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# **Energy Programs in the Agency for International Development**



**Directorate for Energy and Natural Resources  
Bureau for Science and Technology  
Agency for International Development**

**August 1986**

ENERGY PROGRAMS  
in the  
AGENCY FOR INTERNATIONAL DEVELOPMENT

Agency for International  
Development

Bureau for Science and Technology

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Natural Resources

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## PREFACE

AID-assisted countries face major difficulties in affording the energy they need for development, both because of continuing high bills for imported oil and because of the high capital costs of power systems. Even with recent sharp declines in oil prices, the developing countries' balance of payments will continue to suffer from the cost of imported oil. AID estimates that recent reductions in the world price of oil will save 60 oil-importing countries assisted by AID some \$8 billion a year. (The 10 AID-assisted countries that export oil will lose an estimated \$9.5 billion.) Nevertheless, the 22 countries that in 1980 spent over 40% of their foreign exchange earnings on oil will still spend about 26%, and 25 other countries will spend between 13% and 26%. Technical assistance in energy planning becomes even more important in times of unstable oil prices to help countries make the best possible energy investment decisions.

LDCs are caught between their ever-increasing demand for oil and decreasing private interest in domestic exploration and development. In India, for example, oil consumption is growing 6.4% a year, but over the past six years only one foreign oil company has explored for oil. Many international oil companies are delaying exploration until the world price recovers. AID's objective is to find ways to replace imported oil with less expensive indigenous resources.

To maintain present growth trends of 6-7% a year in electricity between now and the end of the century will require capital investments in the AID-assisted countries on the order of \$175-250 billion--or more. AID-assisted countries now spend a large part of their development budgets on energy: Pakistan spends 38%, India 30%, Thailand 32%, Ecuador 20%, Indonesia 20%. In many cases energy is the single largest expenditure, doubling that of any other sector.

Funds are simply not available to keep up with demand; chronic energy shortages are the result. The worst impacts of this are felt in rural areas, where agriculture and small industry development are lagging for lack of needed energy. Innovative ways are needed to provide more affordable energy for sustained development.

Imported oil is not the only problem; half the world's people today live in regions where fuelwood is acutely scarce, yet they depend upon this resource for their warmth and food preparation. In many such locations, fuelwood and charcoal prices have doubled in recent years, placing an intolerable burden on those least able to afford it. By the year 2000, up to 3 billion people will be living in such fuelwood-scarce areas:

Confronted with this worldwide energy crisis, the U.S. Congress amended the Foreign Assistance Act in 1977 to provide funds for an AID energy program. This report provides a summary analysis of AID's energy programs resulting from this mandate.

Information is presented from three different points of view:

- o A general policy framework for energy assistance to developing countries.
- o According to major program implementation areas.
- o The more specialized programs for specific geographic areas.

This report does not substitute for detailed project information from AID officers who are responsible for individual projects (see the Appendix). It also cannot substitute for the views of the developing country officials who have the basic responsibility for deciding on and implementing energy activities in their own countries.

## I. GENERAL POLICY FRAMEWORK

Energy constraints permeate efforts of developing countries to improve their living standards and to increase production, especially food production, to meet the needs of growing populations.

Most developing countries confront two serious energy problems: (a) excessive dependence on imported oil to drive their modern and urban industrial and commercial sectors and (b) dwindling forest resources traditionally used to supply the domestic energy needs of their rural and poor urban populations.

AID has allocated over one billion dollars in energy assistance efforts to 35 developing countries during 1982-87, about \$350 million in Development Assistance (DA) and \$800 million in Economic Support Funds (ESF). Table 1 (between pages 4 and 5) provides a summary of the overall AID energy budget. The table also breaks down the Agency's energy activities into those relating to forestry and all other energy work.

There are significant year-to-year variations in these totals and in the regional pattern of obligation. During the last few years, energy funds have been increasingly oriented toward a few countries--Pakistan, Egypt and Sudan, for example, which receive Economic Support Funds (ESF). The budget for the S&T Bureau's Office of Energy has decreased from \$11.3 million in Fiscal Year 1981 to \$5.3 million in FY 1986. Few new energy programs have been started in countries funded from the Development Assistance account.

AID energy programs provide technical assistance and capital assistance in selected countries in four major policy areas:

- A. Energy analysis, planning and policy development.
- B. Increasing indigenous energy supplies.
- C. Training and institution building.
- D. Research and technology transfer.

In its programs, AID emphasizes the important role of the private sector in supplying adequate energy for Third World needs. Policy studies are funded to help encourage an appropriate climate for private sector investment and ownership of energy resource and production facilities, to stimulate energy conservation investments, and to encourage joint ventures between LDC and U.S. firms.

Energy problems in the developing world have many common elements, yet each country has significantly different individual needs and resources. AID's organization emphasizes the role of

resident AID missions, thus allowing assistance to be adjusted to individual country circumstances.

Bilateral energy programs are administered by these missions within the framework of three regional bureaus: Africa; Asia/Near East; and Latin America and the Caribbean. In addition, the Office of Energy in the Bureau for Science and Technology carries out a wide range of activities in support of these country-oriented programs, including research, development and demonstration, that apply more broadly to many developing countries.

Section II describes these efforts according to the major program implementation areas. Section III describes the regional and Science and Technology strategies.

TABLE 1

## SUMMARY: AID ENERGY PROGRAM LEVELS

	TOTAL (\$ million)	Source of Funds		Energy Activities		Region			
		DA	ESF	NON-FORESTRY	FORESTRY	ASIA/NE	AFRICA	LATIN AMERICA/ CARIBBEAN	CENTRAL
FY 82	142.4	107.0	35.4	103.1	39.3	85.5	10.6	29.8	16.5
FY 83	251.5	69.0	182.5	232.9	18.6	213.1	6.5	17.3	14.6
FY 84	181.3	44.0	137.3	171.7	9.6	119.4	28.1	20.1	13.0
FY 85	167.3	47.3	120.0	159.8	7.5	138.0	4.3	9.0	16.0
FY 86	226.5	44.7	181.9	202.7	23.8	205.8	2.9	7.7	10.1
FY 87 Proposed	193.3	52.7	140.6	162.9	30.4	162.2	3.6	16.7	10.8

DA = Development Assistance  
 ESF= Economic Support Fund

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## II. MAJOR PROGRAM IMPLEMENTATION AREAS

### A. Policy Planning and Analysis

AID helps developing countries better understand energy issues and the ways energy relates to economic development and provides assistance to countries in devising energy policies.

Analysis of policy issues usually points to the importance of a market-oriented approach to energy pricing. The need to develop policies that expand the role of the private sector in the development and management of energy systems is increasingly clear. Finally, it is necessary to tackle economic or institutional distortions that encourage inefficient consumption.

Policy planning and analysis assistance have received significantly increased emphasis by AID in recent years. Energy problems are being exacerbated by local policies that discourage efficiency, encourage unproductive consumption or inhibit investment in the expansion of domestic supplies. Furthermore, there is often a lack of knowledge of energy consumption patterns, the role of traditional fuels, and options for energy planning.

In times of considerable instability of oil prices, as evident in early 1986, the need for energy planning assistance becomes even greater. Price uncertainty can lead to postponement of investment decisions, especially for large power generating facilities. This would lead to significant electricity shortages, retarding economic growth.

Accordingly, AID works with technical and policy officials to strengthen local capabilities in energy planning, gather energy data, and assess policy options. Key policy issues include energy pricing; investment programs to encourage private sector development and management of energy resources; and means to increase efficiency of energy production, conversion, and use.

In recent years, AID has supported policy research on energy pricing, constraints to expansion of energy in Africa, energy requirements and energy efficiency improvements in industrial facilities and for transport, and evaluation of alternative efforts for fuelwood production. Strengthening host country institutional capabilities for energy policy and planning work, including improvement of internal governmental coordination, has been a prominent feature in many AID energy projects.

AID's Office of Energy sponsored a workshop in early 1983 for U.S. and developing-country experts to share energy planning know-how and experience. An energy policy research program in 1984-86 awarded 16 grants and six contracts in such areas as fuelwood economics and marketing, energy for agriculture, and energy relationships to macroeconomic development. Planning pro-

jects have been supported in Sudan, Togo, Liberia, Pakistan, Egypt, Morocco and Tunisia. Some of these have been continued with bi-lateral funds provided by AID's regional bureaus (e.g., "Energy Initiatives for Africa" project) and missions.

AID coordinates energy planning assistance with other donors. Particular attention has been given to the country energy assessment programs of the World Bank and the United Nations Development Program. Though having somewhat different aims and methodology, these donors provide extremely useful summary analyses of the energy situation in the countries concerned and offer an excellent starting point for longer-term efforts supported by AID.

### B. Increasing Indigenous Energy Supplies

AID aims to help countries increase their indigenous energy supplies and improve end-use efficiency. AID seeks to play a catalytic role by sponsoring feasibility studies, training, policy advice and research.

Savings in fossil fuel and fuelwood consumption, when carried out on a significant scale, can have an effect comparable to producing thousands of barrels of oil or planting hundreds of hectares of trees. Increased efficiency of energy production, conversion, and utilization has therefore become an important AID energy assistance activity.

AID's Office of Energy is providing technical assistance to help countries use indigenous fossil fuels (e.g., natural gas; power production from oil shale; use of coal-liquid mixtures in central station power plants) and determine how they might best be exploited. These efforts can lead to profitable follow-up private sector investments.

AID provides Development Assistance funds--both for capital and technical assistance--for fuelwood production and research programs. In selected countries, Economic Support Funds are provided for investments in hydropower and fossil fuels. Additionally, a substantial portion of AID PL-480 (Food for Peace) assistance (Title II and III) finances not only food inputs but local currency costs of forestry/fuelwood activities.

Improving Fuelwood Supplies and Utilization Efficiencies--All four AID bureaus have major programs in this area, which are detailed in the next section. They include community forestry, a wood-based rural energy project, fuelwood production, development of multi-purpose fuelwood tree species, improved stove efficiency, and improved charcoal production.

Within the Bureau for Science and Technology, both the Office of Energy and the Office of Forestry, Environment, and Natural Resources support forestry/fuelwood programs in the field. Through

an inter-agency agreement with the U.S. Forest Service, AID has mobilized U.S. forestry talents for a broad range of overseas technical assistance activities.

The Agency's Science Advisor also supports energy research, both directly and through a multi-year grant to the National Academy of Sciences. Biomass resources and conversion technology are a major research theme. Collaborative studies between U.S. and developing country scientists include fast-growing trees for fuelwood and other purposes and nitrogen-fixing plants as a substitute for petroleum-based fertilizers.

Rural Electrification--AID investments in electric power generation, transmission and distribution and in rural electrification schemes are confined largely to those few countries receiving Economic Support Funds (ESF). In the 1960s and early 1970s, AID was heavily engaged in expanding power production, and more recently in supporting rural electrification as part of its broader interest in rural development. AID rural electrification programs now concentrate in Bangladesh, Pakistan, Indonesia, India. AID is completing projects in Syria, Jordan, Panama, Peru and the Philippines.

AID is also funding major increases in generating capacity in Egypt, as well as improvements in distribution systems. Over \$670 million in ESF funding has been committed to the power sector in Egypt since FY 1976.

Fossil Fuels Development--Pakistan, India, Bangladesh, Indonesia, Thailand, Kenya, and Morocco are being assisted in developing and using their domestic coal, oil, and natural gas resources. The next section details these programs. The private sector will continue to be the major source for financing expansion of fossil fuel supplies. AID technical assistance is designed to facilitate and encourage--sometimes in conjunction with financing from the World Bank and the regional development banks--the investment of private U.S. and local capital in the commercial production of oil, coal and gas.

Renewable Energy Development--AID has pursued a broad spectrum of renewable energy systems (biogas, small hydro, solar, wind, etc.) over the past years, being responsive to LDC interests and the rapid development of renewable technologies underway in the United States. Many smaller-scale systems have been installed and demonstrated in LDCs using AID funds. AID has initiated a reassessment of renewables, with a view to identifying the most important end-uses, such as irrigation pumping, village electrification, and power for communication systems, and matching these with a limited set of the most viable energy systems. Increasing emphasis also will be given to involving LDC and U.S. industry in new activities to assure more widespread application of the systems of choice. Biomass sources and cogeneration systems are

getting increased attention, as well as installations scaled big enough to serve villages, communities, and rural industries, with less emphasis on those for single-family users.

#### C. Training and Institution Building

AID places major emphasis on helping developing countries to build technical, research and managerial capacity related to energy. Training is almost invariably included as a component in the bilateral energy projects that AID finances in some 35 countries. A centrally-funded program provides practical, hands-on training and internships in the United States. AID is also supporting a number of LDC energy laboratories and institutions in expanding national energy capabilities.

#### D. Research and Technology Transfer

AID assists developing countries in designing, testing, and disseminating technologies to help them make the transition from dependence on fuelwood and imported fossil fuels to a more balanced and sustainable mix of energy sources.

AID has, for example, supported research to develop increased power generating capacity, to enhance the efficiency of energy use (in fleet transportation, utilities, industrial use, wood stoves), to use local biomass resources (forest wastes, sugar cane, rice husks) for energy production, to seek substitutes (coal briquettes) for fuelwood, and to develop a broader array of decentralized power sources, including those for cogeneration of steam and electricity. This has included establishment of laboratories and workshops in the developing countries for the design and testing of technologies appropriate to their resources and needs.

### III. BUREAU PROGRAMS

#### A. BUREAU FOR ASIA AND THE NEAR EAST (ANE)

##### 1. Background

Since the oil crisis of 1974, AID-assisted countries in Asia and the Near East have sought to accelerate development of indigenous energy resources and improve the efficiency of energy use. The World Bank, AID, and other donors have carried out assessments and planning studies that have recommended appropriate investment strategies and policy emphases.

In the Asia/Near East region of AID, there are currently more than 45 projects with life-of-project funding of \$1,706 million. These cover seven areas of energy development:

1. Energy policy and planning.
2. Rural electricity distribution.
3. Power generation.
4. Fossil resource development.
5. Renewable energy development.
6. Energy conservation (increased efficiency).
7. Fuelwood production and use.

Actual project activities are discussed in Section 3 below and a funding summary is provided in Section 4.

##### 2. Energy Strategy Focus

As a result of the Asia Energy Workshop among AID field and Washington staff members in April 1985, the strategic focus of ANE energy activities is moving toward three basic objectives:

1. Rational energy pricing.
2. Privatization of the energy system.
3. Expanded energy supplies to agriculture and rural industry.

More rational energy pricing systems are fundamental to expanding investment in indigenous energy development and promoting efficiency in energy use. AID believes that subsidization of capital-intensive energy systems is not an appropriate means for achieving social and economic development goals. Consumer price subsidies should be removed systematically and logically, and producer prices allowed to rise to levels that provide sufficient incentive for private exploration and production investments.

Complementary to the first objective is an effort to promote the privatization of all phases of the energy system. Following the 1974 Arab oil embargo, Asian and Near Eastern governments moved to intervene in the production, processing, and marketing of en-

ergy resources, products and technologies. Greater private investment must be mobilized in indigenous energy resource exploration and production--especially oil, gas, and coal--if Asian and Near East countries are to reduce their dependence on imported oil.

Rural development depends critically on raising productivity in agriculture and rural industries. Energy is a key input to this process, as well as an important output in terms of residual products. This includes, for example, energy involved in the manufacture, distribution and application of fertilizer. ANE missions are increasingly concerned about the development of cost-effective systems for producing and delivering the energy needed to expand rural output. Improvements in the efficiency of energy use are also important and may be achieved at less cost than producing new supplies. These systems include conventional rural electrification approaches, agroforestry, and decentralized, renewable energy technologies and systems.

### 3. Project Activities

Energy Policy and Planning--Projects in Pakistan, Indonesia, Morocco, and Egypt are assisting the government in integrated national energy analyses. A new ENERPLAN office has been established in Pakistan which, with AID assistance, will prepare the Seventh Five-Year Plan in the energy sector. In Indonesia, the Secretariat to the Indonesian Cabinet Level Energy Committee is developing the capacity to link energy and economic development plans on both a national and regional basis.

In Morocco the emphasis has been on approaches to improving choices between alternative energy project investments. Analyzing the policy and investment issues in promoting energy conservation, the commercialization of renewable energy technologies and augmentation or substitution for fuelwood supplies will be central to the new phase of the planning work in Morocco. Egypt, with AID assistance, is creating a new organization for planning under the Supreme Council for Energy. This group is helping to lay the analytical foundation for changes in key policy areas, such as pricing and conservation.

Rural Electricity Distribution--The expansion of electric distribution networks to serve rural consumers continues to be a focus of mission programs in several Asian countries. Projects have been completed in the Philippines and Indonesia. Development of a separate organization for rural electrification in the Philippines proved much more successful than the inclusion of that function in the main national utility in Indonesia. AID is in the latter stages of a project in India to support rural electric distribution in several states. The project has been implemented by the Rural Electrification Corporation, drawing entirely on lo-

cal contractors and equipment. Irrigation pumping is the central load in much of rural India, unlike the Philippines or Indonesia. Yet tariffs to irrigation consumers in India are highly subsidized and have resulted in low revenue for state electricity boards.

AID has made a concerted effort with India's government to establish a well-run Rural Electrification Board and a system of rural electric cooperatives. AID has directly supported the establishment of 17 cooperatives and provided technical assistance and training for the overall Rural Electrification Board system. Load growth in both irrigation and industrial consumers has been good and several cooperatives may reach the break-even point soon. Planning is underway for a program of intensification in the existing AID-supported cooperatives to improve their load factor and financial position.

AID is spearheading a major reform of the electric distribution system in Pakistan. A technical assistance team from Ebasco and American Electric Power are designing a program to modernize management systems, rebuild and rehabilitate high-loss portions of the system, improve the skills of operating and staff personnel, and institute appropriate load management practices. The World Bank and Asian Development Bank are collaborating and are interested in funding some elements of this new program. Projects in both Bangladesh and Pakistan are encouraging the removal of price subsidies and the adoption of long-run marginal cost approaches.

Power Generation--AID is taking the lead role in the construction of two thermal power stations--one in Egypt and one in Pakistan. The Shouba complex in Egypt is being financed by a consortium of donors and Bechtel is providing the architectural and engineering services. The project is ahead of schedule and under budget and will represent a significant addition to Egypt's generating capacity. In Pakistan the Ghuddu 400-megawatt complex is being co-financed with the Asian Development Bank and will use natural gas in a combined cycle arrangement. It will have an efficiency of over 40%, making it the most efficient thermal plant in Pakistan. The firm of Gibbs and Hill is providing architectural and engineering services. The first steam unit was put on line in late 1985. Feasibility studies are nearing completion for a coal-fired power complex at the Lakhra coal field in the Sind province in Pakistan.

A major policy initiative is underway in the ANE Bureau to assess the potential for private investment in small power systems. Feasibility work in Pakistan, India, Thailand and the Philippines is examining cogeneration, small hydro or coal plants, wind farms, and other possibilities for private investment and sale of electricity to the grid. Considerable investment is taking place in captive power to counteract inadequate and unreliable supplies from public utilities. The ANE Bureau is seeking to promote the

policy and institutional climate and mechanisms for private companies and investors to receive a reasonable price for the electricity that they sell to the grid.

Fossil Resource Development--Asia has substantial fossil resource potential, particularly lignite and natural gas. The largest ANE activity is in Pakistan, where efforts have begun to assess coal resources and consider their utilization in power, industry, households and commercial establishments. Coal briquetting is being investigated as a potential substitute for wood fuels, which are in very short supply in Pakistan.

India has the largest coal resources in the developing world, but they are generally low in energy content and high in ash. India has a large research and development effort underway to develop technologies to beneficiate these lignites and convert them efficiently for heat and power. A collaborative research program is underway between the U.S. Department of Energy's Pittsburgh Energy Technology Center and several leading Indian coal research centers in beneficiation, fluidized bed performance, and lignite combustion and gasification. An expanded program of cooperation in coal research and technology development involving U.S. private companies is currently under consideration.

Coal is also a major emphasis of Indonesia's plan to diversify domestic energy supply and consumption. AID is supporting the establishment of a national energy laboratory (Puspipstek), which will work with government and private organizations in carrying out technology assessment and coal and equipment testing. The laboratory will serve as a catalyst to the transfer of U.S. technology in coal-fired boilers.

Private investment in oil and gas development is a goal of the ANE program. In Thailand, AID has helped to formulate the plans for a National Petroleum Institute, which would be a partnership between the public and private sectors for the development of the human resource capabilities of Thailand in oil and gas. The institute was recently created; an AID Office of Energy team is exploring the opportunities to help Thailand improve the utilization of its natural gas resources.

Under an AID contract in Pakistan, the Arthur D. Little Co. has been advising the Pakistan government on approaches to attracting private investment into the Dhodak condensate field. A sizable technical assistance effort is underway in Morocco to help define the geological opportunities for natural gas exploration and promote, together with the World Bank, private investment in exploration.

Renewable Energy Technology Development--Determining the potential for small-scale, decentralized technology using renewable energy resources has won substantial attention during the past

five years by ANE missions. Projects in India, Thailand, Philippines, Nepal, Egypt, Tunisia and Morocco have tested solar, wind, biomass, biogas and small hydro systems for meeting rural and village energy needs. They have helped to develop a core of experts at energy centers in these countries who understand the problems as well as potential of renewable energy technologies. Success in promoting the commercialization of these new technologies has so far been limited.

A review of projects in Asia has established that four technologies have the potential for widespread dissemination (and some have already begun): micro-hydro units in Thailand and Nepal, biogas plants in Nepal, and photovoltaic systems in India. In addition, four other technologies have near-term possibilities for widespread dissemination or transfer to other Asian countries: solar rice dryers in India, biomass gasifiers in the Philippines and Thailand, rice husk pyrolysis systems in Thailand, and wind water pumpers in the Philippines and Thailand.

Key factors associated with the successful systems are: high value attached to system output by potential users, participation by end-users in system adaptation or construction, high-quality local resource base, compatibility with existing local fabricating facilities, and low cost when compared with other methods available for doing the same work.

Energy Conservation--Energy conservation is emerging as a new focus of the ANE Bureau energy program. This development reflects the growing realization of the potential for substantial near- or medium-term payoffs. Also important is improving efficiency as a way of increasing the political acceptability of raising prices to consumers, considering the disillusionment of some with the promises of renewables in the current oil price environment.

An ambitious effort has been launched in Pakistan together with the World Bank. AID supported an expert team that helped develop a proposal for a national energy conservation program. This program was adopted by the Cabinet; AID will assist in its implementation through the Energy Planning and Development project and the Energy Commodities and Equipment project. The initial focus of the program will be on industry and power. Industrial energy conservation is also the focus of a new project in the Philippines that involves a cooperative approach among the Bureau of Energy Utilization of the Ministry of Energy, the private Energy Managers Association of the Philippines, and several financial institutions. AID is working with the private Association of Indian Engineering Industries in India and a program of collaboration and technology transfer is initially focusing on boiler and furnace design, manufacture and control, recovery of waste heat, and cogeneration.

An innovative program in the ASEAN countries (a group of South-east Asian countries that have a treaty relationship with the United States) works on policy and technical issues in improving energy efficiency in buildings, which account for as much as 30% of all electricity used in the region. A pilot project with Singapore suggested savings of up to 30% through more efficient lighting and increased "daylighting" design. This effort is being expanded to the other ASEAN countries to transfer and apply existing technologies to the ASEAN private sector as well as to public entities developing national building and energy policies. New conservation activities are also planned for Egypt and Morocco.

Fuelwood Commitment--AID's Asia/Near East Bureau is strongly committed to increasing the availability of wood and other tree products to rural and urban areas.

Approximately 80% of the wood in Asian countries is used for fuel. The pressure of growing demand is outstripping sustainability. Fuelwood demand and pressure to expand agricultural production are threatening remaining forests, destroying watersheds, and removing a key protective shield for the soil.

Within the context of increasing the incomes of rural people, projects have been undertaken in Sri Lanka, India, Pakistan, the Philippines and Nepal to promote the planting of multi-purpose trees. Since these projects are relatively recent, their impact on the fuelwood situation is uncertain. To expand the availability of suitable and improved tree material to farmers and rural communities, the ANE and S&T Bureaus recently approved a Forestry/Fuelwood Research and Development (F/FRED) project. This project will help expand the research capabilities of Asian countries and provide support to tree planting programs on both technical and social issues. A new agroforestry project is being developed in Bangladesh that will link research, training, and extension in fast-growing trees.

#### 4. Asia Energy Projects Summary

##### Policy and Planning

	Life-of- Project Estimate (\$ million)
391-0478 Pakistan: Energy Planning and Development...	\$ 5.3
497-0318 Indonesia: Energy Planning for Dev. II.....	0.75
497-0300 Indonesia: Energy Manpower and Training.....	1.0
498-0258 ASEAN: ASEAN Energy I.....	0.5
498-0285 ASEAN: ASEAN Energy III - Energy (Conservation and Management).....	2.0
386-0474 India: Alt. Energy Resource Dev.....	0.1
Subtotal.....	\$ 9.7

Rural Electrification (Distribution)

388-0021	Bangladesh: Rural Electrification.....	\$ 69.3
388-0054	Bangladesh: Rural Electrification.....	50.0
386-0462	India: Rural Electrification.....	58.0
391-0473	Pakistan: Rural Electrification.....	75.0
497-0267	Indonesia: Rural Electrification.....	41.0
	Subtotal.....	<u>\$293.3</u>

Energy Resource Development

497-0333	Indonesia: Puspiptek Energy Laboratory.....	\$ 11.8
493-0304	Thailand: Renewable Nonconventional Energy..	5.0
493-0324	Thailand: Micro/Mini Hydroelectric.....	8.1
492-0294	Philippines: Non-Conventional Energy.....	8.0
391-0478	Pakistan: Energy Planning and Development...	18.8
391-0486	Pakistan: Energy Commodities and Equip.....	50.0
391-0487	Pakistan: Lakhra Coal Mine and Power (PID)..	125.0
391-0473	Pakistan: Rural Electrification.....	52.0
386-0465	India: Technologies for the Rural Poor.....	0.8
386-0474	India: Alternative Energy Resource Dev.....	2.0
367-0129	Nepal: Rural Area Development.....	0.5
367-0132	Nepal: Resource Conservation and Utilize....	0.5
498-0272	ASEAN: ASEAN Energy II.....	1.0
	Subtotal.....	<u>\$283.5</u>

Energy Conservation

391-0478	Pakistan: Energy Planning and Dev.....	\$ 3.4
391-0473	Pakistan: Rural Electrification.....	26.3
391-0486	Pakistan: Energy Commodities and Equip.....	50.0
386-0474	India: Alternative Energy Resource Dev.....	0.5
492-0381	Philippines: Tech. Transfer for Energy Mgt..	10.0
498-0272	ASEAN: ASEAN Energy II.....	0.3
498-0285	ASEAN: ASEAN Energy III.....	3.0
	Subtotal.....	<u>\$ 93.5</u>

Fuelwood/Wood Energy

492-0375	Philippines: Rural Energy Development.....	25.0
386-0475	India: M.P. Social Forestry.....	25.0
387-0478	India: Maharashtra Social Forestry.....	30.0
386-0495	India: National Social Forestry.....	84.7
391-0481	Pakistan: Forestry Planning and Dev.....	25.0
383-0055	Sri Lanka: Reforest. and Watershed Mgt.....	5.0
367-0132	Nepal: Resource Conservation and Utiliz....	5.0
498-0276	Asia Regional: Forestry R&D.....	2.5
	Subtotal.....	<u>\$202.2</u>

TOTAL ASIA ENERGY.....\$882.2

5. Near East Energy Projects Summary

Policy and Planning

263-0123.1 Egypt: Energy Policy and Planning.....	\$	8.5
263-0140 Egypt: Science and Technology for Devel. Energy Management.....		47.5*
Energy Training.....		7.1*
608-0180 Morocco: Energy Planning Assistance.....		4.0
150-0001 Portugal: Technical Consultants and Training.....		.3
278-0258 Jordan: Technical Services and Feasibility Studies III.....		.7
270-0080 Yemen: Development Training III.....		2.1
Subtotal.....	\$	<u>70.2</u>

\*Energy portion of noted project

Energy Resource Development

263-0123.2 Egypt: Renewable Energy Field Testing and Demonstration.....	\$	24.1
263-0016 Egypt: Applied Science and Technology--Bioenergy.....		1.2
263-0009 Egypt: Ismailia Thermal Power Plant.....		254.0
263-0030 Egypt: Shoubra Thermal Power Plant.....		263.0
263-0133 Egypt: Urban Electric Distribution Grant.....		51.1
Loan.....		46.0
263-0060 Egypt: Rehabilitation and Modernization of Aswan High Dam.....		100.0
608-0159 Morocco: Renewable Energy Development II....		9.2
608-0176 Morocco: Conventional Energy.....		5.0
Subtotal.....	\$	<u>753.6</u>
TOTAL NEAR EAST ENERGY.....	\$	823.8
TOTAL ANE BUREAU.....		<u>\$1706.0</u>

## B. BUREAU FOR LATIN AMERICA AND THE CARIBBEAN (LAC)

Heavy dependence on petroleum imports to meet ever-increasing commercial energy demands has significantly contributed to the serious balance-of-payments crises currently facing most Latin American and Caribbean countries. Furthermore, over-exploitation of forests to meet domestic demands for fuelwood and charcoal has resulted in severe environmental degradation.

### 1. Orientation

Following the guidelines of the AID global energy policy, the LAC region has placed major emphasis on:

1. Evaluation and development of alternative energy sources.
2. Development of national energy policies.
3. Energy sector and conservation/efficiency analyses.
4. Rural electrification projects (borrowing on larger scale hydroelectric projects).

In the LAC Region, a total of 43 projects support energy development or include energy-related activities such as energy conservation and rural electrification as part of other activities such as housing guarantee loans or natural resource management. All projects stress the importance of developing small-scale alternatives, such as mini-hydro, solar water heating and solar crop drying. Considerable emphasis has been placed on the creating and implementing effective centers for energy management and policy development.

### 2. Actual Projects by Location

In the following, LAC energy activities are discussed according to country or regional organization.

Caribbean Regional (RDO/C)--Growing out of the earlier CARICOM Alternative Energy project, the Cumberland Hydroelectric project (538-0091) in St. Vincent, emphasizes energy efficiency and promotes electrification. It co-finances activities to expand energy production by reducing line losses, refurbishing existing generators, and increasing transmission and distribution capacity. This project will also attempt to create a financially viable electric utility.

Feasibility analyses will continue on alternative energy sources which include biomass for St. Kitts and mini-hydro for St. Vincent, and are part of an Energy Sector Structural Analysis project. Under this initiative, countries selected will develop

specific energy policy reform plans with appropriate technical assistance and will implement alternative energy programs.

Industrial energy audits are underway and assistance is being provided to the utility and transportation sectors to develop appropriate conservation measures. In addition, energy sector assessments will examine energy pricing and taxation structures and policies affecting public utilities.

A St. Lucia Geothermal project is in the planning stage with the purpose of establishing the economic and technical viability of the Qualibou Caldera as a long-term geothermal resource that ultimately can be developed by the private sector. Expansion of the electric grid and improved distribution will be carried out in the Dominica Electrification project. Involvement of the private sector is encouraged through these mechanisms.

Dominican Republic--Energy is clearly a priority concern in the Dominican Republic and two new projects have been proposed based on success of earlier efforts. First, the Energy Policy Development project has gathered information on energy supply and demand to develop a sound national energy policy, and training courses have been conducted. Second, the Energy Conservation and Resource Development project has stressed comparisons of costs and potential benefits of developing various alternative energy sources. Pilot renewable energy projects (e.g., wind, solar, mini-hydro, and biomass conversion plus fuelwood cultivation) have been investigated.

A power plant rehabilitation and maintenance program is being planned for a FY86-89 project start. Rehabilitation of key thermal electric power plants will be financed to improve efficiency and permit realistic utility rates. The National Energy Commission is working on energy investment planning, and with AID help computer hardware and software will replace an inadequate system.

Haiti--Severe deforestation has resulted from the increased needs for food and energy. Reforestation efforts under the Agroforestry Outreach project are underway, with suitable fuelwood species and soil conservation measures being explored. These will also address the associated siltation problems, which jeopardize Haiti's major hydroelectric programs. In this case, Private Voluntary Organizations (PVOs) are doing the actual work with AID backing.

Jamaica--Jamaica relies nearly 100 percent on imported oil for power generation. To date, energy policy analysis has been the main emphasis in Jamaica's energy program. However, an Energy Science and Technology project has examined the development of local energy sources, opportunities for energy conservation and the establishment of institutions needed to attain these goals. Solar, biomass, and waste conversion and coal energy sources have

also been investigated. A proposed Hillside Agricultural Project will explore fuelwood cultivation.

LAC Regional--The LAC regional Energy Resources Development project has provided over \$1.5 million since FY79 to undertake energy sector assessments, surveys and feasibility studies throughout Latin America and the Caribbean. These have led to the adoption of national energy plans, improved exploitation of conventional and nonconventional energy sources, energy conservation and low-cost approaches to alternative energy development.

Central America Regional (ROCAP)--ROCAP assistance in the energy sector has the long-term objective of helping countries develop, manage, and conserve their natural resources. The focus has been on energy conservation and alternative energy development. An Alternative Energy and Fuelwood project has allowed the Central American Industrial Research Institute (ICAITI) to continue research and technical assistance in alternative energy technologies. Emphasis is given to commercial application of these technologies and to management assistance in the future.

A Tree-Cropping and Fuelwood project is carrying on trials of potential fuelwood species, as well as incorporating fuelwood production into other tree-cropping activities.

Natural resource management projects complement the alternative energy projects. The Watershed Management for Sustainable Energy Production project is attempting to reduce erosion caused by extensive deforestation. Such erosion has created serious siltation and shortened the lifespan of hydroelectric power facilities.

A regional Industrial Energy Efficiency project and the Central America Energy Resources project are examining national energy policy issues, undertaking industrial energy efficiency audits, examining energy supply and demand comparisons, and developing an institutional structure to maintain effective evaluation procedures. New potentials in geothermal and peat energy and mineral exploitation throughout Central America are also being investigated.

A Central American Rural Electrification Study project has been evaluating rural energy and the need for rural electric expansion in Central America. Guatemala, Honduras, Costa Rica, El Salvador and Panama are covered by this grant.

Costa Rica--An Energy Policy Development project has aimed at strengthening the capability for energy sector analysis and planning, formulating a national energy policy, and exploring alternative energy resources. Under this initiative, five pre-feasibility studies have been completed, a documentation center has been established, and effective training is underway. A Natural Resource Conservation project has been examining reforestation

and resource management, with some attention to the production of fuelwood. In addition, a Science and Technology project has identified research needs for a number of areas (including energy), formulated research programs, and financed research and graduate training.

Honduras--In Honduras, where 90% of the electricity used is generated by fossil fuels (which make up 17% of all imports), considerable money has been invested in energy development. A rural electrification project has increased the availability of electricity to the farmers and inhabitants of the Aguan Valley in northeastern Honduras. Electricity for this grid is generated by the La Ceiba Generator station, which has four diesel generators.

Two major hydroelectric facilities (El Cajon and El Nispero) funded by international agencies should satisfy all of Honduras' electricity needs. Associated with these projects, the Energy for Rural Development project will concentrate on the construction of mini-hydro generators and distribution systems with the Honduran National Electrical Corporation. A Power Restoration project returned two transformers serving Tegucigalpa to working order.

As in the other LAC countries, fuelwood and charcoal production projects are being emphasized and integrated with natural resource management. More than 125,000 cubic meters of wood are burned each year in Tegucigalca alone. The Natural Resource Management project is assessing fuelwood production and harvesting methods.

Guatemala--Large scale hydroelectric projects such as Chixoy in Guatemala have been funded by international sources. AID's rural electrification effort was aimed at extending distribution of currently generated electricity. AID also funded the purchase of a diesel generator to provide electricity during the period when Chixoy is being repaired and brought on line. Guatemala is also involved in some of the regional projects funded through ROCAP, such as the Program Development and Support project, which is evaluating rural energy needs and rural electrification.

Panama--Primary emphasis in Panama has been on natural resource management and conservation as it relates to energy needs. The Natural Resources Management project and the Watershed Management project both have a component that is associated with improving energy availability through fuelwood production. In each project, efforts are closely coordinated with the Water Resources and Electrification Institute (IRHE), which has an office created solely to develop alternative energy resources. The Alternative Energy Sources project has been aimed at improving IRHE's ability to identify, analyze and develop renewable energy sources and application. This has included biomass, solar and biogas resource demonstration projects.

Peru--Development and distribution of energy resources continue to be a major challenge to Peru. Oil represents about 60% of the total primary energy production, with wood and biomass contributing 30% and hydro and coal providing about 10%. The Consejo Nacional de Energia in Peru is the body primarily responsible for energy planning, conservation and efficiency assessments and the application of appropriate technologies.

High priority has been placed on rural electrification by the government of Peru, which plans to provide at least 23% of the rural population with electricity by 1985. A Small Hydro project in Chongos Altos provides power to about 20 rural communities in the sierra and high jungle areas.

Forestry and fuelwood have not been priority concerns in AID's effort in Peru, although the Soil Conservation project and the Sierra Land Use both have small forestry and fuelwood production components.

Ecuador--An Alternative Energy Sources Project has sought to increase the ability of the National Energy Institute (INE) to influence energy policy and promote non-conventional, appropriate energy alternatives. This has been done in four ways: 1) conduct energy studies and research to inventory energy sources, 2) transfer energy technology and create an information network, 3) demonstrate and disseminate alternative energy and 4) promote energy conservation. The project has improved INE's capabilities and made energy conservation and efficiency national concerns. An information transfer network has been started under this project.

Fuelwood makes up about 80% of the available roundwood used in Ecuador. Thus the importance of managing this national resource cannot be overestimated. Fuelwood production is being considered as a component of both the Forestry and Natural Resources Conservation project and the Alternative Energy Sources project.

### 3. Funding Levels

#### Summary: Energy Funding in Latin America/Caribbean

	(\$ million)					
	<u>FY 82</u>	<u>FY 83</u>	<u>FY 84</u>	<u>FY 85</u>	<u>FY 86</u>	<u>FY 87</u> Proposed
DA	\$ 28.0	17.2	13.0	9.0	6.2	6.7
ESF	1.8	0	8.0	0	1.5	10.0
Total..\$	<u>29.8</u>	<u>17.2</u>	<u>21.0</u>	<u>9.0</u>	<u>7.7</u>	<u>16.7</u>

DA=Development Assistance; ESF=Economic Support Fund

## C. BUREAU FOR AFRICA

### 1. Overview

Africa suffers from the high cost of oil imports and growing deforestation. Indeed, this problem may be more severe for the African Sahel than for any other region of the world.

At a time when increased energy inputs to the agricultural sector are required to feed undernourished populations, the cost of oil imports increased from less than 20% to over 50% (before the recent oil price decline) of merchandise exports in Tanzania, Sudan, Senegal and Kenya.

Fuelwood and charcoal harvesting, which provides more than 85% of the domestic energy supply in many African countries, puts an enormous demand on natural resources. Currently, most fuelwood is simply collected from commonly held areas, as the obvious "least-cost" source of fuel.

AID's Africa Bureau has chosen to divide the problem into two major areas for improvement: First, the need for small scale renewable or alternate energy technologies on a decentralized basis and, second, the need for increased fuelwood production and more efficiency in use of energy by householders. Examples of the first include activities in solar, wind, biogas and hydro energy in Botswana and Mali. Early fuelwood projects have focused on tree planting in 13 countries, with an AID commitment of \$55 million over the past eight years. Under the PL-480 Food for Peace programs, \$125 million has been targeted at reforestation in Africa, in such countries as Burundi, Cape Verde, Djibouti, Kenya, Lesotho, Madagascar, Malawi, Mali, Niger, Senegal, Sierra Leone, Somalia, Sudan, Tanzania, Uganda, Burkina Faso, Zambia, Cameroon and Gambia.

How does AID hope to persuade householders to use fuelwood from tree plantations or woodlots? Especially, how can this group be persuaded to conserve fuels? Principally by means of education in the economic benefits of forestry support to agricultural productivity, and as a source of fruit, forage, medicines and other family nutrients. In addition, benefits of being able to sell additional firewood (or simply eliminating laborious collection) are being stressed. As for conserving fuels, the main ingredient is the provision of technology and assistance to village entrepreneurs to manufacture energy-efficient cookstoves. This subject deserves separate mention below.

### 2. Funding levels (chart on next page)

Summary: Energy Funding in Africa

	(\$ million)					
	<u>FY 82</u>	<u>FY 83</u>	<u>FY 84</u>	<u>FY 85</u>	<u>FY 86</u>	<u>FY 87</u> Proposed
DA	\$ 7.0	6.5	5.8	4.4	2.9	3.6
ESF	3.6	0	22.3	0	0	0
Total	\$ 10.6	6.5	28.1	4.4	2.9	3.6

DA=Development Assistance; ESF=Economic Support Funds

3. Energy Planning and Management

A forerunner to effective AID energy project funding is sound planning, policy and management practices within the host country. Limitations on AID resources require selective use of U.S. expertise. Consequently, improving energy policy analysis and investment decision-making in both public and private institutions and long-term training are all up-front objectives of the Africa Bureau's energy initiatives.

In the case of Sudan, an \$8.4 million Energy Planning and Management Project is providing long- and short-term technical assistance, training and a limited amount of commodities to support energy policy, planning and management capabilities within the National Energy Administration of the Ministry of Energy, Industry and Mining. This assistance has resulted in four years of marked improvement in Sudanese ability to gather and analyze energy supply and demand data, to set priorities for analysis, and to make public and private energy investment decisions.

Somalia has been furnished with a long-term energy adviser to assist in developing a national energy plan and policy. Additional technical assistance is being supplied by AID's Office of Energy in examining the Somalia national power system and grid for operational improvements. Expansion of Senegal's power grid has also been examined with AID help, together with an irrigation pumping assessment comparing diesel and electric pumps.

AID's Office of Energy has also helped to build host country energy capabilities by providing academic or on-the-job training to over 100 African professionals in petroleum geology, energy economics, electric utility engineering, and energy conservation through AID's Conventional Energy Training Program.

A principal vehicle used by the Africa Bureau to address energy problems is the Energy Initiatives for Africa (EIA) project. Funded originally at \$8 million, EIA has identified potential energy constraints, as well as costs and opportunities for using

energy more effectively. This region-wide activity is financing energy assessments (national and sectoral), providing short and long term assistance on energy planning and sharing proven technologies. Likewise, it is spearheading fuelwood and agroforestry subprojects, with emphasis on private entrepreneurship. Specifically, it has sponsored a model communal reforestation project in Rwanda, improved charcoal and solar stove design and usage in Kenya, Botswana, Lesotho, Mali and Sudan, and installed charcoal briquette production from coffee husks in Uganda.

Countries aided under EIA are Malawi, Lesotho, Madagascar, Somalia, Rwanda, Burundi, Djibouti, Uganda, Ivory Coast, Mali, Burkina Faso, Senegal, Sierra Leone, Gambia and Kenya.

#### 4. Energy Conservation

Energy conservation is of obvious importance in the face of declining fuelwood supplies and the need to reduce expenditures for oil imports. A first step is the energy audit, to detect unnecessary losses and determine the means to remedy them. The Africa Bureau is well aware of this need, and for example has sponsored energy efficiency and conservation seminars and audits for Kenyan industries and commercial ventures. Energy conservation planning has been conducted in the Ivory Coast with AID technical assistance, and rural energy surveys of needs and constraints have been sponsored in both Botswana and Lesotho.

Several West African electric utilities and private engineering firms are benefiting from a \$250,000 energy efficiency auditing training program, started in early 1986 and co-sponsored by the Africa Bureau's Office of Regional Affairs and the Economic Community of West African States (ECCWAS). Trainees selected are from firms in Nigeria, Niger, Senegal, Ivory Coast, Sierra Leone and Guinea-Bissau.

The \$4 million Djibouti Energy Initiatives Project, includes a national energy assessment, energy auditing, energy conservation and renewable technologies. Two long-term resident advisers are involved; the project includes commercial, institutional and residential buildings, including low-cost housing.

One common solution to energy conservation is the use of passive solar design in building programs and the incorporation of energy-efficient materials and equipment in new or existing structures. In Botswana and Lesotho, AID has helped develop low-cost housing and office space, reducing energy costs while improving comfort levels by incorporating passive solar energy design. In Malawi, a lending institution was assisted in providing small loans to finance energy-efficient materials, equipment and designs in commercial and industrial ventures.

## 5. Agroforestry

Fuelwood and charcoal harvesting account for more than 85% of domestic energy supplies in many African countries, and this has contributed to serious deforestation and environmental degradation. Accordingly, early AID efforts have focused on tree planting to enhance fuelwood production.

It is the farmers themselves who can halt the spread of deforestation and produce fuelwood. Thus, AID foresters are constantly seeking better ways to work with farmers to promote tree planting. By showing them how to integrate agriculture and forestry, AID hopes to demonstrate that African farmers can afford the practices that will increase fuelwood supplies and protect the soil and water. AID seeks to show farmers how trees can stabilize and rehabilitate the soils of their deforested areas, by adding leaf litter to raise the organic matter levels in the fields and by tree roots that "mine" the deeper layers of the soil. At the same time, farmers are being shown that food, forage and saleable firewood increase family incomes.

Examples of such agroforestry and renewable energy efforts are a wood economics study in Mali, six agroforestry nursery and demonstration centers (with Peace Corp foresters' support) in Kenya, a Rwanda communal forestry project, and a World Bank-led forestry sector assessment in Sudan.

## 6. Charcoal Stoves

Over 6,500 charcoal-conserving metal stoves per month are being manufactured by private Kenyan entrepreneurs as a result of AID's \$4.8 million Kenya Renewable Energy Project. To date 40 to 50 thousand such stoves, incorporating a clay liner adapted from stoves used in Asia, have been fabricated and sold. Technical assistance and training in stove production and marketing have been AID's contribution to this accomplishment.

Kenya is not the only success story in cultivation of energy-efficient stove production and use. To help conserve dung fuels in wood-scarce Lesotho, AID has sponsored production and distribution of palos, or stone stoves. In both Lesotho and Botswana, improved metal stoves have been made available. A \$4.6 million Sudan Renewable Energy Project has likewise resulted in successful introduction of improved charcoal stoves to the private sector. Further, AID is assisting the Mali Solar Energy Laboratory with a \$4.5 million grant that includes technical assistance on improved metal stoves production and marketing and the services of a long-term advisor.

AID is also supporting improved stove design, manufacture and marketing in Somalia and Chad.

Production of charcoal briquettes from coffee husks is the subject of a small AID study in Uganda. In collaboration with the Ministry of Cooperatives and Marketing, AID has financed a small pilot plant at the Busoga Coffee Cooperative, which now produces commercial briquettes from coffee husks. As of January 1984, a total of 13.5 tons of charcoal had been sold to the public, in addition to a large amount given as samples to potential customers and distributors. This was accomplished with a plant designed to use nonmechanical, batch-type, closed kilns, and hand mixing and briquetting machines, thus maximizing the input of labor.

### 7. Renewable and Alternative Energy

Renewable and alternative energy applications are particularly conspicuous in African countries assisted by AID. A Botswana project is comparing the performance and economics of water lifting and pumping equipment powered by wind, photovoltaics and biogas with animal-powered pumping devices and human traction pumps. Currently, 15 windmills and 5 photovoltaic pumps are included in this continuously monitored experiment.

In Mali, the \$4.5 million AID renewable energy project has used photovoltaics for vaccine storage refrigeration, as well as for pumping, lighting, grinding grain and uninterruptible power supplies. Laboratory engineers at the Mali Solar Energy Laboratory can now certify manufacturers' performance claims. This center is also engaged in developing and test-marketing of photovoltaic chargers for flashlight batteries.

In Madagascar, AID is financing the design and construction of a pilot 30-kilowatt facility to power a rice mill. If it is successful, such mills may be established throughout this country. Previously, rice had to be hauled to Madagascar's capital for milling, an extravagant use of motor fuel.

The Office of Energy has addressed investment options for decentralized hydropower to serve important energy and development needs in Madagascar. Since one of the major objectives of this work is to attract the interest of investors, the Office of Energy has been working closely with the World Bank and the U.S. private sector to ensure that economically feasible projects are designed and constructed. The AID mission in Madagascar is also interested in using local currency funds to support these projects.

With the help of the Irish Peat Board, plus other specialists in peat production and use, AID has assisted the Government of Burundi since 1978 in developing the country's peat for energy production.

AID has trained scientists in Rwanda and Burundi in energy management, small decentralized hydropower and other conventional

and alternative energy technologies. Each country has been equipped with an information system as a tool to maximize the use of potential indigenous energy resources.

## D. BUREAU FOR SCIENCE AND TECHNOLOGY

### 1. Goals and Objectives

The AID Office of Energy (S&T/EY), part of the Science and Technology Bureau's Directorate for Energy and Natural Resources, concentrates on three goals: (1) to help reduce economic instability caused by dependence on imported oil; (2) to help insure availability of energy for sustained economic development; and (3) to foster private enterprise energy development.

Since AID-assisted countries are allocating up to 30% of their national budgets to energy, coherent policies and strategies to identify, develop and market indigenous energy resources are essential. The Office of Energy is assisting several countries in designing focused programs of pre-investment analysis. Good "front-end" work helps to avoid the expensive mistakes common in developing complex, high-capital-cost energy systems. Prudent strategies require analysis for uncertainty and an integration of energy elements with broad development goals in agriculture and industry. The volatile world oil market calls for increased technical assistance in energy planning and investment decisions to help assure that the decisions allow economic development to proceed.

Expanding the use of indigenous energy resources will reduce dependence on fuelwood and imported oil, and have a positive impact on foreign exchange. These resources include coal, oil, and gas, as well as renewable sources such as biomass, hydro and solar. In addition, conservation is recognized as a cost-effective means to increase energy supply by improving efficiency. Pursuit of these objectives has led to major initiatives such as coal development in Pakistan, energy from sugar cane in Jamaica, oil and natural gas development in Morocco, and model energy conservation and training programs in Sri Lanka and Ecuador.

### 2. Coal

In the quest to replace oil by indigenous fuels, coal is an important option in at least 20 AID-assisted countries. Pakistan, for example, has enough undeveloped coal to supply a new power generating industry. That country's Lakhra field alone can readily support the first modern coal-fired electric power generating unit of 500 MW. AID-sponsored feasibility studies ultimately could result in significantly expanding the coal output of Pakistan. In addition, there are enough reserves to convert the Pakistan cement industry from fuel oil to coal, and to manufacture smokeless fuel briquettes for domestic and commercial uses as substitutes for fuelwood.

While clearly a major undertaking, Pakistan's energy program is not the only example of S&T/EY activities in coal development.

AID's coal experts also are studying the technique of slurrying low-rank, high-sulfur coal with water, as a substitute for fuel oil for generating electricity. This technology has been successfully demonstrated in the Philippines, with a commitment by the National Power Corporation to identify opportunities for private sector investment. AID is sharing in the cost of a study by the Economic Development Foundation Inc. in Manila.

Vast resources of lignite coal in India are focusing AID attention on coal conversion technologies such as fluidized-bed combustion, coal mixtures, coal beneficiation and coal gasification. Significant work in identification and delineation of coal resources in Costa Rica also has been accomplished under S&T/EY sponsorship.

### 3. Natural Gas as Import Substitute

Important natural gas discoveries in AID-assisted countries promise to provide a desirable substitute for petroleum imports. In the past, AID assistance has been extended to Morocco to help develop gas and oil resources. Pakistan is receiving assistance to facilitate private sector participation in the development of a major gas field. Recently, Thailand discovered natural gas in commercial quantities both in the Gulf of Thailand and offshore of Khon Kaen Province. As a result, AID technical advisory support is being provided to determine the best use of the new resource.

Twelve AID client countries have proven natural gas reserves of more than 174 trillion cubic feet, yet only five (Bolivia, Egypt, India, Indonesia and Pakistan) are producing over 100 billion cubic feet per year. Thus there is obvious room for growth in energy supplies from these resources. Besides the major fields, attention is devoted to developing small gas fields in remote locations to add to rural energy supplies.

One of the most promising principal uses for increased natural gas supplies is transportation. Either diesel oil or gasoline can be synthesized from natural gas. Methanol is an intermediate product, which can be used as a fuel extender, thereby lessening imports of petroleum fuels. India and Indonesia are both considering this option. Alternatively, compressed natural gas can be used directly as a transport fuel. This option is being examined by Egypt, Thailand and Bangladesh.

Energy activities in the coal, oil and natural gas areas are conducted under the Conventional Energy Technical Assistance Project.

### 4. Renewable and Household Energy Resources

Biomass, in the form of wood, charcoal and animal dung, is the dominant rural energy source in most LDCs. Special attention is being given to using coal and agricultural residue briquettes as

a household fuel substitute. This allows unexploited resources and materials often considered waste to become valuable substitutes for scarce fuelwood and imported kerosene and diesel oil.

Most AID countries have agricultural residues and many have unexploited coal deposits. AID's Office of Energy has identified 20 AID countries where briquettes from these materials are a viable option. One of these is Haiti, where a suitable coal resource for smokeless briquette manufacture has been located. Other countries with such prospects include Pakistan, Sudan, Madagascar, Niger, Botswana, Zambia, Indonesia, Peru, Morocco and India, either for coal or biomass briquettes or composite briquettes. As a result of this wide interest, an international network on biomass stoves is being developed to coordinate work supported by various donors and carried out in many developing countries. AID and the Netherlands Ministry of Development Cooperation have taken the lead in organizing this effort.

A special biomass source is "energy cane," which is sugar cane grown to use both fiber and juice for electric power and sugar. Thirty or more LDCs have resources to take advantage of this energy source. Alternatively, fuel alcohol production is possible. The cost-effectiveness of this approach is illustrated by a study in Jamaica (supported jointly by the Office of Energy, the AID mission and the U.S. Trade and Development Program) for using cane to generate power. If results are favorable, this AID investment may leverage a possible initial investment of \$50 million of private capital, eventually resulting in larger investments and potential savings of \$186 million each year in avoided oil costs.

Sugar cane bagasse and trash are one of the most abundant unused fuel sources in many developing countries. (Bagasse is the plant residue left after juice is extracted.) Potential energy contributions from this waste material include heat, electrical production by cogeneration, and fuel alcohol. Calculations show that the potential recovered energy from sugar cane wastes in developing countries worldwide equals 8 to 10 electric generating plants of 400 to 500 MW each. For example, in Jamaica, 100,000 acres of sugar cane are sufficient to support a 400 MW power plant from bagasse alone, and additional output is possible if field trash also is used. To this can be added the production potential for fuel alcohol, estimated at 463 million gallons worldwide with a value of more than \$500 million.

An additional benefit from this innovative program will be much-needed diversification and revitalization of the sugar cane industry in various AID countries.

Another important renewable energy source is hydropower. A representative project in Madagascar includes an S&T/EY pre-investment study, which would be leveraged into an investment of about

\$5 million by the World Bank and the AID Mission in Madagascar. Electricity from the plant will power such agro-industries as rice milling, sisal production, cotton processing and coffee production. A similar approach in Zaire may parlay a modest AID feasibility study into a \$40 to \$50 million loan for agricultural processing applications.

Rice is a major crop in many AID-assisted countries. Yet today rice husks are both an unused potential fuel and an environmental nuisance. Recent developments in the U.S. hold promise for beneficial use of this resource. In Louisiana a 10 MW steam power plant fueled with 250 tons of rice husks per day has been developed. AID's Office of Energy is investigating how this technology can be applied in rice-growing countries to increase energy supplies and rural incomes. Once the technical problems of using abrasive and difficult-to-burn rice hulls are worked out, the potential for using other crop residues as energy sources is encouraging: coconut shells, cotton ginning waste, peanut and other nut hulls, fruit pits, and various fibers.

Two projects in the Office of Energy's portfolio fund the renewable energy activities, the Bioenergy Systems and Technology Project, and the Renewable Energy Applications and Training Project. FY 86 funding for these projects is \$800,000 and \$500,000, respectively.

AID-assisted countries will require staggering amounts of capital, more than \$25 billion in foreign exchange annually, to provide power for rural development and for increases in agricultural and industrial productivity. This level of capital investment will be difficult if not impossible for LDC governments to raise. Consequently, the Office of Energy has been working with AID Missions, LDC governments, the U.S. private sector and the multilateral development banks to stimulate investments in small-scale electric power systems using indigenous resources. Such systems would: allow for private ownership, thus reducing governmental capital investments; diversify the energy resource base; and provide electricity for rural industries and agriculture. Policy revisions permitting private ownership and sales of electricity in selected LDCs are being studied, as well as improved technological concepts for cost-effective power generation in the 1 to 30 MW range.

##### 5. Conservation: Early Energy Savings

Conservation offers the cheapest and quickest way to begin meeting energy demand. Conservation opportunities have attracted the attention of AID-assisted countries and AID Missions. AID Missions have jointly funded activities with the Office of Energy's conservation program. Missions in Sri Lanka, Dominican Republic, Pakistan and Costa Rica joined in the initial effort. Future participation is expected from Egypt, Haiti and other AID Missions.

Other countries examining their conservation potential include Thailand and Indonesia. The Office of Energy has identified 33 AID-assisted countries that have attractive conservation opportunities.

Energy audits demonstrate that savings of 10% to 15% in commercial, industrial and electrical generating facilities are possible with such low-cost remedial measures as combustion controls, better insulation and improved operation and maintenance practices. Further savings are possible at increased capital costs by measures such as waste heat recuperators, turbine replacements and cogeneration modifications.

Effective conservation programs require a favorable institutional and policy setting. Recognizing this, the Office of Energy assists LDCs in building in-country expertise and training personnel in energy management. Policy issues include areas such as the elimination of price subsidies that discourage wise use of energy resources. Pakistan is a good example; a national energy conservation center has been strengthened by using a computerized analytical model and energy data base to improve decision-making in the energy sector. AID considers this a prototype for other developing countries.

S&T/EY's Energy Development and Conservation Program (EPDAC) has two major components, conservation and planning. The Conservation budget for FY 86 is \$1 million out of a total EPDAC budget of \$1.8 million.

#### 6. Training a Key Tool

Recognizing the importance of training in energy development, S&T/EY has organized a systematic training program for LDC energy personnel on behalf of AID Missions. The Conventional Energy Training Program sponsors approximately 250 participants each year in academic or short-term training programs that provide exposure to U.S. technologies and practices. Graduate level training in science and engineering with an energy emphasis has been provided. Other short term programs consist of a variety of short courses and on-the-job training. Selected candidates are placed as interns with such companies as Southern California Edison and Pacific Gas & Electric, as well as other U.S. oil, mining and energy-related companies. The S&T/EY funding contribution in FY 86 totals \$1.6 million.

Training is an important element of institutional development. Special efforts in Sri Lanka and Ecuador have trained energy management experts, auditors and engineers. In Sri Lanka alone, 10 facilities have been analyzed for energy efficiency, including both private and public industrial operations such as breweries, textiles plants, tire factories, paper mills, sugar refineries and hotels. An encouraging note is the emergence of an interna-

tional network of energy managers, starting with the voluntary formation of the Sri Lanka Energy Management Association (SLEMA).

In Central American countries, AID missions, with Office of Energy assistance, have trained 66 participants in fossil-fuel resources, 25 in energy management and 40 in renewable energy technologies. In Costa Rica, a program to train bus and taxi drivers in energy efficiency already has resulted in a 20% fuel saving.

#### 7. Agricultural Development Demands Energy

Increased energy supplies and more efficient utilization are essential for agricultural development. In Sudan, for example, disrupted supplies of electricity and petroleum during 1984 resulted in a loss of 130 million Sudanese pounds (U.S. \$100 million) in agricultural output when critical irrigation and tillage operations could not be carried out. Somali farmers recently lost half of their crops when irrigation stopped because of the lack of diesel fuel for pumps.

These examples illustrate the importance of energy supplies to maintain and expand agricultural productivity. The United Nations Food and Agricultural Organization (FAO) has found that each 1% increase in agricultural production requires a 2% increase in commercial energy availability. The energy is required for irrigation, mechanization, transportation and post-harvest processing.

Agriculture is a primary focus for AID's overall development assistance strategy. The availability of water, which often requires pumping, is a crucial part of agricultural development. The Office of Energy is collaborating with other AID offices to evaluate the applicability of a range of power systems for use in irrigation and water supply and to examine the energy constraints to irrigation programs. For example, S&T/EY is working with the Africa and Asia/Near East Bureaus to help determine the best approach for irrigation projects in those regions.

In the past, selection and application of pumps and power systems in many LDC countries has occurred with inadequate technical and economic information. This lack of data on field performance, operation, repair and servicing costs has frequently resulted in improper selection of pumping systems and inappropriate applications. Several assessments are underway in Mali, Niger, and Somalia to make preliminary recommendations for measuring and comparing the technical and economic performance of various pumping options. Results of the Botswana Comparative Pumping Assessment will be used to develop a standard methodology to evaluate various power and pumping systems.

In addition, the Office of Energy is collaborating with the S&T Office of Agriculture to examine energy constraints on pumping in case studies of rehabilitation and locally managed irrigation

schemes in Africa. Potential case studies will include systems in Senegal, Niger, Kenya and Zimbabwe. S&T/EY also is looking at the implications for agriculture of energy system expansion such as river basin development and rural electrification. Assistance to missions in India and Pakistan is planned for groundwater assessments to identify options for expanded pumping to be used in conjunction with surface irrigation.

AID's Office of Energy has only modest budget resources to help alleviate large energy imbalances in the agricultural sector. Yet these funds can leverage investments from other donors and the private sector. As in other AID energy initiatives, this may best be accomplished by sponsoring a series of model programs or pilot projects in selected countries. The objectives of pilot projects in the energy-for-agriculture area include: a better understanding of the appropriate technology and energy requirements to meet irrigation needs; assisting missions and host countries in strengthening training capabilities relative to selection, equipment testing, and operation and maintenance of pump systems; and examining the linkage between agricultural expansion and energy requirements. The Energy for Agriculture activity is now included in the Renewable Energy Applications and Training program.

## 8. Conclusion

Energy is a driving force for development. Countries require increasing supplies of energy to support their expanding economies. Without sufficient energy, development lags. The energy constraints faced by most developing countries are severe. These countries share the common problem of inadequate energy supplies to fuel economic growth, and to cook food. These energy requirements result in unmanageable claims on foreign exchange to import oil, and in environmental degradation from an over-exploitation of fuelwood resources.

AID's Office of Energy promotes development of the most cost-effective energy supplies necessary for sustained economic growth. Its program offers technical assistance for analysis, planning, and policy development; help to develop indigenous energy supplies; training and institution building; research and technology transfer; and encouragement of private sector investment from domestic and foreign sources. These activities play an important role in integrating energy requirements with program objectives in other sectors.

Resources of AID's Office of Energy are modest. It often acts as a catalyst or broker working with host governments, AID missions, lending institutions, other donors, and public and private institutions to expedite the development of viable energy projects. By sponsoring reconnaissance and feasibility studies, AID programs facilitate the implementation of capital projects by financial

institutions and the private sector. Both AID's direct assistance activities and those which work in concert with other development interests continue to help AID fulfill its mandate to mitigate the energy crisis that is so much a part of life in the developing world.

APPENDIX I

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