PN-AAG-Y84

BNL 50890

333.7
P172a

BROOKHAVEN NATIONAL LABORATORY DEVELOPING COUNTRIES ENERGY PROGRAM

PROGRAMMATIC AREAS FOR U.S. ASSISTANCE FOR ENERGY IN THE DEVELOPING COUNTRIES

December 1978

POLICY ANALYSIS DIVISION
NATIONAL CENTER FOR ANALYSIS OF ENERGY SYSTEMS
BROOKHAVEN NATIONAL LABORATORY

prepared for
UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT
Under PASA No. ERDA/TAB-995-18-76 with the
U.S. Department of Energy

BNL 50890
UC-13
[General, Miscellaneous, and Progress Reports
(Nonnuclear) - TID-4500]

PROGRAMMATIC AREAS FOR U.S. ASSISTANCE FOR ENERGY IN THE DEVELOPING COUNTRIES

PHILIP F. PALMEDO, ROBERT NATHANS,
EDWARD BEARDSWORTH, AND GERHARD TSCHANNERL

with major contributions from

Russell J. deLucia, Meta Systems, Inc.
William Knowland, Overseas Development Council
Paul S. Lorris, Brookhaven National Laboratory
Vinod Mubayi, Brookhaven National Laboratory

December 1976

POLICY ANALYSIS DIVISION
NATIONAL CENTER FOR ANALYSIS OF ENERGY SYSTEMS
BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK 11973

prepared for
UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT
UNDER PASA NO. ERDA/TAB-995-18-76
with the
U.S. DEPARTMENT OF ENERGY

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the Agency for International Development nor the Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

Printed in the United States of America
Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
Price: Printed Copy $7.25; Microfiche $3.00

March 1979 1695 copies

ABSTRACT

A previous report entitled "Energy Needs, Uses and Resources in Developing Countries" presented an analysis of the energy problems facing the developing countries and the types of solutions that are available to them. In this report a wide variety of U.S. assistance programs which can facilitate those solutions is identified.

The report identifies 28 programmatic areas for assistance activities. In each area specific projects are indicated as examples and the general level of required funding is estimated. Twenty-two programmatic areas cover the development of conventional and renewable energy resources and technologies; six with assessment and planning, energy institutions, and training and education. Two hypothetical overall assistance programs are described with possible project distributions encompassing some twenty countries.

A broadly based U.S. energy assistance program which draws upon the highest quality of U.S. technical capabilities can make a significant contribution to the future economic and sociologic well being of the developing countries of the world.

CONTENTS

List of Tables vi

List of Figures vi

Executive Summary ix

I. INTRODUCTION 1

A. Background to the Study 1

B. Energy Problems of LDCs 2

C. Current and Projected Consumption of Energy 3

D. Prospects for Future Energy Supplies to the Non-OPEC LDCs 11

E. Rationale for U.S. Energy Assistance 13

II. ENERGY ASSISTANCE: PAST AND FUTURE 17

A. Past Practices and the AID Mandate 17

B. Identifying New Programmatic Areas 20

C. Evaluation Criteria 20

III. RECOMMENDED PROGRAMMATIC AREAS 27

A. Introduction 27

B. Energy Resources and Technologies 29

C. Infrastructural and Cross-Cutting Programs 73

IV. DEVELOPING A U.S. ENERGY ASSISTANCE PACKAGE 89

A. Allocation of Funds 89

B. Final Remarks 100

Notes and References 105

APPENDIX - Non-U.S. Donor Assistance Programs 115

Previous Page Blank

LIST OF TABLES

I-1. Country Groups..... 7

I-2. Basic Social and Economic LDC Group Indicators..... 8

II-1. Energy Assistance by Resource and Region, 1970-77..... 18

II-2. End-Use, Source, and C ersion Devices..... 22

III-1. Summary Listing and Scores of Programmatic Areas..... 28

IV-1. Distribution of Financial Allocation..... 90

IV-2. Two Funding Patterns for Energy Assistance Activities..... 92

IV-3. Two Funding Patterns - Summary..... 94

IV-4. Program Example for Country X..... 99

LIST OF FIGURES

I-1. Relationship of Per Capita Energy Consumption to Per Capita GNP.... 4

I-2. Distribution of World Commercial Energy Consumption..... 6

I-3. Total Annual Energy Consumption Projections by LDC Group..... 10

ACKNOWLEDGEMENTS

We are indebted to a large number of people in the energy analysis and development communities who contributed in various ways to this report. Its sponsors in AID, Alan Jacobs and Jerome Bosken of the Office of Energy, Development Support Bureau, provided encouragement and useful advice throughout the project. In addition to the many contributors who are acknowledged in the text through specific references, the following, who participated in a review meeting in Washington on April 17, 1978, contributed to the report's overall perspective and especially to the analysis of Chapter IV.

John Beyer	Robert R. Nathan Associates
Norman L. Brown	U.S. Department of Energy
Charles Ebinger	International Energy
Robert Ichord	U.S. Department of Energy
William A. W. Krebs	Arthur D. Little, Inc.
David Pimentel	Cornell University
Stephen Rattien	DHR, Inc.
Jack Whitelaw	Exxon Corporation

Jack Allentuck, Harry Davitian, and Matthew Reckard of Brookhaven National Laboratory provided valuable advice in regard to specific areas of programmatic assistance. The authors are also indebted to Mary Rusted, Mary Bruck, Georgia Irving, and Elizabeth Seubert for their valued contributions to the editing and preparation of the report.

EXECUTIVE SUMMARY

A. BACKGROUND AND CONCLUSIONS OF THE REPORT

This report outlines the nature and possible scope of future U.S. energy assistance to developing countries* and proposes a list of programmatic areas for funding. It is the second in a series commissioned by the U.S. Agency for International Development in response to the International Development and Food Assistance Act of 1977 which authorizes the President to carry out "studies to identify the energy needs, uses and resources which exist in developing countries."** The first report, entitled Energy Needs, Uses and Resources in Developing Countries (BNL 50786, March 1978) deals with the future energy needs, available resources and energy utilization in the non-OPEC LDCs and examines the energy options available to them for their continued social and economic growth.

The present report elaborates on the solutions to the energy problems advanced in the previous report by transforming them into concrete programmatic areas in which U.S. energy assistance activities can be carried out.

Programmatic Areas

A three-fold approach is suggested for improving the energy resource and technology capabilities of LDCs. A total of 22 programmatic areas are recommended, which are listed in Table 1.

1. Conventional Resources. Many countries have unexplored or unexploited hydrocarbon deposits. Their ability to tap these is limited by their lack of capital and technical manpower. Assistance in assessment, exploration, utilization, and regulation of conventional resources would give some LDCs the ability at least partly to satisfy their future energy requirements from domestic fossil fuel production.

---

* The terms developing country and less developed country (LDC) are used interchangeably to refer to the poorest countries of the world. The 88 non-OPEC LDCs are listed in Table I-1.

** Public Law 95-88, August 3, 1977, Section 114 (b) 1.

Previous Page Blank

Table 1

RECOMMENDED PROGRAMMATIC AREAS*

Energy Resource and Technology Programs

Programmatic Area No.	
	CONVENTIONAL RESOURCES
PA 1	Identification and Assessment of Conventional Resources
PA 2	Exploration and Preparation for Production
PA 3	Utilization of Conventional Resources
PA 4	Regulation and Management
	RENEWABLE RESOURCES
PA 5	Photovoltaic (Solar Cell)
PA 6	Solar Thermal
PA 7	Managing Biomass Production
PA 8	Liquid Fuels from Biomass
PA 9	Electricity Generation and Industrial Energy Supply from Biomass
PA 10	Urban Waste Management
PA 11	Biogas
PA 12	Wind
PA 13	Decentralized Hydropower
PA 14	Conventional Hydroelectricity
PA 15	Storage of Energy
	DEMAND SECTORS
PA 16	Improved Cooking Devices
PA 17	Motive Power for Agriculture
PA 18	Soil and Water Management and Irrigation
PA 19	Fertilizer Production
PA 20	Rural Transportation
PA 21	Food Loss Prevention
PA 22	Urban Systems

Infrastructural and Cross-Cutting Programs

	ASSESSMENT AND PLANNING
PA 23	National Energy Assessment and Planning
	INSTITUTIONS
PA 24	Development of LDC Energy Institutions
PA 25	International and Regional Cooperation
PA 26	Facilitating Private Sector Involvement
	TRAINING AND EDUCATION
PA 27	Village Extension Training
PA 28	Higher Education

*Specific examples of possible activities within each programmatic area are contained in Chapter III.

Since the technology involved is readily applicable and its deployment nearly independent of social and cultural factors, the expected energy impact is quite high. On the other hand, producing greater amounts of conventional energy is only a short-term solution since, in the not far distant future, these limited energy resources will be unable to satisfy further increases in energy demand. The United States has a comparative advantage with assistance in this field since its multinational companies are among the top oil producers and U.S. oil exploration and development technology is recognized to be of the highest quality.

2. Renewable Resources. The energy future lies ultimately with renewable energy sources. Not only will conventional sources be exhausted at some point, but their uneven geographic distribution causes great economic hardship to those LDCs which have no appreciable deposits themselves. More important still, the only way to significantly increase the amount of energy available to the poorer sections of the LDC populations, and particularly to those living in rural areas, is through decentralized renewable energy. The programmatic areas suggested in this category include all the major promising conversion technologies, such as photovoltaics and wind machines, energy from biomass and small and large-scale hydroelectric plants.

Most of these technologies are still in the developmental stage; it will take some years of effort until successful and economically viable units can be manufactured in large numbers in the LDCs. They are also small in scale, and many utilize scarce resources as inputs, such as animal dung or wood, which means that their expected impact on satisfying the national energy demand can only be modest. However, because of the future importance of renewables, their potential role in advancing social development goals, and their relative neglect in the past, these technologies should play an important part in a complete U.S. assistance program. With some of these technologies the United States is in a very good position to assist (such as photovoltaics); with others it is not (such as biogas converters).

3. Demand Sectors. While programmatic areas dealing with conventional and renewable resources aim at increasing the availability of energy of different forms, those areas that focus on demand sectors are primarily concerned with increasing the efficiency of energy use. This is, for example, the case with cooling devices and stoves. Other programmatic areas under this heading deal more with converting future energy utilization technology away from fossil fuels as an input towards renewable energy; such is the case with rural transportation. The demand sectors are end-use oriented and do not specify the energy source or conversion technologies to be used, which in itself is a topic of investigation.

The potential impact on energy resource requirements through greater efficiency in the demand sectors is high and each example has a high development impact. However, the U.S. is in a less advantageous position to assist in some of these programmatic areas since energy saving and conversion to renewables is relatively new and limited in scope in this country. The low level of technology required for some of them and adverse social and economic factors in the LDCs represent additional difficulties for successful U.S. involvement.

In addition to these 22 programmatic areas on energy resources and technologies, six more are suggested which are of an infrastructural or cross-cutting nature. (See Table 1). They deal with assessment and planning, energy institutions, and training and education. They provide an indispensible support to the technology or resource-oriented programs. For example, the local manufacture of improved cooking stoves requires that artisans be trained in making and selling these devices. If an improved stove is developed under PA 16 (improved cooking devices) for, say, the conditions in Senegal, then there must be subsequent support activities for manufacturing and dissemination under PA 27 (village extension training).

Aims of Past and Future Assistance

Until very recently, energy-associated developmental assistance has been concentrated on support for the installation of energy production facilities.

This strategy was part of a larger foreign aid policy which, in effect, encouraged capital-intensive infrastructure investments. In practice this often meant support for the construction of large central electric power stations and distribution grids powered either by hydropower or imported oil. The specific forms of donor assistance consisted of grants and loans for site-specific feasibility studies, planning and construction, technical assistance, and training in operation and management. Assistance for the exploration and exploitation of fossil fuel deposits was left to the private sector. Renewable energy sources were in the past only occasionally included as peripheral components of other rural assistance programs.

The large increase in oil prices in 1973 coincided with a redirection of development assistance policies toward programs directly benefiting the poorest in the LDCs. In the energy field the new emphasis is reflected in the International Development and Food Assistance Act of 1977 which directs AID to undertake "cooperative programs with the developing countries in energy production and conservation, with particular emphasis on programs in research, development, and use of small scale decentralized renewable energy sources for rural areas".*

Formulating Energy Assistance Programs

A "top down" approach is taken in the report which begins by listing activities under the recommended programmatic areas. Examples of such activities for each programmatic area are given in Chapter III. This list provides a framework, and some ideas to field staff, of the kinds of LDC activities that could be supported by the U.S. The actual programs, however, must be developed from the "bottom up", starting with the specific conditions in a developing country and its own energy needs. Together with the government of that country, several programs could then be developed which are composed of various activities selected from the general framework.

Budgeting

The framework provided by the programmatic areas also helps to arrive at estimates of needed funding. Two hypothetical assistance programs were developed using a total annual budget of around $30 million as a reference

---

*Public Law 95-88, August 3, 1977, Section 114 (b).

point. At that level of funding about 4 to 8 projects could be under way at any time in anywhere from 18 to 25 countries. Two possible distributions of the projects are shown in Table 2.

It should be emphasized that the level of $30 million per year is an arbitrary figure used for the purposes of analysis. Nevertheless, the analysis suggests that an assistance program of this general order of magnitude which is well conceived and which draws upon the highest quality of U.S. technical capability can make a significant contribution to the future economic well-being of the developing countries. Further analysis, of a broad policy nature, and considering the full range of pertinent U.S. interests is required before firm recommendations can be made on the level and composition of energy assistance.

Table 2

Two Patterns of Financial Allocation
(for a 3-year period, in dollars)

	Pattern I		Pattern II	
	Proposed Allocation	Percent	Proposed Allocation	Percent
Conventional resources	36,525,000	42	10,850,000	12
Renewable resources	16,275,000	19	33,320,000	38
Demand sectors	8,950,000	10	22,500,000	26
Assessment and planning	5,825,000	7	5,825,000	7
Institutions	10,650,000	12	8,050,000	9
Training and education	8,450,000	10	7,150,000	8
TOTAL for 3-year period	86,675,000	100	87,695,000	100
TOTAL per year	28,892,000		29,232,000	

I. INTRODUCTION

A. BACKGROUND TO THIS STUDY

The International Development and Food Assistance Act of 1977[1,*] authorized the President to carry out "studies to identify the energy needs, uses and resources which exist in the developing countries." In response, the U.S. Agency for International Development (AID) commissioned Brookhaven National Laboratory to carry out a study. The resulting report titled "Energy Needs, Uses and Resources in Developing Countries" was published in March 1978 as a BNL Report.[2] It documents the current energy situation in different categories of the non-OPEC less-developed countries (LDCs)[3] and presents energy and fuel projections of these different country categories to the year 2000. This is followed by a review of the overall supply situation and the capital and institution requirements needed to achieve "self-sufficient" energy production for these countries as a group. The report also contains an assessment of the role of energy in meeting basic human needs and offers a taxonomy of solutions available to the developing countries for coping with their energy problems.

AID also requested Brookhaven to identify and assess programmatic areas for U.S. energy assistance. This request was carried out using inputs from workshops specially put together for the effort, and from consultants and subcontractors. This report presents the results of that second phase of our analysis.

Both reports use a "top-down" approach in the description of the energy situtation in the LDCs and in the presentation of "solutions." That is, they proceed from a global consideration of energy supply and demand in the near and long-term future, to solutions generic to different categories of developing countries, and then to the identification of specific programmatic assistance areas. This procedure has its obvious limitations. To go beyond this point, that is, to evaluate country or region-specific projects or programs, requires input from a "bottoms up" analysis which introduces a full range of developmental parameters and preferences. Only

---

*Notes and references appear at the end of the report.

then can one proceed to establish detailed priorities.

Other limitations apply to our approach. We have restricted our attention to assistance activities aimed at the poor--in particular, the rural poor. This follows only in part from the Congressional mandates applied to U.S. AID assistance. It also evolved out of the results of our first report and those of others which demonstrated the drastic effects that energy shortages are likely to have on the urban and rural poor.

B. ENERGY PROBLEMS OF LDCs.

The current and future energy situation of the non-OPEC LDCs can be summarized in three capsule statements

- For traditional development to continue, oil demands of these countries as a group will grow steadily to become comparable with current U.S. consumption sometime near the year 2000. (This assumes that energy will be used more efficiently and that significant growth in the availability of other fuels is taking place.) This rapid increase (25% over 1975 values) will occur at a time when world-wide production will be diminishing and prices increasing. At an assumed price increase of 50%, the value of this quantity of oil will be close to $100 billion on an annual basis by 2000.

- Attempts by these countries to exploit indigenous resources (hydrocarbons, hydropower, solar) will be limited by shortages of capital and technical manpower. Capital investments in energy resource development and infrastructure will have to increase by 50% and be sustained at these and possibly higher levels if these countries, as a group, are to develop to a point of "net energy self-sufficiency."

- A large fraction of the 3 to 4 billion projected non-OPEC LDC population in the year 2000 will not have available traditional fuels (wood, straw, dung) above those necessary for subsistence cooking levels unless widespread actions are taken to increase the efficiency of collection and usage of these fuels.

The solutions open to these countries fall into two categories. The first entails changes in existing national and local energy support systems. Technically,

these involve the greater use of indigenous resources and shifts toward alternative energy conversion systems (centralized and decentralized) and greater efficiency in end-use utilization of energy. Institutionally, they involve modifications in the decision structure affecting the production, distribution, and consumption of energy. The second requires changes in historical patterns of economic and social development. These range from alterations in the patterning of human settlements to restructuring strategies for economic growth. Because of the interactions between measures taken in one category and their effect on the freedom of action in the other, there is no possibility of describing them in this report in anything more than a passing manner. However, recognition of the interdependencies has influenced our choice of criteria in ranking programmatic areas of assistance.

Underlying all these solutions is a fundamental, and as yet unanswerable, question. To what extent are the historic patterns of economic and social development, as built into the development plans and aspirations of most of the LDCs, coupled to steadily increasing loads on national and local energy support systems? Or, expressed in a more specific form, are there less energy-intensive strategies of growth which can generate employment and higher incomes among the poor? Most of the measures of development, based on historical data, show correlations both with increased commercial energy use per capita and greater reliance on more sophisticated energy support systems. Given the urgency of current energy problems, governmental decisions must be made before we have a very good understanding of the role of energy in development. The acquisition of that understanding should, nonetheless, be given a high priority.

C. CURRENT AND PROJECTED CONSUMPTION OF ENERGY

The current consumption of commercial energy is very unevenly distributed. It ranges from 10 to 15 kilograms of coal equivalent (kgce) per capita to over 3000 kgce, as shown in Figure I-1. Only 6 of the 88 countries in this group have per capita averages above 1000 kgce while, at the other extreme, 24 are below 100 kgce per capita. Three countries--Rwanda, Burundi, and Nepal--have averages of 10 kgce per capita, or less than one-tenth of 1% of the U.S.

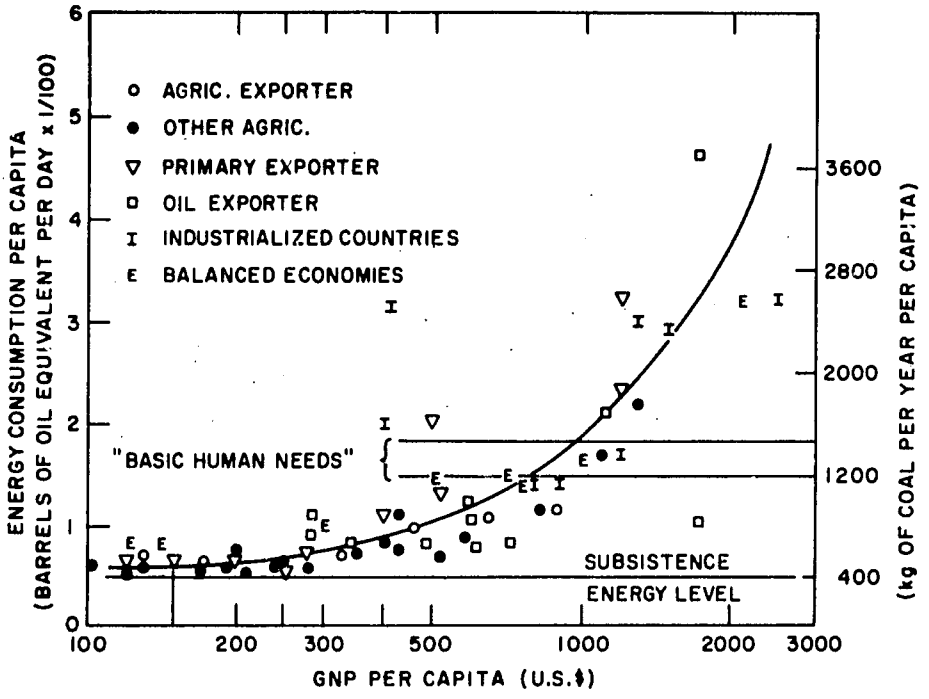

Figure I-1. Relationship of per capita energy consumption to per capita GNP.

Notes:

1. An estimate of 400 kgce per year has been added to each country to account for noncommercial energy use.

2. Subsistence energy level is defined to be the energy input coinciding with minimum provision of food and shelter for survival in a rural setting. The figure of 400 kgce emerges from a number of studies.

3. "Basis human needs" energy level is defined as a level of energy inputs needed to satisfy improved health and nutritional standards. It is based on an evaluation by the Overseas Development Council of the correlation between a physical quality of life index and energy inputs.

average. Inclusion of noncommercial primary energy, which accounts for over 90% of total energy in some low-income LDCs, lessens this gap somewhat. But, this is deceptive since noncommercial energy is used very inefficiently. Figure I-2 summarizes the energy distribution for the world, indicating the number of people living at various levels of energy consumption. As noted, nearly three-quarters of the world lives at or below a level providing "basic human needs," even when noncommercial energy is taken into account. The non-OPEC developing countries contain 41% of the world's population. They consume only 9% of its commercial energy. Non-OPEC LDC commercial energy consumption is increasing rapidly, having risen 250% between 1970 and 1974. Per capita energy consumption increased 175% over this period but in 1974 still averaged only 400 kilograms of coal equivalent (kgce). This amounts to less than 4% of the U.S. average per capita use.

Because the 88 non-OPEC LDCs form a highly disparate group of nations, we have chosen to divide them into categories dependent on the structure of their economies, their exports, extent of urbanization, and per capita income. These categories are used in Figures I-1 and I-2. Table I-1 shows the member countries in each category and Table I-2 a series of pertinent development descriptors for each category.

I. Industrialized countries are those in which industry is the largest sector in terms of percentage of Gross Domestic Product, but where the modern (and predominantly urban) industrial sector exists independently from the traditional urban and rural sectors.

II. Current non-OPEC oil exporters. These countries are dealt with in only a preliminary way since their energy choices are quite different from those of the other countries considered here.

III. Countries with "balanced growth" economies are those in which the industrial sector is relatively developed but not dominant in terms of contributions to GDP, giving them a considerable potential for flexibility in pursuing future development strategies.

IV. Primary exporters are countries in which minerals account for the bulk of total exports and are a major contributor to GDP, but as a

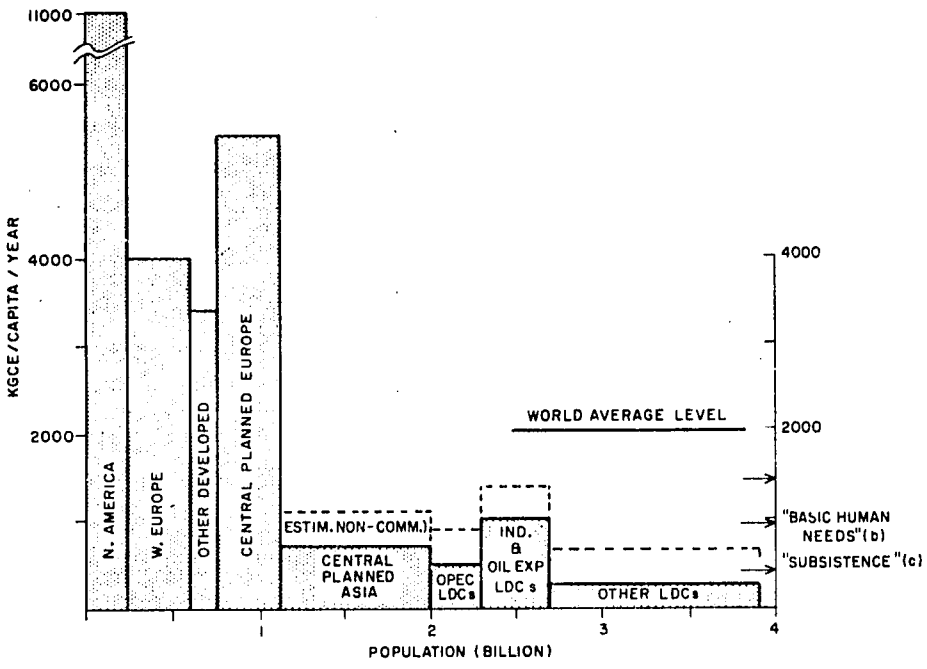

Figure I-2. Distribution of world commercial energy consumption. Annual per capita consumption vs total population (area gives total energy).

TABLE I-1

I. Industrialized

Argentina
Brazil
Chile
South Korea
Singapore
Spain
Taiwan
Uruguay
Yugoslavia

II. Oil Exporters

Angola
Bolivia
Congo
Egypt
Malaysia
Mexico
Oman
Syrian Arab Republic
Trinidad and Tobago
Tunisia

III. Balanced Growth Economics

Colombia
Greece
India
Pakistan
Panama
Peru
Philippines
Turkey

IV. Primary Exporters

Botswana
Guinea
Guyana
Jamaica
Liberia
Mauritania
Morocco
Sierra Leone
Surinam
Togo
Zaire
Zambia

V-a. Agricultural Exporters

Costa Rica
Domini an Republic
Gambia
Guatemala
Honduras
Ivory Coast
Senegal
Sri Lanka

V-b. Other Agricultural

Afghanistan
Bangladesh
Benin
Burma
Burundi
Cameroon
Central African Empire
Chad
Cyprus
El Salvador
Eq. Guinea
Ethiopia
Fiji
Ghana
Haiti
Jordon
Kenya
Lebanon
Lesotho
Madagascar
Malawi
Mali
Mauritius
Mozambique
Nepal
Nicaragua
Niger
Papua N. Guinea
Paraguay
Rwanda
Somalia
Swaziland
Sudan
Tanzania
Uganda
Upper Volta
Yemen A. Rep.

Table I-2

Basic Social and Economic LDC Group Indicators
Mean Figures (By Group)

	Groups	GNP Per Capita 1974 U.S.$	% Urban-ization (1975)	Commercial Energy Consumption Per Capita (1975)	Crude Death Rate (per 1,000) (1975)	Infant Mortality Rate (per 1,000) (1970)	Life Expectancy (1975)	% Income Received by Lowest 20% (1975)	% Income Received by Highest 5% (1975)	% Mnfg Value Added (In Producers Values) to GNP	Export % of GNP	Arable Land (sq.km 10^{-3}) Per Capita
I.	Industrialized	1120	60	1206	8	72	66	4.8	26	40	13	5.1
II.	Oil Exporters	739	51	784	11	79	55	2.4	30	12	9.3	4
III.	Balanced Economies	225	25	288	15	12[illegible]	51	5	25	18	5	3.3
IV.	Primary Exporters	313	29	246	19	77	47	2.5	43.6	8.4	28.8	4.2
V.	Agricultural Exporters	340	23	266	12	81	57	6.4	22	5.9	7.9	3.5
	Other Agricultural	177	15	84	21	130	44	6	21.3	6.9	13.1	4.2

Source: Gordian Assoc. - Population weighted averages of countr[illegible]ta.

group, their mean GDP per capita is considerably lower than those of the industrialized countries with a balanced economy.

V. The countries having agricultural economies include those countries in which agricultural output clearly dominates GDP, being both exported and basic agricultural economies. They are located in East and West Africa, most of Central America, and throughout Asia and South America.

In 1975, liquid fuels accounted for 61% and natural gas 15% of total commercial energy use for this group as a whole. Of the oil-importing members, 29 of the 40 African LDCs, 12 of the 20 Western Hemisphere LDCs, 2 of 3 Mideast LDCs, and 5 of the 11 Asian LDCs depended upon liquid fuels for at least 90% of their commercial energy consumption.

In 1975, all the oil-importing LDCs together imported oil at a rate of 2.7 million barrels per day. The annual value of this oil was $12.5 billion, which amounted to 7% of the total value of annual exports. Capital energy investments averaged $4.2 billion per year, or 7 to 8% of gross fixed capital investments, with the largest share going to electric power systems. Debt service payments for these countries now amount to approximately 10% of total annual export value owing in part to the increased cost of oil. For several countries, including Brazil, Mexico, Chile, Egypt, Pakistan, and Zaire, this figure exceeds 30%.

At the same time, GNP growth rates for most of these countries have slowed dramatically--down from an average of 7.6 to 3.0% between 1973 and 1975. The effects of these oil-related dislocations, according to World Bank projections, will be felt most severely by the lowest income LDCs.

Future demands for commercial fuels were estimated from GNP growth rates and elasticities between energy demand, GNP growth, and energy prices.[5] Non-commercial energy consumption projections were made using estimates of current consumption levels based on subsistence energy requirements and U.N. population growth projections. It was assumed that GNP growth rates would be somewhere between the current lower rates, which reflect post-1973 prices, and the higher levels of the 60's and early 70's. The results are shown in Figure I-3.

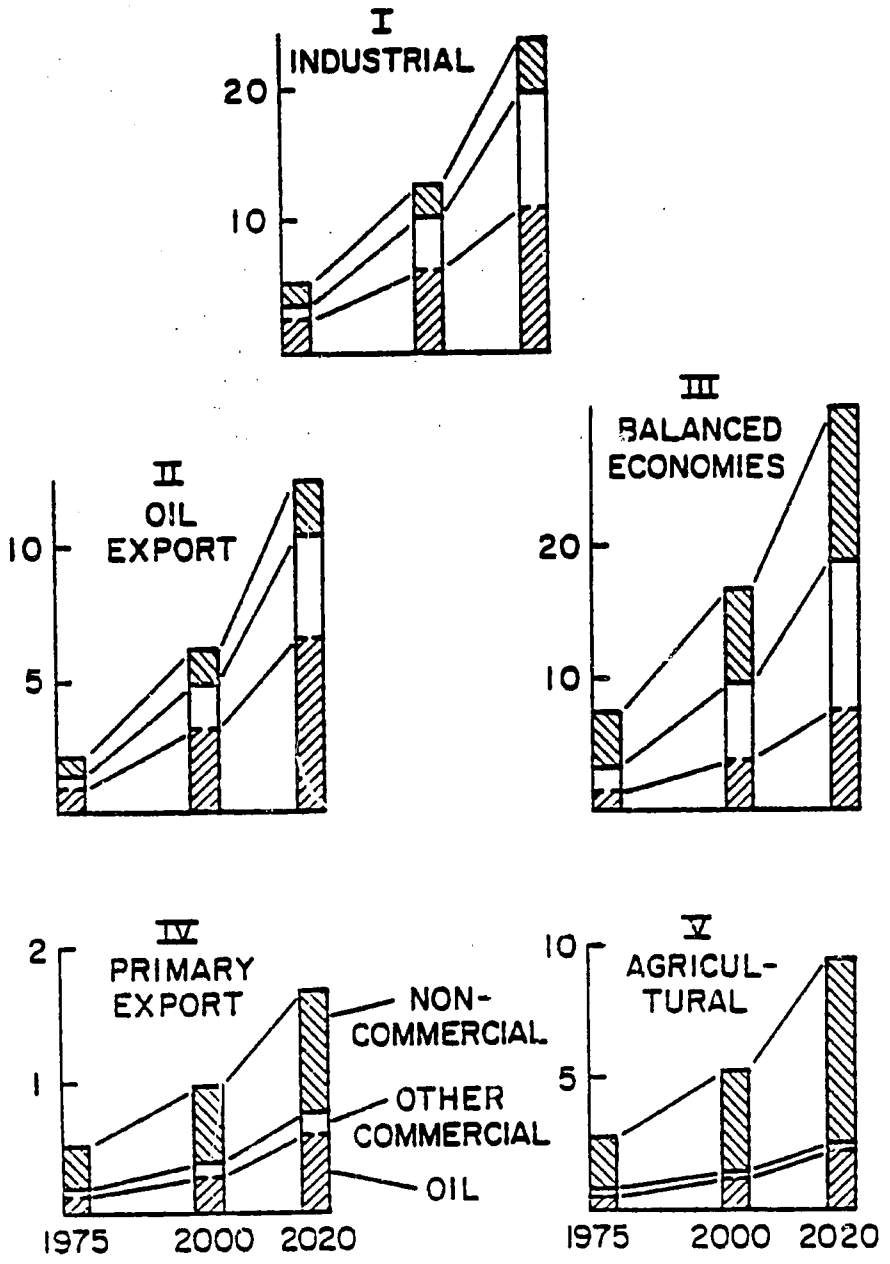

Figure I-3. Total annual energy consumption projections by LDC group (current trends case) (million barrels per day oil equivalent).

Projections to the year 2020 are intended only to identify the major components of the longer-term energy demand, as shown in that figure. In spite of a threefold increase in other commercial fuel resources (coal and natural gas), oil will still account for 55% of total energy demand in the LDCs in 2000. Noncommercial fuel use will also grow. The more industrialized developing countries together will continue to account for the same share of oil use in the year 2000 as they do now, about 45%.

D. PROSPECTS FOR FUTURE ENERGY SUPPLIES TO THE NON-OPEC LDCs

Estimating future energy supplies for individual countries or even groups of countries among the non-OPEC LDCs is subject to large uncertainties. First, estimates of aggregate additions to reserves are highly uncertain. Second, the location of such additions is critical to how quickly they will be exploited. Third, the overwhelming demands of the developed countries and OPEC members for oil and the uncertainties attached to future levels of such demands for fuel in scarce supply will dictate prices on the international market. Finally, uncertainties regarding capital availability for energy infrastructure investments act to limit switching to alternative fuels and conversion systems. As a result, discussions regarding non-OPEC LDC energy supplies can only be stated in terms of a set of disjointed statistics. Even so, these statistics leave little room for optimism.

Of the nonrenewable fossil fuels, oil is the fuel in most demand in all the LDCs, primarily because of its easy transportability. Most world projections show that production of oil by conventional methods will peak around the year 2000. At that time, projected oil demands for the non-OPEC LDCs call for their receiving 25% of world production. Only 7% of the world's present known oil reserves are located in the non-OPEC LDCs. This is concentrated mainly in Mexico, Oman, and Egypt. But approxiamtely 50% of the world's prospective area for petroleum is located in areas falling within the non-OPEC LDCs. It is, therefore, virtually certain that as more drilling proceeds, greater quantities of oil will be found in the LDCs. Although as a group their situation will improve, most of the member countries are still likely to have to rely for the foreseeable future on imported oil either from other

non-OPEC countries or from OPEC.

The usefulness of natural gas in most of the non-OPEC developing countries in the near future is not likely to be limited by supply but rather by constraints on distribution and use. In fact, huge quantities of natural gas are still flared for lack of investment capital for utilizing it whether as a feedstock or for direct combustion. This situation is likely to change relatively quickly if oil prices begin to escalate. As a group, the non-OPEC LDCs appear to contain large quantities of gas reserves. In 1977, for example, although they accounted for only 5% of world production, they accounted for 15% of net world additions.

Except for India, S. Korea, and Yugoslavia, coal is not used in the non-OPEC LDCs. Geologists speculate, however, that supplies of coal and lignite should be widespread. It therefore seems likely that coal will play a much larger role in the energy support sytems of a large number of these countries in the future, particularly in replacing oil in the generation of electricity.

The consumption of electricity in all developing countries has grown rapidly--a large fraction of which has come from exploitation of extensive hydropower potential. (Doubling periods for electricity in many LDCs is 6 to 7 years.) Almost all of this growth has been in the form of large sites requiring extensive grids for distribution of the electricity to urban and rural areas. Sustaining this growth in electricity will be limited by the availability of capital and the need to move to sites more remote from load centers.

Nuclear power now accounts for only a small fraction of installed electric capacity in the developing countries. In 1975 nuclear electricity accounted for about 2.7% of total generation, with more than half of that being produced in Spain. Nevertheless, it is potentially one of the fastest growing energy sources for the larger, more industrialized LDCs. But even then, requirements of scale (integrated grids of at least 7000 Mwe are required to accommodate current minimum plant sizes), high capital costs, uncertainties of fuel supply and waste disposal, and the long lead times will all affect the rate of nuclear power growth. The technical, political, and economic issues

of nuclear power extend beyond the preview of this report, and programs of assistance in the nuclear area are not discussed here. This is by no means meant to minimize the importance of insuring responsible use of nuclear power by all countries.

Future supplies of noncommercial or traditional fuels should be limited by the increasingly serious impacts of the removal of existing forests. But, in fact, rising kerosene prices, clearing of land for increasing agricultural production, and continued urban sprawl are working to accelerate deforestation. On a worldwide basis, estimates of annual forest growth increment vary between 6 and 8 billion cubic meters. This compares with consumption estimates of 7 billion cubic meters. This can be augmented by fuel wood plantation using fast growing species selected for their high energy content. But even if annual growth rates become balanced with consumption on a global basis, distribution networks for getting wood to the rural populations will become necessary.

E. RATIONALE FOR U.S. ENERGY ASSISTANCE

The energy situation in the LDCs directly concerns the United States and other advanced industrial countries. Foremost is a humanitarian concern for the living conditions of the poor. Both the urban and rural poor have been directly and indirectly affected by the reduction in imports of vitally needed petroleum and petroleum-based fertilizer.

The energy based difficulties of the more advanced developing countries will have an increased bearing on the economic, social, political, and security interdependence between these countries and the advanced industrial countries. This interdependence is manifest in international security alliances, trade agreements for food, manufactured goods and mineral supplies and the interlacing private sector arrangements involving growing indeptedness of LDCs.

It is clear that energy consumption in the developing countries must inevitably grow substantially in the face of their rapidly growing populations. To an overwhelming extent this will involve the burning of carbon-based fuels, directly relating worldwide concerns for increasing levels of carbon dioxide in the atmosphere to energy development in the LDCs.

Apart from these general considerations there are a number of specific U.S. concerns and interests regarding the present energy situation in LDCs.

- With the emergence of OPEC as a political force, the dependence of many LDCs on imported oil has subjected them to a new set of potential pressures and constraints. These new forces may be directed counter to U.S. interests
- The U.S. has a strongly stated interest in reducing the proliferation of technology which can facilitate the acquisition of nuclear weapons. The success of the U.S. in convincing the advanced developing countries to seek nonnuclear alternatives to generate electricity will depend on the rate of growth of electric supply-demand gaps and on the availability of alternative technologies and resources.
- World trade patterns in energy technologies and resources that may develop over the next several decades will affect the political development of LDCs and their relationship to the U.S. For example, coal exports from the U.S. would have a direct bearing on our relations with these countries. Likewise, the U.S. may find itself increasingly dependent on oil and gas imports from some LDCs where it is estimated that there are large untapped reserves of these fuels.
- The U.S. has a direct interest in the ability of a number of these countries to service their increasing debts to international agencies and private banks. This ability is directly tied to the continued growth of their economies which in turn depends on their ability to acquire the necessary energy.
- Opportunities for U.S. exports to the LDCs, and U.S. industrial involvement generally, will be strongly affected by the economic health of developing countries and the energy solutions they choose.

Whatever the set of U.S. interests which provide the basic rationale for an energy assistance program, the program must be implemented on the basis of a clear view of the total developmental needs of the countries involved. Those needs and the national energy strategies that can address

them have been discussed in a previous report.[6] In general, the strategies that would be arrived at through an analysis based only on the countries' interests are quite compatible with U.S. policy interests. A possible exception exists in the case of nuclear power. However, to the degree that the U.S. interest is defined in terms of avoiding a "premature committment to nuclear power," and premature is defined in terms of internal economic and energy factors, the commonality of interest is virtually complete.

In addition to considering these various policy interests, new U.S. assistance programs in energy must acknowledge, at the outset, the presence of related on-going efforts by AID itself, international agencies such as the World Bank and the U.N., and other governments. Non-U.S. assistance programs are summarized in Appendix A. At the same time, the selection of specific areas targeted for government support must be consonant with actions being taken in the private sector. In areas where there is overlap, direct U.S. assistance should only be carried out if it can augment these efforts or if it can be shown that these other institutions are not performing adequately.

The participation of the private sector is of particular importance. Federal dollars are often expended with the greatest leverage when they are used to stimulate private investment activities with the recipient countries. In such cases, the federal assistance role may be limited to support of the risk portion of the introduction of a new technology. Private sector involvement, moreover, may often be the best way of assuring continuity of a particular program after federal funds are withdrawn. At the same time, it must be recognized that in many areas of primary importance to AID's mandate--such as the rural poor--there is likely to be little that is of relevance to U.S. commercial interests.

Even more to the point is the importance of commitments and participation on the part of the LDC recipients. Unless these countries give adequate recognition to the proposed energy assistance activities, there is little chance of their being sustained. In many cases the relevance of a given program to immediate, politically important, problems will be the key to its acceptance. Those on the U.S. side of such programs must be sure

that they are also in the long term developmental interests of the recipient country.

The programmatic criteria described in this chapter and the areas recommended in Chapter III explicitly take into account the main elements of the set of U.S. policy interests. They also (implicitly, perhaps) assume a similar mixture of interests on the part of the recipient countries. For some LDCs this may be a premature appraisal, but appreciation of the energy situation by most LDC governments is undergoing rapid change and this view is likely to find recognition in all parts of the world in the next year or two.

II. ENERGY ASSISTANCE: PAST AND FUTURE

A. PAST PRACTICES AND THE AID MANDATE[1]

Developmental assistance associated with energy support systems has, until recently, been concentrated on support for the installation of energy production facilities. This strategy followed from an overall perspective which viewed such installations as being on a par with other capital-intensive infrastructure investments. In practice, this meant support for the construction of large central electric power stations and distribution grids using either hydropower or imported oil as sources. The specific forms of donor assistance were grants and loans for site-specific feasibility studies, planning and construction, technical assistance, and training in operation and management.

Table II-1 shows the percentage distribution of assistance from all sources broken down by region for electricity and renewable and nonrenewable resources for the period 1970-77. Clearly, the overwhelming fraction of energy system monies is going to electricity production and transmission and distribution. In Africa 96% of all energy assistance is allocated to electricity; in Asia 74%; in Latin America 83.5%; and in the Near East 88%. These figures indicate that energy assistance allocations have reflected the same priorities in public and private sector investments throughout the world.[2] The comparatively high cost to obtain one energy unit of output for electricity (5 to 7 times that of coal or oil) accounts in part for the heavy investments in electricity.

Another consideration has been the policy of donors toward investing in exploration and exploitation of fossil fuels. These were regarded as better left to the private sector and in particular to the transnational oil companies. With respect to nonconventional energy resources, these were either ignored or included as peripheral components of other rural assistance programs.

The total energy assistance in the four regions was $21 billion for the 1970-77 period, $0.7 billion in Africa, $3.3 billion in Asia, $4 billion in Latin America and $13 billion in the Near East. The sources of non-U.S. donor assistance are described in the Appendix.

TABLE II-1

Energy Assistance by Resource and Region 1970-77
(in percent)

Electricity	Africa	Asia	Latin America	Near East	World Wide
Electricity, general	64.0	41.0	34.0	65.0	43.0
Hdyroelectric	32.0	21.0	42.0	9.0	30.0
Thermal electric	-	9.0	3.5	4.0	5.4
Steam electric	-	3.0	4.0	10.0	4.0
Total Electric	96.0	74.0	83.5	88.0	82.4
Nonrenewable Resources					
Gas	1.1	13.0	6.0	7.0	8.0
Coal	0.4	2.0	*	-	0.8
Oil	-	10.0	2.5	2.0	5.0
Nuclear	*	*	3.0	*	1.0
Total Nonrenewable	1.5	25.0	11.5	9.0	14.8
Renewable Resources					
Solar	2.0	-	*	3.0	0.5
Biogas/methane/wind	*	*	-	-	*
Geothermal	0.5	*	5.0	-	2.0
Total Renewable	2.5	*	5.0	3.0	2.5
Other	*	1.0	*	-	0.3
Grant Total	100.00	100.00	100.00	100.00	100.00

- Zero

* Negligible amounts

Source: See Ref. 1, Vol. I, p. III-17.

The large increase in oil prices in 1973 coincided with a redirection of developmental assistance policies toward programs directly benefiting the poor, with particular attention to the rural sector. This redirection followed when it became clear to donors and recipients that after a decade and a half of unprecedented economic growth in most of the LDCs, there had been little or no improvement in the life of most of the rural poor. For AID, this recognition took the form of a Congressionally mandated provision to shift the focus of attention away from cities and capital-intensive projects. The manifestation of this foreign assistance emphasis to energy can be seen in the International Development and Food Assistance Act of 1977 which provides AID with $18 million for "cooperative programs with the developing countries in energy production and conservation, with particular emphasis on programs in research, development, and use of small scale decentralized renewable energy sources for rural areas."

But even with the growing recognition by donors of the new importance of "suitable" energy forms, the trends of the last two decades in energy infrastructure investment cannot be easily altered. As long as the momentum of traditional industrialization and urbanization continues there will be an increasing demand for central station electricity, and commercial and international banks will continue to invest in such facilities. There are, moreover, compelling "new" reasons why such investments may escalate even further. Faced with growing deficits due to purchases of oil and higher pressures to increase exports, many LDCs will have no option but to shift fuel usage in their organized sectors to primary electricity. Given these infrastructure investments, grid systems pushing out to rural areas may become increasingly competitive with decentralized alternatives in many areas.

All of this means that energy assistance programs directed toward particular target groups must be assessed in terms of an integrated analysis of local, regional, or national energy supplies, energy needs, and developmental objectives. These assessments must also take note of the influences of existing LDC energy production and distribution service organizations and their ability to plan and manage energy delivery as well as the presence of import substitution policies which favor locally manufactured capital goods over imports.

B. IDENTIFYING NEW PROGRAMMATIC AREAS

As noted earlier, our efforts first to identify and then recommend new programmatic areas for U.S. assistance uses a "top-down" assessment emphasizing rural development in conformance with Congressional AID mandates. It is important to understand that this approach is useful only for defining programmatic categories and areas of assistance. The examples of specific programs falling within each of these areas presented in Chapter III are only intended to illustrate the objectives of each programmatic area and its method of application. Actual programs can be derived only on the basis of information specific to a country or region. The value of this "top-down" procedure is its ability to provide a framework for systematic assessment within the larger context of the world energy situation, U.S. interests, and general development goals. The selected areas also offer a range of assistance activities from which a subset can be chosen to develop an integrated country program in energy assistance. The analysis also offers a means to evaluate the potential benefits from various levels of overall U.S. assistance.

The programmatic areas reviewed in this report are not comprehensive. Our failure, for example, to include a number of centralized energy systems is not intended to denote the lack of their importance. Limitations of time and staff and the obvious current interest in rural decentralized systems gave these particular energy support systems priority. Furthermore, our emphasis here is in technical assistance. The development of large scale, centralized systems is more often an issue of capital investment rather than technical expertise.

C. EVALUATION CRITERIA

Three issues of critical importance discussed in a previous BNL report to AID on "Energy Needs, Uses and Resources in Developing Countries" stand out as focal points for U.S. energy assistance efforts: the rising shortage of non-commercial fuels, the effects of steadily increasing oil prices, and the need to shift away from an overwhelming reliance on oil as a power source.

These issues define the overall goals of a U.S. energy assistance program. It is useful, however, to be more specific about the criteria which should be used to judge assistance programs and projects. In the analysis performed for

this report, the following four criteria were explicitly considered: energy impact, development impact, implementality and the uniqueness of a U.S. role.

1. Energy Impacts

A programmatic area is ranked high in energy impact if the amount of energy, or more properly fuel, that could be provided to the country by the introduction of a technology or indirect effects stemming from other kinds of assistance is substantial. Programmatic areas related to both supply enhancement and increased efficiency in energy use are encompassed in this definition.

Table II-2 illustrates the complexity of estimating energy impacts in precise terms. It depicts a portion of the rural energy systems and shows where present or potential matching exists between energy needs and renewable resources. What is evident is that each technology can have impacts on several areas and that their impacts may only be comparable if we take into account the value of the service being provided by the energy inputs.

An additional difficulty in assessing energy impact is the time horizon in which the results can be expected. Location of an oil or coal deposit can have important intermediate and long-term impacts on energy supply (though not necessarily to the targeted groups) but a negligible near-term energy impact. Use of renewable vs nonrenewable resources also enters. A biomass system can have a modest energy impact compared to that of oil, but it has the virtue of renewability.

Finally, the cost of the impact must be considered. While the capital and operational cost of conventional energy resource, conversion, and end-use systems are known, much less can be said about support systems based on renewable resources. Costs may include not only the energy system itself but the changes that have to be imposed on energy consumers. It will be assumed that economic considerations, in a broad social context will be important criteria in project definition.

In spite of the numerous caveats attached to the use of this criterion, it does serve to establish the expected effects on a nation's or region's supply-demand picture that successful program implementation would produce. It is also

useful for illustrating the equivalency between increased energy use efficiency and enhancing energy supplies. Finally, because not all forms of energy are in short supply, nor are domestic sources to be equated with imports, it provides a basis for considering a richer variety of programmatic areas dealing with a variety of energy support systems.

TABLE II-2

End-Use, Source, and Conversion Devices

Renewable Energy Source	Cooking	Lighting	Heating
Direct solar heat	Solar cooker, heat storage	-	Building design
Photovoltaic	-	Cheap batteries	-
Wood	Improved cooking stove	-	Wood burning stove
Biogas	Cooking stove	Improved lamp	Heating stove
Biomass, general	New types of cooking stoves	-	New & improved heating stoves
Biomass, liquid fuels	Cooking stove	Improved lamp	-
Hydroelectric	-	Lamps	-

2. Development Impact

Energy's value in any society depends on its ability to perform a useful service. It is thus necessary to include a criterion which assesses the extent to which certain energy production and distribution systems contribute to the achievement of social goals. Because the relationship between energy and economic development is a complex one it has to be analyzed in three different aspects.

The first aspect of the relationship expresses the connection between energy sources and a nation's ability to assure long term reliable energy supply. An

assistance program aimed at building up an infrastructure dependent on oil from small local wells may increase dependence on a resource that will soon disappear, thereby increasing the vulnerability of the country to foreign imports. The short-term advantages may outweigh these longer term risks, but these risks should not be ignored in evaluating this program. Development of solar technologies, on the other hand, while capable of limited short-term energy impacts, guarantees a reliable domestic source for an indefinite period. The short-term developmental impact for the oil wells would be high but the long-term developmental impact low. The reverse is true of solar.

The second aspect of the energy-development relationship deals with the development impact of manufacturing and utilizing energy support systems. The multiplier effects of certain energy technologies which can be manufactured locally may be higher than others even though their cost is higher per unit of useful energy output and hence they may have a higher development impact. Other support technologies may provide opportunities for import substitution, and programs aimed at increasing energy end-use efficiency may be labor intensive and, as a result, would be given a high score with respect to development impact. To some extent the development impact arising out of this relationship depends on the overall national development strategies employed. Countries giving high priority to the production of capital goods will find advantages in technologies capable of producing large quantities of process heat. Countries giving high priority to strategies fostering high employment in rural areas will look to energy systems that can provide motive power for cottage industries in remote locations.

The third aspect focuses on the benefits to special population groups from the development of different energy systems. Short-term direct benefits to the rural poor would follow from any increased efficiency in the use of the traditional fuels--wood, straw, and dung for cooking. Longer-term benefits would follow from increases in food production per hectare through the use of irrigation pumps and small tractors, and methanol fuel made from biomass. At the same time, rural electricity from distant central station plants may offer a real alternative to these decentralized energy systems. For this reason, it is inappropriate to rank large systems low simply because of their ability to serve urban industrial

complexes. As these three examples make clear, the development criterion is complex but is a necessary complement to implicit or explicit criteria based simply on energy impact or economics.

3. Implementability

Programs that at first sight appear full of promise often turn out to be either unacceptable or unworkable. This criterion also refers to the importance of adequate management and supporting infrastructure.

To illustrate, consider the substitution of biogas for cow dung in Indian villages on a community basis. Without taking into account the social structure of the village, the ownership of cattle and land, and the use of dung as fertilizers, one has little chance of evaluating its implementability. Similar considerations apply to the mining and distribution of coal in a country lacking experienced individuals and utilities interested in understanding the tasks.

Because of its dependence on local conditions, the implementability of programmatic areas is often difficult to judge. We have, therefore, used this criterion to connote the presence of institutional and social obstacles likely to be found in most LDCs which would act to limit the absorption of the new resource, technologies, or practices into the fabric of the local or national economy. We have also used this criterion to take note of the opportunities for use of local technical and entrepreneurial skills, and of local materials.

4. Uniqueness of U.S. Role

The extent to which knowledge, technology, manpower, and other resources held by individuals and organizations in the U.S. can be used to assist in the LDCs overcoming their energy problems should be taken into consideration in the ranking of programmatic areas for assistance. Some technological areas, for example, improved cooking stoves for rural areas, are so far from recent U.S. experience that other, less developed countries have more to offer than we do. Programmatic areas are ranked high on this criterion where the U.S. has a uniquely strong contribution to made. This could apply either to technical knowledge of resource exploration and exploitation, advanced conversion technologies, transmission systems, or to creating effective organizations for combining public and private sector efforts. The U.S. has a long history of successful public-private collaboration at home and overseas.

A high score for unique U.S. advantage is given for a proven advantage only, where the U.S. has a demonstrated record of superior performance in relation to other donors. This will undoubtedly change once a large program of U.S. energy assistance gets under way. Under such circumstances, U.S. expertise is likely to expand rapidly, particularly if investments are made in U.S. institutions, as has happened in other major areas of U.S. assistance.

To be considered under this criterion is also the question of whether an identified need can be carried out by the private sector or requires assistance support. In general the involvement of the private sector, both in the assisted country and in the U.S., should be maximized in program implementation in order to multiply the benefits from a given investment of U.S. federal funds. Means for inducing private investment in energy development should be sought out at all stages in the development, demonstration and implementation of systems.

A further admonition, which can be applied only at the project, rather than the program, stage is that duplication be avoided with projects funded by other national and international institutions.

III. RECOMMENDED PROGRAMMATIC AREAS

A. INTRODUCTION

In this chapter we describe and evaluate a number of programmatic areas for initiating U.S. energy assistance programs to the non-OPEC LDCs. Actual programs within these areas must be based on the particular needs and conditions of individual countries or regions. Such programs may also include components of more than one programmatic area.

The recommended programmatic areas are divided into two main categories. The first is composed of areas that offer opportunities for intervening in national, regional, or local energy support systems, i.e., they deal with the development of specific energy resources or conversion technologies, or with the individual sectors constituting energy demand. The second contains areas aimed at developing institutions, training manpower, and planning improved capability for planning and implementing such systems. Many of the programmatic areas in the first category can be implemented only if they are combined with activities in the second.

A standard format is used to describe each programmatic area. It includes: (1) an assessment of the importance of the area using the selection criteria noted in the previous chapter; (2) a statement of objectives; (3) a description of the means to be employed in fulfilling the stated objectives; (4) examples of the kinds of programs which might be developed and their cost; and (5) a scoring based on the selection criteria.

The cost estimates given with each example are intended only as a rough indication of the order of magnitude of expenditure needed in this field. To arrive at more accurate figures would require a precise definition of the scope and magnitude of each assistance project.

To provide an overview, the programmatic areas described in this chapter are listed in Table III-1 together with their scores on the four selection criteria. The last column gives an overall score calculated by equally weighting the four criteria and assigning the number 3 to high (H), 2 to medium (M), and 1 to low (L) for the energy resource and technology programs. Since only two criteria are relevant to the second category of

Previous Page Blank

H-3
M-2
L-1

Table III-1

SUMMARY LISTING AND SCORES
OF PROGRAMMATIC AREAS

PA #	Energy Resource and Technology Programs	Energy impact (2x)	Development impact (4x)	Implementability	Unique U.S. role	Overall score
	CONVENTIONAL RESOURCES					
1	Identification and assessment of conventional resources	H6	M8	H3	H3	11 20
2	Exploration and preparation for production	H6	M8	H3	H3	11 20
3	Utilization of conventional resources	H6	M8	H3	M2	10 19
4	Regulation and management	M4	M8	M2	M2	8 16
	RENEWABLE RESOURCES					
5	Photovaoltaic (solar cell)	L2	H12	H3	H3	10 20
6	Solar thermal	L2	H12	H3	M2	9 19
7	Managing biomass production	H6	H12	M2	M2	10 22
8	Liquid fuels from biomass	M4	H12	L1	M2	8 19
9	Electricity generation and industrial energy supply from biomass	M4	M8	L1	L1	6 14
10	Urban waste management	L2	H12	M2	M2	8 18
11	Biogas	M4	H12	M2	L1	8 19
12	Wind	L2	M8	M2	M2	7 14
13	Decentralized hydropower	M4	H12	M2	M2	9 20
14	Conventional hydroelectricity	H6	L4	H3	H3	10 16
15	Storage of energy	L2	M8	M2	H3	8 15
	DEMAND SECTORS					
16	Improved cooking devices	H6	H12	L1	L1	8 20
17	Motive power for agriculture	M4	H12	M2	L1	8 19
18	Soil and water management and irrigation	M4	H12	M2	M2	9 20
19	Fertilizer production	H6	H12	M2	M2	10 22
20	Rural transportation	M4	H12	L1	L1	7 17
21	Food loss prevention	M4	H12	M2	M2	9 20
22	Urban systems	H6	H12	M2	M2	10 22
	ASSESSMENT AND PLANNING					
23	National energy assessment and planning	H		H		12
	INSTITUTIONS					
24	Development of LDC energy institutions	M		M		8
25	International and regional cooperation	M		M		8
26	Facilitating private sector involvement	H		H		12
	TRAINING AND EDUCATION					
27	Village extension training	M		L		6
28	Higher education	H		H		12

22
Biomass prod.
Reduce energy demand:
- Fert. prod.
- Urban systems

20
Conventional
- Identification
- Exploration
Photovoltaic
Decent. hydro.
Reduce energy demand:
- cooking devices
- irrigation
- food loss prevent.

14
Electricity from biomass
Wind

programmatic areas, infrastructural and cross-cutting programs, they were assigned twice the number, i.e. 6 for H, 4 for M and 2 for L to be compatible with the rest.

B. ENERGY RESOURCES AND TECHNOLOGIES

1. Conventional Resources

For the next several decades, and probably well beyond, basic economic and social development in almost every developing country will depend on its ability to secure sufficient supplies of oil and, to a lesser extent, coal and natural gas at nonprohibitive prices. Major international energy companies have not generally shown interest in exploiting small deposits of oil or coal even where such deposits can be significant in terms of domestic requirements. Moreover deposits which appear to be uneconomical in the international market could be of value to countries with little foreign exchange or credit or where local know-how could be used.

There has been virtually no direct U.S. assistance in this area, and, in fact, only recently has the World Bank approved loans for the development of indigenous energy resources. These factors taken together may account in part for the sparse search for oil, gas, and coal in many of the non-OPEC LDCs. For example, only 4.2% of all past drillings for oil have occurred in these countries and there have been few systematic searches for coal.[1] Many oil-importing LDCs regard assistance in the assessment and development of conventional energy resources as deserving high priority. Although conventional oil would be the most valued target, the identification of coal, oil shale, and tar-sand resources would offer usable information to many of these countries.

Support for conventional resource exploration and development must be highly flexible to respond to differences in resource endowments, internal markets, indigenous capacities, and geographical locations among these countries.

The general areas chosen for assistance are: a) resource identification; b) exploitation; and c) regulation and management. There are important U.S. government and private sector roles in these three areas. Where possible,

government assistance efforts should support, but not supplant, private sector activities.

2. Application of Criteria

This area points up the important distinctions between the energy impact and development impact criteria. Obviously, if oil, gas, or coal is discovered, the potential energy impact of specific programs in this area will be high (H). The impact on total national economic growth could also be substantial. But since indigenous conventional resource development can further overall economic development without necessarily improving social goals related to the poor, it receives a medium (M) rating under the criterion of development impact. There can, of course, be exceptions. Certain conventional resource development programs properly designed will be supportive of rural development strategies; but others emphasizing urban use could have deleterious social or environmental impacts. Any number of programs can be selected which seek out the former while minimizing the latter effects.

The programmatic areas (PAs) in this category rank generally high for implementability. The state-of-the-art in exploration and production is very advanced and is directly applicable to situations to be found in the LDCs. U.S. expertise is especially notable in these areas, with the exception of the PAs where cultural factors can play a large role (e.g. PA 4) and where conservation and fuel use versatility are involved (e.g. PA 3). For such reasons, they have been given "medium" (M) ratings.

PA 1 (Programmatic Area 1): Identification and Assessment[2]

Importance:

As a first step, priorities should be established for different conventional resources dependent on the anticipated size of the resources, their potential contributions to the economy of the country, the cost and complexity of technologies required for exploitation, and other relevant factors. The potential cooperation and financial participation of the host government as well as the existence of foreign investors to follow up on the initial aid funding to fully commercialize the development of the resource should also be considered. Preliminary reconnaissance is relatively inexpensive compared with the follow-up cost of exploration and production.[3]

Objectives:

Identification and assessment of the extent of conventional energy resources: oil, gas (natural gas of any type and geopressurized zones), coal, and other solid hydrocarbons (oil shale, tar sands), geothermal and uranium. This includes reevaluation of previously known "submarginal" sources.

Method of Assistance:

Supply of experts and funding for consultants, depending on the requirements of individual countries. This includes mechanisms for transfer of general technical and economic knowledge on conventional resource development.

Examples:

i) Feasibility Studies and Country Visits

There is a lack of information to potential foreign investors in conventional resource availability and, in many cases, to the host countries themselves. The magnitude of the risk to private investors in the development of resources has a direct relationship to the presence of reliable information.[4] A first step in obtaining greater participation of private companies is the existence of preliminary data on reserves. Terms of specialists could:

- obtain first-hand information and review other data, identify the types of conventional resources projects of interest to host governments, and determine which are compatible with their national development plans;
- assess the institutional capabilities to exploit indigenous resources and identify other bottlenecks to development; and
- assess the potential impact of U.S. assistance activities on the country's plan for development and use of the additional resources.

Cost: $175,000 per country assessment team.

ii) Identification of Conventional Resource Development Projects

On the basis of the recommendations of these specialist terms, specific assistance projects such as those described can be undertaken.

Coal: The potential of coal resources to satisfy energy demands in raw or processed forms should be assessed, to provide employment and to meet subsistence needs in rural areas. Such projects should take into account the future utilization possibilities of coal as new conversion technologies develop.

Oil, oil shale, tar sands: Assistance should be given in the evaluation of oil (and other hydrocarbon resources) in sedimentary basins through the synthesis and interpretation of data from past oil and gas exploration with particular emphasis on small oil fields. Such assistance would help attract additional investments from the World Bank to explore and develop these resources. The emphasis should be on multi-resource exploration and, where necessary, include a limited amount of exploratory drilling. Particular attention should be given to the assessment of heavy crude oil possibilities in an area in which the United States has substantial expertise. Location of tar sands and oil-shale deposits which may become a basis for future development using small-scale and semiadvanced labor-intensive technologies should also be singled out.

Gas: In past exploration for petroleum sufficient attention has not been given to natural gas possibilities; and, geopressurized gas possibilities have received no substantive attention in developing countries. Therefore, where appropriate, projects should include all types of natural gas.

Geothermal: Identification of geothermal energy resources is an area in which the United States is developing technological expertise. Equal attention should be given to small-scale resources for local use as well as major resources for central power stations.

Cost: $1 million per country.

iii) Information Exchange Workshops

Periodic workshops can introduce the LDC specialists to recent developments in energy resource identification and assessment techniques. Such workshops can also provide information to potential foreign investors concerning the potential resource exploitation opportunities in these countries.

Cost: $100,000 per workshop.

Selection Criteria

Criteria	Ranking	Remarks
Energy Impact	H	With production technologies known, the discovery of new deposits will directly increase usable energy.
Development	M	No differential impact on targeted socioeconomic groups for most programs.
Implementability	H	Known technology and methods.
U. S. Role	H	--.

PA 2: Exploration and Preliminary Preparations for Production

Importance:

Once a conventional resource has been identified, assistance should include drilling and other direct exploration. Data should be sufficient

to provide a firm basis for the LDC government to enter into a mutually profitable agreement with a private firm, or to secure investments from other sources to exploit the resource on its own. Where merited assistance is indicated, it should be available until production has been initiated.

Scientific exploration, which can be carried out at a relatively low cost, increases the chances of successful production of a resource.[5] Preference should be given at the first stage to surface exploration methods and to possible geophysical and geochemical techniques. Moderately deep drilling (relatively shallow oil and gas deposits and geothermal) should be given a lower priority and deep drilling (deep oil and gas reservoirs, and geopressurized gas deposits) should be given the lowest. No significant exploration programs should be undertaken unless it is known in advance how a new energy deposit will be exploited. Many of these energy sources may have adverse environmental effects associated with their production. These should be considered in evaluating the utility of production.

Objectives:

Exploration of previously identified conventional resources to ascertain whether the deposit justifies commercial production (this assumes the country's ability to initiate production).

Method of Assistance:

Provision of the required technical and financial assistance for the exploration of a deposit up to the stage where preliminary analyses supporting financial backing from outside interest has been completed. Should only a small deposit be found, it may not be large enough to interest a private investor; it could, however, be useful in helping to satisfy a local requirement. In such cases, assistance should be extended toward helping to create a local body for developing the deposits.

Assistance would be given in carrying out the engineering and feasibility studies needed to establish a commercial extraction operation, and also in financing studies to determine the lowest cost options for development, where appropriate, the creation of an indigenous drilling capacity would be encouraged.

U.S. assistance should also include a provision for loans to local resource development entities. Where major deposits are located, U.S. assistance should extend to loans supporting infrastructure development (roads, houses).

Example:

Exploration of an Identified Deposit

Costs will vary with size, nature, and location of the deposit, with type of exploration required, and the number of areas being studied at one time. Surface exploratory methods for a medium-sized deposit: $ 1 million.

PA 3: Utilization of Conventional Resources

Importance:

In some countries the discovery of new conventional resources may present problems in distributing and utilizing the output. Attention should therefore be paid to the transport, conversion, and end-use of the new resources.

Objectives:

Development of the means to absorb the new resources into the national economics.

Method of Assistance:

The needed assistance to achieve this objective will vary. In some cases it may include provision of technical expertise; in others, direct financial aid will be needed, and in still others, supplies of distribution and end-use equipment. Development of equipment for small-scale electricity generation in the U.S. may be required to furnish this kind of assistance.

Examples:

i) Transport Systems

Improvement of construction of roads, railways, and water transport may be needed as part of the national distribution network. Where

significant investments are required, U.S. technical assistance should be limited to systems studies and the development of information required to justify capital loans.

Cost: $200,000 per project.

ii) End-Use Substitutions for Conversion to Other Energy Sources

The shift from one fuel source to another can require investments in end-use devices (stoves, boilers, etc.). For example, the shift from using wood to coal in cooking stoves may require consumers to modify their stoves or purchase new ones. Assistance should be provided to government efforts to affect this conversion, particularly among the urban and rural poor, and in essential industries such as food processing and agriculture.

Cost: $300,000 per country per year.

iii) Small and Medium-Scale Conversion Technologies for Utilizing Conventional Resources

Relatively little R,D&D is being conducted by the Department of Energy on technologies adaptable for the small and medium-scale uses found in many LDCs. R,D&D efforts oriented toward medium-scale coal gasification plants, small and medium-scale geothermal devices, and processes for extracting oil from shale by low-capital-intensive methods would benefit many LDCs directly and provide opportunities for U.S. commercialization of the equipment. When such opportunities can be identified, U.S. assistance should support the required R,D&D. In this connection, small and medium-scale generating equipment is of particular importance to LDCs. Even where the operations cost per kwh generated is greater than that of electricity generated on a larger scale, the savings in capital costs offset the higher production costs. High priority should be extended to the development of new, more efficient, and highly reliable small and medium-sized electrical plants which have the potential for using a variety of nonpetroleum fuels.

Cost: $15 million per project.

Selection Criteria

Criteria	Ranking	Remarks
Energy impact	H	
Development impact	M	See PA 1.
Implementability	H	
U.S. role	M	

PA 4: Regulation and Management

Importance:

In recent years most LDCs have been faced with the need to develop a capability in regulation and procedures to manage their resources in order to maintain a knowledgeable position in dealing with oil and mining companies. To obtain help in increasing their understanding and capability in this area, many countries have approached U.S. government agencies, in particular, the U.S. Geological Survey. Several countries have already received assistance in this area under reimbursable agreements.

Objectives:

Development of capability in interested LDCs in regulating and managing conventional resource development. The required procedures on which assistance is needed include:

1. definition of lease boundaries to assure efficient production of resources;
2. unitization of integrated production plans for oil and gas fields, coal fields, or other resources to assure maximum recovery;
3. regulations and monitoring of offshore exploration and production platforms, pipe lines, and other installations to promote safety and protect the environment;
4. regulation and monitoring of mine health and safety;
5. regulation and monitoring of environmental effects of mining, milling;

6. regulation and monitoring of resource production in relation to total reserves and recoverability;

7. introduction of data management systems for regulation and monitoring of production, for modeling of deposits to develop exploration and production programs, and for use in economic analysis;

8. preparation and publication of production and reserves statistics, and projections of future production; and

9. development of an orderly, well-advertised plan for leasing.

Method of Assistance:

Provision of appropriate technical expertise.

Examples:

i) Management Procedures

Supply short-term consultants for the management procedures noted above.

Cost: $100,000 per country per year.

ii) Standing Consultation

Set up an in-country standing consulation team to be supplemented by a staff of specialists from appropriate U.S. agencies.

Cost: $300,000 per country per year.

iii) Courses on Regulation and Management

Organize an annual course in the United States on regulation and management procedures with the help of appropriate U.S. agencies and universities.

Cost: $100,000 per country per year.

Selection Criteria

Criteria	Ranking	Remarks
Energy Impact	M	Creates conditions for energy production.

Selection Criteria (continued)

Criteria	Ranking	Remarks
Development Impact	M	
Implementability	M	See PA 1.
U.S. Role	M	

Renewable Resources

The particular importance and potential of renewable resources is understood by the finite nature of fossil fuel resources and their non-homogeneous distribution. With prospects of an increasing scarcity of presently utilized nonrenewable energy sources on a world scale, it is only prudent that promising alternative energy sources using renewable resources be developed. This will involve setting up production targets for the next twenty or thirty years to make sure sufficient quantities of renewable energy are being utilized. At the same time, the technologies capable of utilizing renewable resources in urban and rural settings and the institutions for insuring their distribution, use, and maintenance msut be developed.[6]

There is substantial evidence of overexploitation of some renewable resources in many areas and underutilization of others such as water for hydropower on both a small and large scale, solar, wind, and in many instances biomass, including urban wastes.[7]

For each resource it is useful to define programmatic areas in terms of strategies for (1) research and development, (2) information transfer, and (3) deployment (including in-country manufacture of related equipment). The last point requires special comment. One of the key attractions of renewable fuel[5] is that they do not involve the expenditure of foreign exchange. To maintain this advantage, it is desirable that the importation of equipment needed to utilize the renewable be kept to a minimum. Direct employment and utilization of domestic materials (even if they have to substitute for more sophisticated alloys or plastics that might improve performance but would have to be imported) would also favor in-country production.

Application of Criteria:

The renewable resource category includes programmatic areas which are highly diverse with regard to their state-of-engineering development, technical sophistication, range of energy demand applications, and prospects for implementation. The energy impact that can be expected for the group as a whole is generally not rated as high. Only biomass production and conventional hydropower rank high in this criterion, while all other programmatic areas rank medium or low. In many cases this stems from the fact that conversion technologies and the equipment to utilize such technologies are still a long way from the point where they can be widely commercialized. Moreover, some of the most advantageous conversion technologies may never reach the stage where they can be successfully commercialized except under very special conditions.

The development impact of renewable resources is generally high, mainly for two reasons. First, they offer a long-term "solution" as opposed to conventional resources which are in the process of being depleted. Second, they are likely to benefit the rural areas in particular because of the good prospects of developing successful small and medium-scale decentralized systems, many of which are suitable for local manufacture.

The implementability depends on: the complexity, convenience, and reliability of the technologies involved; the dispersed nature of the application; and, the difficulties in overcoming various instituional and cultural obstacles to their wide adoption, particularly in rural areas.

The uniqueness of the U.S. role also varies considerably. It is high in fields where major technological advances have already been made and low in those which have not been an important area of concern in the United States.

PA 5: Photovoltaic (Solar Cell)[8]

Importance:

There are major concentrations of population in the developing nations in the rich alluvial areas of the temperate and tropical regions, where insolation is high throughout the year. A reliable supply of conveniently

usable energy through large-scale gridded electric power systems, such as those developed in the United States and Western Europe, is often possible only with the expenditure of large sums for capital investment. An outgrowth of the high technology of the U.S. space program and the technology development of NSF, ERDA, and now, DOE, has been a government-encouraged terrestrial solar-cell industry. Recently this has focused on achieving a rapid reduction in system cost.[9] Photovoltaic power systems cannot compete with conventional power sources in the U.S. at prices above $.75 per peak watt (Wp). (Current price to DOE $11/wp). Analyses of a series of applications in developing countries show competitive applications beginning at $8. per Wp.[10] Several applications of photovoltaics, in fact, already exist which can be readily transferred to LDCs for field tests or commercial demonstration.[11] A considerable reduction in the cost per Wp of the photovoltaic cells can be expected over the next ten years.

Objectives:

Adaptation of the technology and production processes of photovoltaics to the LDC conditions, suitable applications for photovoltaics should be found and demonstrated with prototypes and the cost of applications should be reduced.

Method of Assistance:

The supply of photovoltaic modules should be provided on a concessional or loan basis: the provision of funds for in-country technology development, identification of local applications, field testing, and dissemination mechanisms; and the provision of technical assistance in system design and component technology.

Examples:

i) Small-scale Irrigation Pumping

When producing water for farms of one to two hectares, current pumping technologies cannot be reduced in scale without large losses in efficiency. These farm sizes are found in many parts of the Nile, Euphrates, Indus, Ganges, Irrawaddy, and Mekong basins, where water is available from the surface and underground at lifts under five meters. The potential impact of small-scale

pumping in these areas has been dramatic. Calculations show that small farmers could afford to pay $1250. per hectare owned and irrigated, or roughly $8. per Wp for power systems to pump water. U.S. manufacturers anticipate being able to offer photovoltaic packages for this amount within one year. Small-scale pumping with a photovoltaic power source, therefore, represents a priority development area. (DOE contractors at MIT's Lincoln Laboratory and the Energy Laboratory are currently planning such an effort.) There is a need for field experience and for demonstration of systems in some selected LDCs. The choice should fall on countries which have economic characteristics such as those described above and in-country technology development and testing capabilities. India, Thailand, Pakistan, Egypt, and Kenya are qualified candidates.

Cost: $880,000 per country for a 2-year period.

ii) Rural Electric Applications in Communications, Health, and Education[12]

Resource requirements for such activities are similar to those for small-scale pumping. Funding should be concentrated in two areas: first the provision of photovoltaic modules for use in tests and applications, and secondly, the funding and general support for developing in-country applications in areas of rural high-quality energy needs.

Cost: $100,000 per application

Selection Criteria

Criteria	Ranking	Remarks
Energy Impact	L	Low (in total Btus) to be saved.
Development Impact	H	High in ability to provide energy to particular socially important junctions.
Implementability	H	Modular, reliable, simple.
U.S. Role	H	Leading to R, D&D.

PA 6: Solar Thermal

Importance:

Technologies using solar energy in the form of low-grade heat have

significant potential for short-term and long-term use in rural areas in developing countries.[13, 14] A common objection to the use of these technologies in LDCs is their current cost in the United States.[15] Some of these technologies (e.g., crop drying and distillation), however, have been in use for years in many LDCs and do not necessarily need sophisticated materials or techniques to perform satisfactorily. Current costs, moreover, are based on the costs of manufacturing small numbers of units in the industrialized countries with their own labor and materials. No significant effort has been made to adapt designs and fabrication techniques to materials and skills available in LDCs.

Objectives:

Development of solar-thermal conversion technologies and applications for LDC conditions, using local labor and skills wherever possible, and development of techniques for the local manufacture of these devices.

Method of Assistance:

Provision of technical assistance and funding for experimentation and pilot development for construction of prototype systems, and of assistance to local artisans or entrepreneurs in setting up a production process.

Examples:

i) Heating and Drying

Applications include crop drying (rice varieties, tobacco, corn, etc.), low-temperature hot water[13] (e.g., for washing), and distillation[16] (e.g., for fresh water supply). These are low-temperature applications of technologies which can be manufactured locally.

Cost: $300,000 per country for a 3-year period involving 3-5 applications.

ii) Refrigeration and Ice Manufacture[17]

Applications including making ice for fish preservation and refrigeration for warehousing of produce. A possible program might involve the construction of ten pilot plants of one-half to one ton capacity in each of five tropical countries. In-country manufacture of

collectors and perhaps also of the cooling equipment might be possible. Powered by a solar-thermal collector system generating electricity.

Cost: $100,000 per application (approximately 50 kw/day peak capacity.)

iii) Pumping

Applications include supply of drinking and irrigation water with pumps under 1 hp for household or village water use with solar-thermal generated steam. The application of efficient small heat engines is required. This may simply involve the application of an existing technology, or experimentation and pilot development, for construction with local labor.

Cost: $100,000 per country for 2-4 applications.

Selection Criteria

Criteria	Ranking	Remarks
Energy Impact	L	Low in total Btus to be gained.
Development Impact	H	High is ability to target socially important function.
Implementability	H	
U.S. Role		

PA 7: Managing Biomass Production

Importance:

Inefficient and unwise use of the land which generates biomass has led to deforestation and desertification in many areas, damaging the environment and reducing the productivity of land.[18, 19] It is important to design programmatic areas of assistance which cannot only provide new sources of usable energy inputs to LDCs (in particular to rural populations) but which can also limit environmental damage.

Objectives:

Reduction of the environmental, social, and economic impacts resulting from unwise exploitation of biomass (primarily forest) resources and making

biomass fuels available as an energy resource.[20] More specifically, there is a need 1) to assess the extent of existing deforestation and its current and projected rates and to establish the major determinants in different areas; 2) to evaluate the use of wood-based fuels and improve the efficiency of its production, including the use of by-products; 3) to increase the efficient use of agricultural wastes; and 4) to improve biomass fuel farming and cropping methods.

Method of Assistance:

Funding in-country studies by local institutions; supply experts in various fields as needed; support purchases of equipment; train LDC individuals in forest management; and convene workshops for dissemination of new findings.

Examples:

i) Preliminary Deforestation Survey

Global compilation of inventories, production rates and current disposition of forestry in LDCs; identification of main regional causes of deforestation.[21]

- Areas to be covered:
  - . Latin America - Amazonian and La Plata Regions.
    - Andean and Middle American Region
  - . Sub-Saharan Africa - Sudan and Sahelian Region,
    - Central and Southern Africa
  - . Southwest Asia and North Africa
  - . South Asia
  - . Southeast Asia

Cost: $600,000 total.

ii) Improved Wood-Based Fuel Technologies

Development and testing of improved pyrolysis technologies. Current methods of charcoal production in LDCs are inefficient; AID efforts in this area should be expanded. Multiple tests of improved stationary and mobile units, and development of local manufacturing capabilities should be emphasized. To yield useful results the program would have to cover at least two contries.

Cost: $200,000 per country.

iii) Use of Agricultural Residues

Major uses of agricultural residues (including the slash from slash-and-burn agriculture) are used for cattle feed, soil nutrients and conditioning, and fiber. Studies should be carried out to determine: (a) The value of different residues as feed for cattle in a variety of regions over the next several decades. (b) The value of residue retention on different agricultural soils. Here, a strong theoretical analysis and review with attention to soil types is needed. Two sub-issues should be considered: the impact of using slash-woody material for charcoal production rather than use of ash on site, and the relative merits of putting agricultural residues into a biogas digester or leaving them directly on the fields. The study should also be sensitive to the impact of different assumptions about fertilizer availability and consider their relative productivities in different regions over the next decade. (c) The value of some agricultural crop residues and forestry residues as feedstocks for pulp and wood products. A review of the status, development, and possible deployment in different regions of technology using crop residues as feedstocks is needed. This should include an appraisal of residue utilization in the forest products industries in certain regions. The availability of crop residues will also be influenced by changes in yields and in the residue coefficients of crops in different regions. This work may be synthesized with the analyses described above to yield some insight into changes in the pattern of desirable residue availability over the next decade.

Cost: $450,000 per country.

iv) Technology Development of High-Yielding Biomass Fuel Crop Systems

This activity should be designed around major agroclimatic regions. Three experimental centers for testing in district agro-climatic zones would probably be a useful minimum over the next five years. Such centers would preferably be in addition to existing institutions. The three broad zones of greatest interest are humid tropical, monsoonal tropical, and submontane tropical. Conceivably, a distinction

might be drawn between savannah (drier) and forested (more humid) monsoon zones.

Cost for a 100-hectare station with basic scientific facilities: $350,000.

v) Intensive Biomass Fuel Farming and Cropping Systems

Technology transfer of biomass fuel systems to supply rural needs on a small scale is the primary focus of this activity. Emphasis should be placed exclusively on fast-growing biomass systems - trees, grasses, shrubs, and aquatic plants, which offer an important option.[22] This activity could be linked with Technology Development Centers so that they may monitor and provide extension to village plots.

Cost: Start-up management assistance and monitoring can come to $10,000 per year per plot in the initial phases (which may last only several years for each plot). (The ASTRA experimental plot in Bangalore, India, costs about one-half this.)

Cost for a station of 5 plots: $75,000 per year.

Selection Criteria

Criteria	Ranking	Remarks
Energy Impact	H	Can be a major source of liquid and other fuels.
Developmental	H	Can boost local employment and rural regional development.
Implementability	M	Socioeconomic limitations to small-scale management.
U.S. Role	M	Forest management as distinct from reforestation.

PA 8: Liquid Fuels From Biomass

Importance:

The major interest of many LDCs is to reduce their dependency on oil imports. While improvements in biomass utilization technology may be of interest for limiting environmental damage from current practice, there is an equal, if not greater, interest in displacing oil with fuels derived from biomass.[23]

Objectives:

Development of technology for extraction and utilization of liquid or

gaseous fuels from biomass to be substituted for refined petroleum products, either in a highly refined or a less refined form.

Method of Assistance:

Provision of funds and technical assistance to (a) develop the conversion technology for biomass-generated fuels, (b) adapt existing energy conversion technology, using petroleum products to accept fuels derived from biomass, and (c) find suitable energy uses and demonstrate technologies where biomass fuels can replace petroleum products.

Examples:

i) Ethanol Systems Study

The Brazilian ethanol program represents an important initiative in producing highly refined fuel from biomass for use in automobiles. The principal aims of this program appear to have been rural development.[24] A careful review of Brazil's program together with a feasibility study of launching comparable programs in other interested LDCs should be made.

Cost: $100,000 per study.

ii) Ammonia and Methanol Production from Biomass

At the interface between environmental and oil conservation concerns is the possibility of ammonia production from biomass after gasificatoin. A variety of factors suggest that the most useful application might be in relatively small-scale plants located in areas where distribution of fertilizer is expensive and where as a consequence intensification of agriculture has been uneconomical.[25] The usefulness of such manufacturing units needs to be assessed by investigating different economic and engineering issues. Since this technology is similar to the one for clean synthesis gas manufacture, it is also proposed that some attention be given to an investigation of methanol manufacture.

Cost: $200,000 per study.

iii) Power Heat Engines with Biomass Crude

There is a potential for using crude biomass-derived fuel in

stationary heat engines such as diesel, Sterling-cycle, and steam engines.[26] Detailed engineering analysis should be made of how practical, reliable, and cost effective systems might be adapted to a variety of industrial and agricultural uses, taking several countries into consideration. Low-RPM diesels, capable of being manufactured in small machine shops, should be considered. They could possibly be made to operate on either the char or the oil-fraction of a crude pyrolysis. These units, if developed, could be used for efficient cogeneration of steam and electricity (or mechanical power) more economically than conventional boilers. Low-energy gasifiers offer another option of this type.

Cost: $150,000 per study.

Selection Criteria

Criteria	Ranking	Remarks
Energy Impact	M	To serve transport sector using conventional inefficient locomotion technology.
Development Impact	H	
Implementability	L	
U.S. Role	M	Chemical and mechanical engineering experience.

PA 9: Electicity Generation and Industrial Energy Supply from Biomass

Many areas with substantial industrial and urban populations are remote from primary indigenous resources of lower-cost alternatives to oil and gas. In these areas the use of biomass-powered central-station power plants for base of intermediate load in the 50 to 100 Mwe range may warrant serious consideration.[27] Similar arguments may apply to energy needs for industrial facilities.

Although this technology is primarily oriented towards satisfying urban energy needs, it promises high benefits to the rural sector through the control of deforestation. The more intensive management of forest areas and the higher commercial value of output per hectare relative to traditional forestry uses are likely to prevent further degradation of forests. This approach could also influence industrial siting and this, combined with stimulation of the rural

economy resulting from supplying the raw material, could lead to accelerated development of a market economy in these areas. The option is also relatively labor intensive, thereby creating additional employment opportunities.

The potential applicability of this approach is difficult to estimate; at U.S. levels of consumption it could only supply a rather small fraction of urban demand. In LDCs where consumption is far smaller per capita, the contribution could be of considerable importance to remote cities.

Objectives:

Generation of electricity from biomass in central power plants and/or development of the use of biomass for satisfying large-scale industrial energy needs.

Method of Assistance:

The technologies to use biomass material in this manner exist. What is required are improvements in boiler design, such as fluidized beds for biomass burning. These may be more efficient and reduce the cost. The primary limitation will be the required land areas for biomass production. With present biomass production techniques, the land area for biomass production required will be three-to-five times larger than the reservoir surface area usually required to obtain an equivalent amount of hydroelectric capacity.[28] This kind of land area is more easily obtained in LDCs than in the U.S. because their land ownership patterns facilitates the regulation of large areas of forest. A key problem is to assure state utilities and private industries of a reliable supply of fuel in the face of sharp climatic changes. It is recommended that construction of such facilities be arranged through use of special credit terms.

Examples:

i) Identification of Biomass Production Systems

Identification of large-scale uses for biomass can be made through feasibility studies to identify specific production/use systems. Although the formal nature of this program is in the form of an assessment, it would also identify construction opportunities that can be implemented within a five-year period.

Cost: $200,000.

ii) Engineering Review of Current Facilities and Analysis of the Economic Feasibility in Areas Identified in (i)

Several projects, each with distinctly different characteristics, should be selected. Such a selection might include: production of central station electricity, industrial steam with cogeneration, and charcoal production for use in manufacturing steel.

Cost: $150,000 per application. Review of iron and steel manufacture would require greater expenditures.

iii) Improving Forest Production

Relatively conventional intensive forestry techniques are to be used[29] with pilot facilities for higher-yielding techniques to be tested. The possibility of using wood-drying techniques would be evaluated.

Cost for smaller facilities: $75,000 per project per year.

Selection Criteria

Criteria	Ranking	Remarks
Energy Impact	M	
Development Impact	M	
Implementability	L	
U.S. Role	L	

PA 10: Urban Waste Management

Importance:

There are many environmental problems associated with garbage burning; dumping of garbage in the open consumes energy. Proper management procedures can lead to improved sanitation as well as generation of energy from wastes.[30] By-products, like metallic wastes and fertilizer, can be recovered. If adapted to an integrated urban waste management, these techniques have been found to be cost effective in the developed countries.

Objectives:

Better management of urban wastes so that they become energy source materials.

Method of Assistance:

Programs would provide technical assistance and cooperation to local

institutions and governmental agencies to conduct waste surveys for assessing potential usefulness as energy source materials.

Examples:

i) Survey of Urban Wastes

A few urban centers should be selected for surveys and analyses. Included would be: (a) garbage statistics of domestic, commercial, and industrial areas; (b) energy content - analysis of garbage samples; (c) enumeration and study of different garbage collection, transport and disposal procedures; (d) statistics on sewage quantity, collection techniques, and treatment methods; (e) economic analysis of combined sewage treatment and energy generation systems.

Cost: $50,000 per survey of an urban center.

ii) Evaluating Waste Utilization in Specific Settings

Utilization of waste resources can only be maximized if local conditions pertaining to the availability of equipment and expertise are known, as well as the economics of collection and disposal economics, and the environment. A review of existing technologies must be conducted. Modification of some of these and development of new, more efficient technologies that can be adopted locally must be addressed. A study should be made of the possibilities for increasing energy generation and water management with extra inputs evaluated; e.g., sewage water and their conversion into biogas, protein cake, and fertilizer. The study will require two years.

Cost: $200,000 per study.

iii) Design and Demonstration of Energy-Waste Systems

The design of an integrated waste management system for each area consisting of various subsystems for waste collection, separating, waste recycling, energy generation, conversion, and distribution. The installation of demonstration centers in selected urban areas for monitoring and evaluation.

Cost for five years - $5,000,000 per medium-sized metropolitan center.

Selection Criteria

Criteria	Ranking	Remarks
Energy Impact	L	
Development Impact	H	Social benefits may be as important as energy benefits.
Implementability	M	
U.S. Role	M	

PA 11: Biogas

Importance:

Biogas conversion is an energy technology which can provide fuel and fertilizer and incidentally improve sanitation, water quality, and forest quality.[31] These units utilize human and animal excrement, city sewage, organic industrial wastes, and plytomass (e.g., straw or water hyacinths). The fact that they have not spread more rapidly up to now is partly due to high capital costs, and to institutional problems affecting collection of the inputs on a regular basis. Recently, however, a Chinese design costing only $5 to $25 was developed and built with bricks and cement. It has proven so useful in China that over four million units have been constructed since 1970.[32] This does not mean the system will spead as rapidly in other LDCs, but clearly, as oil prices increase, this design is likely to find much wider application.

Objectives:

Development of suitable designs for biogas generation. The designs should draw exclusively on local materials and skills.[33] The cost for small units is to be brought below $50 per unit, first in Latin American and South Asian countries, and eventually in all interested LDCs.

Method of Assistance:

There are two likely target groups: potential entrepreneurs who would set up rural biogas plants in response to demand, and cooperatives successful in other ventures and desirous of expanding their activities into biogas. It appears reasonable to conclude that small units can be built for under $50 in much of South America and Southern Asia. These should be readily marketable.

U.S. assistance should select target areas in several interested countries and identify entrepreneurs and cooperatives from these areas. These persons can be trained in "how-to-construct" and be provided with loans for starting capital on favorable terms. Additional back-up support should be given in preparation of construction, operation, and maintenance procedures, and in monitoring performance. Local support for analyses of optimal feedstock inputs should also be provided for:

Examples:

i) Biogas Technology for Concentrated Sources

Special biogas technology projects should focus on activities providing residues of concentrated sources of input materials, such as sewage treatment plants, piggeries, poultry farms, and ranches. Training of contractors to install units with approved design and monitoring of their operation can provide important information on the day-to-day operation of such units. Some of these installations could involve pilot projects using aquaculture effluents.

Cost: $100,000 per country.

ii) R&D Support

R&D support pertaining to: utilization of water hyacinths and other weeds; low-temperature control problems; separation and use of carbon dioxide (e.g., dry ice manufacture); and pathogen behavior in digesters fed with night soil. All involve the setting up of experimental units, except for the last item which might be limited to a literature search with special attention to the anaerobic digestion and the Chinese biogas literature.

Cost: $50,000 per center.

Selection Criteria

Criteria	Ranking	Remarks
Energy Impact	M	
Development Impact	H	Accelerates rural development and has one potential for sanitation improvement.

Selection Criteria (Continued)

Criteria	Ranking	Remarks
Implementability	M	Requires action on the part of many individuals.
U.S. Role	L	Potential for intra-LDC cooperation.

PA 12: Wind[34]

Importance:

Wind can be important as a renewable resource in many areas of the world.[35] It cannot, however, satisfy the total energy needs of an area and must, therefore, be made part of a larger energy system.

Wind turbines in the 1/4 to 10 hp range have been used for centuries to pump water. The characteristics of wind energy and pumping requirements are well matched. The generation of electricity from wind can be reasonably efficient, and wind turbines in sizes up to 10 kw are commercially available in various countries.[36] Horizontal axis wind turbines are usually self-starting at wind speeds in excess of 6 mph; in larger sizes they must be turned out of the wind, or feathered, at wind speeds above 30 mph. The vertical axis turbines are generally held to be less severe than for horizontal axis units. Current technology is well developed for both classes of machines up to the 10 kw range. Larger turbines are being designed for up to 1000 kw.

Objectives:

Introduction of the use of wind turbines in areas with sufficient wind.[37] This would require collection of wind data, area-specific feasibility studies of specific types of wind turbines, and development of auxiliary generators, motor pumps, and storage devices. At present, large wind machines are in an early stage of development. A multiplicity of small machines should be better suited to most, but not all, LDC applications. It is worth emphasizing that much of the equipment for these small wind turbines can be manufactured in many of the LDCs.

Method of Assistance:

A variety of different inputs are needed. Some involve technical, financial, and advanced equipment assistance to the LDCs; others require

support to develop specific technologies in the United States. Programs in this area could be carried out by industry, government, and university consortiums both in the U.S. and in the LDCs.

Examples:

i) Gauging Networks and Data Analysis

Design of wind gauging networks, supply and installation of recording equipment, taking measurements, and establishment of decoding centers. Data should be generalized to larger areas, giving the wind pattern in certain regions.

Cost: $400,000 per country over a 2-year period.

ii) Economics of Wind Turbines

This study concerns the systems economics through a range of wind turbine sizes as well as the overall economics of grouping wind turbines to operate at a constant frequency as contrasted with variable speed machines using the AC-DC-AC link.[38]
Duration: 1 year.

Cost: $100,000.

iii) Windmill Designs for LDCs

Modification of existing windmill designs for application in LDCs. The work of an existing U.S. experiment station could be expanded and some prototypes supplied, installed and test in LDCs.

Cost: $200,000.

Selection Criteria

Criteria	Ranking	Remarks
Energy Impact	L	Limitation of wind availability
Development Impact	M	
Implementability	N	
U.S. Role	M	

PA 13: Decentralized Hydropower

Importance:

Small water-power sites can satisfy a good proportion of rural energy requirements in LDCs.[39] Decentralized (mini) stations drastically reduce transmission costs and losses and also allow other small-scale power generating units (wind or biomass) to be integrated into the local grid. Mini-hydro systems have different designs, depending on whether they have a low or high head. As with large-capacity hydropower installations, development should always be considered in coordination with other resource options and ecological considerations.

Objectives:

Harnessing of the energy potential of small water-power sites to produce electricity or direct mechanical drive for compressors, heat pumps, and other uses.

Method of Assistance:

R,D&D, financial support, technical assistance, supply of advanced equipment, and training for in-country efforts are required. Training would provide manufacturing system, maintenance, and operation expertise. Technical R,D&D should focus on developing suitable energy conversion devices such as heat pumps and hydraulic rams. Cooperatives and/or local entrepreneurs should be provided with financial and managerial training support.

Examples:

i) High-head Impulse Turbines

These types of installations could be located in areas away from an existing grid, and utilize locally made wheels and electrical equipment. Capacities range from 10 to 100 kw in most cases. Possible uses are water pumping and heating, running small processing mills, and fertilizer production. In some cases, electric power may also be available for nearby communities.

Cost for initial projects of ten 25-kw units per country: $500,000 (of which $1250 foreign exchange for initial project.)

ii) Low-head Turbines

Low-head turbines can be installed on irrigation canals or small slow-moving streams. Generated electricity can be fed into local grids, supplying clusters of villages. Activities include setting up shops for the manufacture and repair of machines and providing training for operators. Where possible, turbines and electrical equipment should be made locally. Most installations will run from 200 to 300 kw. Initial focus should be directed to countries with extensive under utilized canal drops which are experiencing difficulties with their rural electricity supply systems.

Cost for ten units of 25 kw each per country: $625,000 (based on average installed cost of 2,500 per kw, $450 of which in foreign exchange).

Selection Criteria

Criteria	Ranking	Remarks
Energy Impact	M	
Development Impact	H	
Implementability	M	
U.S. Role	M	

PA 14: Conventional Hydroelectricity

Importance:

The generation of electricity from hydro sources can provide this benefits in the form of recreational and other multipurpose uses. The known hydroelectric potential in South America, Africa, and Southeast Asia is approximately 1,800,000 MW, of which only 50,000 MW (less than 3%) is currently used in large-scale generating stations. It is estimated that in Western Europe and North America only 30 to 50% of the known hydropower potential can effectively be utilized. On this basis, 500,00 or 900,000 MW remain to be developed in LDCs. In many cases high voltage direct current transmission (HVDC) will be needed to transport the energy to the consuming centers. It may be necessary to obtain regional cooperation in order to exploit many major hydropower sites,

since they have the potential to supply enough energy for several countries, and the very large capital investments required may be justifiable only on such a basis.

Objectives:

Acceleration of the construction of hydroelectric power stations and transmission networks.

Method of Assistance:

The use of joint teams of local and U.S. experts to survey and plan expanded hydroelectricity generation.

Example:

Survey of Hydroelectricity Supply Sites

Survey country and region hydroelectric potentials (both large and small sites) in a few selected countries. A typical survey in a medium-size country would require a team of outside consultants working for a period of one year with local utilities and ministries.

One of the results of the survey would be the definition of a feasibility/evaluation of individual sites. Zaire, Thailand, and Burma offer examples of countries where there are large unused hydroelectric capacities.

It is presumed that funding for the site-specific feasibility studies, once identified, would come from local sources or development banks.

Cost: $1 million per country.

Selection Criteria

Criteria	Ranking	Remarks
Energy Impact	H	
Development Impact	L	Generally none for rural uses; also no differential impact as a function of income.
Implementability	H	
U.S. Role	H	

PA 15: Energy Storage[40]

Importance:

The storage of energy can reduce the amount of equipment necessary to supply a given load pattern and reduce fuel usage. The most widely used form of storage is pumped water. This is normally applicable where terrain allows for natural storage. In such cases, efficiency is around 60 to 70%. Storage of electricity can be achieved with limited batteries. But those capable of frequent charge-discharge cycles are more costly. More sophisticated schemes using electrically generated hydrogen and fuel cells do not appear to be suitable for near-term applications in most of the LDCs. The storage of energy using phase-change materials holds promise of allowing high-density energy storage at relatively low cost, but difficulties are being experienced in obtaining a large number of cycles with inexpensive materials.[41]

Objectives:

Technology development of promising types of energy storage systems and in-country demonstrations of their application.

Method of Assistance:

Support of technology development in the United States and the host country. Technical and financial support is needed for planning and feasibility studies to introduce storage systems appropriate to the setting in which they will be used.

Examples:

i) Assessment of Storage Needs

Many applications of renewable resource technologies in LDCs require storage. To be able to properly direct technology transfer and research regarding storage, the type, amount, and length of storage needed in LDCs should be determined.

Cost: $200,000 per country.

ii) Survey of U.S. Storage Technology and LDC Applications

Survey of the state-of-the-art of U.S. storage technology with

R&D into their applicability to LDCs. Would also include phase-change materials.

Cost: $200,000 for the survey.

iii) Low-Grade Energy Storage

Develop technology for improving existing methods of low-grade energy storage. This should be undertaken in collaboration with one or more LDC. The development project would take up to one year.

Cost: $350,000.

iv) Pumped Storage Applications

Assess the suitability of pumped storage for certain LDC storage needs and assist LDCs in selecting sites for pumped storage installations.

Cost: $100,000 per country.

Selection Criteria

Criteria	Ranking	Remarks
Energy Impact	L	
Development Impact	M	
Implementability	M	
U.S. Role	H	

Demand Sectors

Programs in this category focus on important energy-consuming activities where there is the potential for achieving improved energy end-use efficiencies or subsituting more abundant fuels for those in scarce supply. High-priority target areas are the food system and low-income rural and urban households. Programs in these areas often involve changes in the patterns of energy use. As such, they face difficulties or implemention. Energy consumption is not only diffuse but involves habits deeply imbedded in the culture of a society.

While programmatic areas in the energy resource and conversion technologies focus on a specific source and conversion technology, those dealing

with energy demand must be directed toward a specific device or process which is performing a social function. At the same time, any changes introduced into such end uses must be consistent with expected modifications in the local supply/conversion system.

Application of Criteria

The demand sectors singled out for programmatic areas of energy assistance are those where fuel shortages are likely to pose serious problems for the consumer or where a drastic improvement in the energy efficiency or type of source used can reasonably be expected in the near future. Even with this restriction, the energy impacts of programmatic areas in the demand sector are rated high for only half the areas. The others are given a medium rating. Success of the efforts directed toward many of the targeted areas is not expected to alter national energy supply-demand pictures. But all have a high development impact. All but one is directed toward rural energy use. The urban case deals with the energy problems of the urban poor. Only a medium ranking on implementability has been assigned to most programmatic areas because of the high interaction with social customs. Marked departures from this ranking should be expected from country to country and in the event of unusually difficult national energy demand/supply situations.

Because the nature of energy use and the technologies employed in rural areas of developing countries is foreign to recent U.S. experience, a relatively low ranking is given to the applicability of a special U.S. role.

PA 16: Improved Cooking Devices

Importance:

Assurance of an adequate supply of energy for cooking at reasonable prices is one of the greatest energy problems faced by the poor in the LDCs. The cooking of food consumes 60% of the energy used in the food system in the rural areas, and almost all the energy used for cooking is from biomass sources such as wood, crop residues, and dung.[42] Excessive use of these biological resources has produced severe environmental degradation.[41] Increasing the energy efficiency of fuels used in cooking is of primary importance on both accounts.

The quantities of fuels that may be saved are substantial. A simple stove might improve the heat transfer efficiency by a factor of 2 to 3. Moreover, on a household basis the investment in hardware equipment will be relatively small. The primary difficulties will be found in designing implementable programs in the field.

Objectives:

Two major activities are required to develop "appropriate" improved cooking devices with increased energy efficiency and to insure their use: significant investments in the distribution of the improved devices and the eduction of users through the use of extension services.

Methods of Assistance:

Studies and research projects to be undertaken jointly with local institutions; village outreach should be supported through training and deployment programs; innovative means of distribution should be encouraged and prototype equipment supplied.

Examples:

i) Survey and Evaluation

Review current cooking practices through sample surveys of different regions and income groups: conduct evaluations of these practices to determine their efficiencies and operational defects and transferability.

Cost: $500,000

ii) Design Improvement

Fund improvements in local designs which use local materials and skills.

Cost: $250,000 per country.

iii) Manufacture and Demonstation

Support demonstrations using locally manufactured improved cooking devices. Includes their local manufacture.

Cost: $500,000 per country per year.

Selection Criteria

Criteria	Ranking	Remarks
Energy Impact	H	
Development Impact	H	For nearly all low-income strata of the rural populations.
Implementability	L	
U.S. Role	L	

PA 17: Motive Power for Agriculture

Importance:

After cooking, food production is the second largest energy user in the total food system.[43] This includes energy input form animals, human, and power-driven engines.[44] Most traditional agricultural economies are unable to produce enough food.[42] Appropriate commercial energy inputs could increase the food supply substantially.

Objectives:

An increase in the productivity of agricultural labor through the introduction of appropriate power technology in agriculture and improved cultivation practices, e.g., improved seeds, fertilizer, and pesticides. This must be balanced against a second objective of maximizing the efficient use of energy in agricultural production, rather than viewing it as a replacement for labor. Guarding against environmental damage in the form of greater soil erosion and water runoff which often results from mechanized plowing and tilling must be given proper attention in designing specific programs in these areas.

Method of Assistance:

Research should be conducted in current raditional agricultural practices and support given to the development and demonstration of new implements driven by humans, animals, and power engines. Programs in this area may be considered energy extensions of current agricultural assistance programs. Adequate attention should be paid to new agricultural developments and the implied energy requirements, including existing farming systems such as crop rotation and interplanning.

Examples

i) Reduced Fillage

Some recently-developed agricultural practices in the U.S. dispensing with some of the ploughing and weeding could be applied to LDCs. Staffing and financing of mechanized agricultural experiment stations for selected crops and locations.

Cost: $200,000 per experiment station per year.

ii) Appropriate Agriculture Technology Fund

Many appropriate technology devices for agricultural production have been developed, but their adoption has been very slow. A revolving loan fund on an individual or cooperative basis could be combined with demonstrations of proven devices that are energy efficient and use locally available energy sources.

Cost: $150,000 per country per year for 5 years.

iii) Manufacture of Appropriate Farm Machinery

Tried and proven agricultural production equipment that is energy efficient and uses locally-available energy sources need to be manufactured in sufficient quantitites within the country. A loan fund plus U.S. business expertise could facilitate their small and medium-scale production.

Cost: $1 million per country.

Selection Criteria

Criteria	Ranking	Remarks
Energy Impact	M	
Development Impact	H	
Implementability	M	
U.S. Role	L	U.S. farm mechanization is very advanced but is also very dependent on oil and other petroleum-based products.

PA 18: Soil and Water Management and Irrigation

Importance:

Soil and water resources are being rapidly degraded in many parts of the world, resulting in reduced productivity of the land (for the production of food and cash crops).[45] Increased fertilizer application could partly offset these losses. A significant quantity of fossil energy is also employed in irrigation.[46] Technological information and appropriate incentives for the farmers are needed to implement effective soil and water conservation that can reduce the inputs of fertilizer and irrigation water.

Objectives:

Increased efficiency of energy use in agricultural production through the development and introduction of sound soil and water managment practices, including irrigation.

Method of Assistance:

Funding and technical assistance for field studies, demonstration projects, and training.

Example:

i) Earthen Dams

Construction of small earthen dams to reduce soil erosion and improve the retention of groundwater; feasibility studies, and the supply of designs and construction equipment should be included.

Cost: $400,000 per country.

ii) Crop Rotation Subsidies

A pilot project of providing subsidies to farmers for proper cooperation that would cut down on soil erosion and the loss of soil fertility. Initial funding and expert assistance in setting up such a system could lead to a host country government program of providing such subsidies from farm taxation.

Cost: $500,000 per country for a 2-year period.

Selection Criteria

Criteria	Ranking	Remarks
Energy Impact	M	Indirect effect on energy demand.
Development Impact	H	
Implementability	M	
U.S. Role	M	

PA 19: Fertilizer Production[47]

Importance:

Projections of fertilizer demand in the LDCs by the Agricultural Services Division of FAO in 1974 suggest an increase by a factor of 4 in nitrogen requirements by 1985 and by a factor of 10 by the year 2000. It is projected that the future energy demand for fertilizers (primarily nitrogen) will be second only to that required for food preparation. These projected needs for fertilizers could be reduced an estimated 20 to 30% if better use were made of animal dung, crop residues were not burned, and effective soil and water conservatoin practices were employed. Fossil feedstocks used in the production of ammonia for fertilizer may be either oil, natural gas, or coal.[48] Ammonia may also be made from water and purified nitrogen with the application of electricity.[49] To be used on small farms, ammonia must be converted to urea, requiring a capital investment comparable with that for an ammonia plant.

Fertilizer plants using water electrolysis by hydropower now cost about 2.5 times as much as a comparable plant using natural gas; energy requirements also run higher by a factor of 3. Costs for plants using coal are somewhat higher. Both processes are at the pilot stage of development. While it will be necessary for most LDCs to continue to import phosphorus and potassium to produce balanced fertilizer, urea production could become much more widespread if the electrolysis or the coal-based process can be developed to the point where they become competitive with oil and natural gas-based systems.[50]

Objectives:

The possibilities for non-petroleum-based fertilizer production

should be assessed at the country level*; to conduct R,D&D on small and medium-scale process plants. Processes adapted to individual country needs which could become the subjects of collaborative efforts should be given the highest priority.

Method of Assistance:

See example.

Examples:

i) Development of Small-Scale Fertilizer Plants

R,D&D on systems based on small-scale coal and electrolysis to help reduce capital costs and produce standardized designs for such plans capable of being manufactured abroad.

Cost: $1 million per plant.

ii) Facilitating Manufacture of Fertilizer Plants

Provide loans and grants to construct such plants in the LDCs, particularly in the low-income oil-importing countries.

Cost: $400,000 per country.

iii) Management Training

Support commercial firms to train persons from LDCs in management of fertilizer production operations.

Cost: $100,000 per country.

Selection Criteria

Criteria	Ranking	Remarks
Energy Impact	H	
Development Impact	H	Rural development impact.
Implementability	M	
U.S. Role	M	Even though a leading producer of fertilizer, experience with unconventional small-scale methods is limited.

*In Nepal, for example, a recent study[49] pointed out the potential of small-scale hydropower for electrolytic fertilizer production, but emphasized the need to analyze cost factors, the characteristics of fertilizer demand, mineral resources, etc.

PA 20: Rural Transportation

Importance:

Transportation is indispensable in linking resources, raw materials, equipment, labor supply, and demand centers. The capital investment and operating expenses required to establish and maintain reliable transport routes, and in some LDCs for the development of vehicle fleets, exceeds the transport share of GDP in developed countries. Existing power-driven means of transport in LDCs are based almost entirely on oil. In an effort to reduce the dependence on imported oil, other energy sources must be used to drive vehicles as much as possible. A large amount of research and experimentation is needed in this field. There is a special need for improved transportation within and among villages.

Objectives:

Development of designs for energy-efficient transport systems, including road and truckbed construction and vehicles for the distribution of goods and the movement of passengers in urban and rural areas.

Methods of Assistance:

Research vehicle design; planning of studies for energy-efficient transportation networks for regional development.

Examples:

i) Survey of Existing Transportation Modes

Examine present costs and particular problem areas of internal transportation in LDCs to provide a useful "baseline" and comparative information. Special attention should be given to farm-to-market transport systems.

Cost: $600,000 for the comperative survey.

ii) Bicycles and Pedal-Powered Vehicles

Adapt pedal-powered vehicles to rural areas which are suitable to poor roads, adverse terrain, and utilizing locally available materials, construction, repair, etc. Bicycles are generally the most energy-efficient means of transporting people and small loads

in urban areas or regions with good roads. They can be modified to serve a number of purposes. The research period required is approximately four years.

Selection Criteria

Criteria	Ranking	Remarks
Energy Impact	M	
Development Impact	H	
Implementability	L	
U.S. Role	L	

PA 21: Food Loss Prevention

Importance:

Although the demand for energy resources related to preventing food losses is the lowest of any element in the food system, it is expected that total world food supplies could be significantly increased through this means.[51] Pre- and post harvest crop losses are estimated to total 48% of all food production. About 20% of these losses are due to post harvest attacks by pests that could be averted by the use of simple improved storage facilities. Another 35% of pest losses occur in the field, and is more difficult to prevent. Preharvest pest loss reduction also requires scientific advice and field research to establish sound pest management programs which should lead to optimizing the use of energy-consumptive pesticides and bioenvironmental control methods.

Objectives:

Development and distribution of storage designs that reduce post harvest crop losses. Present storage systems should be studied, problem areas identified, improvements in storage deisgn initiated, and aid given in the construction of storage facilities and their introduction in villages.

Method of Assistance:

Technical and financial assistance should be given to append a storage and crop pest control unit to an existing agricultural development institution in LDCs. Studies in appropriate village storage designs and low-energy

preharvest pest control are included.

Examples:

i) Village Grain Storage

Survey of the wash village grain storage method in a country and of the sources of losses. Development and testing of improved storage designs. Appropriate means should be found to disseminate the results on a regional or national scale.

Cost: $200,000 per country.

ii) Small and Medium-Sized Storage Sites

Suitable existing designs of storage silos on the village or district level should be identified and applied to particular countries. The necessary institutional arrangements, such as cooperatives or state marketing bodies should be included in the program.

Cost: $500,000 per country.

Selection Criteria

Criteria	Ranking	Remarks
Energy Impact	M	Indirect energy saving.
Development Impact	H	
Implementability	M	
U.S. Role	M	Advanced knowledge of large-scale grain storage.

PA 22: Urban Systems

Importance:

In view of the very high urbanization rates to be found in the majority of developing countries (frequently involving a doubling of the urban population in 15-year intervals), measures that alter the structure of new buildings can have a significant impact within five years, by which time they could affect 20% of the urban areas. Within 15 years, fully one-half the urban areas could be affected. Significant opportunities exist for greater efficiency both in direct energy use and in the energy employed in construction in urban areas in many LDCs.

Energy conservation measures should be introduced into the manufacturing processes of construction materials and choice of materials into the operation and building and other urban structures.

Objectives:

Increase in the energy efficiency of new additions to urban areas.

Method of Assistance:

Support of urban planning studies, development and demonstration of building designs, country visits by teams of experts.

Examples:

i) Urban Planning Assistance

Perform studies on a range of urban planning problems, including industrial and residential siting, transportation and housing, environmental assessment and monitoring. Projects could include visits by teams of experts (three-to-five people for six weeks) or collaborative planning activities.

Cost: $150,000 per urban region per year.

ii) Housing Designs

Design low-energy-consuming, low-cost housing which incorporate maximum use of natural light and minimize the use of mechanical power for heating and cooling by control of sunlight and air penetration. Such designs can reduce the use of cement, steel, glass, metals, plastics, synthetic fibers, and other energy-intensive materials while still providing comfortable, well-grouped working and living spaces. They can also promote the use of locally available wood, adobe, natural fibers, and other materials that can be substituted. Current U.S. assistance programs in the housing area should be reviewed for their energy implications.

Cost for each design and demonstration program for 3-years: $200,000 to $300,000.

iii) Commercial Buildings Energy Design and Implementation

Provide technical assistance in establishing an dimplementing energy design standards. These programs could have a significant energy impact, especially in view of the large fraction of total energy use represented in hotels (where tourism is important), hospitals, and government buildings. In particular, solar water heating promising. Would also include demonstration of selected energy-conserving technologies or designs for use in commercial buildings.

Cost: $400,000 per country.

Selection Criteria

Criteria	Ranking	Remarks
Energy Impact	H	This potential is in the long term.
Development Impact	H	If targeted to urban poor.
Implementability	M	Requires long-term view.

C. INFRASTRUCTURAL AND CROSS-CUTTING PROGRAMS

Programmatic areas which either provide vital support to complement the technology-oriented programs in Section I above, or deal with an aspect of the energy system which is not technology oriented fall within this category. Most of the technologies and approaches noted above are new not only to LDCs but to the United States as well. They can be expected to be apopted in LDCs only if the creation of indigenous capability becomes a focus of U.S. energy assistance activities. This development of local technical and institutional capability is, of course, often much more difficult than simple technology transfer.

Assessment and Planning

Lack of information about potential energy resources and levels and the structure of consumption is a serious impediment to planning and policy making.[52] Resource and energy demand surveys are, therefore, a prerequisite for effective planning. Very few LDCs have a sizable planning and analysis

staff working continuously on energy-sector planning, and even less attention is given to rural and domestic energy problems. There is a pressing need for the support of these planning activities which can lead to the formulation of an energy section of national planning ministries.

Application of Criteria

Since the programmatic area in this section provides essential infrastructural and cross-cutting support for energy-source or technology oriented programs, they would be rated high on energy impact as well as on development impact.

Energy assessment and planning studies are also relatively easy to carry out. Nearly all LDCs have institutions in and outside the government which, given the right kind of assistance, can undertake or collaborate with the required studies and planning exercises. Therefore, programmatic areas in this section are rated high for implementability.

The U.S. advantage for giving this kind of assistance is medium-to-high. The rich U.S. experience with information gathering and processing is somewhat marred by the paucity of experience with rural areas in LDCs.

PA 23: National Energy Assessment and Planning

Importance:

Energy is now recognized as a major factor in national economic development. Energy systems analysis and planning can play an important role in formulating energy strategies and policies which may further the economic and social zones of a country. In most countries of the world there is no provision to include energy considerations in the planning processes. The relatively sophisticated electric sector planning covers only one small component of the role of energy in development. Assistance in energy planning can be one of the most effective (and least costly) ways of improving the energy posture of developing countries over the long term.

Objectives:

The creation of an indigenous energy analysis and planning capacity. A prerequisite is an adequate national data base on the supply and demand

for energy. Energy planning and analysis in a developing country must be closely linked with economic and social planning while reflecting the engineering aspects of energy support systems. This requires an interdisciplinary approach which seeks to integrate energy into all aspects of economic and social development.

Method of Assistance:

U.S. and Third World experts in data systems and energy/economic analysis and planning should be sent to LDCs for short periods to assist in the initiation of energy planning activities. In some cases it may be necessary for such individuals to assist in the development of appropriate planning institutions. Where matters of urgent importance require a U.S. team to carry out a country energy assessment, maximum participation from the host country should be encouraged. Grants should also be provided to bring planners to work for limited periods in U.S. energy planning and analysis centers. Courses in energy planning should be given in the United States and at centrally located regional centers throughout the world.

Examples:

i) Establishing an Energy Information System

Set up an energy information system. This will involve gathering energy statistics vital for planning a country-wide survey; establishing appropriate procedures for ongoing monitoring; and making appropriate arrangements for storing and processing energy-related data. All data must be collected systematically and placed in a usable format for easy access. These data should include basic geological information, and the results of surveys of existing conventional and unconventional resources (including renewables) and of energy demand and consumption patterns. In addition to information on the current situation, projections of future supply and demand must be included.

The United States should establish a general format for national energy information and design computer programs that are compatible with the computer systems used in developing countries and also

with the formats specified in U.N. energy accounting. The "software" for a national energy information system could then be offered to any country interested in such a system. Assistance would include the implementation of an energy information system, the assembly and analysis of information from a variety of sources, and the design of a system to gather further information as needed.

Cost for development of a basic information framework: $200,000.
Cost for implementation assistance: $75,000 per country.

ii) Assistance in Energy Analysis and Planning

Provide a team of analysts, including experts in resource evaluation, energy technologies, energy systems analysis, and economic planning to evaluate opportunities for energy assistance. Local institutions and capabilities should be used whenever possible.

Demand/consumption studies and projections form the basis of understanding the full implications of external interventions. Energy analysis can, in this way, be directly tied to national economic and social development plans and/or targets as well as to the evaluation of specific projects. Few LDCs have undertaken such comprehensive energy sector planning efforts; many continue to plan only the electrical network by itself leaving the rest of the energy demands to the nonenergy sectors. As a result, renewable and noncommercial resources are either neglected entirely or are considered only in the context of a particular project.

Cost: Methods development: $250,000 over two years
Application: $200,000 per country.

iii) Rural Economic and Resource Studies

Support studies which include social components as well as economic and technical considerations designed to allow appropriate evaluation. In most LDCs the economic geography and social structure and production systems in the rural areas are not sufficiently understood to come up with sound energy-related policies and programs, especially those

policies relating to traditional and renewable resources such as straw, dung, and biogas. The mechanisms with which these resources are produced and allocated are critical to the evaluation of the efficiency and distributional consequence of particular interventions, whether the intervention be hardware oriented, like biogas plants, or policy oriented, like price subsidies for particular fuels.

Cost: $125,000 per study.

Selection Criteria

Criteria	Ranking
Implementability	H
U.S. Role	H

Institutions

The successful implementation of energy programs in these areas will require:

1. the presence of a sufficient number of personnel on various levels trained in energy management;
2. the existence of institutional structures to facilitate development and transfer of energy-related technology; and
3. the ability of these institutions to initiate, finance, manage, and operate innovative energy delivery systems.

The programmatic areas outlined below focus on three aspects of the institutional infrastructure in energy: (a) assistance to LDCs in developing their own internal institutions and the relationships among them; (b) the role of international organizations fostering multilaterial cooperation and direct cooperation between instituions of developed and developing countries; and (c) the means to encourage private sector involvement in LDC energy activities.

Application of Criteria:

The implementability of these programmatic areas is medium-to-high.

Institutional changes in general meet with only moderate success and tend to have a long lag-period. The U.S. advantage in providing assistance in this field is problematical. Some other developed countries and international agencies have had more experience in this area. The private sector is an exception.

PA 24: Development of LDC Energy Institutions and Energy Planning Groups

Importance:

The formulation and implementation of energy plans requires strengthening and coordinating various ministries and other governmental or nongovernmental bodies. The addition of an energy component in existing ministries in LDCs would be helped by the creation of separate energy planning groups. Groups in the relevant ministries would be coordinated with those in the local administrative units, and with comparable groups in other specialized institutions, such as the central bank.

Objectives:

Strengthing of, and in some cases, creation of institutions in LDCs that can adequately deal with a variety of aspects of energy.

Method of Assistance:

General support grants should be provided in addition to advice on how to organize such energy planning groups.

Examples:

i) Creation of Energy Planning Groups

Creating an energy planning group in the planning ministry or natural resource ministry of LDCs requires funding for technical assistance personnel, for in-service training, and for office space and equipment.

Cost: $150,000 per country per year for a 2-year period.

ii) Creation of Cooperatives for Exploting Mini-hydropower

A public cooperative would be created to develop, operate, and manage small hydropower development. Such co-ops could support a trained

cadre of technicians to maintain the units and could manage individual installations or a system of such installations tied into a local network.

Cost: $100,000 per country per year.

Selection Criteria

Criteria	Ranking
Implementability	M
U.S. Role	M

PA 25: International and Regional Cooperation

Importance:

Much of the information required by LDCs to improve their energy situations (particularly in rural applications) exist in the Third World. Efforts to develop international and regional cooperative undertaking to improve on and disseminate this information help all countries.

Objective:

Promotion of cooperation between countries, institutions, and individuals for the purpose of improving techniques in energy production and use and their dissemination. Where appropriate, these would include institutions and individuals in the developed countries as well.

Method of Assistance:

Several ways of achieving these objectives are described in the examples given below.

Examples:

i) Information Exchange in Energy Technologies

Promote regional and international cooperation in exchanging information on the development, adaptation, and transfer of energy technologies. Existing and emerging regional energy research institutes would be provided with funding to support exchange of technical personnel. Existing contract research

centers in LDCs would be used to conduct region-wide field tests, evaluations, and necessary adaptations of existing technologies to improve their suitability to that region. For example, biogas activities that are quite far along in Asia could be introduced on a wide scale to Central America by arranging for a regional set of field tests and demonstrations by an established contract research center such as ICAITI in Guatamala.

Cost: $50,000 per research center per year.

ii) Exchange of Personnel

Provide for the exchange of scientific and technical personnel in the energy field. This would take the form of internships or fellowships for LDC personnel to work or study abroad, or to support U.S. technical personnel working in LDC institutions and participation of LDC personnel in international meetings and conferences.

Cost: $100,000 per country per year.

iii) Collaboration Between the United States and LDC Academic Institutions

This form of assistance can be particularly effective if it is structured to reduce the dependence relationship accompanying other educational programs. The interaction between U.S.-based institutions and those in LDCs also can provide an effective way of establishing close working relations between individuals from the different institutions. A typical collaboration period would be four years.

Cost: $250,000 per institution per year.

iv) Establishment of an International Energy Institute

Establish an energy institute to coordinate and conduct international energy-related development efforts. This has been recommended by various organizations and studies. It could take the form of a separate institute or adjunct to an existing

institution. Institute functions would include high-priority research on prototype technologies that are widely transferable; coordination of multinational research projects; logistical support for technical conferences; assessments of local energy resources, needs, and usable technological innovations; operation of information services; training manpower; and technical assistance for developing extension capabilities. The international agricultural research institutes provide a model for this type of institute, which should be autonomous private organizations with international legal status, an international staff, and a self-perpetuating board of governors serving in an individual capacity.

Cost: $5 million over 5 years.

Selection Criteria

Criteria	Ranking
Implementability	M
U.S. Role	M

PA 26: Facilitating Private Sector Involvement

Importance:

National energy development efforts must have the commitment of both public and private sectors of a developing country. National and multinational companies can perform a central role in making energy development self-sustaining.[53] National companies may also be in the best position to make investments that are decentralized and relatively less capital intensive. Multinational companies, on the other hand, can offer rapid transfer of technology and management experience, pooled research efforts, international training opportunities, spread of investment risks, and acess to capital. The United States government's role should be to facilitate, not supplement, the role of private enterprise.

Objectives:

Increased intervention of the private sector both internally and externally to LDCs, particularly where this can enhance the realization of

self-sustained energy programs.

Method of Assistance:

The form of required assistance differs somewhat according to whether companies that are external or internal to a country are involved. Externally, the increased involvement of multinational companies calls for assistance to the LDCs in the form of technical aid and training to establish better mechanisms to attract and effectively deal with these companies. Internally, the mobilization of the country's own private sector depends on expert advice by the U.S. on how energy ventures can be made more attractive for private initiative. U.S. programs will need coordination with similar activities of the World Bank and other private-sector initiatives.

Examples:

i) Energy Information

Establish an energy information network especially for the private sector to serve as a stimulant to private sector investment. Before investing in LDCs, the private sector requires up-to-date information. The energy information provided by the U.S. government to the private sector needs improvement. Reliable data on natural resources, availability of skilled and unskilled labor, and government policies must be provided on a regular basis.

Cost: $250,000 per year.

ii) Prefeasibility Studies

While sponsoring short-term technical and economic analyses of energy-related products and processes the private sector is often unaware of the market potential for various energy-related products and/or processes. These studies would be analogous to several that U.S. AID has conduted to identify potential markets for products such as jojoba oil (a sperm whale oil subsitute) and guagle rubber. (Both plants grow in semiarid zones).

Cost: $100,000 per study.

iii) Risk Reduction for Business Investments

Private sector participation can be increased through investment guarantees and other financial incentives. These might include utilization of the U.S. Overseas Private Investment Corporation (OPIC) investment assurance arrangements; and encouragement of international financial institutions to be more responsive to the decentralized renewable energy sector. For example, AID could arrange for initial purchases of a minimum number of units for U.S. corporations which have developed a product or process particularly applicable to LDC requirements.

Cost: One-time outlay of $5 million minimum.

Selection Criteria

Criteria	Ranking
Implementability	H
U.S. Role	H

Training:

Training programs must be provided on a number of levels ranging from village extension workers to university programs and middle level government officials. The purposes of all of these programs must be to sensitize the participants to the critical role of energy in improving the well being of their constituencies as well as to familiarize them with what can be accomplished through the use of alternative energy technologies and energy-saving techniques.

Application of Criteria:

Training programs are always difficult to implement, particularly at the village level. Formal courses can be set up but unless care is taken to integrate university educational programs with course for village extension workers, the overall effectiveness of these programs as a whole will be marginal. Similarly, seminars for government officials, local leaders, and small businesses must be followed up by the dissemination of appropriate information to maintain interset and provide up-to-date reports on new advances.

The U.S. role will vary from program to program. At the village level it will be marginal, but it can be significant in the university programs and seminars.

PA 27: Village Extension Training

Importance:

The development of appropriate means of transferring energy information and materials to the people in the village in large numbers is essential for the success of programs in technology development and planning and thus constitutes one of the most fundamental needs of the LDCs.

Objective:

Provision of energy-related training to individuals who can play a pivotal role in introducing improvements in the energy system. The targeted persons whould be village development (or extension) workers, village women, teachers, and artisans. The training could either be separate programs concerned with specific energy issues, or additions to already existing training programs.

Method of Assistance:

Existing rural training institutions would be expanded to add energy as a component. Support provided would be in the form of equipment, funding, and possibly the addition of personnel to existing programs.

Examples:

i) Energy Training for Village Development Workers and Village Women

Train extension workers and low-level administrators in rural areas to make them catalysts for improvements in village energy systems. This is a traditional area of U.S. support to which an energy dimension can be added. Provide energy-related training to women in recognition of their role in collecting fuel and water, constructing cookers, and food-crop processing. Assistance would consist of materials and institutional support for existing rural training institutes.

Cost: $2 million per country for 3 years.

ii) Training of Artisans and Small Business Owners

Conduct special programs to train artisans and small business owners in energy technologies. Although these groups are by no means the poorest in these areas, they appear to play a pivotal role in the development and poularization of new technologies. Courses would include technical and managerial training and should be directed toward expanding the skills and perceptions of the participants in energy. Assistance would consist of support for the training institutes and equipment.

Cost: $300,000 per country for 2 years.

Selection Criteria

Criteria	Ranking
Implementability	M
U.S. Role	L

PA 28: Higher Education

Importance:

There is a shortage of trained technical personnel in most LDCs to develop and implement energy programs. Training carried out wherever possible in the LDCs themselves or at regional institutions can strengthen indigenous institutions in their knowledge of energy technologies and energy-saving techniques in household use and food production.

Objectives:

Offer mid-career training to middle level government officials, academicians, and private sector employees on various current aspects of energy, either through formal programs or special seminars.

Method of Assistance:

The general need is for funding, personnel, and equipment. U.S. assistance could support existing universities and technical colleges as well as LDC research institutes. This is a tradition area of support for AID, and its role could be expanded to include general programs or specific

studies in energy, including energy-related technology.

Examples:

i) Energy Issue Seminars for Senior Officials

High-level teams would be sent to the developing countries to make presentations to the senior governmental officials. These teams should be of such a stature that they would have little difficulty in gaining the attention of the senior administrators for a short period of time. Highly regarded U.S. institutions, such as the National Academy of Sciences, could provide two or three teams of two or three senior scientists knowledgeable in the ares of energy.

Cost: $25,000 per seminar based on a minimum 5 seminars in proximate countries.

ii) Advanced Multinational Courses

Courses in specific advanced technologies are to be organized for multinational groups from industry, government, scientific institutions and universities. These courses may be held in either developed countries or in regional technical centers. They would be geared primarily to reaching professionals with some experience. The program would be of three-to-twelve months duration and focus on specific areas such as solar technologies, sectoral energy planning, and rural energy needs. The courses would be designed to draw on expertise in various U.S. and foreign institutions. These courses would facilitate the development of informal information exchange networks between professionals who attended the course together. Several precedents exist in courses on other topics sponsored previously by AID.

Cost: $500,000 per year.

iii) LDC-University Programs in Energy Systems

Initiate university programs involving undergraduate and post-graduate training in the sciences, technology, the economics of

energy, and energy use. It may not be necessary to start entirely new undergraduate programs in all cases. Material and personnel support could be provided to modify existing courses and curricula in many LDCs.

Cost: $50,000 per country per year plus initial outlay of $100,000.

iv) Scholarships for Energy Training in the United States

Support scholarships for individuals to undertake degree training in energy-related academic programs in the U.S. However, such programs constitute only a supplement to the educational efforts in the LDCs themselves, which must be the main focus of the U.S. assistance.

Cost: $25,000 per student.

Selection Criteria

Criteria	Ranking
Implementability	H
U.S. Role	H

IV. DEVELOPING A U.S. ENERGY ASSISTANCE PROGRAM

A. ALLOCATION OF FUNDS

The programmatic areas discussed in the previous section provide the raw material from which energy assistance programs can be formulated. That formulation must be based, of course, on a consideration of the specific needs and desires of specific countries. There are, however, a number of policy issues that must be addressed in establishing U.S. assistance policy. One issue is the overall balance between programs of various sorts--say between those emphasizing the development of conventional resources and those emphasizing small scale technologies and renewable resources. Another central issue is the overall funding level for energy related assistance. The programmatic definitions summarized in the previous chapter are useful in addressing aspects of both those issues.

It should first of all be noted that many of these activities have a high unit cost, and can therefore be scaled up or down only in a few large steps. For example, the identification of development projects under Programmatic Area 1 has an estimated unit cost of $1 million per LDC. This activity can therefore be scaled up or down only in steps of $1 million. Furthermore, some of the activities are closely related to one another, and an expansion or contraction of one must be repeated for its associated activities in order to maintain the same chances of success. For example, the identification and assessment of conventional resources (PA 1) must precede exploration and preparation for production (PA 2).

Priorities Among Programmatic Areas

A two-way approach was used to obtain a relative ranking of importance among the recommended programmatic areas. The first is the scoring of each programmatic area on how they perform in the selection criteria discussed in Chapter II. This score is summarized in Table II-1 and discussed under each programmatic area in Chapter III. The second approach is to apportion a fixed amount of resources to each of the six major programmatic categories. The question of both the scoring and the apportionment of funds was posed to a

Previous Page Blank

panel of experts from various public and private organizations. The panel reached a concensus for the scores on the selection criteria (see Table III-1), but had considerably differing views on the desirable proportion of funding allocation to the six categories. Three patterns of allocation were discernable, which can be characterized as shown in Table IV-1.[1]

TABLE IV-1

Distribution of Financial Allocations

	Pattern I	Pattern II	Pattern III
Conventional resources	40	12	9
Renewable resources	18	37	22
Demand sectors	10	25	21
Assessment & planning	10	9	18
Institutions	12	9	22
Traning & education	10	8	8
TOTAL	100	100	100

Pattern I emphasizes conventional resources with an allocation of 40% of the total energy assistance funds to that category, while Pattern II puts 37% on renewable resources. Pattern III de-emphasizes assistance for conventional resources and divides the funds fairly evenly between renewable resources, demand sectors, assessment and planning, and institutions.

Underlying this difference in scoring patterns are differing views on what kinds of solutions will make an impact on the energy problems of LDCs. One difference is the time scale considered to be most important. The advocates of the long-run perspective (expressed in Pattern II) consider further development

along the path of conventional energy to be growth in the wrong direction and, therefore, to have a negative overall impact.

Those who favor a distribution similar to Pattern I argue that the energy pay-off of renewables is too uncertain and will come, if at all, in the distant future. In the meantime the energy situation will get worse and is likely to reach a crisis point, if some temporary relief is not obtained through the discovery and production and utilization of conventional resources. Advocates of Pattern III would leave conventional and renewable resource development primarily to the initiative of private enterprise and emphasize assistance in preparing the groundwork for such involvement in the LDCs.

Model Financial Allocation for Two Distribution Patterns

What would an overall U.S. assistance program composed of the programmatic elements discussed above look like and what would it accomplish? In order to address that question we have composed two hypothetical programs, one with the balance of Pattern I and one with the balance of Pattern III. In composing the programs a span of three years was considered since many program elements take place over that time period. The program that was analyzed was a "mature" one, which would result after at least two years of build-up. A somewhat arbitrary total funding of about $29 million per year was found to be convenient for analytical purposes.

Table IV-2 shows two model allocations of funds to the examples of activities under programmatic areas described in Chapter III. This illustrates the difference in the point of view emphasizing conventional resources (Pattern I) and that emphasizing renewable resources (Pattern II), and shows the order of magnitude of expenditure needed for the different programmatic areas in order to make an impact on solving the energy problems of the LDCs. Such a breakdown of energy assistance funds provides the needed "top-down" framework from which specific country programs can be formulated (i.e., "bottom-up"). Once the desirable distribution pattern between categories of programmatic areas has been chosen and a level of total funding for LDC energy assistance has been determined, a master list of available activities for a specified number of countries, similar to the one presented, can be prepared. The allocation

TABLE IV-2

TWO FUNDING PATTERNS FOR ENERGY ASSISTANCE ACTIVITIES

(In dollars, typically for a 3 year period)

Programmatic Area and Example	Unit Cost	Pattern I No. of Units	Pattern I Cost	Pattern II No. of Units	Pattern II Cost
CONVENTIONAL RESOURCES			*16,525,000		*10,850,000
PA 1 Identification and assessment			*15,425,000		* 6,250,000
i. Feasibility and assessment	175,000 per country	15 countries	2,625,000	10 countries	1,750,000
ii. Identification of development projects	1,000,000 per country	12 countries	12,000,000	4 countries	4,000,000
iii. Information exchange workshops	100,000 per workshop	8 workshops	800,000	5 workshops	500,000
PA 2 Exploration and preparation for production					
Surface exploration of medium-sized deposit	1,000,000 per deposit	12 deposits	*12,000,000	2 deposits	2,000,000
PA 3 Utilization of conventional resources			* 5,500,000		* 1,700,000
i. Transport systems	200,000 per project	5 projects	1,000,000	4 proj[illegible]	800,000
ii. End-use substitutions for conversion	300,000 per country per year	5 countries-3 years	4,500,000	1 coun[illegible] years	900,000
iii. Small and medium conversion technologies	15,000,000 per project	-	-	-	-
PA 4 Regulation and management			* 3,600,000		* 900,000
i. Management procedures	100,000 per country per year	3 countries-3 years	900,000	2 countries-3 years	600,000
ii. Standing consultation	300,000 per country per year	2 countries-3 years	1,800,000	-	-
iii. Courses on regulation and management	100,000 per country per year	3 countries-3 years	900,000	1 country-3 years	300,000
RENEWABLE RESOURCES			16,275,000		*33,320,000
PA 5 Photovoltaic			* 5,400,000		* 6,620,000
i. Small-scale irrigation pumping	880,000 per country-2 yrs.	5 countries-2 yrs.	4,400,000	7 countries	4,620,000
ii. Rural electric applications	100,000 per application	10 applications	1,000,000	20 applications	2,000,000
PA 6 Solar thermal			* 1,500,000		* 3,000,000
i. Heating and drying	300,000 per country-3 yrs.	3 countries	900,000	6 countries	1,800,000
ii. Refrigeration and ice manufacture	100,000 per application	2 applications	200,000	4 applications	400,000
iii. Pumping	100,000 per country	4 countries	400,000	8 countries	800,000
PA 7 Managing biomass production			* 2,125,000		* 4,475,000
i. Preliminary deforestation survey	600,000 for global survey		600,000		600,000
ii. Wood-Based fuel technologies	200,000 per country	2 countries	400,000	4 countries	800,000
iii. Use of agricultural residues	450,000 per country	2 countries	900,000	4 countries	1,800,000
iv. High-yielding biomass fuel crops	350,000 per station per year	-	-	1 station	1,050,000
v. Intensive fuel farming systems	75,000 per station per year	1 station-3 years	225,000	1 station-3 years	225,000
PA 8 Liquid fuels from biomass			* 400,000		* 400,000
i. Ethanol systems study	100,000 per study	1 study	100,000	1 study	100,000
ii. Ammonia and ethanol production	200,000 per study	1 study	200,000	1 study	200,000
iii. Powering heat engines	150,000 per study	1 study	100,000	1 study	100,000
PA 9 Electricity generation from biomass			* 225,000		* 800,000
i. Identification of biomass prod. systems	200,000 for the study	-	-	-	200,000
ii. Reviews of current facilities	150,000 per application	-	-	1 application	150,000
iii. Improving forest production	75,000 per project per year	1 project-3 years	225,000	2 projects-3 years	450,000
PA 10 Urban waste management			* 600,000		* 3,600,000
i. Survey of urban wastes	50,000 per survey	4 surveys	200,000	4 surveys	200,000
ii. Evaluating waste utilization	200,000 per study-2 years	2 studies	400,000	2 studies	400,000
iii. Energy-waste systems	5,000,000 per center-5 years	-	-	1 center-3 yrs. initially	3,000,000
PA 11 Biogas			* 600,000		* 1,200,000
i. Technology for concentrated sources	100,000 per country	4 countries	400,000	8 countries	800,000
ii. R & D support	50,000 per center	4 centers	200,000	8 centers	400,000
PA 12 Wind			-		*1,100,000
i. Gauging networks and data analysis	400,000 per country-2 years	-	-	2 countries	800,000
ii. Economics of wind turbines	100,000 for the study	-	-	-	100,000
iii. Windmill designs for LDCs	200,000 for the study	-	-	-	200,000
PA 13 Decentralized hydropower			*1,625,000		* 4,375,000
i. Hi-head impulse turbines	500,000 per country	2 countries	1,000,000	5 countries	2,500,000
ii. Low-head turbines	625,000 per country	1 country	625,000	3 countries	1,875,000
PA 14 Conventional hydroelectricity					
Survey of hydroelectricity supply sites	1,000,000 per country	3 countries	3,000,000	6 countries	6,000,000
PA 15 Energy storage			* 800,000		* 1,750,000
i. Assessment of storage needs	200,000 per country	2 countries	400,000	4 countries	800,000
ii. Survey of US technology	200,000 for the survey	-	200,000	-	200,000
iii. Low-grade energy storage	350,000 for the study	-	-	-	350,000
iv. Pumped storage applications	100,000 per country	2 countries	200,000	4 countries	400,000
DEMAND SECTORS			*8,950,000		*22,500,000
PA 16 Improved cooling devices			*2,250,000		* 5,500,000
i. Survey and evaluation	500,000 for the survey	-	500,000	-	500,000
ii. Design improvement	250,000 per country	1 country	250,000	2 countries	500,000
iii. Manufacture and demonstation	500,000 per country per year	1 country-3 years	1,500,000	3 countries-3 yrs.	4,500,000
PA 17 Motive power for agriculture			*1,050,000		* 3,100,000
i. Reduced tillage	200,000 per station per year	1 station-3 years	600,000	2 stations-3 yrs.	1,200,000
ii. Appropriate agriculture technology	150,000 per country per year	1 country-3 years	450,000	2 countries-3 yrs.	900,000
iii. Appropriate farm machinery	1,000,000 per country	-	-	1 country	1,000,000
PA 18 Soil and water management			*1,300,000		*2,600,000
i. Earthen dams	400,000 per country	2 countries	800,000	4 countries	1,600,000
ii. Crop rotation subsidies	500,000 per country-2 years	1 country	500,000	2 countries	1,000,000
PA 19 Fertilizer production			*1,900,000		*4,800,000
i. Small-scale fertilizer plants	1,000,000 per plant	1 plant	1,000,000	2 plants	2,000,000
ii. Facilitating manufacture of plants	400,000 per country	2 countries	800,000	6 countries	2,400,000
iii. Management training	100,000 per country	2 countries	100,000	3 countries	300,000

*Calculated totals.

TABLE IV-2 (continued)

Programmatic Area and Example	Unit Cost	Pattern I No. of Units	Pattern I Cost	Pattern II No. of Units	Pattern II Cost
PA 20 Rural transportation		-	-	-	* 900,000
i. Survey of transporation modes	600,000 for the survey	-	-	-	600,000
ii. Pedal-powered vehicles	100,000 per country per year	-	-	1 country	300,000
PA 21 Food loss prevention			* 900,000		*2,100,000
i. Village grain storage	200,000 per country	2 countries	400,000	3 countries	600,000
ii. Storage silos	500,000 per country	2 countries	500,000	3 countries	1,500,000
PA 22 Urban systems			* 1,550,000		*3,500,000
i. Urban planning assistance	150,000 per region per year	2 regions-3 years	900,000	4 regions-3 yrs.	1,800,000
ii. Housing designs	250,000 per design-3 years	1 design	250,000	2 designs	500,000
iii. Commercial buildings energy design and implementation	400,000 per country	1 country	400,000	3 designs	1,200,000
ASSESSMENT AND PLANNING			* 5,825,000		*5,825,000
PA 23 National energy assessment and planning			* 5,825,000		*5,825,000
i. Energy information system	200,000 for framework plus 75,000 per country	15 countries	1,325,000	15 countries	1,325,000
ii. Energy analysis and planning	250,000 for method dev. plus 200,000 per country	15 countries	3,250,000	15 countries	3,250,000
iii. Rural economic and resource studies	125,000 per study	10 studies	1,250,000	10 studies	1,250,000
INSTITUTIONS			*10,650,000		*8,050,000
PA 24 LDC energy institutions			* 5,400,000		*4,500,000
i. Creation of energy planning groups	150,000 per country-2 years	15 countries-2 yrs.	4,500,000	12 countries	3,600,000
ii. Cooperatives for mini-hydropower	100,000 per country per year	3 countries-3 yrs.	900,000	3 countries-3 yrs.	900,000
PA 25 International and regional cooperation			* 3,900,000		*2,400,000
i. Information exchange in energy technologies	50,000 per center per year	3 countries-3 yrs.	450,000	3 countries-3 yrs.	450,000
ii. Exchange of personnel	100,000 per country per year	4 countries-3 yrs.	1,200,000	4 countries-3 "	1,200,000
iii. Collaboration US and LDC acad. insts.	250,000 per institution/year	3 countries-3 yrs.	2,250,000	1 country-1 yr.	750,000
iv. International energy institute	1,000,000 over 5 years		-		-
PA 26 Private sector involvement			* 1,350,000		*1,150,000
i. Energy information	250,000 per year	3 years	750,000	3 years	750,000
ii. Prefeasibility studies	100,000 per study	6 studies	600,000	4 studies	400,000
iii. Risk reduction for business investment	5,000,000 one-time		-		-
TRAINING AND EDUCATION			* 8,450,000		*7,150,000
PA 27 Village extension training			* 3,200,000		*2,900,000
i. Village development workers and women	2,000,000 per country-3 years	1 country	2,000,000	1 country	2,000,000
ii. Artisans and small business owners	300,000 per country-2 years	4 countries	1,200,000	3 countries	900,000
PA 28 Higher education			* 5,250,000		*4,250,000
i. Seminars for senior officials	125,000 for 5 seminars	15 seminars	1,875,000	10 seminars	1,250,000
ii. Advanced multinational courses	500,000 per year	3 years	1,500,000	3 years	1,500,000
iii. LDC-university programs in energy system	250,000 per country-3 years	4 countries	1,000,000	3 countries	750,000
iv. Scholarships for energy training in the US	25,000 per student	35 students	875,000	30 students	750,000
GRAND TOTAL FOR 3 YEARS			86,675,000		87,695,000
GRAND TOTAL PER YEAR			28,892,000		29,232,000

*Calculated totals.

TABLE IV-3

Two Funding Patterns - Summary
(For a 3 year period, in dollars)

	Pattern I		Pattern II	
	Proposed Allocation	Percent	Proposed Allocation	Percent
Conventional resources	36,525,000	42	10,850,000	12
Renewable resources	16,275,000	19	33,320,000	38
Demand sectors	8,950,000	10	22,500,000	26
Assessment and planning	5,825,000	7	5,825,000	7
Institutions	10,650,000	12	8,050,000	9
Training and education	8,450,000	10	7,150,000	8
TOTAL FOR 3-YEAR PERIOD	86,675,000	100	87,695,000	100
TOTAL PER YEAR	28,892,000		29,232,000	

presented here is intended only as an example and not necessarily our recommendation for the correct size and distribution of the U.S. energy assistance package.

The end results of the allocation are summarized in Table IV-3. Out of a total annual allocation of about $29 million per year for a 3 year period, 42% would go for assistance with conventional resources under Pattern I, 19% for renewables, 10% for demand sectors, and the remaining 29% for infrastructural and cross-cutting programs. Under Pattern II only 12% would go to conventionals while 38% would go to renewables.

The funding pattern for energy assistance was arrived at in the following manner. Starting with Patterns I and II of the distribution of financial allocation to the six categories of programmatic areas from Table IV-1, a total outlay for energy assistance of $90 million, covering a period of 3 years, was allocated to the six categories of programmatic areas. For example, under Pattern I conventional resources receive for the 3 year period 40% of $90 million, or $36 million. Next, those $36 million were divided between the examples of activities under conventional resources to give a balanced and reasonable package for conventionals, which required several iterations until the desired total was reached. This step of the procedure is, of course, highly subjective, taking into account in an intuitive fashion the overall scoring of each programmatic area from Table III-1, the need for a well balanced and integrated energy package, the state of the art in the U.S. and LDCs, the geographical distribution of assistance to several LDCs, etc. The process was then repeated for Pattern II of the allocation and for the other categories of programmatic areas.

An examination of Table IV-2 reveals certain characteristics of these model allocations.

1. When the $29 million allocation is divided by the total of 28 recommended programmatic areas, an average allocation of $1 million per PA per year results. However, because there are only four PAs under conventional resources, they receive a much higher allocation than the average, even in Pattern II (with one exception), where the emphasis is supposedly on renewables. This implies that under both patterns of financial allocation conventional resources play

an important role. For renewable resources as well as for PAs that represent demand sectors, the funds have to be distributed over a large number of PAs, reducing the allocation to each. Similarly, the six last PAs, which are infrastructural and cross-cutting programs, also have a relatively large individual allocation under both patterns.

2. The number of countries to be covered with this allocation varies in a similar fashion as with the financial allocation: where there are only a few programmatic areas in a category, which is the case for conventional resources and the infrastructural and cross-cutting programs, the number of countries to be covered by programs is relatively large. Thus the model allocation provides feasibility studies and country visits (under PA 1) to a maximum of 15 countries under Pattern I. Likewise, the maximum number of countries to be provided with any one activity is 15 in Pattern I. These are feasibility studies and country visits (under PA 1), setting up energy information systems and energy analysis and planning (both under PA 23), and the creation of energy planning groups (under PA 24). On the other hand, a maximum of 8 countries are to be provided with any single activity of renewable resources in Pattern II (5 in Pattern I). The number is even smaller for the demand sectors. Looking at the entire assistance allocation for both patterns, one can notice that a large number of activities are to be provided for only 1, 2 or 3 countries each.

3. The unit cost of the different activities has a large range (see Column 1 in Table IV-2). There are a number of activities which cost only $100,000 per country or per application, and those can therefore be carried out in a large number of countries. The majority of activities have a unit cost of under $400,000, with only a few of $1 million and over. Activities with a high unit cost can be funded only in very few countries, if at all. An exception to this, however, is surface exploration (PA 2), which is to be carried out in 12 countries under Pattern I.

4. The time period for each activity is usually specified under the unit cost. Many activities are of limited duration, ranging from a few days (i.e., country visits under PA 1) to two years (i.e., small-scale irrigation pumping under PA 5). It is important to note, however, that many

activities are sequential, requiring a series of them to fully realize the benefits of each. Economics of scale, and the time that has to be spent on establishing a close relationship between the donor and the cooperating LDC, all point to the need for a longer time commitment and a carefully worked out series of inter-related energy activities to be prepared for any one country. Where a large number of countries is involved in one activity, such as 8 countires for biogas technology (PA11) under Pattern II, the assistance will have to be spread out over several years to avoid administrative problems in the U.S. and duplication of effort in LDCs.

Preparing Country-Specific Programs

It has been stressed repeatedly in this report that the end product of assistance planning, the actual program to be funded and implemented, must be country-specific and designed from the "bottom up", based on a thorough knowledge of the specific conditions, and particularly the energy problems and needs in that country. For this purpose a country energy assessment should be carried out for each prospective collaborator, which has not been included in the package of energy activities discussed here. This knowledge will also help the donor to make the necessary choice about which country to assist in the energy field, and with what kind of program, and for how long. If vital information is gathered only in the course of an assistance program already under way in a particular country, it might turn out that a program of a different nature should have been offered there in the first place.

Once this knowledge is on hand, the suggested way to proceed with formulating a program for a country or a group of countries is to use the funding pattern in Table IV.2 as a "basket" from which activities appropriate to specific countries can be picked, some of which are complementory. In this manner programs can be put together for one country after another until all the allocations on the list (Table IV-2) have been exhausted. As an example, the program shown in Table IV-4 has been designed for a fictitious country X. This package emphasizes conventional resources, even though one activity for renewables is included. The

example merely serves to illustrate how to use Table IV-2 to prepare the final product that is a country-specific program.

The following are some of the characteristics of the fictitious Country X implied by this program.

1. The program represents the beginning of energy assistance to this country, including some of the basics, such as the creation of energy planning groups. This is necessary because the fictitious country is assumed to have practically no prior energy planning or program.

2. From prior knowledge there appears to be some prospect of finding deposits of conventional energy there. It was therefore decided to concentrate on conventionals for this country rather than hoping for a pay-off with renewables in the long-run. Renewable energy technology will probably come on the agenda in future years.

3. The country has a policy for and the potential for agricultural modernization, and fertilizer use is likely to continue rising. It is therefore one of the countries where energy in agricultural production should be investigated.

The total cost of this program for a 3 year period is $4,100,000, distributed over the years as shown in Table IV-4. If this is assumed to be the average desirable energy assistance expenditure per country, then the total stipulated assistance allocation for all LDCs of about $90 million for 3 years could finance activities in 21 countries.

To conclude the discussion on the model assistance allocation, it should be pointed out that Table IV.2 contains very few global or regional activities, and none that provide support for work in the U.S.--in the form of technology research, information transfer, energy input-output studies, etc.--for alleviating the energy problems in the LDCs. These would still

TABLE IV-4

Program Example for Country "X"
(three-year period, in dollars)

Activity	PA No.	Cost/$ Thousands Year 1	Year 2	Year 3	Total
Energy analysis and planning	23	250	-	-	250
Seminars for senior officials	28	125	-	-	125
Creation of energy planning groups	24	75	75	-	150
Feasibility studies and country visits for conventional resources	1	75	100	-	175
Conventional resources information exchange workshop	1	-	100	-	100
Two rural electric applications of photovoltaics		-	200	-	200
Facilitating the manufacture of fertilizer plants	19	-	200	200	400
Appropriate technology development for motive power in agriculture	17	-	225	225	500
International and regional information exchange in energy technology	25	-	75	75	150
Identification of conventional resource development projects	1	-	-	1,000	1,000
Prefeasibility studies for private sector involvement	26	-	-	100	100
Exploration of medium-sized deposit		-	-	1,000	1,000
TOTAL		525	975	2,600	4,100

*Assumes a five-country program for that activity.

have to be added to make up a comprehensive U.S. energy assistance package, and would have to include research in the U.S. and in other developed countries on alternative energy resources and technologies (including participation by the Department of Energy), global assessments, and impact studies on the progress and effectiveness of energy assistance programs.

B. FINAL REMARKS

The energy problem in almost all countries of the world is acute, pervasive, and long term. These descriptions apply with particular urgency to most of the non-OPEC developing countries. Solutions on the scale necessary to make a substantive difference will require far-reaching decisions on the part of LDC governments regarding growth and development strategies. Lower administrative levels of government will find that many of their decisions are affected by energy considerations. The ambience created by these conditions will present both problems and opportunities for assistance reaching well beyond the selection of appropriate energy support systems.

A general point about all energy assistance deserves reemphasis. The ultimate aim of technical assistance in energy is to make such assistance unnecessary. In many of the programmatic areas discussed in the previous section there is the choice between assistance in carrying out projects and training in carrying them out. Creating a local capability to perform energy policy analysis is much harder than developing a national energy plan. Creating a local capability to carry on increasingly sophisticated solar energy research is much more difficult than transferring existing solar technologies. But only if indigenous technical and planning capabilities, including the requisite institutions, are developed will U.S. assistance monies be well spent.

The acuteness of the energy problems facing the developing world casts a light of urgency on the programs discussed in this report. Indeed, one should be concerned whether such programs, at levels at which they are likely to be funded will be at all adequate. The definition of programs has, to a certain

degree, been conditioned by an assumption of a surprise-free future in which assistance proceeds in an "orderly" manner as a transition is effected away from overwhelming dependence on oil and noncommercial fuels. The recommended programmatic areas should be termed "conservative" in the sense that they assume the time is available to carry out many of these programs. But time may be the one crucial element lacking. There may not be time to train the people, to create the proper institutional structures (within AID and in the LDCs), or to modify the infrastructures. If this is true, then a different set of priorities may have to be established for assistance. It is obvious that U.S. energy assistance in most of the programmatic areas recommended in Chapter III must have a continuity lasting over decades if they are to be effective, and they must approach a critical size. In this respect, energy-directed assistance bears a resemblence to food-directed assistance.[2] There are, however, important differences.

Food assistance agencies can always fall back on emergency deliveries if all else fails. This may not be possible with energy unless provisions are made to store transportable energy (oil) for such purposes. Food assistance also deals with a single sector of the economy and can be so directed. Energy assistance, even if directed toward the rural areas, must deal with many more elements--the urban poor, cottage industries, transportation, government infrastructure investments, and so forth. Technologies employed in increasing food production are of a limited range. Energy technologies form a much more diverse group.

The similarities between energy and food assistance stem mainly from the fact that both require a restructuring of the patterns of production, distribution, and consumption. Both require, as a result, the building of institutions and investment in human capital. Energy assistance, like agricultural assistance, had problems of introducing new technologies and practices into basically static societies. Energy assistance, like food assistance, will involve the development of indigenous technologies. And finally, the need for both will be around for a long time.

A number of the points made at the conclusion of the earlier report in this series, entitled "Energy Needs, Uses and Resources in Developing Countries,"

with regard to energy solutions in developing countries apply as well to energy assistance programs. In particular, we wish to stress again that in establishing assistance policy we should not prejudge or attempt to impose solutions. There is a strong tendency among those working in the energy field to advocate certain technical solutions on the basis of philosophical commitments. The advocate of nuclear power, or of small-scale technology, is able to cloak his advocacy in a mantle of "hard technical data and analysis." But in many cases the technical solution has been imposed on the problem rather than being derived from a clear understanding of the problem. In this respect the current Developing Countries Program of the Department of Energy is following a productive strategy. Collaborations are being formed with representatives of the countries themselves to analyze systematically their energy supply-demand situation, and to identify opportunities for resource and technology substitution. That analysis can then form the basis of identifying collaborations in resource evaluation, technology RD&D, training, and planning. In this same context, the programmatic areas discussed at the end of the last chapter are particularly important.

Need for Continuing Program Planning

Earlier in the report we distinguished between "top-down" and "bottom-up" analyses of programs and projects based on an evaluation of the energy and technical/political situation in an individual country. These two kinds of analyses provide the core of a broader set of planning and policy analysis activities that should be carried out to guide a U.S. energy assistance program. Policy analysis, based on a combination of the top-down and bottom-up analyses, should be a continuing activity, with the major purpose of creating an optimal set of energy assistance programs to consider specific country needs, the global energy situation, U.S. foreign policy interests, and other assistance programs with the countries concerned.

The programmatic areas discussed in this report have primarily been ones of demonstration and training. We have implicitly assumed that development of new technologies will be taking place and that basic questions requiring answers will be addressed through research. In instances where the energy R&D programs of the Department of Energy can be augmented to include technologies

and research issues pertinent to developing countries, they should be encouraged to do so. An assessment of incremental R&D requirements might be carried out which considers existing DOE programs in the light of the recommended programmatic area in Chapter III.

We have repeatedly emphasized the pervasiveness of energy in society and the interrelationships between questions of energy use and supply and those of economic and social development. At all levels, assistance programs must be developed in close relationship with each other. The energy needs and implications of all assistance programs must be considered. The assistance programs in agricultural development discussed above should be examined in terms of their long-term energy implications.

Need for Program Coordination

There is now a very rapidly growing recognition of the energy problems of developing countries as well as of the potential role of assistance activities. At the same time, as noted earlier, groups of developing countries in various regions of the world are beginning to recognize their common problems and interests in energy. As new programs are formulated around the world, there is a critical need for coordination. Otherwise, there is a risk that the world effort in energy assistance to developing countries will be duplicative in some areas and incomplete in others.

Particular developed countries have natural geographical areas of concentration, based on historical and current political factors. They may also have particular areas of technical advantage or experience that need not be duplicated in other countries. A continuing committee could be formed among the major donor countries to exchange information in this area, under the aegis of an international agency or as an independent entity. Such a committee would also be an appropriate vehicle to examine the possibility of a more substantive institution for carrying out, coordinating, and supporting energy R&D for developing countries.[3]

Regional (multinational) coordination, involving both donor and recipient countries, has the potential advantage of fostering cooperative energy

activities at the regional level as well as coordinating assistance activities. A number of existing organizations such as the Association of Southeast Asian Nations (ASEAN) and the Club du Sahel are the logical vehicles for this activity. Coordination at the national level must, of course, be the responsibility of the recipient countries.

A U.S. Policy Perspective

The ideas developed in this report and its predecessor have been developed on the basis of a contention that the United States, indeed the developed world as a whole, has a major stake in the continued economic and social development of the third world. That stake is based on commercial, humanitarian, and geopolitical interests. It is also clear that adequate and appropriate energy supply is one critical factor in economic and social development of third world countries.

In this report we have in effect laid the foundation for an analysis of the benefits that could accrue to the U.S. from an active program of energy assistance to developing countries. That analysis should proceed by considering in more detail the U.S. interests that are at stake, the benefits to the recipients of energy assistance and thus the ultimate benefits to the U.S. and the rest of the developed world, for various types and levels of assistance of programs. Such a policy analysis would not be easy, requiring as it would a global political perspective, but it would provide a much needed basis for the formulation of U.S. policy in this critical area.

NOTES AND REFERENCES

CHAPTER I

1. Public Law 95-88, August 3, 1977, Section 114(b)1.

2. P. F. Palmedo, R. Nathans, E. Beardsworth, and S. Hale, "Energy Needs, Uses and Resources in Developing Countries," BNL-50784 (March 1978), Brookhaven National Laboratory, Upton, N.Y.

3. In this report the terms developing country or less-developed country (LDC) are used interchangeably to refer to the 88 poorest countries of the world. They are listed in Table I-1. In general, we do not deal with the major oil-exporting countries, the members of the Organization of Petroleum Exporting Countries (OPEC). Those countries have large developmental problems, but they are quite different from those that exist in the energy-deficit countries which are the main focus of this report.

4. "Noncommercial" or "traditional" fuels are those not generally bought and sold (though they are in some instances) and which are widely used in rural preindustrial economies. They include wood, dung, and agricultural waste.

5. For each of the country groups, projections were made of future demand for "primary commercial energy," using actual 1975 consumption as a starting point and assuming a continuation of current trends in the rate of GNP growth and the ratio of that rate to the growth rate for energy. The "income elasticity" was estimated for oil to be from 0.8 to 1.1 for different country groups in different time periods, for electricity between 1.0 and 1.8 with comparable values for gas and coal. Assumed GNP growth ranges from 3.6 to 6.3 percent until 1990, and from 2.8 to 5.4 percent thereafter. These are conservative assumptions, leading to lower projections of future demand than other recent analyses. For noncommercial energy, population estimates were multiplied by a minimum subsistence per capita consumption level.

CHAPTER II

1. This section is based on a report to Brookhaven National Laboratory by Donovan, Hamester and Rattein, Inc., "Review of Literature, Conferences, and Programs Concerning Energy Assistance to Less Developed Countries," Washington, D.C., December 1977.

2. The data on assistance are not sufficiently complete to allow accurate conclusions about trends in energy assistance since 1973. To gather the necessary statistics, reports by some additional donors should be obtained and analyzed.

3. The amounts are probably underestimates since the data are incomplete. See Reference 1, Appendix C, Volume III.

4. For a definition of biomass see Reference 21 of Chapter III.

5. This is the World Bank loan of $35 million to Israel for industrial research and development of solar energy for commercial use as "prime movers" and electricity for rural areas. In 1978, however, the World Bank expects to finance a tourism project in Nepal which will utilize solar energy to meet the needs of trekking camps for tourists where other forms of energy for cooking and heating must be carried in by porter at great expense. The significant question regarding this interest in alternative renewable energy systems is whether or not the "seed" money invested in this area will be followed by increasing financial allocations in the 1980s.

CHAPTER III

1. Of the 126,000 drillings that have taken place so far in LDCs only 24,000 were in Africa and Southeast Asia and the remainder in Latin America. This compares with approximately 2.5 million drillings in the United States

2. The national assessment and planning of all energy resources form the subject of another programmatic area, PA 23. PA 1 focuses on conventional energy resource identification and assessment as a first step in a comprehensive coverage and conventional resource assistance, going from PA 1 to PA 4.

3. Two cases are mentioned in a United Nations report for cost comparison. In the first case the cost of preliminary reconnaissance was one twenty-fifth of the cost of exploration and appraisal drilling, and one eighth in the second. (United Nations, Department of Economic and Social Affairs, Petroleum Exploration: Capital Requirements and Methods of Financing, p. 13, 1962.

4. "...the enormous contribution made by geology and geophysics to the success of modern oil exploration may be judged from what is called the success ratio (that is, the ratio of successful wells to the total number of exploration wells drilled), taking into account the various exploration wells singly or in combination, used to determine the drilling site of the exploration well. This is shown in the following figures:

No scientific exploration	success ratio 1:30
Geological exploration	success ratio 1:10
Geophysical exploration	success ratio 1:6
Geological & geophysical exploration	success ratio 1:5

These ratios are based on figures from the United States. If those from the world outside, particularly from the Middle East, were available they would put modern exploration methods in an even more favorable light." (Royal Dutch Shell. The Petroleum Handbook, London: Shell International Petroleum Co. Ltd., 1959, pp. 71-72. Quoted by Michael Tanzer in The Political Economy of International Oil and the Underdeveloped Countries, Beaucare Press, Boston, 1969, p. 125.)

5. See References 3 and 4.

6. Applications in remote communications and in remote health services have been shown to be economically viable at today's prices in such areas as Central Africa. Work by NASA Lewis, Cleveland is under way in remote small-scale applications though at low funding levels. For a survey of present applications, see D. Smith, "Photovoltaic Power in Less Developed Countries," U.S. Energy Research and Development Administration, (March 24, 1977), and Smith and Allison. Future LDC applications with detailed calculations are discussed in Charles Weiss and Simon Pak (World Bank), "Developing Country Applications of Photovoltaic Cells," presented at the Natl. Solar Photovoltaic Program Rev. Mtg., U.S. Energy Research and Development Administration, Washington, D.C., January 1976.

7. Charcoal and firewood shortages are examined by Erik Eckholm in The Other Energy Crisis: Firewood (Worldwatch Institute, Washington, D.C., Sept. 1975). Some particularly acute forage problems are discussed by Eckholm and Lester R. Brown in Spreading Deserts--The Hand of Man (Worldwatch Institute, Washington, Aug. 1977).

8. Solar cells, usually in the form of thin film wafers, are semiconductor devices which generate direct sunlight. The device may convert from 3 percent to a little under 30 percent of incident solar energy into dc electricity. See Energy for Rural Development, Ref. 10 below, pp. 87-110.

9. Some of the more advanced photovoltaic concepts now in the experimental stages are discussed by Allen Hammon, "Photovoltaics: The Semiconductor Revolution Comes to Solar," Science (July 29, 1977). A comprehensive review of photovoltaics is given in Joseph A. Merrigan, Prospects for Solar Energy Conversion by Photovoltaics (MIT Press, Cambridge, 1975).

10. For an overview of renewable resources for LDCs, see Energy for Rural Development, Renewable Resources and Alternative Technologies for Developing Countries (Nat. Acad. Sci., Washington, D.C., 1976); and Denis Hayes, "Energy for Development: Third World Options," Worldwatch Paper 15, Dec. 1977.

11. "Consumers currently buy electricity generated primarily from fossil fuels, from the electric utilities at a price somewhere between two and nine cents per kilowatt hour depending on location and type of use, but still mostly at a price in the lower half of this range.

"Since the 'fuel' for solar energy utilization is free, and since system maintenance costs are expected to be relatively low, the price-determining component for solar electric energy is the capital cost of the system. And at the current prices of $2,000 per square meter for silicon photovoltaic arrays, $30 per kilowatt hour of storage capacity for batteries, and $30 to $100 per kilowatt power rating for inverters and regulators--electrical energy by photovoltaic conversion would cost close to 30¢ per kilowatt hour, depending on interest and other costs of capital. For general application solar cells are thus not competitive

today." Martin Wolf, "Photovoltaic Solar Energy Conversion," Bull. At. Sci., (Apr. 1976) pp.26-28.

Photovoltaics are economically viable, however, where alternative energy sources could be delivered only at a high cost. This is demonstrated for communications by Ted Blumenstock and Anthony E. Clifford, "Solar Energy Comes Down to Earth," Communications, (Apr. 1976) pp. 2-5.

12. See Bruce Chalmers, "The Photovoltaic Generation of Electricity," Sci. Am., Oct. 1976.

13. For current applications in the U.S., see An Economic Analysis of Solar Water and Space Heating (ERDA, Washington, D.C., Nov. 1976); William Metz, "Solar Thermal Energy: Bringing the Pieces Together," Science, Aug. 12, 1977; and Office of Technology Assessment, Application of Solar Technology to Today's Energy Needs, Washington, D.C., June 1977.

14. A concise technical introduction to solar thermal applications can be found in Energy for Rural Development, pp. 61-86, Ref. 10. A similar introduction together with a review of literature and of various pieces of equipment is in the Energy Primer: Solar, Water, Wind and Biofuels (Portola Institute, Menlo Park, CA, 1974) pp. 4-51.

15. For a review of solar energy programs and perspectives in LDCs see F. deWinter and J. W. deWinter, Editors, Description of the Solar Energy R&D Programs in Many Nations (Atlas Corp., Santa Clara, CA, Feb. 1976); and "Solar Energy in Developing Countries: Perspectives and Prospects," PB-208550 (1972), Nat. Acad. Sci, available from NTIS, Springfield, VA.

16. Ron Alward (Brace Research Institute), "Solar Distillation as Appropriate Technology," presented to the Int. Solar Energy Soc., Los Angeles, July-August 1975.

17. R. K. Swartman, "Intermittent Absorption Refrigeration Systems" SAN/1122-76/2, pp. 231-237; M. F. Merriam, University of California/Berkeley, "Design Aspects of Solar Powered Icemakers" (draft report).

18. For a review of forest farming in the U.S. see Mitre Corporation, Silvicultural Biomass Forms, Technical Report No. 7341 to ERDA, 6 Vols., May 1977.

19. Two symposia dealt in detail with the generation of clean fuels from biomass, including wastes. See Ref. 20.

20. A.D. Poole, "Bioenergy in Underdeveloped Countries," Energy From Biomass, A Conceptual Overview, Washington, Institute for Energy Analysis, 1977.

21. For inventories on forestry reserves see, for example, World Forest Inventory, (Food and Agriculture Organization, Rome, 1965); and Keith Openshaw, "Wood Fuels for the Developing World," New Scientist, January 31, 1974. A study of fuelwood consumption in a Tanzanian village is reported in Patrick and Anne Fleuret, "Fuelwood Usage in a Peasant Village," J. Develop. Areas, 1977.

22. In the energy field the term biomass refers to solid, liquid, or gaseous fuels derived from renewable organic materials. They are used either in their natural form (such as forests) or as process derivatives (such as liquids from agricultural wastes).

A concise introduction to biomass production and conversion can be found in the Energy Primer, Ref. 14, pp. 106-113. The possible production of biomass fuels from organic wastes in the U.S. is studied by Larry L. Anderson, "Energy Potential from Organic Wastes: A Review of the Quantities and Sources," Washington, Bureau of Mines Information Circular 8549, 1972.

23. The Brazilian ethanol program is described by Allen Hammond and Jose Goldemberg, Science, 1977, 1978. A brief technical overview of alcohol production from biomass is given in the Energy Primer, pp. 148-153, and in NAS, Energy for Rural Development, pp. 180-190, both in Ref. 14.

24. Several papers presented at two symposia on clean fuel production from biomass deal with production aspeces of biomass. They are published in two volumes, both entitled Clean Fuels from Biomass and Wastes, symposia sponsored by the Institute of Gas Technology, held at Orlands, FL, Jan. 1976 and Jan. 1977.

25. For a history of such efforts see the Energy Primer, Ref. 14, pp. 148-150.

26. Three papers on power generation from biomass in the U.S. were presented at the Symposium on Clean Fuels from Biomass and Wastes, Ref. 24. They are by Klumb (No. 4), Bargman and Betz (No. 6), and Beardsley (No. 17).

27. At a conservative 20t/ha and 70 percent boiler efficiency, 100 Mw of steam at 80 percent capacity factor would require 11,000 ha of cultivation. Assuming that 50 percent of the surrounding area is utilized, the harvested area would have a radius of 8 km.

28. See the paper by Beardsley mentioned in Ref. 26.

29. Several papers presented at two symposia, both entitled Clean Fuels from Biomass and Wastes, Ref. 24, have a bearing on this subject.

30. Numerous publications exist on biogas. For a scientific introduction see, for example, Methane Generation from Human, Animal, and Agricultural Wastes, Nat. Acad. Sci., Washington, D.C., 1977; and John T. Pfeffer and Jon C. Liebman, "Conversion of Organic Refuse to Methane," No. PB 235-468, available from NTIS, Springfield, VA, 1974.

31. A great deal of experience has been gained in India with biogas plants. Some important references are M. A. Sathianathan, Biogas, Assoc. of Voluntary Agencies for Rural Development in India, New Delhi, 1975; J. K. Parikh and K. S. Parikh, "Mobilization and Impact of Biogas

Technologies," Energy, 2 (1977)pp. 441-445; and C. R. Prasad, K. K. Prasad, and A. K. N. Reddy, "Biogas Plants: Prospects, Problems and Tasks."

Other experiences in Asia (except for China) are described by S. K. Subramanian, "Biogas in Asia," a paper prepared for the Int. Develop. Res. Ctr., Nov. 1976. A case study of Nepal is made by A. B. Karki and B. A. Coburn, The Prospects of Biogas as one of the Sources of Energy in Nepal, Mimeo, CA 1977.

32. An Indian version of the popular Chinese design of a small concrete biogas plant with no moving parts is described by K. C. Kandelwal, "Dome-Shaped Biogas Plant," Compost Sci. (Mar./Apr. 1978) pp. 22-23.

33. In a paper entitled "Power to the Poor," A. K. N. Reddy of the Institute of Science contrasts fertilizer production from biogas plants with coal-fueled units. A large coal-fueled fertilizer plant produces 230,000 tons per year. It takes 26,000 biogas converters to product the same amount.

> "But the biogas plants would cost $15 million less to build, and all the money invested would be spent inside India, saving $70 million in foreign exchange. The biogas plants would provide 130 times as many jobs and these jobs would be located in the villages, where most people live and where employment is needed. Biogas plants would also produce the fertilizer where it is used, drastically reducing transportation requirements. Finally, while the coal-fired plant would consume enough fuel every year to meet the energy needs of 550 Indian villages, the biogas plants would produce enough fuel each year to meet most of the energy needs of 26,000 Indian villages." (Taken from Denis Hayes, Energy for Development, Ref. 1C.)

34. A large collection of papers giving comparative technical and economic data can be found in the Mitre Corporation, Proc. 3rd Workshop on Wind Energy Conversion Systems, Washington, D.C., June 1975, ERDA. A cost study.

35. For an annotated bibliography on the subject, see Barbara L. Burke and Robert N. Meroney, Energy from the Wind, Solar Energy Applications Laboratory, Colorado State University, Aug. 1975. A very good technical introduction can be found in NES, Energy for Rural Development, Ref. 10, pp. 113-136. See also Putnam, Power from the Wind, Van Nostrand.

36. For an evaluation of LDC windmill applications see Marshal F. Merriam, "Windmills for Less Developed Countries," Technos, April-June 1972.

37. See R. Ramakumar, "Harnessing Wind Power in Developing Countries," IECEC Record (1975) pp. 966-973.

38. See NAS, Energy for Rural Development, Ref. 10, pp. 137-164, which also contains references to the Chinese. A literature survey and review of some equipment is given in the Energy Primer, Ref. 14, pp. 52-73.

39. This number refers only to large generating stations and does not take into consideration mini-hydroelectric ones (smaller than 100,000 kw) whose potential has not even been estimated for most regions of the world. The emphasis on large projects to supply energy to large consuming centers has dwarfed any attempt to look at these potentials.

40. For an introduction to energy storage see NAS, Energy for Rural Development, Ref. 10, pp. 202-208.

41. For selected references see D. Pimentel, "Energy Use in World Food Production," Environ. Biol., (1974), Cornell Univ., Ithaca, NY; D. Pimentel, "The Energy Crisis: Its Impact on Agriculture," Encyclopedia della Scienza e della Tecnica (Mondadori, Milan, 1976), pp. 251-266; and R. Revelle, "Requirements for Energy in the Rural Areas of Developing Countries," Science, 1977. Two very good case studies on India are presented by A. K. N. Reddy and K. K. Prasad, "Technology Alternatives and the Indian Energy Crisis," Economic and Political Weekly, Aug. 1977, pp. 1465-1502; and D. Pimentel and N. Beyer, "Energy Use in Indian Agriculture," unpublished manuscript, 1976.

42. D. Pimentel et al., "Land Degradation: Effects on Food and Energy Resources," Science 194 (1976)pp.149-155; and Lester R. Brown, The Twenty-Ninth Day (W. W. Norton, NY, 1978).

43. "According to the Asian Agricultural Survey: 1976, Manila: Asian Development Bank, April 1977, in 1972 in India, 130,000 tractors provided less than three million horsepower while 85 million draft animals provided an estimated 34 million horsepower." (Quoted by Denis Hayes, Energy for Development, Ref. 10. See also B. A. Stout and C. M. Donning, "Selective Employment of Labor and Machines for Agriculture Production," Monograph No. 3, Inst. of International Agriculture, Michigan State Univ., East Lansing, MI, 1974.

44. See Arjun Makhijani with Alan Poole, Energy and Agriculture in the Third World (Ballinger Pub. Co., Cambridge, MA, 1975); and Arjun Makhijani, Energy Policy for the Rural Third World, (Int. Inst. Environ. and Develop., London, 1976). The authors argue that villagers unable to buy or rent land have no income or political leverage except at times of peak demand. If machinery is used to shave the peak labor demand and alternative employment is not provided, the poorest will either move to the city or starve, or both. Clearly, new employment opportunities must be made available at the time that the labor-saving technologies are introduced. See also, Roger Pevelle, "Energy Use in India," Science, June 4, 1976.

45. Supporting papers, World Food and Nutrition Study, Vol. II, (Nat. Acad. Sci., Washington, DC, 1977).

46. Although only about 10 percent of the world's crop acres are irrigated, a significant quantity of fossil energy is employed for irrigation. See the data in FAO, Land and Water Division, 1964, published in D. Pimentel,

"Energy Use in World Food Production," Ref. 41. For a cost comparison on powering small irrigation pumps in LDCs by conventional and renewable energy sources, see Vinod Mubayi and Tien Le, "irrigation in Less Developed Countries, unpublished manuscript, Brookhaven National Laboratory, March 1977.

47. For a comparison of these processes see, for example, Donald M. Nafus, "Alternative Strategies of Fertilizer Production in Developing Countries," Cornell Univ., 1976.

48. A country the size of Uruguay would require a plant producing 200 metric tons/day. If the fossil base were natural gas, the capital cost would be $21 million.

49. Owen W. Livingston and Jorge Polo, "Potential Small-Scale Fertilizer Processes for Developing Countries: The Nepal Example," presented at a Joint Seminar by the Council on Science and Technology of Nepal and the Asia Society of the U.S., Pokhara, Nepal, Feb.-Mar. 1977. The summary report of the seminar is entitled Ad Hoc Seminar on Development of Small-Scale Hydroelectric Power and Fertilizer Porduction in Nepal, ADSP Reports, Asia Soc. of the U.S.

50. Although fertilizer supplies may be augmented by more effective use of crop residues, dung and other technologies (i.e., nitrogen fixation in green manures), it must be realized that fossil fuels will be necessary to supply the bulk of added fertilizer. Therefore, fossil fuels and other resources must be allocated by developing nations to meet their fertilizer needs for food production unless they rely entirely on external sources.

51. See, for example, M. C. Bourne, "Post Harvest Food Losses--the Neglected Dimension in Increasing the World Food Supply," Cornell Int. Agri. Mimeograph No. 53, Cornell Univ., 1977; and H. H. Cramer, "Plant Protection and World Crop Production," Pflanzenschutznachrichten 20 (1967) 1-524.

52. Under structure of consumption is meant the economic and social distribution of consumption. Information is also lacking about demand.

53. What is considered commercially viable might depend on the circumstances. When comparing the benefits of exploiting a small deposit of a conventional resource which accrue to the respective LDC government and a multinational company, it is likely that the LDC government will have additional benefits over the multinational--assuming the cost is the same for the two--such as the premium on foreign exchange saved through not importing this resource; the foreign exchange premium on the portion of the resource that can be exported (if any); the training and experience of local manpower on all levels; the encouragement to local industry to produce certain equipment for the exploitation and transport of the resource; control over allocation of the resource; and others.

54. The concept of "village development workers" must be stressed here. Through the addition of new functions, agricultural extension workers have often become multipurpose extension workers. However, it is not simply a question of adding rural energy expertise to their already overloaded portfolio of tasks, but that the training be restructured to emphasize the integration of these various functions into an overall concept of development.

CHAPTER IV

1. The figures entered in Table IV-1 represent the average allocation made by the members of a panel of experts. Two members conformed to the Pattern I, three to Pattern II, and three to Pattern III.

2. See J. W. Howe, "Toward a Global Approach to the Energy Problem," in R. D. Hansen, The U.S. and World Development: Agenda in Action, (Praeger, New York, 1976).

3. See J. Bernstein, "An International Network for Energy Research and Development," Appendix E to: Energy Organization Options (Nat. Acad. of Public Admin., Washington, DC, Dec. 30, 1977).

APPENDIX

Non-U.S. Donor Assistance Programs

Previous Page Blank

World Bank (IBRD): The World Bank, the oldest and largest of the international development banks, has a long record of energy development programs, especially electric power generation, transmission and distribution. Bank loans and technical assistance have been provided for project studies, facility construction and operation, manpower training, and expansion.

Although electric power production and distribution are likely to remain a large part of its lending programs, the World Bank has recently increased its loan and technical assistance efforts to develop domestic oil, gas, and coal resources where prospects exist. While the Bank has no plans for downstream investments such as refineries or petrochemical plants, it will finance production and distribution activities, such as drilling, mining and pipelines. The Bank will also finance sector surveys to formulate overall planning and energy policy recommendations, and studies to analyze energy subsidy programs and alternative fuels for electrical generation, and is also supporting a number of studies and projects to increase rural electrification in specific locations.

The Bank's 1973 energy program represented 12 percent of its total lending. The 1977 figure accounted for 16 percent, and plans call for increasing involvement as the Bank continues its development strategy of emphasizing investment which directly affects the well-being of the poor.

International Development Association (IDA): The International Development Association was established to provide assistance for the same purposes as the World Bank, but on terms that would bear less heavily on the balance of payments of the borrowing countries. Though legally and financially distinct from the Bank, IDA is administered by the same staff. IDA primarily assists countries which are very poor, mainly those with a per capita annual income of less than $375. More than 40 countries are eligible under this criterion.

IDA energy loan assistance has been the same kind as provided by the Bank, i.e., construction of hydro- and thermal power stations, related transmission

and distribution facilities, technical assistance, manpower training in facility operation and maintenance, and investment and management studies.

United Nations (UN): The United Nations Organization has a minimum of 18 agencies (not including the international and regional banks and funds) engaged in programs related to energy development. However, most of the U.N.'s energy-related efforts are conducted by the following specialized agencies:

- Center for Natural Resources, Energy and Transport (CNRT) is the central unit for energy matters, particularly the support and implementation of technical cooperation projects in LDCs
- United Nations Development Program (UNDP). Development of energy programs, including national energy policies, either through technical assistance--advisors and researchers--or its Special Fund to finance large-scale projects.
- Office of Science and Technology. International research and development programs for new sources of energy.
- Statistical Office. Production and consumption data.
- U.N. Environment Program. Studies to analyze the environmental impact of energy resource extraction, production, and use, and the feasibility of harnessing renewable energy sources in rural areas.

The U.N.'s involvement covers most aspects of energy development assistance, including technical or monetary assistance for all phases of power generation and distribution, the preparation of legislation, training, equipment purchases, management and operations, mineral exploration, and feasibility studies. Like other donors, the U.N.'s more recent energy activities increasingly have focused on energy-poor LDCs. It has also expanded its operational activities to include exploration for oil and gas.

Asian Development Bank (ASDB): Even before the 1973 oil embargo and subsequent oil price increases, the Asian Development Bank dedicated a large portion of its loan and technical cooperation efforts to energy projects. Since 1968, financing for the study, planning, construction, and operation of electric power facilities, as well as projects focusing on resource exploration and

pipeline construction, has generally consumed more than 20% of the Asian Development Bank's total disbursements.

Since 1974, the Bank has requested its clients to reexamine investment priorities within the energy sector, and to focus on projects based on indigenous sources of power generation with minimal reliance on imported petroleum resources. In addition to promoting national energy policy development, the Bank has also increased its financing of oil and gas exploration and production.

Inter-American Development Bank (IDB): The Inter-American Development Bank, a regional bank supporting economic and social development in Latin America, provides assistance to its developing country members through loans and technical cooperation. The Bank's energy development loan efforts (approximately 14% of disbursements) have emphasized electric power, especially hydroelectric, for both urban and rural areas, as well as other capital-intensive projects. Projects have included construction of dams, powerhouses, and distribution systems, oil and gas pipelines, rural electrification, and related feasibility studies. Technical cooperation projects have typically involved feasibility studies and institutional and manpower development.

Other International Banks: The African Development Bank and the Arab Fund for Economic and Social Development provide loan financing for central power construction in Africa and the Middle East. The Caribbean Development Bank, the Venezuelan Investment Fund, and the Central American Bank for Economic Integration provide financing for electric power facility construction and expansion in Latin America.

Organization for Economic Cooperation and Development (OECD): The OECD is conducting several studies including alternative energy strategies for developing countries; supply factors in low-cost nonconventional energy; development of an LDC data bank; and a review of past energy and economic growth relationships to identify common patterns of development.

Sweden: The Swedish International Development Authority's (SIDA) energy program has focused on hydro and geothermal power. Assistance includes construction and operation of central power stations, manpower training, organizational and management development, rural electrification, and environmental

impact assessments. SIDA program efforts to date include: hydro projects in Turkey, Tanzania, and Kenya; geothermal surveys in Tanzania; rural electrification in Botswana and Kenya, including a socioeconomic impact analysis of electrification; provision of spare parts and a study of future electricity demand in Guinea-Bissua; and hydropower plant operation and personnel training in Zambia.

Canada: The Canadian International Development Agency's (CIDA) energy program forms about 15 to 20% of CIDA's annual disbursement and absorbs (Canadian) $200 million annually. The program started in the 1950s when it focused exclusively on capital-intensive electric power projects and technical assistance. Today's program is broader and concerns overall energy sector needs and production, and total economic development. CIDA is involved in project analysis, some resource inventories, national and regional energy planning (with plans to expand these efforts), utility management, staff training, hydroelectric projects, and capital projects in oil and gas exploration.

The energy program, with projects in over 30 countries, is larger now in absolute dollar terms than previously (although it constitutes a smaller percentage of overall disbursements). While CIDA has been a leader in the nuclear assistance field, it does not plan to expand its aid in this area.

The International Development Research Center of Canada (IDRC) is a semiautonomous public corporation (most of its 13 board members are LDC nationals) devoted to promoting research in developing countries, particularly concerning the socioeconomic aspects of introducing technological change. Its current projects include the evaluation of methane manufacturing and application in Thailand, Sri Lanka, the Philippines, and Korea, and of windmills as an alternative energy source in Ethiopia. In addition, IDRC has produced a complete bibliography on biogas.

West Germany: The Ministry of Economic Cooperation has traditionally been involved in centrally located electrical generation and transmission systems including design, construction, operations, and training. In response to new problems brought on by the energy crisis, the Ministry has become increasingly

concerned with the question of utilizing indigenous energy resources in developing countries, especially those of solar heating and cooling, photovoltaics, and wind.

United Kingdom: The Ministry of Overseas Development's energy program has focused primarily on central power system generation, transmission, distribution, and operations. Among its energy-related projects have been feasibility studies, planning, technical assistance, capital aid for construction, the provision of equipment, spare parts, manpower training, and mineral resource surveys. The program has been in effect for some time, with projects in Latin America, Africa, the Middle East and Asia. In recent years the Ministry, either through its own divisions or through providing funds to outside organizations, such as the Intermediate Technology Development Group, has undertaken research projects on small-scale application of nonconventional energy sources, such as methane, wind, geothermal and low-head hydrogeneration.

France: French assistance efforts are carried out by the Ministry of Foreign Affairs, through: its Department of Scientific and Technical Cooperation; the Ministry of Cooperation, which deals with African countries; and the Ministry of Industry and Research, which is responsible for promoting the development and application of nonconventional energy sources.

The Ministry of Cooperation's program includes research assistance in laboratories, provision of project technicians, and subsidization of the financing of energy research equipment, particularly in the Sahel. Projects range from solar battery-powered television in Niger, to feasibility studies regarding the use of local fuel (wood, sawdust, agricultural by-products, and solar) and related pilot experiments in West Africa, to studies of solar and wind-operated water pumps for cattle and irrigation.

The Ministry of Industry and Research has sponsored numerous studies and pilot projects in Latin America, Africa, and the Middle East focusing on geothermal, wind, methane, and direct and indirect solar conversion.

The Netherlands: Considerable hardware-oriented research is under way in the Netherlands covering a wide variety of alternative energy sources. The

Ministry for Development Corporation is currently drawing upon technical expertise from several universities and private groups to conduct major studies on the application of wind and solar energy in developing countries.

The two principal efforts are the Wind Power for Developing Countries Project, a five-year program begun in 1975 which includes both hardware and software research, and a study of the difficulties involved in introducing solar energy in the world's poorest countries.

The Ministry also supports Foundation TOOL in projects for the production of hydroelectric, low-head radial-flow turbine generators for developing countries and equipment design for methane production.

Kuwait: The Kuwait Fund for Arab Economic Development was originally established to provide loans and technical assistance to the Arab countries. It has since expanded its operations to include non-Arab, Asian, and African countries (54 % of these loans are in the electric power sector). Projects have included gas production, hydro and thermal power station, and transmission line construction, electrification of irrigation works, and rural electrification.

Japan: The Economic Cooperation Fund of Japan has provided funds for electric facility construction in Southeast Asia, the Middle East, and Africa. It has financed a minimum of $125 million in Indonesia for oil and gas exploration and production.

In addition to the above aid donors, numerous other non-U.S. government organizations; including nonprofit, private volunteer, and quasigovernmental organizations; are performing research or providing assistance to help the LDCs meet their energy problems. In fact, some of these organizations have a lot of practical on-site experience in applying nonconventional energy sources through intermediate and small-scale technology. The list, not to be considered complete, includes:

- Volunteers in Technical Assistance (VITA), a U.S. group, is involved in developing, improving, and promoting appropriate technologies throughout the Third World. They estimate that 19% of their effort goes to resolving problems in energy production.

- The International Institute for Applied Systems Analysis (IIASA) and the Rockefeller Foundation undertake studies of LDC energy prospects.
- The Overseas Development Council (ODC), World Watch, and the World Energy Conference are studying renewable energy sources for developing countries.
- The International Energy Agency of the OECD, the Italian Department of Energy Technology, and several universities in the U.S. and abroad are involved in studying demand projections and the role of energy in economic growth.
- The Intermediate Technology Development Group in U.K., the Indian Development Institute of Science, the Foundation TOOL and the Royal Tropical Institute (both of the Netherlands), OXFAM, and several church missions are studying technology development and transfer or are operating on-site experimental projects.
- The Japan Economic Research Center is studying the question of financing LDC energy requirements.