$R^2 = 0.98074$$

where: C = consumption of energy in thousand barrels-of-oil equivalent

$\overline{GNP}$ = Gross national product at constant 1972 prices

$\overline{P}$ = energy price index (1972 = 100)

3/

The results suggest that every percent targetted increase in GNP will require an increase in energy consumption by 1.5 percent. On the other hand, a one-percent increase in price of energy reduces energy demand by 0.35 of one-percent reflecting a rather inelastic relationship.

Energy use per capita vs. the GNP/CAP. in 1976 U$ for selected countries.

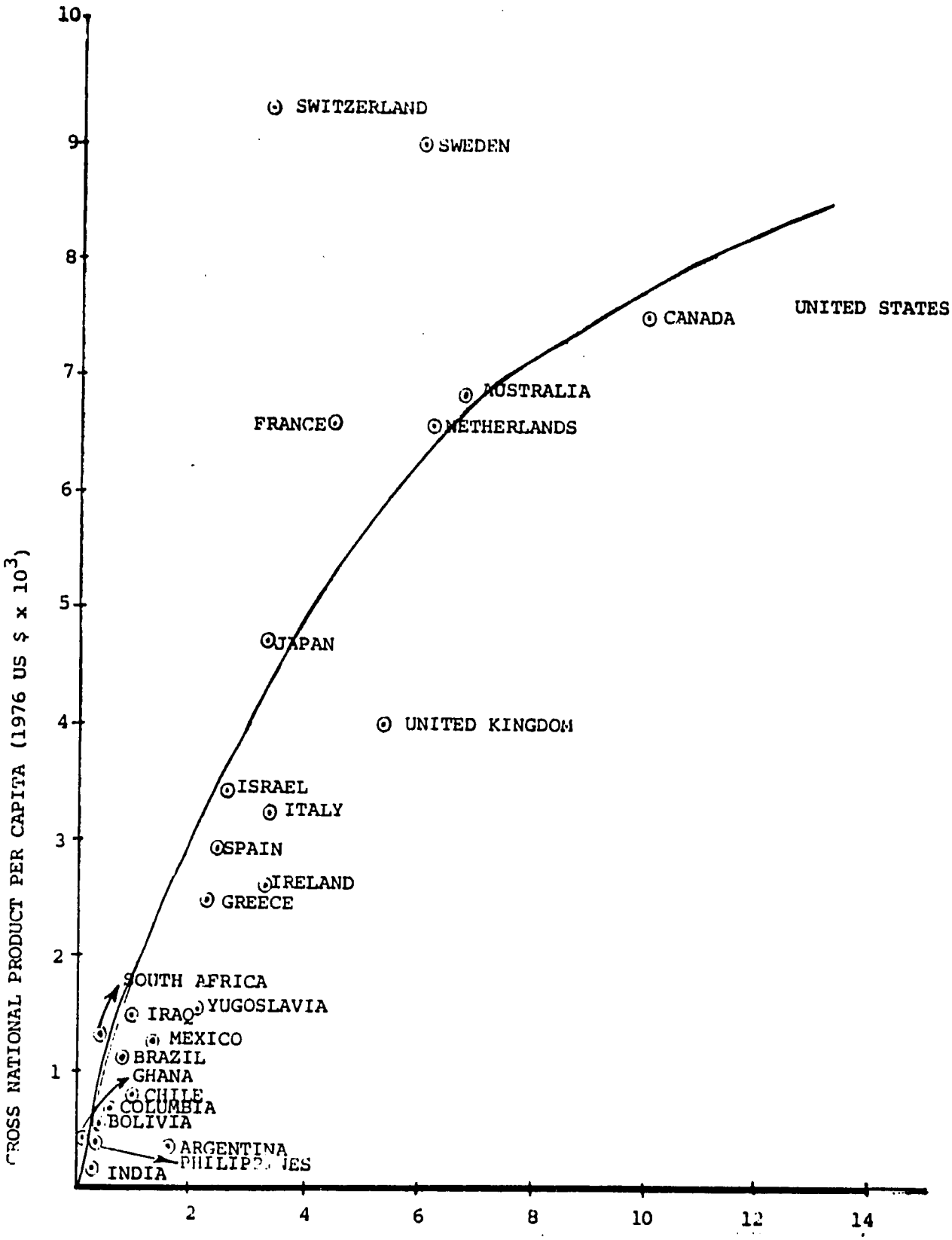

Figure 1: Total energy per capita ($x10^3$kgms./capita)

Source of basic data: World Energy Supplies, 1978, United Nations.

A similar trend appears to be the experience of other countries. Figure 1 shows the energy consumption per capita for several nations. There is a clear trend toward higher consumption of energy as a nation industrializes and increases its gross national. The increasing use of energy per capita tends to produce an increase in gross national product per capita. However, the effect appears to be less pronounced once a nation passes into a state of relative affluence (approximately beyond $1000 per capita GNP as reflected in Figure 1). This does not mean that gross national product can be increased just by using energy, but it means that energy is one of the requisites to increasing the production of goods and services.

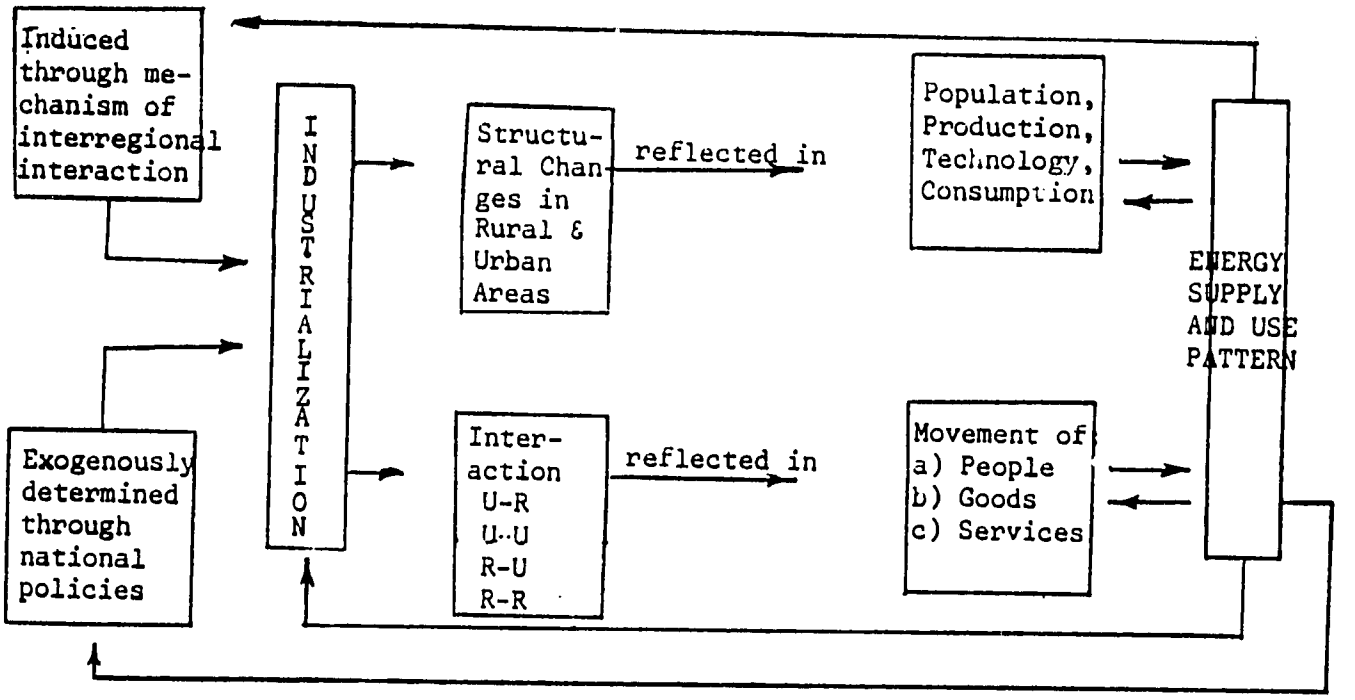

Figure 2
INDUSTRIALIZATION-ENERGY INTERACTION

Schematically, the industrial-energy interaction concept is shown in Figure 2 (above). In a very broad consideration, industrialization is seen to be the result of two possible, but not necessarily mutually exclusive, stimuli: (a) exogenously determined through national policies, and (b) induced through a mechanism of interregional interaction.

The process of industrialization, once underway, will bring out structural changes in rural and urban areas reflected in changes in population, industrial production, consumption patterns, and technological applications. Moreover, there will be increased interaction between urban-rural, urban-urban, rural-urban and rural-rural reflected in the movement of people, goods, and services.

Both will impact on the energy supply and use patterns. The relationship between industrialization and energy supply is thus a two-way mechanism. On the one hand, socio-economic developments will in some way influence the end-use energy demand (Figure 2). On the other hand, the available alternative types of energy that may be tapped may create constraints on just how far and how fast this development effort can go.

Toward An Industrial-Urban Energy Strategy

Let these observations on energy and economic development relationships pass as a simplification. Let us now turn to some specifics with which we are going to have to deal as we face our new realities, namely: the energy use and supply patterns.

In energy planning, it is essentially necessary to estimate future energy demands of an urban area by forecasting developments of socio-economic activities such as population, industrial production, movement, etc. The current picture of the uses of energy in the Philippines as well as urban energy demand is shown in Figure 3.

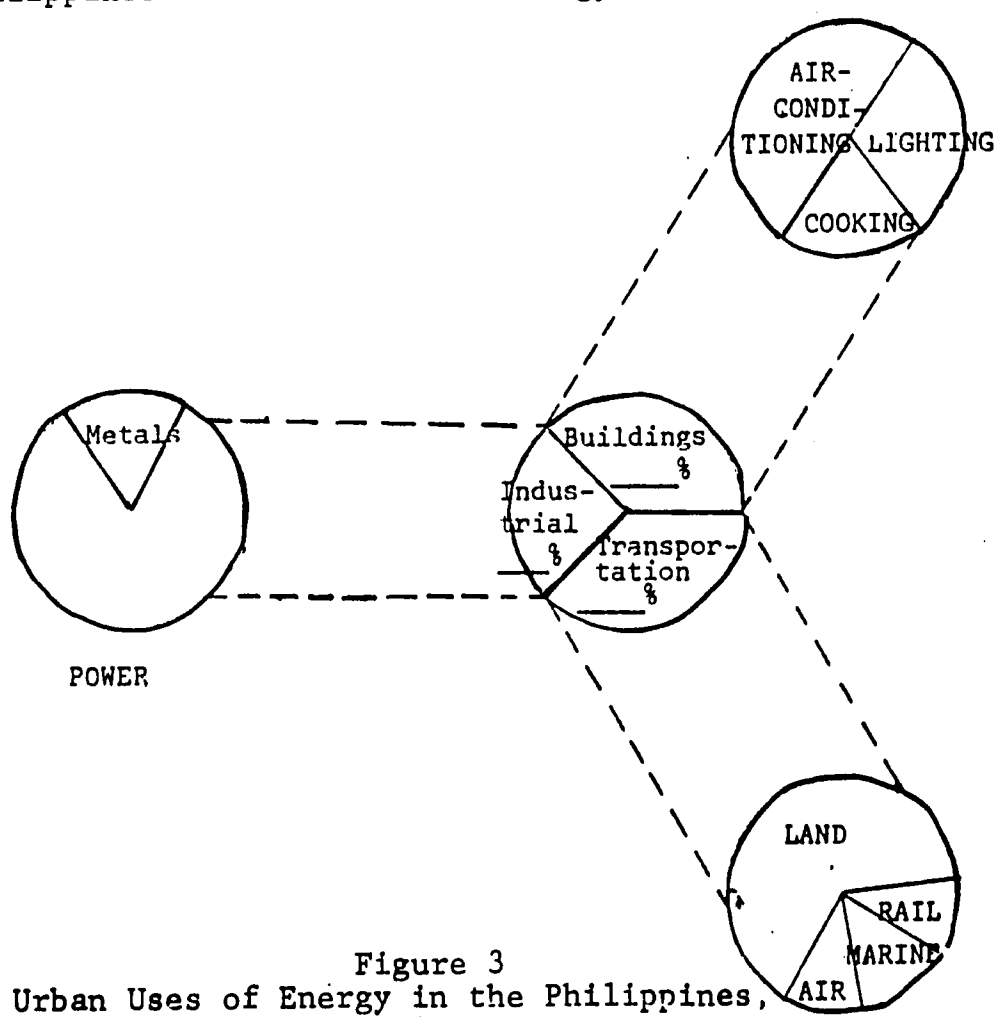

Figure 3
Urban Uses of Energy in the Philippines, 1978

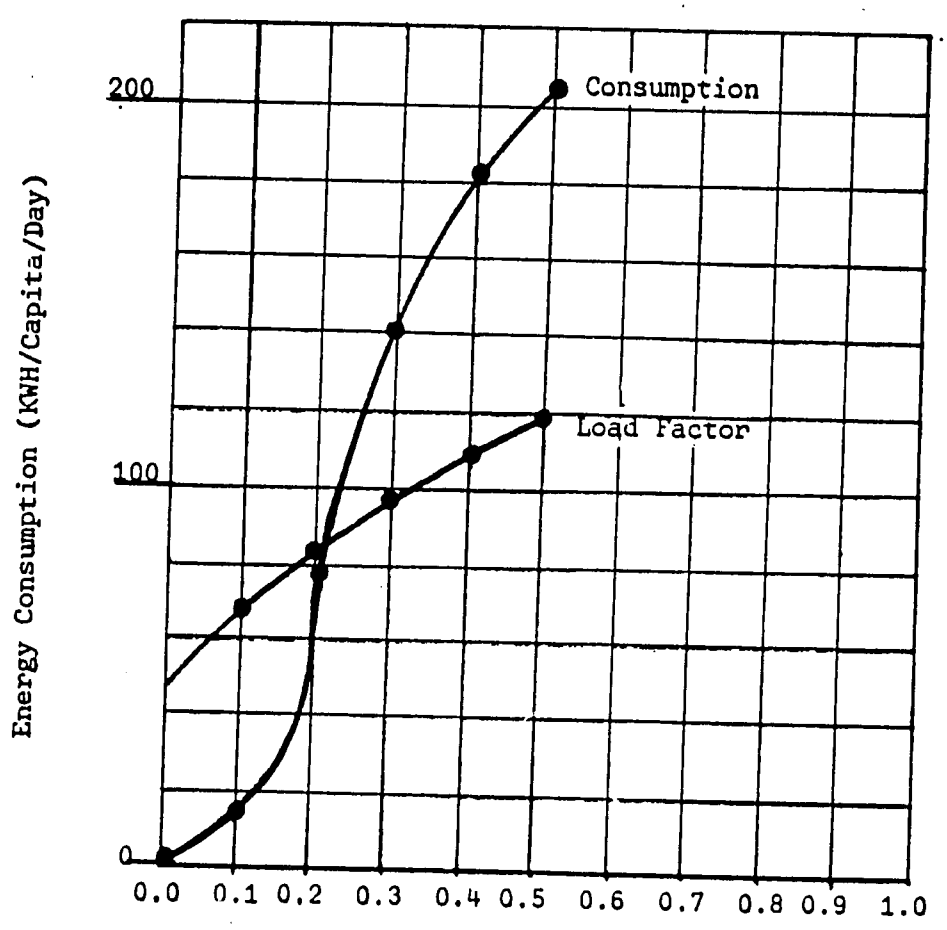

Figure 3a: Energy Consumption as Function of Industrial Contribution to GNP.

The two largest concentrations of energy demand in the area are accounted for by transportation and industry. During the past two decades there has been an increasing tendency for industry and transportation to become more energy-intensive. During the fifties and sixties, most industries responded to increased demand for production by becoming more energy-intensive and less labor-intensive. The automation that replaced manual labor in a number of industries attests to this fact. During the same period, fossil-fuel energy has been the main source of power in moving people and goods and in the provision for physical comfort. As most of the post-Independence industries were both foreign-financed and foreign-trade oriented, it is easy to see why Manila offered a natural vantage point for the location of the greater proportion of the country's industrial plants. The presence of natural port facilities provided a cheap source for receiving essential material inputs from abroad, including imported oil. With the added advantage of being surrounded by large areas of rising export-oriented agricultural incomes (coconut and coffee plantations of Southern Luzon), it grew into a center of industrial concentration for both internal and external markets. Historically a great center of traditional commerce, Manila grew into a strong pool of urban population concentration and a focal point for the process of political modernization and administrative control.

The close interconnection between urbanization and industrialization within the "context of a free enterprise system meant that the physical and spatial configurations of cities have been determined largely by entrepreneurial values." 4/

Cheap and easily available energy supplies in the past have permitted several decades of urban/industrial development to ignore the energy consequences of inefficient urban design and industrial decisions. Industrial activities have been obstructed by serious problems caused by its concentration, e.g., overpopulation, traffic jams, housing shortages, draining power resources, and others as such.

What then should we do? If urban governments expect to exercise responsibility and authority in urban development and management they must be cognizant of the energy dimension, particularly in the generation of electricity and transportation. They must be willing and able to develop an energy policy design capability. This should involve descriptive as well as prescriptive capabilities. However, whatever the degree of sophistication one operates in, a policy analysis starts with a consideration of a set of planning premises, namely: adaptability, diversity, reliability.

Premises

Since supply of primary energy sources appears to be uncertain and will remain to be scarce, whatever energy system to be adopted

must be capable of modification and easily adjustable to change. Given a choice among several project options, a project that is easily and inexpensively modified is clearly more desirable than one that is not.

Secondly, power supply should not be dependent on a single technology. For as practicable as possible alternative energy systems must be considered. Research on the technological viability and economics of various power supplies, e.g., electric technologies, should continue. Nevertheless, given a choice among several project options, a project that relies on technologies whose overall impacts have already been ascertained appear to be more desirable than those that are yet to be assessed, other things being equal.

Finally, energy systems that can stand on their own, that can operate within the market forces without the need to hang on the strength of a government regulation may be more desirable.

In short, the choice of the energy systems must be made by fitting the energy environment within these premises. A schematic representation is shown in Figure 4.

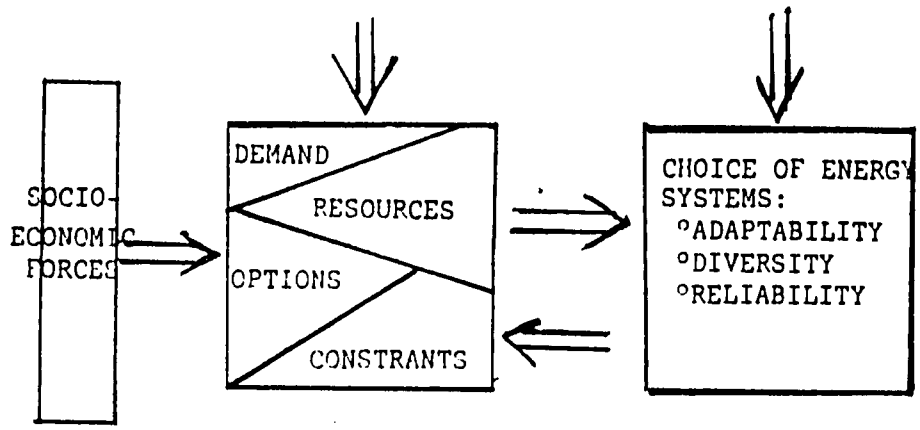

Figure 4

Energy Systems

For instance, in two main energy consuming sectors, power and transport, several innovative conceptual approaches can be taken:

1. Time-of-Use Pricing in Power Sector

To better crystallize concepts, it is best to start from fundamentals.

The commodity that is being demanded in electricity use, is wattage (and measured in watts). This is to be differentiated from watt-hours which gives us the number of hours that a given wattage

is used. By virtue of practice, convention, or convenience, the latter has been the unit under which electricity sales have so far been transacted, so that the public mind has been conditioned to think of power in terms of kwh. In an earlier regime, sales in terms of kwh was perhaps more economically convenient and practical. However, in an era of mounting capital costs and heavy infra-structural requirements, a conceptual reorientation may be in order.

A power generating (transmission and distribution) system is generally installed to deliver a certain level of power capacity (watts) to the market (load) at the appropriate time. This level is measured in watts. Needless to say, the system's load level will usually vary with the particular hour-of-use, and so power expansion programs in the days of low capital costs had traditionally planned on meeting peak-hour load requirements to avoid brownouts or rationing of deficient capacity during those periods.

In a "mature" power system, which features a combination of different types of power generating units, the cost of delivering or providing each and every watt into the system or grid will entail a marginal running cost, largely in terms of mobilizing energy to turn that unit's turbine.

For run-of-the-stream hydro systems, the energy would be provided by the volume and head of the water flowing by gravity through its penstock. For thermal systems (oil, coal, nuclear, and dendrothermal), it would be the fuel volume burned to produce steam for turning the turbines. Storage hydros present a minor complication. The direct costs do not readily reflect the opportunity value of the power. Except for a pump storage hydro, the marginal cost would be practically nil. But the real economic value should reflect the substitute energy that would otherwise have been required to deliver the same MW at that particular time (since stored hydro power can accommodate a time-trade, it does not have the same marginal cost valuation as a run-of-the-hydro) in that grid. A pump storage complex of course would have to be valued at the higher of its opportunity value or the cost of the power required for pumping which would vary depending on the type of fuels being used during pumping. If off-peak nuclear pumping is employed, it probably is not proper to cost the uranium consumed (it would have been consumed anyway whether a pump complex existed or not). The pump complex therefore "saves" part of what otherwise would have been wasted excess nuclear power and energy. A geothermal system uses almost "cost-free" steam pressure (negligible variable costs) from the earth. Coal and dendro systems necessitate coal or wood production, handling, and burning.

As a result, a utility can stack up the different types of units according to rising variable or marginal costs and satisfy any load level by running units from the lowest to highest marginal cost. Assuming reasonable observance of good operating and maintenance procedures, the cost to deliver a marginal KW from any one

unit up to its full capacity would, for all practical purposes, almost be considered constant.

Therefore, in a typical grid, one might stack existing power units as in Appendix A; the merit-ordering follows the rule of sequencing units from the lowest unit to the highest marginal cost unit in a grid.

Example:

Variable Cost/KW-hr.

	N. P. C.*
Run-of-the-stream hydro	nil
Geothermal steam	0 - .15
Nuclear	.05 - .07
Coal	.18
Wood	.20
Bunker/Gas/Diesel	.20
Pump Storage (Nuclear)	.0 - .10
Storage Hudro (depends on grid)	.18 - .20
Pump Storage (oil)	.30

* For illustration, assume equal costs to economy

The same stacking order can be presented graphically via a textbook marginal-cost schedule on a two vector chart, which features as the independent variable on its horizontal axis, the MW-level supplies; and the marginal cost of delivering the last watt of the total (MW) supplies at that particular time or hour as the dependent variable on the vertical axis.

Time increments are chopped up in terms of hours for practical convenience (that is, we measure each relevant instance in hour units)since a demand level is most likely to be sustained for at least an hour and since a power unit will most likely be operated, even intermittently, at least an hour at a time. This also allows MW sales to be quoted in kwh for rate purposes.

Therefore, the horizontal axis will need off MW demanded or supplied at a particular instance of time or hour (instead of the more conceptually-precise increment of milli-second).

Graphically, the chart might look like the one shown in Appendix B. Needless to say the stacking order (or shape of the marginal cost curve) for any particular hour may change depending on whether certain units are derated or brought down for repairs, preventive maintenance or any other scheduled shutdown.

The Daily Load Curve: The Demand Side

On the other side of the coin, we have the daily load curve which may be projected on the basis of updated information about the hourly structure of the market for a 24-hour period, which may or may not be sensitive to seasonal variations (e.g., summer air-conditioning loads, heavy Christmas production loads).

A typical Luzon daily load curve for 1978 is shown in Exhibit C.

Marginal Cost Pricing as the Synthesis of the Load Curve and the Supply Schedule

The two can be married by translating a daily load curve into a load duration curve, and stacking up power generating units inside the latter curve, merit-ordered according to rising marginal cost.

Alternatively, we can join Exhibits A & B along A's horizontal axis and trace back load levels to the marginal cost schedule and read off the appropriate marginal cost for purposes of pricing marginal power demanded (at levels below maximum supply capacity).

For demand levels pushing against maximum capacity limits (lunch peaks, motel peaks, evening peaks) a surcharge equal to discounted capital charges (cost of capital plus depreciation) from adding incremental (or marginal) KW-capacity needs to be imputed, annuitized over the commercial life of that plant and divided by the total number of projected peak-hour use for any given year.

Therefore, what is proposed is short-run marginal costing for off-peak hours and a variant of long-run marginal costing for peak hours.

Advantages and Disadvantages

I will assume away the problems of social economic accounting. I will presume that appropriate shadow exchange rates for labor, capital and foreign exchange will be provided by the competent government agency(ies). Therefore, it has only two (2) main disadvantages remaining:

1. It is unclear how feasible the application of hour-of-day pricing would be in the case of residential customers.

2. Even assuming residentials would be initially shielded, the approach requires a systems conversion to slightly-expensive time-meters, for both industrial and commercial customers.

On the other hand, it has a number of advantages:

1. It backs out of an inflation-rate problem.

2. It eliminates the problem of using the same discount rate over long planning periods.

3. It is really anchored on marginal cost principles which are not blurred out by involved but theoretically-compromised methodologies.

4. It is easier to explain, because all the costs are directly visible in the exhibit diagrams, except for peak-hour uses.

5. It avoids confusing and debate-prone inter-temporal cost-comparisons and mixing.

6. It uses a proven commercial technology (i.e., time meters).

7. People live with time of purchase pricing throughout most of their daily lives (evening price of sampaguita, market stall fish, etc. are usually low).

One of the more cited objections to hour-of-day pricing concerns the rate instability that comes with unpredictable fuel price movements. However, this is a reality that is common to the two-proposed methodologies. In fact, even today, utilities are already allowed fuel cost recoveries (even over-recoveries) by all types of fuel adjustment clauses. So today, consumers are already being subjected to rate fluctuations without too much of a market chaos occurring.

2. Mass Transit Considerations and War Surplus Economics

The Yom Kippur War of 1973 has led to the realization of the existence of inefficiencies in many an energy application. We find many people questioning the energy efficiency of present systems of transporting people within our major urban areas, particularly Metro Manila. This section will outline strategies to make these systems more efficient as well as to reduce total urban transportation energy consumption.

The public transport system in Metro Manila is almost wholly road-based and is supported by a fleet of buses and jeepneys and auto-calesas. The buses with seating capacity ranging from 16 to 75 consist of imported truck chasis with locally-fabricated shells designed to maximize seating capacity. Jeepneys, on the other hand, are small public transport vehicles developed from ex-US army jeeps. Jeepneys can carry as many as 16 passengers and operate along fixed

routes like buses. Auto-calesas are smaller versions of the jeepneys with seating capacity for 8 passengers and in general enjoy route flexibility within a defined territory. Both buses and jeepneys offer frequent services on busy routes. For all intents and purposes, the only important differences between buses and jeepneys is in their sizes. There is therefore no greater advantage to be gained from competition between jeepneys and buses than between rival bus (or jeepney) operators. The important question is whether there is an advantage in employing vehicles of different sizes, and if so, where.

On high demand routes where buses can achieve a high load factor, (see Table 1) and also offer a frequent service, studies by the Metro Manila Commission show that buses consume less fuel per passenger than jeepneys do.

TABLE 1

Roads where buses run at average journey speeds of less than 15 kph and carry more than 50 passengers per vehicle:

	Morning Peak Period
Quezon Blvd., Espana and Quezon Blvd. Ext.	Southbound
Quezon Blvd. Ext.	Northbound
Taft Avenue Through Ermita	Both Directions
Buendia Ave. and Ayala Ave.	Toward EDSA
EDSA between East Ave. and Cubao	Southbound
	Evening Peak Period
Aurora Blvd. through Cubao	Westbound
R. Magsaysay Blvd.	Eastbound
Espana	Both Directions
Quezon Blvd., Ayala Ave., Buendia Ave., and Taft Ave.	Northbound
EDSA between East Ave. and Cubao	Southbound
Sections of Magsaysay and Aurora Blvd.	Westbound

Based on actual survey conducted by MMTC along designated routes operated by MMTC on March 18, 1976.

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Table 2 shows the energy requirements for various road vehicles. Jeepneys consume 0.0118 liters per passenger per kilometer while buses consume 0.0047 liters per passenger per kilometer. Moreover, with an average occupancy of 130 percent more passengers than jeepneys, buses were found to be more efficient in the use of road-space (see Table 3). However, this advantage of the bus is relevant only on certain routes and at certain times when there is high transport demand.

TABLE 2

ENERGY REQUIREMENTS FOR ROAD VEHICLES

Vehicles	Types of Fuels	(Ltr./Km.) Fuel Consumption				Liters/ passenter/ kilometer
		Capacity	Rural	Urban/Peak	Non-Peak	
Motorcycle	G	1	-	-	0.033*	0.330
Tricycle	G	2	-	-	0.050*	0.0250
Jeepneys	G	12	0.110	0.168	0.149	0.0118
Minibus	D	35	0.120	0.213	0.177	0.0049
Bus	D	60	0.171	0.380	0.286	0.0047
Cars	G	5	0.102	0.290	0.132*	0.0264

*Average consumption.

SOURCE: Planning and Project Development Office, A Study of Transport Alternative for Energy Conservation (1975)

Nevertheless, jeepneys have an important role to play in urban transport schemes. Jeepneys are useful on small streets and on poorly surfaced roads where buses are not suitable. Rationalization of the transport system should encourage the utilization of buses on principal roads and to relieve congestion, jeepneys should provide services between residential areas and principal bus routes and on secondary roads. While it may be possible to argue that passengers prefer buses for longer distances for reasons of comfort, they find jeepneys convenient for short trips. As such, it appears that jeepneys are still needed until an efficient and effective backbone system is introduced to replace it. The fact that jeepneys have survived over the years (and in fact, are even more profitable than buses) without benefit from any BOI incentives and based solely on use of "second-hand" engines and without any formal "jeepney industry" set up, must be recognized. The role that jeepneys

play as a viable urban mass transit mode must be carefully considered.

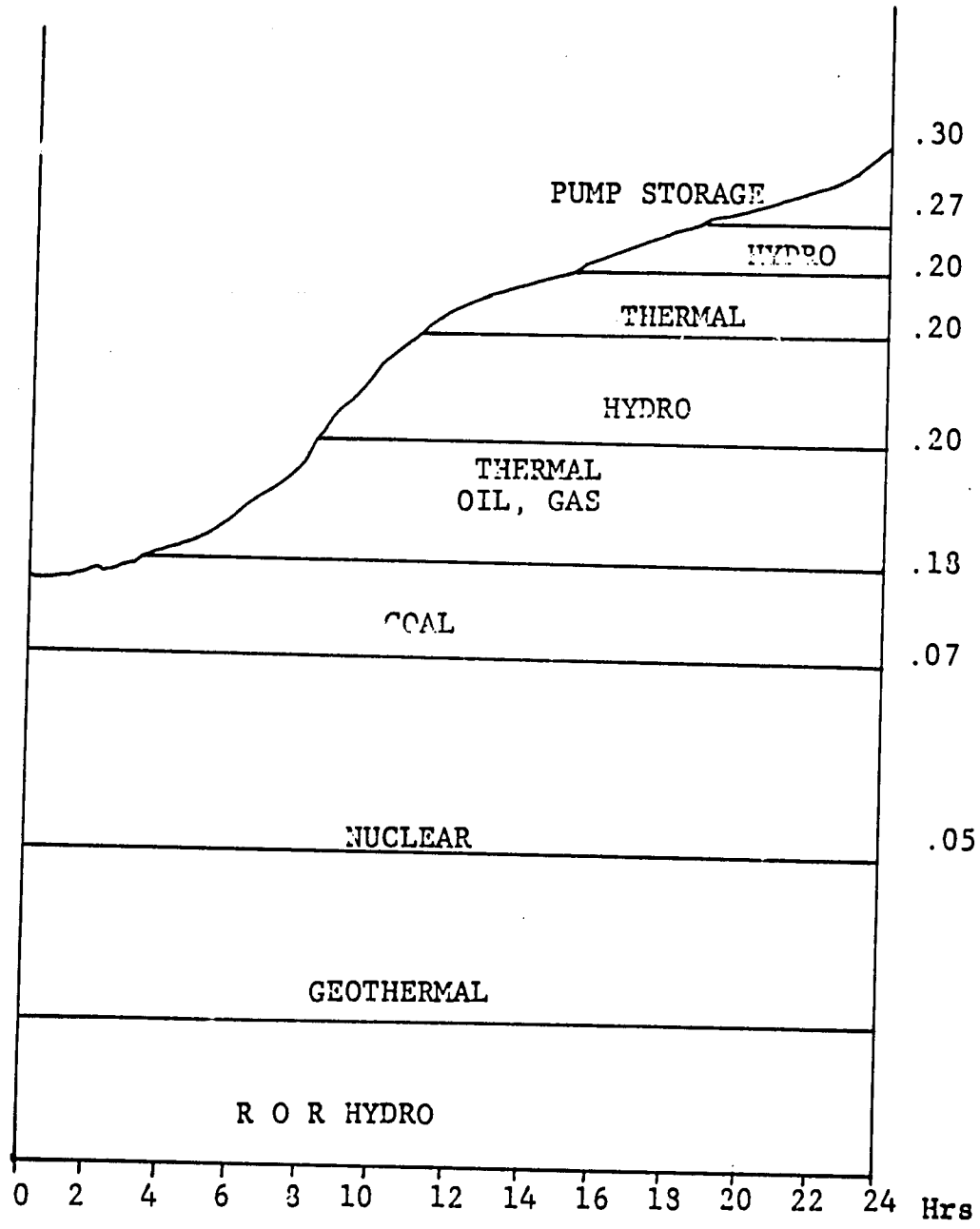
TABLE 3

EFFICIENCY OF DIFFERENT VEHICLES IN THE USE OF ROADSPACE

	p.c.u.* Equivalent	Average Occupancy	Passengers carried per p.c.u.
Taxi	1.0	1.2	1.2
Private Car	1.0	2.0	2.0
Jeepney	1.5	12.0	8.0
Bus	3.0	55.0	18.3

*Passenger car equivalent.
SOURCE: MMETROPLAN (Final Report, 1977)

APPENDIX A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HYDRO
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THERMAL
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HYDRO
.20
THERMAL
OIL, GAS
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COAL
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NUCLEAR
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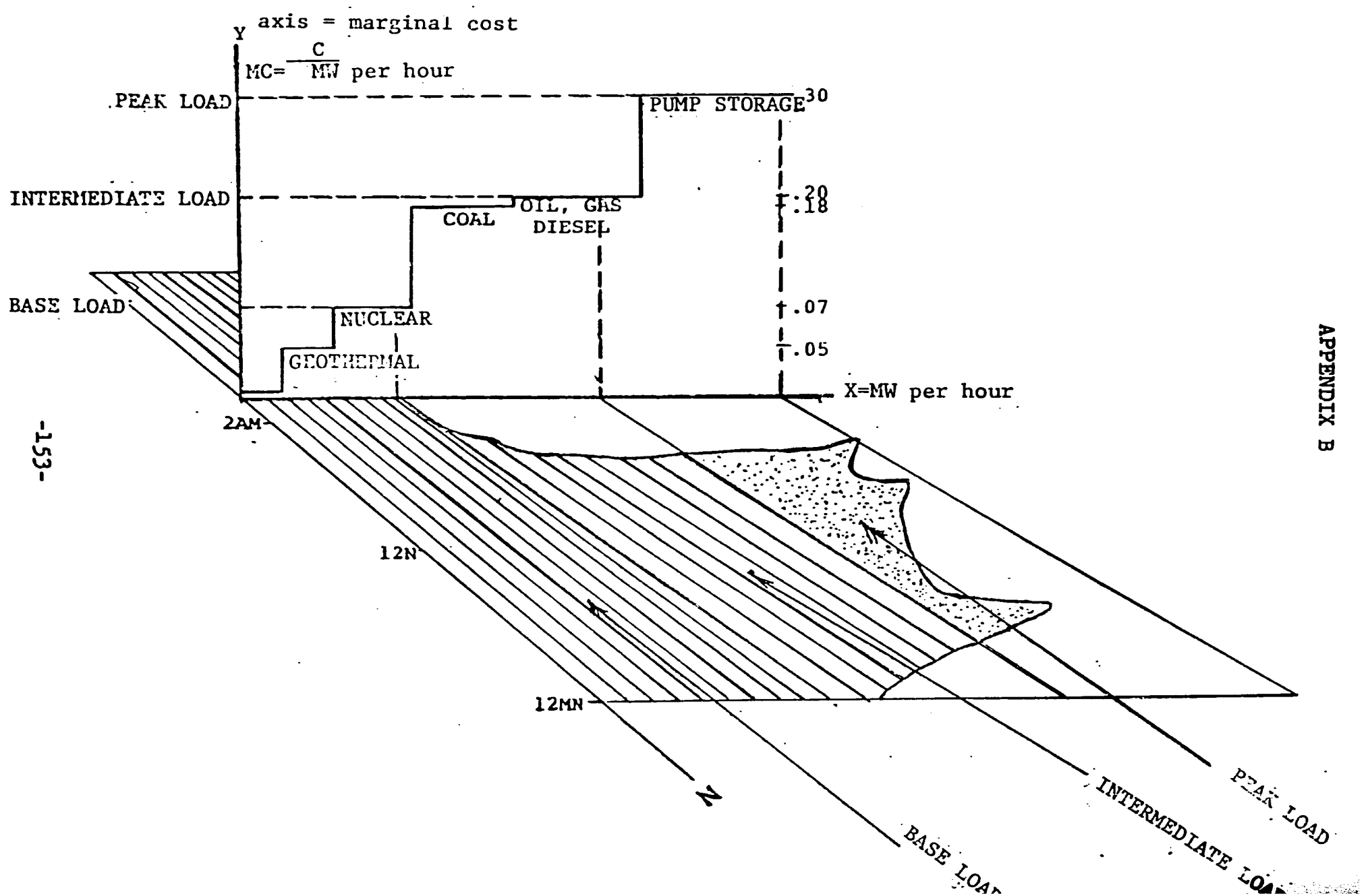
GEOTHERMAL
R O R HYDRO
0 2 4 6 8 10 12 14 16 18 20 22 24 Hrs.


axis = marginal cost
Y
MC= C/MW per hour
PEAK LOAD
INTERMEDIATE LOAD
BASE LOAD
PUMP STORAGE
30
.20
.18
.07
.05
COAL
OIL, GAS
DIESEL
NUCLEAR
GEOTHERMAL
X=MW per hour
2AM
12N
12MN
N
BASE LOAD
INTERMEDIATE LOAD
PEAK LOAD

REFERENCES

1. Carlo M. Cippola, The Economic History of World Population. (Baltimore, Maryland: Penguin Books, 1972) p. 35.

2. National Academy of Science, Energy for Rural Development: Renewable Resources and Alternative Technologies for Developing Countries. (Washington, D.C.: National Research Council, 1976) p.1.

3. Statistical Regression Analysis of Energy Consumption, cf. Ten Year Energy Plan (1979 - 88), Ministry of Energy, 1979.

4. Barbara Ward, Human Settlements: Crisis and Opportunity, Ottawa, Canada, 1974.

Energy Consumption Aspects and the Rural Sector
Sri Lanka

D.G. Senadhipathy

Introduction

Sri Lanka is an Island located in the Indian Ocean between 5°59' 9°50' North Latitudes and between 79°42' and 81°52' East Longitudes. The country has an area of 65,000 sq.kms.

The topography of the country comprises of a mountainous area in the South Central part rising in elevation to 2400m. surrounded by a coastal plain which is narrow in the West but broadens out to a vast tract in the North and the East. The rainfall is unevenly distributed over the Island. The Monsoon rains occur in two periods. The South West monsoon is from March to September and the North East monsoon is from October to January. The annual rainfall varies from 500 cms. in the South West wet zone to less than 150 cms. in the dry zone, located in the North-East and South-East. The relative humidity varies generally from about 70% during the day to about 90-95% at night. There is appreciable sunlight throughout the year with an average solar insolation of 5Kwh per sq. metre per day. The annual rainfall over the entire area of the Island is estimated at 132,000 million cubic metres.

The Economy of the Country

The population of Sri Lanka is about 14.5 million (mid 1979) growing at the rate of 1.7 per cent per annum. Nearly 80 per cent of the population lives in the rural areas where the main economic activity is agriculture.

The per capita GNP in 1978 was Rs.917 at constant (1959) prices or Rs.2548 at current prices. The rate of growth of GNP at constant prices had been about 3.5 per cent per annum during 1971 to 1976. In 1977 the real GNP increased by 4.4 per cent, and in 1978 by 8.2 per cent. The sectoral composition of the GNP in 1977 and 1978 at constant (1959) Factor Cost Prices and the growth rates for each sector are shown in Table 1.

Sri Lanka is largely dependent on the export of tea, rubber and coconuts for its foreign exchange earnings. In 1978 the earnings from the three major exports viz: tea, rubber and coconut products amounted to Rs.9,394 million making up 71% of all exports. Industrial exports made up only 15% of total exports in terms of value. The same year, 38 per cent of the import bill was on consumer goods, 39 per cent on intermediate goods (Petroleum 16 per cent), and 23 per cent on investment goods.

*Secretary & Commercial Manager, Ceylon Electricity Board

Table 1

GNP at Constant (1959) Factor Cost Prices and Growth

	Value		Percentage Share		Rate of Growth
	1977	1978	1977	1978	
1. Agriculture, Forestry Hunting & Fishing	3,828	3,990	31.8	30.7	4.2
2. Mining & Quarrying	311	411	2.6	3.2	32.2
3. Manufacturing	1,505	1,632	12.5	12.6	8.4
4. Construction	480	619	3.9	3.8	31.0
5. Eletricity, Gas, Water & Sanitary Services	102	123	0.8	0.9	20.6
6. Transport, Storage & Communication	1,198	1,285	10.0	9.9	7.3
7. Wholesale & Retail Trade	1,623	1,780	13.5	13.7	9.7
8. Banking, Insurance & Retail Trade	229	263	1.9	2.0	14.8
9. Ownership of Dwellings	360	274	3.0	2.1	-24.0
10. Public Administration & Defense	702	760	4.9	4.8	8.1
11. Services	1,703	1,797	14.2	13.8	5.5
12. GDP	12,042	13,043	-	-	8.3
13. Net Factor Income from Abroad	-25	-41	-0.2	-0.3	64.0
14. GNP	12,016	13,002	100.0	100.0	3.2

(Source: Central Bank of Ceylon, Annual Reports)

Consumption of Energy Recent & Projected

The principal sources of energy in Sri Lanka are oil, hydro-electricity and firewood. Reliable data is not available for firewood consumption although various estimates have been made indicating that nearly two-thirds of the total energy consumption is being met by firewood. Minimal quantities of coal is also used. The consumption of energy on the basis of supply sources for the period 1950-1975 and estimated forecast for the future are given subsequently.

The total energy consumption for the year 1977 was about 10,000 Gwh (electricity replacement). The breakup of this value is as follows:

1200 Gwh from hydro electricity
2800 Gwh from oil products
6000 Gwh was produced by traditional fuels such as firewood, and agricultural residues.

The per capital annual energy consumption in 1977 was as follows:

85 kWH (Electrical)
200 kWH (Commercial - inclusive of petroleum products & electrical)
715 kWH (Total - inclusive of petroleum products, electrical & firewood).

The consumption of commercial energy (excludes firewood) in the different sectors of the economy was very nearly as follows: (The latest figures available were for the year 1975).

Domestic Sector	20%
Industries Sector	33%
Transport Sector	40%
Other	7%

Before the oil crisis, the expenditure on oil imports was about Rs.80 to Rs.100 million per year which was about 5 to 6% of the total export earnings of the country. At the present time the expenditure has gone up to Rs.3000 million per year representing about 22% of the total export earnings.

Table 2

Energy Consumption in Sri Lanka 1950-75 in Primary Units

Year	Electricity (hydro-electric) in Gwh.	Oil Products in '000 tonnes	Coal & Coal products in '000 tonnes
1950	46.0	206.0	293.0
1960	257.7	535.0	256.3
1965	309.7	620.1	136.7
1970	624.9	893.0	25.0
1971	703.6	852.0	15.5
1972	732.2	924.0	12.0
1973	627.8	963.4	10.0
1974	880.7	764.6	10.0
1975	865.8	731.2	10.0

Table 3

Energy Consumption in Sri Lanka 1950-75 In Common Units of Measurement i.e. Gwh.e.r.

Year	Electricity (hydro-electric) in Gwh.e.r.	Consumption of oil Producers in Gwh. e.r.	Coal & Its Products in Gwh.e.r.	Total Commercial Energy Consumption in Gwh.e.r
1959	46.0	618.0	549.4	1213.4
1960	257.7	1605.0	480.6	2343.3
1965	309.7	1860.3	256.3	2426.3
1970	624.9	2679.0	46.9	3350.8
1971	703.6	2556.0	29.1	3288.7
1972	732.2	2772.0	22.5	3526.7
1973	627.8	2890.2	18.8	3536.8
1974	880.7	2283.8	18.8	3193.3
1975	965.8	2193.6	18.8	3178.2

This table is built up from Table 2. Conversion factors are:

(a) '000 tonnes of oil products = 3 Gwh
(b) '000 tonnes of coal products = 1.875
(c) 1 Gwh. = 10^6 kWH.

The relative share of different fuels in the total commercial energy consumption in percentages is given in Table 4.

Table 4

Year	Percentage Share of Electricity (Hydrel)	Oil Products	Coal
1950	3.8	50.9	45
1960	11.0	68.5	20
1965	12.8	76.6	10
1970	18.6	80.0	*
1975	30.4	69.0	*

*Figure unavailable

If the energy consumed in different forms is brought down to a common unit it is found that in the year 1977, the total energy requirements of 10 TWH were met by petroleum products 28%, hydroelectricity 12%, and firewood and other fuels 60%.

Table 5 below shows the electrical energy consumption pattern expected over the period 1979 to 1983.

Table 5

Electrical Energy Consumption and Requirements In Gwh Expected for the Period 1979-1983

Class of Consumption	1979	1980	1981	1982	1983
Domestic	116	124	133	142	153
Industrial	715	812	209	1018	1143
Other	490	539	596	677	757
Total Consumer Demand	1321	1475	1638	1837	2053
Total Demand on Generation Gwh.	1508	1685	1866	2089	2319
Total Demand on Generation MW.	307	338	367	411	456

In arriving at the above forecasts the requirements of large industries schedule up to 1980 have been taken into consideration individually and for the existing industries and increase in consumption over 1976 consumption has been applied and account for working at increased capacity. Consumption of the new large industries schedule for after 1980 has been assumed to increase at the rate of 15% from 1981 to 1984. The rates of growth adopted for the

other significant consumption sections over the period 1979-84 are: Domestic sector 7.07, Small & Medium industries sector 7.57%, commercial sector 8.0% and bulk supply sector 6.0%.

For the longer term demand prediction, regression analysis using GNP growth rate of the different sectors of the economy have to be used. Based on this the total demand on energy generation until 1980 are predicted and given below. The GDP growth rates assumed are, Manufacturing & Mining 8.1%, Agriculture 1.9%, Transport and other sectors 5.5%. A population growth rate of 2.0% per annum also has been assumed.

	1985	1986	1987	1988	1989	1990
Total Consumption (Gwh)	2431.4	2696.1	2989.3	3314.8	3679.5	4092.0
Generation Demand (Gwh)	2796.1	3100.5	3437.7	3812.0	4231.4	4706.0

Crude oil processed by the Ceylon Petroleum Corporation oil refinery for domestic use and exports, in Million Metric tonnes is given in Table 6 below:

Table 6

Year	1971	1972	1973	1974	1975	1976	1977
Quantity	1.54	1.78	1.77	1.52	1.47	1.47	1.50

Consumption of different oil products in Sri Lanka (inland sales in '000 tonnes) are given in Table 7 below:

Table 7

Year	Motor Gazolene	Kerosene Diesel	Auto Diesel	Heavy Oil	Furnace Oil	LPO
1971	137	269	250	85	111	0.1
1972	132	278	264	71	179	0.0
1973	130	270	261	68	235	0.2
1974	95	213	244	44	169	0.5
1975	95	211	264	36	144	1.0
1976	101	207	258	33	126	2.0

The predicted estimate of consumption of oil products is as follows:

Table

Estimate of Consumption of Oil Products

Product	Consumption in 1976 in '000 tonnes	Likely rise in growth of consumption per annum	Consumption in 1982
Gasolene	101.4	4%	128.3
Kerosene	206.7	7%	310.0
Auto-diesel	257.6	10.2%	361.4
Heavy diesel	33.0	-	50.0
Furnace Oil	126.2	6%	210.0
Total:	724.2	8.2%	1168.7

A very tentative forecost of oil demand obtained after discusstion with the Ceylon Petroleum Corporation is as follows:

Forecast of Oil Demand
(In Thousand Metric tonnes)

Year	1985	1990	2000
Total Oil Demand	1682	2241	2550

Firewood

The area under Forest cover in Sri Lanka is roughly 0.6 million hectares (1.4 million acres) under proclaimed forests, a similar area of proposed reservations and about 2 million hectares (4.4 million acres) under crown forests. A major portion of firewood is supplied by the rubber plantations which become available due to the replanting of rubber cultivation under a Government Subsidy Scheme. Substantial amounts of firewood are also supplied in the form of wood-wastes from saw mills, paddy husks and from wastes available from coconut plantations and tea plantations.

Firewood plays a very important role in the domestic fuel economy of Sri Lanka. The firewood that could be extracted annually from the proclaimed forests, crown forests and other reservations without damage to the ecology has been estimated to be less than 0.1 million tonnes. Residuals from saw mills and wastes from coconut cultivations account for about 0.5 million tonees annually. About 1.0 million tonnes of firewood is estimated to be available due to replanting of rubber trees. The present demand is estimated at 4.0 million tonnes annually of which about 2.4 million tonnes come from home gardens, forests and waste lands.

At present, large extents of forest are being cleared for agriculture and village settlement schemes under Mahaweli and other Multipurpose Projects making available large stocks of firewood, but its impact on the supply of firewood to cities is not felt due to transport difficulties. Burning down of forest cover to enrich the soil by the chena (slash and burn) cultivation also lead to the depletion of this resource. The irregular and irrational exploitation of forests for firewood and timber could eventually cause irreparable damage to the environment and seriously inhibit the development of this energy resource.

No reliable statistics of the current consumption levels of fuelwood in Sri Lanka are available. The State Timber Corporation and the Forest Department supply only a very fraction of what is consumed on a national scale. The forest fuel extracted between 1970 and 1975 were as follows:

1960 -- 2.101 million cu.ft.
1965 -- 8.887 million cu.ft.
1970 -- 3.119 million cu.ft.
1975 -- 2.463 million cu.ft.

The above figures exclude other sources of fuelwood such as saw mill waste, coconut tree waste, rubber wood, village garden waste etc.

Figures of estimates of fuelwood consumption in Sri Lanka published in the Pre-investment Survey of Forest Industries (Final Report) F.A.)., 1969 are given below:

Year	Estimated consumption of fuelwood per head per year	Estimated Total Consumption
1952	15.5 cu.ft.	125.2 million cu.ft.
1958	15.0 cu.ft.	140.7 million cu.ft.
1963	11.6 cu.ft.	124.5 million cu.ft.

The pattern of demand of firewood in the future cannot be predicted but can be influenced by such steps as restriction on felling of trees, clearing of jungle areas, introduction of more efficient firewood cookers etc.

Proposals for Meeting the Energy Demand

Oil Products - If the present proposals for both on-shore and off-shore exploration for oil in the North and North Eastern Shores of Sri Lanka are successful then Sri Lanka may not have to import her requirements of oil. Otherwise the entire requirement would have to be imported. Priority is given to the exploration for oil in the North and Eastern parts of Sri Lanka.

Electricity - It is proposed to meet the demand for electicity mainly from the hydro resources except for initial requirements of thermal generation in 1980/81 for the next 15 years or so, the

existing hydro potential which is between 1500 and 2000 MW would suffice, after which sources of energy other than hydro would have to be resorted to. In this connection, a tentative electrical energy balance chart is shown in Annex 1. In the development of Hydro resources, the accelerated development of the Mahaweli River is given top priority, a description of which is given below.

Mahaweli Development Project - It is an irrigation power development project aimed at diverting the waters of the Mahaweli river to the dry zone in the north. The project area covers 31% of the whole Island, and 55% of the dry zone. It includes the Mahaweli Ganga Basin, the Basins of the Maduru Oya and Rivers in the North Central part of the Island. The Mahaweli Development scheme when completed envisions among other things, the provision of irrigation waters for 654,000 acres of new land and assured supply of water for 246,000 acres of land already under cultivation, and the settled of the unemployed population in agricultural pursuits in the newly irrigated areas. The estimated power and energy from the Mahaweli river and its tributaries are as follows and account for more than 70% of the total hydro-power yet available for development in the country.

Estimated Power and Energy From the Mahaweli Ganga and Tributaries

(The estimates are subject to revision after detailed study.)

Power Plants	Installed Power (MW)	Annual Energy (Gwh)
Mahaweli Ganga (Main River) (10 Power Plants)	685.0	1680.0
Kotmale Oya (6 Power Plants)	327.2	710.1
Amban Ganga (5 Power Plants)	157.3	576.3
Uma Oya (9 Power Plants)	126.6	477.9
Badulu Oya and Loggal Oya (6 Power Plants)	48.5	147.6
Other Tributaries (5 Power Plants)	42.6	139.9
Total:	1387.2	3741.8

The power from the Mahaweli would be fed into the National Grid and would go a long way in the development of the Urban and Rural areas of Sri Lanka. It is expected to provide employment for about a million people and enable achievement of self-sufficiency in agricultural products. The Mahaweli Development Scheme is estmated to cost Rs.15,000 Million (U.S. $1,000 Million).

The accelerated Mahaweli Development Program - Now under way envisages the construction and commissioning of the following hydro-power projects:

	MW	Gwh/Annual	Expected Commissioning date
Victoria (Stage I)	216	686	1984/85
Randenigala/Rantambe	146	600	1986/87
Kotmale	225	376	1983/84
Maduru Oya	08	25	1982

The remaining hydro-power resources would be harnessed during the period 1988-94.

Non-Conventional Source of Energy

In Sri Lanka to meet the future energy requirements for the next 15 years or so, the most obvious course is to develop its hydro resources. However, it takes approximately 6 years to get a hydro power plant investigated, erected and commissioned. If the demand continues to grow at the present growth rate of 11-12% the hydro-power potential would be exhausted in about 15 years, and since Sri Lanka has no other known fuel sources it is essential that the available sources be conserved so that it could be available for the future. Also oil based products and nuclear fuels in the future would be more and more scarce. It is clear that the search for other sources of energy such as solar, wind, sea-thermal, bio-gas becomes imperative in preference to fossil fuel fired and nuclear power stations. Conservation of available energy as well as more effective use of available energy becomes a matter of paramount importance.

In the Search for Non-Conventional Sources of Energy

The UNEP in association with the Ceylon Electricity Board has started a pilot project to use wind, solar and bio-gas energy at a village called Pattiyapola in the South of Sri Lanka. Under this pilot project wind energy, solar and bio-gas are utilized in an integrated manner. A 3000 cu.ft. capacity bio-plant using wet cattle dung is used to run a 50HP gas engine directly coupled onto a 37KW 400 V 3Ø 50c/s AC generator. Four wind mills of 2 KW each will generate electricity at 125-150 V DC and would be used to charge a bank of storage cells. The solar thermal unit will generate 7.5 KW of energy through a Rankine Engine coupled to a 7.5 KW AC 3 phase 408 V 50 c/s generator and will be used to charge the storage cells. The energy stored in the batteries would be inverted and fed into distribution lines to meet the day demand and off-peak demand which is only a fraction of the peak-demand of the village.

The Industrial Development Board of Sri Lanka has developed a closed hearth fire-place in place of the normal open hearth fire-place so common in Sri Lanka with a view to reducing the consumption of firewood for cooking. This hearth could also be modified to use paddy husk or coconut husk as fuel which is thrown away at present.

The National Engineering Research and Development Centre of Sri Lanka is in the process of developing a solar cooker with an insulating material with coconut husk as the base which need not be exposed to direct sun-light but would act as a black-box tapping incoming infra-rays and not allowing it to go out, but generating sufficient heat to cook ingredients such as rice and curry in about half an hour on a cloudless day.

NERD also intends to build a small sea-thermal plant with foreign collaboration as a pilot project at Trincommale in the East Coast of Sri Lanka, feasibility studies on which are to begin this year.

Nearly 30-40 years back most of the tea and rubber factories in the Central hills in Sri Lanka had mini-hydro plants varying from 30HP - 100HP, using water running down the perennial streams and rivulets. But with the advent of the transmission grid most of these factories took to main grid supply. The Ceylon Electricity Board has felt that, in view of the high costs of energy both thermal as well as hydro, for purposes of conservation it would be essential to revitalize the concept of mini-hydro schemes. With this in view the Ceylon Electricity Board is investigating suitable sites specially in irrigation systems to establish mini-hydro units that could fuel a particular area without being connected onto the main grid.

In the use of firewood for cooking the Forest Department as well as the Water Resources Board of the Sri Lanka Government has drawn the attention to the suburban and the rural folks to the importance of planting of fuel trees in their home gardens, trees that would growt quickly in about 5-6 years and could be replanted as a continuing source of fuel. A plan called Ipil-Ipil is now being introduced to home gardens in Sri Lanka.

Energy and Development of the Rural Sector

The increased availability of energy is an important factor in any effort to improve the well being of the rural masses. While manual and animal labor is likely to remain a significant component, other forms of energy are needed to avoid drudgery, increase productivity and improve the quality of life. The benefits from the improved energy supplies are often difficult to measure in strictly economic terms but there is generally large social benefits associated with such development as provision of adequate lighting facilities, improved water supply, etc. With this in view the Government of Sri Lanka through the Ceylon Electricity Board has launched on an ambitious village electrification program which is to be initially financed through the Asian Development Bank. Also the Government has launched on District integrated Rural Development Projects with the help of foreign collaboration at the District

Ministry levels.

Rural Electrification

Over 75% of Sri Lanka's local population lives in its villages; of the 24,900 odd villages in the country, about 8% has so far been electrified and roughly 5% of the total rural population has received electricity. On the current program about 250 villages a year are being electrifed on funds provided by the Government through the decentralized budget. In order to accelerate the pace of rural electrificiation the Asian Development Bank assistance has been sought, a project report has already been prepared by Messrs. Tate Consulting Engineers of Bombay and an Appraisal Team from the Asian Development Bank has already had discussions with the Ceylon Electricity Board and loan negotiations are to begin almost immediately for the foreign component of expenditure on the accelerated Rural Electrification program, which will enable the Ceylon Electricity Board to electrify over 500 villages a year during a four year period from 1981. The cost of the A.D.B. loan being U.S. $.21 Million. The intention is to continue and increase the present pace of rural electrification to enable the rural folk to enjoy this facility, for which a special Rural Electrification Division is to be created in the Ceylon Electricity Board.

It is correct that the capital expenditure on rural electification where the national grid has to be extended is heavy and the return money-wise minimal, but to maximize on the return it is of paramount importance that the electricity in the rural areas be channeled for productive usages, such as pump irrigation from ground water resources, agro-base industries involving tea, rubber, coconut, paddy and sugar cane, ice plants for fisheries, saw mills, brick and tile manufacturers, and other small scale village industries, such as manufacture of textiles, coir-ropes, furniture and traditional handicrafts and the success of the electrification program will to a large extent depend on the promotional measures to be taken to ensure that the rural sector uses the energy not only for lighting, but also for productive purposes generating employment in the rural sector. A special load promotion unit is to be set up in the Ceylon Electricity Board for this purpose, which is collaboration with other Government Agencies would provide incentives to the rural folk to set up Cottage Industries by giving them financial help and technical know-how, etc. At the moment, lighting in the homes which do not have electricity is by means of bottle lamps using kerosene which is sold at a subsidied price after refining the crude oil that has to be imported. With electrification, there would be a reduction in this subsidy, as well as a reduction on the drain on foreign exchange by lesser use of kerosene on a national basis. The impact of electricity on the social conditions in the villages has, however, been considerable.

Social Impact in the Rural Sector Due to Electrification

Rural electrification will make practical the holding of evening classes in vocational, technical and allied subjects. It will also promote adult education.

Work at Cottage Crafts particularly of the women folk tends to shift and not necessarily be tied up to day light hours, leading to longer hours of activities in the households and closer interaction between parents and children.

Community life in the village is centered around the Community Centres and other local associations and the lighting of these centres, with provision of television facilities, will contribute a lot for the betterment of the cultural activities of the people and promote their education and knowledge in farming and other activities.

The village temple in Sri Lanka has been the centre of religious life and social activity and would probably be the first place to be electrified in a village. This will contribute to a large extent to enhance the social and religious activities of the people, as the temples would be open for more hours of activity in the late evenings after work.

Electricity will also enhance the quality of medical facilities and services in the village dispensaries and the rural hospitals and social benefits of hospital electrification is manifold.

Provision of urban life amenities and entertainment in the rural sector of which electricity can be an important agent may make villages more attractive to the educated youths and curb population migration from the village to the city.

Electricity creates rural industries and agro based industries in the village level thus creating and generating employment for the educated youths who are not likely to be content with traditional agricultural pursuits and practices.

However it has to be mentioned that one has to ensure that household electrification be not restricted only to the rich, as in such case it would be considered as a "Status Symbol" and create disparity in the village and adverse social effects. The poorer households who are not in a position to bear the initial cost of house wiring and service connections would have to be given financial assistance by way of loans which could be recovered in long and easy installments.

District Integrated Development Projects

It is generally recognized that the provision of energy whether electrical or otherwise can create conditions for growth of industries and commerce and bring about significant changes in agriculture, industry and way of life of the people. Plans and policies of the Government in respect to Cottage Industries, Agricultural Development, Fisheries, Forestry,

Rural Financing, etc. has to be coordinated along with the energy input to obtain maximum results and to obtain integrated development. For this purpose the work in the Rural Sector of the various Government departments, such as Irrigation, Agriculture, Highways, Industries, Fisheries, Banking and Rural Credit, etc., has to be coordinated and an integrated plan of action drawn for a particular area or district. For coordination of the various activities "steering committees" for each area or district has been appointed under the auspices of the Ministryof Plan Implementation and so far three integrated rural development District Projects are under way with foreign collaboration, vis:

District	Funding Agency	Total Cost
1. Kurunegala	World Bank	Rs. 365 million
2. Matara	Swedish International Development Agency	Rs. 14 million for 1979
3. Hambantota	Norwegian International Development Agency	Rs. 2.3 million for 1979

The objectives of the District Integrated Development Projects are to raise the standard of living, reduce unemployment, and increase the potential of the district by making maximum use of the resources of the area. The three District Projects are to be test cases for future programs and their success is dependent to a large extent on the input of energy, especially electricity.

It has also to be mentioned that in the integrated development programs the participation of the people in the activities of construction are actively sought, e.g. when electricity lines are laid to give supply to the villages in a district, the clearance of the way-leaves and sometimes the digging of pits for planting line supports are done on a "Shramadana" (voluntary) basis by the people of the village, who do not request compensation payment for the trees cut nor wages for the work done, as they feel that with the extra money saved an extra length of line could be constructed to cover the particular village.

International and Regional Cooperation

On the aspects of the regional cooperation in the use of energy in the rural sector for the betterment of the living conditions of the rural masses the following points are submitted for consideration:

Formal and Informal Exchanges at meetings and publication and circulation of available information in the form of news letters under the auspices of the Bureau, of the activities of various Government and other Agencies actively involved in the use of energy on rural development.

Exchange of information on research conducted on the use of non-conventional sources of energy such as wind, solar, bio-gas, and organic recycling to provide an alternative to chemical fertilizers, should be made available to the regional countries so that duplication of research could be avoided and minimum cost models could be achieved.

Assistance be given both financial as well as by way of expertise in the development of hydro resources macro as well as mini in the case of countries which still possess substantial hydro-electric resources.

In the sphere of rural electrification financial assistance be given for the purchase of non-indigenous construction material and information be exchanged on construction techniques that would minimize construction costs using local materials and labor.

Training facilities be made available for young people in the countries of the region who are embarking on ambitious rural development programs on the practices already followed by the other countries in the effective use of energy both conventional and non-conventional.

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References

1. Annual Reports of the Central Bank of Sri Lanka.

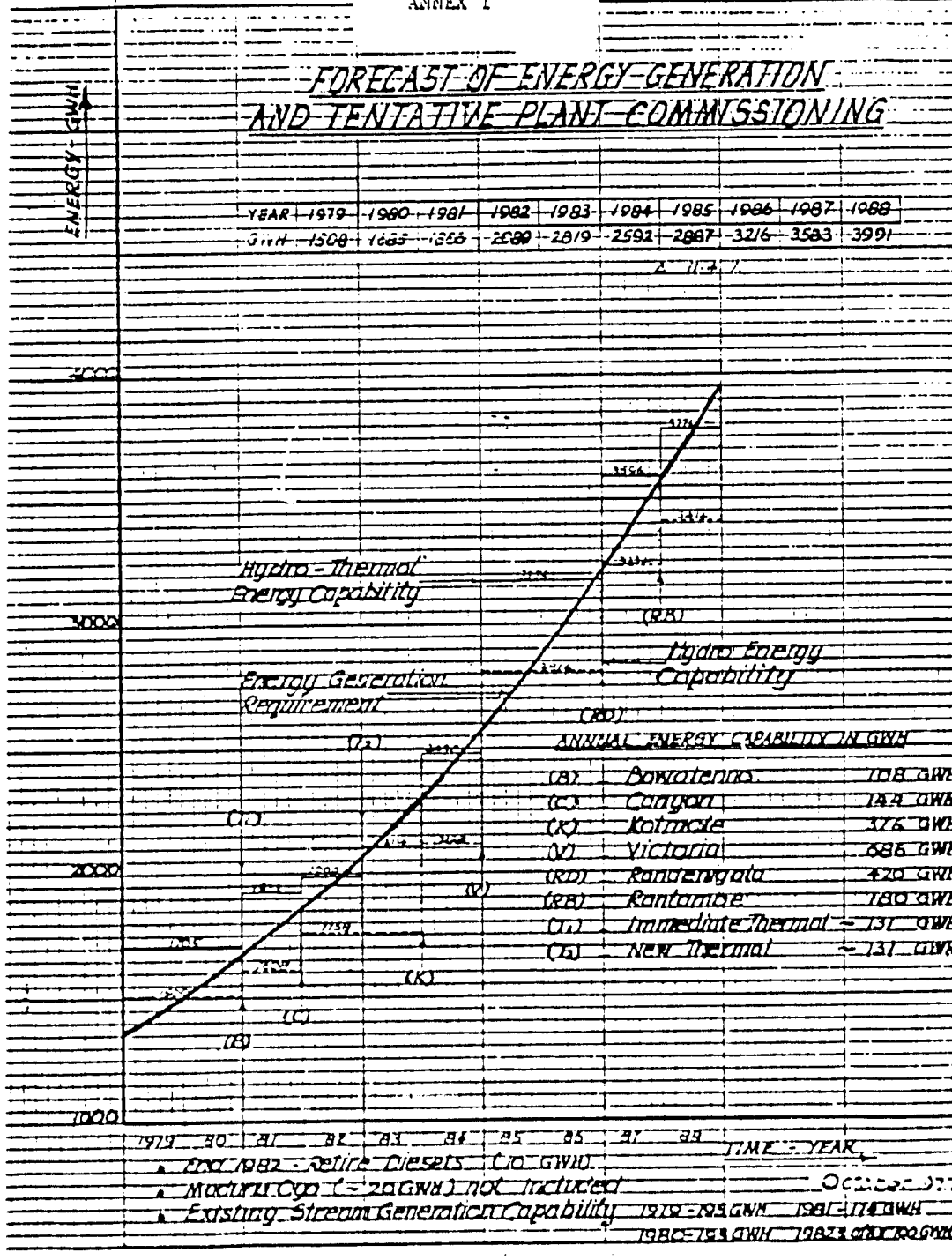
2. Towards and Energy Policy in Sri Lanka, T.B. Shanker & G.B.A. Fernandos.

3. Energy Requirements and Plans in Sri Lanka, Prof. K.K.Y. Perera & G.B.A. Fernandos.

ANNEX 1

FORECAST OF ENERGY GENERATION AND TENTATIVE PLANT COMMISSIONING

YEAR	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
GWH	1508	1685	1856	2089	2819	2592	2887	3216	3583	3991



ANNUAL ENERGY CAPABILITY IN GWH

(B)	Bowatenna	108 GWH
(C)	Canyon	144 GWH
(K)	Kotmale	376 GWH
(V)	Victoria	686 GWH
(RD)	Randenigala	420 GWH
(RB)	Rantambe	180 GWH
(Ts)	Immediate Thermal	~ 131 GWH
(Tc)	New Thermal	~ 131 GWH

Role of Forestry in Pakistan's Rural Development

G. M. Khattak*

The means of livelihood of the rural population of Pakistan are determined largely by the physical conditions of their habitat. The farmer of the irrigated plains lives mainly on crop agriculture. In the moist mountain and foothill and plateau lands, crop agriculture and animal husbandry are both important and the relative contribution of each to the family income is generally determined by topography. The inhabitant of the arid and semi-arid zone subsists largely on livestock. The potential for the contribution of forestry to Pakistan's rural development will therefore be discussed separately for each of these three zones.

The Irrigated Plains

The total cropped area on irrigated lands is about 13.35 million ha (33 million acres) growing mainly wheat, rice, cotton and sugarcane. Pakistan's development heavily depends on the productivity of its irrigated lands. Forestry can help in increasing this productivity by better management of the watersheds and through encouraging tree planting on farmlands. Since watershed management is implemented on moist mountain lands and can be a potent instrument of their development, this subject will be discussed while considering the contribution which forestry can make in the development of moist mountains.

Traditionally, the Pakistani plains farmer has always been fond of growing trees. He allows them to grow for shade, timber, and because they look nice. In recent years, even the progressive farmer is becoming interested in growing trees on his farm, due to several reasons: high prices of wood, demand of match factories based on fast growing hybrid poplars, paucity of reliable labour for agricultural operations when required, possibility of heavy crop losses caused by insects and diseases and vagaries of weather, and the realization of the ameliorative effect of trees on environment.

So far it has not been possible to make full use of this newly created interest. The Forest Departments maintain nurseries for supply of planting stock to the farmers and launch tree planting campaigns during the spring and summer rains. But their main responsibility is the protection and management of State-owned forests and they can devote only that time, energy, and money to tree planting on farmlands which is left over after the requirements of State-owned forests are met. And this is very little.

Needed is a separate Forest Extension Wing in the Forest Departments of Punjab and Sind, adequately financed, and staffed by foresters trained in the science and art of motivating the rural communities for tree growing on irrigated farmlands.

*Director General, Pakistan Forestry Institute

A very important reason for launching a massive programme of planting of suitable trees at appropriate sites on farmlands is to increase the production of fuelwood. Fuelwood is the major source of energy for cooking and heating in rural areas. But it is so expensive and so difficult to obtain that most farmers use animal dung and agricultural residues for these purposes. Instead of being burnt, both these should be incorporated in the soil to increase its productivity.

The Moist Mountain, Foothill and Plateau Lands

Though precipitation is generally adequate in this zone to sustain dry-farming, the area under crop agriculture is limited by topography. Livestock husbandry and other avenues of employment must therefore supplement the income of the family from agriculture. Forestry has a major role in the development of this tract: Most mountain lands are steep and cannot support stable crop farming. The correct land-use for such lands is forestry integrated with livestock husbandry and fruit or crop farming - the different uses either combined in various ways or zoned to ensure the maintenance and optimum utilization of the productive capacity of the site. In addition to maintaining the productivity of the mountain lands, such an endeavour will also reduce soil erosion thereby decreasing the rate of siltation of waterways and water storage reservoirs. Large opportunities also exist for increasing local employment in afforestation and rangeland improvement, wood-based industries, and tourism based on outdoor recreation.

Current Programmes

The major programme of rural development through forestry is being implemented under the label of watershed management. The objective of the programme is to discourage cultivation on steep mountain slopes and to encourage the planting of timber, fuelwood, fodder and fruit trees on such slopes. It also envisages voluntary reduction in the number of livestock to rangeland productivity and to reduce soil erosion. This programme is mainly concentrated in the Hazara Civil Division of the North West Frontier Province and is now being extended to other moist mountainous areas also.

Though the programme has achieved considerable success, its efficiency can be further improved if a separate Watershed Management Wing is created in the concerned Forest Departments and staffed by persons who have been trained in the integrated management of privately owned mountain lands through the motivation of their owners. The Pakistan Forest Institute has prepared a scheme which if sanctioned and implemented, will enable it to conduct research and impart education in this field.

Coniferous cover about 1.3 million ha in the moist mountains of Pakistan. Of this area, about half is sufficiently stocked to support harvesting. The main forest industry in this zone at present is timber harvesting and sawing of logs into intermediate sized to facilitate extraction. Attempts are development of mountain lands by increasing employment, training labour,

raising wages and improving communications. To conduct research and provide training in the harvesting and processign of wood, the Forest Institute is attempting to upgrade its Forest Products Research Division.

Since more intensive timber harvesting would necessitate more intensive timber management, greater attention is being paid to reducing the length of rotation, and improving the quality of planting stock and of methods of regeneration. The large scale application of these improvements would generate considerable employment in the moist mountains, at higher wages.

The only minor forest produce obtained from the mountain forests at present is resin - tapped from the chir-pine. A number of herbs occur in forest areas which are used in indigenous and even allopathic systems of medicine. Greater attention to this hitherto under-utilized resource can supplement the meagre earnings of the people living in the mountains.

The Unirrigated Arid and Semi-arid Zone

This zone occupies by far the greater part of Pakistan, comprising the whole of Baluchistan and the Northern Areas; and the unirrigated parts of Sind and Punjab, and North West Frontier, excluding the moist mountains. The average annual rainfall over the tract varies from about 10 to about 500 mm. The adverse effects of low precipitation are aggravated by its pronounced seasonality and high variability. Agriculture crop production in this zone is hazardous. But cultivation is extended even to arid tracts in years of good rainfall. In the semi-arid part, the main sources of income are dry farming, livestock husbandry and outside employment. In the arid tract, dependence is almost entirely on livestock grazed on rangelands, often in conjunction with some form of nomadism to make the maximum use of the available forage.

The natural vegetation of the arid and semi-arid zone has greatly deteriorated due to over-grazing and cutting and uprooting of woody vegetation for fuel, continued over centuries. Massive programmes of the rehabilitation of natural vegetation are needed to stop desertification and increase the supply of fuel and fodder. The task is as difficult as it is necessary. In the semi-arid zone, several useful trees, shrubs and grasses can be grown if the local people can be pursuaded to afford them protection from grazing when needed. As the arid parts are approached, even the technical aspect of the task becomes progressively more difficult.

A viable approach to the problem of rural development in the arid and semi-arid zone would be the integrated management of natural vegetation for the production of livestock and fuelwood and for maintaining the productive capacity of the site. Agriculture crop production and horticulture could also be encouraged where soil and moisture conditions are conducive. Such programmes could be started by the Forest Departments either on lands under their control or under private ownership. In both cases, a multi-disciplinary approach would be needed, requiring knowledge of plant and livestock management and of the means of enlisting the

enthusiastic participation of the local people.

The critical input for the successful implementation of such programmes is a group of knowledgeable and dedicated workers in the field of Range Management, with additional knowledge of animal production and of the techniques of motivating primitive rural communities. Initial steps in launching this programme would therefore be the creation of the capability of training such groups and of organizing separate Wings within the concerned Forest Departments for the implementation of such programmes.

Summary

About 30% of the land area of Pakistan is under crop farming, the rest is under various wild-land uses, mainly grazing. Because the greater part of the country is arid and semi-arid, only about 5% of its total area bears tree growth. Wood is scarce and so is fodder because vegetation has been cut and lopped and overgrazed for centuries. The result is wide spread soil erosion in the mountains and the uplands, and shifting sand dunes in sandy plains.

To increase the supply of wood and fodder, and to reduce soil erosion in the mountains, a massive programme of the rehabilitation of natural vegetation is needed all over the country. Such a programme will have to be implemented through the motivation of the rural masses. The most important prerequisite for launching this campaign is a group of dedicated workers fully conversant not only with the concerned physical and biological sciences but also with the techniques of motivating primitive rural communities. Immediate arrangements must therefore be made for training such workers.

III. AID Background Papers

INDIA

Energy, Environment and Forestry

Introduction

India's energy problems are daunting. This year's oil price increases, combined with a slight rise in oil import volume, are expected to raise India's import bill for oil from $2 billion in 1978 to $3.5 billion in 1979. In 1980 the import bill could be $4.5 billion, or 35 percent of all imports. The country is in the grip of a power crisis stemming largely from bottlenecks in coal production, rail transport and thermal power generation, exacerbated by shortages of hydroelectric power resulting from the severe 1979 summer drought. The power shortage may be costing India several points of GNP growth, and is contributing to this year's decline in foodgrain production. The country is also facing a longer-term ecological crisis related to the use of "non-commercial" fuels - firewood, dung , and agricultural waste. As in many other countries, firewood consumption is contributing to deforestation and land degradation, and the use of dung and agricultural wastes as furl is diverting large quantities of material from higher-value uses as fertilizer and compost.

India's population is now 650 million and is expected to increase to perhaps 970 million by the year 2000. Per capita GNP is $150. By the definitions used by the Government of India (GOI), 25 to 45 percent of the population is now below the poverty line (and by AID's definition, perhaps 80 percent). Any possibility of eliminating poverty by the year 2000 will depend on tripling or quadrupling the consumption of "commercial" energy (oil and gas, coal, electricity), increasing or at least maintaining the level of non-commercial energy consumption, and supplementing both with "non-conventional" energy sources (direct solar, biomass conversion, wind, etc.).

This paper briefly discusses energy needs and alternatives related to poverty reduction in rural India. The first section provides an overview of current and projected aggregate energy demand, and possible sources of supply, while the second section discusses rural energy needs and supply options specifically. The third section reviews some of the constraints India will have to overcome in meeting the energy challenge, particularly for rural areas, and discusses relevant GOI policies and programs. The concluding section suggests some ways in which the Agency for International Development might assist. For the purposes of this paper, environmental issues and forestry are treated only in relation to the "firewood crisis"; broader environmental questions and non-fuel objectives of forestry are largely ignored.

Energy Overview

The energy situation in India is characterized by a gradual decline in the relative importance of non-commercial energy, rapid growth in the use of commercial energy (particularly oil and electricity), low consumption of commercial energy by the agricultural sector, and high intensity of energy use per unit of GNP. Measured in terms of coal replacement, the unit generally used in India to provide comparability among energy sources, non-commercial energy has declined from 60 percent of the total in 1960 to about 40 percent at present. The consumption of firewood, dung and vegetable waste has however continued to increase in absolute terms, from an estimated 159 million tons (in original units) in 1953-54 to 277 million ton in 1975-76 (including 133 million tons of firewood, 73 million tons of dung and 41 million tons of vegetable waste) 1/. These non-commercial fuels are used primarily for cooking and heating in both rural and urban areas, and consumption has roughly kept pace with population growth. By contrast, the annual growth rate of commercial energy consumption over the period 1950-54 to 1975-76 was 6.8 percent or nearly twice the annual GDP growth rate of 3.7 percent. Electricity consumption has grown most rapidly, (10.3 percent), followed by 7.4 percent for oil products and 4.2 percent for coal. Agricultural use of commercial energy has been growing rapidly, but industry and transport still account for about three-fourths of consumption. As of 1975-76, commercial energy consumption by fuel and by sector was as follows (in million tons of coal replacement) 2/:

There have been a number of efforts to project future demand for commercial and non-commercial energy consumption in India. Offical projections through 1990-91 were published by the Government of India (GOI) Fuel Policy Committee, which issued its final report in 1974 after the first round of oil price increases. For non-commercial energy, the projections indicate a sharp decline in relative importance to under 20 percent of total consumption, although the absolute decline in consumption is minimal. For commercial energy demand was projected to grow at about 8 percent annually, reaching over 3½ times the 1975-76 level of consumption by 1990-91 (even with some improvements in fuel efficiency). Under the most optimistic assumptions concerning fuel substitution away from oil, the Fuel Policy projections showed oil declining about one-third of overall commercial energy consumption, coal remaining at about one-fourth and electricity increasing commensurately 3/. A more recent effort to extend projections to the year 2000 indicated similar orders of magnitude of demand, with requirements growing at 5.8 percent annually for oil, 8 percent for coal, and 8.8 percent for electricity 4/. New estimates of demand to the year 2000 prepared by the GOI Working Group on Energy Policy are expected to be published shortly.

India's pattern of development seems to have been relatively energy-intensive compared with other countries at similar stages of development. Detailed comparisons and analyses do not seem to be available, but figures in the 1979 IBRD World Development Report indicate that the energy input (in kilograms of coal equivalent required per dollar of GNP is 1.6 for India, as compared with the low income country average of 1.1 and the middle income country average of 1.2 5/. This suggests that there may be substantial energy economies which can be exploited in the future, and that India might be able to achieve high GNP growth at lower energy growth rates than the various long-term projections have indicated.

With adequate investment and improved utilization of facilities India should be able to meet demand increases for coal and for electric power. India's coal reserves are estimated at 83 billion tons (as compared with present consumption of about 100 million tons annually), and less than 20 percent of the country's hydroelectric potential has been exploited thus far 6/. India also has vast reserves of thorium, but these will not have value until fast breeder reactors become a reality. Reserves of uranium and petroleum on the other hand are quite limited. Known uranium deposits may be inadequate to support any expansion of India's nuclear generation capacity. Potentially recoverable oil reserves are estimated at 1500 million tons, as compared with present production of about 13 million tons per year (260,000 barrels per day), present annual consumption of 30 million tons (600,000 b/d), and projected annual consumption exceeding 100 million tons by 1990-91.

The situation regarding noncommercial fuels is less clear-cut. Fuel accounts for about 20 percent of the uses of the estimated 200 million tons of agricultural waste available annually and for about 40 percent of the approximately 170 million tons of dry dung from India's roughly 200 million cattle. Total availability of both agricultural wastes and dung will probably remain constant or increase slightly, although it would probably be desirable to reduce the amount of each devoted to fuel. There have been

no country-wide assessments of the sustainability of current firewood consumption of over 130 million tons annually. Although there are frequent references to widespread deforestration in India, there are no comprehensive data on fuelwood collection, land clearing, timber exploitation, or on trends in time spent on fuel collection by rural households. The area under forest in India is estimated at 75 million hectares (or somewhat less than one-fourth of the total geographical area), and all but 15 million hectares is rated as "exploitable" or "potentially exploitable" 7/. If it is correct that forest plantations under Indian conditions can be expected to obtain average yields of 8 tons of firewood per hectare, then current firewood demand cound be met on somewhat over 15 million hectares, or about one-fifth of the forested area 8/.

With respect to non-conventional energy resources, there is bountiful solar radiation in India for most months of the year. However, wind speeds tend to be relatively low, limiting the prospects for harnessing large amounts of wind energy. The potential for development of geothermal energy is also limited. 9/

Energy and Rural Development

There have been several recent attempts to estimate energy use in rural India. The broad results are that agricultural production accounts for about one fourth of energy use and households for about two thirds (primarily for cooking), and that all but about 10 percent of the energy used is provided by human or animal labor and by non-commercial fuels. The best-known of these estimates, published by Revelle in 1976, involved piecing together evidence from a large number of data sources to arrive at aggregate estimates for rural energy use. However, these results have been broadly confirmed for northern India by a survey of 1500 households in 1975-76 and for an individual village in southern India in a survey carried out in 1977. For the general results from the Revelle and northern India studies, see Tables 1 and 2 10/.

The northern India study, conducted by the National Council of Applied Economic Research (NCAER) in New Delhi, also provides data on levels of energy use by income class. While energy use is not as skewed as incomes, the poorest households use less than one-fourth as much energy as the wealthiest households (0.8 versus 1.3 tons coal replacement per year). 11/.

Although these studies themselves do not provide direct information on changes in energy requirements under various rural development patterns, they do provide some indirect indications as well as a useful framework for discussion. In the northern India survey, for example (Table 2), commercial fuels account for only about 7 percent of total energy use; non-commercial fuels account for 67 percent, animal power for 9 percent, human power for 5 percent, and the energy content of fertilizer for 1 percent. In terms of uses, households account for 45 percent of the energy consumed, and of that only 2 percent comes from commercial fuels (coal and coke, kerosene, and electricity). Agriculture accounts for 26 percent, off-farm rural enterprises for 6 percent, transport for 2 percent and construction for a fraction of 1 percent. Within agriculture, about 12 percent of the energy is provided by electricity and diesel fuel (primarily for irrigation pumpsets), and somewhat under 5 percent by fertilizer. The remainder comes from

animate sources. Rural enterprises rely on commercial fuel (45 percent) as well as human labor (8 percent), while transport relies primarily on commercial fuels (about 40 percent) and animal draft power (about 55 per cent).

Energy uses could also be classified by form of end-use, rather than by sector. In the village surveyed by Reddy, for example about 79 percent of the energy is used for medium-temperature heating (kilns), 2 percent for lighting, somewhat over 1 percent for mobile power, and 1 percent for stationary power (water pumping and milling). 12/

Household Energy Use

For the purpose of discussing future rural energy demand and supply prospects, it is convenient to use the sources of demand suggested by Tables 1 and 2: household uses, agriculture, rural enterprises, and transport. For household uses, as we have seen , the most important sources of energy are non-commercial or "traditional" fuels. The NCAER survey found that only 2 percent of the households use coal or coke, and 9 percent use electricity (although fourty percent of the population in the six states surveyed live in electrified villages). By contrast, 75 percent reported using firewood at some time during the year; similarly, 74 percent reported using vegetable wates, and 81 per cent reported using dungcakes. Kerosene, however, is used by 96 percent of the households, almost exclusively for lighting. 13/

Virtually all households, in fact, apparently use commercial energy-either kerosene or electricity - for lighting. Even among the lowest-income group (household income of $120 per year of less), 99 percent use kerosene for lighting, and 2 percent use electricity. In the highest income group (household income of $1500 per year or more), 70 percent use kerosene and 45 percent use electricity. 14/ (Obviously many households use both.) Also, the highest income households consume about twice as much kerosene (about 25 instead of 11 litres per year) and seven to forty times as much electricity as the lowest - income households. 15/ This indicates that rising rural incomes would tend to be accompanied both by rapid increases in kerosene and electricity for lighting. It would be technically possible to use biogas, but it creates safety hazards in houses with thatched roofs, and suffers from other limitations discussed below. 16/ Alcohol would be another possibility, but alcohol production from biomass is not generally considered an important energy potion for India, given the scarcity of agricultural land. Electricity could be generated from solar energy, biogas, or wood, but the cost of installation and power would still prevent most rural inhabitants from using electricity for lighting, and would require continued reliance on kerosene.

For cooking, which accounts for the vast bulk of household energy use in India, the differences in consumption by income group are also substantial: the highest-income households use about three times as much energy for cooking as the lowest-income households. 17/ However, there is little evidence of a shift from non-commercial to commercial fuels as incomes increase. Consequently rising rural incomes are likely to be accompanied by a rise in average household use of firewood, vegetable waste, and dung cakes, unless there are greater efficiencies in utilization (i.e., improved stoves). Commercial energy (kerosene, electricity, bottled gas) is likely to remain too expensive, but there are major non-commercial or non-conventional alternatives; the most important of these are manmade forests, biogas, and solar cookers.

There has been a great deal of work done in India on improved stoves, although most of the effort seems to have gone into solar cookers and improved designs for stoves using commercial fuels. 18/ Solar cookers have generally not been acceptable because they require cooking during daylight hours outdoors, whereas cooking in the villages generally takes place after dark or before dawn, and is regarded as a private activity which must be done indoors. 19/ However, water sould be heated to low temperatures in simple solar water heaters, and the preheated water could then be used for boiling (e.g., rice). Reddy has estimated that this could reduce firewood consumption in the village he studied by 35 percent. 20/ Regarding improved wood stoves, cost seems to be a major problem. Traditional stoves ("chulas") are costless, or nearly so, while the cheapest models of improved stoves probably cost $5.00 However, the GOI will be testing the acceptability of improved stoves under a World Bank - supported "social forestry" project in the state of Uttar Pradesh. During the project period improved stoves estimated to be twice as efficient as traditional stoves will be installed in 1000 villages.

An alternative for household energy use which has been tested more widely than improved stoves is biogas. Biogas or "gobar gas" is the combustible gas produced by the anaerobic fermentation of cellulose containing organic materials, such as cow dung, crop residues, vegetable wastes, etc. Cow dung is the preferred raw material for bio-gas generation in India, since there is no religious or social stigma attached to its use. Digested manure or slurry, a by-product of the gasification process provides an additional benefit in how form of fertilizers rich in nitrogen.

The Khadi Village Industries Commission (KVIC) has developed units varying in output from 60 cubic feet a day (cft/day) to 100 cft/day for individual household use. 21/

The cost of such units averages $300 equivalent and can serve the cooking needs of a family of five as well as provide enough energy for two 40 watt bulbs for two hours of use a day. Some 65,000 to 70,000 units have already been installed in India. 22/

Problems associated with the individual units relate primarily to the investment and operating costs for the economically least well off village members. As a low cost energy option to be used on a wide scale, bio-gas units developed so far are too expensive for most rural families. Some 70% of the Indian population fall below a poverty line set at approximately $100 per capita year, or one-third the average investment costs of an individual unit. Also, only about 10 percent of India's rural households own the 4-5 cattle needed to provide manure to run the biogas plant. 23/

The advantage of large-scale community plants that would benefit all households irrespective of socio-economic status are recognized, and answers to questions concerning the technical, social, and economic viability of community systems are being sought through pilot projects. The main technical advantage of community size plants lies in the economies of scale possible with large-scale storage tanks. Experience gained so far, however, reflect a number of problems related to the organization and management of

community systems. Furthermore, economies of scale may be offset somewhat by diseconomies involved with high distribution costs involved in serving households scattered over wide areas. In addition, annual labor costs increase proportionately with increased generating capacity as the amount of raw material required will have to be collected further and further away from the village. 24/

The other major cooking-related energy option is to increase the supply of fuelwood, both to keep private costs down for the rural poor and to reduce the social costs of large-scale land degradation and deforestation. As noted in the overview above, there does not seem to be comprehensive data available on the environmental damage associated with current and projected levels of firewood use in India. However, the consequences of population pressure for deforestation are evident in a state such as Punjab, which has only 4 percent of its area under forest (as compared with the national average of 23 percent). 25/ There is also little agreement on trends in fire wood consumption. The Fuel Policy Committee projected a decline in fire wood consumption by 1990-91 whereas the National Commission on Agriculture projected a 50 percent increase in consumption by between the early 1970 and 1990-91 26/, the survey data cited above on incomes and fire wood consumption suggest that the latter is more likely to be correct, although much would depend on the rate of substitution of dung for fire wood. That the scope for substitution is substantial is clear from the NCAER survey: in the hill regions of northern India, which are more heavily forested then the plains, firewood accounts for two thirds of household energy use and dung cake for 5 percent; in the plains, firewood accounts for 37 percent and dung for 27 percent.

In spite of the population density in India there is apparently not a shortage of land for fuelwood production. The NCAER estimated that the land under permanent fallow owned by state of local governments in the northern region could produce 52 million tons of firewood per year if planted with fast-growing species. This compares with present consumption of 18 million tons (somewhat less than 1 ton per household) or 27 million tons in 1990-91 if consumption rose by 50 percent. 27/ (It is also interesting that the rate of consumption in norther India if projected to the rest of the country, would imply total annual firewood consumption of about 70 million tons or about one-half of other estimates)

Although land is available, and although "community forestry" or "social forestry" has had official GOI support since the 1952 National Forestry Policy statement, social forestry projects have not generally been successful. There are recent indication, however, particularly from the state of Gujarat, that social forestry projects can be successful if organized to provide adequate incentives to local communities. Under a program launched in 1969, trees have been planted along 600 kilometers (or 35 percent) of all state roads and canals and 3000 of Gujarat's 18,000 village have established community woodlots. 28/ The program is now being expanded with World Bank Support.

Energy Use in Agriculture

Energy inputs are required in agriculture for land preparation,

cultivation, fertilization, irrigation and harvesting. As noted above, commercial energy accounts for a relatively small percentage of total agricultural use at present (16 percent, including fertilizers). Commercial energy use, however, is likely to expand particularly rapidly with agricultural intensification. Revelle estimated, for example, that full irrigation development would require fuel-based energy for pumping amounting to four times the animal, diesel and electrical energy now used. He also estimated that chemical fertilizer use and draft power (including power from small tractors) would have to triple if India were to approach U.S. yields for foodgrains. 29/

The NCAER study does not speculate on future commercial energy requirements for agriculture, but the survey data clearly illustrate the energy implications of alternative agricultural development patterns. On small farms (4 hectares and below), energy use is about 50 percent higher than on large farms (8 hectares and above). However, only 7 percent of the energy is provided by fuels (primarily for irrigation) whereas on large farms (which are likely to be partially mechanized) 27 percent is provided by fuels; on the largest farms (16 hectares and above) over 75 percent is provided by fuels, and fuel use per hectare is 6 to 8 times higher than on small farms. 30/

This same contrast is brought out by data on energy inputs on farms with tube wells versus farms using tractors. The energy input per hectare on farms with tube wells is 50 percent greater than energy input on farms with tractors and no tubewell. However, the fuel energy input on the farms with tubewells accounts for less than twenty percent of the total, as compared with a fuel energy input equivalent to half of the total on farms with tractors; also irrigated farms use about half as much fuel per hectare as tractorized farms (but over twice as much human and animal energy per hectare). 31/ Fuel use for irrigation tends to complement labor and animal traction, whereas fuel use for tractor's substitute for human and animal effort.

Whatever the future role of tractor mechanization in Indian agriculture, the demand for fuel for use in mobile power units is likely to increase. As in the case of lighting, there do not seen to any obvious alternatives to the use of the standard commercial sources of energy. Biogas, alcohol, coal liquifaction or gasification, and liquid or gaseous fuel generated by pyrolysis are possible technical alternatives, but it is doubtful that they will be economic at any time in the near future. The economics of biogas as a fuel is heavily affected by the high cost of compression and storage; there do not as yet appear to be any detailed studies of the economic feasibility of substitution of biogas fuel for gasoline and diesel fuel in India, however. For the other alternative fuels, the economics of the widespread use in India should correspond to the economics of their use elsewhere, (but adjusting for the fact, that coal is probably relatively more abundant and biomass relatively less abundant in India than the developing country average).

The prospects for alternatives to conventional energy sources appear somewhat more encouraging, although very controversial. The traditional animate sources of energy for groundwater irrigation have been replaced

at an increasingly rapid rate by diesel and electric pumps. According to one estimate, about 3.3 million electric pumpsets and 2 million diesel pumpsets are now in use in India, and ground water availability would support an eventual total of 12 million. 32/ Electricity under planned rural electrification programs will be available for same percentage of these additional irrigation pumping requirements, and in general the availability of abundant coal and hydroelectric potential for central generation makes rural electrification from regional grids an attractive course for India. However, the high distribution costs of electricity will act as a constraint on the rate of expansion of rural electrification, which presently reaches about 40 percent of India's villages.

The major alternatives to electricity and diesel fuel for irrigation pumping are alternative fuels such as biogas and "producer gas" from pyrolysis, direct solar energy applications (photovoltaics or solar thermal power), small-scale hydroelectric power, and wind power. The latter is of limited relevance for India, because winds are highly seasonal and wind speeds are relatively low. 33/ The scope for small-scale hydroelectric power is also limited, partly because the regions with the greatest small-scale hydro potential (e.g. the Himalayan foot hills) can generally rely on gravity flow irrigation, and the regions which rely on groundwater irrigation (e.g. the Gangetic plains) are relatively distant from small-scale hydroelectric sources.

Regarding the other alternatives, Reddy has argued that wind power and producer gas are possibilities but that direct solar power is too costly and that the use of biogas faces problems due to the need to transport the biogas to scattered pumpsets in pipelines or cylinders. 34/ Unfortunately, he has presented no economic analysis of the various alternatives. Ramesh Bhatia has recently presented data for small farm irrigation in the state of Bihar, however, which indicate that biogas is the most economic alternative. 35/ Bhatia's analysis assumes that biogas can be used in a mixture of 80 percent gas and 20 percent diesel fuel in a dual-fuel engine, or that 100 percent biogas can be used in modified gasoline or diesel engine. He also assumes that biogas availabilities in typical villages will be enough for either irrigation or cooking but not both. The competitiveness of electricity, diesel fuel and biogas depends heavily on the cost of electrical connections (which varies by location), the assumed shadow cost of diesel fuel, and the capital costs of biogas plants (which is lower for the Chinese designs recently introduced in India). On the basis of his analysis, Bhatia concludes that biogas should be used for irrigation pumping rather than cooking, and that other fuels (e.g. coal) be promoted to meet household energy needs. He advocates further research on photovoltaics, but notes that costs would have to decline substantially before they could be competitive.

In addition to energy for on-farm motive power and for irrigation, substantial increases in energy inputs will be needed for fertilizer. Chemical fertilizers require energy both for the feedstock and for the production process. India is already experimenting with fertilizer production from coal and is putting substantial emphasis on reducing fertilizer requirements through modifications in cropping practices and expanding the utilization of organic fertilizers (including slurry from biogas digesters). Time limitations have precluded any effort to treat fertilizer requirements and alternatives in this paper, however.

Energy Use for Rural Industry and Transport

According to the NCAER survey results reported above, both rural enterprises and rural transport are fairly heavily dependent on commercial energy sources (45 percent and 40 percent, respectively), although they account for a relatively small percentage of aggregate rural energy use (6 percent and 2 percent, respectively). While appropriate projections of energy demand for rural enterprises and rural transport are not available, in response to high rates of agricultural growth, increasing market orientation, and growing interdependence both within the rural economy and between the rural and urban sectors.

In the case of rural enterprises most of the discussion of household and agricultural uses also applies to rural commercial and industrial users of energy. Kerosene is used primarily for lighting and is difficult to replace until electric lighting becomes economic for large numbers of consumers. Non-commercial fuels are used for heating, including heating for pottery-making, brick-making, etc. Coal and coke can be used for this purpose, and in fact coal and coke already account for one-fourth of total energy use by rural enterprises. 36/ Electricity is used largely for stationary power for oil extraction plants, grain mills, etc. The alternatives here correspond to the alternatives for irrigation. Since most of the establishments of this kind are likely to be in the larger and less remote villages and towns, however, conventional rural electrification is likely to be relatively more accessible for rural enterprises than for irrigation.

The problems facing rural transport are similar to those applicable to on-farm motive power. In both cases a liquid or gaseous fuel is required for powered vehicles, and in both cases animal power is still a major alternative. According to the NCAER survey human energy (bicycles) and animal energy (animals and animal carts) account for over half of the energy used for rural transport, while diesel fuel (tractors, trucks and buses) accounts for a third and coal (trains) for about an eight. 37/ There are some well known efforts under way in India to improve the efficiency of the bullock cart, although there are obvious limitations to the extent to which efficiency can be increased. 38/ Reddy has calculated that each major transport mode in the village he studied has a range within which it is the most cost effective: the wheelbarrow up to 1/3 kilometers, the bullock cart up to 2.5 kilometers, the tractor from 2.5 to 8 kilometers, and the truck over 8 kilometers. 39/ Since growing specialization within the rural economy will probably lead to expansion of traded output at a rate exceeding the overall output growth rate, the role of the tractor and truck transport will probably expand rapidly as well (in spite of India's extensive railway system). As in the case of tractors or other powered implements, it appears that it will be extremely difficult to find economic alternatives to the conventional fuels for rural transport.

Policies and Programs for Rural Energy Development

The above discussion of present and prospective patterns of rural energy use in India indicates that broad-based agricultural and rural

development will be possible only if several interelated energy problems are solved. The most important are providing adequate fuel supplies and improving fuel efficiencies for cooking; expanding conventional energy supplies and developing alternative energy sources for irrigation pumping and rural industries; and likewise expanding conventional energy supplies and eventually developing alternative energy sources for on-farm motive power and for motor vehicle transport.

Solving these problems will require that India overcome a number of constraints in addition to those imposed by limited physical resource availabilities. These constraints might be classed as technological, organizational, social, and financial. Technological constraints include the absence of adequate technical options as well as lack of knowledge concerning the mix of rural energy technologies which is most appropriate for various locations in India. The most serious organizational constraints are the weakness of mechanisms for the dissemination or commercialization of appropriate energy technologies, and the generally poor performance of public sector management in commercial energy supply. The major "social" constraint is the general absence of social arrangements capable of bridging the divergence between private and social benefits and costs of rural energy programs; this applies particularly to afforestation and to the large-scale introduction of biogas technology. The importance of financial constraints is self-evident in a country with a per capita GNP of $150.

Policies are not an evident constraint to rural energy development. India has probably been ahead of most developing countries in analyzing energy problems in a comprehensive manner and devising appropriate policies. The first systematic energy study was carried out by the Energy Survey of India Committee in the early 1960s. The survey recognized the importance of non-commercial fuels for rural and urban households, and emphasized coal and nuclear power development to avoid excessive reliance on petroleum. 40/ The second comprehensive energy study was carried out by the Fuel Policy Committee in preparation for the Fifth Five Year Plan (1974-79), and was completed in 1974. 41/ The general recommendations of the Fuel Policy Committee report were accepted by the government as the basis for national energy policy. The broad features of India's energy policy, have been summarized by S.K. Mukherjee as follows: 42/

> The national energy policy considers coal as the principal source of energy in the country, and accordingly recommends its exploitation and utilization to a maximum amount for meeting the energy demand in India. In case of oil, the policy is to substitute oil wherever · technically and economically feasible by other forms of energy to reduce the quantity of import and to maximize indigenous production. The electricity production should be based on the use of hydro power, coal and nuclear energy, and the growth of electricity porduction should be adequate to meet future needs including additional demand arising from the use of electricity in place of oil. The national energy policy also gives high priority to meeting rural energy needs and recommends a rapid increase in the use of biogas, setting up of a social forestry programme and development of non-conventional energy source, like solar, wind, tidal and geothermal energy.

The policy also recommends appropriate pricing measures to promote the desired pattern of energy use and energy conservation and provide an adequate return to the industry. An ambitious research and development program relating to the energy sector and specifically for introduction of non-conventional energy sources were also recommended in the national energy policy.

Consistent with these policies, the draft Sixth Five Year Plan (1978-1983) envisages the expansion of thermal and hydroelectric power capacity by nearly 75 percent (from 26,000 installed megawatts in 1978 to 44,500 MW in 1983), electrification of 2 million pumpsets and an rapid expansion of "social forestry" and "farm forestry" activities, development of a large-scale program for village biogas production, and substantial expansion of research and development work on other non-conventional energy sources (emphasizing solar thermal and photovoltaic applications for irrigation pumping). 43/

Expansion of conventional energy supplies will of course contribute substantially to overcoming the problems of energy supply for irrigation and industry and fuel supply for farm equipment and transport vehicles. With respect to the latter, alternative energy sources are important in the long run, but only modest progress is likely over the next five to ten years. By contrast, development of alternative energy sources for water pumping and rural manufacturing could proceed fairly rapidly over the next five to ten years. This would be particularly important for the forty percent or so of India's villages which are unlikely to be reached by conventional rural electrification over the next decade. The problem of fuel suppliers for cooking can be addressed in some measure by increased supplies of conventional fuel such as coal, kerosene and bottled gas, but the basic requirement is expansion of traditional energy supplies, particularly firewood. Since the expansion of traditional and non-conventional energy supplies is so crucial to rural development, the remainder of this section is devoted to a brief discussion of the Government of India's programs in forestry and non-conventional energy.

Considerable thought being given in India to the design of forestry activities to satisfy industrial, household, and environmental needs. The 1976 National Commission on Agriculture report on the forestry sector indicated that a revised national forestry policy for India should be based on planning for and balancing certain important needs including (a) maximizing forest productivity with a view to the growing demand for industrial raw materials, timber and other forest produce for defence, communications and domestic needs, and to augment employment potential; (b) providing small timber and fuel need requirements of the rural population; and (c) checking denundation and erosion in mountainous regions and catchments of rivers on which depends perennial stream flows, fertility of the land in catchments and the useful life of dams and reservoirs. 44/

The NCA report contains a number of recommendations including suggestions for revised institutional arrangements at the Center and states to better address social forestry issues and to provide training and information gathering to permit better management of forestry

resources to meet social, environmental and production objectives.

Prior to issuance of the 1976 NCA report, however, the National Commission submitted an Interim Report Social Forestry in 1973. This report stressed the socio-economic importance of social forestry in the rural community as well as in the management of forest resources. The report stated that by taking up the program of raising trees, grasses and fodder in the farmer's own lands, village common, wastelands and degraded forests close to habitation, it would be possible to meet requirement of fuelwood, fodder, small timber for rural housing and agricultural implements and serve the objectives of protection of agricultural fields against wind and soil erosion.

In spite of this early commitment to broader forestry development objectives, social forestry programs are still lagging behind production forestry. One of the major reasons for this is obvious - production forestry has not required major reforms in the nature of the forester's role and in his relations with the villagers. This latter relationship appears critical to an effective social forestry program. Suitable technology does not appear to be a major constraint since Indian foresters have a long tradition in terms of adaptive research. Even with that, however, a more comprehensive approach to meeting community needs including fuel, fodder, food and shelter will require additional research to develop appropriate technical and management packages.

The major constraints appear to be organizational and social. Over the past several years, there have been attempts on the part of many states to develop appropriate social forestry programs but comprehensive proposals have been difficult to develop. On the organizational side, forestry agencies must go through a thorough reform of doctrine and procedures to reorient themselves from the traditional role of protection of forests from the villagers to the newer role of development of forests for the villagers. Social forestry further requires an educative process to make villagers aware of the benefits that can be provided by appropriate forest management and to enhance their ability to express their own views as to what is required by the community.

Several states have taken up active programs - some with donor financing designed to be responsive to social forests objectives. Approaches have included the more traditional tactic of planting trees on degraded lands, canals, roadsides, etc., but with sufficient production (including barbed wire and guards) to prevent illegal harvesting of the trees by villagers or damage by their livestock. However, there now appears to be a realization in a number of states that the success of any social forestry program will best be assured by strong community understanding of and participation in the program.

Several states are being assisted by external donors (including the World Bank, Norway and Sweden) in testing a variety of approaches. It may be that different approaches are required in different states depending on the institutional framework within the state and the sense

of community that can be evoked. In some cases a more traditional "enforcement" approach may be the best way to start a program while at the same time trying to develop increased community participation. Other states - such as Gujarat - may have inherent social structures that would be more receptive to greater involvement at the village level at the outset.

Under the general framework of social forestry, the GOI has recognized the need to take on integrated approach to what is being called "environmental" forestry. There has been particularly the foothills of the Himalayas, that not only impact on the areas themselves but affect catchment areas fed by the rivers flown through these hills. Programs are under investigation to develop a comprehensive approach to provide environmental safeguards and utilize these forest resources for economic growth.

While organizational and social constraints appear to be especially important at this time for social and environmental forestry programs, financing will become an increasingly important issue as additional states develop pilot and demonstration programs to the stage of large replication. Estimates of investment requirements are unfortunately not available. As an example of the financing involved, however, the total cost of the World Bank-assisted Uttar Pradesh Social Forestry Project is $45 million, and it will reach only about 10 percent of the rural population of Uttar Pradesh.

In the case of non-conventional energy programs, technology is still the major constraint to widespread application in rural areas. With the exception of biogas generators, organizational and social constraints have not been particularly important, and financing has been a constraint only in the sense that most non-conventional energy technologies (including biogas plants) are not within the financial means of the bulk of the rural poor. The Government of India's current non-conventional energy programs are directed toward improving technologies and reducing costs to the point that some of them will become economically viable and suitable for dissemination or commercialization.

At the present time the Government of India is supporting significant R & D programs on solar energy and on biogas technology. Major solar R & D efforts include work on solar drying of wheat, rice, spieces and timber; solar-powered cold storage units; fabrication of photovoltaic cells and experiments with various applications: performance evaluation of a 10 KW solar thermal power plant commissioned in January 1978, and development of prototype windmills. 45/ Research on biogas technology has been underway in India since the late 1930s, although it is only in recent years that utilization of biogas plants is now being carried at eight centers in India under the All India Coordinated Project on Biogas Technology and Utilization. The R & D efforts include all aspects of biogas technology as well as socio-economic evaluation and assessment of the biogas extension and credit programs of the Khadi and Village Industries Commission (KVIC), the GOI agency responsible for promotion of biogas utilization. 46/

As R & D work proceeds on non-conventional energy sources, a technological constraint which is emerging more clearly is lack of

knowledge concerning the mix of commercial and non-commercial (or conventional, non-conventional and traditional) energy technologies which is most appropriate for various patterns of energy supply and demand in rural India. The emphasis in most discussion has been on demonstrating the superiority of one or another technical option in a particular application. As R & D progresses and applications become more feasible, however, it will be increasingly important to understand the specific role each energy technology can play in a total energy system in the widely varying technical, social and economic conditions of India's villages.

AID Assistance Possibilities

AID is providing assistance to the Government of India in the energy field under a $2 million grant designed to support the application of science and technology to benefit the rural poor. The project provides for collaboration of U.S. and Indian institutions on specific sub-projects which do date have emphasized non-conventional energy development. The first two sub-projects likely to be approved include (a) a proposal for solar energy utilization for drying of agricultural produce after harvest and during food processing in village communities and (b) the development and testing of a rural energy center to harness renewable energy resources (solar radiation, solar hear, wind, biogas and falling water) that would be applicable and responsive to a village's energy needs. The emphasis in this latter sub-project would be on small scale systems and decentralization of energy generation and transmission. A third major sub-project under consideration also includes an integrated energy system for rural application by using a solar photovoltaic system, solar thirmal power plant, vapor absorption refrigeration system and biogas plant.

USAID will continue to explore the possibility of other suitable energy sub-projects under the existing grant. It is possible over a medium term that successful demonstration of sub-project activities will lead to a wide spread application of the technology involve. Financing of a larger program spreading a successful technology developed under the grant would provide a potential follow-on activity.

Further exploration is going on in the GOI concerning the development of an integrated energy system applicable to remote village areas in different parts of the country using non-conventional and non-commercial energy sources. A meeting was recently held under the chairmanship of the Secretary of Agriculture and Irrigation to discuss the need to develop systems utilizing solar energy, biogas, wind, energy plantations, etc. acceptable to local populations. The main objective would be to study the techniques of providing simple and easy-to-operate equipment for generating energy in remote villages. At the request of the government, AID participated in this meeting and will continue a dialogue with appropriate Ministries charged with the task of developing concrete proposals for instituting pilot projects for integrated energy systems for selected areas.

While the World Bank and Norwegian and Swedish governments are involved in projects in the forestry sector, the potential and need

for further development are substantial, as discussed earlier. To the extent the GOI is interested in further donor assistance to this sector, USAID would be interested in exploring a possible program including expansion and management of forest resources for fuel as well as environmental control. A natural complement to such such a program would include improving the efficiency of energy use in wood burning stoves.

The above approaches focus on the area of renewable and non-conventional energy development. In the conventional energy sector, AID is assisting the rural electrification program of the GOI under a $58 million loan authorized in FY 1979. In India, rural electrification is primarily utilized for the energization of pumpsets for irrigation, although the uncertainty of the power supply may still cause some farmers to opt for diesel even in electrified areas.

Footnotes

1/ S.K. Mukherjee, "Energy Policy for India: Basic Issues and Future Prospects, Paper prepared for the Meeting of the Ad Hoc Committee on Energy Problems of Development Countries, World Energy Conference, Bombay, January 1979, Table 9.

2/ GOI Planning Commission

3/ For details, see A Ramachandran and J. Gururaja, "Perspectives on Energy in India", Annual Review of Energy, 1977, Table 5, and GOI, "Report of the Fuel Policy Committee," New Delhi, 1974, Chapter 3.

4/ Ramachandran and Gururaja, Table 6, and Kirit S. Parikh, Second India Studies - Energy, Macmillan, New Delhi, 1976.

5/ IBRD, World Development Report 1979, Washington D.C., August 1979, Table I.

6/ For details, see Ramanathan and Gururaja, and the Report of the Fuel Policy Committee, Chapter 4.

7/ ibid.

8/ The 8-ton per hectare yield figure is used in the NCAER northern India rural energy survey.

9/ Report of the Fuel Policy Committee, Chapter 4.

10/ Table 1 is taken from IBRD, "Prospects for Traditional and Non-Conventional Energy Sources in Developing Countries", World Bank Staff Working Paper No. 346, July 1979, the table is based on Revelle's 1976 article. Table 2 is from NCAER, "Survey of Rural Energy Consumption in Northern India", New Delhi, forthcoming, pp. 21 and 22. The percentages have been added. The states covered are Haryana, Himachal Pradesh, Jammu & Kashmir, Punjab, Rajasthan, and Uttar Pradesh. For a presentation of similar information in flow chart form for a village Bangladesh, see Figure 1 (pp.19) of World Bank Staff Working Paper No. 346. The village study mentioned is reported in Amulya Kumar N. Reddy, "Alternative and Traditional Energy Sources for the Rural Areas of the Third World", paper prepared for a Royal Institution Forum on "Third World Energy Strategies and the Role of the Industrialized Countries", June 20-22, 1979, London.

11/ NCAER, op.cit., p 62.

12/ Reddy, op.cit., Table 3.

13/ NCAER, p.71.

14/ NCAER, p.71.

15/ NCAER, p.73.

16/ Lalit J. Sen, "Rural Energy Scene in India", Productivity, January-March, 1979.

17/ NCAER, p.70.

18/ For a discussion of the latter, see R.K. Gupta, "Efficiency of Utilization of Domestic Fuels", paper presented at the International Seminar on Energy, Administrative Staff College of India, Hyderabad, January 1979.

19/ Sen, op.cit., p.665.

20/ Reddy, 1979, p.6.

21/ Sen. op.cit., p.665.

22/ ibid., p. 666, and GOI Planning Commission.

23/ ibid

24/ ibid., pp. 666-668. For additional references to the extensive Indian literature on the technical, economic and social feasibility of biogas, see Ramesh Bhatia, "Economic Appraisal of Bio-Gas Units in India; Framework for Social Benefit Cost Analysis, Economic and Political Weekly, August 1977.

25/ R.C. Ghosh, "The Socia-Economic Consequences and Constraints to Use of Land and Forest for Energy and Organics in India" paper prepared for "Biological and Sociological Basis for a Rational use of Forest Resources for Energy and Organics: An International Workshop", Michigan State University, May 6-11, 1979.

26/ ibid.

27/ NCAER, pp. 120-125.

28/ For a discussion of the Gujarat experience, see Bill Knowland and Carol Ulinski,"Traditional Fuels: Present Data, Past Experience and Possible Strategies", paper prepared for the Agency for International Development, September 1979: and Erik Eckbolin, "Planting for the Future: Forestry for Juman Needs", World Watch Paper, 26 February 1979, pp. 48-56.

29/ Revelle, "Energy Use in Rural India", Science, June 4, 1976.

30/ NCAER, p.95.

31/ ibid., p.96.

32/ Sen, op.cit., p. 670.

33/ For a discussion of the possible role of wind power in India,

see AKN Reddy and K. Krishna Prasad, Technological Alternatives and the Indian Energy Crisis, "Economic and Political Weekly, August 1977.

34/ Reddy, op.cit., p.9.

35/ Ramesh Bhatia, "Energy Alternatives for Irrigation Pumping: Some Results for Small Farms in North Bihar, "Institute of Economic Growth, New Delhi", 1978.

36/ NCAER, p.98.

37/ ibid., p.104.

38/ For a discussion of these efforts and their role in helping to meet India's rural energy demands, see N.S. Ramaswamy, "Animal Energy", paper presented at the Interantional Seminar on Energy, Administrative Staff College of India, Hyderabad, January 1979.

39/ Reddy, op.cit., p.8.

40/ Government of India,"Report of the Energy Survey of India Committee", New Delhi, 1965. For a useful brief discussion of the evolution of Indian energy policy, see Mukherjee, op.cit.

41/ GOI, "Report of the Fuel Policy Committee", op.cit.

42/ Mukherjee, op.cit, pp. 3, 4.

43/ Government of India, "Draft Five Year Plan 1978-83", sections on Forestry (pp. 149-57) and Energy (pp. 162-175).

TABLE I: Estimated Energy Use in Rural India
(GJ per capita per year)

Source of Energy	Agriculture	Domestic Activities	Lighting	Pottery, Brick Making, Metal Work	Transportation & Other Uses	Total	Percent
Human Labor	0.6	0.4		0.05	0.1	1.0	9.5
Bullock Work	1.3				0.2	1.5	14.1
Firewood & Charcoal						4.4	40.3
Cattle Dung		6.4		0.7		1.8	16.3
Crop Residues						1.0	9.4
Subtotals from Local Sources	1.8	6.8		0.7	0.3	9.7	89.5
Petroleum & Natural Gas							
Fertilizer	0.3					0.3	3.1
Fuel	0.1		0.4			0.5	4.4
Soft Coke		0.1				0.1	1.2
Electricity							
Hydro	0.05		0.05			0.05	0.4
Thermal	0.1		0.05			0.2	1.5
Subtotal from Commercial sources	0.6	0.1	0.5			1.1	10.5
Total	2.4	7.0	0.5	0.7	0.3	10.9	100.0
Percent	22	64	4	7	3		100.0

Source: Adopted from R. Revelle, "Energy Use in Rural India," Science, 4 June 1976.

Rural Energy Consumption in Northern India

Energy Consumption 10^{12} K. Cal.

Source of Energy	Households	Agriculture	Establishments	Construction	Transport	All Sectors	Percent
Commercial Fuels							
Coal/Coke	0.47	-	3.83	-	0.68	4.98	1.64
Electricity	0.32	1.99	0.17	-	0.01	2.49	0.82
Kerosene	3.44	-	1.13	-	-	4.57	1.50
Diesel oil	-	7.57	0.35	-	1.70	9.62	3.18
Petrol	-	-	-	-	0.16	0.16	0.05
Furnace oil	-	-	0.33	-	-	0.03	0.01
Total Commercial Fuels	4.23	0.56	5.51	-	2.55	21.85	7.21
Non-Commercial Fuels							
Firewood	84.32	-	4.03	-	-	88.35	29.17
Dung cake	57.95	-	1.94	-	-	59.89	19.77
Vegetable waste	49.85	-	5.72	-	-	55.57	18.35
Charcoal	0.69	-	1.15	-	-	1.84	0.61
Total Non-commercial Fuels	192.81	-	12.84	-	-	205.65	67.89
Animate Sources							
Man Power	-	13.87	1.65	0.20	0.16	15.88	5.24
Draft Power	-	53.50	-	-	2.77	56.27	18.58
Total Animate Sources	-	67.37	1.65	0.20	2.93	72.15	23.82
Nitrogen	-	3.26	-	-	-	3.26	1.08
Total, All Sources,	197.04	80.19	20.00	0.20	5.48	302.91	100.00
Percent	65.05	26.47	6.60	0.07	1.81	100.00	

Source: National Council of Applied Economic Research (NCAER), "Survey of Rural Energy Consumption in Northern India", New Delhi, forthcoming.

NEPAL

Energy, Environment and Forestry

Introduction

Nepal lies in the Himalayan mountain Range. It's northern neighbor is the People's Republic of China. It is bounded on the east, west and south by India. With a size and shape similar to the state of Tennessee, Nepal lies between longitudes 30 and 88 east and latitudes 26 and 30 north (about the same latitude as Florida). The country is about 800 kilometers long and it's north-south width averages about 160 kilometers. Nepal has an area of 142,000 km^2. The country can be divided into three lateral geographic zones: 1) The Terai in the south a strip of land extending up to about 300 meters along the entire length of Nepal's southern border with India; essentially a northern extension of the Gnagetic Plain, 2) The Middle Hills, which encompass the Siwalik and Mahabharat Ranges and a number of mountain valleys. The attitude in the Middle Hills extends upward to about 5,000 meters. 3) The Himalayas, which include 23 peaks over 8,333 meters. Eight of the world's ten highest mountains are partially or wholly in Nepal: Everest, Kanchenjunga, Lhotse I, Makalu, Lhotse II, Dhaulagiri, Manaslu and Cho Oyu. Despite their forbidding height, the Himalayas are pierced in several places by rivers which have their origins on the Tibet Plateau and by high passes.

Nepal's ethnic makeup reflects large-scale immigration of both Tibeto-Burman speaking and Indo-Aryan speaking groups. Approximately 30 languages and dialects are spoken. Nepali is the official language. The population is approximately 14 million and expanding at over 2.5 percent per year. The average life expectancy at birth is 44 years. Of the population over 5 years of age 14 percent are recorded as "literate" (self declared, able to sign name).

About 91 percent of the working age population is directly dependent upon the practice of traditional agriculture for a livelihood. Over 60 percent of the people in Nepal live in the hills and mountains. The population density in the mountain and hill regions ranges from 24 to 103 persons per km^2 of total land area. However, when related to arable land in this rugged environment the density actually reaches 1,493 persons per km^2. This compares with the terai density of 379 per km^2, which has two-thirds of the country's cultivatable land. The typical rural family relies for its sustenance on the produce of less than 0.4 hectare of mostly marginal and submarginal land. It is estimated that 85 percent of hill farm households do not produce enough food to meet their own consumption requirements, and 50 percent of the terai farm households are similarly deficient.

Some two-thirds of all farm households must obtain supplementary income in order to survive. The IBRD indicates that the average per capita GDP is $120 but, generally, the rural people have an annual per capita income of less than $70.

In high mountain areas an estimated 1.9 percent of the land area is cultivated, while roughly 10.5 percent of the hill area is cultivated and 48 percent of the terai is under cultivation. Practically all mountain and hill land suitable for agriculture or pasture is being utilized. According to World Bank figures the land use picture is as follows:

Forests	35.5%
Cultivated area	16.3%
Grassland	12.0%
Permanent Snow	14.9%
Other	21.3%

The countries climate is highly varied ranging from tropical to artic environments. It has a monsoonal influence with precipitation ranging from less than 400 mm to more than 6,000 mm. Of this precipitation 80-90% falls during the months of June through September and upwards of 70-80 percent runs-off during this time. There is little surface or underground storage. Nepal is transected by four major river systems served by over 6,000 streams and rivers.

Nepal's greatest resource is its climate. The climate plus the spectacular mountain scenery contribute to making the country a major tourist attraction. The forest resources have yet to be exploited in a rational way and there is opportunity for forest-based industries. There are no massive mineral deposits, but there are minor deposits that could eventually be exploited. It is estimated that the hydroelectric potential is in the realm of 83,000 mega watts; this compares with presently installed capacity of 45 mega watts.

It is with this brief summary of Nepal's ecosystem that a picture of major problems, barriers and actions required to overcome the constraints can be developed.

Major Problems

From the environmental point of view the major problem is the rapidly expanding almost 100 percent agarian dependent society. However, only 16 percent or less of Nepal's landscape is suitable for intensively managed agriculture crops. Land with slopes over 45 degrees are being mined for crop production. Agriculture production is decreasing because mined outputs such as fertilizers are not being replenished.

One major effect of the increasing populations need to demand more from the static land base is the accelerating rate of dissappearing forests. It is estimated that in the last decade 1 million hectares of mountain forest have either dissappeared or been destroyed. This represents a decrease by about 25 percent from 1964 to 1975. At the present rate of forest mining, remaining accessible forests in the mountains could dissappear in the next 15 years and 25 years in the terai.

The combination of agriculture stretching the limits of land capability and the removal of ground cover, either by forest exploitation or over grazing by cattle, contributes to the production of sediment and increasing flood peaks. The rivers of Nepal annually carry over 240 million cubic meters of soil to India. This loss has been called Nepal's most precious export.

The power structure and the people themselves openly acknowledge the critical situation of land and resource degradation. The ability to cope with the situation is compounded by several interacting problems:

1. Nepal has a weak physical infrastructure. There are few roads and transportation into mountain areas is almost wholly dependent on aircraft or goods being carried on porters backs. There is a serious lack of office space and housing for technicians to work and live in the districts. This constrains decentralization efforts.

2. There is a lack of trained staff to administer the various programs and provide effective and efficient leadership for national as well as local operational efforts.

3. An effective coordination/education program that gets the small farmer and his ideas into the planning and implementation system is not well established.

4. Limited progress has been made on developing and improving environmental using techniques within resources capability. i.e.: efficient wood using stoves.

5. There is lack of a national coordinated planning effort aimed to reversing the land degradation process.

6. There is a major defenciency of basic resource data required to develop sound planned projects. i.e.: while water development is said to be most important, projects are often under engineered because hydrologic data is lacking. Soil resource information is sketchy at its best.

In Fifteen Years

The most important energy source will continue to be firewood from the forest. Ninty five percent of wood removed from the forest is used as fuel. It is doubtful that this consumption will change drastically over the next 15 years because of the lag period of installing alternative sources of energy such as hydro-power and bio-gas. Solar energy is being developed as well as bio-gas, but these are not expected to reach the rural majority. Except for local contributions of wind energy, mainly for deep well pumping, this source is limited in use. However, these types of uses will relieve the pressure on wood using around

urbanized centers. It is estimated that in order to get forest into a managed sustaining level about 1.3 million hectares of new forest plantations are needed by the year 2,000. Therefore, there will continue to be a problem of managing forests to produce multi-products such as fodder, fuel and timber essential for community life.

There will continue to be problems with sedimentation and floods. While programs and projects are underway to address the crises, the poor infrastructure will continue to prohibit marshalling forces necessary to tackle the problem in all areas. i.e.: electrification will be mainly centered around urban areas due to the high costs of installing lines in mountainous country.

Major Barriers

Technical

A large number of the Nepalese have been educated out of the country and are aware of most of the techniques that can be applied in a given situation. The main stumbling block is not having walked through a complete operational sequence that not only demonstrates the technique, but can be portrayed as a success story. Often there is a missing link in the chain of events; i.e.: a qualified hydrologist with a background in sedimentation to advise on stream regimes. Little has been spent on adaptive research.

All the components for micro-hydro installation are available in country, but missing is a large cadre of local talent to install and maintain the plant.

Previously, most forest management efforts were spent in preparing detailed management plans for large blocks of timber in the "flat" terai. It was a clearcut, burn and plant situation. With the need to accelerate forest operations in the mountains, the knowledge of how to manage existing scattered patches of timber while foresting potential forest land is not well understood.

The conceptual and technical shortcoming are most immediately related to a general shortage of well trained and motivated technical personnel. Parrallel to this constraint is the failure to mobilize local (rural) human resources. Up to now it has been a catch-twenty-two situation - - - lack of trained manpower and infrastructure to effectively train the rural population so they can efficiently play a role in the decision making process allowing known techniques to be implemented and maintained.

Economics

Though Nepal is a poor country, finance has not been a serious development constraint. For example, HMG/N has included within its budget for the last two years funds to establish the Nepal Remote Sensing Center. This was based upon the USAID/N proposal to assist in developing the center. The Remote Sensing Center is to provide natural resource inventory data to various agencies and aimed towards designing projects to reduce environmental degradation. This use of up-to-date technology demonstrates a positive approach to improving project preparation and execution.

Because subsistence agriculture demands so much attention there has been little opportunity for the local communities to diversity their labor. This should change as energy needs develop and labor is required for construction and maintenance.

Social

Rural Nepal is a highly deversified and pluralistic society that is hierachically ranked. Traditional community decision - making is broadly based and governed by many social norms which incorporate participation by the rural poor in an egalitarian manner. Historically the power structure has been managed by a strong top-down approach. However, there has been a shift in policy towards such things as: (a) more bottom-up planning, (b) targeting small scale projects to benefit the rural poor (c) more emphasize on small farmer hill agriculture (d) local community involvement in natural resource conservation (e) use and training of local people as extension agents and (f) decentralization of development activities.

Cultural

Most Nepalese communities used to have (and often still have) traditional systems of resource regulation. However, these systems were usually concerned with the right of exploitation and distribution rather than with conservation.

Forest and pasture land resources have traditionally been an indespensible component of the subsistance systems used by Nepalese farmers to maintain their livelihood. Many villages of Nepal had systems in which forests and pasture lands were considered community property that could only be used by non-community members through payment of fees or other commodities. Because of the small populations and an "abundance" of resources there was rarely any reason for local communities to develop their own methods of resource conservation.

A very strong contributing factor applying pressure to the land base is the great numbers of cattle, buffalo, sheep and goats. Cattle particularly are a cultural heritage. While they are part and parcel to the cultural scene, under the present management system, these animals contribute very little to maintaining a cover crop to protect soil surfaces from washing away.

Actions Required

1. People will basically have to change many of their present land use practices.

2. Planning will have to integrate the top-down-bottom-up approach within which the small farmers/landless population are involved.

3. Donor projects will need to be structured so that they fit into the Nepalese system.

4. Training programs will be required to properly prepare for skills needed during design, through implementation and/or construction and to handle follow-up maintenance. This training may have to be individualized in order to develop required skills.

5. Technicians must be trained to be sensitive to the peoples needs.

6. Projects may have to be phased over longer periods in order to insure that country talents carry through the whole management process, rather than depend upon expatriates to short cut the process.

External Assistance Needs

In Nepal USAID has selected a two pronged assistance approach. First is assistance at the national level to help accelerate the institutional development of the GON's planning, evaluation and administrative capacity and national service delivery system. The second and concurrent effort is at the local level which includes the intervention under national level assistance plus attention to under employment, weak participatory/resource mobilizing institutions, lack of appropriate technology and lack of modernizing skills.

Within this context, USAID/N is involved with HMG/N in the design of two major and one small scale assistance programs dealing with Energy, Environment and Forestry.

1. Resource conservation and utilization.

   The primary thrust of the Resource Conservation Utilization Project is toward land conservation, i.e.: making land more

productive by applying land-use practices appropriate to the control of soil erosion and flooding, and thereby introducing effective management of soil and water resources.

The project's field operations will focus on four selected areas representative of hill and mountain conditions in Nepal, especially with respect to combinations and/or intensities of typical soil and water conservation problems. Within these four ecological systems, discrete but complementary activities will center on the application of tried practical means to reverse existing environmental degradation by advocating and demonstrating practices which allow a better balance between man and nature. Special attention will be given to (a) soil erosion, (b) deforestation, (c) watershed run-off, and (d) stream flooding.

At the National level the project will focus on assisting in the institutionalization of the HMG Department of Soil and Water Conservation and other supporting agencies, the establishment of the Tribhuvan University Institute of Renewable Natural Resources, and the creation of the Ministry of Forest Training Wing to carry out in-service education programs. These activities will lead to the protection, improvement and use of natural resources in ways which promote the highest possible economic and social benefits for the nation.

Specific project actions for this 15 year (3-five year phases) project include (1) inventory and monitoring of ecological conditions and change in four selected, representative watershed areas, (2) watershed management to reduce flood peaks and improve water and land use, (3) forest management to increase (4) exploration of energy alternatives, (5) irrigation and on-farm water management, (6) improvement of drinking water supplies, (7) range and pasture improvement, (8) agronomic research and extension, (9) horticultural nursery development and extension, (10) fisheries development, (11) personnel training and (12) infrastructureal building of decentralized facilities. Parallel actions will focus on rural employment alternatives, and identification/application of alternative cropping systems and energy resources.

2. Rapti Zone Project

The Rapti Zone Project is a proposed multi-sectoral rural development project covering five administrative districts - - Rukum, Rolpa, Sallyan, Pyuthan, and Dang-Deokhuri - - in Farm Western Nepal. It is one of a number of Integrated Rural Development Projects being implemented or planned by the Government of Nepal (HMG/N) with donor support in various multi-district areas of the Kingdom.

The situation in the Zone, with the evolving HMG/N policy on integrated rural development, the experience in Nepal to date with integrated rural development, and the specific concerns and mandate of AID have led to the formulation of the following "working" objectives and sub-objectives for the program:

(1) To quantitatively and qualitatively improve food production and consumption by the rural poor.

a. Increase local production of food grains, vegetables, fruits, livestock and poultry as ecologically and culturally appropriate.

b. Improve equity of access to basic nutritional needs within rural communities, households and between sexes.

c. Stablize or decrease the negative environmental effects of mixed hill farming.

d. Improve the stock and accessibility of basic environmental resources needed for survival - soil, water, fuel, fodder and timber.

(2) To improve and increase income generating opportunities within rural areas which are accessible to poor farmers, landless laborers and occupational castes.

a. Increase the number of profitable cottage industries, crafts and small rural industries.

b. Expand the level of rural works projects employing paid (cash or food) labor.

c. Improve local quality control and marketing mechanisms for existing cash crops.

d. Encourage local ability to develop and utilize appropriate technologies to increase productivity.

(3) To strengthen the capacity of panchayats, cooperatives and other local organizations to plan, implement and sustain local development efforts.

a. Improve the capability and resources of District and village panchayats to plan, coordinate and implement development efforts.

b. Expand the number and effectiveness of cooperatives and other functional groups.

(4) <u>To provide basic services at the District and Village level through joint local-central efforts.</u>

a. Strengthen the role of local panchayats, cooperatives and other organizations in initiating and maintaining effective agricultural, health, family planning and educational services.

b. Develop effective staffing and supply models for the locally supported and controlled provision of basic services.

c. Strengthen the ability of central agencies to provide services and resources to support locally initiated efforts including potable water systems.

d. Provide greatly expanded training and access to training for local level technicians, workers and para-professionals.

3. Bio-Gas Research Development/Construction

USAID/N has provided a Grant to the United Mission to Nepal. The purpose of this grant is to provide support to a project to make bio-gas, an alternative, renewable energy source (in replacement of wood and kerosene) available to more people in Nepal, especially poorer farmers and people living in the hill areas.

Other donor activities are also making strong contributions. The World Bank is in the final stages of providing $25 million for a five year community forest project. The Canadians are into a thorough analysis of water resources looking to harness the countries most valuable assest. Several large Hydro-structures are underway by the Koreans and Germans. UNDP, the British, Australians, Japanese are all involve.

PHILIPPINES

Energy, Environment and Forestry

Carol S. Harlow*

Introduction

Over the past 15 years, Philippine energy consumption has more than doubled. In the process, the national economy has become increasingly dependent on imported oil and vulnerable to OPEC price increases. By the mid 1960's, Philippine oil equivalent energy consumption was averaging 36.5 million barrels per year for a population of 36 million people, or roughly one barrel per person (1). By 1978, the Philippine population had reached 45 million and per capita energy consumption had increased to the equivalent of over 1.9 barrels of oil per year, or 86.2 million barrels. Of that total, only 6% can be accounted for in non-oil resources. Before 1973 oil imports had never amounted to more than 13% of the Philippines total import bill, but by 1978, the total had reached 23.3% and is undoubtedly higher now following several recent oil price increases. In 1973 approximately 10% of Philippines export proceeds were allocated to pay for oil imports. By 1978 over 33% of total export revenues were required to pay for imported oil. The Philippine Ministry of Energy has determined that oil imports have accounted for 71 percent of the nation's trade imbalance since 1974.

Faced with a pervasive and potentially disastrous dependence upon imported oil, the Philippines has recently embarked on a major program to define and utilize its indigeneous energy resources. The government now has a target to meet 54% of its energy requirements with indigeneous sources by 1988. The Phillippine energy program has stressed conventional energy resource exploration and development, power generation, electrification and downstream facilities (fuel processing and delivery systems). The program has recently been given increased prominence and budget. Its main emphasis has been on adapting available technologies for low-power rural uses. Table 1 below describes the current Philippine Ten Year Energy Plan.

*Project Coordinator, USAID-GOP Joint Project in Nonconventional Energy Development in collarboration with James D. Baird, General Engineering Officer & George Carner, Program Planning Officer, USAID.

Table 1

Philippine National Energy
Source Mix, 1979-1988
(In Million Barrels of oil equivalent, MMB)

	1979		1983		1988	
	Volume	%	Volume	%	Volume	%
Power						
Hydro	5.6	5.96	11.3	8.75	22.3	11.6
Geothermal	0.98	1.05	5.8	4.5	9.7	5.06
Nuclear	--	--	--	--	6.5	3.4
Coal	0.26	0.28	3.1	2.4	13.5	7.05
Nonconventional	--	--	0.015	0.01	0.17	0.09
Nonpower						
Oil	63.7	68.3	75.5	58.5	107.1	55.8
Coal	1.5	1.6	5.6	4.3	6.3	3.3
Nonconventional	0.006	--	0.913	0.71	2.7	1.4
Oil Share		91.1		79.4		68.07
Per Capita Consumption	2.0 bbls		2.5 bbls		3.4 bbls	

Financial requirements for the Ten Year Energy Program, as shown in Tables 2 and 3, total more than $13 billion U.S. at 1978 price levels (2).

Table 2

Overall Financial Requirements for Philippine Ten Year Energy Program
(In Million U.S. Dollars)

	Energy Resource		Power Dev.		Downstream Facilities		Electrification	
	$	%	$	%	$	%	$	%
Sector totals	1,787	13.1	8,744	64.1	1,093	8.0	2,017	14.8

Table 3

Ten Year Financial Requirements for Energy Resource Development
(In Million U.S. Dollars)

	Oil & Gas		Coal		Geothermal		Uranium		Nonconventional	
	$	%	$	%	$	%	$	%	$	%
Sector totals	860	48.1	136	7.6	608	34.0	38	2.1	146	8.2

Of the total projected financial requirements for the Ten Year Philippine Energy Development Program, an overwhelming percentage, 64.1%, would be required for electrical generation facilities, while 12 percent is earmarked for conventional energy resource development and only 1% for nonconventional resource development.

Forests represent one of the most vital natural resources in the Philippines. Yet, the Philippines is destroying its forests at an alarming rate. In 1968, over 55% of the country was forested. By 1978, forests covered only 43 percent of the land, a net decline in forested area of 3,798,764 hectares (3). Dr. Adolfo Revilla of the University of the Philippines at Los Banos has estimated that over 79% of Philippine households use fuelwood for cooking and that by 1985 this use will require 48.5 million cubic meters of fuelwood per year (37.9 million barrels fuel oil equivalent) (4). Revilla has also estimated that wood fuel demand will require a cumulative cutting of 1.04 million hectares by 1985, 1.88 million hectares by the year 2000 and 3.08 million hectares by 2025. These figures are in addition to trees cut in commercial logging operations.

Environmental stresses attributable to deforestation have been observed for many years in Luzon and the Visayas and more recently in Mindanao (5). These include increasing frequency of destructive floods, increasing sediment load of rivers, decreasing productivity of crop lands, outbreaks of plant pests and diseases and recently, "dust storms" over the Ilocos which indicated increasing desert-like conditions. In areas of steeper slopes, forest destruction is causing noticeably accelerated erosion, landslides, mudflows, clogging of downstream irrigation systems and siltation of croplands and dam-reservoir systems.

Problems in Energy, Environment and Forestry

The following are major energy problems confronting the Philippines, including their effect on the environment and the health or existence of the nation's forests:

1. Heavy dependence on a limited number of energy sources, a majority of which must be imported. Although the Philippines is making estimable progress in development of its indigeneous energy resources, including oil, geothermal, coal and uranium, the country is still dependent on imported oil for over 80% of its bulk energy supplies, with no near-term prospects for significantly lessening such dependence.

Present Philippine fuel supplies are vulnerable to sudden major price increases and interruptions. This situation is of critical proportions and could affect the development potential and

political stability of the country as well as the well-being of a majority of its citizens. It is impractical to consider simply abandoning existing capital equipment designed to operate on petroleum-based fuels or on centrally-generated electricity. One obvious strategy which is now being followed by the government, that of developing indigeneous oil and geothermal resources to directly substitute for oil imports, may not produce results fast enough to avoid major economic dislocations caused by a lack of affordable energy supplies for a wide variety of businesses and industries.

2. Continued Pursuit of High energy technologies and policies in the Government's economic growth plans. According to the Philippine Ministry of Energy's Ten Year Energy Program, published this year, "It is not conceptually possible to accommodate higher growth levels with a lower consumption of commercial energy." This development strategy is apparently based on the familiar (primarily western) strategy of increasing labor productivity through industrialization, most commonly accounted for in the ratio of output per unit of labor. Much of the apparent productivity of labor in developed countries, particularly in the United States, has been largely due to large energy subsidies as well as heavy capital investments. This is particularly so in U.S. agriculture which has substituted cheap fossil energy and fossil fuel-based chemicals for human labor as well as for natural soil fertility and pest control.

3. Uneven distribution of energy supplies given widely dispersed island geography. Remote rural areas of the Philippines have become dependent on centrally distributed, petroleum-based fuels during the post-World War II period of cheap and abundant oil and oil distillates. In an era of scarce, expensive fuel supplies, inhabitants of these areas are most likely to suffer fuel shortages and/or be forced to give up their livelihoods which have become unprofitable due to high energy costs.

4. Undervaluation of the potential of renewable energy resource technologies by Philippine energy planners and external funding agencies. Although the Philippine Ministry of Energy has recently begun a new development program aimed at eventually augmenting the nation's gasoline fuel supply by 20% with ethyl alcohol and the National Electrification Administration has begun a pilot program for developing 3-MW wood-fired thermal power plants and mini-hydro units for future rural electrification, there are presently no plans for supplying, or investigating the possibility of supplying, "commercial" centralized or decentralized energy supplies from renewable resources. Technologies which appear to be capable of either augmenting present energy supplies or displacing the use of expensive imported oil in the Philippines are already commercially available in the U.S. and other industrialized countries or will be within the next five years. These include: large-scale wind

generators (50 KW-3 MW), ocean thermal electric plants, photovoltaic cells for dispersed or centralized applications, solar thermal power plants, oceanic kelp farms for methane production, and biomass-fuelled power plants (possible fuels include wood from energy plantations, agricultural and forestry wastes, and municipal solid wastes).

At this time, the Philippine Government's program for developing small-scale renewable resource devices and infrastructure for rural energy development is receiving attention internationally. However, the bulk energy planning upon which the nation's future industrialization and economic development plans will depend appears to be largely focused on conventional technologies which are dependent on non-renewable fuels, and have major negative environmental impacts. Government energy plans have not yet incorporated the idea of matching energy quality and technological scale to end use needs. Thus, we see a high forecast demand for centrally-generated electricity in the Philippine Ten-Year Energy Plan. If that demand were to be disaggregated by end use, it is likely that much of it would be for low-grade heat and stationary mechanical power which could be supplied more cheaply and simply be decentralized renewable resource technologies.

While developed countries and international funding agencies have, over recent years, provided technical assistance and funding for small-scale "appropriate" technology development, as well as technology and financing for large conventional energy conversion facilities, there are presently no technology transfer efforts being undertaken for the slightly larger-scale, technically sophisticated renewable resource devices now available in developed countries.

5. Unmanaged use of wood as an energy resource coupled with heavy competition for other uses is resulting in an annual denudation rate of 172,000 hectares vs. an annual reforestation rate of 50,000 hectares. Although the Philippine Ministry of Energy undertook a census-type survey to determine the pattern of household energy use last year, the results of that survey have not yet been processed. Thus, the amounts of wood and other marginally-commercial fuel sources which constitute a mahor portion of rural energy use in the Philippines are not yet accounted for in official government energy planning and are still essentially unmanaged.

Barriers

1. Although the Philippines has a sophisticated energy planning group, national energy planning is based primarily on supply projections. Planners lack detailed end use data and complete, up-to-date cost and technical performance information on the full range of available energy options. Using the current approach can only document how bad the current situation is without providing the means to make fundamental policy choices for positive qualitative change.

2. Major investments have been made in buildings and industrial equipment requiring the use of imported fuels for their operation. Conversion of these facilities to indigeneous or indigeneous-renewable fuels may in some cases be impossible and in almost every case, will require additional investment for retrofitting.

3. Developed countries and international lending agencies have not made a concerted effort to provide LDC energy planners and utility executives information on alternative technologies which could substitute for imported oil. In this case "Donor Organization Mind Set" seems to be the barrier. The World Bank and other multilateral financial institutions have emphasized highly capital-intensive technologies, while AID has perhaps interpreted its role of "aiding the rural poor" too narrowly. Thus, limited information on and funding for sophisticated, small-to-intermediate-scale energy technologies has been made available to LDC countries.

4. The Government does not have an effective national program for forestry management, and individuals lack incentives to refrain from destructive uses of forest resources. Vested interests continue to exercise substantial influence, thus preventing consistent enforcement of watershed protection laws. In addition, upland migration is not being managed in a way to avoid major damage to forested areas.

5. High status is derived from possession of "modern" facilities: bigger is better mental attitude.

6. There is a lack of perception by both government and external funding agencies that underlying causes of energy problem can be solved.

7. The Government has failed to involve the private sector in national energy planning efforts (9), both as a means of providing business lenders and the general public with an enhanced awareness of the nature of national energy problems and as an inexpensive, effective means of drawing upon the knowledge and experience of private-sector groups and individuals in providing pragmatic solutions.

Actions

1. The Government should adopt comprehensive end use demand-oriented energy planning techniques using continuously updated data on the technical characteristics and economic feasibility of all available energy conversion technologies. While not an end in itself, comprehensive energy planning is a necessary first step toward the diversification and decentralization of energy supplies. It would emphasize indigeneous renewable resources for both decentralized rural end users and for centralized urban and commercial/industrial uses. To accomplish this task, a thorough end use analysis and alternative disaggregated forecasts of energy end use demand should be undertaken to determine the bulk energy supplies (firm electricity and liquid and gaseous fuels) necessary for future national development; which end uses, i.e., stationary mechanical energy process heat, and intermittent electricity, could be supplied from decentralized sources; and the appropriate technology mix for both large/centralized and small/decentralized needs. Comprehensive energy planning would also include development of an inventory of possible sites where renewable energy resources could be exploited, an element especially critical when facilities dependent on ambient conditions for their operation are being considered for use, i.e., wind generators, solar electric devices and ocean thermal plants. The comprehensive energy plan would thus provide information which would enable the government to optimize its investment in energy conversion equipment for both conventional and renewable energy resources.

2. National energy planning should focus on the use of renewable, indigeneous energy resources to meet increasing energy demands and on retrofitting existing capital equipment where technically and financially feasible. To accelerate the conversion of existing equipment to use indigeneous resources and, where possible, lower grade energy, an incentive program must be devised to encourage the private sector to undertake the necessary action. Customs exemptions, tax incentives and low cost revolving loan programs are possible means of implementing such a program. Over the longer term, new capital equipment should be designed to use available indigeneous energy resources.

3. To encourage development of a more decentralized energy distribution system, technical and financial information on possibilities for the local manufacture of small-scale energy conversion devices should be disseminated to both small and large entrepreneurs. At this time, private industry cannot be expected to fill this role. Large multinational corporations do not have vested interests in renewable energy technologies, and their marketing capabilities are thus not available to promote these devices. The renewable energy technology field is dominated by small independent manufacturers who, as a rule, do not have the resources to field international sales teams.

To fill this information gap, international lending agencies should provide a comprehensive program of education and technical and financial assistance for introducing renewable energy devices now being developed and used in the industrialized countries. An in-country technology transfer program aimed at both large, urban-based corporations and rural entrepreneurs could be used to stimulate local investment in the manufacture and/or use of dispersed energy conversion facilities. Government institutions capable of reaching and being trusted by the target audience would be a requisite to the success of such a program. For the rural component, the rural electric cooperatives developed under the auspices of the Philippine National Electrification Administration would be logical outlets for such information.

4. To promote optimum forest resource use and watershed development, consideration must be given to the use of wood as an energy resource. Such a program cannot be successfully undertaken as a single-purpose effort. The result must be integration of Philippine policies, laws, and management practices that affect forest resources in a manner that promotes optimal watershed development the welfare of watershed inhabitants and the health of both natural and man-modified ecosystems.

The development of short-rotation fuelwood plantations should be undertaken to help alleviate local shortages of fuelwood; provide employment in rural areas; provide fuel for small-to-intermediate-scale power plants; and rehabilitate denuded watersheds. Such plantations could be developed on a scale ranging from a few hectares for production of local cooking fuel to thousands of hectares for the production of fuel for multimegawatt-scale power plants. Under tropical conditions the Salvador strain of Giant Ipil-Ipil (Lencaena leucocephala) appears to be ideal for this purpose; however, there has been no systematic investigation of the silvicultural parameters governing the productivity of this species, nor have there been efforts to identify other native species that might also be used for biomass fuel production.

Traditional long rotation (50-60 year) forestry entails a lengthly investment period for the landowner (whether private of government) during which time no income and no jobs are generated. In contrast, short-rotation forestry is a labor-intensive operation which can produce a variety of products, in addition to fuel or pulpwood, and provides a steady stream of income throughout the life of the project. People who now feel they must burn Philippine forests to make a living from marginal agricultural efforts (Kaingin farming) could be provided steady employment in fuel farming projects.

More than 5 million hectares of denuded lands are presently available for reforestation in the Philippines. These lands could provide the resource base for meeting both projected fuelwood demands based on current use patterns and for developing alternative sources of wood resource-based energy, such as wood-fired thermal electric plants ("dendro thermal"), methanol, charcoal, synthetic oil and distillates and producer gas.

5. In its efforts to attract new industries and in planning other development activities, the Government should consider energy implications in determining the value of the project to the economy. In evaluating industrial project, the appraisal should include consideration of output per unit of energy consumed and a determination as to whether the industry's products would encourage conservation or promote energy waste.

External Assistance: The A.I.D. Role

Presently, A.I.D.'s role in energy assistance, other than in providing the impetus for rural electrification patterned on the U.S.'s own rural electrification program, is relatively minor. Current projects focus on testing of small-scale energy devices potentially suitable for rural applications, rather than on the integration of intermediate-scale facilities into the existing buld energy supply system, or technical assistance in developing non-renewable energy minerals. Given this situation, the following observations can be made:

1. If a goal of A.I.D. is to implement a strategy of providing small-scale energy devices to the rural poor, emphasis on applied research and development may not be the most effective way to accomplish the goal. While pilot demonstration projects do serve a purpose, devices built and installed in rural areas under this type of program are likely to be abandoned after the technicians have gotten the data they need to know on how and how well the equipment operates. To provide real and lasting energy assistance to the rural poor, the people to be assisted must be consulted. The devise in question must meet a real energy need and local knowledge and mechanical skill drawn upon to design and build the equipment. Continuity for maintenance and supply of spare parts must also be provided to avoid having the equipment abandoned when repairs are required. One possible means of accomplishing these objectives would be to utilize Peace Corps Volunteers as rural energy extension agents, providing them with access to adequate training and the financial resources to carry out small-scale energy hardware projects. Another would be to utilize the rural electric cooperative network for similar purposes. In any case, successful programs as defined above require implementation-oriented agencies for program execution.

2. No activities are now being undertaken to encourage integration of renewable-resource based technologies into existing bulk energy supply systems. A.I.D. efforts in this field could take several forms:

a. A.I.D. can assist in initiating an end-use demand-oriented energy planning survey to provide the Philippines with the comprehensive technical and financial data needed to determine optimal near- and long-term energy development strategies. The planning effort should encompass a time span sufficient to allow for a complete turnover of existing capital plant and match the quality of end-use energy needs with thermodynamic quality of energy supplies. To minimize future vulnerability to supply interruptions and resource depletion, maximum feasible reliance should be placed on renewable energy resources. Information produced as a result of the assessment could provide a basis for future hardware investments by other international lending agencies.

b. Provide liaison for information exchange between such Philippine Institutions as the National Power Corporation, the National Electrification Administration, Manila Electric Company and Philippine National Oil Company and U.S. public and private organizations involved in advanced studies in renewable energy technology. These include the Gas Research Institute (Oceanic biomass fuel production); the Bonneville Power Administration and Tennessee Valley Authority (electric system coordination and integration of megawatt-scale wind-generators and wood-fired power plants into existing transmission grids); and the Electric Power Research Institute, progressive public and private utilities such as Southern California Edison and Eugene (Oregon) Water and Electric and the National Aeronautic and Space Administration (applications of integrated village-scale renewable energy systems and large-scale wind energy systems). In addition, A.I.D. might encourage U.S. manufacturers of large-scale wind equipment to acquaint Asian energy planners and utility personnel with operation of such equipment.

It is likely that many developing countries view the United States as dealing from a weak position in promoting energy assistance. The question might well be asked silently, if not out loud, "Why do you think you can help us solve our energy problems when you can't solve your own?" There is no real answer to that question. However, only limited information has been disseminated about successful U.S. efforts in developing and using new technologies, particularly efforts being undertaken by the private sector and regional government authorities.

Presumably as a result of discussions at this conference, policy decisions will be made which will determine what role A.I.D. anticipates playing in energy development. Considering the Agency's limited budget and staff, it appears U.S. efforts might best be focused on the initiation of comprehensive energy assessments and the introduction of prototype equipment designed to exploit renewable energy resources. While these contributions will not have an immediate impact on the national energy sector in the country under consideration, AID's role might then be perceived as central or catalytic, or both.

References and Notes

(1) Philippine Ministry of Energy, Ten Year Energy Program 1978-1988, February, 1979. Probably does not include the use of fuelwood for cooking and other domestic uses.

(2) Ibid.

(3) Telesforo W. Luna, Jr., Land Resources Development in the Philippines, in "Journal of the Natural Resources Management Forum," Philippine Ministry of Natural Resources, Natural Resources Management Center, Vol. 1, No. 8.

(4) A.V. Revilla, Jr., Critical Issues in Forest Resources Managemnet in the Philippines, Inaugural Lecture for the SEARCA Professional Chair in Forest Resources Management, August 1, 1979, College, Laguna, Philippines.

(5) Ibid.

(6) Although plans are not yet finalized, the Ministry of Energy's Center for Nonconventional Energy Development will be entering into an agreement with the Federal Republic of Germany for testing a 10 KW photovoltaic-power irrigation pumping system.

(7) Severo R. Saplaco, Problems, Issues and Strategies on Watershed Management in the Philippines in "Journal of the Natural Resources Management Forum," Philippine Ministry of Natural Resources, Natural Resources Management Center, Vol. 1, No. 7.

(8) In areas where deforestation is a major or potential problem, bulk hydro facilities cannot be considered "renewable" due to their short life spans caused by siltation, nor can they be considered environmentally benign given the public health problems and social disruptions often created by major hydro projects. Given the uncertain hydrologic characteristics of geothermal reservoirs, geothermal cannot be classified as "renewable" although it is a major potential energy resource in the Philippines which can be expected to contribute significantly to the nation's future energy supply.

(9) Other than resource service contractors and rural electric cooperative officials.

THAILAND

1979 Oil Price Increases and Their Economic Costs to Thailand

Jesse W. Wright and Sarunya Chaloryoo*

Conclusions

This report estimates that the 58% oil price increase in 1979 could cost Thailand $911 million more than last year's oil bill. In 1978 Thailand spent about $1.1 billion on petroleum products thus the 1979 OPEC price increase alone almost doubles Thailand's petroleum import bill. Approximately $638 million is due to the price increase alone. $126 million is attributable to an oil-induced higher price for non-oil imports and a $147 million reduction in Thai exports could develop should the industrialized countries fall into an oil-precipitated recession. The analysis is extended to 1984 by assuming 10% annual price increases and holding import volume at the 1979 level. This modest assumption is estimated to add as much as $907 million to the country's oil bill over the five year period. In other words, if Thailand can achieve oil conservation, development of alternative energy sources, and oil prices only increase ten percent per annum, the oil import bill in 1984 will be almost triple 1978's petroleum import cost. Thailand's overall development is dependent upon adequate energy supplies and rural development requires greater use of fertilizer, pesticides, mechanization and truck marketing. This report demonstrates that, even maintaining current levels of petroleum use, substantially higher amounts of resources must be channelled into oil purchases.

Introduction

Over forty percent of Thailand's entire energy requirements are met by petroleum products and over eighty percent of the energy needs of the market economy depend upon petroleum. Thailand is generally considered to be energy impoverished and even its recent natural gas discoveries are not expected to meet more than a minor fraction of future demand. Initially almost all of the new natural gas will go into meeting a higher demand for electrical generation. Only by 1984 will significant quantities of natural gas go into other sectors. However, gas substitution for oil imports will reach a maximum of 20% by 1985 and fall off rapidly thereafter. The Gulf of Thailand natural gas is a significant development for Thailand but not nearly the panacea it was thought to be two years ago. Prior to 1973 petroleum imports comprised only about 10% of the country's import bill but due to rising volume and prices this figure now stands at about 21%.

In this report we estimate the costs, to Thailand, of recently announced OPEC price increases totalling 58% for 1979. We then project petroleum costs out to 1984 assuming an annual 10% oil price increase. We begin by considering three major impacts of an oil

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price increase upon Thailand's balance of payments: (1) Thailand is a net oil importer and will, of course, experience higher import cost when it attempts to maintain an historic volume of oil imports; (2) the higher oil price will also raise the cost of production in industrialized countries with the consequence that Thailand will be faced with a set of higher non-oil import prices; and finally; (3) the industrialized countries will experience some loss of GNP growth with a resulting weakening of demand for Thai exports.

A second set of costs are primarily domestic in their effects. While they involve higher cash flows we are only interested in their societal costs. For example, higher petroleum prices obviously mean higher inflation for the Thai economy and inflation being a regressive tax will disportionately harm lower incomes. Secondly, changing the price of petroleum products relative to all other prices will force oil consumers to increase their budget allocation for necessary petroleum products or turn to less desirable alternatives. Using fewer petroleum products may be an ideal solution for presently industrialized countries, but it may not be optimal for Thailand where oil is more of an intermediate than a consumer good. Higher oil costs force Thailand to allocate more of its resources for recurrent operating expenses and less for development investment. Finally, we note that under formerly low oil prices Thailand has made considerable investment in petroleum dependent transportation and energy systems. Continuing escalation of petroleum prices could cause early abandonment of these systems at no small cost to the country.

This paper only attempts to estimate the direct money costs associated with Thailand's changing balance of payments position and we only mention the above societal costs. Furthermore, this analysis makes no adjustments for off-setting monetary or fiscal policy nor for the potential off-setting effects of higher commodity export prices.

Table I

Impact of Higher Petroleum Prices on Thailand's BOPs 1/
($ Millions)

	Cost of 58% Price Rise in 1979	Accumulated Cost of 10% Annual Price Rise to 1984 2/
Rise in Petroleum Import Cost (CIF) (1978 import cost = $1.1 billion)	638	738
Rise in Non-Petroleum Import Cost (CIF) (1978 Import cost = $3.5 billion)	126 3/	169 5/
Reduced Value of Thai Exports (FOB)	147 4/	-0- 6/
Total Costs to Thailand of oil price rise	911	907

Probable Consequences

A. Higher Domestic Oil Prices

In the first six months of this year, OPEC countries have increased oil price levels three times as shown in Table II. The latest oil prices have been increased approximately 40% over the level of the preceeding period of April-June 1979 and 58% over the level of December 1978. As a result, Thailand has had to increase the retail oil prices about 40%-64% over Jan.-Mar. 1979 levels (Table III).

It is extremely difficult to judge whether the increases in the domestic price of refined products are economically justifiable or not because the costs of refining crude oil into petroleum products in Thailand as well as refinery prices are not made public. However, rough estimates can still be made by comparing the actual increase in the average C.I.F. price of imported crude oil with the actual weighted net price increase of the refined products (after deducting the tax increase). The weighted price increased is about 1.27 baht/litre (Table IV) whereas the increase in the C.I.F. price of crude oil comes to about 0.43-1.13 baht/litre. Apparently, the rise in the prices of the refined products can cover the rising cost of crude oil since April 1979. In fact, the present price structure covers the rising cost of crude oil since last December, so long as the C.I.F. price of crude oil does not exceed U.S. $22.8 per barrel.

B. Higher Cost Production

Table V illustrates that the percent of total petroleum consumption differs widely by sector as does the type of petroleum consumed and the new price of petroleum by product. The costs of production (due to petroleum price increases only) then will differ widely as seen in Table VI. The products most affected by the rising oil price, 57.65% on average, are Transporation and Communication, Marine Fishing Products, Mineral Production and Industrial Products. The production cost will be expected to rise by 16.74%, 6.36% and 6.04%, respectively.

Agricultural products will have the least impact because they at present use small amounts of oil. (We note that while the cost of production in agriculture has risen by .5 to 1.3% due to oil, paddy prices due to strong international demand have risen by 2.96% higher than the same period last year. It would seem then that at least until now, the agricultural sector does not seem to be greatly affected by recent oil price increases. This does not, however, take into account the inhibiting influence of higher prices on agricultural expansion).

C. Higher Wholesale Price Index and Consumer Price Index

The sharp rise in oil prices has resulted in a CPI for the Whole Kingdom and WPI in 1979 to go up by 2.8% and 2.13%, respectively. (Table VII). Regarding the total rise (which includes trend and other effects, the effects of the 1st, 2nd and latest price increases) the WPI and CPI for the Whole Kingdom will rise by 10.43 and 11.12%, respectively. This does not necessarily mean that the impact of the latest increase will be to immediately push the price indices up by the full amount. This will occur only after each sector has fully adjusted to the situation and passes along the increase in the production cost to the consumer. It may take a month or more depending on the firm's decision as well as the government's intervention policies.

D. Lower Economic Growth Rate, Higher Inflationary Rate and and External Debt

"The short-term depressing effects of higher oil prices on aggregate demand and investment will reduce the capital stock and real GNP in the long run if the investment expenditures lost in the short run are not made up". 7/ The latest oil price increase is expected to slow Thailand's growth rate by the end of this year to only 7%; down from the earlier forecast of 8% and inflation will rise to about 11% up from last year's 8%. 8/

Furthermore, Thailand must face the incurring of more foreign debt as the country is not able to finance the additional oil import cost through increasing exports (due, in part, to a shrinking import demand caused by oil-induced economic slow down in industrialized countries). Certainly, most of the new foreign borrowing will be channeled into operating expenses, not development. It has been estimated that 9/ the additional increase in LDC debt by 1985 is about US. $37.5 billion if global inflation over the 7 year period (1979-1985). This assumes LDC oil imports at currently expected rates, no repayment of principal, and interest payments on new borrowing at 10% per annum. For the same period, OPEC will have additional revenue amounting to about US. $373 billion. Thus a transfer from OPEC to the LDCs of about 10% of these additional proceeds could finance the aggregate increase in LDC debt caused by the increase in oil prices. Otherwise, LDC imports and domestic growth rates will decline.

E. Higher Budgetary Cost

Since the initial oil prices increases in 1973, the RTG has been subsidizing oil consumption. The main budgetary impact has been through the use of oil reserve funds. The degree of subsidization for earlier years has been estimated at about ฿400 million monthly but in view of recent OPEC price increases the cost could approximate ฿900 million monthly if subsidization of domestic oil prices continued to be policy. The RTG, however, has come to the realization that this policy is unacceptably expensive. With the latest round of domestic price increases, retail prices are thought to be approximately what would prevail in unfettered markets. As a result, budgetary subsidization of low domestic oil prices has ended with the sole exception of the Electrical Generating Authority of Thailand (EGAT). EGAT continues to subsidize electric consumption by about ฿200 million monthly. The Government has already tried once to increase electricity and water rate by 50% but urban opposition is so strong that these increases have had to be recinded. In Thailand, it would appear to take an extraordinarily strong government to pass along higher food, petro and utility prices to the urban consumer. The present government to its credit has been successful in raising food and petroleum prices.

F. Distribution of Income

The absolute and relative distribution of income is almost certain to improve due to higher energy prices. There are three primary reasons: first, Bangkok (where a disproportionately high number of wealthy are found) uses over sixty-three percent of all Thailand's energy but unlike the rest of the country it depends almost exclusively upon petroleum based energy; secondly, the formerly fast growing sectors transportation, industry and services (where high incomes had been earned) are highly dependent upon petroleum energy and will grow less fast; and finally, alternative energy sources are rural based and rural areas will be net suppliers of energy to urban areas to the future. We note in passing that the bettering distribution of income is brought about by some slices of the economic pie growing less fast -- not a particularly attractive turn of events.

Table II

Period of time	Oil Price Level (US. $:barrel)	Change (as % of the previous period)	Change (as % of December 1978)
December, 1978	12.70	-	-
Jan.-Mar., 1979	13.45	5.91	5.91
Apr.-Jun., 1979	14.55	8.18	14.57
Jun.-Sept., 1979	18-23.5	23.71-61.51	41.73-85.04
Average	20	39.46	57.48

Table III

Oil Category	Old Price* (baht/litre)	New Price (baht/litre)	Increase (baht)	Increase (%)
Premium gasoline	5.60	7.84	2.24	40.00
Regular gasoline	5.12	7.45	2.33	45.51
Kerosene	3.06	4.20	1.14	37.25
High speed diesel	3.03	4.88	1.85	61.06
Low speed diesel	2.93	4.71	1.78	10.75
Fuel oil 600	1.86	3.04	1.18	63.44
Fuel oil 1200	1.79	2.93	1.14	63.69
Fuel oil 1500	1.77	2.90	1.13	63.84

Gas size of containers	Old Price (baht/litre)	New Price (baht/litre)	Increase (baht)	Increase (%)
12.0 kgs.	66	90	24	36.36
14.5 kgs.	79	108.5	29.5	37.34
15 kgs.	82	112.5	30.5	37.20
25 kgs.	123	173.7	50.7	41.22
45 kgs.	221	31.32	92.2	41.72
50 kgs.	245	347.4	102.4	41.80

* U.S. $1 = 20.47 baht

Table IV

Category	Weights (%) 10/	Price Increase (Baht: Litre)	Tax Increase (Bath: Litre)	(2)-(3)	[illegible]
Gasoline	20.40	2.29	.95	1.34	27.3[illegible]
Kerosene	2.63	1.14	.24	.90	[illegible]
Diesel	33.11	1.82	.45	1.37	45.36
Fuel	41.44	1.15	-	1.15	47.66
LPG	2.29	2.03	-	2.03	4.65

The weighted price increase = $\frac{127.42}{100}$ = 1.27 baht/litre

Table V

Sector	Share in Oil Consumption 11/	Type of Oil Used 12/	% Increase in Oil Price
Agriculture	10%	DB	60.75%
Industrial	17	FO & HSD	63.20 13/
Construction	1	HSD	61.06
Electricity and Water Supply	19	FO	63.66
Transporation and Communication	39	PG & HSD	50.26 13/
Commercial Service and Other	3	PG & DB & K	50.38 13/
Energy Sector Consumption	6	FO	63.66

DB = Diesel; HSD = High Speed Diesel; PG = Premium Gas; FO = Fuel Oil; K = Kerosene

Table VI 14/

	% Increase in Cost of Production
1. Agricultural Products	0.51-1.34
2. Fishery Products	
- Fresh Water Products	2.08
- Marine Products	6.36
3. Industrial Products	1.06-6.04
4. Transportation and Communication	13.56-16.74
5. Mineral Production	1.75-6.09
6. Services	0.97-1.98

Table VII

	Weight in Percentage	Rate of Increase Price Index (%)	Rate of Increase in Price Index 1979 (%) Trend and Others	Effects of 15/ the 1st, 2nd Price Increase	Effects of 16/ the latest Price Increase	Total Effect
1. Whole Sale Price Index (1978 = 100)	100	+4.8	+7.15	+1.15	+2.13	+10.43
a. Domestic Products	75.09	+6.34	+8.34	+1.26	+2.48	+12.08
1) Agricultural Products	28.43	+0.97	+4.30	+0.40	+0.78	+5.48
2) Foodstuff	19.14	+5.17	+0.77	+2.23	+4.39	+7.39
3) Industrial Products	27.52	+15.37	+16.33	+1.47	+2.90	+20.70
b. Import Products	24.91	-0.33	+3.36	+0.83	+1.71 17/	+5.90
2. Consumer Price Index (1979 = 100)	100	+7.9	+6.82	+1.48	+2.82	+11.12
a. Foodstuff	-3.67	+3.87	+5.08	-1.63	-3.22	9.93
b. Others	96.33	-8.67	-8.17	-1.36	-2.68	+12.21

Footnotes:

1/ We calculate import costs rise and export value lost from base year 1978. Source: Bank of Thailand, August 1979, Vol. XIX, No. 8.

2/ The accumulated totals represent additional import costs from an annual 10% increase in oil prices. We have assumed no growth in import volume from 1979 to 1984. On the other hand we have also assumed that Thailand's natural gas coming lon line in this period will not diminish petroleum imports.

3/ Previous econometric work in oil price increases has estimated that a 45 to 60% increase in petroleum prices will be translated into a 3.6% higher non-oil merchandise import bill for capital-good importing countries. We also use this parameter in the present analysis.

4/ Again, previous work has shown that developed countries are expected to absorb a 2.4 % short-term decline in GNP growth when a 45 to 60% petroleum price hike is experienced. This decline in growth of GNP in the industrialized countries will, in general, reduce the non-OPEC LDC export value by about 3.6%.

5/ The rise in the non-petroleum import bill is assumed to rise .7% annually or one-half the rise of the 58% increase in petroleum prices.

6/ Assumed to be zero since we cannot expect industrialized countries to annually absorb a 2.4% decline in GNP growth in the medium term.

7/ A. Bradley Askin, "How Energy Affects the Economy", D.C. Health and Company, 1978, page 47.

8/ Reported by the Bank of Thailand.

9/ INR/Department of State Report, July 1979.

10/ Prapath Premmani, Situation, Problem Encounter and Sceneries in Fulfilling Energy Demand in Thailand, National Energy Administration, 1979.

11/ National Energy Administration, Annual Report, Bangkok: 1978

12/ Prapath Premmani, op. cit.

13/ Weighted average on the % increase in oil proce.

14/ This table has been estimated by Bank of Thailand.

15/ Include the increase in fuel oil prices on the 22nd of March 1979.

16/ The government has increased the oil prices by 57.65% on average.

17/ Calculate based on the 37.46% increase in crude oil price (US. $20/barrel).

Note: Table VII has been estimated by Bank of Thailand.

INDONESIA

Energy, Forestry and Environment

William H. Littlewood*

Issue No. 1 (Major Problems)

Indonesia's overwhelming problem in energy is not one of resources but one of distribution. Its energy resources are not located where its people and industry are located. Ninety million (i.e. 65% of Indonesia's population of 140 million) live on the islands of Java and Bali, which are about the size of Louisiana and constitute only 7% of Indonesia's land area. Furthermore, the original forests of Java and Bali are long gone, replaced by people and rice fields in particular. Indonesia's limited fossil fuels and present forest resources are scattered on the other, underpopulated islands, away from the Java population density of 1690 persons per square mile. The population density of these outer islands, 13,000 of them, is only 182 persons per square mile, compared to the Java population density of 1690 persons per square mile. Industry is concentrated in West Java, which is also the location of Jakarta, now about 6 million. Fifty percent of electric power used is locally generated by diesel or gasoline driven generators. The centrally-generated (oil fired) grid for the remaining 50% is very limited. Highly subsidized kerosene substitutes for wood in areas where wood is scarce (e.g. Java-Bali).

Specific Points: (not priority ranked)

(1) Oil - Limited and in small resevoirs (i.e. relatively high cost for exploration/extraction), which are scattered (i.e. off-shore, on-shore, jungle) although the oil is of high quality (low in sulphur).

(2) Gas - Exists where there is low industrial or domestic usage potential, i.e. away from markets. LNG production and transport is high cost, and like oil, may best be exported rather than used domestically.

(3) Coal- Plentiful, but in isolated areas, and of low or mixed quality (e.g. 40% water content). Lack of means of transport to markets. Requires expensive processing for export markets.

(4) Hydro - Good resource, but limited exploitation potential due to location vs need problem. The more obvious hydro potentials are already exploited. New demand areas may displace thousands of families and cover thousands of hectares of rice lands. Electric power grids not yet well developed for transferring power to markets.

(5) Geothermal - Moderate potential, but problems of isolation, insufficient heat, corrosive nature, conversion to power, lack of transportation of power to markets, etc.

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(6) Biomass - Plentiful in lightly populated areas, but on Java and Bali, with 65% of the population and most of the land under cultivation, biomass "energy farms" have limited potential due to space restrictions. If energy farms are established in less populated islands, there are added costs to process and transport the energy. Biogas, pyrolytic conversion, and alcohols have important but limited potentials.

(7) Nuclear - Some uranium, but with the lack of a national power grid and the high capital costs and high technology required for nuclear energy, this is in the distant future.

(8) Wind - Very limited, as most of Indonesia does not have steady, strong winds.

(9) Direct Solar - Reasonable sunlight, but also many tropical rains. Large arrays of flat plate collectors have many problems. Only potentials appear to be limited village and household use. Photovoltaic generation still too costly, particularly as an import.

(10) Data - Scarcity of energy-related data, quality of energy-related data, ability of personnel to compile, process, analyze data, and lack of energy data computer banks are all major problems.

(11) Other - The usual LDC problem of insufficient capital and low level of skilled technical and management personnel. Academically trained energy specialists are very, very limited.

Issue No. 2 (Major Barriers):

The major barriers to problem solution are specifically lack of capital, lack of technical skills (both training and experience), lack of academically-qualified (B.S., M.S., Ph.D) personnel, and geophysical and demographic barriers. Especially important is the fact that the population is scattered on 13,000 mountainous islands, but with a very heavy concentration of both population and potential industrial users in one geographic area (Java-Bali). That area, however, is weak on energy resources. There are also social barriers (over two hundred local languages, for example).

Specific Points: (not priority ranked)

(1) Capital - To gain foreign currency, Indonesia is exporting its oil and gas, and using the funds for development. Producing the capital for large project (e.g. conventional hydropower, nuclear, oil exploration/extraction) may be beyond its capacity for a long time, particularly since it is still recovering from the Pertamina (state oil company) losses of some years ago. Other priorities, e.g. food (Indonesia is the world's biggest importer of rice) compete for capital and educated manpower.

(2) Education - Relatively few highly educated persons are found in Indonesia, particularly in the newer field of "energy". The few Ph.D and M.Sc. degree level people are often overextended in responsibilities, holding several important jobs simultaneously. Even the B.Sc. level is inadequate. Poor English language capability -- since most of the world's technical literature is in English--is also a barrier. Expatriate hire is normally used to fill the gap, but that is not a long term solution.

(3) Management - Management theory, practise and experience is generally sparse in Indonesia. As new managers become trained, they are quickly absorbed in expanding business and development activities.

(4) Technical - Inadequate depth of practise and experience in highly technical skills required for a large energy plant or installation. Vocational schools and on-the-job training opportunities are inadequate. Teachers are also in short supply.

(5) Geographic - Indonesia is composed on 13,000 inhabited islands spread over an area the width of the continental U.S. The consequent transportation and communication barriers are considerable, and apply particularly to energy, as the market is concentrated in West Java, but the resources are elsewhere. The topography is mountainous, roads are poor, and conditions are often difficult, which inhibit exploitation of energy resources.

(6) Demographic - As mentioned elsewhere, the population is concentrated on Java-Bali, and industry and the heaviest population center is in West Java.

Issue No. 3 (Actions Needed)

The energy challenge is so great in Indonesia that the local government (national and provincial), donor institutions and private organizations need to pull together in a coordinated fashion to have a meaningful impact. Human resource development, because of the long lead times for education and experience, should be the highest priority coupled with institution building, timed to be ready as the new energy-trained manpower becomes available. Hopefully, the raising of capital will follow as the capability to use it wisely is demonstrated. The manpower development program should initially focus on producing a cadre of highly trained (M.Sc. and Ph.D level) "energy leaders", in both software aspects (energy economics, energy policy and planning, energy administration and management), and hardware aspects (various energy technologies, energy data processing, etc.). Development of this "indigenous energy cadre" will provide a base for assessing energy needs and resources, and determining policies and organization to match the resources with the needs, from family and village levels up to large industry levels.

Specific Points: (not priority ranked)

(1) Higher Education - Local government and donor should jointly develop a plan to place a significant group of potential energy leaders in M.S. and Ph.D program abroad, to prepare them for their forthcoming responsibilities. Local graduate and undergraduate education in energy matters should be upgraded quickly and significantly. Energy Education Centers should be established at the best of the local higher institutions of learning, to provide an educational focal point for energy software and energy technological education. Teacher training colleges should develop a special line in "energy".

(2) Technological Education - Vocational and undergraduate schools should have special curricula in relevant energy technologies to supply technicians to energy industries (e.g. an electric power lineman), or to village-level energy technology (e.g. a biogas generator). How to repair energy devices should be taught.

(3) Energy, Surveys, Analysis, and Planning - A program of assessments of resources and needs should be made. A computerized energy data bank should be established and used as a tool in planning and developing policy.

(4) Biomass Conversion - A study, followed by program development, should be made on the various potentials, cost effectiveness, environmental impact, dissemination and other factors concerned with biomass conversion, particularly for decentralized energy needs (homes, villages, small industry).

(5) Energy for Food and Water - A special program on the relationship of energy to food production, processing and marketing, and on the supply of water, should be made for Indonesia. (A survey or feasibility study may be required). The objective would be to assure an adequate food and water supply despite aberrations in energy supply, and to improve the food-energy cost ratio.

(6) Alternative (decentralized) Energies (other than biomass conversion) - Institutional development and programs focussed on development of alternatives such as wind energy, micro-hydro, photovoltaics, solar collectors, etc. for providing energy to homes, villages and small industry should be pursued.

(7) **Rural Electrification and other Energy Distribution** - A program of energy distribution development, e.g. rural electrification, peak load leveling, transport of coal, oil, gas, wood charcoal, etc. should be established. A survey of present and future energy demand and distribution may be required. Efficiency and cost equity should be stressed.

(8) Energy R&D Laboratory - Such a laboratory should be established and assisted, to work on local energy problems and opportunities.

(9) Coal Production and Distribution - The technology and management of a program on extraction, processing, transportation and utilization of coal is of primary importance in Indonesia, as the resource is large, and coal is the primary alternative for most domestic power generation needs.

(10) Technological Hardware Production - A survey might be made on the "hardware" needed in Indonesia's future energy programs, and division made as to what might logically be produced locally within a 10-20 year program, and what should continue to be bought from developed countries. A maintenance and repair program for energy technology hardware, whether imported or domestic.

(11) Other- (Including "Energy Assistance Policy Workshop"). There are many other potentials for "Actions Needed" and energy technical assistance: An "energy assistance" workshop arranged by the U.S. National Academy of Sciences and the G.O.I., with broad donor participation, might help the G.O.I. sort out the more realistic suggestions, develop time frames and budgets, and develop policy. (Funding for a GOI/NAS energy assistance policy workshop can be partically supplied by USAID-GOI Science and Technology Project).

Issue No. 4 (Types of External Assistance):

The most urgent type of external assistance needed in Indonesia is human resource development, along with commensurate institutional and program development so as to use efficiently the trained manpower as it is produced. Technical assistance by carefully selected experts will be required. As these indigenous energy institutions develop, selected equipment and instrumentation will be required, but the lead time is considerably less than that required for the human resource development, and there is the possibility that the GOI may purchase it directly.

Specific Points: (priority listed)

(1) Higher Education - Because of lead time and the importance of a highly educated cadre of managers and technical experts specializing in "energy", this should be the primary time of technical assistance, coupled with institution building.

(2) Training of Technicians - Secondary priority should be on the training of technicians, the people who make, run and repair the energy systems devised by the more highly educated group.

(3) Institution Building - Institutions and organizations are necessary to utilize the above educated and trained people. Technical experts should help design and establish these institutions concurrent with the education and training. Initial assistance in management may be needed.

(4) Equipment/Instrumentation - Provision of the types of instrumentation and equipment which cannot logically be manufactured locally (because of quality or time requirements) should be made.

Issue No. 1: Major Problems in Forestry

In Indonesia the total forest area is estimated at 122 million hectares, or 64 percent of the total land area. The problems of forestry are highly complex, being influenced by the size of the archipelago, which links the continents of Asia and Australia extending 5,110 km west to east and 1,888 km north to south (making administrative control difficult); the population - the fifth largest in the world (which, on Java, exerts great pressures for farm land); the climate with an annual average rainfall of 2500 mm (which leads to heavy erosion); and the economic situation (which leads to over-exploitation of forest resources). These factors have lead to a high degree of forest destruction, and subsequent soil erosion--which, taken together with denuded area, affects 20 percent of total land area. The average rate of erosion on Java is presently estimated at 3.65 mm per year. Assuming the present rate of erosion continues, the average annual rate will increase to 5.19 mm per year by the year 2000.

Destruction of the once-forested watersheds and subsequent soil erosion, particularly on Java, has destroyed many traditional irrigation systems, has heavily silted streams and reservoirs, and is responsible for annual floods in the lower coastal areas. Unless logging regulations are enforced--especially outside Java, and watersheds properly protected, Indonesia (particularly Java) will have great difficulty in attaining, self-sufficiency in food stuffs.

Issue No. 2: Major Barriers to Solving Problems

Barriers include technical, economic, social and cultural aspects. Technical -- inadequate distribution of trained foresters, especially off Java, and the absence of a national soil conservation service to provide the multidisciplinary actions required. Economic -- forest resources are an exploitable commodity which, given the size and spread of the archipelago, make control difficult if not impossible. Social and cultural -- shifting cultivation is a traditional farming practice which is extremely difficult to control and the peasant farmer has little idea of the damage caused by felling trees to plant food crops and the subsequent erosion -- he is only trying to feed himself and family.

Issue No. 3: Actions Needed to Overcome Barriers

Four basic objectives for forestry in Indonesia have been outlined during the third 5 year development period, beginning in April 1979:

1. Step up forestry production to increase job opportunities, raise the income of the masses, support industrial development, and increase foreign exchange earnings through exports.

2. Build up the forests as a natural resource, replanting damaged areas and relocating people where necessary.

3. Awaken a public sense of responsibility for helping promote forest conservation, especially in rural areas where forests are a closely integrated part of people's lives. Manage forests in such a way that the people will be directly aware of their benefits.

4. Take steps to preserve the soil as a vital resource including both reforestation and prevention of future damage.

Donor assistance has been available since the early 1960's, providing training in all aspects of forestry, and many attempts at watershed control-- most of which has not been too successful, mainly because of the lack of continuity.

USAID believes that the conservation of soil resources will not be properly addressed until a national soil conservation service is organized at the level of a Directorate General under the Department of Agriculture.

Additionally, the concept of agro-forestry needs to be accepted and implemented, with particular reference to Java.

Above all, development strategies are required which meet the basic requirements of the rural poor, through their involvement and participation. These might include a) combining forest replanting with the cultivation of food crops, b) road construction not only for logging but with rural development objectives in mind, c) all forestry activities should provide for direct lingage with the socio-economic framework of the rural communities, and d) extension services should be made available to help the rural peoples to plant their own fuelwood, shelter belts, wood lots, etc.

Issue No. 4: Types of External Assistance Needed

The development of manpower resources (research and extension) is the most critical factor. Simultaneously, instruction on the conservation of natural resources must be included in the school curricula, beginning with the primary grades. AID's role should be in assisting in the establishment and development of a national soil conservation service.

Currently, AID is engaged in the following activities which have impact on the forestry sector:

1. Citanduy LL: Watershed and Enviormmnet Protection. The second phase of a river basin and upper watershed development project in the provinces of West and Central Java.

2. Provincial Area Development Programs which have, as a part of their activities, the extensification of Leucaena and other ground covers in the interest of soil conservation and land reclamation.

3. Present Agriculture Education for Development Project includes forestry as a component. Up-coming graduate agricultural school project will include forestry as a field of emphasis, as will the Eastern Islands Agriculture education project.

S R I L A N K A

Energy, Forestry and Environment

John R. Eriksson*

Introduction

This paper is cast in terms of the issues posed by the guidelines for the Conference. Energy has come to the fore as a critical development problem with the sharply increasing oil prices of the last six years. Energy has always been an essential element in development, for the application of more productive technology typically has energy consumption implications. The impact of the last six years has been to force development planners to consider alternative energy resources and technologies more systematically. Difficult decisions are required because the development and widespread application of alternative energy conversion technologies and sources also require in varying degree scarce capital and technical/managerial resources.

Issue 1: Major Problems in Energy, Environment and Forestry, and their Relationship to Development Goals.

a. Dependence on forestry resources for energy, especially by households, in the face of serious deforestation and its environmental and developmental consequences.

(1) In Sri Lanka, as in other low income countries, energy, environment, and forestry problems are closely interrelated. This stems largely from the fact that Sri Lankan households which account for about 70% of total energy consumption, in turn derive 85-90% of their energy needs from firewood. In rural households, which still account for almost 80% of the population, the reliance on firewood is even greater (about 98% of rural households met their cooking energy needs with firewood in 1969-70).

(2) Forest cover in Sri Lanka has declined since 1956 from 44% to about 20% of the total land surface; forest coverage of watershed areas is even less, at about 9%. Ecologists believe the current forest cover in watershed areas is below the minimum for adequate protection of watershed and soil stability. Contributing factors have included (1) land clearing for settled agricultural use; (2) slash and burn ("chena") agriculture with progressively shorter rotation periods; and (3) exploitation of trees (legal and illegal) for construction, household fuel, and industrial fuel (tea, ceramic, brick and tobacco manufacture). The Accelerated Mahaweli River Development Program will result in almost 20% of the remaining forested land in Sri Lanka being cleared, which would bring forest cover to about 16-17% of total land area. With increasing population, unless forest resources and energy and other development needs can be better managed, it will be impossible to maintain a productively adequate forest cover.

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(3) Without adequate protection of remaining watershed forest areas, it may not be possible to attain Sri Lanka's ambitious development objectives, including reaching basic food self-sufficiency, and reduction of unemployment and poverty through expansion of employment and incomes. Key elements in Sri Lanka's strategy include expansion of irrigated land for agriculture and exploitation of hydroelectric resources for expanding agriculture, industry, transportation and other sectors. Unless measures are undertaken now, watersheds will not in 10-15 years be able to provide sufficient and reliable water to meet this expansion.

(b) Dependence on imported petroleum, especially by the commercial sector, in the face of escalating world price and a finite supply of hydro-power.

(1) Sri Lanka has no known deposits of such "conventional" energy sources as petroleum and coal although there is a planned resumption of oil exploration in the Palk Straits between Sri Lanka and India. There are modest peat deposits north of Colombo that may become economically viable for exploitation as the cost of other energy sources increase. Crude oil imports, after declining from 1.8 million metric tons in 1973 to 1.4 million in 1976 as a result of domestic economic stagnation and world price increases, are increasing again because of renewed economic growth, and are expected to reach 2 million metric tons by 1980. While this represents more than a 40% volume increase over 4 years, the increase in value will undoubtedly be well over 300%, owing largely to escalation of petroleum prices. In 1973 petroleum imports accounted for about 10% of export earnings; in 1978 this proportion was over 19%.

(2) In 1975, petroleum products accounted for about 25% of total energy consumption in Sri Lanka. Commercial transportation is virtually entirely dependent upon petroleum products as a source of energy and domestic lighting is heavily dependent upon kerosene -- over 95% of rural households and over 60% of urban households used kerosene for lighting in 1969/70. Continued sharp escalation of petroleum prices will increase balance of payments and inflationary pressures, jeopardizing attainment of development objectives. For example, the long-standing substantial subsidy of kerosene was recently eliminated by a 3-fold price increase which reportedly reduced demand for kerosene by 25%. In response, there is bound to be some increase in the demand for firewood, particularly by those urban households which use kerosene for cooking (23% in 1969/70). This, along with transportation costs, may well explain the 20% increase in the cost of urban firewood during the last year.

(3) Projections of electric energy requirements have implications for dependence on imported petroleum. In 1975, while electricity generation accounted for only a little over 11% of total energy consumption in Sri Lanka, and only 3% of energy consumption of households, it accounted for almost 25% of commercial energy consumption, and 56% of energy consumption in industry. The growth of electricity consumption, after slowing to 4-6%

annually in the mid-70's, accelerated to 12% in 1978, and requirements are expected to increase at an annual rate of 9-10% in the next 10-15 years. In addition to expected increasing demand from industry and commerce, including from the new and potentially large Free Trade Zone north of Colombo, the electrification of railway transportation in the Colombo region and possibly in the entire country has been proposed.

About 20% of Sri Lanka's current electric power capacity is supplied by thermal plants dependent on petroleum products; the balance is from hydro sources. The current peak capacity of 320 megawatts (MW) is only slightly above recently experienced peak consumption of 310 MW. To keep up with projected growth in demand during the next few years, additional thermal capacity (at least 100 MW) will be required. From 1983 to the mid-1990's, major new hydro-electric facilities (associated in large part with the Accelerated Mahaweli River Development Program) are expected to meet further projected growth in demand. At some point in the 1990's, however, the hydro-electric potential of Sri Lanka will have been fully exploited.

(4) In the absence of the identification and development of major new energy sources, Sri Lanka will be forced to turn in the mid-nineties to an increasing dependence for electric power upon imported petroleum. One consideration which will influence the timing at which this point is reached is the strategy adopted on rural electrification, usually defined as being tied to the national grid. There are about 25,000 villages in Sri Lanka of which about 8% are currently electrified. The expansion of rural electrification has not kept up with population, however. It has been estimated (in the Sankar and Fernando paper, op. cit.) that over twice as many households are formed each year as get added to the rural electric power grid.

A proposed Asian Development Bank loan is currently under negotiation would permit doubling (to 500 a year) the number of villages electrified between 1981 and 1985. Major rural electrification issues include (1) how fast rural electrification should be pushed in relation to ability of households and enterprises to pay, (2) what emphasis should be given to use for production vs. use for consumption, (3) whether there should be equitable access by all households in a community, and (4) whether rural electrification should be redefined to include alternative, decentralized sources of electric power.

A useful discussion of the economic and social benefits of rural electrification is given in the Sri Lanka Country Paper by Mr. Senadhipathy, op. cit., pp.13-15.

(5) Two post-hydro era "conventional" alternatives to petroleum-fueled central electric power generation being given consideration is Sri Lanka are coal and nuclear energy. Coal, which would have to be imported, appears to have the edge in policy discussions at the moment, but nuclear energy may not be entirely ruled out. Both sources pose well-known environmental

costs and hazards. If planned resumption of oil exploration in the Palk Straits results in major discoveries, this picture could of course change significantly.

Issue 2: Major Barriers to Solving these Problems

The extent of "conventional" energy resources and of land available for forest cover impose barriers, but ones which can be rendered less serious by actions taken with respect to technical, economic and social barriers. These "natural barriers" in effect become the "problems" (as in the previous section) to be addressed.

a. Technical barriers

(1) Inadequate information on energy consumption, especially by households, and on the rate of depletion of forest resources.

(2) Insufficient reforestation effort, and inefficient practices (species, planting techniques, harvesting).

(3) Insufficient and inefficient energy conversion of forest products and agricultural waste (sawdust, coconut waste, rice husks) through such techniques as briquetting and charcoaling.

(4) Lack of efficient low-cost cooking and lighting appliances.

(5) Lack of technologies to economically tap alternative renewable energy sources.

(6) Insufficient numbers of trained professionals and paraprofessionals in the above areas.

b. Economic barriers

(1) Financial resources. The barrier posed by lack of sufficient financial resources depends upon the technical or resource barrier in question. Development of some new energy technologies in such fields as solar and nuclear energy can be extremely expensive. Reforestation with improved species, development of more efficient energy utilization techniques and appliances, and selective development of certain new energy technologies, along with associated training, can be considerably less expensive.

(2) Rubber replanting policy. Rubber wood still accounts for an estimated 25% of forest fuel to the domestic sector in Sri Lanka. Replanting has lagged behind the recommended rate but is sensitive to subsidy incentive policy.

(3) Pricing policy for petroleum products. As noted above, the demand for petroleum products, including kerosene, has responded to pricing policy -- but not proportionately (demand is relatively price inelastic). Pricing policy for kerosene is

complicated by the extent to which kerosene and firewood are substitutes.

(4) Cost of some new energy technologies (e.g., solar electric power) may still be out of reach of rural households.

c. Social barriers

(1) Reluctance by foresters and households to plant new untested forest species.

(2) Reluctance by households to employ new energy technologies or appliances.

(3) Traditional control-enforcement approach of foresters and mutual hostility between villagers and foresters.

(4) Reluctance of villages to establish and maintain village wood lots.

(5) All four of the above barriers may reflect at least in part little or no effort on part of Government to inform the public of the nature and magnitude of the problem.

Issue 3: Actions Required to Help Overcome Barriers

a. Institutional actions

A new governmental body which draws on the various relevant line and general policy ministries is required due to the multiple and inter-related aspects of energy problems. The GSL has formed an Inter-Ministerial Energy Policy Planning Committee. This Committee has recently made recommendations to the Cabinet which may in turn lead to the establishment of a permanent energy body or authority. Consideration is reportedly being given to establishing a Ministry of Energy. An analytical capability should be created in whatever institution emerges in order to develop policy options consistent with development objectives on such issues as rural electrification, nuclear energy, etc.

b. Technical actions

(Note that several of these lines of action would simultaneously reduce pressures on forest resources and petroleum imports).

(1) Obtain improved information on domestic energy usage and on deforestation through cooperative government, university and donor efforts, employing low-cost sample survey techniques and satellite and aerial photography.

(2) Introduce higher-yielding species both for watershed protection and for fuelwood purposes on a pilot basis in reforestation efforts (e.g., Albizzia moluccana, Sesbania grandifolia, Leucaena leucocephala (Ipil-ipil), and Calliandra, spp).

(3) Employ improved planting techniques (seedling sleeves, augers, inter-cropping of tall (Calliandra) and short (Albizia) species, etc.) Select species and techniques through additional research which are more productive under (Sri Lankan) conditions.

(4) Refine low-cost techniques for more efficient utilization of forest and related agricultural waste (briquetting of sawdust, coconut waste, cane stalk and rice husk).

(5) Refine and introduce low-cost charcoaling kilns. Use charcoal, particularly in such industrial activities as tea, ceramic, brick, tobacco and steel manufacture to significantly improve the heat efficiency of fuelwood and simultaneously reduce demand for petroleum. Charcoal becomes economically superior to firewood as transport distance increases (beyond a distance of 30 to 45 miles based on one investigation in Sri Lanka).

(6) Refine and promote the introduction of efficient, low-cost household energy appliances. Closed hearth fireplaces or ovens sharply reduce the consumption of firewood compared to the open-hearth fireplace traditionally employed by rural households in Sri Lanka and other countries. Designs which have been developed in Sri Lanka and elsewhere can increase the heat efficiency of firewood by 50%, as well as increase the efficiency of charcoal and such waste products as paddy and coconut husk. Cost is typically low and some designs are feasible for construction by rural households. Developmental and promotional work on such devices should be re-invigorated and expanded. More efficient but still relatively low-cost kerosene lamps are also reportedly adaptable for household use.

(7) Identify, refine and apply low-cost technologies which tap local alternative energy sources. Selectivity is of great importance here. Large scale but low-cost solar installations are not yet on the immediate horizon. Costly R & D is still required. In these circumstances, an appropriate course for Sri Lanka would be to maintain adequate monitoring capability of developments in the industrial countries where massive R & D in this field is taking place. There are several areas, however, where the potential appears more promising for utilizing economically viable technologies on a small scale basis suitable for decentralized household, enterprise or village use and capable of being locally operated and maintained. These include (a) mini-hydro devices in the hill districts and in irrigation channels, (b) bio-gas generators where animal populations and vegetable wastes could provide sufficient raw material supply, (c) wind-powered water pumps, and (d) low heat-requirement solar devices (e.g., for fish curing, paddy drying, wood drying). Some activity in each of these areas is already underway in Sri Lanka or has been proposed. The complex, multi-source system utilizing storage batteries found in the UNEP-sponsored village pilot project in Southern Sri Lanka is reported to be high cost and to require operational expertise beyond the resources of the village. It is nonetheless an interesting

experiment to test the feasibility of an integrated, multi-source system at the village level (see Senadhipathy paper, p.11, for brief description). A regional center in Asia for R & D on alternative energy technologies has been suggested. A possible limitation to this approach is that relevant environmental and socio-economic conditions can be very country-specific.

c. Economic actions

Scarce resources, including energy resources, are allocated most efficiently when prices are permitted to reflect full cost. Exceptions made primarily for equity reasons are most effective when the subsidized price can be made to apply exclusively to the intended beneficiary group. For example, to compensate for the recent sharp increase in the price of kerosene, the GSL issued a limited number of kerosene coupons to households in the lower half of the income distribution. Public investment can be channelled into (1) resource and utilization surveys (in Sri Lanka, for improved information on household energy consumption, forest resources and deforestation, location of suitable mini-hydro sites and of peat deposits); (2) massive energy generation and distribution activities with high fixed costs (e.g., major hydro-generation and transmission); (3) resource generation and conservation activities where "external" (non-market) costs and benefits are significant (forestry); and (4) research, development and training in all areas, including alternative energy sources and appliances. External donors should consider support in these areas of capital costs, research and development, training, pilot projects, and dissemination of information on and promotion of utilization of already known and tested approaches and technologies.

d. Social actions

Improved knowledge of and sensitivity to the role of energy in local cultures can lead to formulation of approaches which overcome resistance to the use of new species, techniques and technologies. For example, women -- in rural Sri Lanka as in many countries -- play an important role in household energy consumption as gatherers of firewood and as preparers of food. This suggests that women should not only be consulted in the development of new technologies but that women should be employed as researchers and extension agents. Some women are employed as home economist/agricultural extension workers in Sri Lanka. Tree cultivation and improved firewood utilization could be added to their training. Knowledge of the culture is also essential if household or village wood lots are to be successfully encouraged. New approaches in place of the traditional role of foresters are required, such as the "forestry extension service" concept proposed for Sri Lanka. Under this approach, the forester would become an extension agent providing seed material, including new species, and advice to communities trying to establish village and homestead wood lots. Enforcement of laws and penalties against illicit tree felling would be turned over to district administration and law enforcement authorities. Such local level organizations as, in Sri Lanka, Rural Development Societies and Lanka Mahila Samitis (Women's Societies) could play a

constructive role in community reforestation efforts.

Issue 4: Types of External Assistance, Including Role of AID

General comments on types of external assistance have been indicated in the previous section. This section will focus on the AID role. AID's legislation would appear to exclude support for major power generation facilities except in special circumstances where there was strong assurance that the poor would benefit and that AID financing in a multi-donor context was essential. In Sri Lanka, other donors have been identified for major power generation projects.

The other areas mentioned in the previous sections fall clearly within AID's mandate. USAID/Sri Lanka is either about to provide assistance or is considering possible assistance in most of these areas. We anticipate initiation in January 1980 of a "Reforestation and Watershed Management" loan/grant project, to be implemented by the GSL's Forestry Department. This project represents the first donor-assisted, integrated approach in Sri Lanka to the inter-related problems of energy, environment, forestry and development. The main elements of the project would develop:

a. National Forest Inventory Map from LANDSAT imagery and the on-going USAID/GSL "Agricultural Base Mapping" Project;

b. National Forestry Research Program to pursue adaptive research on new and traditional varieties, planting, cultivation and harvesting techniques, hydrological problems, etc;

c. National Forestry Training Program to cover in-service and new hire, short term and long term, and para-professional as well as professional needs. Subject matter would include appropriate harvesting, extension and utilization techniques as well as biology, planting and cultivation;

d. National Forestry Extension Service to encourage and monitor the establishment of homestead and village wood lots through provision of seed materials, tree management information, etc.;

e. Nurseries and tree plantations in the upper catchment of the Mahaweli River to establish and protect watershed and stabilize the soil;

f. Fuelwood nursery plantations in and around the Mahaweli agricultural settlement areas; and

g. Charcoaling operations to promote effective utilization of timber cleared for the Mahaweli and fuelwood programs.

All three planting components (d-f) will utilize new fast-yielding species in substantial proportions.

The GSL and USAID intends to provide modest support under the Development Services and Training Grant for two pilot "alternative" energy type projects;

(1) placement of solar drying kilns (from the Forest Products Laboratory in Wisconsin) to be used for drying rubber wood, and

(2) re-design of petrol-powered fishing boats to be primarily sail-powered, supplemented by small diesel engines for minor manoeuvring.

In addition, USAID participant training grants have been made to two GSL officials for short-term energy policy-planning programs at the State University of New York at Stony Brook (SUNY). SUNY has also been assisting the Ceylon Electricity Board with surveys of urban and rural household energy consumption, and the rural energy study program of the East-West Center at Hawaii has established contacts with the GSL. The possibility of providing assistance for pilot utilization of rice husks as a source of energy for rice processing has also been discussed.

AID is supporting a major Environmental Assissment of the Mahaweli River Development Program. This assessment is being undertaken for the GSL by a 12-person multidisciplinary team from the U.S. consulting firm, TAMS. An interim report of the one-year effort, which began in July, is expected in December. The current phase of the Mahaweli Program, which is the focus of the assessment, is expected to settle over 100,000 families on newly irrigated land in downstream areas and through construction of a series of storage reservoirs and hydro facilities, meet a major share of Sri Lanka's growing electric power requirements over the next 15 years. The Program, which is expected to come to a total cost of over $1.6 billion, occupies a lead position in Sri Lanka's current development strategy. The Environmental Assessment is analyzing potential environmental impacts from the perspectives of hydrology, soils, wildlife, fish and forest resources, public health and epidemiology, economy, society and culture, and is to make implementable recommendations for avoiding or mitigating potentially adverse environmental consequences. Proposed AID financing of the downstream irrigation facilities for one of the sub-areas or "systems" is under consideration.

The Mission also has under consideration for FY 81 funding a modest "Alternative Rural Energy Technologies" project which would provide technical assistance, training and equipment for introduction of pilot projects for selected low-cost technologies that would tap such local, renewable sources as bio-gas, mini-hydro, solar energy and wind.

Although the possibility of assistance for extension of the national power grid for rural electrification is recognized in the FY 81 USAID/Sri Lanka Country Development Strategy Statement (CDSS), the Mission is not currently considering capital assistance in this area. AID has with Mission concurrence, supported through central funding to the National Rural Electric Cooperatives Association (NRECA), a recent study for the Ceylon Electricity Board of training needs for rural electrification. The Asian Development Bank is to provide a loan which will assist in meeting the capital resource requirements for expansion of rural electrification.

BANGLADESH

Energy, Forestry and the Environment

Peter Leifert*

The Problem

The development goals of Bangladesh will not be attained if the interrelated problems of the energy, forestry and environment sector are not solved. A rapidly increasing population, industrial development, growing urbanization, and year round, intensive agricultural practices are all contributing to worsening fuel scarcity, forest depletion, and environmental degradation. These problems will be analyzed in more detail in the next three sections.

Energy: 1/

A comprehensive energy study conducted by the Asian Development Bank in 1976 showed that 74% of Bangladesh's energy requirement is supplied by traditional fuels such as cow dung, rice hulls, and firewood. Non-traditional sources, specifically imported petroleum products and coal, indigenous natural gas, and hydroelectricity provide the remaining 26% of the country's total energy consumption. An analysis of this consumption pattern, as detailed in Table 1, indicates that the growing demand for energy is not likely to continue to be satisfied from these sources. This is due to a current population growth rate of 2.8% 2/ and an expected growth in commercial energy demand estimated from 8 to 15 % per year resulting from increases in agricultural, domestic, and industrial usage.

The demand for traditional fuels is expected to increase by 140% by the year 2000. On the supply side however, the availability of cow dung has not increased significantly over the last 10 years, as the livestock population has grown at less than a 1% annual rate. Due to shorter stem HYV plantation, the rice straw supply decreased by 10% from 1969 to 1974 and the trend should continue. The rice hull supply has increased with rice production but hulls are used basically in rice parboiling, cattle feed, and rice mill steam engines and little remains for other applications. Jute sticks have decreased in availability by approximately 20% since 1969 due to both a decrease in jute production and their growing value for other uses.

Accurate statistics on firewood, leaf, and twig (for fuel) availability are difficult to obtain; however, field reports have consistently stated that supplies are dimishing significantly while the price to purchase and effort needed to gather these materials have gone up. Bagasse for fuel is derived mainly from sugar cane whose production has declined by approximately 12% over the last 10 years.

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Table 1

Total Energy Consumption in Bangladesh (1974)

Category	Fuel Sources	% of Consumption of Category	% of Consumption of Total
Traditional	Cowdung	25	18
"	Rice straw	18	13
"	Rice hulls	24	18
"	Jute sticks	6	4
"	Firewood	3.5	3
"	Leaves & twigs	9	7
"	Bagasse	5.5	4
"	Other wastes	9	7
	Total all Traditional	100	
Non-Traditional	Petroleum	50	13
"	Natural gas	38	10
"	Coal	8	2
"	Hydro	4	1
	Total all Non-Traditional	100	
	Total All		100

In the category of non-traditional fuels, as in most countries of the world, the importation of increased amounts of petroleum and coal to satisfy growing transportation and electrical generation needs has been detrimental to the foreigh exchange reserve and balance of payments position. In this respect, more than 50% of Bangladesh's annual foreign exchange is being used for energy source imports. 3/ This includes a significant net outflow of foreign exchange to the oil producing Middle East. Foreign aid offered by Moslem, OPEC nations does not approach the amount Bangladesh must spend at current market prices for petroleum imports. Further, no special arrangement for reduced prices has granted Bangladesh due to its Moslem cultural or poverty status.

The prospects for greater use of hydro power within Bangladesh are limited by the flat deltaic nature of the land. Natural gas is used mostly for fertilizer production and as fuel for electrical power generation. This natural gas, the proven reserves of which are quite considerable, will provide a valuable indigenous natural resource input to the supply side of the energy equation. However, a limiting factor to the effectiveness of gas in solving the energy source problem is the anticipated prohibitive distribution costs related to meeting the demands of the rural sector.

Forestry ... 4/

The 1979 Statistical Yearbook of Bangladesh calculates total forest area in the country as 16% of total land area. However, ninety percent of these forested lands are in low population areas of difficult access. Moreover, much of what has been called "unclassified state forests" and new "reserve forests" are without tree cover, making a more realistic forest statistic in the order of 9-10%.

The second largest of these areas (30%) is in the south west of the country and is called the Subderbans. A 20 year felling cycle is employed in this estuarine and swampy territory which is entirely under the protection of the government in the "reserved" category. The main agents of destruction are man (encroachment and illegal lumbering), wind (typhoons with winds up to 120 miles per hour), rivers (shifting of the delta) and animals (deer, wild pigs and crabs being fond of various leaves, young shoots and seedlings).

The targest area, called the Chittagong Hill Tracts (56%), consists of both tropical wet-evergreen and tropical mixed evergreen in the northern section. While it is fairly large, it contributes a proportionately low level of timber and fuel for reasons of previous overcutting of accessible areas, inaccessibility of timbered zones, and political insecurity. The southern Hill Tracts contain large patches of savannah and plantations of mahogany and teak, with over 75% reported to have been badly exploited by shifting cultivators using "slash and burn" methods (jhuming) who have reduced a traditional ten year rotation to three years. This has been due to rapid increase in population and the formation (for hydroelectric generation) of Kaptai Lake. The creation of Kaptai Lake forced many plough cultivators to leave the flooded valley and resort to jhuming. More will be said on the amplified effect of this shift in the cultivation pattern in the next section on environment.

Per capita consumption of timber for wood based industries, construction, and fuel, has decreased by over 50% since 1965-66 5/ . This has caused more intensive use of agricultural residues for fuel and increased consumption of bamboo for construction. Thus, in order to meet future projected requirements of timber, fuelwood, and bamboo, the Department of Forests has planned expanded harvesting operations and the acceleration of clear cutting and replantation cycles from the present 65, 40, and 30 year managed conversion periods to a 40 and 20 year harvesting cycle.

In addition, the Department of Forest of the Ministry of Agriculture and Forestry is proposing the following strategy as input to the government's next 5 year plan (1980-84):

1. Accelerated cutting of the high, difficult access forests through infrastructure creation and training and expansion of numbers of forestry personnel.

2. Aforestation and reafforestation of existing "reserved" forest lands.

3. Waste reduction in forestry and related forest product production.

4. Replenishment of homestead tree and bamboo plantations through propaganda, seedling distribution, and non-monetary short term incentives.

5. Reduction of use of regular wood in favor of panel products, especially in the use of particle board for furniture production.

6. Optimization of use of existing industrial capacity.

In order to implement this program, it has been estimated that the BDG forestry budget will have to be increased by between 16 and 28 percent each year through 1985. This is obviously quite doubtful in a land of scarce financial resources and perennial short term crises.

Also of potential importance is a plan recently announced by the President to greatly increase the number of trees planted in homesteads and village woodlots. This is not a totally new idea however, as seedlings have been distributed in the past by the government. In the newly announced program as in the past, the rural populace has as yet been offered no incentives nor has a competent government implementation infrastructure been created to distribute, provide extension services, monitor, or evaluate progress.

...and the Environment 6/

Those acquainted with Lester Brown's book, The Twenty Ninth Day should easily comprehend the building enironmental crisis within Bangladesh. Bangladesh, the larger geographic region known as Bengal, and neighboring Nepal, may be rapidly becoming the proof of his thesis. In the author's opinion, after reaching the limit of productivity of a region's cropping, grazing, and forestry systems, the resource base itself begins to be eaten away. Also it is uncertain that the application of additional labor or capital resources is able to reverse the trend to erode this resource base.

While recognizing the global nature of the environmental damage, a general analysis of environment as air, water, and noise pollution, or environment as "the quality of life" or "life in its totality" is beyond the scope of this paper. Rather, the rest of this section will deal with an examination of how the system in Bangladesh has begun to break down.

Undoubtedly, a colonialist history has contributed to the environmental plight of Bangladesh. However, when discussing the current predicament, population and the immense pressure induced by crowding approximately 87 million people into a country slightly smaller than Wisconsin, must be understood to be the pre-eminent causal variable in the equation. A population density of approximately 1600 people per square mile 7/ (the United States has approximately 60) has been evolved primarily through a lowering of the mortality rate caused by improved health science & services. The three examples which follow illustrate how devastating this population growth has been.

1. Jhum (swidden) cultivation in the Chittagong Hill Tracts in southeast Bangladesh is rapidly destroying 3400 square miles of "unclassified state forests" (40% of total Bangladesh forest area). Only one quarter presently remains under trees. 8/ The deterioration of these forests is directly attributable to shifting, slash and burn cultivators, as previously outlined. This type of cultivation has destroyed the higher forests, spread weeds, and intensified erosion. In this area of steep slopes and high population density, soil conservation is becoming a very real problem. Flooding due to rapid rainwater runoff during the monsoon season has become a particular problem of valley people.

   In sufficient river flow during the dry season has already caused the temporary shut down of the hydroelectric generators at Kaptai Lake (1979) causing significant problems to the sections of the economy which rely on this source of power. The lake itself, due to silting from the higher, denuded lands, is considered by some to be in peril. 9/ This silting is also changing the character of the Karnaphuli, Sangu, and Matamuhuri river beds, raising them by continuous deposition and causing floods in the surrounding areas. Horticulture projects and terracing schemes are being employed to decrease the rate of degradation. These efforts however, are hampered by an unstable political situation, the difficulty of introducing new cultural/economic practices, and the lack of raw materials for terracing projects.

2. The northeastern region of the country originally contained little natural forest, but due to increasing population pressures even that has been destroyed. At present the lack of forests and water shed management has caused what some refer to as predesertic conditions and others as complete desertification in an area of approximately 3000 sq. miles. This desertification is reported to be spreading yearly.

3. The Padma, Brahmaputra and Teesta Rivers originate in the Himalaya Mountains in Nepal and Bhutan. Due to the over exploitation of forests in northern Bangladesh, West Bengal (India), and the countries to the north; overclearing and cultivation in these areas; and terrace cultivation in the Himalayan hills, soil erosion and higher runoff rates are occurring on a massive scale. These major Bangladesh rivers, as the outlets for the northern rain waters and snow melt, are being adversely affected by the upriver soil erosion taking place.

   The soil deposited in the rivers is raising the river beds causing "chars" and sand bars which subsequently cause river bank erosion due to the inability of the rivers to contain the heavy water flow. The flooding of vast tracts of land adjacent to the rivers has caused considerable yearly crop damage and loss of human life. So far, dredging and embankment projects have not been successful in countering this situation which has been in progress for hundreds of years but only recently has developed into a negative environmental factor. With increasing population and use, embankment overflows are no longer slight, simply depositing nutrient laden silt on the land affected. Soil fertility is now more often adversely affected as more top soil is being carried off than deposited.

The Barriers

As noted in the Missions FY 1981 Country Development Strategy Statement

(CDSS), in the major constraints to growth with equity in Bangladesh are: population growth, the HYV production strategy, foodgrain distribution and procurement policies, land tenure, lack of basic infrastructure, BDG control of industry, and political and institutional weakness. In addition, the areas of energy, forestry, and the environment suffer from a related, inadequate level of technological and management expertise. Two indicative examples of barriers to solving the previously outlined problems follow.

1. In the area of energy institutions, there is currently no adequate BDG planning, coordination and policy making body. Applied research and pilot project activities in the field of renewable energy sources are being carried out by various ministries and institutions with little coordination or pooling of resources. For example, to date, seven single or multiple family bio-gas generation pilot plans have been built by four organizations. 10/ Of these, five are presently functioning. One of the four groups, through international donor assistance, is attempting to initiate a large scale implementation program, even though its design is not cost efficient. Indeed, its design is not even the most cost efficient among the seven pilot plants which have been built.

2. There are currently some 500 employees of the Forestry Department who have obtained some post high school training in forestry (this inculdes less than 50 university degree holders). These trained officer's are enjoined with the tasks of overseeing regeneration, harvesting and marketing of the produce and protection of the forests themselves, in addition to conducting research and education programs. In most locations, such as the Chittagong Hill Tracts, where in one section a single forester has the responsibility for 40,000 acres, it is impossible for these experts to perform all of their dictated functions. Most time is spent in supervising the marketing of the forest products. Afforestation programs and research are of a lower priority due to the high, immediate demand for timber and allied produce. While dedicating himself to the marketing responsibility, a great deal of theft of timber takes place - estimates usually range around 50% of forest outputs. Allegedly, low salaries and lack of adequate fiscalization have contributed to corruption in the Forestry Department so that illicit timbering operations are encouraged and/or coordinated by amny foresters themselves. In this regard, an outside consultant working with a central BDG planning agency voiced the opinion that a primary necessity for improvement of the forestry sector is the reorganization of the Forestry Department itself.

Policy and Strategy Design

In attempting to formulate policy and delineate roles and the nature of external assistance in an energy, environment, and forestry development strategy, we must recognize that we are dealing with a system of significant complexity and change. In Bangladesh, for example, government priorities and attention fluctuate as crises arise and scarce domestic development resources are redirected and/or over-extended. In the three areas of this paper's concern, a change in one will most likely affect the others, thus adding to the complexity of the situation under analysis.

This complexity leaves two strategy design options: 1) to define roles and a detailed assistance strategy which may undergo constant modification as resources and conditions change; and 2) to define a strategy in broad enough terms as to allow for any actions deemed necessary at any point during the policy implementation period.

In simple situations, a successful strategy under the first option may be no problem to formulate. Indeed, it may be so obvious as to require little or no conscious thought, i.e.,...to cross the lake, I must get into the canoe and paddle. In more complex situations, a strategy under this same option may become quite detailed and require numerous revisions as conditions change..... increasing a company's share of total market sales can rely on adjustments in advertising, packaging, pricing, etc. to changes in demand/preference variables.

Complex strategies are usually a series of, "if this/then that" or action/reaction sets. With future values unknown for some variables (interest rates, for example) or a lack of capability to identify what significant future variables will be (such as technological breakthroughs), attainment of goals can depend on the flexibility allowed in modifying a plan of action and the speed with which this modification may be made. Even in the more simple circumstances, this flexibility is necessary....would I paddle across the lake if a storm suddenly appeared?

When considering these two options, we should also draw on the American domestic experience where outlining, defining, gaining acceptability for, and initiating the implementation of a detailed energy policy continues to be a massive task. In countries such as Bangladesh, there are more significant political and technological limitations and even greater slowness in the bureaucracy's recognition, and project implementation capacity.

Between these two options then, the more broadly defined, flexible system appears to be the logical choice. This is true, not because it is more desirable but because our first option is impractical given the complexity and limitations to formulating such a comprehensive, "contingency plan" system.

Proposed Program and Roles

Each project undertaken under the guidance of the defined area strategy will be individualistic in nature. In general, roles and resources along with barriers to implementation will change from project to project and country to country. As an example, a Ministry of Rural Development or the like any be an effective vehicle of extension activities in one country while in another, such as Bangladesh, no efficient government extension mechanism may exist.

For Bangladesh, an energy, forestry, and environment development strategy should recognize the limitations of the government's capacity to administer large-scale development efforts. Lack of trained manpower, bureaucratic inefficiencies, corruption, and political limitations, amongst other variables, are considerations in the development programming process.

In this, context, the role of an external donor agency in Bangladesh may well be all inclusive. While attempting to be a development catalyst, the donor's role is also one of identifying a development problem area, determining possible action programs and evaluating the capabilities of potential counterparts to perform project activities. It is also one of providing a wide range of technical and administrative assistance, training, and/or furnishing commodity inputs, after taking the lead in the design of the project itself. Projects which are "of the people and by the people", are more desirable in many ways and should be encouraged. Given government institutional and political weakness and past experience, however, indications are that the lead in development work must come from the donor community until the slow process of building an indigenous capacity has been consummated.

In recognition of the seriousness of this state of affairs, in addition to its high priority on the development hierarchy, the following AID actions are proposed:

1. The establishment of an easily accessible source of funds for short-term IOC or PSC consultancies. This pool of funds, made available by the Asia Bureau, will be accessible for the Missions to assist project development or related research efforts on a short notice basis. This regional funding source should also make reasonable amounts of funding available to host country and expatriate organizations and individuals in order to encourage development and implementation of efforts in concerned areas. A mechanism which contains some similarities to this proposal is the Improved Rural Technology Project which has recently been implemented by AID AFR/RA.

2. The establishment of a position(s) of "Regional Energy Advisor" (REA) similar in design to the Regional Legal Advisor or Regional Engineer. The REA would provide assistance in project development and liaison between USAIDs and between the USAIDs and AID/W.

3. Maximum use of the private business sector through the provision of aid and other donor incentives. This effort will be aimed at encouraging such things as joint development ventures between U.S. and host country forest product firms in afforestation and reafforestation programs, and the manufacture of alternative energy devices, under license, with technical assistance provided by developed country commercial corporations.

4. AID resources should be allocated to the maximum possible extent in such a way as to satisfy individual country development program needs. This would minimize regional studies funding of a more academic and statistical nature. Such studies are currently being financed by a number of different bi-or multi-lateral donors, including AID. This duplication of effort and the academic nature of some of the studies themselves contribute little to the resolution of individual country development problems.

5. Establishment of an ASIA Bureau policy which recognizes the need for maximum flexibility in project design. This policy will recognize the significant devergence of needs from country to country and place minimum limitations on the design of development efforts.

6. The policy as elaborated should include a provision for the subsequent designing of an implementation strategy which recognized the individual nature of each country's concerns. Each Mission, with AID/W expert assistance, will be responsible for negotiating a combined development strategy in the concerned areas jointly with host government planning officials. These combined strategy statements, prepared in the Misssions and approved in Washington, will form the basis for future Mission development efforts. In this way, AID contributions to host country development efforts may be efficiently incorporated into host country planning strategies according to their hierarchy of needs. By developing a joint strategy statement (host government - USAIDs - AID/W), the entities concerned may more effectively plan and implement development programs, having been assured of agreement on strategy, needs and availability of material and financial resources.

Footnotes:

1/ All data in "Energy" section taken from Source Nos. 1,2,3,&7

2/ USAID Population Division Statistic

3/ Source - Bangladesh Council of Scientific and Industrial Research (BCSIR)

4/ Data in "Forestry" section taken from sources Nos.4,5,6,8,&10

5/ Source No. 1

6/ Data for "Environment" section taken from sources Nos.7,8,&10

7/ Current estimated population of 87 million people living on 52 thousand square mile of land.

8/ Source No. 10

9/ Source No. 7

10/ Source No.11

SOURCES

1. 1979 - Statistical Yearbook of Bangladesh, Bangladesh Bureau of Statics, Ministry of Planning.

2. "Bangladesh Energy Study," administered by Asian Development Bank and funded by UNDP, 11/76.

3. World Bank, "Staff Appraisal Report of Greater Khulna Power Distribution Project," 5/79.

4. "A Study on Forestry," Aliff International, Prepared for General Economics and Planning Division, Planning Commission, BDG.

5. "Supply and Demand of Forest Product and Future Development Strategies Project Document," UNDP, for Agricultural Division, Planning Commission.

6. Draft, "Perspective Plan (1980-2000)" and draft, "Second Five Year Plan" of Forestry Department, Ministry of Agriculture and Forestry, BDG.

7. "Deforestation and Ecological Hazards in Bangladesh," article in Bangladesh Observer by M.N. Nabi on 8/30/79.

8. "An Estimate of Long Term Timber Trends and Prospects in East Pakistan," by A.K.M.G. Rabbani and M. Hussain, 1965.

9. "Energy System and Prostpect of New Sources of Energy for Bangladesh - A Test Case," M.N. Islam - paper presented to First International Symposium on Policy Analysis and Information Systems, Duke University, Durham, N.C. U.S.A., 6/79.

10. Geography of Bangladesh, H.E. Rashid, University Press Limited, Dacca, Bangladesh, 1977.

11. "Bio-gas Plant in Bangladesh," pamphlet by Agriculture Information Service, Ministry of Agriculture and Forestry, 1978.

PAKISTAN

Energy Issues

Issue No. 1 - Major Problems

A. Oil Import Bill

Pakistan is dependent on oil for 48% of its commercial energy needs.

Only 10% of the total oil required is produced locally, the remaining being imported from the Middle East.

Oil Bill has shot up from US Dols 152.4 million in fiscal year (FY) 1973-74 to Dols. 925.0 million during the current (1979-80) financial year.

The estimated expenditure on oil accounts for 24% of the projected imports and 53% of the expected commodity exports. This is about 46% of the Dols.2 billion annual trade deficit expected to continue at least for the next five years.

B. Exploitation of Energy Potentials

Probable coal and oil reserves are limited.

Country is rich in natural gas (over 17 trillion cubic feet) and Hydel (above 9,000 megawatts) generation.

Proper exploitation of these potentials require heavy financial commitment not available to Pakistan.

C. Energy Comsumption Patterns

Consumption of oil products is biased towards the middle distillates (jet fuel, kerosene, and diesel) necessitating extension of the present annual refinery capacity of 4.7 million tons of import of middle distillates directly.

Intensive technology requiring excessive energy consumption is synonymous with modernism and the trend is likely to continue.

Rural economy receives small proportion of the total commercial energy supply, both domestically produced and imported.

Government appears to lack interest in the development of non-conventional energy, other than nuclear.

D. Pakistan is a Wood_Deficient Country

About 35% of its commercial wood needs have to be imported.

Imports of timber and wood-based products, principally long fiber pulp and papers (mainly newsprint) were about Dol 51 million for 1977.

Timber prices high, almost double those in North America and Europe.

Non-commercial wood demand, mainly for firewood, are substantial.

E. Denudation of Forests

Use of non-commercial energy sources results in reduction in the supply of cow dung (which is used as fertilizer), depleting the forestry wealth, and leading to the erosion of the soil and silting of dam reservoirs and river basins.

Forested areas, mostly unproductive scrub forests, presently account for only 3.7% of the total land area against a desirable 20% (compared with 32% in U.S.A.).

Over-grazing

F. Environmental Considerations

Pollution has reached a stage of inviting public attention.

Desertification-desert encroachment on productive areas in the Province of Baluchistan has reached an alarming level.

Pakistan's major environmental problems, however, are waterlogging and salinity. By 1977-78 an estimated 26 million acres of land required protection from waterlogging and salinity.

Issue No. 2 - Major Problems

A. Natural

Country's energy resource endowments are limited.

Salinity and waterlogging are primarily on account of rise in ground watertable and increase in river water salinity.

No research has come to surface that could suggest whether human errors have aggravated desertification.

B. Political/Institutional

Possible fuel reserves are reported to be in the politically volatile Province of Baluchistan.

The government presently deems it advisable to stop the inflow of Afghan Refugees in the forested northern areas.

Energy and water resources sectors managed by the government appear to lack incentives common in commercial operations

C. Economic

Gross domestic product (GDP) has grown at slightly over 3% during 1973-78 against growth in energy consumption by nearly 7% per annum. Pakistan is a chronic case of deficit in budget and balance of payments, and its development expenditure (non-recurrent) is largely financed externally.

The fifth plan allocation of Dol 3,350 million for the energy sector and Dol 670 for drainage and reclamation is not concomitant with the size of the problems.

D. Technical

Availability of technical manpower is limited. Technical personnel are inclined to emigrate to the Middle East.

Research on finding a solution for waterlogging salinity has been limited. What research has accomplished did not result in viable solutions.

Lack of specific land-use clarification and lack of a long-range plan coordinating forestry, livestock and other agricultural practices.

E. Social and Cultural

Excessive use of energy is treated as a symbol of affluence and fails to attract social condemnation.

Pressures from high population growth rates and population intensity, which result in high demand for firewood, aggrevates deforestation problem.

Absentee ownership and the lack of incentive for squatters/ sharecroppers to protect and maintain property belonging to others.

Poverty levels that force most rural people to be unconcerned with long-term problems since they tend to view life in more basic terms, i.e., survival.

Issue No. 3 - Required Action

A. By the Government

Arrest and perhaps reverse the trend towards divergence between the GDP and energy consumption growth rates.

Reduce energy consumption through public education and efficient management.

Intensify oil exploration. Exploration now very slow. Government blame companies doing exploration and vice versa.

Promote the development of proven oil and gas reserves.

Institutionalize and strengthen research capabilities.

Evolve a realistic plan to check the immigration of technical workers.

Concentrate on the development of non-conventional energy, especially solar biogas and small hydro-electric plants.

Development of comprehensive long-range forestry development plan including institutional development, training, land classification and integration of forestry, livestock, etc., and introduction of incentives to private owners to increase and introduce better management practices of forested areas.

B. By the Private Sector

Accelerate exploration and development of oil and gas. Exploration is now in the hands of eleven international companies.

Promote forestation particularly in areas suitable for orchards (fruits and nuts) and for fast-growing timber species.

C. By the International Donors

Appreciate further Pakistan's economic difficulties, likely to be accentuated through the presently reduced net aid inflows.

Provide liberal technical assistance.

More involvement in non-conventional energy initiatives such as solar, biogas, wind, etc.

More involvement in rural oriented energy projects such as rural electrification. (with curtailment of U.S. aid, no international donor is currently involved in financing rural electrification projects in Pakistan).

Issue No. 4 - External Assistance

We don't envision a role for AID assistance in the near term.

Our experience indicates that other external assistance should focus on the development and strengthening of Pakistani public and private institutions working with conventional and non-conventional energy, environmental matters and forestation.

In addition to the institutional development aspect, training, pilotprojects, and importation of appropriate technology, are examples of desirable external assistance.

Energy and Development in Asia: A Regional Perspective

Robert F. Ichord, Jr.*

I. Energy Problems as Major Constraints to Development

The process of agriculture and industrial development has historically involved the introduction and substitution of inanimate energy and capital for animal and human power and labor. Although increasing attention is being given to the possibility of decoupling energy and GNP growth, expanding production and incomes in developing Asian countries will require large increases in energy consumption. Substantial capital investments will be needed to produce, convert, distribute, and utilize indigenous and imported energy resources.

Commercial energy consumption has been increasing in most of the AID-assisted countries in Asia. During the period 1970-76, India, Indonesia, the Philippines, and Thailand experienced an annual average growth rate of nearly 5% or over. (See Table I). A major share of expanding commercial energy demands in these countries, as well as in Bangladesh, Sri Lanka, Nepal and Fiji, is being supplied by imported petroleum. Even Indonesia, a net exporter and member of OPEC, has been importing Middle East oil for domestic consumption while exporting its premium, low-sulphur crude oil to Japan and the United States. Oil accounts for over 80% of commercial energy consumption in Sri Lanka, Thailand, the Philippines, Nepal, Indonesia and Fiji. (See Table II)

The eight-fold increases in world oil prices since 1973 have seriously exacerbated the economic problems of the oil-importing Asian countries and contributed to their increasing external debts (See Table I). The combined cost of the oil imports of India, Thailand, and the Philippines in 1978 was over $4 billion. (See Table III) Although governments have tried to insulate domestic consumers from the full impact of the oil price increases, domestic retail prices have been increased, resulting in slower economic growth and higher inflation rates. Political demonstrations and strikes have sometimes followed from these price increases, particularly by urban labor groups.

The future prognosis for world oil prices is a pessimistic one, since the restrictive production policies of leading oil exporting countries will likely result in continued upward pressure on world oil prices. The Iranian crisis illustrated the tenuous nature of the international supply system and cut-backs in crude deliveries to Asian countries resulted in shortages in several countries. For example, lack of diesel fuel grounded half of Thailand's fishing fleet and halted irrigation pumps in India.

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These trends call into question the viability of past development models based on plentiful, low-cost petroleum. Even if current per capital oil consumption remains the same, projected increases in population alone would increase petroleum demand in the seven AID-assisted countries by almost 600,000 barrels per day by the year 2000. (See Table IV) Although the World Bank estimates the potential petroleum resources of Thailand, India, and the Philippines as "very high" and of Bangladesh as "high", it is extremely unlikely that such a future level of demand could be met by indigenous production. Yet, increasing production and incomes in Asia, especially in the rural areas, will require increasing amounts of energy. Where will this energy come from and at what costs to Asian socities?

The countries of concern, with the exception of Fiji, do have indigenous energy sources that can help to substitute, in varying degrees, for oil. Table V gives the major potential conventional energy options using indigenous energy resources. Yet, it is important to remember that a substantial percentage of total energy consumption in these countries comes from "non-commercial" or traditional sources. The majority of the rural population depends on these fuels. A rought estimate of the breakdown between commercial and traditional sources is shown in Table VI. Data on the use of traditional sources is, however, fragmentary and longitudinal analysis is almost impossible. A recent World Bank study projects an increasing consumption of fuelwood and charcoal for all eight countries from 1976 levels as estimated by the FAO. (See Table VII)

This likely growth in demand will add to major existing pressures on the land and forests. Over the next 10-15 years, and even sooner in some cases, we may see many of the same negative environmental and productivity impacts as are currently evident in Nepal, if actions are not taken to protect the remaining forests.

Increases in agricultural production are critical to reducing pressures for clearing of lands and to developing the domestic savings from which to finance new capital and social investments. Exports of agricultural products have traditionally been the mainstay of many of these countries. Currently, though, an increasing percentage of the earnings from these export sales are going to pay for more expensive petroleum imports that are consumed largely in the urban areas.

A major problem is the subtantial losses and inefficiencies that occur during the growing, harvesting, drying, storage, milling, and marketing of the agricultural produce. Schemes to improve this situation involve the expanded application of energy and energy-related technologies (e.g. irrigation pumps, fertilizers, crop dryers, mechanized plows and transport, refrigeration).

Energy is also a critical ingredient in improving health, through such applications as water purification, refrigeration of medicines, hot water for washing dishes and treating cuts and injuries, and space heating in colder mountain climates. Likewise, energy is essential to the operation of radios, TVs and other communications device that can accelerate and broaden educational opportunities.

And there is some evidence from programs in the Philippines that a causal relationship exists between rural electrification and declining birth rates.

In sum, whether Asian societies will be able to provide sufficient food, water, shelter, employment, health and educational services to their growing populations, will depend in considerable measure on the improved availability and distribution of energy and on the more effective management of forest and other natural resources.

The Asian developing countries are, however, caught in a dilemma. The costs of supplying energy in programs to increase agricultural production, improve health and education and provide electricity are soaring and are assuming an increasingly large percentage of overall expenditures on development programs. Traditional fuel sources used by the poor are being rapidly depleted and the cost of commercial substitutes is prohibitive for these groups, even at highly subsidized prices. At the same time, rising costs of oil imports and of technologies for developing indigenous energy resources are constraining the growth in finances available for development programs.

II. Barriers to Overcoming these Problems

Serious economic, technical, political and cultural barriers exist to overcoming this dilemma. Asian developing countries are limited in their ability to finance the importation and/or indigenous manufacture of energy technologies and devices (coal, geothermal, nuclear, oil, natural gas, solar, hydro) that can develop and convert indigenous energy resources. As in the industrial countries, subsidized prices for petroleum and electricity, while serving important distributive social goals, would seem to discourage investments in higher-cost alternatives, in the absence of at least as advantageous subsidies for the alternatives.

Inadequate technical knowledge of the resource base, use patterns, and the options for developing or restoring (in the case of reforestation) indigenous resources is clearly an important factor inhibiting the development of effective policies. The unproven technical reliability, as well as the high per unit cost, of certain new and renewable energy technologies hinders their acceptance and use as a substitute for traditional

and conventional energy sources.

Political and institutional forces, of course, have a major influence on the allocation of resources to deal with these problems. Political interests combine in certain cases to block the implementation of reforestation programs. The administrative capability of governments to implement effective policies is lacking in a number of countries. And restrictive or exclusionary policies toward foreign private investment in energy resource development in certain countries hamper progress on reducing oil-import dependence. On the other hand, the irresponsible actions of certain foreign investors and their domestic associates results in exploitation of forest resources without concern for the environmental consequences.

Cultural and educational barriers may also substantially inhibit the introduction of energy-producing or -saving technologies or techniques at all levels of society.

III. Action Possibilities

A wide range of actions is required to deal with the above problems and barriers. Governments must make concerted efforts to develop national policies that integrate energy, forestry, and environment concerns within an overall development framework. The establishment of an information flow from the key areas and groups affected is a prerequisite to developing sound policies. Coercive and uninformed bureaucratic intervention in local communities creates confrontation and delays the design of cooperative programs that combine local and central government resources.

Governments should take, and in most instances they are taking, a more rational perspective toward the multinational companies and the technical/capital resources they have at their disposal. Donors should supplement public and private sector expenditures through capital and technical assistance in energy, forestry and environmental surveys; in the research, development, and demonstration of new technologies; in training and institution building; and in the exploration and development of conventional energy resources. Donors can play an important role in fostering information exchange between countries on experiences in particular technologies or reforestation programs.

IV. AID's Role

AID has a critical role to play in increasing understanding of the energy implications of alternative development strategies,

particularly those oriented toward improving incomes for the rural poor. The focus on this equity dimension of development should not preclude the consideration of the larger energy supply and demand management issues facing Asian governments. National decisions on energy technologies and pricing policies will, because of the strategic nature of energy in modernization, condition the overall pattern of economic growth in the country. In other words, investments in programs to meet basic human needs will be fundamentally influenced by macro energy policy decisions.

We propose that AID/Asia Bureau programs in energy should emphasize efficiency in energy use (both traditional and conventional energy) and the development of alternative, especially renewable, energy resources for meeting basic development needs over the next 20 years. A 1973 study sponsored by the Rockefeller Foundation on "International Energy Supply: A Perspective from the Industrial World" concluded: "The development of alternative energy sources may help developing countries to restructure their long-term economic development plans in the light of the prospective world energy situation, and to design development strategies that avoid their becoming 'hooked' on oil in the way industrial countries are now."

In the area of renewable energy alternatives, a number of technologies currently exist that can be matched with important tasks in both the rural and industrial/commercial sectors. (See Table VIII) While many of these technologies have extremely high initial costs, their operating costs are generally assumed to be lower; and they can be produced domestically with indigenous design or licensed foreign technology. Their decentralized nature is also well-suited to off-grid applications. The prospect is for major reductions in the cost of many of these technologies by 1985 (See Table IX) Thus, their costs are declining while those of petroleum and other non-renewable energy sources are rising.

AID/Asia Bureau programs can therefore help accelerate this transition as well as draw on the USG-supported solar RD&D program, which at close to $1 billion in FY80 is by far the largest in the world.

The United States Government should, of course, continue to support capital assistance to Asian countries by the World Bank and Asian Development Bank for conventional energy resource exploration and development. While AID should help in low-cost preliminary resource surveys, our primary role should be to assist Asian countries assess the potential role of renewable energy sources in meeting both near-term and longer-term energy needs. Five years from now the countries we help should be able to answer questions as to the economic, technical, environmental, and social feasibility of selected

technologies in the areas of solar thermal, solar electric, wind conversion, biomass conversion, mini-hydro, passive solar design, and conservation.

To accomplish this goal, our projects must be designed so we can meaningfully compare and generalize from the results. In addition, the assessment and evaluation of renewable energy technologies must be done with respect to the full range of options, including nuclear power in certain cases. Such a comprehensive approach is essential in order for the U.S. not to be viewed as pushing an inappropriate technology on the developing countries while we use oil and conventional resources. The experience of the Atoms for Peace program contains important lessons with respect to pushing a particular technology without concern for the total development context.

Finally, in our efforts to increase the efficiency of energy use and develop renewable energy technologies, we must be guided by the fact that energy is but a means to an end. Its production and use can degrade as well as improve the physical quality of life. Planning must increasingly take into account the distributive aspects of energy development and consumption, whether centralized or decentralized, whether intra-national or international.

Table 1

Country	Commercial Energy Consumption MB/doe 1976	Commercial Energy Consumption Growth Rate	Oil Consumption MB/d 1976	Oil Consumption Growth Rate	Net Oil Imports MB/d 1976	Net Oil Imports Growth Rate
Bangladesh	37	na	16	na	23	na
Sri Lanka	20	-4.3	18	5.3	28	-4.5
India	1861	5.4	403	5.3	327	6.9
Nepal	2	0.0	2	0.0	2	0.0
Indonesia	426	14.8	359	19.4	-	-
Philippines	201	4.9	190	4.5	211	5.9
Thailand	185	7.0	175	6.8	175	8.5

Country	Oil Cons./Capita B/P/Yr.	Oil Cons./Capita Growth Rate	Balance of payments (mill.$) 1970	Balance of payments (mill.$) 1976	External Public Debt (mill.$) 1970	External Public Debt (mill.$) 1976
Bangladesh	0.07	na	na	-260	na	1943
Sri Lanka	0.5	-5.5	-68	-6	311	682
India	0.2	0.0	-453	1063	7935	12392
Nepal	0.1	0.0	na	39	3	44
Indonesia	1.0	16.5	-358	-1054	2505	10141
Philippines	1.6	2.3	- 55	-1101	635	2126
Thailand	1.5	3.8	-231	- 577	322	822

Source: Petroleum Economist, October, 1976

Table II

Composition of Commercial Energy Demand
in Selected Asian Countries: 1976 (%)

Country	Coal	Oil	Gas	Hydro/Nuclear
Bangladesh	12.5	44.1	40.9	2.4
India	73.7	21.7	1.1	3.5
Sri Lanka	0.3	90.2	-	9.6
Thailand	1.0	94.5	-	3.5
Philippines	1.2	94.6	-	4.2
Nepal	5.8	81.1	-	13.0
Indonesia	0.7	84.3	1.4	0.7
Fiji	3.8	96.2	-	-

Source: United Nations

Table III

Cost of Net Petroleum Imports in Selected Asian Countries: 1978

Country	Cost ($ million)	% of Imports	Debt Service Ratio
Bangladesh	$152	12%	12.6%
India	2,010	25.7	16.2
Sri Lanka	250	24.8	17.0
Thailand	1,130	22	4.0 (public)
Philippines	1,030	33	19
Nepal	25	12	3
Fiji	44	13 (1977)	4.4 (1977)

Table IV

Projected Future Oil Consumption in Year 2000 under Constant Per Capita Oil Consumption

Country	Population (millions)	Per Capita Oil Consumption (barrel/person/year)	Total Oil Consumption (thousand b/d)
Indonesia	135.2 (1976) 198 (2000)	1.0 (1976)	359 (1976) 542 (2000)
Bangladesh	80.4 (1976) 146 (2000)	.07	16 (1976) 28 (2000)
India	620.4 (1976) 958 (2000)	0.2	403 (1976) 525 (2000)
Thailand	43 (1976) 76 (2000)	1.5	175 (1976) 312 (2000)
Philippines	43.3 (1976) 75 (2000)	1.6	190 (1976) 328 (2000)
Sri Lanka	13.8 (1976) 21 (2000)	0.5	18 (1976) 29 (2000)
Nepal	12.9 (1976) 22 (2000)	0.1	2 (1976) 6 (2000)
		Total	1163 (1976) 1770 (2000)

Sources: Petroleum Economist (See Table I); World Bank, World Development Report, 1978.

Table V

Major Alternative Energy Supply Options Using Indigenous Resources

Philippines: hydro, geothermal

Thailand: lignite, natural gas

India: coal

Sri Lanka: hydro

Bangladesh: natural gas

Indonesia: coal, natural gas, geothermal

Nepal: hydro

Table VI

Estimated Current Percentage Breakdown between Commercial & Non-Commercial Energy Consumption

Country	Commercial	Non-Commercial
Bangladesh	26%	74%
India	65	35
Sri Lanka	40	60
Thailand	46	54
Philippines	60	40
Nepal	4	96
Indonesia	48	52
Fiji	40	60

Table VII

Estimates of Fuelwood and Charcoal Use: In Selected Asian Countries
1976 and 1985 (Projected)
Million GJ

Country	FAO 1976	%	World Bank Projection 1985	%
Nepal	94.61	2.9	107.10	2.8
India	1285.19	40.0	1482.70	38.3
Sri Lanka	45.95	1.4	52.28	1.3
Bangladesh	152.38	4.7	231.03	6.0
Indonesia	1207.12	37.6	1484.76	38.4
Fiji	.12	0.0	.05	0.0
Philippines	249.69	7.8	307.46	8.0
Thailand	174.99	5.5	201.00	5.2
Total	3210.05		3866.38	

Source: World Bank Staff Paper #346

1 GJ = 0.17 Barrels of Crude Oil

TABLE VIII

Some Examples of Industrial/Commercial Applications and Technologies

Technologies \ Application	Freezing for food process	Cold storage plants (food & medical supplies)	Mining operations (electrical	Aqueduct water pumping for urban areas	Hot water for food processing & boiling	Industrial process steam	Process heat for textile dyeing & drying	Hot water for hotels & general use	Refrigeration for food storage & processing.	Irrigation for export agriculture	Desalination	Concrete block curing	Lumber drying
Solar thermal (flat plate & evacuated tube	N	N	N	N	C	N	N	C	N	C		C	C
Concentrating solar termal (electric & mechanical)	N	N	N	N	N	N	N	N	N	N		N	N
Solar Ponds					C		C	C					
Biomass (direct combustion low blu gas)					C	C	C	C				C	C
Biomass (anaerobic digestion)								C					
Biomass (fermentation)			C										
Biomass (T.C. medium blu gasification)					L	L	L	L				L	L
Intermediate wind (electric)			M	M						M	M		
Large Wind (electric)			N	N						N	N		
Concentrating solar cells	N	N	M	M					M	M	M		
Intermediate large integrated solar system	N	N	M	M	M	M	M	M	M	M	M	M	M
Solar thermal (concentrators for electricity or process heat)	N	N	N	N		N	N		N	N		N	N
Low head hydroelectric	C	C	C		C		C		C				

TABLE IX

RENEWABLE ENERGY TECHNOLOGIES FOR DEVELOPING COUNTRIES

Some Examples of Rural Applications and Technologies

Technologies \ Applications	Small electric power	Communications, education & training	Hot water	Irrigation pumping	Well pumping	Spinning	Sawing	Cooking	Crop & grain drying, threshing & grinding	Intermediate electric power for village clusters	Refrigeration for food storage & medical supplies	Small-scale cottage industries	Cooling for institutional buildings
Solar cells (flat plate & med. concentrators)	C	C		C	C	C	C	C	C	N	C	N	
Solar thermal (flat plate, trough, simple concentrating cookers)			C	C	C	C	C	C	C				N
Small wind (electric & mechanical)	C	C		C	C	C	C	C				C	
Low head hydro (electric & mechanical)	C	C		C			C	C		C	C	C	C
Biomass (direct combustion/low Btu gasification)	C		C	C	C	C	C	C	C	C	C	C	C
Biomass (anaerobic digestion)	N		C					C	C				
Solar cells (thin film & high concentration)	M	M		M	M				M	L	M	M	
Solar thermal (concentrators for electricity)	N	N		N	N				N	N	N	N	N
Intermediate wind (100kW.1000kW)		N		N	N	N	N			N		N	

Key: C = Current, commercially available by the end of calendar year 1979.
N = Near term, commercially available between 1980 & 1983.
M = Mid-term, commercially available between 1984 & 1988.
L = Long term, commercially available between 1989 & 1999.

IV. Working Group Reports

Report of Working Group on

India & Nepal

Introduction

Under the format of the conference, small working groups were constituted to consider the problems, barriers, actions and the possible AID/US role concerning energy and related forestry and environmental issues of specific countries. While India and Nepal were grouped together, consideration of these issues for the two countries was undertaken separately although there is obvious overlap in some of the principal areas.

Problems

A. India

A listing of the problem areas in the order of priority as identified by the working group is presented below. The first four problems were given approximately equal weighting and should be considered as a group in posing the major problem areas to be addressed.

1. Lack and high cost of liquid fuel for transport

India is highly dependent on outside sources for petroleum and petroleum products which impact heavily on the transportation sector. The present concern is based both on the impact on the balance of payments because of high and increasing costs of oil as well as the potential difficulty in the availability of such oil, should worldwide supply be constrained.

2. More energy for agriculture: Irrigation, Fertilizer, Traction

Electricity and diesel provide the prime source of energy for groundwater irrigation and are critical to the operation and expansion of minor irrigation. The availability and reliability of electric power as well as the availability and cost of diesel can impact severely on agriculture potential in India as witnessed this year during the drought when both power and diesel supplies were in great shortage. Fertilizer is dependent on oil and the availability and price will be reflected by the market situation of oil. Traction in the form of farm and related agro-based machinery also is dependent on oil and electricity.

3. Meeting domestic cooking needs without environmental degradation - fuelwood/alternatives

Domestic cooking needs for rural areas also in part for urban areas are primarily dependent on fuelwood. There is a growing concern over the utilization and availability of fuelwood and its impact on the environment.

4. Electric and heat energy for industry - Urban/Rural

The availability of energy to fuel the industry sector in both urban and rural areas is considered a major problem for India in its economic development.

5. Increase India's coal production

The predominant generating sources for India's power are dependent upon coal. The availability of coal will continue to play the critical role in any expansion and efficient supply of power.

6. Feasible conservation steps: Transport, Industry, Cooking

While the scope may not be considered substantial there appears to be possibilities of some significant saving of energy through more efficient uses of vehicles, heavy machinery and stoves in the above sectors.

7. Capture available energy in the hill for food production

(See discussion under Nepal, Section B.2 below.)

8. Domestic lighting needs

The primary form of lighting in the rural areas is kerosene which again is dependent on availability and price of the primary petroleum product. Rural electrification also provides domestic lighting in the rural areas to a limited but expanding number of villages, but it is dependent on available power generation.

9. Capture and utilize Nepal hydro power

Recognition was given to the potential for increased power availability for India by development of hydro-electric resources in the Nepal hills. At the same time, it was understood that the size of such projects and political relations and consideration between Nepal and India are critical aspects in addressing any such power development.

B. Nepal

1. How to meet domestic cooking needs

This was considered the most significant energy problem for Nepal because of the heavy reliance on fuelwood and the impact this has on the use of forest and wooded areas. Inherent in this problem are the serious environmental considerations resulting from such heavy demand for forest products.

2. Capture available energy in the hills for agriculture

The hill areas were viewed as a place where very little comes in or goes out; therefore, maximization of resources in a relatively self-contained manner is required. This includes the development of small-scale hydro-electric systems to meet local power needs and provide improved water control for irrigation.

3. Utilization of Nepal hydro-electric resources

While tremendous potential of hydro electric power exists in Nepal, the costs of developing such sources are extremely high and the utilization of power limited within the country itself. Considerations of riparian rights of Bangladesh, China and India as well as a market for use of such hydro resources would be part of any consideration of this problem.

4. More energy for agriculture

As in the case of India acceleration of agricultural development would require additional energy inputs, particularly for irrigation and fertilizer.

5. Electricity for heat energy for industry

While not as significant a need as in India because of the nature of the two economies, additional sources for electricity and heat were considered problems in further developing urban and rural industry in Nepal.

6. Domestic lighting

Kerosene, virtually the sole domestic lighting source in rural areas, is subject to the availability and price in the international market.

7. Conservation of energy sources

While this permeates transport, industry and cooking usages, it would appear that cooking with its high dependency on firewood would provide the most immediate opportune area for conservation practices.

Barriers

A number of barriers were identified in considering how to best address the problems listed above. A listing of these barriers is contained in Attachment A and provides the backdrop against which possible actions were considered to meet the problems and overcome such barriers.

Actions and AID/US Role

A. India

Actions were considered in the framework of short activities, i.e. those that could be undertaken immediately, medium term representing a period from 5 to 10 years and those actions which are primarily within the purview of the Government of India.

Action to be undertaken	Possible AID/US Assistance
1. Short Term	
a. Expand Conventional Energy Supplies	
- Lower prices/balance of payments problem caused by increased oil prices.	Possible US role in international fora where such issues are being discussed.
- Accelerated oil exploration	US support of World Bank initiatives to assist developing countries in oil exploration; other US initiatives that may develop out of high US Government concern for oil supplies.
- Rural Electrification	USAID current and possible further assistance to expand rural electrification in India.
- Expansion of coal and hydroelectric resources	Re hydro, a possible AID role in multidonor effort to expand India's hydro electric potential.
- Expansion of chemical fertilizers	Current USAID program on the importation of fertilizers; possible bilateral or participation in multilateral effort for expansion of domestic fertilizer production.

- Technical cooperation in improved efficiency for industry, power, transport.	Potential transfer of US technology for improved efficiency in these sectors with US/India Sub Commission on Science & Technology as potential mechanism to effectuate such collaboration and transfer.
b. Expand traditional energy supplies.	
- Forestry for firewood	Potential USAID assistance in social forestry program.
- Expansion of biogas activity (noting concerns on issues of community vs. family size plus equity issue that may be involved in such a program).	Possible requirement of a credit program calling for donor assistance, e.g. under India's existing Agricultural Refinance Development Corporation credit program.
c. Research and development on non-conventional energy	
- Role of nonchemical fertilizer	Collaboration with US on any developing technologies.
- Rural energy systems	Existing US grant supporting development of nonconventional energy sources; support of proposed GOI program to develop integrated energy centers adoptable to specific ecological zones.
d. Improved efficiencies	
- Improved stoves	Inclusion as part of potential USAID social forestry program.
2. <u>Medium Term</u>	
a. Research and development on synthetic fuels	Potential interchange of US research efforts.

b. Improved efficiencies

- Transport, coal combustion, wood combustion, industry	Collaboration under Science & Technology Sub Commission.
c. Research and Development on non-conventional energy	USAID support of GOI programs.

3. Actions primarily within purview of Government of India

a. Policy toward multinational corporations

Need for GOI involvement of multinational corporations for technology investment in exploitation of potential oil resources and in development and supply of power generation equipment.

b. Politics and management of coal/power sectors

Potential for improved energy supply through more efficient use of existing coal/power resources.

c. Pricing and fiscal policies

It was noted that much planning had been done in this area by the GOI and that it was ahead or equal to most countries in such planning.

B. Nepal

Actions to be undertaken	Possible AID Role
1. Encourage/promote government to focus on energy planning and policy.	
- One of the principal problem areas identified was the lack of GON understanding and attention concerning energy and the related environment and forestry issues. It was considered critical for the success of any action program to have the understanding and support of the government and a framework developed by the government to address energy issues.	(Specific USAID actions and proposed involvement should be identified and enumerated in this section by Nepal mission for this draft. Consideration should also be given to possible U.S. action other than AID.)

2. Establish/utilize present institutions

- Research and training to meet serious manpower constraints to plan for and implement necessary actions to address energy problems. " "

3. Resource data collection

- A serious gap was identified in understanding the base both in terms of agricultural resources and energy resources considered necessary for any effective planning. Emphasis was given to surveys and investigations of water and forest resources. " "

4. Support integrated development activities contributing to increased food production using readily available power.

- The prime example discussed was impoundment of water to create irrigation facilities and micro/hydro to develop energy for agriculture and small industry. " "

5. Contribute to accelerating the national reforestation planning

- Forest management " "
- Research " "
- Community involvement in forest activities " "
- Private sector involvement by conversion of sub-marginal lands to forest plantings. " "

6. Accelerate incountry adaptive research

- Readily available technologies - water, trees, stoves " "
- Alternative energy sources - solar " "

7. Watershed Management that supports supply of resources to meet energy demands		
- This consists of a recognition for the need for appropriate water/land management to protect engineering structures such as hydro facilities that provide critical energy needs.	"	"
8. Livestock management	"	"
9. Major river basin planning		Possible USAID involvement as part of a multidonor effort; dependency on a multi-country agreement.
10. Mini hydro development		
- Considered to be capital intensive and more appropriate for IFI financing.		

Summary

The results of the working group analysis demonstrated a rather marked constrast between the resources and programs needed to address energy and related environmental and forestry problems of Nepal and India. The prime assistance needed for India appears to be in the conventional energy area and require substantial capital resources to implement. This would range from accelerated oil exploration, improved exploitation of coal resources, development of hydro power and rural electrification. In Nepal, the focus tended toward institutional improvement, primarily the need to develop the understanding and planning capability to address energy problems, trained manpower to implement action programs and to survey the resource base necessary for appropriate planning. There was of course overlap in the approach and resources required in each country. In addition it may be that given limited resources, AID's role may be more restricted in addressing the major problems in conventional energy for India and that USAID programs in both countries focus on forestry and nonconventional energy resources.

Attachment A

Constraints

Transport

High cost of petrol
Inadequate domestic oil resources
Inadequate technology for synthetic fuels
Inefficient use of fuel
Lack of substitutes for liquid fuel

Agriculture

Irrigation

Lack of substitutes for diesel
High cost of rural electrification - low load factor

Fertilizer

Inadequate supplies
Diversion of dung

Traction

Availability and cost of diesel
Reliability and cost of electric power

Cooking

Rising cost of fuelwood
Inadequate fuel resources
Inefficient use of cooking fuel
Competition for agricultural residues and wood
Difficulty of biogas

Electricity and Heat Energy

Difficulty of coal production and transport
Lack of substitute for coal
Inadequate electrification, forests and hydro for rural use.

General

Balance of payments
Land availability for forests
Rural poverty - lack of ability to pay
Rural inequality
Energy pricing - political sensitivity
Village social organization

Report of Working Group on the Philippines and Thailand

The three attachments summarize the results of the working group sessions for Thailand and the Philippines.

Attachment I. Lists the ten energy problems that the group rated as the most important for the Philippines (left column) and Thailand (right column). Generally they can be summarized as an overdependence on petroleum (with no apprent alternatives for Thailand), increasing demands on energy from almost all sectors coupled with an over-reliance on inefficient energy systems and intensive energy use patterns. The lack of a responsive energy policy and the inequitable distribution of energy resources concentrated in urban sector, as well as deforestation were also identified as energy problems.

Attachment II. Shows a matrix of the major problems and some barriers to overcoming them. The letters "P" and "T" in the boxes signify whether the group thought the barriers related to Thailand, the Philippines, or both.

Attachment III. Lists possible actions that might be appropriate for Thailand and the Philippines to take in order to address the identified energy problems and constraints.

Attachment I

Problems

Philippines	Thailand
1. Dependence on oil.	1. Dependence on oil
2. Equity of energy distribution.	2. Energy for industrial growth
3. Energy for industrial growth.	3. Energy for intensive agriculture.
4. Lack of data on energy resources, use.	4. Equity of energy distribution.
5. Underestimation of potential of renewables. and Lack of responsive energy policy.	5. Lack of suitable alternative resources.
6. Fuel for transportation. and Meeting rising expectations.	6. Fuel for transportation.
7. Inadequate recognition of role of traditional fuels.	7. Deforestation.
8. Deforestation.	8. Over reliance on inefficient systems.
9. Energy for intensive agriculture.	9. Meeting rising expectations.
	10. Lack of responsive energy policy.

Attachment II

Also Identified as Barrier

Barriers Problems	Economic	Political/ Institutional	Resource	Technical	Socio-Cultural
Dependence on Oil	P T (Fuel for transportation; electricity generation)	P T (Energy subsidies; rising expectations)	T (Lack of suitable alternative resources)	—	
Equity of Energy Distribution	P T (Fuel for transportation, electricity generation, low income)	P (No effective institution) T (Public pressure from Middle Class)	P T Scarcity	P T (Geography)	
Energy for industrial growth	P T (cost)			P T (Efficiency of use) Available Alternatives	
Energy for agricultural growth		P T (Western energy intensive approach)	P T	P T (Western energy intensive approach)	
Deforestation	P T (Tree Poaching) (Trading off between energy & food)	P T			P
Fuel for transportation	P T (Reliance & heavy investment in inefficient modes)	P T (Meeting rising expectations)			
Underestimation of potential of renewable energy resources		P T (Energy-inefficient architecture) (alternative fuels for transportation)			

Attachment II - Continued

Barriers Problems	Economic	Political/ Institutional	Resource	Technical	Socio-Cultural
Respective Energy policy	? (Fuel for transportation) (real pricing)	—			
Inadequate recognition of role of traditional fuels		?		P	

Attachment III

Actions

1. Mobilize credit.

2. Incentives for conservation.

3. Incentives for alternatives.

4. Publicity for conservation and use of alternatives.

5. Survey and analysis of resources, end uses, and needs - and technologies.

6. Training/technical assistance in:

   conservation
   alternative technologies
   energy planning
   social/environmental impact mitigation.

7. Technology adaptation and delivery-oriented to practical implementation.

8. Planning and development for indigeneous energy resources, including renewables.

9. Consideration for energy implications in government planning for all sectors.

10. Adaptation of renewable energy technologies to suit local conditions and manufacture, and dissemination of information to business sector.

11. Development of responsive energy policy.

12. Institutional arrangements that facilitate implementation of policy (authority, funding, personnel, etc.)

13. Development of decentralized energy systems.

14. Integration, into forest management, of wood as an energy source, at all levels.

15. Development of direct contact and supportive arrangements between developed and developing country institutions.

16. Expansion of extension capabilities in renewable and traditional energy in rural areas, sensitive to local-felt needs.

17. Hydropower development support through landuse controls and reforestation.

Report of Working Group on

Indonesia and South Pacific

Indonesia and the islands of the South Pacific occupy radically different positions in the energy spectrum. Indonesia is a major oil exporter, with crude oil exports of 1.3 million barrels per day, while the South Pacific region is totally dependent on imported petroleum. The world oil supply/price situation therefore poses different problems for these two areas.

Major Problems

The working group identified three major energy-related problems in Indonesia: (1) environmental stability/resource depletion; (2) distribution and misallocation of resources; and (3) urbanization. Each problem was seen to have several aspects as indicated in Attachment A. Together these problems were viewed as posing a serious economic, political and ecological threat to Indonesia's future development. The situation of rising energy demands was also true for the South Pacific; yet their major problem was the inability to expand exports to pay for the higher priced petroleum imports. Deforestation was seen more as a future problem, since coconut husks and agricultural residues were used in most areas for cooking and/or wood was generally available.

Barriers

The general barriers to these problems were identified as: (1) shortages of trained personnel; (2) institutional and resource management capability; (3) limited capital availability; (4) inadequate data, analytical work, and technology research, development and demonstration. These barriers were considered as they relate to the specific aspects of the major problems (see Attachment B). For Indonesia, capital was seen as less important than the social and institutional factors. For the South Pacific, capital is a major constraint as well as skilled personnel and organizational capacity. Rising costs of fertilizer and the lack of refrigeration, for example, limit productivity in agriculture and fishing.

Action Possibilities

The working group reviewed current programs of the Indonesia government with respect to each problem and the external assistance being provided by the World Bank (power, coal), New Zealand (geothermal), West Germany (solar), Japan (hydro and petroleum), U.S. (planning, training, rural electrification, renewable energy technologies), Italy (nuclear) and the Netherlands (wind and mini-hydro). These general recommendations

were outlined: (1) the creation of an energy development fund from the recent increased revenues from higher oil prices; (2) the initiation of a comprehensive energy educational program at both the professional and vocational level; and (3) intensified surveys of natural resources and planning studies. Specific action possibilities are listed in Attachment C.

AID Role

The working group concluded that AID programs in Indonesia and the South Pacific should not be limited to rural energy concerns but should consider urban energy demands and their implications for rural resources and the development and use of alternative energy sources in urban as well as rural areas. Specific emphasis should be given to small and intermediate hydro power, geothermal applications, integrated watershed/river basin programs, the demonstration of solar technologies, research on the costs/benefits of rural electrification, and investigations into firewood marketing systems.

Attachment A

1. Environmental Stability/Resource Depletion

   a) Declining Oil Resources - The Indonesian economy is heavily dependent on oil exports; yet production and reserves have been declining in recent years.

   b) Deforestation - Population pressures and demands for timber and wood are causing severe deforestation problems in parts of Java, Sumatra, Kalimantan and the other islands.

   c) Soil Stability - Deforestation and land-use practices are threatening the basic constitution of the soil in several areas.

   d) Lack of Conservation - No major strides are being made to conserve natural resources for the use of future generations.

2. Distribution and Misallocation of Resources

   a) Fuel Subsidy - The subsidy of domestic petroleum of over $1 billion annually has encouraged rapid growth in oil consumption and led to the need to import petroleum products.

   b) Distance of Resources from Markets - The concentration of the population in Java and the location of oil, gas, and coal resources on the other islands increases the difficulty and cost of development and transporation of the resources to markets.

   c) Urban-Rural, Per-Capita Energy Gap - The gap in per capita energy consumption is widening between urban areas, consuming conventional fuels and charcoal, and the rural areas, consuming mainly agricultural residues or residual wood.

3. Urbanization

   a) Increasing Urban Demand - The growing urban population and consumption is placing increased pressures on resources located in rural areas, e.g. firewood, hydropower, coal.

   b) Excessive Dependence on Oil - Urban areas are becoming highly structured around a petroleum economy that may not be sustainable in the long-run.

Attachment B

Problems/Barriers	Trained Personnel	Institution/Management Capacity	Economic	Data/Analysis/Technology
1. Environmental Stability/Resource Depletion				
a) Declining oil reserves	expertise needed for development of oil & other indigenous energy resources	need multi-disciplinary approach; coordination	capital investment in alternatives, coal, geothermal, hydro, solar, conservation	resource data analysis of alternative technologies, natural energy lab
b) Deforestation	forest extension workers	central/local cooperating regional policy		resource data, analysis of alternative technologies, natural energy lab.
c) Soil Stability	soil scientists			education
d) Conservation	conservation specialists	same as (a)		education
2) Distribution & Misallocation of resources				
a) Fuel Subsidy				data on impact of energy pricing
b) Distance [illegible] to market	researchers, transportation specialists	improved organization in energy/transport sectors	capital expenditures on transportation system w/ outer islands	data analysis of alternative sell-/transportation policy
c) Urban/rural [illegible]	rural energy extension workers	integration of energy sector analyses into overall development planning at both central & regional levels, e.g. fertilizer, rural electrification	access by small rural industries to credit on reasonable terms	analysis & data on rural energy needs, impact of rural electrification, testing of renewable, decentralized technologies

Attachment B Continued

Problems/Barri-	Trained Personnel	Institution/Management Capacity	Economic	Data /Analysis/ Technology
3. Urbanizati n				
a) increasing urban demand on rural resources, e.g. firewood, coal, hydropower	environment/natural resource analysts & data collectors	need for implementation of environmental/regional analysis & planning		information on urban firewood use & possible substitutes
b) excessive urban dependence on oil	urban planners, conservation specialists	need urban/regional coordination & formulation/implementation of conservation regulations	fiscal policy toward conservation	information on efficiencies of current systems & potential modifications.

Attachment C

General Actions:

(1) Creation of an Energy Development Fund
(2) Comprehensive Energy Education Program at Professional and Vocational Level
(3) Natural Resource Surveys and Planning Studies

Specific Actions:

I. Problem #1: Environmental Stability/Resource Depletion

A. Resource Development

1. Coal

a. resource exploration and analysis
b. environmental analysis
c. coal laboratory
d. monitor new coal technologies

2. Gas

a. investigate productive use of flared gas
b. methanol economics

3. Geothermal

a. accelerated development
b. investigation of new applications
c. improved climate for foreign investment

4. Solar

a. investigation/demonstration of solar technologies
b. analyze results of German solar village

5. Wind

a. support ITB work in this area
b. collect and analyze local wind data

6. Hydropower

a. support feasibility studies for additional large hydro
b. investigate production and installation of intermediate and small hydro
c. analyze role of small hydro in irrigation projects

7. Nuclear

   a. analyze results of Italian-assisted feasibility study
   b. expanded uranium prospecting

B. Reforestation and Soil Stability Research

C. Conservation

   a. stove research
   b. patterns of urban/rural energy use
   c. energy needs or rural industries

II. Problem #2: Distribution and Misallocation of Resources

A. Oil Price Impacts

   1. Analyze effects of oil price increases on domestic oil consumption
   2. Analyze effects of oil price increases on firewood and charcoal consumption
   3. Analyze social impacts of increased domestic oil prices

B. Development Pattern

   1. Support more efficient systems of resource extraction, transporation, and generation
   2. Analyze energy supply/demand implications of geographical dispersal of industrial development

C. Improved Equity in Energy Distribution

   1. Analyze impact of rural electrification
   2. Analyze potential for decentralized energy supply
   3. Analyze impact on agriculture of energy price increases

III. Problem #3: Urbanization

A. Research into Marketing Systems for Firewood

B. Research on Mass Transit and Industrial Efficiency

C. Public Relations Campaign to Conserve Oil

Report of Working Group on

Sri Lanka and Bangladesh

The report of the Sri Lanka/Bangladesh working group is divided into two sections. The first is a series of generalizations which flow from a distillation of the discussion. The second section discusses each country separately. The discussion will cover (i) energy problems and (ii) possible actions. Details of the problems are included as an annex.

I. Generalizations

Energy problems and how they have been addressed reinforce the integrated nature of energy and development.

- o Sri Lanka has serious energy problems but is taking action to address them in a sensible and realistic way.
- o Bangladesh, with a myriad of developmental problems is also having difficulties coping with its energy problems.

In both countries with important hydro resources and dependence on traditional fuels for cooking we see the integrated nature of energy/forestry/environment.

- o Fuelwood in Sri Lanka is a principal source of energy for cooking. The amount of watershed deterioration is now threatening the country's most important electricity generation/oil import substitution effort (Mahaweli Project for electricity). In Bangladesh, the resource base is deteriorating and survival is an important objective.
- o In both countries, more energy at reasonable prices is needed, for both commercial and traditional energy.
- o In both countries, demand is outstripping supply. Dependence on imported oil is a significant development constraint. Pressure exists on traditional fuels, causing deforestation.

Both countries have common barriers, though the degree of severity is different.

- o analysis/understanding
- o financing
- o technology
- o social/cultural dimensions

While in some areas, (e.g. hydropower), the technology is developed, a better understanding of energy requirements is needed.

- The countries should have an assessment of needs, uses and resources for rural and urban village/urban/oil and other fossil fuels.

- How much can renewable energy technologies substitute for oil and how feasible are they from the economic, technical, social dimension (e.g., biogas digestor, photovoltaics, improved stoves, wind)?

- What is the substitutability between commercial and traditional fuels, e.g. rural electrification in Sri Lanka?

- Fast growing tree species have important potential. What can they contribute?

- Consideration should be given to maintenance procedures/ systems. A three-tiered system with initial responsibility has attractive potential. Women at village level trained in the first level may have greater success because (i) they run the systems and (ii) they are less likely to leave the village.

Full consideration must be given to trade-offs in the introduction of new technologies which have negative side effects.

- Rice straw is important fuel source in Bangladesh and new "miracle" varieties produce less bulk for fuel use.

- Sri Lanka is building a dependence on costly petroleum based fertilizers and insectides.

- Increased planting of trees will create competition with land for agriculture production.

- There are multiple solutions to different levels of problems. We need to match energy sources and energy needs.

- Training, government policy and local institutions are critical factors in addressing energy problems. In the training area, we should be aware of opportunities for Technical Cooperation among developing countries.

- We should underscore the importance of women, not as women's issue but as production issue. Women's participation is absolutely essential to any proposals for cooking fuels. If we do not recognize and design (including participation in planning) programs to encompass realistically the women's role, program success will be jeopardized.

- While each country has common problems of dependence on and cost of imported oil and pressure on fuelwood, the peculiar resource endowments, government and social organization and stage of development emphasize the need for caution in making generalizations. In fact, the mix of problems and barriers is indicative of the status of economic development in each country.

II. Sri Lanka

A. Energy Problems

Sri Lanka's major energy problems are:

- Dependence on use of imported oil (22% of fx earnings)

  no fossil fuels - imported oil is used for:

Transport	40%
Kerosene	27%
Industry	22%

  There are fewer animals for fertilizer and draft power. There is increasing dependence in agriculture on more expensive petroleum-based fertilizer and insecticides.

- Watershed deforestation, soil erosion, siltation caused by:

  settlement
  fuelwood demands
  agriculture-forestry
  slash/burn agriculture

- Inadequate supply of household fuels

  fuelwood
  kerosene

B. Barriers to Solution of Energy Problems

The major barriers to solutions of Sri Lanka's energy problems are:

(No attempt was made to list the following in priority order)

- Insufficient financial resources
- Limited understanding of the energy needs, uses and resources. This includes both traditional fuels and investigation of fossil fuels (particularly in coastal waters).
- Insufficient trained personnel.
- The lack of a sufficiently integrated approach to energy and development. The GOSL needs to articulate its strategy and policies with the coordination and implementation of specific actions. This needs to happen at the national, regional, and local levels.
- Insufficient use, understanding and availability of technologies to fully utilize Sri Lanka's renewable energy resources. Specific barriers include training, sociocultural, financial, and technical.

C. Actions

1. Already Taken

Sri Lanka has already moved ahead with several activities to address its energy problems. These are included below in no particular order of priority. They respond to the energy problems listed in II A above.

- Tapping its hydro power resources for electricity generation (the Mahaweli project).
- Encouraging private foreign sector exploration for oil/reducing kerosene subsidies for household fuels.
- demonstration projects (UNEP/central electricity board and government and university experiments).
- Studies of its energy problems, training and new curriculums.
- Establishing government energy policies and organizational structure (e.g., the government district development program, a government Interministrial level committee, and establishment of the Mahaweli

authority.

- o Training in energy and forestry.
- o Government incentives for tree planting (e.g., rubber replanting and free land and free trees).

2. Possible Actions

The following are a list of possible actions to address the energy problems stated in section II A above. The listing corresponds to the three problems. Where overlap exists, possible actions are not repeated.

Dependence on imported oil

- o expansion of rural electrification program with centralized and de-centralized activities.
- o widespread dissemination of information
- o increase research and development, testing and demonstration of new and renewable technologies (e.g. water plants for biogas digestors)
- o encourage private sector activities both through policies and government intermediaries (e.g. improved stoves, charcoal industry)
- o additional analytical studies to increase understanding of the problems
  - exploration of mini-micro hydro sites investigating streams and irrigation channels and gathering hydrological data
  - intensified studies at traditional energy supply and demand (including study of household use and appliances, changes in uses, and participation of women)
- o expanded training in conventional energy systems (rural electrification, hydropower) and in non-conventional (biogas, wind, solar) TC/DC exchange should be explored
- o continued refinement of energy strategies and policies

- creation of an energy council
- communication of new developments
- analysis of integrated approach and options
- use of consultants (from developed countries and through TC/DC).

Watershed deforestation, soil erosion, siltation

o expand and modify forestry college curriculum -- include study of agro-forestry and watershed management

o strengthen government programs to encourage aforestation

- new species development
- new forestry techniques
  - -- mixing species
  - -- erosion control
- more government incentives
- more research and development
- increased allocation of resources from
  - -- external financing
  - -- government of Sri Lanka

o increased review and research on interdependence of energy/forestry/environment

Inadequate supply of household fuels

o increase production of fuelwood through

- woodlots
- social forestry
- home gardens

o government incentives and programs to support local level production and support

- coordination and support of NGO activities
- greater participation of village and local organizations
- education and public awareness programs including the involvement of NGO's and the participation of women

III. Bangladesh

A. Energy Problems

The following are the significant Bangladesh energy problems. They must be considered within the context of Bangladesh's overall development pattern in which overriding issues color all other's. These are (i) the high population density and population growth in the country and (ii) the inherent capacity of the government in planning, coordination, and implementation to address energy and related development problems.

Problems

o Destruction of resource base (for short-term energy/ agricultural needs).

Examples:

1. fruit trees cut for energy & construction materials.
2. Dung & agricultural/forest by-products used for fuel and not fertilizer.

o Reduction in traditional fuel

1. agricultural residues
2. dung
3. forest products
4. other by-products and wastes

o Insufficient exploitation of natural gas

o Deforestation, flooding, siltation, soil erosion

1. controllable in country (watershed & desertif)
2. uncontrollable neighboring country (watershed)

o Modern sector dependence on imported oil

1. transport
2. electrical power generation

- Inadequate indigenous prime materials for energy development

B. <u>Barriers to Solution of Energy Problems</u>

The barriers to solving Bangladesh's energy problems include:

- Insufficient financial reources (f/x & l/c)
- Limited technical/administrative experience
  1. Brain drain to Mid-East
  2. Quality and quantity of university and technical training
- Lack of coordination in energy development program
  1. renewable/non-renewable
- Communication/Information dissemination
- Local Institutions/organizations
  1. coordination among (horizontal)
  2. linkages to central government and NG (vertical)
- Insufficient technology/use of renewable resources and improved intermediate/appropriate technology
- Limited understanding of options
  1. costs -
  2. benefits - potential
- Insufficient land transport
- Lack of regional cooperation
  1. India
  2. Nepal
- Negative side effects of new technology
  1. example: short stems (fuel) from HYV
- Limited involvement of women
  1. planning
  2. implementation

C. Actions

1. Already taken

The following are actions which the Government of Bangladesh has already taken in addressing its energy programs

- o Secure foreign assistance ($2 billion planned)
  - Planning natural gas exploitation
  - People to Mid-East (remittances)
  - Rural electrification
  - Fertilizer development
- o Technical assistance -- donors
  - training -- in-country and outside
- o Government support
  - Support for NGO program
  - Involvement of ministries
  - Government incentives to private sector
  - Some research organization studying -- para statal
  - High level international talks of utilization of water resources

2. Possible actions

- o Alternative technologies
  - Dissemination of information, communication, NGO's, public awareness
  - Increase R & D; testing, pilot projects (esp. water plants for biogas)
  - Encourage private sector activity in areas like briquetting of agricultural waste, charcoaling and improved stoves through government intermediaries.
  - Improve fuelwood approaches (social forestry, village wood lots, home gardens)

- Studies
  - Exploration of mini-micro hydro sites (including hydrology, streams and irrigation channels)
  - Intensify household energy studies (energy appliances and uses, change of uses, participation of women).
- Training
  - Expand activities
  - TC/DC
  - Rural electrification, renewable, non-conventional
  - Support of NGO's
- Support integrated approach
  - Finance consultants
- Commodity support
  - Finance non-indigenous materials for rural electrification
- Forestry (watershed)
  - Expansion and modification of forestry college curriculum (fuelwood, social forestry as well as watershed)
  - Agro-forestry
  - Forestry management
  - Different forestry techniques
  - Tree species
  - Erosion control
  - Woodlots, home gardens