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AGENCY FOR INTERNATIONAL DEVELOPMENT
Washington, D.C. 20523

PROJECT PAPER

THAILAND - RENEWABLE NONCONVENTIONAL ENERGY

USAID/Thailand

July 1979

Thailand

Renewable Nonconventional Energy

Project Paper

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ABBREVIATIONS

AID/W	-	Agency for International Development, Washington, D.C.
AIT	-	Asian Institute of Technology, Bangkok
ASRCT	-	Applied Scientific Research Corporation of Thailand
BOB	-	Bureau of the Budget
CDD	-	Community Development Department, Ministry of Interior
CSC	-	Civil Service Commission
CU	-	Chulalongkorn University
DMR	-	Department of Mineral Resources
DOA	-	Department of Agriculture, MOAC
DOE	-	U.S. Department of Energy
DTEC	-	Department of Technical and Economic Cooperation
EGAT	-	Electricity Generating Authority of Thailand
EMP	-	Energy Master Plan
KMIT	-	King Mongkut's Institute of Technology
MOAC	-	Ministry of Agriculture and Cooperatives
MSTE	-	Ministry of Science, Technology and Energy
NEA	-	National Energy Administration
NEIDCT	-	National Energy Information and Documentation Center for Thailand

NESDB	-	National Economic and Social Development Board
NSO	-	National Statistical Office
PEA	-	Provincial Electricity Authority
PID	-	Project Identification Document
REC	-	Regional Energy Center
RERIC	-	Renewable Energy Resources Information Center
RFD	-	Royal Forest Department
RTG	-	Royal Thai Government
USAID	-	US AID Mission, Thailand

Currency Equivalents

U.S. $	1.00	=	Baht (฿)	20.00
Baht (฿)	1.00	=	U.S.	0.05

Area Equivalents

1 rai	=	0.16 hectare (40 x 40 meters)
1 hectare (ha.)	=	6.25 rai

AGENCY FOR INTERNATIONAL DEVELOPMENT

PROJECT PAPER FACESHEET

1. TRANSACTION CODE: C (A = ADD, C = CHANGE, D = DELETE)

PP

2. DOCUMENT CODE: 3

3. COUNTRY/ENTITY: THAILAND

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7. PROJECT TITLE (Maximum 40 characters): RENEWABLE NONCONVENTIONAL ENERGY

8. ESTIMATED FY OF PROJECT COMPLETION: FY 84

9. ESTIMATED DATE OF OBLIGATION: A. INITIAL FY 79; B. QUARTER 4 (Enter 1, 2, 3, or 4); C. FINAL FY 79

10. ESTIMATED COSTS ($000 OR EQUIVALENT $1 –)

A. FUNDING SOURCE	FIRST FY B. FX	C. L/C	D. TOTAL	LIFE OF PROJECT E. FX	F. L/C	G. TOTAL
AID APPROPRIATED TOTAL				4,000	1,000	5,000
(GRANT)	( )	( )	( )	(4,000)	(1,000)	(5,000)
(LOAN)	( )	( )	( )	( )	( )	( )
OTHER U.S. 1.						
OTHER U.S. 2.						
HOST COUNTRY		20	20	54	3,096	3,150
OTHER DONOR(S)				1,010		1,010
TOTALS		20	20	5,064	4,096	9,160

11. PROPOSED BUDGET APPROPRIATED FUNDS ($000)

A. APPROPRIATION	B. PRIMARY PURPOSE CODE	PRIMARY TECH. CODE C. GRANT	D. LOAN	E. 1ST FY 79 F. GRANT	G. LOAN	H. 2ND FY ___ I. GRANT	J. LOAN	K. 3RD FY ___ L. GRANT	M. LOAN
(1) FN	200	090		5,000					
(2)									
(3)									
(4)									
			TOTALS	5,000					

A. APPROPRIATION	N. 4TH FY ___ O. GRANT	P. LOAN	Q. 5TH FY ___ R. GRANT	S. LOAN	LIFE OF PROJECT T. GRANT	U. LOAN
(1)					5,000	
(2)						
(3)						
(4)						
TOTALS					5,000	

12. IN-DEPTH EVALUATION SCHEDULED: MM 07 YY 82

13. DATA CHANGE INDICATOR. WERE CHANGES MADE IN THE PID FACESHEET DATA, BLOCKS 12, 13, 14, OR 15 OR IN PRP FACESHEET DATA, BLOCK 12? IF YES, ATTACH CHANGED PID FACESHEET. 1 (1 = NO, 2 = YES)

14. ORIGINATING OFFICE CLEARANCE

SIGNATURE: Donald D. Cohen

TITLE: Director USAID/Thailand

DATE SIGNED: MM 7 DD 37 YY 9

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AID 1330-4 (3-78)

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THAILAND

RENEWABLE NONCONVENTIONAL ENERGY

PROJECT PAPER

I. Summary and Recommendations

A. Costs

The project total costs are as follows:

AID Grant	-	$5,000,000
UNDP	-	710,000
ADB	-	300,000
RTG Budget*	-	3,149,900
Total	-	9,159,900

*(In US$ equivalent at US$1 = ฿20)

B. Purpose

The project will assist the RTG work toward reducing imported energy resources, arresting environmental degradation due to deforestation, and creating increased income opportunities in rural areas. This will be carried out through:

- developing RTG institutional capacity to perform and sustain energy policy planning.

- introducing and testing renewable energy technologies in rural areas, and

- developing and testing techniques for disseminating such technologies.

C. Description

The project has two reinforcing components: an institutional development emphasis; and the testing, adaptation and dissemination of renewable energy technologies relating to rural needs.

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D. Analyses

The analyses in the project paper conclude that the project is technically, financially and socially feasible and that planning is sufficiently developed for implementation to begin.

E. Implementation

The RTG acting through DTEC will be the Grantee. NEA, however, will be the primary managing and implementing agency with participation of other RTG agencies and organizations as appropriate.

F. Waivers

Although most foreign exchange costs will be expended in the US, the US may not in all cases be the appropriate source for a given technology. Accordingly, Code 935 waivers will be justified and issued on a case-by-case basis by the USAID Dirtor. Similarly, and particularly to encourage the development of a continuing capability to support the technologies, it is proposed that up to $500,000 may be expended in Code 941 countries.

G. Statutory Requirements

These have been met. See Annex II.

H. Issues

None.

I. Recommendations

That the project paper be approved. Further, that in view of the experimental character of the project, the large portion of technical assistance (est. $2.8 million) and the substantial RTG contribution, it is recommended that AID assistance be authorized under grant funding to the RTG.

Note: The project reflects an RTG initiative with USAID. The work of project development, however, was provided main assistance by an AID-funded team from META Systems, Inc. Much of the substance of this project paper, including annexes, includes or reflects material developed by the META team. Further specific attribution is not hereafter made.

II. Project Background and Description

A. Background

Energy is a key element in any effective rural development strategy, and this is specifically acknowledged in the Country Development Strategy Statement (CDSS):

"As modern agricultural techniques become more widely adopted, rural Thailand will exert increasing demand for energy in the form of fertilizer, irrigation pumping, traction, crop processing, transportation to market, etc. Much of this demand will be based on petroleum as the energy source unless positive steps are taken to introduce alternatives. Substantial investment in a national rural electric system, which is a major objective of the RTG, will create a future reliance on increasingly expensive petroleum imports.

The energy demand for agricultural production purposes will be additive to the needs of rural areas for cooking, lighting and other amenities. The demand for wood and charcoal for cooking in particular is already seriously affecting forest areas and could threaten the ecological system on which Thailand's rural development is based if problems of sustained usage of these renewable resources are not promptly addressed.

AID proposes assisting the RTG to reduce its dependency on imported energy sources by developing and introducing alternative energy resources ...." (p.45)

This Renewable Nonconventional Energy Project is product of that Mission purpose. Formulating a program, however, to deal with renewable energy opportunities must reflect the following impacts and data difficulties:

1. Impacts of Rural Energy Use Patterns

- Rural people have little perception of the urban, industrial "energy crisis"; the rural crisis is one of development. Energy responses, therefore, must address the alternatives in terms of the immediate and tangible development benefits for rural people.

- The village poor and landless are the hardest hit. They have less access to wood fuels, residue and energy for agricultural inputs. Any program with equity as well as development objectives must act to improve this access.

- There are large inefficiencies in current rural energy use, e.g., human effort in fuel gathering, low end-use efficiency in stoves, etc., and too little energy used in agriculture and craft work. Increased productivity can be achieved by the use of more energy.

- The environmental implications of current rural energy use are substantial, particularly soil depletion from deforestation and non-return of nutrients.

2. Data Difficulties

- There is a lack of reliable data to estimate crop and animal residues.

- There are inadequate forestry statistics for fuel wood.

- There are problems in existing consumption studies. Frequently these do not use actual measurement but rely on user estimates.

- There is a lack of information on residue to production relationships.

- There are few measurements of heat value, of moisture content of residues, dung, or different wood fuels, or of efficiency of end-use devices (stoves, kilns, etc.).

- There are inadequate data on availability of fuel source to the user.

- There is insufficient information on the resource balances involving fodder, fuel, construction material, fertilizer, and their competition for residues.

This project has been designed to reflect the complexities of rural energy use, to overcome some of the data difficulties, and to develop increased institutional capability for meeting the energy requirements for development.

See also the discussions at Annexes III and IV respectively for the Thai macro energy use picture and a village energy profile. The macro discussion is clear in the conclusion that the bulk of Thai energy use is both rural and potentially from renewable energy sources. Similarly, the village profile identifies the resource depletion implications of current energy use in a Northeast village, and reviews potential alternative applications to meet the requirement from renewable resources. Both the macro and village discussions are clear that the current rural energy use is a major cause of resource depletion. But both also support the technological feasibility for development of the renewable energy alternatives which are the subject of this project.

B. Description

The project has two complementary and reinforcing themes. First, and the longer item in its implications, is an institutional development component. This is designed to provide the basis for development and implementation of a continuing rural energy policy for Thailand. The second component involves carrying out a series of tests and adaptations of renewable energy technologies related to rural energy needs. This rural-oriented energy technologies component will be carried on at the same time as the work of institutional and data base development goes forward. Accordingly, at the end of the project there should coincide a tested selection of rural renewable energy applications and the data and institutional base to implement them in the framework of a broader RTG energy policy.

III. Detailed Description and Analysis

A. Institutional Development

This component incorporates support for four distinct but related activities: (1) assistance in establishing the National Energy Information and Documentation Center and six Regional Energy Centers, (2) assessment of renewable and non-renewable resources, (3) support of RTG capacity for monitoring of technological changes in rural energy, and (4) village and rural energy data collection, development of energy conservation guidelines, and staff support and training, each in context of the Thai Energy Master Plan (EMP) Study.

1. National Energy Information and Documentation Center and Regional Energy Centers

The National Energy Information and Documentation Center, Thailand (NEIDCT) will be established as a centralized source of energy information in support of RTG energy policy and planning. Similarly, the six Regional Energy Centers (RECs) will provide an area focus for energy data collection, project implementation and information dissemination. The functions of the NEIDCT and RECs, as well as the plan for development and staffing of these centers, are set forth in detail at Annex V.

Briefly, the NEIDCT will be established over the five years of this project with a total staff of approximately 12 persons. Space will be required adequate to house 3-5,000 books, up to 200 journals, reading areas, storage for statistical records, and facilities for a computer terminal. The six RECs will be on a correspondingly smaller scale, with an expected staff for each of six to seven persons, a small reference library, vehicles or other transport and housing for staff. The first two RECs should be established by the end of the second project year, with all six in place by the end of the fourth year.

Both the NEIDCT and the RECs will be part of the NEA. The NEIDCT, however, will perform a main role as a center for information for all RTG agencies - and the private sector - concerned with energy questions. The RECs will incorporate more an extension capacity on the part of NEA, providing NEA with the facility to carry out area data collection, disseminate information locally, monitor energy activities, and implement such activities directly through the RECs themselves.

REC extension workers will be assisted in their activities by other, existing NEA field workers, local universities, CD workers and US Peace Corps volunteers, as well as other public and private community workers. As technologies are proven in demonstration villages, such agents will be given

short course training by NEA to enable them to assist in wider disseminatio of the technologies.

2. Assessment of Renewable and Non-Renewable Resources

The resources assessment and analysis activity will provide assistance in evaluating the potential for solar, biomass, and micro-hydro energy. Although data on these renewable resources have been collected for years, only recently has there been significant interest in their use. In consequence, a great deal of existing information requires organization and analysis, in addition to the collection of new data. As a necessary corollary to this renewable energy emphasis, an assessment will also be carried out of the Thai reserves of lignite, tar sands and oil shale, and of geothermal energy potential. The two assessments are necessary to form the whole as a basis for development and implementation of RTG energy policy. The assessments themselves provide this resource, but equally important the activity will provide the vehicle for development of a capacity in NEA to carry out such assessments on a continuing basis. The two assessments will be conducted in close coordination with the activity to be carried out in support of the EMP, and much of the data collected will also provide material for the specific resource applications in the rural oriented technologies component of this project. Annex VI sets forth a detailed discussion of the resources assessment and analysis activity, which is briefly outlined below.

a. Solar

Solar energy is probably the most rapidly developing technology field in the world. Actual solar technologies cover a broad spectrum from low-cost village-built dryers to sophisticated high-technology power towers for electricity generation. Each may have an energy place in Thailand but determining this first requires analysis of the patterns of solar insolation and of the potential needs and uses.

In the United States today, the two most widely applied solar technologies are domestic water heating, which is of limited relevance to Thailand, and solar architecture, which is of great importance for Thailand given the increasing magnitude of the air-conditioning load. Traditional Thai architecture, like traditional architecture the world over, is well-united to local climatic (solar) conditions. On the other hand, the present extensive Thai construction of international architecture type buildings requires massive energy inputs, and can only be feasible in an era of cheap oil.

Understanding of (solar) micro-climates in Thailand is therefore necessary for better building design. It is also relevant to a range of other technologies that have differing roles to play in Thailand's energy future. Examples are water lifting, medium and high-temperature industrial water use, refrigeration, and electricity generation. There are accordingly a series of design decisions to be made regarding use of solar energy that depend on better knowledge of the direct and diffuse components of solar radiation in Thailand.

This work will continue data collection and analysis to support already existing solar groups at Chulalongkorn University and King Mongkut's Institute of Technology. In addition to the relevance of solar energy for building design, the focus will be on assessment of the solar energy role in development of agriculture and small industry in rural Thailand.

b. Biomass

The potential for utilizing biomass based energy alternatives can only be fully assessed on the basis of better information about potential sources - firewood, crop residues and animal dung. This information must have national and regional statistical characterization; but also village specific characteristics are required for these sources.

The effort will begin with review of existing information including district and, where available, village agricultural production and animal population data. It will also review forest land use and land capability information. If current air photo-mosaics exist for selected village areas, necessary complementary ground fieldwork will be undertaken to allow better inference from crown cover and other data.

Dependent on the review of existing information, alternative fieldwork programs may be undertaken, but the target will be to develop adequate information for the following classes of information:

(1) Production Estimates - Macro and micro estimates of industrial and fuel wood production; estimates of production of primary agricultural products and concomitant agricultural residues.

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(2) Residue Relations - Estimates of variations of residue with crop species (e.g., HYV, floating or traditional rice), production/processing (mode of rice milling); timber processing (generation of sawdust, use of bark, branches, etc.).

(3) Energy Content - Estimates of the heating values of residues, both laboratory-dry and at various moisture contents representative of typical use situations, for all major crop residues, forest species and industrial wood byproducts, charcoal and animal dungs.

(4) Availability of Source/Residue - Estimates of actual availability of source/residue to potential users.

(5) Efficiency of Fuel Use - Measurement of conversion efficiencies for typical stoves, braziers and other end-use devices, e.g., kilns.

c. Micro-Hydro

This activity will review and draw together - both for the North and other areas - collected data on micro-hydro potential. This will include use of the NEA gauging station data as well as other relevant material. The review will provide the basis for field data collection and site inspections. Both the information assembled and the analysis will be channeled into the total data available to NEA, to be applied both for broader planning purposes and in support of the specific micro-hydro activity in the rural oriented technologies component of the project.

d. Lignite, Tar Sands, Oil Shale, Geothermal

In an effort to alleviate dependence on imported fuel, Thailand is continuing to explore, assess, and exploit its indigenous non-renewable energy resources. This activity is aimed at providing assistance in assessing and evaluating data on four sources which are already in various stages of development lignite, tar sands, oil shale and geothermal. No assistance with actual exploration is involved.

Lignite is currently being exploited in two regions, the North and South. The known deposits are of low to medium quality with low to medium heat values, high moisture content, and considerable ash and sulphur. Primary use

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(75 percent in 1977) is for electric power generation. The remainder is largely used in the tobacco curing, lime, food, and rubber industries. Exploration for lignite has yet to cover many areas and assessment of known areas is incomplete. Some work has been done by EGAT, DMR, the Defense Energy Department and Chiangmai University on tar sands which is primarily of long-term interest, but both oil shale and geothermal resources have had some investigation. Preliminary estimates of oil shale in the North are about 2500 million tons. A three year geologic program has been completed and a program of drilling and analysis is continuing, but only a portion of the samples have been analyzed.

Preliminary work indicates the location of a number (over 40) of hot springs with temperatures from 40-100°c in Thailand. Some exploration work was carried out with technical assistance from the Government of New Zealand in 10 selected areas; additional work is to be done by Thai geologists. * Initial investigation suggests that the geothermal sources may not warrant development for power generation but could possibly be viable for use in such applications as tobacco curing. It is more likely, however, that geothermal heat will be unable to compete with the use of lignite or direct solar (as that becomes available as a known technology).

3. Energy Technologies Monitoring

The energy technologies monitoring activity is designed to assist the RTG develop the capacity to keep abreast of developments in the use of non-conventional energy resources. It is expected that the emphasis on technologies will change over the course of the project as Thai needs are further identified and as technology development proceeds. Activities at the outset, however, are expected to encompass the following technology categories:

- Solar thermal electric technologies. EGAT, Chulalongkorn University, and the King Mongkut's Institute of Technology are embarked on solar electric R&D programs. Cooperation with work going on in other countries can help prevent duplication while fostering development of solar collector technology that employs Thai materials and ingenuity. Closely connected with this work will be monitoring of advances in collector design and fabrication

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* NEA, EGAT, DMR, and Chiangmai University.

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with a view toward industrial use of medium and high temperature heat. Related also will be monitoring of advances in solar refrigeration and solar thermal water pumping.

- Biomass conversion technologies.
  Support elsewhere in this project is given to demonstration of technologies that can be cost-effectively justified for use in rural Thailand today, but other biomass conversion technologies are worth monitoring with a view toward development of later pilot schemes: e.g., advanced pyrolysis, gasification, biomass direct-fire generation, thermochemical production of methanol, fermentation production of ethanol, fermentation production of ethanol, fuel cells, and plant crops as hydrocarbon sources.

- Oil shale uses and applications.
  Although exploitation remains speculative because of the unknown extent of the resource, the economics of exploitation, and the importance of the environmental effects of oil shale development, keeping abreast of the technology is important. Reevaluation of priority will follow the assessment of resource availability (see above).

- Photovoltaics.
  Costs of solar cells are thought to be nearing economic break-even points for many applications. Because the next five years are likely to see solar cells widely used, it is important that Thailand keep abreast of utilization and manufacturing technologies. Photovoltaic technology is likely to increase in priority over the course of the project.

- Windpower.
  It is conceivable that substantial electrical power could come from offshore wind machines in the Gulf of Thailand. Alternatively, fertilizer (nitrogen) could be produced by offshore wind machines. Given this extraordinary energy potential, coupled with more

limited possibilities for small scale wind electric generation in selected rural areas, Thai scientists and engineers will be supported in their effort to keep abreast of the latest developments of this technology. This will complement an ongoing EGAT wind energy project with the Prince of Songkla University and King Mongkut's Institute of Technology.

4. Support of the EMP

An "Energy Master Plan Study" (EMP) project, sponsored by the UNDP and executed by the ADB is scheduled to start later this year (1979) and be completed in 18 months. While the Study addresses renewable resources and the supply and consumption of energy in the rural areas, it is comprehensive in scope and the emphasis is necessarily on the formal or commercial fuels sector. AID assistance in support of the EMP therefore essentially supplements for the renewable energy area, the data to be developed and assistance provided under the EMP Study. Annex VII attaches the terms of reference for the Study and sets forth in detail the activities under this heading. These are briefly outlined as follows:

a. Pre-feasibility/Feasibility of Renewable Energy Alternatives

There are a number of possible renewable energy based alternatives which are not part of the EMP or of the resources assessments of this project, but which could warrant preliminary analysis and, if positive, further investigation. These include the following: offshore wind electric, alcohol from biomass, and direct fire or pyrolysis of biomass for power generation. Other renewable energy alternatives may also be worth preliminary investigation. If any of these appear economically and technically attractive, they would be subject to further analysis such that their costs and performance characteristics could be defined to at least the prefeasibility level or better.

b. Rural Energy Survey

The importance of defining the characteristics of rural energy consumption is discussed at Annex III. As mentioned earlier, current estimates are quite uncertain, the last extensive survey having been done a decade ago. NEA will undertake a major survey with follow-up investigations, as well as detailed studies of particular villages (see c. below).

The survey will address in particular the distinction in patterns of energy use between domestic and industry/ processing activities in rural areas. The EMP Study is to provide technical assistance to NEA in the design and conduct of sample surveys, and this activity will supplement that assistance.

c. Detailed Village Resource Studies

The discussion in Annex IV indicates that village energy systems are complex, many of the potential energy sources such as crop residues have alternative uses, there is seasonality of energy demand and supply, the dimensions/ constraints of animal and human labor are unclear, etc. In order to comprehend existing patterns of resource utilization and energy requirements sufficiently to design energy related intervention programs, detailed micro studies are required. These studies will be aimed at preparing the baseline physical, social and economic information for development of rural energy strategies. A topology of villages will be developed and studies undertaken in representative villages with the view to defining village profiles.

d. Feasibility of Village Energy Systems

This will be an analogy at the micro scale of the comprehensive analysis at the macro scale being undertaken in the EMP. The effort will examine the opportunities for different energy technologies to meet the current and projected future energy requirements of specific villages. The result of the analysis will be energy technology plans for specific villages, with representative plans developed for classes of village types.

e. Staff Support

The activity will ensure that data as it is developed under the components of this project are available to the EMP Study and conversely. The point is one of coordination.

f. Training

The longer term utility of the EMP will depend on the informed responsiveness with which it is adjusted to changing conditions and data. Toward this purpose two types of training will be included under this activity: (1) long-term academic training in selected energy problems of relevance

to Thailand and (2) seminars, workshops and special courses directed to energy policy, planning and management needs.

g. Energy Conservation

Energy conservation represents both in the immediate and long term the most obvious and available mechanism for efficient Thai use of energy, both renewable and non-renewable. The rural-oriented technologies component of this project will include a specific working conservation activity directed to small industry. Under this activity, however, NEA will address the macro implications and requirements of a comprehensive conservation policy addressing all sectors, but with a specific focus on renewable resources and measures to reduce non-renewable resources depletion. The NEA will carry out a survey of conservation methods and technologies, review these against the technical data being developed through the EMP, establish parameters for a conservation data base and reach planning and policy recommendations for a general Thai energy conservation program.

B. Rural Oriented Technologies

This core component of the project is designed to accelerate the use of proven cost-effective energy technologies in rural areas. The objective is to test and adapt such technologies, and develop and test techniques for disseminating them, while the work of institutional development under Part A above goes forward. The end of project should see a coinciding of developed institutional capability and data, with the availability of tested rural energy applications. Together, these should provide the threshold conditions for addressing a whole front of Thai rural energy uses.

Technologies have been identified for inclusion in this rural demonstration component according to responsiveness to certain criteria, i.e., the technology: (1) meets a development need of the poor, (2) has a positive environmental impact, (3) is low-cost and can be fabricated and maintained with local materials and skills, (4) has the potential for wide-spread, large impact, (5) is affordable and theoretically controllable by individuals or by small groups of poor peasants and the landless, (6) has the flexibility to adapt to differing conditions within Thailand and to changing conditions over time, and (7) is cost-effective now or is expected to be so by the end of the life of this project. To the extent that a few technologies have been included in the project without meeting all the above criteria, it was because they compensate

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by singular advantages against other criteria. Except for village woodlots which will largely be the responsibility of the RFD, the approach to technology dissemination will make the six RECs the eventual focus of design selection, village monitoring,demonstration, training and extension efforts. As mentioned above, two of these will be established by the end of the second project year, with two in place in each of the succeeding two years. The activities, therefore, will not wait for REC establishment but will proceed at the outset in selected pioneer villages. Implementation and monitoring will then be taken on by the RECs as they are established. Each of the technologies has a regional emphasis; for example, biogas in the Northeast, micro-hydro in the North, and water lifting in the Central area.

The project will not be research oriented, but will foster selection and adaptation of existing energy device designs. After selection of promising designs, pre-selected villages will test the devices under purchase, operation, and maintenance arrangements specified for each type of technology. Monitoring of experience, conducted in such a way as to be able to modify design, materials, or fabrication details to make them more suitable for local conditions, will be conducted over a period of two to three years in the case of most technologies. Once a design has proven itself in village use, training of villagers, RTG field officers, entrepreneurs, and voluntary organization village workers will proceed under REC auspices, and with technical assistance as appropriate.

Five rural-oriented energy technologies have been identified as being of particular significance for rural development in Thailand: biomass conversion; small-scale (micro) hydropower; solar drying and distillation, solar process heat; water lifting; and village woodlots. Within each of these categories specific technology demonstration programs will work with those technologies best meeting the above criteria. Annexes VIII - XII describe in detail the program proposed for each technology.

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[1] The various devices to be tested will be purchased and manufactured locally. They will be designed (or designs selected)on the basis of suitability for later quantity production and marketing by Thai industry. Although the testing and introduction phases under this project may involve subsidizing the costs to farmers and villagers of the new devices, continuation of subsidies is not intended. Full commercialization will be encouraged as demonstrations succeed and demand builds for the new devices.

1. Biomass Conversion

This activity will emphasize use of Thailand's abundant biomass resources for small scale energy needs. The most cost-effective energy conversion

innovations will be [illegible] through more efficient utiliz[illegible]on of existing resources and (2) through the development of new energy sources such as currently wasted agricultural residues. This biomass conversion activity has six components. (See detailed discussion at Annex VIII.)

a. Improved Stoves

Since cooking represents about 80 percent of the total energy consumed in rural areas, a program to improve stove efficiency would be especially attractive. Open wood fires are typically five to 10 percent efficient; wood stoves may be 25-30 percent efficient. In any stove development program local cooking practices must be carefully studied to design appropriate and efficient stoves. Charcoal stoves also represent a major area for improvement because they are currently only 15 to 20 percent efficient but widely used in the rural and urban areas.

Such a stove development program would be applicable to all of Thailand, rural and urban, and could have a more immediate impact on the fuel wood situation than any other project conceived. The development and introduction of more efficient stoves can be accomplished in a matter of years - not decades. Such a program, therefore, will provide short-term energy relief that will be complementary to other renewable resource programs.

b. Biogas

Sixty-two percent of the water buffalo and 44 percent of the cattle in Thailand are located in the Northeast. Accordingly, of all the alternate energy schemes considered for that region, there should be particularly good potential in the production and use of biogas from abundant and under-utilized animal wastes (see discussion at Annex IV of village resources). Also, successful biogas plants have already demonstrated the process locally, and there appear to be few cultural restraints to its use. Because there are significant technical improvements in biogas production that have recently been developed, especially in the storage of biogas and avoidance of corrosion problems, any biogas program should take advantage of these new developments. Moreover, the potential of community digesters should be investigated. Because cost is of major interest, new design concepts will be evaluated for selection of appropriate, low-cost designs.

c. Improved Charcoal Production

Charcoal is utilized in both rural and urban Thailand and touches the lives of more Thais than any other fuel. A program to improve the conversion efficiency of charcoal kilns is seen as an immediate need because present practice leaves considerable room for improvement. Further, the development of economical means for recovering logging

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residues and reforestation wastes is of special concern. Because charcoal making occurs both at a relatively small scale, using family size rice hull or earth kilns, and at a large scale applicable to logging/reforestation wastes, this activity will involve appropriate efforts applicable to these widely different activities. Such an activity could provide an expanded revenue source for rural areas and benefit the entire country in reduced charcoal costs.

d. Pyrolysis of Agricultural Residues

While the Central region is the most prosperous area, its forest areas are furthest removed; it will therefore face particular difficulties as firewood supplies dwindle. Because charcoal is widely used in this region and because charcoal can be produced by pyrolytic conversion of excess agricultural residues, especially rice husks and straw, there is significant potential for application of this technology in the Central region. Not only would pyrolytic conversion of rice hulls and straw provide a source of charcoal that could be briquetted for domestic uses or sold as an industrial fuel, but it would also produce an oil by-product that could be used as a kerosene substitute for domestic cooking or lighting. Excess oil could be sold as an industrial fuel. The pyrolysis off-gas could also be used to operate irrigation pumps or power village industry.

Currently AID and the Government of Indonesia are involved in a technology development/demonstration program involving pyrolysis of rice hulls. This Thailand activity will take advantage of that program, which should be well advanced by the time this activity is initiated.

e. Energy Conservation for Small Industry

Throughout Thailand there are numerous small industries relying on petroleum, coal or firewood. In selected industries, such as ceramics, fuel costs represent 30 percent of gross income and profit margins run only 10-15 percent. The rapid escalation of energy costs is having an adverse impact on many of these small businesses, thus there is demonstrated need for an energy conservation program applicable to these small industries. The activity would be in the nature of a technical assistance and information program, involving workshops with local industry throughout Thailand.

f. Conversion System Integration

As a longer range but potentially significant activity the integration of various bioconversion technologies will be examined for wide applicability of concepts to Thailand. This would include, for example, biogas digesters linked to fish ponds and pig production; rice bran residue from ethanol fermentation as chicken feed, chicken manure as pig feed, pig manure as biogas/fertilizer feedstock, biogas as engine fuel, and waste heat for distillation of the ethanol.

2. Micro-Hydropower

Extensive areas of the North and smaller but significant sections of the South and Central regions have the necessary conditions for hydropower: abundant rainfall transformed by underground storage into perennial flow in hill streams. Perhaps 100,000 km^2, or 20 percent of Thailand, is topographically, climatologically, and hydrologically attractive for development of small-scale hydropower. Development of the full potential of such a dispersed resource is out of the question. But, particularly where both a need for power and a micro-hydro potential exist, this renewable resource is attractive. Per the discussion at Annex IX, it is clear that micro-hydro for electricity generation is currently cost-effective with diesel for any but the lowest load factors, and it is particularly applicable for the North.

Under this activity, a pioneer micro-hydropower program will be carried out, and will involve assisting up to 10 villages to develop hydro resources for productive purposes. The turbines and most of the equipment will be manufactured in Thailand. NEA already has the basis for a turbine test laboratory and this project will provide limited equipment to enable the laboratory to do hydraulic testing of turbines. The activity will be carried out by NEA but in coordination with the Provincial Electricity Authority (PEA).

The end of the activity should see a capacity for production in Thailand of standard turbine units, but more important a technical/administrative/cost blueprint for micro-hydropower activities to facilitate such developments in an increasing number of the areas where conditions create the potential.

3. Solar Drying and Distillation, Process Heat

Average solar radiation in Thailand is reasonably high, and while the climate has a strong seasonal nature, there is comparatively little variation in the amount of available

radiation. Thus there is usually adequate radiation over most of Thailand to run solar applications effectively. At the same time, solar radiation's greatest advantage as an energy source is that it is available throughout the country, without need of a distribution system. It can be converted to usable energy directly where that energy is needed. Thus it offers a powerful potential for decentralized development.

Annex X sets forth a detailed discussion of the solar energy activity in this project, but briefly, it will have two elements. First, solar crop dryers and solar stills. These are both examples of technologies that could be completely crafted and used (and even refined) at the village level. Direct sun-drying of crops is currently the most common use of solar-energy in rural Thailand. Considerable losses, however, are estimated to occur with natural sun drying. In addition, there is a problem of drying the first rice crop during the wet season, when the grain has a high moisture content. Similarly, solar drying also represents a potential source for distillation of water for cleaner water or salt harvesting. For the latter, this technology could be particularly attractive in the coastal areas of the South, for example, where the wood fuel for charcoal is becoming increasingly more distant. For cleaner water, the health benefits are obvious.

The technologies for solar drying of foods and for solar distillation of water have already been proven. There is certainly room for further adaptation of existing designs to specific Thai needs and conditions, and since the basic technology is simple and easy to understand, the villagers themselves will be able to best adapt the designs to their particular needs. The main effort, therefore, will not be to further research the technology, but to spread an understanding of existing technology down to the village level.

Second, there is also potential in Thailand for practical industrial application of solar process heat, both air and water systems. Many industries in Thailand use hot water or air in their manufacturing process, and many of these industries are already or could be located in rural areas or rural-towns. Solar process heat, in fact, could offer some prospect of making it easier for small industries to relocate away from urban centralized fuel and power sources.

The end of project should see a developed potential for widespread application of solar drying technologies in rural Thailand. This should be coupled with at least a heightened awareness in the rural industry sector of the potential for the use of solar energy in process heat, and at least the start of an expansion of the technology.

4. Water Lifting Technologies

Much of the increase in Thailand's agricultural production over the coming decades will be from improvement of yields on rainfed land. Irrigation development, however, will remain a critical corollary component of the agricultural sector.

In many parts of the country, water is available in abundance but a meter or so below the level of the cropland. This water can be used to help to avoid the effects of delayed rains, monsoon droughts and premature drying of rice fields toward the end of the monsoon; it can expand dry season irrigation from existing rivers and streams in many parts of Thailand, and it can provide modest amounts of irrigation for Northeast Thailand. See discussion of this activity at Annex XI.

Pump irrigation does not require dams, massive land acquisition, and complete canal systems. It can benefit a single household, a group of households, a village, or even larger groups, but it does not depend on establishment of a complex organizational structure for water management.

At the present time, however, pump irrigation is held back by the following disadvantages.

(a) It consumes increasingly expensive, imported fossil fuels.

(b) It utilizes engine-pumps with relatively high maintenance costs.

(c) It is only economical at a scale (five horsepower and up; 70 rai or more) beyond the capability of the small farmer.

Three technologies will be demonstrated in this project for lifting water: wind, biogas, and solar photovoltaic. Encouragement will be given to dissemination of other technologies where appropriate: hydraulic ram, crop residue fired steam engine, animal power, and solar thermal, but emphasis will be upon the three most promising technologies. Wind, biogas and

solar photovoltaic energy in particular coincide in potential with the rural Thai renewable energy resource base. A technically and cost feasible result for any one of the three technologies will have substantial implications for rural development and basic needs requirements.

5. Village Woodlots

Estimates of the size of the present forest estate of Thailand vary considerably, but there is no disagreement that the area is being rapidly reduced. The fact that the demand for firewood continues to increase at the same time that supply is dwindling and prices rising, alone provides substantial incentive for increasing wood supplies. But there is also an increasing awareness of the environmental degradation resulting from depletion of forest cover, and that by itself should be sufficient incentive. The activity which will be carried out under this heading, therefore, responds to both issues. For detailed discussion of this program, see Annex XII.

The technology exists for scientifically farming and harvesting wood from small village tree lots to satisfy village needs and produce a small surplus for sale. Thailand's climate is also favorable for growing a number of the fast growing species. The number of potential social and technical variations calls for the establishment of a number of pilot and demonstration village woodlot projects. These can be expected to include use of village grazing land, village rural land, individual family house lots, etc. The scale of the activity will be limited to 20 villages in two provinces of the Northeast.

The objectives will be to: a) provide a sustained supply of wood fuel for both woodlot owners and non woodlot owners, (b) lessen the pressures on cutting of trees in the natural forests and poaching of trees on public land in general, c) create employment opportunities and increased income for rural families, d) develop techniques to be used as an important first step towards a country-wide scheme, and e) stimulate interest in tree farming by demonstrating the benefits which can come from such development.

The activity will be carried out principally by the Royal Forest Department (RFD) in coordination with NEA. Given the magnitude of the resource degradation issue - as well as the increasing pressure on available wood fuel - this component has a major potential for contributing to the long term Thai need for effective resources management.

6. Summary

All the technologies proposed, with the possible exception of solar photovoltaics for water lifting, meet the social/technical cost criteria set forth above. By and large, they are cost-effective, have a positive environmental impact, meet a development need of the poor, are controllable by individuals or small groups of poor peasants, and have the flexibility to respond to differing conditions in Thailand. Most, however, require additional testing and some adaptation for use in Thailand.

Despite experience in Thailand with some of the technologies proposed for inclusion, none is in widespread use for domestic, agricultural or industrial purposes today. Each technology to some degree poses a different set of organizational or social challenges to widespread diffusion. In the case of some, such as micro-hydro, the problem is one of maximizing utilization for village development. In the case of others, such as village woodlots, social, economic and organizational issues will need to be tested. In fact, the primary risks associated with pursuing these rural energy technologies are organizational and social issues. For these reasons, the rural oriented technologies component of the project has the dual objectives of testing and adapting the technologies for use in rural Thailand, and of developing and testing techniques or methodologies for organizing their application and dissemination.

IV. Economic Analysis - Cost Effectiveness

Annex XIII sets forth a detailed economic analysis for each of the rural oriented technologies (except for micro-hydropower which is examined separately at Annex IX). In each case, it is concluded that application of the technology can be cost-effective and economically feasible for Thailand, and in fact reflects a longer term economic imperative. In addition to the specific analyses at Annexes IX and XIII, however, there are broader economic arguments to be made in support of the total project.

Underlying the economics of the project are two major and interdependent end goals: (1) conservation of forest and wood resources, and (2) greater input of useful energy into rural areas for economic and social development. Benefits of these types are often difficult to quantify. As a result, economic analysis of the proposed activities cannot in every case provide quantification of costs and benefits.

In Thailand, although no recent surveys have been undertaken, it is estimated that the largest energy source for heat or mechanical energy is wood fuel either as fuel wood (firewood) or charcoal. It constitutes about half of such energy use. The burden this demand places on Thailand's wood resources - forests and other tree areas - together with the increasing need for agricultural land, is tremendous. As described in the discussion at Annex III of Thailand's resource base, the forest areas are rapidly diminishing - what covered over half of the kingdom less than a decade ago may cover only a third or a quarter presently. This rate of depletion or exploitation has serious economic implications.

The primary economic effects revolve around the loss of a valuable resource which provides fuel and a multitude of forest products, primarily logs and lumber. Replacing the fuel with other sources would be both difficult and costly, with the most currently feasible alternative being liquid or gas petroleum products, materials which have an extremely high foreign exchange cost if imported and high opportunity costs if produced domestically. The foreign exchange revenue lost from diminishing exports of forest products would also be great. In addition there would be the domestic expense of higher building costs due to higher cost of wood or from having to use other building materials. Beyond these effects would be the opportunity cost of not having maintained a renewable resource which would provide a continual stream of valuable products for future generations.

The cost of replacing this resource would be extremely high. The benefits of conservation of wood resources, therefore, not only reflect the cost of immediate replacement, but also the lost benefits of a well managed renewable resource.

A secondary but no less important economic effect of the depletion of forest resources arises from the fact that they are crucial to the maintenance of Thailand's environment. The importance of upland forests to the overall quality of watersheds is clearly recognized. The catastrophic repercussions on lowland delta area of deforestation has been evidenced elsewhere in the world - gradual destruction of lowland agriculture due to siltation and flooding. Given the singular importance of agriculture to Thailand's economy, a large benefit accrues from this vital aspect of forest conservation. But since it is difficult to quantity, no monetary benefit has been attached to it. Nevertheless, this benefit underlies most of the programs recommended in the project and adds an urgency to the implementation of the project beyond the quantifiable economic benefits.

Another general benefit or goal of the project is to increase the availability of useful energy in rural areas. This energy could be applied to a wide set of tasks - pumping, crop drying, water purification, lighting, heating, mechanization, etc. - which result in better living and health conditions. Energy is an intermediate good in production or attainment of a particular end; the demand for energy is a derived demand. The benefits from increased energy use can range from those which are strictly economic in the case of pumping for irrigation, to health in the case of cleaner water from solar distillation or education through lighting. Energy is only one input into the system, however, and the returns which are directly attributable to it cannot always be separated.

All the technologies included in the project will yield economic benefits in at least the above ways. In some cases, using observable market or shadow prices, the economics can be quantifiably evaluated, but in all cases benefits will accrue. And these will principally affect the rural areas.

The benefits of more efficient wood utilization - improved stoves, improved charcoal production techniques, conservation in rural industries, use of logging and sawmill residues - are clear: lower fuel costs and reduced depletion of forest reserves. Given present efficiencies, the costs of increasing them by 50 to 100 percent will be small. Pyrolysis and biogas offer better utilization of agricultural and animal wastes, not only reducing wood fuel consumption but also providing new sources of energy. These new sources could be used more efficiently

and in a wider variety of ways than wood fuel or the original residues. The costs of conversion equipment are not insignificant but the benefits are appreciably greater. There are also, of course, opportunity costs for the raw materials, however a significant portion of these materials are presently underutilized.

Solar, wind and micro-hydro provide sources of energy at the local or village level. The possible benefits are numerous: increased food storage ability, water pumping, solar distillation for drinking water or salt harvesting, lighting, heating, tobacco drying, etc. The costs are primarily for the conversion technology and in most cases are already economic; in other (e.g., photovoltaic) they should become economic or obtainable by all economic classes in the near future as research and development continues.

Summary

This analysis and those set forth at Annexes IX and XIII for the most part only address direct benefits accruing to the user of the technology. No attempt has been made to measure all of the societal benefits expected to result. Notwithstanding this general underestimation of benefits, the analysis demonstrates that in principle each of the activities appears to be economically viable. In comparing the attractiveness of investments in nonconventional renewable, energy resource technologies - including the costs of the institutional basis - with investment in other sectors of the Thai economy, the urgency and importance of the benefits and goals support the activities outlined in this project.

V. Social Analysis

The nature of Thai social and political structure does not pose major barriers to changing the efficiency and technologies of the use of traditional fuel resources. Nor does the culture function as an impediment to the adoption of renewable resource technologies not now commonly used in Thailand, or to the conduct of the institutional development component of the project which would create the conditions for such changes or adoption of new technologies. However, in order to evaluate socio-cultural acceptability in more detail, the five rural oriented technologies have been examined in terms of the following dimensions: predictable cultural barriers to acceptance, likely pathways for diffusion, and probable incidence of social and economic benefit likely to result from introduction and utilization.

This analysis, including discussion of the status of women, is set forth in detail at Annexes XIV and XV. Annex XIV reviews the analysis for the project generally; Annex XV discusses the village woodlots activity separately in view of the particular issues which attach in the case of that program. Both analyses discuss the social implications and conclude as above that there are not major barriers to the changes or innovations envisioned by this project. They do show, however, that the rural people are the real implementing agents and beneficiaries of the project. In general, the conclusions show that the wide range of technologies included for testing and adaptation in the project will require a variety of pathways in order to maximize utilization. This is no more than consistent with the innovative and experimental character of the whole project.

The following is a brief summary of the social factors relevant to applying the principal rural-oriented technologies included in the project.

A. Biomass

There do not appear to be serious cultural impediments to the adoption of the biomass technologies included in the project. However, pathways for diffusion and probable incidence of social benefits vary substantially.

Although biogas entails the handling of dung and the use of the resulting methane gas principally for cooking, Thai culture does not appear to preclude wide acceptance of the technology. Instead possible barriers to its wide acceptance

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include the fact that the decision to invest and maintain biogas facilities may not necessarily be made by those most likely to benefit from the investment (women). Another possible barrier is need for arranging financing. Biogas technologies diffusion will probably require Government or private voluntary organizations making credit available and will engage a need for community organization. Furthermore, biogas will principally be suitable in areas with many animals, e.g., the Northeast.

Pyrolysis, on the other hand, is only usable in situations where large amounts of agricultural residues are available. It will therefore benefit rice mill or lumber mill owners rather than the small farmer, although the small farmer should eventually benefit from increased fuel supplies at reduced cost. Improved energy efficiency in small industries will also benefit one rather small subgroup of the population -- those engaged in small-scale industry in rural areas. However, the technology is likely to pay for itself on a sustaining basis, and to the degree to which it keeps these small businesses from going out of business, it will contribute to preserving off-farm economic activities in rural areas.

The incidence of social and economic benefits deriving from improving the efficiency of wood-burning stoves and from improved charcoal production techniques can be expected to be widespread. Also, both appear likely candidates for commercial marketing. Neither, however, is without potential difficulties. In the case of the stoves, the decision to invest in and maintain them may not be made primarily by those expected to derive primary benefits, the women charged with cooking responsibilities. Further, more efficient wood-burning stoves will reduce or eliminate smoke now sometimes employed for preservation of meats. The extent to which this would be a constraint, however, is probably limited, particularly if the alternative benefits are clearly demonstrated. There do not appear to be any social constraints to improving techniques of charcoal production, although an institutional constraint to dissemination of the technology is that most charcoal production is not legally sanctioned.

B. Solar

With the exception of solar tobacco curing, the solar technologies proposed are likely to benefit small farmers and small agro-processors. The availability of solar dryers increases the possibility of growing cash crops, while the use of solar

stills increases the possibilities for small farmers to continue in the salt business against increasing fuel prices. Solar dryers are also likely to improve nutrition through better food preservation, while in the use of stills for production of cleaner water, the health benefits are generally recognized among the rural population. Palatability may, however prove to be a constraint, and acceptance would require time at least. The application of solar energy, on the other hand, for industrial process heat use should engage no social issues.

C. Micro-Hydro

Although there are clearly no social constraints to the use of electricity, community participation will be required for development. Such involvement is always a social issue, and the requirement is addressed in the criteria set forth for selection of the pioneer villages (see Annex IX). Such participation is a condition to selection and the benefits should ensure that it is forthcoming. In general, to the degree that micro-hydro is utilized for productive purposes, it can be expected to benefit the entire community through increased economic activity.

D. Water Lifting

With the exception of solar pumps, because they are not divisible, most water lifting technologies will benefit larger farmers. Assuming financing is accessible, solar pumps on the other hand should benefit the smaller farmers. Water lifting technologies will also only benefit farmers in those regions where water is already fairly accessible. Nonetheless, the potential area of application and beneficiary population are both large, the benefits are demonstrable, and the technology is neutral.

E. Woodlots

The establishment of village woodlots would benefit a large number of poor people through increasing availability of a widely used fuel source. However, organizational and social barriers will need to be overcome in order to make the establishment of village woodlots feasible. The testing of ways to do that is a main purpose of this experimental activity.

Principal among these obstacles are competing demand for land use, the need to ensure cooperative village participation, and the related necessity to organize equitably the distribution of labor inputs and benefits. Also, the long time

lag between initial investment in a village woodlot and harvesting will undoubtedly deter some potential participants. In addition, the woodlots program will require substantial technical advice and assistance if an unacceptable loss level - which would act to defeat the purpose of the activity - is to be avoided. This, in turn, will call for a large role by the RFD and for close cooperation between the R&D and other local RTG agencies working at the village level.

If the program succeeds, the woodlots are expected to supply the needs of participants for wood fuel and to yield a commercially marketable surplus, in addition to the broader environmental profit to the country at large which would accrue from spreading of the concept. Accordingly, while success will have to overcome recognized hurdles, they are not insurmountable, and the potential benefits certainly merit the effort.

In response to the need to find ways to address these questions, the activity will probably test several approaches. These are detailed as alternatives at Annex XV. In addition to the main community or village woodlot concept employing public land, these include variations from the use of temple land to growth on family house lots. It could even be that tree growing diffusion among families in that way could have as large a long-term impact as the basic community concepts. In any case, where feasible, all of the alternatives will be tried. The lessons learned from the experiment may point the way to a more general response to the whole question of wood fuel expansion and equitable income generation.

F. Status of Women

As pointed out in the discussion at Annex XIV, to understand the role of Thai women with regard to a particular energy technology and locality, specific data would be required in each instance. The data to be developed through the project, and the project evaluations, will record much of this. At this point, it is probably adequate to recognize that virtually all the technologies addressed by the project involve the use of energy by women. This is particularly true across the whole range of activities concerned with cooking, but also includes crop drying, pumping of water for irrigation or domestic use, etc. While women are acknowledged as playing an important role in family decision-making, in order to enhance that role and encourage its extension to the selection of technologies beyond the home in areas affecting their lives, each activity needs to assure that women are involved as participants in the testing and adaptation of the technologies. Also women should be specifically included in the

response groups for the data gathering effort across the whole project. It may be that one of the most effective ways to ensure that this proves to be the case in each instance is to include women staff in the responsible RTG implementing agencies. That is, therefore, a project recommendation and will be reflected as the covenant in the project agreement.

Summary

In order to increase the chances that successful adaptations will result from the experimental activities in the project, a wide variety of technologies has been included. Each has its own social and organizational implications. For this reason, the need to test and develop techniques for diffusing the technologies, as well as testing the concepts themselves, is a main project purpose. However, while substantial attention needs to be focused on the issues of organization and diffusion, Thai culture does not by and large pose major barriers to acceptance of the technologies, and in no case are the impediments considered insurmountable.

VI. Financial Analysis

A. Introduction

The financial plan for the project is an aggregation of the estimated financial requirements for the 13 individual project components or activities plus the overall coordinating consultant. Table 1 displays the plan by project component and category of assistance (e.g.,technical assistance, training, equipment) whereas Table 2 displays the plan by category of assistance by year. Together these summary tables provide the information required for the project financial analysis.

The financial plans for each project component, broken down by category of assistance by year, are provided at Annex XVI.

B. Foreign Exchange/Local Currency

The financial tables do not break down costs into foreign exchange vs. local currency costs. However, with the exception of the equipment category, the planned breakdown is clearly defined; all AID funding is for foreign exchange costs except:

(1) Consultant services from AIT - 18 person months for $54,000 total. Thai consultant services for village woodlots - 54 person months for $94,500.

(2) Local transportation by short term consultants on public carriers - amount undetermined but probably less than $25,000.

(3) Local subsistence (per diem) of short term consultants. Although this item will be disbursed in dollars, it will be used for the most part by the consultants to purchase local accommodations and food. Total amount is estimated at $354,600.

(4) Training at AIT - 54 person months for $27,000 total.

(5) Workshops and other. These will be local costs mostly for establishment of woodlots, but also rent of conference facilities, stenographic services, translation, duplication, etc., incidential to the conduct of conferences for technology transfer in Thailand. Total amount is estimated at $234,000.

(6) Equipment. Some items such as solar cells and vehicles (trucks and jeeps) clearly are foreign exchange costs. However, wherever feasible local fabrication is desired and is built into the design of the project components. The best present estimate is that about half of the equipment budget of $1,039,500 will be spent in local currency.

On the RTG side, all the financing will be for local currency costs except for participant travel. Although a large portion of this $54,000 item may pay for travel on Thai International Airlines, it should be considered a foreign exchange cost since it is for international travel.

C. Basis for Cost Estimates

Most of the project components have well defined plans for the activities that will be undertaken and thus costing them is relatively straightforward. Plans for training and equipment can be set forth with some certainty but much of the planning for technical assistance requirements to carry out even well defined activities effectively can only be considered a best estimate at this time. In a project such as this, much of the precise need and timing for needed consultancies will become apparent only as the work unfolds; technical problems requiring expert advice will occur during the selection and design of various equipment items, breakthroughs in technology will occur and priorities will change with improved data and more knowledge. In the aggregate, the estimates, derived from the recommendations of energy experts, are sound and on the conservative side (i.e., amply provided for). Nevertheless, flexibility will have to be expected in both timing and among the various components.

D. Cost Components

U.S. consultants, both long and short term, are costed at $7,500 per month. This is based on assumed salaries of $3,000-4,000 per month and 100 percent overhead rates. Airfares are costed at $2,200 per round trip with allowance made for travel of three dependents and household effects for each long term consultant. Wherever possible excursion airfares will be utilized for short term consultants thus reducing the costs for this item. Per diem for short term consultants is costed at $1,800 per month ($60x30 days). Training is costed at $4,500 per month. Actual costs for this item may be lower since much of the training is of the study tour type and does not involve academic fees. Adequate estimates were made for equipment items.

Table 1
FINANCIAL PLAN
BY PROJECT COMPONENT AND CATEGORY OF ASSISTANCE

($1,000's)

	AID FINANCED						
	TA	Training	Equipment	Workshops & Other	Total AID	Total RTG	TOTAL
NEIDCT	116.4		75.5	-	191.9	148.0	339.9
RECs	-	-	246.0	-	246.0	1,395.6	1,641.6
Resources Assessment							
- Solar	150.5	148.5	70.0	-	369.0	47.3	416.3
- Biomass	182.7	-	50.0	-	232.7	26.0	258.7
- Mycro-Hydro	53.1	-	-	-	53.1	22.5	75.6
- Lignite, Oil Shale Tar Sands, Geothermal	298.8	162.0	15.0	-	475.8	27.0	502.8
Energy Tech. Monitoring	198.7	216.0	50.0	-	464.7	120.0	584.7
Energy Master Plan	282.2	270.0	2.0		554.2	135.3	689.5
Rural Oriented Tech.							
- Biomass	462.5	58.5	67.0	65.0	653.0	442.2	1,095.2
- Micro-Hydro	101.3	13.5	170.0	13.0	297.8	202.2	500.0
- Solar Drying & Dist. Process Heat	96.9	-	15.0	-	111.9	43.2	155.1
- Water Lifting	219.5	54.0	207.0	20.0	500.5	131.1	631.6
- Village Woodlots	210.5	18.0	72.0	136.0	436.5	318.0	754.5
Coordinating Consultant	366.4	-	-	-	366.4	91.5	457.9
Contingency	-	-	-	-	46.5	-	46.5
	2739.5	940.5	1039.5	234.0	5000.0	3149.9	8149.9

Table 2

FINANCIAL PLAN
BY CATEGORY OF ASSISTANCE BY YEAR

($1,000's)

AID $	PROJECT YEAR 1	2	3	4	5	TOTAL
Technical Assistance						
Long Term Consultants	85.5	291.0	111.0	21.0	-	508.5
Short Term Consultants	291.5	602.5	370.0	273.5	52.5	1590.0
Travel & Transportation	57.7	104.5	63.7	36.7	8.8	271.4
Local Subsistence (per diem)	66.3	140.1	84.3	66.3	12.6	369.6
Training	108.0	217.5	495.0	90.0	30.0	940.5
Equipment and Materials	152.5	556.5	275.5	30.5	24.5	1,039.5
Workshops	-	-	28.0	35.0	10.0	73.0
Other	12.5	22.1	36.25	44.8	45.35	161.0
Contingency	-	-	-	-	46.5	46.5
Sub Total	774.0	1934.2	1463.75	597.8	230.25	5000.0
RTG ฿ ($ equivalent)						
Salaries & Staff Related Costs	170.5	389.6	481.4	510.8	492.0	2,044.3
Participant Travel	18.0	16.5	18.0	1.5	-	54.0
Local Support & Subsistence	8.7	30.3	15.0	-	-	54.0
Facilities & Construction	28.5	268.5	235.0	195.0	-	727.0
Other	14.4	56.0	57.85	69.4	72.95	270.6
Sub Total	240.1	760.9	807.25	776.7	564.95	3149.9
TOTAL	1014.1	2695.1	2271.0	1374.5	795.2	8149.9

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E. Contingency - Inflation

The overall projected costs displayed in the financial plan appear to leave little contingency out of the proposed $5.0 million grant, only $46,500. However, per the discussion above, allowance for contingencies and inflation is built into the cost component. An element of contingency is inherent, for example, in the whole program for technical assistance where the scheduling of work and costs is particularly amenable to project control. In addition, actual salaries may average less than provided for, at least initially, and some consultants may be hired directly under personal services contracts eliminating the need for overhead. This, together with the flexibility in the overall estimate for technical assistance, provides adequate room for inflation and contingencies.

F. RTG Costs and Commitment

The figures on the RTG side are based on estimates of NEA and include salaries, travel and per diem costs at prevailing RTG scales. The rate used for participant travel is $1,500 per roundtrip based on fares available to the RTG on its own, and other, international carriers.

In a complex project such as this with a variety of activities and participants, it is difficult to capture fully all RTG costs over the entire project period. The RTG costs shown tend to reflect only additional costs which are directly attributable to the new, or at least newly defined, project activities. Additional RTG support for the project will be provided from existing and ongoing budgets of various departments.

The RTG costs shown for the project will have to endure the RTG's regular annual budget review process. However, with the participation of RTG planners in the project design, and concurrence in the project by the Thai Bureau of the Budget, Department of Technical and Economic Cooperation, Civil Service Commission and other review agencies, there is a clear commitment by the RTG to provide the necessary budget allocations to cover not only the costs identified in the financial plan but other costs which are likely to arise as well. The obligation to do so will be appropriately reflected in the initial conditions precedent and in the covenants. In addition, energy and rural development, the key themes of this project, are of high priority to the RTG and there is reasonable certainty that the RTG will provide all required support to ensure that the AID inputs are fully productive.

G. Reasonableness and Firmness of Costs

On the basis of the above analysis and discussions, USAID concludes that the anticipated costs of undertaking the project are reasonable, are reasonably firm and that the financial planning for the project is adequate.

H. Periodic Consultations

Notwithstanding the conclusion stated in Part III.G. above, the comments under Parts III.C. and III.F. make apparent the need for periodic reviews of financial planning to assure that it reflects current priorities and activity needs as the project proceeds and to assure that appropriate Thai budgetary action is being taken to support the proposed activities. Thus, NEA with the help of the coordinating consultant will undertake reviews at least annually and will consult with USAID in updating implementation and financial plans. Those plans will identify projected activities and their costs for each project component over the next year for which RTG budget is approved and for the following year for which RTG budget is requested.

I. Disbursement Procedures

Disbursement of foreign exchange for equipment and consultant services (from firms or individuals) will be made directly to suppliers under USAID issued Direct Letters of Commitment. For local currency payments to AIT for services and training, and possibly also to some local equipment suppliers, a similar direct disbursement approach will be used. The remaining minor disbursements by USAID for local currency will be on an actual cost reimbursement basis to the RTG. Disbursement for participant training and for consultant services by USG agencies, if any, will be under standard, established AID procedures. Detailed instructions for each type of disbursement will be covered in letters of implementation.

J. EMP Study

Tables 1 and 2 reflect the proposed AID assistance and related RTG budget. Not included in the Tables, are the funds assigned to the EMP study itself. These total as follows: UNDP - $710,000; ADB - $300,000; and RTG - $130,000 equivalent. These figures are reflected in the overall project funding totals in the logical framework (Annex XIX) and project paper facesheet.

VII. Environmental Statement

The whole premise on which this project rests is one of environmental improvement. There is little question this in fact will be the result, and the PID on that basis was accorded a negative IEE determination. The basic point of the project looks to a reduction in environmental degradation and a corresponding increase in the application of environmentally protective technologies.

This is obviously true of the range of activities associated with the institutional development component of the project, particularly the assessment of renewable energy technologies and the development of a facility for monitoring of energy technology progress. The project in this component also acts to supplement the proposed EMP Study by addressing in greater substance the whole range of renewable and rural energy alternatives, a component which in the longer term may be more significant in positive environmental terms than the basic reach of the EMP. (See Annex VII for scope of EMP Study: which also calls for an assessment of environmental impact of the program to be recommended by the Study.) Also, the including in this project component of the assessment of non-renewable resources - e.g., lignite, tar sands, etc. - similarly should provide an environmentally protective threshold for decisions on the future exploitation of these resources.

The second component of the project, rural-oriented technologies, in each case is directed to activities which have as their purpose the testing and encouragement of energy use compatible with positive environmental effects. This is certainly true for the whole category of biomass conversion - the design of new stoves, biogas use, more efficient production of charcoal, the use of pyrolysis, the program for small industry conservation and the study of conversion system integration. It is equally true for the related development of water lifting technologies and the use of solar energy for crop drying, water stills and process heat.

It also applies for the village woodlots program, which has the most immediate and compelling positive environmental impact of all the activities addressed in the project. To the extent this component is able to encourage the growth of local wood fuel supplies, displacing or retarding the present rapid degradation of the forests - with results not only on the forest areas themselves, but with implications for watershed management, erosion, delta water flow, etc. - this element of the project can only have the most positive of environmental effects.

One area, however, in which project specific environmental implications will need to be addressed is the micro-hydro activity. In principle this element also shares the purpose of energy use compatible with environmental criteria. As each of the 10 subprojects, however, are developed it will be necessary to look to the specific environmental effects of the particular subprojects. For each of them, therefore, environmental review will be included as part of the planning process.

In general, therefore, the environmental and ecological effects of the project in each of its components can only be regarded as positive, reflecting both the immediate and longer term purpose of the design effort.

VIII. Implementation Arrangements

A. Introduction

Detailed and specific descriptions of the activities and actions required to implement the project components are contained in the technical annexes (Annexes V-XII). Schedules for the components are presented at Annex XVIII.

Overall responsibility for managing the project rests with NEA which will also have prime responsibility for implementing certain project components. Implementation of other components will be assigned by NEA to other organizations either directly or through subcommittees or working groups. No single approach is appropriate for such a wide variety of subject areas and types of activities; the approach taken in each case will be that most appropriate to the particular situation.

Various organizations will work directly with NEA or will be represented on the subcommittees and working groups. The more important participating organizations are EGAT (particularly in some elements of the resources assessment and energy technologies monitoring activities, DMR (resources assessment), RFD (village woodlots), DOA, CDD, and various universities. DTEC and the coordinating contractor will play important supporting roles in arranging training and technical assistance and in procuring commodities.

B. Roles of Various Organizations

1. NEA

As overall manager of the project NEA will be responsible for providing leadership and momemtum in achieving the project purpose and for coordination and control of project activities. The NEA Board, which includes representation of other agencies of the RTG (see Annex XVII), will be the approval point for changes in project priorities or overall plans and for resolving issues. Within NEA itself there will be established a project management office and a project manager appointed. It will be that person's responsibility to coordinate the work of various organizations, to monitor and follow-up to assure that schedules are adhered to and that work is carried out within the scope of approved plans.

Within NEA, the Regulatory Division will be responsible for implementing the EMP support and the NEIDCT components of the project. The Technical Division will be responsible for implementing the RECs and the rural energy technologies activities. In addition, the Technical Division will be the principal NEA focus for the energy technologies monitoring and village woodlots programs. The Investigation and Planning Division will be principally involved in the resource assessments.

Obviously, coordination of such an array of activities will be a large task. Fortunately, however, the work under each of the components breaks down into fairly straightforward steps. Also, the interrelationships of one project to another should be adequately addressed within NEA through the mechanism of the project management office, and with the other involved agencies through the subcommittees and working groups. Because the project is a response to RTG initiatives in the first place, engaging the participation of all of the agencies concerned, there is already a working understanding of the project activities among these agencies. In particular, through its direct participation in the project design, NEA has a developed appreciation for the total project concept and for each of the activities. It also has good relationships with the other project participants; in the course of project design NEA established itself as the project leader and has won the approval of the RTG Cabinet to continue this role.

On general implementing capability, NEA currently has a total of 1,547 employees. These include 590 Civil Service staff, 657 permanent employees (regular RTG employees but without full Civil Service benefits), and 300 temporary personnel. Most of the professional and technical staff are Civil Service, but of the total 190 engineers assigned, 46 are among the temporary employees category. NEA expects to assign existing professional staff to this project, but may in addition recruit up to 20 new employees for this program. NEA's budget from the RTG increased from $5.88 million (U.S. Dollars equivalent) in FY 1977 to $12.04 million in the current fiscal year. For FY 1980, NEA will be allocated $30.2 million.

For both adequate budget and staff, there are no issues expected with respect to RTG approvals. Assurances on both points will be reflected in the project conditions precedent and in the covenants.

2. Coordinating Contractor

A coordinating contractor is needed to provide a link between NEA and the US energy community. The primary role of the contractor will be to help identify appropriate sources of technical assistance and training, to facilitate contacts in the US and to help make arrangements for study tours and for the timely provision of commodities and services. The contractor will also assist NEA in overall project management and will keep NEA and Thai scientists currently informed on energy technology developments in the US and elsewhere.

Current plans for this contract include situating one consultant in Thailand for about 30 months beginning January 1980, with 12 additional person months of short term service in the US or Thailand over the life of the project. During the first year the long term consultant is on board, a reevaluation will be made to consider whether the long term consultant might better serve NEA and the project by being located in the US and making periodic visits to Thailand. Budgeted funds are sufficient in either case.

3. DTEC

DTEC will be the designated agent for offshore procurement of all services and equipment except for those which may be provided by USG agencies. Also it will make arrangements for participant training, although in this field it will share responsibilities with the coordinating contractor, USAID and AID/W, OIT. DTEC, as the agency officially designated by the RTG to receive foreign grant assistance and under long established and understood PIO procedures, will be the point of fiscal control for US grant funds made available to the RTG. It will participate in project evaluations. For international travel of participants, DTEC will provide RTG funds from a special account available for this purpose.

4. USAID and Other USG

USAID will assist the RTG in project implementation to the extent feasible, monitor the project, provide necessary AID approvals, participate in evaluations, and generally perform all the functions normally associated with an AID monitoring role.

Early arrival of the coordinating consultant is important since that person will help in identifying other consultants needed in the early stages of various project activities. Prompt startup of support for the EMP is important because it may contribute to the ADB/UNDP financed

work on the EMP study. Therefore USAID and NEA have agreed that the coordinating contractor should be handled as a direct USAID contract, this being the most expeditious method.

A USAID project committee has been appointed to monitor the project. Given the complexity of the activities and the probable requirement for close support and monitoring, the USAID is establishing a senior engineering position with specific responsibility for this project. The SPAR is in preparation and MODE clearance has been secured. The candidate is expected to be on board by September 1979, which is in the beginning stage of project implementation. This person will have monitoring responsibilities for the USAID's remote sensing project as well as the energy project, but it is expected that he will devote at least 50 percent of his time to overseeing the implementation of the energy project. He will be supported in addition by two direct-hire Thai engineers, one of whom is already on board.

AID/W, ASIA/TR will provide general backstopping for the project including liaison with the US offices of the coordinating contractor and will work and make arrangements with other USG agencies such as USGS or DOE as may be necessary to secure required services or support for the project from them. AID/W, OIT will make training arrangements under established PIO/P procedures when requested to do so.

C. Procurement

Offshore procurement by DTEC will be in accordance with AID Handbook 11. DTEC is familiar with these AID procedures and has successfully procured both services (using an approved model contract) and equipment under recent AID financed projects (e.g., TTMS and Rural Primary Health Care). Contracting for the few (probably five) long term consultants contemplated will not present a workload problem. The number of short term consultancies to be arranged is about 100. However, many of these represent follow-up visits by individuals already contracted for, others will likely be provided under the coordinating consultant contract and still others will be arranged without direct DTEC involvement under PASAs. Thus, with help from the coordinating consultant, the total load, though heavy initially is manageable by DTEC and will lighten considerably after the first year.

Contracts for services with individuals as well as with firms or educational institutions are contemplated, depending on where the greatest skill

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and expertise is available. Besides solicitation from sources known to the RTG, the coordinating contractor and the USG, periodic public notice will be made in the US of requirements for consultants. This will be in addition to the earlier advertisement for the coordinating consultant contract. These periodic notices will be placed in the Commerce Business Daily or other publications. Minorities and women will be specifically encouraged to participate through firms or organizations so identified or as individuals. In all cases, NEA or the implementing organization designated by NEA will select or approve the firms and individual consultants for the various assignments.

Each designated implementing agency will handle its own procurement for Thai source commodities under established RTG procedures subject to review and approval by USAID. Prior USAID experience has been that standard RTG procedures conform satisfactorily to AID Handbook 11 requirements. USAID intendes to handle procurement of the coordinating consultant under normal direct AID competitive contracting procedures.

See Part IX.D. regarding waivers of U.S. source/origin requirements.

D. Schedule

As noted at the beginning of this Part, schedules for the individual project components are presented at Annex XVIII, based on initial steps as follows:

Grant authorization by AID	Jun 79
Project agreement signed	Jul 79
Selection of coordinating consultant begins	Aug 79
Initial conditions met	Sep 79
NEA additional staff recruitment begins	Sep 79
USAID project officer assigned	Sep 79
NEA initiates preliminary survey	Sep 79
Coordinating contract signed	Dec 79
Coordinating consultant on board	Jan 80

Actual project implementation can begin in January 1980 and that is the date contemplated on the individual schedules.

Activities under all project components should be well underway by July 1980. Allowing for two years of project experience, the first major evaluation is scheduled for July 1982.

IX. Conditions Precedent, Covenants, Negotiating Status and Waivers

A. Conditions Precedent

To initial disbursement - designation of representatives and RTG assurance of adequate budgetary and staff support for the project.

To disbursement for technical assistance services - satisfactory contractual arrangements.

To disbursement for training - training approved, candidate selected and RTG funding arrangements completed.

To disbursement for local costs - agreement on the estimated costs and components to be funded.

B. Covenants

- Assurance of continuing adequate budgetary and staff support for the project.

- Agreement to consult with AID annually during the project for the purpose of bringing implementation and plans up to date.

- Agreement to emphasize the recruitment and retention of women staff for work on project activities.

- Agreement to encourage the dissemination of rural renewable energy technologies successfully developed by the project.

C. Negotiating Status

The project has been under intensive discussion with NEA, NESDB, DTEC and other concerned RTG agencies since the beginning of 1979. The project components themselves were identified by the RTG participants as those which reflect highest priority for Thailand in the field of renewable nonconventional energy. The corollary assessment of non-renewable resources also represents an RTG priority and is a necessary component of a total resources evlauation. The project paper has been reviewed by the RTG and there is agreement on all substantive elements of the project, including sharing of costs, the priorities identified in the

project and the conditions and covenants. USAID does not, therefore, see any obstacles to or expect any delays in execution of the project agreement.

D. Waivers

Given the range of nonconventional technologies addressed in this project, it is probable that the US will not in every case be able to supply the most appropriate source of technical assistance. It could well be, for example, that sources in Western Europe have much greater experience in certain of the technologies. Higher conventional energy costs have long provided a stronger incentive in Europe than in the United States for experimentation with renewable non-conventional energy uses. Accordingly, as this project proceeds, there are expected to be instances where the most appropriate source of advice, equipment or training could well be non-US. Since the purpose of the project is to provide a resource for a range of the most efficient and innovative renewable technologies, it would not consistent to restrict the source of the technology if in fact the most appropriate experience is not found in the US.

In general, it is expected that most of the services, equipment and training will in fact come from the US. But in order not to constrain the technological reach or boundaries of the project, 935 waivers will be issued by the USAID Director on a case-by-case basis where the facts indicate that the US is not the appropriate source. The total amount involved would not exceed $500,000 over the life of the project. In each case when such non-US procurement is approved, USAID will document the justification.

Since the project will also include the funding of certain costs in Thailand and Code 941 countries, use of the grant funds for this purpose should also authorized. In particular, the project will encourage local fabrication wherever feasible as a way of ensuring a continuing capacity to sustain the technologies involved. Also, in certain instances it may be appropriate to support fabrication or procurement in neighboring countries. Not only are there the possible benefits of a spread effect involved, but also the availability in the area, as opposed to the US, of non-Thai resources is a better measure of the real cost of the technologies and of their future potential. This category of expense in Code 941 countries is not expected to exceed $500,000 of the total grant over the life of the project.

AID's usual policy of following host country contracting procedure will be adhered to except for the coordinating contractor which will be a direct USAID contract to assure prompt startup of these services.

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X. Evaluation

Evaluation is threaded throughout the project and in fact provides the substance of much of the work under the rural oriented technologies activities. This component is based upon initial surveys, selection of alternative designs, identification of pioneer villages for the tests, and follow-up through the course of adaptation and final recommendations. The establishing of base line data and the succeeding process of evaluation are integral to each activity.

Similarly, the institutional development component - including the resources assessments, rural energy surveys, village resource studies, energy technologies monitoring, etc. - will also provide a continuing source of data. As discussed at the outset of the project paper, all these activitie should converge by the end of project to provide the RTG with the institutional, technological and data base for renewable energy planning and policies.

One principal point to be addressed in the annual evaluations therefore, is the extent to which these two components are in fact on such a converging course. In end of project terms, this is a main question. The annual evaluations will also addres the general progress of the project in technology and communications terms, and the need for revision of targets.

Given the tangible and immediate impact which should result from reviews of the rural oriented technologies component, the periodic evaluations will probably focus more on their progress and problems, than on the institutional component. So far as these rural oriented technologies activities represent the main project effort to test and spread the use of renewable energy technologies, they would be the core of the evaluation agenda.

Accordingly, the special evaluations will take place only after the rural oriented technologies are substantially underway. Therefore, although there will be prior annual evaluations, the first in-depth review will not take place until July 1982, i.e., two years after the activities have begun.

The periodic evaluations and the 1982 evaluation should address, for example, the following:

- general progress toward completion of the activities,
- obstacles to attainment of objectives and alternatives,
- new research and development data available from other countries which affect the viability of the technology being evaluated,
- continuation of activities as planned, reorientation to meet changing circumstances, or termination,
- postponement of activities until further information, training, staff, or implementation capability can be attained,
- reallocation of budget support among activities,
- involvement of women.

The 1982 evaluation will be a key element in project redesign where necessary. A similar in-depth evaluation will also be scheduled for the end of project. The evaluations will be joint RTG-AID, with the assistance of such expert technical advice as may be required. Funding in the project, both in the AID grant and the RTG budget, should be adequate to cover costs of the evaluations.

ANNEXES
TO

Project Paper
for

RENEWABLE NONCONVENTIONAL ENERGY PROJECT

(Project No. 493-0304)

USAID/Thailand

July 1979

ANNEXES

I.	PID Cable
II.	Statutory Checklist
III.	Macro Energy Picture
IV.	Micro Energy Picture
V.	National Energy Information and Documentation Center (NEIDC)/Regional Energy Centers
VI.	Resources Assessment
VII.	Energy Master Plan
VIII.	Rural Oriented Technology - Biomass
IX.	Rural Oriented Technology - Micro-Hydropower
X.	Rural Oriented Technology - Solar Drying & Distillation, Process Heat
XI.	Rural Oriented Technology - Water Lifting
XII.	Village Woodlots
XIII.	Detailed Economic Analysis
XIV.	Social Analysis - Overall Project
XV.	Social Analysis - Village Woodlots
XVI.	Financial Plans
XVII.	N E A Charter and Organization
XVIII.	Implementation Schedules
XIX.	Logical Framework
XX.	Section 611 (E) Certification
XXI.	Draft Authorization

R 252324Z AUG 78
FM SECSTATE WASHDC
TO AMEMBASSY BANGKOK 8519
UNCLAS STATE 217532

RECEIVED - 28 AUG 78

SUBJECT: RENEWABLE NONCONVENTIONAL ENERGY PID (493-0304)

REF: BANGKOK 21377; (B) STATE 178586

1. APAC REVIEWED PID AUGUST 21. A/AA/ASIA, M.H.B.ADLER, APPROVED PID WITH COMMENTS BELOW TO BE DEALT WITH BY ENERGY TEAM AND IN PP PREPARATION.

2. APAC STRONGLY SUPPORTS APPROACH TAKEN IN PID: THAILAND HAS MAJOR ENERGY CONCERNS PROFOUNDLY AFFECTING NATIONAL CAPABILITY TO IMPROVE QUALITY OF LIFE OF POOR MAJORITY. A.I.D. HELP IS APROPRIATE TO DEVELOP THAI INSTITUTIONAL CAPABILITIES TO EVALUATE AND IMPLEMENT BEST APPROACHES TO ENERGY PROBLEMS.

3. APAC WAS CONCERNED THAT SOME PROPOSED SUBACTIVITIES WOULD NOT, IN FINAL STAGES, PREDOMINATELY BENEFIT THE POOR MAJORITY. THIS CONCERN SHOULD NOT AFFECT SUBACTIVITIES ASSISTING INSTITUTION BUILDING AND ANALYSIS OF NATIONAL ENERGY SITUATIONS, BUT REQUIRES CRITICAL SCRUTINY OF SUBACTIVITIES INVOLVING CONSTRUCTION OR DEMONSTRATION ACTIVITIES NOT LIKELY TO BE REPLICABLE FOR THE BENEFIT OF THE NEEDY. THIS CONCERN SHOULD BE EXPLORED WITH ENERGY TEAM NEXT MONTH WITHOUT DELAYING THRUST TO LAUNCH ANALYTICAL AND INSTITUTIONAL BUILDING EFFORTS.

4. IN FURTHER PROJECT DEVELOPMENT AND DISCUSSIONS WITH ENERGY TEAM, MISSION SHOULD CONSIDER WHETHER FAA SECTION 103 FUNDS MIGHT NOT BE UTILIZED FOR SOME OR ALL OR CONTEMPLATED ASSISTANCE. FAA SECTION 103(C) CONTEMPLATES ASSISTANCE IN MEETING RURAL ENERGY NEEDS AND FAA SECTION 119 CONTEMPLATES 103 FUNDING OF ENERGY DEVELOPMENT FOR RURAL AND SMALL SCALE REQUIREMENTS.

5. ALL OF THESE FUNDING CATEGORIES WITHIN GENERAL A.I.D. POLICY CONCERN FOR ORIENTATION TO NEEDS OF THE POOR MAJORITY AND ARE SUBJECT TO CONSTRAINTS IMPOSED BY FAA SECTION 116 THAT A.I.D. ASSISTANCE BENEFIT THE NEEDY.

UNCLAS

6. DEPARTMENT OF ENERGY (DOE) HAS ALSO PROVIDED COMMENT ON PID (BEING POUCHED TO USAID). ENERGY TEAM WILL DISCUSS DOE COMMENTS WITH RTG AND MISSION NEXT MONTH.

7. AMONG DOE OBSERVATIONS ARE THAT SOME SUBACTIVITIES (E.G. GEOTHERMAL DEMONSTRATION PLANT) MAY BE MORE EXPENSIVE (DOLS. 5-10 MILLION) THAN PRELIMINARY ESTIMATES AT PID STAGE. THIS RAISES QUESTION WHETHER THEY ARE QTE LOW-COST UNQTE ALTERNATIVES. SIMILAR EXAMINATION OF WORK OF OIL SHALE AND TAR SAND GROUP MAY SUGGEST THAT VERY COSTLY DEVELOPMENT WORK NOW UNDERWAY IN WEALTHY COUNTRIES SHOULD BE COMPLETED AND EVALUATED BEFORE THAI ENTER VERY EXPENSIVE DEVELOPMENT AREA.

8. DOE HIGHLY SUPPORTIVE OF EFFORT OBTIAN FULL PICTURE ENERGY SITUATION. DOE SUGGESTS THAT DEMAND PICTURE AS WELL AS SUPPLY PICTURE BE EXAMINED. ALSO SUGGESTS GENERALIZED ENERGY RESOURCES MAP MIGHT BE ASSISTED BY USGS.

9. AID/W WILL EXPLORE POSSIBILITIES FOR DESIGN TEAM FOR PP AND ADVISE SOONEST. CHRISTOPHER

CHECKLIST OF STATUTORY CRITERIA

COUNTRY CHECKLIST

A. GENERAL CRITERIA FOR COUNTRY	A. GENERAL CRITERIA FOR COUNTRY
1. FAA Sec. 116. Can it be demonstrated that contemplated assistance will directly benefit the needy? If not, has the Department of State determined that this government has engaged in consistent patterns of gross violations of internationally recognized human rights?	Yes. N/A.
2. FAA Sec. 481. Has it been determined that the government of recipient country has failed to take adequate steps to prevent controlled substances (as defined by the Comprehensive Drug Abuse Prevention and Control Act of 1970) produced or processed, in whole or in part, in such country, or transported through such country, from being sold illegally within the jurisdiction of such country to U.S. Government personnel or their dependents, or from entering the U.S. unlawfully?	No.
3. FAA Sec. 620(b). If assistance is to a government, has the Secretary of State determined that it is not controlled by the international Communist movement?	Yes.
4. FAA Sec. 620(c). If assistance is to a government, is the government liable as debtor or unconditional guarantor on any debt to a U.S. citizen for goods or services furnished or ordered where (a) such citizen has has exhausted available legal remedies and (b) debt is not denied or contested by such government?	No.

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5. FAA Sec. 620(e)(1). If assistance is to a government, has it (including government agencies or subdivisions) taken any action which has the effect of nationalizing, expropriating, or otherwise seizing ownership or control of property of U.S. citizens or entities beneficially owned by them without taking steps to discharge its obligations toward such citizens or entities?	No.
6. FAA Sec. 620(a), 620(f); FY 79, App. Act Sec. 103, 114, 606. Is recipient country a Communist country? Will assistance be provided to the Socialist Republic of Vietnam, Cambodia, Laos, Cuba, Uganda, Mozambique, or Angola?	No. No.
7. FAA Sec. 620(i). Is recipient country in any way involved in (a) subversion of, or military aggression against, the United States or any country receiving U.S. assistance, or (b) the planning of such subversion or aggression?	(a) No. (b) No.
8. FAA Sec. 620(j). Has the country permitted, or failed to take adequate measures to prevent, the damage or destruction, by mob action, of U.S. property?	No.
9. FAA Sec. 620(l). If the country has failed to institute the investment guaranty program for the specific risks of expropriation, inconvertibility, or confiscation, has the AID Administrator within the past year considered denying assistance to such government for this reason?	The investment guaranty program is in effect.

10. FAA Sec. 620(o): Fishermen's Protective Act of 1967, as amended, Sec. 5. If country has seized, or imposed any penalty or sanction against, any U.S. fishing activities in international waters,	No such seizures have taken place.
a. has any deduction required by Fishermen's Protective Act been made?	(a) N/A.
b. has complete denial of assistance been considered by AID Administrator?	(b) N/A.
11. FAA Sec. 620(q): FY 79 App. Act Sec. 603.	
a. Is the government of the recipient country in default for more than six months on interest or principal of any AID loan to the country?	a. No.
b. Is country in default exceeding one year on interest or principal on U.S. loan under program for which App. Act appropriates funds?	b. No.
12. FAA Sec. 620(s). If contemplated assistance is development loan or from Economic Support Fund, has the Administrator taken into account the percentage of the country's budget which is for military expenditures, the amount of foreign exchange spent on military equipment and the amount spent for the purchase of sophisticated weapons systems?	Development Assistance Grant Funds are proposed. In any case, yes, as reported in annual report on implementation of Sec. 620(s).

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13. FAA Sec. 620(t). Has the country severed diplomatic relations with the United States? If so, have they been resumed and have new bilateral assistance agreements been negotiated and entered into since such resumption?	No. N/A.
14. FAA Sec. 620(u). What is the payment status of the country's U.N. obligations? If the country is in arrears, were such arrearages taken into account by the AID Administrator in determining the current AID Operational Year Budget?	Not in arrears.
15. FAA Sec. 620A: FY 79 App. Act, Sec. 607. Has the country granted sanctuary from prosecution to any individual or group which has committed an act of terrorism?	Not to the knowledge of the Mission.
16. FAA Sec. 666. Does the country object, on basis of race, religion, national origin or sex, to the presence of any officer or employee of the U.S. there to carry out economic development program under FAA?	No.
17. FAA Sec. 699, 670. Has the country, after August 3, 1977, delivered or received nuclear enrichment or reprocessing equipment, materials, or technology, without specified	No.

arrangements or safeguards? Has it detonated a nuclear device after August 3, 1977, although not a "nuclear-weapon state" under the non-proliferation treaty?

B. FUNDING CRITERIA FOR COUNTRY	FUNDING CRITERIA FOR COUNTRY
1. Development Assistance Country Criteria	
a. FAA Sec. 102(b)(4). Have criteria been established and taken into account to assess commitment and progress of country in effectively involving the poor in development on such indexes as: (1) increase in agricultural productivity through small-farm labor intensive agriculture (2) reduced infant mortality, (3) control of population growth, (4) equality of income distribution, (5) reduction of unemployment, and (6) increased literacy?	Yes. See FY 1979 CDSS.
b. FAA Sec. 104(d). If appropriate is this development activity designed to build motivation for smaller families through modification of economic and social conditions supportive of the desire for large families in programs such as education in and out of school, nutrition, disease control, maternal and child health services, agricultural production, rural development, and assistance to	The project is concerned with rural energy applications, the lessening cost and increasing ease of which should contribute to the objectives set forth in this section, including problems of malnutrition, etc.

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urban poor? Are problems of malnutrition, disease, and rapid population growth addressed by coordinated assistance?

2. Economic Support Fund Country Criteria

a. FAA Sec. 502B. Has the country engaged in a consistent pattern of gross violations of internationally recognized human rights?

No.

b. FAA Sec. 533(b). Will assistance under the Southern Africa program be provided to Mozambique, Angola, Tanzania, or Zambia? If so, has the President determined (and reported to the Congress) that such assistance will further U.S. foreign policy interests?

c. FAA Sec. 609. If commodities are to be granted so that sale proceeds will accrue to the recipient country, have Special Account (counterpart) arrangements been made?

Commodities will be included for project purposes; this is not a commodities for resale project as such. Limited resale will be to serve project purposes (e.g., emphasize local/village responsibility). The proceeds to the RTG would only be a fractional portion of the support the Thai Government is already providing for this project.

d. FY 79 App. Act Sec. 113. Will assistance be provided for the purpose of aiding directly the efforts of the government of such country to repress the legitimate rights of the population of such country contrary to the Universal Declaration of Human Rights?

d. No.

FAA Sec. 620B. Will security supporting assistance be furnished to Argentina after September 30, 1978?	N/A.

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CHECKLIST OF STATUTORY CRITERIA

PROJECT CHECKLIST

A. GENERAL CRITERIA FOR PROJECT	A. GENERAL CRITERIA FOR PROJECT
1. FY 79 App. Unnumbered; FAA Sec. 653(b); Sec. 634A.	
(a) Describe how Committees on Appropriation of Senate and House have been or will be notified concerning the project;	a) The project was not included in AID's 1979 Congressional Presentation, although it does appear in AID's 1980 C.P. Congressional notification of an FY 1979 authorization of the project will therefore be necessary.
(b) is assistance within (Operational Year Budget) country or international organization allocation reported to Congress (or not more than $1 million over that figure)?	b) assistance is not within the FY 1979 OYB.
2. FAA Sec. 611(a)(1). Prior to obligation in excess of $100,000, will there be (a) engineering, financial, and other plans necessary to carry out the assistance and (b) a reasonably firm estimate of the cost to the United States of the assistance?	The project incorporates a component of pilot and demonstration activities intended to test and adapt rural energy technologies as well as developing and testing dissemination strategies and techniques. In this connection, the project will generate engineering, financial and other studies needed.
3. FAA Sec. 611(a)(2). If further legislative action is required within recipient country, what is basis for reasonable expectation that such action will be completed in time to permit orderly accomplishment of purpose of the assistance?	3. No further legislative action is required
4. FAA Sec. 611(b); FY 79 App. Act, Sec. 101. If for water or water-related land resource construction, has the project met the standards and criteria as per the Principles and Standards for Planning Water	N/A.

and Related Land Resources dated October 25, 1973?	
5. FAA Sec. 611(e). If project is capital assistance (e.g., construction), and all U.S. assistance for it will exceed $1 million, has Mission Director certified and Regional Assistant Administrator taken into consideration the country's capability effectively to maintain and utilize the project?	N/A.
6. FAA Sec. 209. Is project susceptible of execution as part of a regional or multilateral project? If so why is project not so executed? Information and conclusion whether assistance will encourage regional development programs.	No. The rest of the question is therefore not applicable.
7. FAA Sec. 601(a). Information and conclusions wheth project will encourage efforts of the country to: (a) increase the flow of international trade; (b) foster private initiative and competition; (c) encourage development and use of cooperatives, credit unions, and savings and loan associations; (d) discourage monopolistic practices; (e) improve technical efficiency of industry, agriculture, and commerce; and (f) strengthen free labor unions.	Since this is essentially a pilot and demonstration activity the project will not in and of itself affect international trade or strengthen free labor unions. However, planned conservation activities will improve efficiency. Further, in experimenting with different strategies and techniques for diffusing the technologies the use of cooperatives and commercial marketing will be tried as well as alternative pathways.
8. FAA Sec. 601(b). Information and conclusion on how project will encourage U.S. private trade and investment abroad and how it will encourage private U.S. participation in foreign assistance programs (including use of private trade channels and the services of U.S. private enterprise).	Most of the offshore procurement financed under this project is expected to be from the United States.

9. FAA Sec. 612(b); Sec 636(h). Describe steps taken to assure that, to the maximum extent possible, the country is contributing local currencies to meet the cost of contractual and other services, and foreign currencies owned by the United States are utilized to meet the cost of contractual and other services.	The Thai Government contribution to the costs of this project will exceed 25 percent. There are no U.S. owned local currencies available for this project.
10. FAA Sec. 612(d). Does the United States own excess foreign currency and, if so, what arrangements have been made for its release?	No. N/A.
11. FAA Sec. 601(e). Will the project utilize competitive selection procedures for the awarding of contracts, except where applicable procurement rules allow otherwise?	Yes.
12. FY 79 App. Act Sec. 608. If assistance is for the production of any commodity for export, is the commodity likely to be in surplus on world markets at the time the resulting productive capacity becomes operative, and is such assistance likely to cause substantial injury to U.S. producers of the same, similar or competing commodity?	The project is not for this purpose. The remainder of the question is therefore not applicable.
B. FUNDING CRITERIA FOR PROJECT 1. Development Assistance Project Criteria	FUNDING CRITERIA FOR PROJECT
a. FAA Sec. 102(b); 111; 113; 281 (a). Extent to which activity will: (i) effectively involve the poor in development, by extending access to economy at local level, increasing labor-intensive	(i) The institution-building component of the project will not directly involve or benefit the poor although it will contribute to increasing the availability of energy in Thailand; however the rural technologies component will involve the rural poor in testing and adapting technologies as well as in the means of

production and the use of appropriate technology, spreading investment out from cities to small towns and rural areas, and insuring wide participation of the poor in the benefits of development on a sustained basis, using the appropriate U.S. institutions; (ii) help develop cooperatives, especially by technical assistance, to assist rural and urban poor to help themselves toward a better life, and otherwise encourage democratic private and local governmental institutions; (iii) support the self-help efforts of developing countries; (iv) promote the participation of women in the national economies of developing countries and the improvement of women's status; and (v) utilize and encourage regional cooperation by developing countries?

disseminating them in order to improve Thailand's rural energy system and enhance Thailand's prospects for rural development.

(ii) One of the strategies for the dissemination of rural energy technologies which will be tested is reliance on cooperatives for diffusion as appropriate.

(iii) This is essentially a self-help project involving a main Thai effort toward better use of renewable energy of Thai sources.

(vi) The technologies involved, if proven practicable, will help the role of women through less labor requirements.

(v) A successful renewable energy program should lead to emulation in this region.

b. FAA Sec. 103, 103A, 104, 105, 106, 107. Is assistance being made available: (include only applicable paragraph: e.g., 1, 2, etc.,--which corresponds to source of funds used. If more than one fund source is used for project, include relevant paragraph for each fund source).

(1)(103) for agriculture, rural development or nutrition; if so extent to which activity is specifically designed to increase productivity and income of rural poor; (103A) if for agricultural research, is full account taken of needs of small farmers;

(1) The program is designed directly to work with increasing rural productivity through better use of energy.

(2)(104) for population planning under 104(b) or health under 104(c); if so, extent to which activity emphasizes low-cost, integrated delivery systems for

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health, nutrition, and family planning for the poorest people with particular attention to the needs of mothers and young children, using paramedical and auxiliary medical personnel, clinics, and health posts, commercial distribution systems and other modes of community research;	No.
(3)(105) for education, public administration, or human resources development; if so, extent to which activity strengthens nonformal education, makes formal education more relevant, especially for rural families and urban poor, or strengthens management capability of institutions enabling the poor to participate in development;	No.
(4)(106) for technical assistance, energy, research, reconstruction, and selected development problems; if so, extent activity is:	Yes. See below.
(i) technical cooperation and development, especially with U.S. private and voluntary, or regional and international development, organizations;	No.
(ii) to help alleviate energy problem;	4)(ii) The project is directed to the better uses of renewable energy at the rural level.
(iii) research into, and evaluation of, economic development processes and techniques;	No.
(iv) reconstruction after natural or manmade disaster;	No.
(v) for special development problem, and to enable proper utilization of earlier U.S. infrastructure, etc., assistance;	No.
(vi) for program of urban development, especially small labor-intensive enterprises, marketing systems, and financial or other institutions to help urban poor participate in economic and social development.	No.
(5)(107) Is appropriate effort	Yes. Development with application of appropriate

placed on use of appropriate technology?	technology is the whole substance of this project.
c. FAA Sec. 110(a). Will the recipient country provide at least 25% of the costs of the program, project, or activity with respect to which the assistance is to be furnished (or has the latter cost-sharing requirement been waived under Sec. 124(d) for a "relatively least-developed" country)?	Yes. See Part VI of the project paper.
d. FAA Sec. 110(b). Will grant capital assistance be disbursed for project over more than 3 years? If so, has justification satisfactory to Congress been made, and efforts for other financing or is recipient country "relatively least developed?"	This is not a project of capital assistance. The remainder of this question is therefore not applicable.
e. FAA Sec. 281(b). Describe extent to which program recognizes the particular needs, desires, and capacities of the people of the country; utilizes the country's intellectual development; and supports civic education and training in skills required for effective participation in governmental and political processes essential to self-government.	Insufficient renewable energy and the drain current fossil fuel imports place on the Thai economy are serious constraints to rural development. The pilot and demonstration activities financed by this project will seek to alleviate this problem. All project components will be implemented by the National Energy Agency of the Thai government and other local institutions, such as the universities.
FAA Sec. 122(b). Does the activity give reasonable promise of contributing to the development of economic resources, or to the increase of productive capacities and self-sustaining economic growth?	Yes
2. Development Assistance Project Criteria (Loans Only)	
(a) FAA Sec. 122(b). Information and conclusion on capacity	N/A.

of the country to repay the loan, including reasonableness of repayment prospects.

(b) FAA Sec. 620(d). If assistance is for any productive enterprise which will compete in the U.S. with U.S. enterprise, is there an agreement by the recipient country to prevent export to the U.S. of more than 20% of the enterprise's annual production during the life of the loan? N/A.

3. Project Criteria Solely for Economic Support Fund

(a) FAA Sec. 531(a). Will this assistance support or promote economic or political stability? To the extent possible does it reflect the policy directions of section 102? N/A

(b) FAA Sec. 533. Will assistance under this chapter be used for military, or paramilitary activities? N/A.

CHECKLIST OF STATUTORY CRITERIA

STANDARD ITEM CHECKLIST

A. PROCUREMENT	A. PROCUREMENT
1. FAA Sec. 602. Are there arrangements to permit U.S. small business to participate equitably in the furnishing of goods and services financed?	Yes.
2. FAA Sec. 604(a). Will all commodity procurement financed be from the U.S. except as otherwise determined by the President or under delegations from him?	Yes.
3. FAA Sec. 604(d). If the cooperating country discriminates against U.S. marine insurance companies, will agreement require that marine insurance be placed in the U.S. on commodities financed?	Yes.
4. FAA Sec. 604(e). If offshore procurement of agricultural commodity or product is to be financed, is there provision against such procurement when the domestic price of such commodity is less than parity?	Agricultural commodities or products are not to be financed. Therefore, the remainder of this question is not applicable.
5. FAA Sec. 608(a). Will U.S. Government excess personal property be utilized wherever practicable in lieu of the procurement of new items?	Yes, although it is not expected to be practicable.
6. FAA Sec. 603. Compliance with requirement in Sec. 901(b) of the Merchant Marine Act of 1936, as amended, that at least 50 per centum of the gross tonnage of commodities (computed separately for dry bulk carriers, dry cargo liners, and tankers) financed shall be transported on privately owned U.S. flag commercial vessels to the extent that such vessels are available at fair and reasonable rates.	This requirement will be complied with.

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7. FAA Sec. 621. If technical assistance is financed, will such assistance be furnished to the fullest extent practicable as goods and professional and other services from private enterprise on a contract basis? If the facilities of other Federal agencies will be utilized, are they particularly suitable, not competitive with private enterprise, and made available without undue interference with domestic programs?	Yes. The use of other Federal agencies will conform to the criteria listed.
8. International Air Transport. Fair Competitive Practices Act, 1974. If air transportation of persons or property is financed on grant basis, will provision be made that U.S. flag carriers will be utilized to the extent such service is available?	Yes.
9. FY 79 App. Act Sec. 105. Does the contract for procurement contain a provision authorizing the termination of such contract for the convenience of the United States?	Yes, they will do so.
B. CONSTRUCTION	B. CONSTRUCTION
1. FAA Sec. 601(d). If a capital (e.g., construction) project, are engineering and professional services of U.S. firms and their affiliates to be used to the maximum extent consistent with the national interest?	N/A.
2. FAA Sec. 611(c). If contracts for construction are to be financed, will they be let on a competitive basis to maximum extent practicable?	Yes.
3. FAA Sec. 620(k). If for construction of productive enterprise, will aggregate value of assistance to be furnished by the U.S. not exceed $100 million?	No.

C. OTHER RESTRICTIONS	C. OTHER RESTRICTIONS
1. FAA Sec. 122(e). If development loan, is interest rate at least 2% per annum during grace period and at least 3% per annum thereafter?	N/A.
2. FAA Sec. 301(d). If fund is established solely by U.S. contributions and administered by an international organization, does Comptroller General have audit rights?	N/A.
3. FAA Sec. 620(h). Do arrangements preclude promoting or assisting the foreign aid projects or activities of Communist-bloc countries, contrary to the best interests of the U.S.?	Yes.
4. FAA Sec. 636(i). Is financing not permitted to be used, without waiver, for purchase, long-term lease, or exchange of motor vehicle manufactured outside the U.S. or guaranty of such transaction?	Yes.
5. Will arrangements preclude use of financing:	None of the activities listed is involved in the project.
a. FAA Sec. 104(f). To pay for performance of abortions or to motivate or coerce persons to practice abortions, to pay for performance of involuntary sterilization, or to coerce or provide financial incentive to any person to undergo sterilization?	
b. FAA Sec. 620(g). To compensate owners for expropriated nationalized property?	
c. FAA Sec. 660. To finance police training or other law enforcement assistance, except for narcotics programs?	

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d. FAA Sec. 662. For CIA activities?

e. FY79 App.Act Sec. 104. To pay pensions, etc., for military personnel?

f. FY79 App.Act Sec. 106. To pay UN assessments?

g. FY79 App.Act Sec. 107. To carry out provisions of FAA Sec 209(d) and 251(h)? (Transfer to multilateral organizations for lending.)

h. FY79 App Act Sec. 112. To finance the export of nuclear equipment, fuel, or technology or to train foreign nationals in nuclear fields?

i. FY79 App.Act Sec. 601. To be used for publicity or propaganda purposes within U.S. not authorized by Congress?

MACRO ENERGY PICTURE

ENERGY IN THAILAND

Describing energy use in a geographic area can involve several levels of analysis. The broadest perspective examines all types of energy: radiation (insolation), chemical and mechanical in all forms, both animate and inanimate. This would involve determining total solar radiation or energy striking the surface as well as the portion of this energy captured by the system in the form of biomass or total plant productivity. This productivity is the source or basis for transformation into human energy via food, animal energy and manure via fodder, fuel wood and charcoal via trees, and fuel or char or industrial products via bagasse and other agricultural residues from plants. These energy or fuel sources are being generated on a continual renewable basis.

Other fuel sources represent the residue of past capturing of solar energy by biomass which are non-renewable: petroleum or oil, coal, lignite and peat. Supplementing biomass production but still representing the conversion of solar energy is wind power due to atmospheric convections and water power due to the cycle of evaporation of surface water and condensation at higher elevations. In addition to solar energy there are other fundamental energy sources in the form of inorganic (chemical) matter and gravitation forces such as inorganic fertilizers, radicactivity and geothermal heat.

This larger perspective of fundamental energy sources and the numerous transformations they undergo provides a unified system in which current problems interface: human nutrition, agricultural productivity, forest land productivity, land fertility, renewable versus non-renewable energy potentials. In a country such as Thailand whose agricultural and forest products are its largest resource, such an analysis could provide insights into the relative biomass productivity of different land uses and therefore indicate present or upcoming problems as well as beneficial directions for land use development. An analysis on this scale is not a part of this discussion, but the components of this project should result in a major contribution to the capacity of the RTG to address the total energy picture at that level.

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The first perspective which will be quantified in this discussion examines the energy flows which are one step away from being transformed into mechanical work or useful heat. The mechanical forms include human and animal work, combustion or steam engines, and electric motors, whereas useful heat represents cooking, drying and process heat applications. The energy flows of this system can become quite complicated and it is important to recognize the wide variation in efficiences of use of the various energy sources. Furthermore these efficiences or outputs of useful energy also depend on the method or technology of energy utilization. An open fire using wood for cooking may only provide five percent of the total heat produced for food processing, whereas use of an enclosed vented oven may quadruple the efficiency of use. On the other hand, biogas or natural gas for cooking may be as much as 40 percent efficient. This issue of efficiencies is often overlooked in examining traditional energy systems where the common remark is on the low level of energy used. Often the problem is that low levels of useful energy are captured; however, the gross input of energy can be extremely high usually from non-commercial energy sources.

Table 1 presents the gross inputs or consumption of energy in Thailand for 1977; no accounting concerning efficiency of use has been attempted due to the variety of uses of each source and the differential efficiencies.

In the next section the source of these different estimates are discussed. As can be seen, renewable energy sources (i.e., all except petroleum, coal and lignite) account for about 70 percent of the total. Although these sources are generally considered to be renewable, in Thailand this is only partially so due to several factors such as decreasing soil fertility and deforestation.

The more commonly used version of energy consumption tables contains only inanimate energy forms. For some social policy decisions it is quite clear that human energy and that fraction of animal feed which is converted into human food should be dealt with separately; however, in an analysis of energy inputs for agriculture it is a crucial component and is included above in Table 1 and discussed below. As for animal feed which is converted into animal energy, its exclusion from more common energy use figures is probably due to the complexities of calculating it and the lack of

Table 1. Gross Energy Consumption in Thailand, 1977

Energy Source	Source for Amount	Energy 10^{12}kcal	%
Petroleum products	NEA*	97.8	28%
Hydroelectric power	NEA*	10.2	3%
Coal and Lignite	NEA*	2.3	1%
Bagasse	NEA quantity; recalculated energy content**	9.9	3%
Paddy husk	assumed 25% utilization**	3.1	1%
Human energy	human food - 1800 kcal/ day/person**	28.8	8%
Animal energy	animal feed**	76.1	22%
Fuelwood and charcoal	Openshaw 1972 FAO survey: 1970 use**	116.5	34%
	Total	344.7	100%

* National Energy Authority, Thailand Energy Situation '77

** For details underlying these estimates see below.

information on magnitude and different uses (agriculture, transport, food) of this energy source. Nevertheless this energy use for transport or agricultural work represents an energy demand which parallels the more easily quantified use of commercial fuels such as petroleum products for the same activities, although with significantly different efficiency rates. The figure in Table 1 above for this element, and the discussion below, reflect the limitations of current available data.

Table 2 presents gross energy consumption for inanimate sources and compares the figures available in the NEA annual energy report to those estimated in the next section.

Table 2. Inanimate Energy Consumption in Thailand, 1977

Energy Source	Amount 10^{12}kcal NEA Figures		Amount 10^{12}kcal META Team*	
Petroleum products	97.8	82%	97.8	41%
Hydroelectric power	10.2	8%	10.2	4%
Coal & Lignite	2.3	2%	2.3	1%
Bagasse	8.3	7%	9.9	4%
Paddy husk	0.4)		3.1	1%
Fuel wood	0.4)	1%)		
Charcoal	0.2)	)	116.5**	49%
	119.6	100%	239.8	100%

(per capita (1977 population of 44 million people) : 5.45×10^6kcal)

* META Systems AID-funded feasibility study team, April 1979.

** Estimated wood fuel use in 1970 by FAO study.

For the fuelswhich are generally considered as commercial - petroleum products, hydroelectric power, coal and lignite - the consumption levels from the NEA report were used. Practically if not all of this commercial fuel use passes through the market place on a cash basis, and therefore, recorded use is quite accurate. For the other fuels, their supply is extremely decentralized, and their use as fuel occurs at their source and generally does not pass through the market place. Furthermore if such fuels are marketed, the consumption is unrecorded. For these reasons, this fuel use can only be roughly estimated. The most important problem in this area concerns the use of wood fuel; as can be seen in Table 2 the difference between the NEA figures and those in the META team report is extremely large. The figure used in the report was taken from an FAO study by M. de Backer and K. Openshaw, Timber Trends Study - Thailand (Project Working Paper, Detailed Description of Survey and Results; 1972) which surveyed wood use by all sectors and included a residential survey of nearly 6,000 households.

Based on Table 2, potentially renewable energy sources (i.e., all except petroleum, coal and lignite) accounted for about 60 percent of the total energy use in 1977, with fuel wood and charcoal accounting for approximately one half.

Table 3 shows a sectoral breakdown of inanimate energy use. Domestic energy use (cooking, lighting, heating, etc.) is the largest demand sector, nearly consuming one half of the total. The next largest is industrial use which accounts for one quarter of total energy consumed. If animate energy (human and animal) and chemical energy (fertilizer from both organic + inorganic sources) were included, the agricultural sector would increase significantly. Given the urban-rural breakdown for domestic wood fuel use (90:10 per de Backer and Openshaw) and rough estimations of rural sectoral breakdowns, it appears that rural energy use accounts for somewhat over half of total inanimate (excluding chemical) energy use. If animate and chemical energy use were included, the rural energy use would be well over half of total energy use.

Estimation of the Availability and Consumption of Traditional Energy

This section will outline the method by which traditional energy supplies and demands were estimated. The following traditional energy sources will be discussed: agricultural residues (straw, paddy husk, bran, bagasse), animal energy, animal residues, human energy and finally firewood and charcoal.

Table 3.: Sectoral Breakdown of Energy Use by Source in 1977(10^{12}kcal)

Consuming Sector / Energy Source	Domestic	Industry	Transport	Agriculture	Commercial, Service, Construction, Other	Electric Power	Total*
Fuelwood/ charcoal	106.3	8.9			1.3		116.5
Petroleum products	1.9	18.0	40.4	10.7	7.0	19.9	97.8
Hydroelectric power						10.2	10.2
Bagasse		9.9					9.9
Agricultural residues (paddy husks)	1.6	1.5					3.1
Lignite		0.83				1.2	2.1
Coal		0.2					0.2
Electric power***	6.3	20.0		.04	4.9		(31.3)**
Total*	116.2	59.4	40.4	10.8	13.3	(31.3)**	240
%	48%	25%	17%	4%	6%	-	100%

* Columns and rows do not sum exactly due to rounding.
** These amounts were not part of the total in order to avoid double counting.
*** In determining sectoral use of electric power, generation, transmission & other losses (23×10^{12} kcal) were distributed across the consuming sector in proportion to electric power use.

Agricultural Residues

The availability of agricultural residues was calculated by the use of several conversion factors which are needed to estimate the production level of crop residues by crop and then their energy content. These factors represent averages from actual measurements reported in various parts of the world. No studies calculating these factors for Thailand have been located at this time; therefore, the representative factors in Table 4 were used. Due to the approximate nature of these factors, they were assumed to be the same for all parts of Thailand though there are clearly regional variations. However, the significant variation in cropping patterns across Thailand results in different regional availabilities of agricultural residue resources. As a result, regional crop production statistics were used; the most readily available set were for the four major geographic regions: North, Northeast, Central and South. This breakdown probably captures the major geographic variations in residue availability; however, there are instances where a more detailed examination would be necessary. One example would be the case of the areas where high yielding rice varieties, which produce significantly less straw than traditional varieties, are used or are introduced. Another example may be the difference between Northeast farms which grow maize as a second crop rather than cassava. Maize production provides significant residues whereas cassava does not.

The Agricultural Statistics of Thailand, Crop Year 1976/77 report published by the Division of Agricultural Economics of the Ministry of Agriculture and Cooperatives provides regional crop production for paddy only. For the other major crops, the META team relied on the work of Russell Brannon in Agricultural Sector Assessment - Thailand (January 1978) a report prepared for AID. He calculated regional percentages of land planted and of production for most crops using unpublished agricultural data as well as regional yields. His results are average for the period 1971 through 1975. In Table 5, the amounts of residues were calculated by multiplying the regional production figures by the ratio of residue to product factors from Table 4. The energy content of the residues is the product of the heat content and the amount of residue.

Table 4. Conversion Factors Used in Traditional Energy Estimates

Agricultural Residues

Residue	Ratio of Residue at Field Moisture to Crop Production	Energy Content at Field Moisture (10^6 kcal/metric ton)
Paddy straw	2.	3.300
Rice husks	0.25 of paddy	3.300
Rice bran	0.05 of paddy	3.600 (0% moisture content)
Maize residue	2.5	3.300
kenaf stick	2.	3.300
bagasse	0.5	2.270 (50% moisture content)
Cassava	0	-

Animal Feed/Fodder Requirements

Animal	Annual Energy Requirement (10^6kcal)	Source
Cattle	5.2[illegible]	Odend'hal (in West Bengal)
Buffalo	8.3	
Pig	2.	approx 1/3 cattle and buffalo intake based on relative weight of animals presented in biogas study by Applied Scientific Research Corporation of Thailand

Animal Residues

Animal	Annual Manure Production (metric tons dry wgt/head)	Energy Content (0% moisture content) (10^6 kcal/metric tons)
Cattle	1.00	3.6
Buffalo	1.25	3.6
Pig	.30	3.6
Fowl	.005	3.6

Table 5. Crop Residue Availability, 1976/77*

Residue \ Region	NORTH Residue 10^6mton	NORTH Energy 10^{12}kcal	NORTHEAST Residue 10^6mton	NORTHEAST Energy 10^{12}kcal	CENTRAL Residue 10^6mton	CENTRAL Energy 10^{12}kcal	SOUTH Residue 10^6mton	SOUTH Energy 10^{12}kcal	WHOLE KINGDOM Residue 10^6mton	WHOLE KINGDOM Energy 10^{12}kcal
Rice Straw	8.22	27.1	9.37	30.9	10.21	33.7	2.34	7.7	30.14	99.4
Rice Husks	1.03	3.4	1.17	3.9	1.28	4.2	0.29	1.0	3.77	12.4
Rice Bran	0.21	0.7	0.23	0.8	0.26	0.9	0.06	0.2	0.75	2.7
Maize Stover	2.81	9.3	1.87	6.2	2.00	6.6	–	–	6.69	22.1
Kenaf Stick	–	–	0.36	1.2	–	–	–	–	0.37	1.2
Cassava	–	–	–	–	–	–	–	–	–	–
Bagasse	0.90	2.0	0.56	1.3	9.82	22.3	–	–	11.28	25.6
Total	13.17	42.5	13.56	44.3	23.57	67.7	2.69	8.9	53.00	163.4
Per capita** (10^6kcal)		4.62		2.94		4.73		1.63		3.71

* For conversion factors, see Table 3. Also this table underestimates crop residues in that it excludes some residues from tobacco, rubber and other agricultural products.

** Using total population of 44 million people in 1977 with 32.5% in the Central region, 20.9% in the North, 34.2% in the Northeast and 12.4% in the South.

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The total availability of agricultural residues is about 160×10^{12} kcal and the overall level of utilization for this fuel implied by the energy consumed in Table 2 (only inanimate energy) is about 8 percent. This figure is mostly likely lower than the actual use of crop residues for fuel. There has been reporting of some fuel use of residues other than husks and bagasse such as corn cobs; however, there is no way presently of estimating this use. For bagasse the utilization rate implied by the NEA figures is about 40 percent. For rice husks the level of utilization was assumed to be about 25 percent rather than that implied by the NEA data of 7 percent (276,000 tons out of total 3,770,000 tons). The revision is based on observations in the Northeast and Central regions where rice husks were used in charcoal, rice and brick production. In charcoal production, husks were used to smother the initial firing of the wood and many of them become charred in this manner; this method is a significant improvement over the use of dirt which is often used in traditional charcoal production. Husks are also used to fire bricks, and in rice mills, and in addition the husk ashes are used as a raw materials for additional bricks. The utilization rate does not assume that these practices are widely used in other parts of the country. Another method of charcoal production which may be common is first covering the burning wood with leaves and then dirt.

The low utilization of crop residues for fuel is due to their use as animal feed and fertilizer and to the current availability of wood fuel, although given available information it is difficult to ascertain the relative importance of these factors. However, based on some calculations, written reports and field observation, the level of crop residue utilization is significant.

With regard to fertilizer use, straw is often plowed into the soil as part of land preparation. More often it appears that the straw is burned and the ashes are spread on the field. The degree of such occurrences is unknown. With regard to use as animal feed, crop residues clearly seem to be an important source. Animals feeding on straw piles in fields and around homes and on the rice straw stubble in fields are a common sight. There is also a good deal of grazing on non-agricultural land and it is difficult to determine the relative contribution of these two feed sources. Nevertheless it is possible to estimate the demand for animal feed and compare it to the availability of crop residues which can be fed to animals.

Using representative figures for annual feed requirements for different animals from elsewhere in Asia, the demand for animal feed was estimated as shown in Table 6. These requirements estimates are based on amounts reported in West Bengal and are slightly higher than other estimates. It could be argued that these figures should be raised for Thailand. The information on the distribution of livestock across the four major regions was available in Brannon's report (above) which had the same figures as the latest agricultural yearbook (1976/77). For cattle and buffalo, since their number fluctuates, an average for the years 1973-76 was used. For pigs there is a distinct downward trend and therefore the 1976 population was used. Table 6 shows the estimation of animal feed requirements and is the basis for the amount used in Table 1. The results of Table 6 indicate that possibly half of the applicable crop residues are used as animal feed. It is difficult to calculate a percentage because of the uncertainty concerning the amount of feed consumed on pasture, or forest land. It is clear from the results for the Northeast that this grazing is necessary. The most significant conclusion which can be drawn from these results is the clear evidence of surplus residues in the North and Central regions and of a tight supply in the Northeast. As will be discussed later in the report, these conclusions have specific implications with respect to energy technologies for the different parts of Thailand.

Animal Energy

As mentioned above, the animal feed requirement was used as the gross indication of animal energy consumed in Thailand both for mechanical work and a transformation into human work via food (see Table 1). There are several other ways in which animal energy can be calculated. One alternative method is estimation of the actual useful work performed both in transportation and in agricultural work (i.e., ploughing). This amount of work is comparable with machine (tractor, truck) energy use and the economic tradeoffs between these technologies can be examined. At this point no analysis of this type has been performed for Thailand although a limited amount of data on buffalo-day agricultural requirements is available. Such an analysis would prove useful in an examination of traditional agricultural practices and of the inputs required for its improvement.

Table 6: Animal Feed Requirements*
and Comparison with Crop
Residues Availability, 1976

Region \ Animal	CATTLE Number 10^3 head	CATTLE Feed 10^{12}kcal	BUFFALO Number 10^3head	BUFFALO Feed 10^{12}kcal	PIGS Number 10^3head	PIGS Feed 10^{12}kcal	ANNUAL TOTAL FEED REQUIREMENTS (10^{12}kcal)	CROP RESIDUE AVAILABILITY** (10^{12}kcal)
North	979	5.09	1245	10.33	826	1.65	17.07	37.1
Northeast	1927	10.02	3543	29.41	737	1.47	40.90	37.9
Central	776	4.04	727	6.03	988	1.98	12.05	41.2
South	724	3.76	238	1.98	469	0.94	6.68	7.9
Whole Kingdom	4406	22.91	5753	47.17	3020	6.04	76.13	124.2

Note: It is important to recognize that some fraction of the feed requirement is met from grazing on non-agricultural land.

* Fowl were not included.
** Total of only rice straw, rice bran, maize residue.

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Animal Residues

Animal residues or manure is rarely used in Thailand for fuel. Nevertheless a great deal of manure enters the energy system in the form of chemical energy as fertilizer. At this time there does not seem to be any estimate available as to the extent of this use or as to the effectiveness of its use. However based on observations and qualitative statements in rural village studies, there does appear to be a surplus or a great deal of unused manure. Using the representative conversion factors presented in Table 4, the total availability of dry manure is estimated in Table 7. The total availability of manure is approximately 45 x 10^{12}kcal, which ignoring collectability problems, per capita availability is equal to about 20 percent of present per capita energy use of inanimate energy. With at a minimum the nightly corraling of animals, approximately half of the manure may be collectable for fuel or other use. The Northeast with its large animal population has the largest availability of manure, and therefore would appear to be the most likely target of programs involving its use. Presently there are several programs exploring the use of manure as a source of biogas with mixed success. It may be that the major problem is the cost of the equipment since surveys indicate that most people are willing to collect and utilize the manure in this manner. However, there does appear to be resistance to the use of human excreta or night soil.

Table 8 estimates the potential contribution of biogas to Thailand's, and in particular the Northeast's, energy supply. The fresh manure production per annum and gas production per kilogram of fresh manure figures were taken from a study by the Applied Scientic Research Corporation of Thailand, Pre-Feasibility of the Biogas Technology Application in Rural Areas of Thailand (February 1979). This study references an NAS study and the ESCAP Biogas Newsletter and the unit gas production estimates are at expected current yields; they do not reflect the upper theoretical yields. The collectability percentages are merely rough estimates, but intend to be somewhat practical.

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Table 7: Animal Residue Availability, 1976
(dry; 0% moisture content)

Region / nimal	NORTH		NORTHEAST		CENTRAL		SOUTH		WHOLE KINGDOM	
	10^6mton	10^{12}kcal	10^6mton	10^{12}kcal	10^6mton	10^{12}kcal	10^6mton	10^{12}kcal	10^6mton	10^{12}kc
Cattle	0.98	3.52	1.93	6.94	0.78	2.79	0.72	2.61	4.41	15.8(
Buffalo	1.56	5.60	4.43	15.94	0.91	3.27	0.30	1.07	7.19	25.8!
Pigs	0.25	0.89	0.22	0.80	0.30	1.07	0.14	0.51	0.91	3.2(
Fowl	n.a.	n.a.	0.08	0.29	n.a.	n.a.	n.a.	n.a.	0.31	1.1
Total *	2.79	10.01	6.66	23.97	1.99	7.13	1.16	4.19	12.82	46.12
er capita vaihbility 10^6kcal/yr)		1.09		1.59		0.50		0.77		1.05

* Regional totals do not sum to kingdom total because regional distribution of fowl population was not completely available.

Note: See Table 4 for conversion factors.

Table 8: Potential Annual Yields of Biogas from Animal Residues

animal	percent collectable	kg wet manure/ animal/year	m^3 biogas/ kg wet manure	animal population (10 head)	potential annual biogas production (10^6 m^3)
			WHOLE KINGDOM		
cattle, buffalo	50%	5045	.0467	10.16	1197
pig	75%	1241	.0872	3.02	245
Chickens	75%	34.2	.1215	49.9	155
					1597

at 5000 kcal/m^3, total potential = 8.0×10^{12} kcal
annual per capita rural potential * = 0.22×10^6 kcal

			NORTHEAST		
cattle, buffalo	50%	5045	.0467	5.470	644
pigs	75%	1241	.0872	.737	60
chicken	75%	34.2	.1715	14.15	44
					748

at 5000 kcal/m^3, total potential - 3.74×10^{12} kcal
annual per capita rural potential * = 0.26×10^6 kcal

The urban rural breakdown is 17:83 for the entire country and 4:96 for the Northeast according to the World Bank country report.

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The table shows the biogas potential to be about 8×10^{12} kcal per year of which about 47 percent lies in the Northeast.

For the Northeast, this potential can meet nearly 10 percent of the total domestic use of fuel wood and charcoal (per the FAO report above by de Backer and Openshaw (see also discussion below)).

Human Energy

As with animal energy there are several ways of determining the use or output of human energy. However for the purposes of this discussion, one of the simplest was used for primarily illustrative purposes: total caloric intake. Other methods, such as energy consumed in economic activity or useful energy produced, were not considered due to their complexity. The average caloric intake was based on an NESDB report on food and nutrition development.** For the estimate in Table 1, it was assumed that the total average caloric intake was 1900 kcal per person daily and that 95 percent of this intake was met by non-meat and dairy sources. The meat and dairy sources were excluded because these amounts are captured under the consumption of animal energy.

Fuel Wood and Charcoal

As shown in Table 2, the largest discrepancy between official figures and other sources occurs for the consumption of fuel wood and charcoal. The forest resources of Thailand are very extensive, wood is widely available, and as a result much of the wood consumed as fuel was collected by the actual consumer without passing through the market place. Furthermore, due to the nature of most wood collection and the informal small scale nature of fuel wood and charcoal marketing, records do not reflect the majority of fuel wood and charcoal use.

** Subcommittee on Food & Nutrition Planning, National Economic and Social Development Board in Cooperation with USAID and UN International Children's Fund, Technical Information and Base-line Data for the Formulation of National Plan on Food & Nutrition Development (1977-1981); February 1977.

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The primary alternative to the official figures is the de Backer and Openshaw 1972 FAO Report to the Government of Thailand, Present and Future Forest Policy Goals: A Timber Trends Study 1970-2000 (No. TA 3156). The study involved extensive surveying of both fuel and non-fuel wood and estimated national wood consumption by use for 1970. Of importance to this present discussion was the wood fuel survey which involved examining residential or domestic, industrial and social services wood fuel use. The residential survey sampled nearly 2400 rural households in 19 provinces over the four major geographic regions of Thailand. It also included 3550 urban households of which nearly half were in the Bangkok-Thonburi area. The sample constituted about 0.05 percent of all rural households and about 0.25 percent of all urban households. The results of the residential surve are presented in Table 9.

Using the conversion factors of 0 6 metric ton per cubic meter of roundwood equivalent (de Backer and Openshaw) and of 4.0 million kcal per metric ton of wood (equivalent to 7200 Btu per pound), residential or domestic wood fuel use in 1970 amounted to 106.3 x 10^{12}kcal. De Backer and Openshaw estimated industrial and service sector wood fuel consumption in 1970 to be 3.7 and 0.56 million cubic meters or 8.9 and 1.3 x 10^{12}kcal respectively.

Due to numerous uncertainties concerning the trend of wood fuel use over the past eight years since the FAO study, fuel wood and charcoal use were reestimated using the per capita figures. Using a total population of 44 million people currently and the FAO per capita wood fuel use of 1.23 m^3, present residential wood fuel use would be 130 x 10^{12} kcal. This is an increase of about 24 x 10^{12}kcal which represents a 10 percent increase in the total for inanimate energy consumption for Thailand in 1977, solely due to population growth. This new figure does not take into account several possibly significant trends. First of all it ignores the increased percent of the country's population in urban areas, which would lower fuel wood use and increase charcoal use. Secondly, the net effect of the issue of the substitution between commercial fuels (LPG, kerosene) and wood is unclear. Whereas the real growth of income in some cases leads to increased use of commercial fuels, the significant increase in the price of these fuels has possibly

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Table 9: Results of FAO Residential Woodfuel Use Survey *

PER CAPITA **
(m^3 per capita)

Region		Woodfuel	Fuelwood	Charcoal
Rural	1.27		0.76	0.51
North		1.25	0.79	0.46
Northeast		1.35	0.95	0.40
Central		1.17	0.36	0.81
South		1.24	0.86	0.38
Urban	1.00		0.11	0.89
Bangkok/ Thonburi		1.00	0.10	0.90
other urban		0.99	0.12	0.88
Total	1.23		0.67	0.56

Annual Consumption of Wood Fuel, Total 1970

(million m^3)

Region		Woodfuel	Fuelwood	Charcoal
Rural	39.0		23.4	15.6
North		9.5	6.0	3.5
Northeast		16.3	11.5	4.8
Central		8.2	2.5	5.7
South		5.0	3.5	1.5
Urban	5.3		0.6	4.7
Bangkok/Thonburi		3.2	0.3	2.9
other urban		2.1	0.3	1.8
Total	44.3		24.0	20.3

* Page 92 Project Working Document; all units in roundwood equivalents; assumed 6.0 m^3 R.E per metric ton of charcoal.
** This is the average for all households whether consuming woodfuel or not.

counteracted this possible income effect. Thirdly, the effect of Government policies to protect forest land and the effects of possible shortages due to deforestation are also unclear.

Based on the FAO study, per capita wood fuel use would be 1.23 m^3 or 2.95 c 10^6kcal. This level of household fuel wood and charcoal use is in line with figures from around the world as shown in Table 10. The figures in the Table were calculated using different factors in some cases which accounts for the difference between the figure used for the Thailand national average and the one presented above.

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TABLE 10 ; HOUSEHOLD TRADITIONAL FUEL USE
(ANNUAL PER CAPITA ESTIMATES -- 10^9 JOULES)

Country	Locale	Year	Total Traditional Fuel Use	Firewood and Charcoal	Animal Residue	Agri-cultural Residue	Percent of National Population Using Traditional Fuels	National Average Traditional Fuel Use[1]
			(For Traditional Fuel Users Only)					
Bangladesh	national	1973/74	2.56	.41	.77	1.38	91%	2.32
Gambia	national	1972	17.3	17.3			99%	17.3
India	rural	1970	7.16	4.38	1.77	1.02		
Kenya		1960	10.9	10.9				
Nepal	national	1974/75	8.5	8.2	.1	.2	99%	8.5
Nigeria	northern, urban	1972	10.5	10.5		n.a.		
Peru	national	1976	17.7	15.1	— 2.6 —		60%	10.8
Sudan	national	1964	14.2	14.2			99%	14.2
Tanzania	rural[8]	n.d.	29.9	29.9				
	national[9]	1961	12.3	12.3				
	national[10]	1970	23.2	23.2			99%	23.2
Thailand	national	1972	14.2	14.2			97%	13.8
Uganda		1959	10.9	10.9				
Upper Volta	rural	1977	4.2	2.3		1.9		

[1]The relationship between the national average for per capita traditional fuel use and the traditional fuel user average is based on the percent of the total population which uses such fuels. Specifically the national average is the product of actual use estimates and the percentage of users.

MICRO ENERGY PICTURE

Village-Level Analysis in the Northeast

Analysis of the social, economic and environmental aspects of rural energy development will have both macro and micro components. The analysis set forth in Annex III above examines specific rural energy fields of opportunity in the context of Thailand's overall rural energy requirements. This micro analysis involves examination of a program in a specific location within a particular set of macro conditions. These levels intersect in that the macro analysis is based to some degree on the micro with regard to the viability of the individual investment. Therefore it is necessary to examine and evaluate the feasibility and worthwhileness of the proposed technologies at the micro or, for the purposes of most of the rural technologies addressed in the project, the village or family level.

In order to provide a context for such analysis, a representative village in the Northeast region of Thailand was constructed from numerous sources. This village is representative in the sense that the per capita resource endowments, land use patterns and general economic conditions reflect those for the Northeast in general. Therefore much of the information used were aggregate figures for the entire Northeast which were scaled down to village level quantities. This aggregate data was supplemented by several village level studies of locations in the Northeast as well as elsewhere is the country.

For regional information the sources generally used were the reports by Russell Brannon, Agricultural Sector Assessment - Thailand (January 1978; and by the World Bank, Thailand: Toward a Development Strategy of Full Participation, A Basic Economic Report (September 1978). Also used were several Agricultural Economics Research Bulletins prepared by the Division of Agricultural Economics, MOAC as background work for Thailand's Fourth Five-Year Agricultural Development Plan (B.E. 2520-2524). The distribution of farm sizes is based on data from the General Farm Survey 1973/74 by the Division of Agricultural Economics, MOAC which was presented in the Brannon report. The village level cropping pattern is based on information from all of these reports.

Village level livestock population were derived from MOAC and Brannon. Farm and household level information was available from the studies by the Chulalongkorn University Social Research Institute such as Village Khon Kaen - Social and Economic Conditions of a Rural Population in Northeast Thailand by Amara Pongsapich with the collaboration of Jacques Amyot and Friedrich W. Fuhs (Bangkok, 1976). This study surveyed village and household level data for four villages in Khon Kaen province during the late 1960s. Other descriptions of village life were also examined.

Northeast Village Model

This village has 105 families and a total population of 677 people. At the center of town is the primary public school and at the outskirts is the temple with adjacent land and a rice mill with a 15 horse power diesel engine capable of milling 5-6 tons of paddy daily. Nearby is a small pond used for fishing and drinking water. The land surrounding the village is of varying altitudes; the lowlands being primarily partitioned into rice paddies whereas the higher land is used for upland crops. There are scattered trees in the fields and around homes. At any time much of the farm land lies a fallow; on some of the land brush and small trees are growing. In the dry season, cattle and buffalo graze on the paddy stubble in the fields and/or piles of cut and stacked rice straw.

Of the 105 households in the village, 100 are primarily farmers while the remaining five include the miller, two teachers, a store owner and possibly a Government official. The farmers can be divided into three classes: poor, middle and rich according to farm land and livestock resources. The average household size for the village is nearly 6.5 people. Slightly more than half of the families are nuclear rather than extended; however, this varies over time as families pass through the cycle of nuclear to extended to nuclear as the family size expands when the children grow up and their spouses, generally husbands, move in with the family, and then contracts as the children and their spouses set up separate households. Table 1 shows the basic demographic data along with average land and livestock resources by class. Average farm size is 20 rai.

With regard to agricultural production, although rice (glutinous with some non-glutinous) is the primary crop,

Table 1. Village Demographic, Land and Livestock Resources by Class

PER HOUSEHOULD

Class	Family Type %nuclear	%extended	person/ household	average farm size	No. of Animals Cattle	Buffalo	Pig
Non-agri-cultural	100%	0%	4	-	-	-	1.
Poor	80%	20%	5	9.4	ø	1	ø
Middle	50%	50%	6.5	25.4	1	2	0.25
Rich	25%	75%	8.5	62.5	2	2.5	1.

TOTALS

Class	Number of households	Number of persons	Total farm land (rai)*	Total number of animals Cattle	Buffalo	Pig
Non-agri-cultural	5	20	-	ø	ø	5
Poor	23	115	216	ø	23	ø
Middle	56	364	1400	56	112	14
Rich	21	178	1313	42	53	21
Total:	105	677	2929	98	188	40

* Net of two percent for household structures.

the principal upland crop varies depending on location in the Northeast. In this village, as is typical of the Northeast, there is no double cropping and all rice is rain-fed only. The cropping intensity (percent of farm land actually planted or harvested) was assumed to be about 60-65 percent with 70 percent of the crop land planted with rice. The cropping intensity was varied slightly by farm class, being higher for the poor and lower for the rich. Despite the availability of aggregate cropping pattern data for the Northeast, no detailed information was located on how cropping patterns vary by farm size. It was assumed that poor farms grow only rice, that middle farms plant 80 percent of their farmed land with rice, and that the rich farms plant slightly over half their land with rice. When a village level average is calculated, the basic assumption of 70 percent of planted land in rice is met. Table 2 shows the cropping patterns and the levels of agricultural production for the different classes. The yields per rai used were about 220 kg. rice, 1980 kg. cassava, 340 maize and 150 kg. kenaf.

As can be seen from Table 3, the village as a whole produces a surplus of rice; however, on a class level some transfer will be required, possibly in the form of income for agricultural work or for services such as rice milling. The level of this surplus reflects the fact that reportedly the Northeast as a whole presently produces a five percent surplus and that the farm households must also supply the non-agricultural households which are about 25 percent of the total households in the Northeast.

Table 4 examines the availability and demand for animal feed. This situation could vary significantly depending on location in the Northeast. Villages growing maize will have an abundant source of feed from crop residues whereas cassava or kenaf producing villages will require pasture land off-take to supplement their supplies of paddy residues.

Table 2. Village & Class Cropping Patterns and Agricultural Production

I. Cropping Pattern*

	Per Farm					Per Class			
		Cropping	land harvested(rai)				land harvested(rai)		
Class	land(rai)	intensity	total	paddy	other	No.of farms	total	paddy	other
poor	9.4	70%	6.58	6.58	0	23	151.3	151.3	0
middle	25.4	65%	16.25	13.00	3.25	56	910.0	728.0	182.0
rich	62.5	60%	37.50	19.76	17.74	21	787.5	414.9	372.6
			Village totals:			105	1848.8	1294.2	554.6

Village cropping intensity : 63%

percent of land harvested in paddy : 70% assumption based on NE cropping patterns

II. Agricultural Production** (metric tons annually)

	Per Farm				Per Class			
		other				other		
Class	paddy	Cassava or	maize or	kenaf	paddy	Cassava or	maize or	kenaf
poor	1.45	0	0	0	33.3	0	0	0
middle	2.86	6.45 or	1.09 or	0.49	170.1	361	61	28
rich	4.35	35.2 or	5.96 or	2.70	81.3	739	125	57
		Village totals:			285.	1100 or	186 or	85

* These cropping patterns do not take into account vegetable gardens. The "other" catagory for the NE could be cassava, maize or kenaf depending on location and market conditions.

** The yields were taken from Brannon for the NE; they were assumed to be constant over farm size though there is some evidence that the smaller farms obtain higher yields.

Table 3. Village & Class Food Balances (rice only[1])

	Per Household				Per Class		
Class	Paddy production (tons)	net rice availability[2] (tons)	annual demand[3] (tons)	surplus(+) deficit(-)[4] (tons)	net rice availability (tons)	annual demand (tons)	surplus(+) deficit(-) (tons)
non-agricultural	0	0	0.66	- 0.66	0	3.3	- -3.3
poor	1.45	0.80	0.83	- 0.03	18.4	19.0	-0.6
middle	2.86	1.67	1.07	+ 0.60	93.7	59.9	+33.8
rich	4.35	2.54	1.40	+ 1.14	53.4	29.5	+ 23.9
		Village totals:			165.5	111.7	+ 53.8

1. Due to the varying availability of a second food crop and since it appears that possibly 80 percent of a rural NE Thai caloric intake is in the form of rice, a daily caloric intake of rice was assumed to be 1600 kcal or one pound of rice daily. This intake level amounts to .165 metric ton of rice per capita annually; this figure nearly matches the average apparent domestic per capita intake nationally over the past 10 years. Although there are undoubtably variations in food and rice consumption across class, this was not included due to lack of specific data. Note in Annex III above, the NESDB nutrition study caloric figure nationally was 1900 kcal per person, 95 percent of which was from non-meat and dairy sources. This would be comparable to the 80 percent/1600 kcal figure for rice for the NE, taking account of a probable average lower than a national figure.

2. Net rice availability is assumed to be the total amount of rice produced on the farm (65 percent of paddy production) less 10 percent for losses and seed requirements.

3. Annual demand is .165 for rice per capita multiplied by number of persons per household.

4. Surplus or deficit is net rice availability less annual demand.

Table 4. Village and Class Annual Feed Balances

I. Village Feed Requirements

animal	annual intake/need	crop residue, equivalent(tons)	number of head	Total feed demand (tons)
cattle	5.2×10^6 kcal	1.6	98	157
buffalo	8.3×10^6 kcal	2.5	188	470
pig	2×10^6 kcal	0.6	40	24
				651 tons - total annual feed requirement

II. Village Feed Availability from Crop Residues

crop	crop production (tons)	residues: crop ratio	total crop residues (Tons)
paddy straw	285	2.	570)
paddy bran	285	0.05	14)) 584 tons for cassava and kenaf growing village
maize residues	186	2.5	465
			1049 tons for maize growing villages

III. Village Balance

A. For maize growing villages crop residues meet annual feed requirements.

B. For cassava or kenaf growing villages, a minimum of 67 tons of annual feed or about 10 percent of the total requirement must be met by offtake from grazing or pasture land

IV. Household Feed Balances (including only paddy straw)

class	annual feed requirement (tons)	on-farm rice straw availability (tons)	shortage (-) or surplus (+) (tons)
non-agricultural :	only animals in this class are pigs owned by the miller who feeds them bran.		
poor	2.5	2.9	+ 0.4
middle	6.7	5.7	- 1.0
rich	10.0	8.7	- 1.3

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These tables summarize the present agricultural situation of this village. Although a detailed calculation of the conditions of the village in the future was not undertaken, some trends seem likely based on the results of the National Crop Model of Thailand for the present Agricultural Development Plan. Two of the major pressures on the Northeast agricultural situation will be increasing population growth and decreasing soil fertility. The forecasts for 1981 indicate decreasing rice yields and an overall decrease in total crop income. The percent of land irrigated remains low although there will be at least a doubling of that area. The Northeast is expected to become a net importer of rice to meet household needs. Therefore on the village level, the rice surplus will decrease as the ratio of farmland to population decreases. The poor will need to earn more income in order to be able to purchase rice. In general the per capita availability of resources will be less.

With regard to the availability of wood fuel in the Northeast, regional average would be misleading in light of the wide variation in actual availability in different parts of the Northeast. Whereas the northern and western parts of the region still have forests, much of the rest has little forest resources.

According to the 1972 FAO timber study of de Backer and Openshaw, there were 7.8 million hectares of forest land in the Northeast in 1970. The standing stock of these forests is the lowest of any region of Thailand. Recalculating the FAO figures to reflect both sawlog size and small timber, Northeast forest land had on the average about 43 m^3 per hectare standing stock with an annual increment of only about 1.0 m^3 per hectare. This compares to the reestimated country averages of 71.5 and 1.8 m^3 per hectare respectively. The total Northeast demand for residential wood fuel in 1970 according to the FAO study was 16.3 million cubic meters (11.5 fuel wood and 4.8 charcoal). Comparing this demand with the total annual increment of Northeast forests of about 8 million cubic meters, and the infeasibility of meeting the deficit from non-forest land, clearly indicates at least one motivation for the apparent deforestation of this region. In fact according to more recent statistics, the forest area of the Northeast was reduced to 5.10 million hectares in 1973 according to the Royal Forest Department.*

The sources of non-crop biomass for a village or household in the Northeast accordingly appear to fall into the following categories:

(i) forested public land
(ii) deforested public land
(iii) private land
(iv) imported or purchased biomass.

The present level of information concerning the sources of woodfuel is very limited. The FAO study had national demand met by the annual increment of small size forest timber plus a variety of other sources, such as from mangrove forests, rubber plantations, removals by shifting agriculture, falling losses off crows (falling timber tops), and production from farmlands. The latter source, farmland production, was the largest of these other sources at eight million m^3 in 1970. Given the total area of farmlands in 1970 of about 15.5 million hectares, the average off-take was about 0.5 m^3 per hectare from farmland. No regional estimates of this off-take were presented, but in light of the relatively low productivity of Northeast forest land, for the purposes of this exercise it will be assumed that Northeast farmland yields 0.3 m^3 of wood fuel per hectare annually. For grazing or animal feed purposes it will be assumed that deforested public land and non-cropped private land yields one ton per hectare of feed annually. This figure is meant to be conservative to represent the fact that if such land were significantly more productive it would be planted; however, no actual figures concerning the productivity of this land were located.

Based on these estimates of useful biomass productivity, the various land requirements involved in meeting domestic wood fuel and grazing can be examined. First the resources available from the village farmland will be summarized. Non-cropped farm land amounts to 35 percent of total farm land (after netting out 2 percent for household structures).

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* p.7 of Chapter 2 of Thailand's Fourth Five-Year Agricultural Development Plan B.E. 2520-2524 Guidelines prepared by Division of Agricultural Economics, MOAC (Agricultural Economics REsearch Bulletin No. 114 August B.E. 2519).

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Therefore, about 1025 rai or 164 hectares of land is available for some animal grazing with a potential yield of about 164 tons of feed annually; this amount appears to be adequate to meet the feed requirements not met by rice straw and bran. (From Table 4 for a cassava or kenaf producing village, the minimum pasture land requirement was 67 tons.

On the household level, the middle and rich class farms are able to supply themselves with adequate grazing on their non-cropped land. The middle class farm would have an annual yield of about 1.4 tons of feed for grazing whereas their minimum requirements would be about 1.0 tons annually. For the rich farm, the annual yield of feed from these lands would be about 3.5 tons and their minimum requirements about 1.3 tons. (See Table 4 above.) To the extent that deforested public lands are accessible, the availability of feed from grazing is even larger.

The balance between crop residues and pasture land as feed supplies and the demand for feed is quite sensitive to a number of factors (in non-maize producing villages). First of all it must be recalled that feed requirements per animal are based on studies in West Bengal and are most likely underestimates of the actual requirements of Thai livestock. A 10 percent increase in feed requirements would push the minimum off-take required toward the limit of pasture land productivity. A second issue is the actual yield of pasture land about which there is great uncertainty. Given the present conditions and the general trend of soil fertility in the Northeast, increased productivity per unit of land is not likely. The implications of this situation are that as both human and animal populations increase, the pressures for increased farm land will grow for not only increased crop production but also for increased pasture land. This system is sensitive to the relative growth rates of human and animal populations, land planted for rice and other crops, and cropping intensity. For example the taking over of pasture land for cropping can either increase or decrease the availability of feed depending on the crop. Furthermore forestation programs may reduce the availability of pasture land unless alternative supplies of feed are ensured.

With regard to wood fuel, annual domestic demand in the Northeast according to the FAO study is 1.35 m^3 per person; therefore, the total model village demand is 914 m^3 annually. If the annual yield from farmland is 0.3 m^3 per hectare,

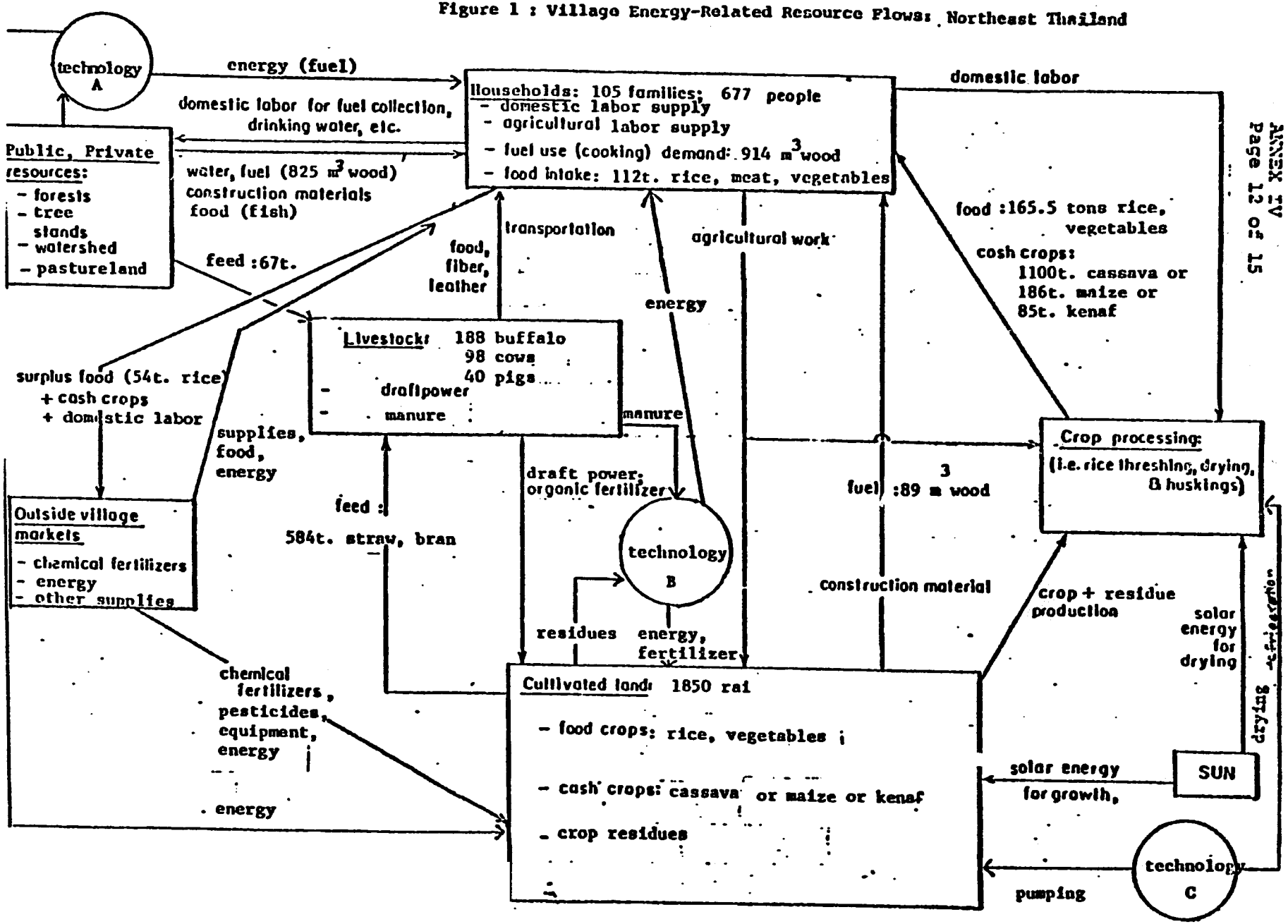
this source would contribute 141 m^3 or about 15 percent of the total demand. The remaining 773 m^3 must be met by either forested public land or imported wood fuel. If this amount was supplied by the annual increment of the forests, about 770 hectare of forest would be needed; an area equal to about 1.65 times the area of the village. For the Northeast in 1970 forest land area was about 85 percent of the farm land, and since forest land has been decreasing, this ratio (1.65) of accessible forest to farm land is only rarely available. The remaining options for wood fuel supply are imports or deforestation. If total forest clearing were practiced, about 18 hectares of Northeast forest land would be deforested annually to meet village level requirements.

If 773 m^3 of fuel wood were purchased at ₱60/m^3, the cost (₱46,400) would amount to about one-fifth of the value of the surplus rice produced (at ₱4/kg of rice). If a woodlot were to be established in this village, its size would have to be at least 47 hectares (assuming 16.5 m^3 per hectare annually) which represents about 10 percent of the total village area.

Figure 1 presents a flowchart outlining the major resource flows within the village. The quantities indicated are all based on Tables 1 through 4 and the accompanying text. The circles in the figure represent opportunities for the introduction of village-level energy technologies. Technology A could be improved charcoal production, improved stoves, a microhydro project or a village woodlot. Technology B could be biogas or pyrolysis (or even composting). Technology C could be solar pumping or solar drying. Because of the diverse but interdependent use pattern of different resources, the introduction of an energy technology will alter a multitude of resource flows.

An example, the introduction of the pyrolysis of agricultural residues, will be examined. A one ton per day unit operating 150 days per year will require 150 tons of residues annually: 70 tons of paddy husks and 80 tons of paddy straw. Approximately 37.5 tons of charcoal and 22.5 tons of pyrolytic oils will be produced. Figure 2 summarizes the resource flows affected by the technology. Inputs for pyrolysis divert 80 tons of straw from animal feed thereby requiring 80 more tons of fuel from pasture land. The charcoal produced is equivalent to about 225 m^3 of wood

Figure 1 : Village Energy-Related Resource Flows: Northeast Thailand



(assuming $6m^3$/ton of charcoal) supplied for fuel to households. This diminishes the fuel wood required from the forest land and private land from 825 m^3 to 600 m^3. Furthermore the pyrolysis unit required capital, but the pyrolysis oils can be sold to outside markets which will generate cash income. Overall with regard to material flows, the pyrolysis unit reduces the need for forest resources at the expense of increasing the need for pasture land or fodder. In turn fodder could be provided on a more intensive basis by growing leucena for fodder on remaining pasture land.

Another example is presented in figure 3 which outlines the effects of the introduction of biogas plants. In this case, biogas diverts the use of manure from direct use as fertilizer as well as requires capital and labor from the household. On the other hand the biogas units provide fuel for the household, fertilizer and possibly pumping energy for the cropland. In addition biogas decreases the demand for wood from the forest land and also increases crop production, thereby either raising cash income or reducing food purchases.

These example were provided in order to show how a detailed analysis of the resource flows in a village will apply in the evaluation of a new technology.

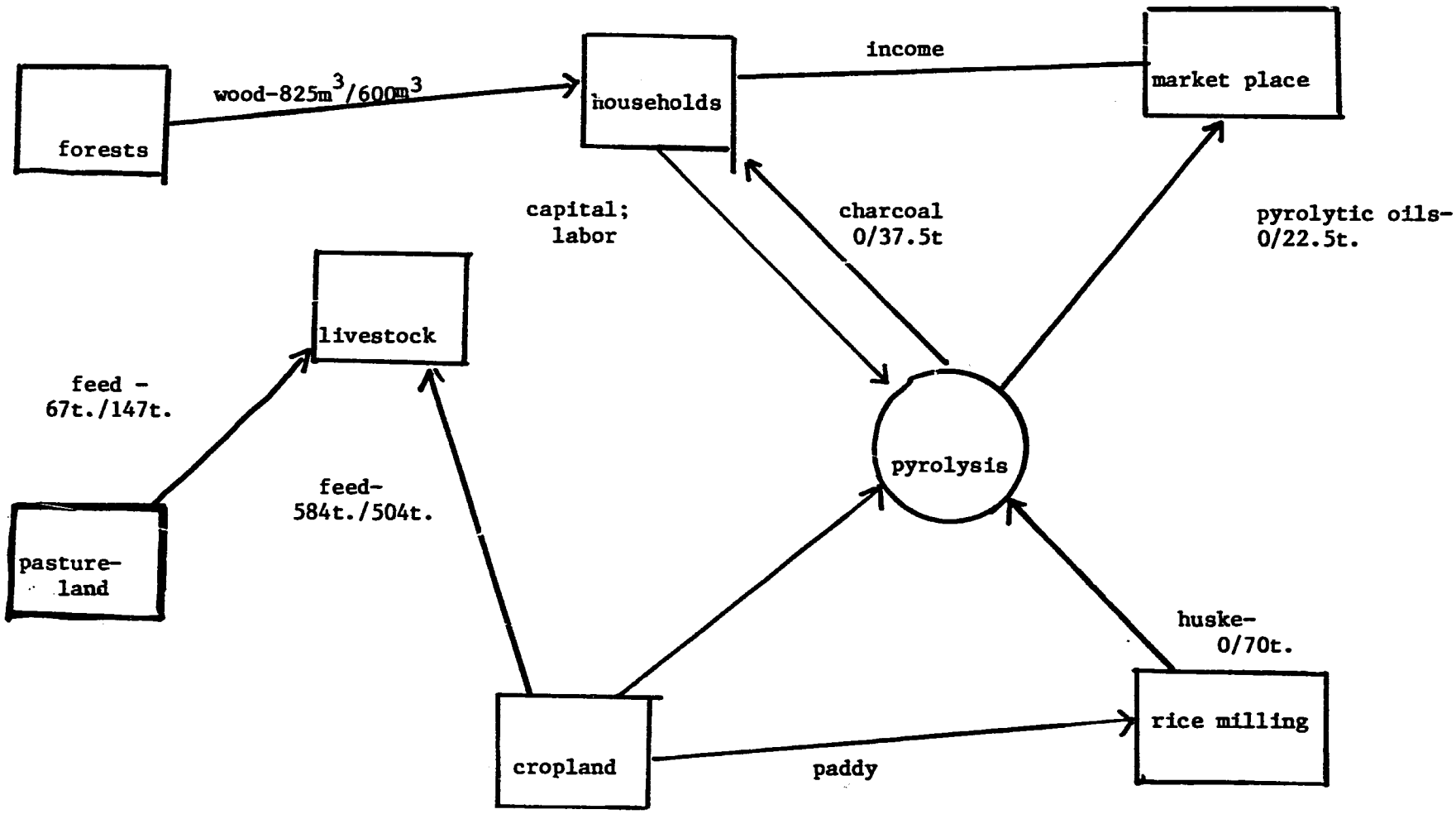


Figure 2: Altered Annual Resource Flows Due to Pyrolysis of Agricultural Residues
(flows before/after introduction of technology)

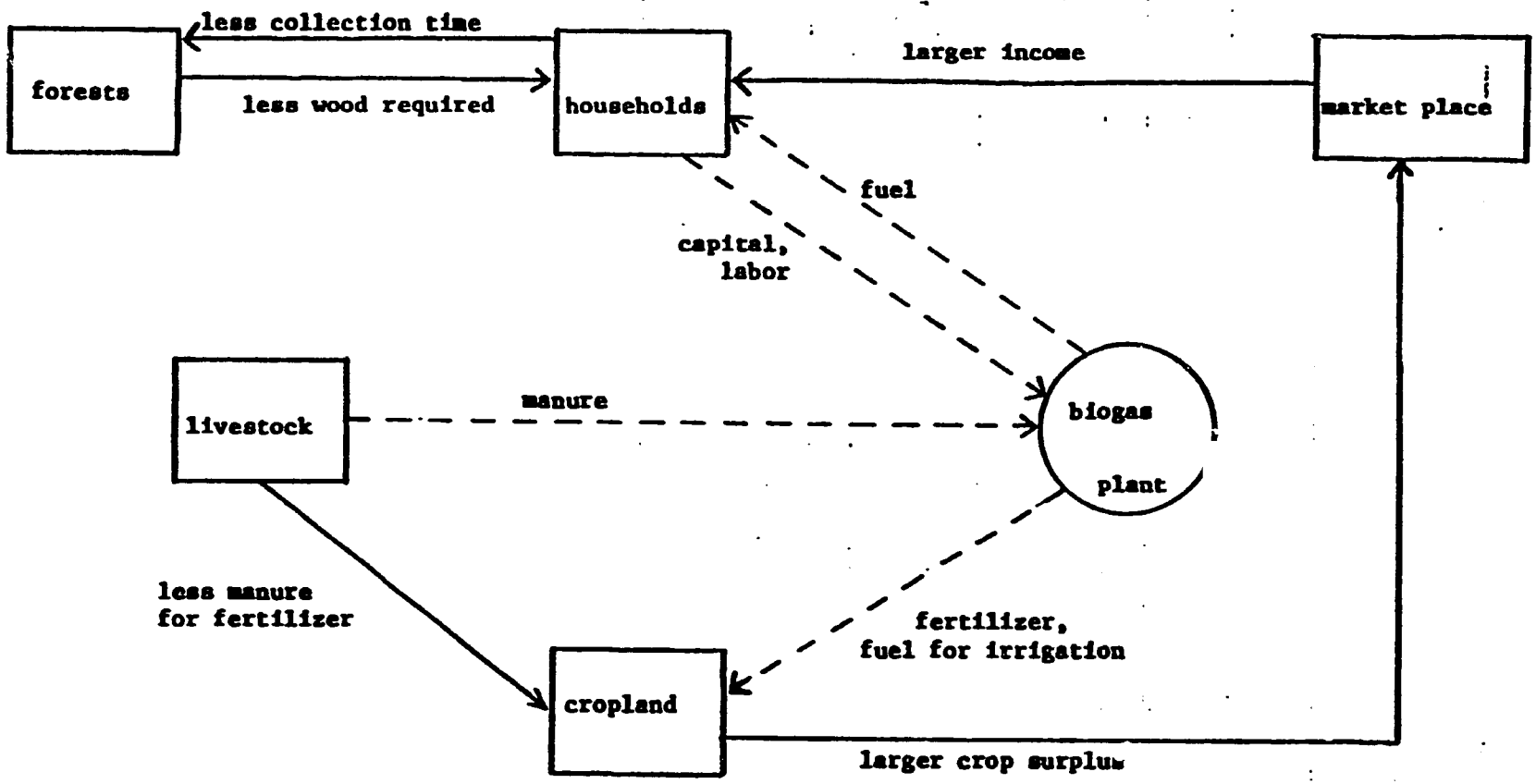


Figure 3: Altered Resource Flows Due to Biogas Plant

(new flows: ——————>)

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ENERGY NATIONAL/INFORMATION AND DOCUMENTATION CENTER, THAILAND AND REGIONAL ENERGY CENTERS

A. The National Energy Information and Documentation Center, Thailand

The National Energy Information and Documentation Center for Thailand (NEIDCT), will be developed and implemented over a period of five years. Its objective will be to establish a centralized source of information on energy, on which various Government, semi-public and private bodies can draw, for preparing studies and conducting research needed for planning and policy-making activities.

The NEIDCT's responsibilities will include:

- collection, processing, and publishing accurate, complete and up-to-date statistics on energy;
- designing a system to answer specific questions put forward by private and public sectors on energy statistics and data.

Specific activities will be as follows:

(1) preparation of an inventory and analysis of the need for data and information on energy, and analysis of the available data sources as well as the available data and selected documents;

(2) acquisition and processing of relevant data and documents;

(3) development of an appropriate coding system for the registration of data sources based on an acceptable standard;

(4) development of questionnaires to be sent out at regular intervals, the results of which would be entered and stored on punched cards;

(5) development of computer programs for processing, storing, and retrieving these data;

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(6) preparation and dissemination of publications and reports derived from the data and documents;

(7) preparation and enforcement of legislative and administrative measures for the reporting of statistics on energy production and consumption by individual firms.

The NEIDCT will be located at the National Energy Authority (NEA) of Thailand. It will draw from relevant resources located at the Electricity Generating Authority of Thailand (EGAT), the National Statistical Office (NSO), the National Library, the Asian Institute of Technology (AIT) Library, and the Renewable Energy Resources Information Center (RERIC) at AIT.

During the initial period of its development the Center will emphasize the collection, storage, and dissemination of data required specifically for rural energy.

The NEIDCT will require office space for a staff of five to six persons during the first year. The staff is anticipated to grow to 10 persons by the fifth year. By the second year the facility will require space to house 3,000-5,000 books, 100-200 journals, and approximately 50 linear feet of file storage for statistical records. It will require a reading room with space and furnishings suitable for 3-6 users, and during the third year will require space for a computer terminal and related reference materials.

The NEIDCT will not duplicate the RERIC at AIT. The RERIC houses publications about renewable energy resources. NEIDCT will house, primarily, statistical data and policy-related publications specifically related to Thailand's national energy resources and policy administration.

Statement of Work

The NEIDCT program will be performed via eight major task areas, as follows:

Task 1. Planning and Design of the NEIDCT.

Task 2. Development of Procedures and Standards.

Task 3. Identification of Resources and Establishment of Organizational Relationships.

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Task 4. Identification of Users and User Requirements.

Task 5. Selection of Resources.

Task 6. Acquisition and Processing of Resources.

Task 7. NEIDCT Services.

Task 8. NEIDCT Evaluation and New Activities.

The following task descriptions include (1) a summary of subtasks to be performed, (2) the approximate period of performance, and (3) anticipated reports and products.

Task 1. Planning and Design of the NEIDCT

The specific plans for the NEIDCT will be developed and described and its mission will be defined. The NEIDCT will then be planned in detail. Subtasks to be performed are described as follows:

1.1 Development of NEIDCT Mission Statement.

1.2 Establishment of Priorities Among Resources, User Groups, Services.

1.3 Determination of Rural Energy Information Requirements.

1.4 Determination of Ancillary Energy Information Requirements.

1.5 Preparation of a Detailed Plan for Years 1-2, General Plan for Years 3-5. Initially this Task will require approximately three months, but the substance will continue thereafter as a general planning activity.

The product of this Task will be a design document with subsequent memoranda describing additional detail or required modifications to the original plan.

Task 2. Development of Procedures and Standards

Procedures and standards for the collection and reporting of data will be developed. The procedures and standards will contribute to the development of new legislation related to data reporting. This work will be performed according to the following Subtasks:

2.1 Development of Procedures, Forms, and Standards for Energy Related Data Surveying, Collection, Analysis, and Reporting (primarily NEA).

2.2 Development of Procedures, Forms and Standards for Energy Related Data Reporting by Non-NEA Organizations.

2.3 Development of Procedures, Forms and Standards for Data Bank Collection, Analysis, and Description (e.g. data bank from other Government agencies).

2.4 Development of Procedures, Forms and Standards for Document Acquisition, Analysis, and Description.

2.5 Procedures, Standards, and Forms for General NEIDCT Management and Resources Control.

This Task will be emphasized throughout the first and second project years. It will continue throughout the project, providing a mechanism for new developments and related requirements to be incorporated in a systematic manner.

The products of this Task will include (1) a specifications document which details the procedures, standards, and forms to be used within the NEIDCT; and (2) memoranda describing requirements and recommendations for legislation related to data collection and reporting.

Task 3. Identification of Resources and Establishment of Organizational Relationships

According to the results of Tasks 1 and 2 and the mission scope and priorities established therein, organizations that can provide data and related administrative and technological resources to the NEIDCT will be identified and consulted. Inter-organizational agreements will be established to ensure satisfactory exchange of data and information, and where required, appropriate reimbursement.

Inter-organizational relationships will be sought with organizations such as the following:

-- Electricity Generating Authority of Thailand.

-- Asian Institute of Technology.

-- Thailand National Documentation Center, ASRCT.

-- ESCAP/UN.

-- National Library of Thailand.

-- National Statistical Office.

Organizations to be identified will include Government and non-Government, Thai and non-Thai.

The work will be performed via the following Subtasks:

3.1 Identification of Data Resources.

3.2 Identification of Document Resources.

3.3 Identification of Computer-Related Capabilities.

3.4 Establishment of Agreements and Liaison with Organizations Identified During Subtasks 3.1, 3.2 and 3.3.

3.5 Identification of Needs Not Satisfied by Existing Resources.

This Task will be emphasized during the second and third years, continuing throughout the project.

The products of this Task will include (1) lists of organizations, their representatives, and mailing addresses; and (2) inter-organizational agreements executed between the NEA and other organizations.

Task 4. Identification of Users and User Requirements

Using the results of Tasks 1 and 2 as a guide, users will be identified, described, and located. Their requirements will be determined and, as service is provided, their satisfaction will be assessed. The work will be performed via the following Subtasks:

4.1 Identification of User Groups and Individuals.

4.2 Determination of User Requirements.

4.3 Assessment of User Satisfaction.

Subtasks 4.1 and 4.2 will be emphasized during the second and third years. Subtask 4.3 will be emphasized after the second year, continuing throughout the project.

The products of this Task will include (1) lists of user organizations, individuals, and mailing addresses; (2) reports resulting from user surveys; and (3) analysis of user correspondence and other user feedback, e.g., from extension activities addressed in Task 7.

Task 5. Selection of Resources

Available data and information resources will be examined and selection of those relevant to the mission of the NEIDCT will be made. Selected resources will be further screened to determine those that should be acquired, processed, and stored within the NEIDCT and those that should be recorded and described and to which NEIDCT should make referrals only.

Subtasks to be performed are as follows:

5.1 Screening Available Resources for Relevance.

5.2 Screening Selected Resources for Acquisition vs Referral.

This Task will begin in the third year and will continue throughout the project.

Products will include (1) a report describing the types of resources selected for acquisition vs. referral; and (2) a document which describes an NEIDCT directory of referral resources.

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Task 6. Acquisition and Processing of Resources

Data and document resources will be acquisitioned, catalogued, controlled, analyzed, described, coded, stored, retrieved, synthesized, and reported. Resource and user mailing lists and related correspondence will be managed and controlled.

Subtasks to be performed on all resources, including data, documents, and referral resources, are as follows:

6.1 Implementation of Procedures for Acquisitions.

6.2 Acquisition.

6.3 Cataloguing and Control.

6.4 Analysis, Description, and Coding.

6.5 Storage and Computation.

6.6 Retrieval, Synthesis, and Reporting.

6.7 Mailing List Management.

6.8 Correspondence Control.

This Task begins during approximately the third year of the project and continues throughout.

Products will include (1) data banks, (2) a document collection, (3) referral directory file, (4) mailing list files, and (5) correspondence control files.

Task 7. NEIDCT Services

The work performed for the preceding Tasks will result in the production and dissemination of energy data and information services including publications, responses to individual inquiries, special reports and data compilations, and current information services. This Task will also include the production of extension services and related educational and promotional materials.

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Subtasks will include the design, preparation, production, and dissemination or delivery of the following:

7.1 Publications.

7.2 Responses to Inquiries.

7.3 Special Compilations and Reports

7.4 Current Information Services.

7.5 Library.

7.6 Extension Activities, including:

7.6.1 Promotional and Educational Materials.

7.6.2 Workshops, Seminars, Training Programs, Exhibits.

This Task will begin during the fourth project year and continue.

Products of this Task will include the following: (1) annual reports, (2) promotional materials, (3) educationa materials, (4) referral directories, (5) statistical compilations and reports, (6) bibliographies, (7) state of th art reports, (8) special administrative reports, (9) response to individual inquiries, (10) library catalogs, and (11) bibliographies.

Task 8. NEIDCT Evaluation and New Activities

The NEIDCT will be evaluated on a continuing basis. New activities will be planned according to user needs in relation to the availability of new resources and technologie

Subtasks will include the following:

8.1 Correlation of Results of User Needs/Satisfactio Assessments with Resource Availability.

8.2 Assessment of New Technologies, State-of-the Art of Energy Information Activities, New Informatio Resources.

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8.3 Design, Development, and Initiation of New Activities.

This Task will begin during the last quarter of the fourth project year and will continue.

Products will include (1) quarterly reports of NEIDCT progress and user assessments, (2) quarterly reports on new resource and technology assessments, and (3) proposals for new activities.

Management Plan

The NEIDCT will be administered, managed, housed, and staffed by the NEA. The NEA will furnish the required expertise related to energy and energy-related statistical data. The NEA publishes annual reports and a monthly newsletter on energy and related resources in Thailand. For these publications the NEA collects and analyzes a wide variety of data and information resources. It is proposed and recommended that, for the following functions, additional support should be obtained from other organizations. These functions are as follows:

Information Center Design; Materials Selection and Acquisition: The Asian Institute of Technology (AIT) Library has recently developed the Renewable Energy Resources Information Center (RERIC). While the NEIDCT will have significantly different requirements and different activities from the RERIC, it will be advantageous to draw from AIT's experience and their tie-in with the energy information community. Also, AIT's expertise and experience in library and information science will be valuable to NEA. For example, it will be more economical to adapt coding and cataloging formats and standards which have been developed at AIT, and which conform to international standards, than it would be for NEA to develop new procedures. It will also have the eventual advantage of allowing NEIDCT and AIT to exchange data bases and materials without costly conversions of data and programs. In addition, AIT has access to a number of computer programs which are free of charge via UN-related organizations. Installation of these programs at the NEIDCT computer facility would be feasible and result in an economical approach.

It is therefore recommended that the NEA should engage a team of information center specialists from AIT.

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Data Processing: The Data Processing Center of Thailand, National Statistical Office (NSO), presently provides limited computer services to the NEA. The computer hardware and software resources of the NSO are particularly well-suited to the requirements of the NEIDCT. Also, the NSO computer facility is located near the NEA. Therefore, it is recommended that the NSO's computer facility should be used to support the NEIDCT.

Educational and Training Extension Activities: An important activity of the NEIDCT will be the education and training of user groups about the availability of energy information resources and how to make the most effective use of them. The Electricity Generating Authority of Thailand (EGAT) has been performing similar educational extension services related to their technical information center. It is recommended that the NEA should take advantage of EGAT's capabilities, especially since the NEA and EGAT audience will be, in many cases, from the same user groups.

Personnel and Staffing Requirements

The personnel estimated for NEIDCT are as follows:

Manager (Grade 7): The NEIDCT Manager's background should include several years of Government experience, particularly in agencies related to energy issues. The Manager should have knowledge of statistics and technical information, preferably with some exposure to automated data processing, It is preferable that the Manager should have an appreciation for serving and educating users of information services.

During the first and second project years the Manager will be required full time. Thereafter, he will be required half-time.

Energy Subject Specialist (Grade 6): The Energy Subject Specialist will require knowledge about energy technology in the Government and particularly the regulatory setting. This person should be drawn from NEA's present staff.

The Energy Specialist will be required on a one-fourth time basis from the project's beginning.

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Technical Information Specialist (Grade 6): The Technical Information Specialist (TIS) will require experience in statistical data systems and information retrieval systems. Knowledge about energy data and familiarity with energy data user groups is essential. The TIS will be required on a full-to-half-time basis.

Statistician (Grade 5-6): Present NEA Statisticians would be preferable. The Statistician will be required half-time. An alternate staffing plan is to employ Grade 5 and Grade 6 Statisticians on a one-fourth-time basis.

Librarian (Grade 4): The Librarian's background should include document processing experience rather than conventional library experience.

The Librarian will be required on a half-to-full-time basis.

Library Technician (Grade 3): The Library Technician should be experienced in reference library work and should be skilled in cataloging and document processing. Statistical data analysis skills are preferable.

Systems Analyst (Grade 5): The Systems Analyst should have combined experience in statistical, management information, and document retrieval systems. Library systems experience is desirable.

The Systems Analyst will be required half-time.

Computer Programmer (Grade 4): The Computer Programmer requires experience similar to that of the Systems Analyst.

The Computer Programmer will be required half-time.

Media Specialist (Grade 5) and Training Specialist (Grade 5):

The Media and Training Specialists should be experienced in conducting workshops, seminars, and training programs. They should be familiar with presenting highly technical data and information to a wide variety of user groups, with several levels of sophistication.

These personnel will be required on a half-to-full-time basis.

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Translators (two) (Grade 4): The Translators should be familiar with NEA's information and the needs of the user groups. Present NEA Translators are preferable.

The equivalent to one full-time translator will be required.

Clerical Staff: As required.

B. The Regional Energy Centers

The Regional Energy Centers (RECs) are essential components of a developing rural energy program for Thailand. The RECs will provide a fundamental area and rural outreach capacity to NEA, a means of continuing in contact with rural energy needs and changes, and most importantly of providing a focus for information dissemination. They will function as centers of energy data collection, will monitor and follow-up on NEA-initiated rural energy programs, and function as coordinating centers for energy related activities in their areas of responsibility.

The physical requirements for the RECs are limited. Essentially, they amount to land, office space and housing for approximately six to seven staff.

The staffing of each REC will be along the following:

Chief of the REC (Grade 6): The Chief should have experience generally in both management and in the substance of energy questions.

Energy Technologists (2) (Grades 5-6): These will normally be engineers, particularly with rural experience.

Energy Protectionists (2) (Grades 3-4): These staff will essentially function as technical development personnel, with an emphasis on the uses of rural energy.

Extension Workers (2) (Grades 3-4): These personnel should be generalists (communication development type experience) with a facility or experience in rural communications.

Each REC will also have for equipment one two-ton truck and two jeeps, plus communications facilities (movie cameras, projectors, video tapes etc.). These basic components will provide the

working equipment for an outreach or extension program in each area, but the job will essentially depend upon the motivation of staff and close support by NEA.

Six RECs will be established. One each in the North and Northeast respectively at Phitsanuloke and Maha Sarakham. These will be the first two set up. They will be followed by two each in the Center and South regions. The program calls for establishing the first two RECs by the end of the second project year, with two each (one Center and one South) in each of the two succeeding years.

RESOURCES ASSESSMENT

Introduction

The program to be carried out under this heading will directly complement and support the work being done under the rural oriented energy technologies component of the project. The latter will address and work directly with the potential applications for biomass conversion, micro-hydropower, solar energy and water lifting technologies, as well as with the village woodlots activity. This resources assessment activity will provide data under three of those categories - solar, biomass and micro-hydro - which will supplement and provide the context for the activity specific data developed through testing of the applications for each technology. The body of data assembled by NEA through this broader resources assessment activity will become the recipient, in turn, of the information from the rural specific activities.

As a necessary component of a total resources assessment, this activity will also address the Thai reserves of oil shale, tar sands, lignite and geothermal energy. This, together with the renewable resources component , will add to the information base for formulation and implementation of an RTG energy policy. The assessments themselves actually assemble the data, but equally as important is the longer term impact of the activity in strengthening the capacity of NEA to conduct such assessments on a continuing basis. This activity will also directly contribute data to and generally be conducted in close coordination with the work being done under the Energy Master Plan (EMP) and the component of this project in support of the EMP.

I. Solar

Solar energy is one of the most rapidly developing technology fields in the world today. The technologies cover a broad spectrum from the low-cost, village-built dryers and stills of this project under the rural-oriented energy technologies program, to sophisticated, high-technology power towers for electricity generation. Each may have its energy role to fill, but without further analysis of the patterns of solar insolation and of the potential needs and uses for solar energy, it is difficult to select and design the technology.

In the United States today, the two most widely applied solar technologies are domestic water heating, which is of limited relevance to Thailand, and solar architecture, which is of outstanding importance given the increasing magnitude of the national air-conditioning load. Traditional Thai architecture,

like traditional architecture everywhere, is well-united to local climatic (solar) conditions. On the other hand, international architecture, as applied in Thailand as well as elsewhere in tropical countries, requires massive energy inputs for comfortable living and working. This approach can only continue to be feasible in an era of cheap oil.

Understanding of (solar) micro-climates in Thailand is necessary to better building design. It is also of utility to a range of other technologies that have differing roles to play in Thailand's energy future. Examples are water lifting, medium and high-temperature industrial water use, refrigeration, electricity generation, drying of crops, etc. The long term design decisions to be made regarding use of solar concentration depend,however, on better knowledge of the direct and diffuse components of solar radiation in Thailand. The role of the rural oriented technologies component of this project in supplementing this activity through direct testing and application is discussed above.

In addition to development of new data, the work under this heading will continue data collection and analysis to support already existing solar groups at Chulalongkorn University and King Mongkut's Institute of Technology. The focus will be on assessment of the solar energy role in development of agriculture and small industry in rural Thailand.

The activities generally under this program will include:

- Assess current and traditional architectural concepts and the applicability of solar architecture.
- Identify needed instrumentation and analyses.
- Assist in development of data for and coordinate solar component to the EMP.
- Procure solar and meteorological instrumentation.
- Develop and assemble solar electricity generation data, conduct analyses and computer simulation in working with solar electric group.

- Tour of one Thai expert to U.S. institutions; e.g. Solar Energy Research Institute, Weather Service, Universities of Colorado and Wisconsin to discuss solar data collection and analysis.

- Tour of two Thai experts (from C.U. and K.M.I.T.) to U.S. institutions involved in solar electric generation.

- Participant training in solar assessment techniques.

II. Resource Assessment - Biomass

The potential for utilizing biomass based energy alternatives can only be fully assessed on the basis of better information about potential sources: firewood, crop residues, and animal dung. This information must have national and regional statistical characterization; but also village specific characteristics are required for these sources.

The effort will begin with a thorough review of existing information, including district and where available village agricultural production and animal population data. This initial effort will also review forest land use and land capability information. If current air photo-mosaics exist for selected village areas, necessary complementary ground fieldwork will be undertaken to allow better inference from crown cover and other data.

Dependent on the review of existing information, alternative fieldwork programs may be undertaken but the target will be to develop adequate information for the following classes of information.

Production Estimates - Macro and micro estimates of industrial and fuel wood production. Estimates of production of primary agricultural products and concomitant agricultural residues.

Residue Relations - Estimates of variations of residue with crop species (e.g., HYV, floating or traditional rice), production/processing (mode of rice milling); timber processing (generation of sawdust, use of bark, branches, etc.).

Energy Content - Estimates of the heating value of residues, both laboratory-dry and at various moisture contents representative of typical use situations. These estimates should be made for all major crop residues, forest species, industrial wood byproducts, charcoal and animal dungs.

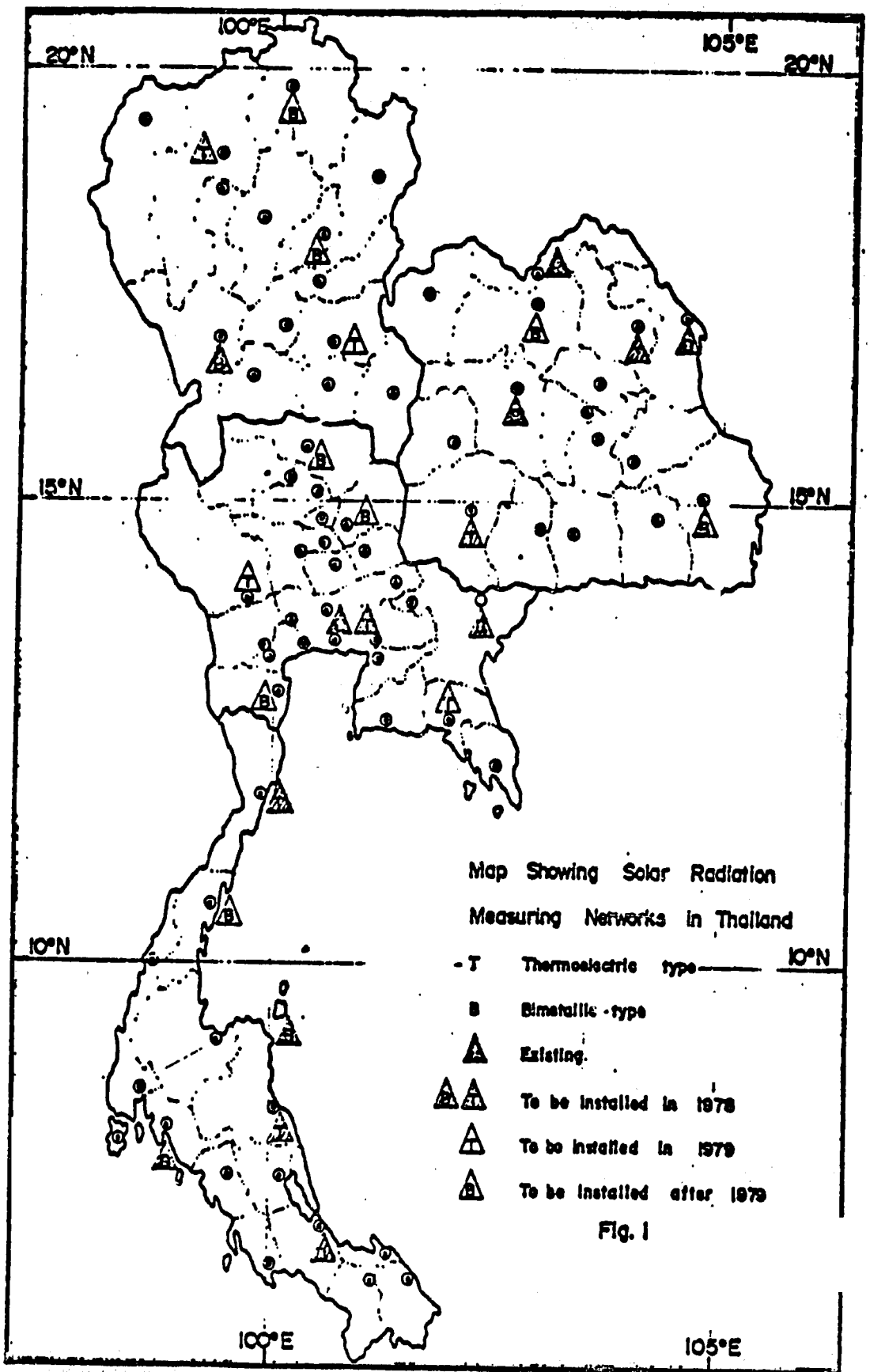

Fig. 1

Source: NEA

Availability of Source/Residue - Estimates of actual availability of source/residue to potential users. This availability can vary for any number of reasons: current practices regarding residue use, e.g., field burning, selling of surplus to other animal owners; grazing or stall/tethering, animal husbandry practice and concomitant dung concentration; as well as spatial concentration or dispersal of wood fuel supplies.

Efficiency of Fuel Use - Measurement of conversion efficiencies for typical stoves, braziers and other end-use devices, e.g. kiln. (This will be coordinated specifically with the village survey work under the EMP support component (see Annex VII).)

The approach in this effort will be sequential, an initial team should undertake the review discussed above. Subsequently in consultation with those involved in other related project activities they will formulate a detailed work program.

III. Micro-Hydropower

The activities under this heading will form the backdrop for the work to be done in the site specific micro-hydropower component of the rural oriented technologies program. The effort in this assessment effort will be to draw together - both for the North and other areas - collected data on micro-hydro potential. This will include use of the NEA gauging station data, as well as other relevant material.

The data review will provide the framework for yield data collection and site inspections. All of this will be fed into the total of micro-hydro information available to NEA, both for planning purposes as well as to supplement the specific micro-hydropower activity. The assessment will particularly ensure that data for this area is available or included in the EMP support component and the EMP itself.

The activity will involve limited short-term technical assistance working directly with NEA.

IV. Lignite, Tar Sands, Oil Shale, Geothermal

In an attempt to alleviate dependence on imported fuel, Thailand is continuing to explore, assess and exploit its indigenous energy resources. This element is aimed at providing assistance in the efforts to assess and evaluate four sources: lignite, tar sands, oil shale and geothermal. No assistance with actual exploration is involved.

Lignite is currently being exploited in two regions, the North and South. The known deposits are of low to medium quality with low to medium heat values (3-6000 heat/kg), high moisture content, considerable ash and sulphur. The primary use (75 percent in 1977) is for electric power generation. The remainder is largely used in the tobacco curing, lime, food, and rubber industries. Exploration for lignite has yet to cover many areas and assessment of known areas is incomplete.

Little work has been done on tar sands which is primarily of long-term interest but both oil shale and geothermal resources have had some investigation. Preliminary estimates of oil shale in the North are about 2500 million tons. A three year geologic program has been completed and a program of drilling and analysis is continuing. Only a portion of the many samples have been analyzed. Preliminary evidence indicates oil contents of 7-10 percent, in some areas deposits are at very shallow depth, i.e., at less than 50 feet.

Preliminary work indicates the location of a number (over 40) of hot springs in Thailand with temperatures from 40-100°c. Some exploration work was carried out with technical assistance from the Government of New Zealand in ten selected areas; additional work is to be done by Thai geologists. Initial investigation suggests that the geothermal sources may not warrant development for power generation but could possibly be viable for use as a heat in such applications as tobacco curing. In the tobacco areas, fuel wood is becoming increasingly scarce. (It is more likely, however, that tobacco curing would turn to lignite (which the industry is using already) or solar as that becomes available as a known application.)

The effort will review existing data for each of the resources, and assist in the design of a future program of exploration, assessment, and analysis with periodic technical assistance following an initial review mission. Thai professionals would be trained in various assessment and analysis techniques both through on the job training and special courses designed to address particular needs.

THE ENERGY MASTER PLAN

A. Introduction

The Energy Master Plan (EMP) component of this project is essentially a support activity. The EMP Study, financed principally by the UNDP ($710,000) but also by the ADB ($300,000), and executed by the ADB, proposed a detailed and comprehensive energy review with projections and recommendations up to the year 2000. The Study is expected to start later this year (1979) and be completed in 18 months. See EMP Study terms of reference as attachment to this Annex.

The Study addresses all major energy areas, including non-renewable resources such as lignite, natural gas, oil shale, petroleum and imported coal, and the renewable field as well. It specifically covers supply and consumption of energy in the rural areas, including assistance to NEA in design and conduct of sample surveys, and assesses the status of non-conventional energy prospects.

The terms of reference note the non-conventional energy project proposed to be provided by AID, that the project may develop relevant information for the EMP Study, and the EMP consultant is enjoined to coordinate with the AID-financed activity. The requirement for coordination, however, is subject to the needs and work schedule of the EMP Study and if results of the AID project activities are not available within those schedule limits, the terms of reference may be revised to enlarge the scope of the EMP consultant for development of data under the non-conventional energy heading. The terms of reference are specific in recognizing that, whatever other sources of data may be available, the EMP Study consultant is "primarily responsible" for satisfactory conduct of the Study and for developing the required data.

B. EMP Support

Essentially, therefore, the extent to which the activities being carried out under this project will furnish data to the EMP Study is a matter of timing. The resources assessments and rural oriented technologies activities under this project are all directed to development of a greater depth and expanse of data than looked to under the EMP Study. This project also includes as a main activity, under the rural oriented technologies component, the broadening of the experience base itself. All of this goes well beyond the limits of the EMP Study, which clearly has a different purpose - the development of a basic planning document

or program against which later data and developments can be measured.

Given the scheduled timing of the EMP Study and of the components of this project, the probabilities are that except perhaps for limited early data assembled at the initial stages of the activities, the components of this project will not contribute much data or experience results to the EMP Study. That might change, of course, if the EMP Study were substantially delayed or this project accelerated, but certainly neither is a recommended course. Completion of the EMP Study as early as possible should provide a main framework for the later development, assessment and analysis of data - and the policy implications thereof - under this project. Conversely, acceleration of the work under this project would tend to defeat the purposes of the project itself, the careful and thorough testing of energy alternatives against the backdrop of full renewable energy assessments.

In that context, therefore, this component is essentially directed to support activities for the EMP Study, supplementing the assistance being provided in certain areas under the Study. It will also serve directly to coordinate and relate the work being done under the components of this project and the conduct of the EMP Study. To the extent that data is developed under either project, both will benefit.

1. Pre-feasibility/Feasibility of Renewable Energy Alternatives

There may be renewable energy alternatives not addressed by the EMP Study, or by the resources assessments under this project, which could warrant preliminary analysis, and if positive, further investigation. Even in the case of such alternatives which are covered by the EMP Study, the data base could in some instances benefit from more detailed analysis or variations on the analysis. This would also apply to the product of the resources assessments under this project. In addition, the conduct of such analyses - to pre-feasibility or feasibility level - would provide NEA with an immediately relevant training opportunity conducted in context of a major energy technical assistance program under both the EMP Study and this project.

2. Rural Energy Surveys

The EMP Study notes that the consultant will provide technical assistance to NEA in the design and conduct of sample surveys and studies of the rural energy situation. The rural energy

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component of the EMP Study itself is expected to take place over the first eight months of the Study implementation. NEA itself will do much of the data collection for thi. requirement. Under this project, technical assistance will be provided to supplement that being furnished under the EMP Study. This will involve work with NEA in field-testing of survey methodologies, designing additional survey work and programs, training on the job, etc. The idea is to reinforce and assist in the development of a capacity in NEA for continuing conduct of rural level survey work, and actually to work with NEA staff in carrying out such surveys over the project term. Some limited equipment may also be included under this heading as specific needs are identified.

3. Detailed Village Resource and Energy Studies

In addition to the energy technology specific activities under this project, and the energy specific focus of the EMP Study, there is a complementary need to have more accurate profiles of the village as an entity. A great deal of the data to make up such profiles would necessarily be a product of the other components of this project, and of the work under this EMP Study, but this activity could conform that data - supplementing it with others - to construct micro or village profiles of energy resources and demand. Village physical resources (e.g., land by capability and use), capital resources (housing, equipment, etc.), demographic, social and economic data, etc., in addition to direct energy related information, would all become part of the profile. The activity would look to the development of improved baseline data at the village level for support and development of rural energy strategies. The activity would be based on a selection of representative villages by area. The data developed and the profiles constructed may feed in information to the EMP Study and certainly to the resources assessments components under this project. Limited technical assistance in study design and periodic assistance in assessment, data review, etc., would be provided under this project.

4. Feasibility of Village Energy Systems

This activity will involve assisting NEA to develop a methodology for assessing the feasibility of village energy systems. Essentially, what this means is initiation of a procedure or systematic way for examination of the alternative energy technologies as they would apply to identified village needs. This would include costing and working out the feasibility and implementation of the selected technology in terms of specific village resources and

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needs. The activity would involve an integration of data derived both from the EMP Study and from the other components of this project. As the village profiles under item 3 above became available, these would be incorporated in this procedure. The product would be a series of representative energy plans at the village level developed for classes or types of villages. In the later stages of this activity, those classes or types would be set in the context of the village profiles above. The effort should result in development of a methodology which would allow subsequent village site specific energy feasibility reviews to be done as a matter of routine and quickly. It would become a capacity of NEA, and it would in turn reinforce the data base at the macro level on a continuing basis.

5. Staff Support During the EMP Study

This activity will ensure data as it is developed under all of the components of this project are available to the EMP Study, where the schedule of the Study permits. It will also act to channel to those components relevant information, findings, recommendations, results, etc., developed by the EMP Study, as it is carried out. This would involve providing consultant resources under this project to work with NEA to ensure an optimum exchange and flow of data both ways and to assist in addressing energy planning questions as they might develop through either project. The point is one of coordination, to ensure to the extent possible that the work of each, the Study and this project, benefits the other and the total effort, and does so without unnecessary duplication.

6. Training

Training is an essential component of the institutional development aspects of this EMP support component. The longer term utility of the EMP will depend to great extent on the informed responsiveness with which it is adjusted to changing conditions and data. To respond effectively will always require a mix of technical and policy judgments, based on sound understanding of the technologies and the issues. Accordingly, two types of training are proposed under this heading, both types limited in amount but concentrated for effect.

The first would be a limited component of long-term academic and specialized technical training in selected energy problems of particular relevance to Thailand. The problems could be on the renewable resources side or non-renewable, although rural and renewable needs will be given emphasis. Training would be at the

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M.S. level at specially selected U.S. institutions, but the new Energy Technolcgy Program at AIT is also an alternative. Candidates would be selected from a range of disciplines - engineering, economics, statistics, computer programming, planning, etc. - depending on the particular qualifications and the role to be filled or substantive area addressed.

The second type of training will involve the conduct of seminars, workshops and specially designed short courses, each addressed to the policy,planning and management needs of specific energy issues and alternatives. These will be particularly designed to support the utility of the EMP as a main planning and policy mechanism for the RTG. Emphasis will be on the rural and renewable energy side, but without excluding non-renewable resource issues. Technical assistance under this heading will largely come through the other components of this project, but in some cases particular other consultant assistance may be identified for a specific energy or policy issue which needs address.

7. Energy Conservation

Energy conservation represents, both in terms of immediate need and the longer term, a most apparent and available mechanism for the efficient Thai use of energy, renewable and non-renewable. This activity, accordingly, will assist NEA - in context of the conduct of the EMP - in addressing the macro information and requirements of a comprehensive conservation policy addressing all sectors. There will be a specific focus on renewable resources and measures to reduce non-renewable resources depletion.

In this activity, the NEA will survey conservation methods and technologies, review these against the technical data being developed through the EMP, establish parameters for a conservation data base and reach planning and policy recommendations for a general RTG energy conservation program.

Specifically identified technical assistance will be provided to work with a designated conservation policy team in NEA. The total activity should extend over about a year period in the data collection, analysis and recommendations formulation phase. The conservation planning facility thus developed would then become a long-term resource of NEA.

Attachment: Terms of Reference for EMP Study.

THAILAND: ENERGY MASTER PLAN

Terms of Reference

1. The Energy Master Plan (EMP) study will be carried out within the framework of systems analyses requiring integrated consideration of the various work components or inputs. Whilst the terms of reference have been arranged under different categories for presentational convenience, the need for an integrated approach must be kept in view at all times.

2. The EMP study will cover a period of 21 years, viz., 1979-2000. The level of analyses and projections for the period of (the) next few years up to 1991 will be intensive and detailed while that for the period after 1991 will be broad and somewhat aggregative.

3. The Consultant will work closely at all the stages of the work, with the counterpart support personnel from the NEA and provide opportunities for their meaningful participation in the EMP. The Consultant will make every effort to draw on the energy sector work - ongoing and accomplished - within and outside of NEA in accomplishing the Project; however, the Consultant will be primarily responsible for the satisfactory completion of the Project and for developing the necessary data.

A. Economic Studies

1. Review the recent economic growth experience and the present economic situation of Thailand, with a view to identifying major considerations and constraints that will be relevant to the prospective growth of the economy.

2. Examine the projections of economic growth that may be available in the light of the said considerations and constraints and the stated socio-economic objectives of the Government and develop necessary modifications.

3. Develop modified projections of the most plausible growth scenarios for the years 1980-2000 in such disaggregated form as will be necessary for the EMP study. This part of the work will be done in close consultation with the National Economic and Social Development Board (NESDB) and other private and public agencies concerned with economic development planning in Thailand.

4. Examine currently available views and information regarding the future supplies and prices of petroleum imports for Thailand and specify appropriate assumptions to be made in this regard for the EMP.

5. Taking into account such specified assumptions, as well as the prospective energy and non-energy uses of natural gas and the national desire to conserve (non-renewable) resources, determine the value of natural gas appropriate for consideration in the EMP analyses.

6. Standardize various parameters relevant to developing cost estimates of alternative projects on a comparable basis, viz., shadow prices, cost of capital, rates of inflation, etc.

B. Analysis of Renewable Energy Alternatives

7. Examine the available data on energy consumption and further supplement it with the studies and surveys necessary to obtain information on the details of present energy use. Those details would comprise, inter alia, the amount, form and function of energy used in various economic activities, including information on the mode and practice of energy use, and price-consumption tendencies.

8. In the context of the above energy-usage analyses, formulate effective demand management measures for: (a) reducing avoidable energy consumption; (b) increasing efficiency of energy used through improved practices; and (c) moderating expansion of highly energy-intensive activities.

9. Formulate modified energy input requirements for various economic activities and develop estimates of the level and the composition of energy needs for the most plausible growth scenarios.

10. Based on the needs of the projected economic growth and its structure, estimate the non-energy demand for the relevant energy resources.

11. Review available information on the supply and consumption of energy in the rural areas, particularly the energy supplies from non-commercial resources (e.g., firewood, animal and agricultural wastes). To supplement this information, assistance will be provided to the counterpart and/or relevant Thai agencies in the design and conduct of sample surveys and studies of the rural energy situation.

12. Estimate the likely energy demand in the rural areas in future years and assess the adequacy of the existing non-commercial resources to meet the same. In the light of these analyses specify relevant implications such as depletion of forests and increase in kerosene demand.

C. Study of Supply Options

13. Review and examine the operations of the existing production-distribution facilities and the related practices of the energy supply agencies (power utilities, refineries, etc.) with a view to assessing the possibilities of increasing their efficiency.

14. Identify and formulate supply development and improvement possibilities offered by individual sub-sectors within the timeframe of the EMP, and develop an order of magnitude of costs, probable sizes and time scales in the manner suitable for comparative consideration. In formulating such project possibilities, their interrelationship with one another and their impact on other projects and sub-sectors will be taken into account; similarly, sensitivity of their economic attractiveness to selected variations in the world oil prices will also be assessed in an indicative manner.

15. For the purpose of accomplishing the work in paragraph 14 above, all available data, resource assessment efforts, feasibility-type studies, engineering investigations and project proposals for the various energy sub-sectors will be studied. This will include, inter alia, examination of the proposals/issues in individual sub-sectors as follows:

a. Hydroelectric Power

- Development of the more promising hydroelectric projects indicated in the available studies.

- Possible development of the inter-country hydro-electric projects for which a certain amount of information is available and their impact on the country's energy supply situation.

- Prospects of mini-hydropower projects for developing decentralized supplies in the rural areas.

b. Petroleum

- Examine the alternative power generation plans and determine the most suitable plans for developing oil-based power plants in the context of the demand and the power system characteristics of Thailand.

- Consider the need for additional refinery capacity to meet the pattern and size of the anticipated oil product demand in the next few years.

- Review the alternative possible locations for such capacity expansions and make recommendations as to the most favourable practicable locations.

- Determine the most suitable crude or blend of crudes required to meet the projected product demand in the optimum manner.

- Review existing practices and technology in other countries, resulting therefrom, recommend refinery pollution abatement and energy conservation equipment to be installed.

- Based on the longer term petroleum product demand forecasts, determine the optimum refinery expansion schedule up to 2000 and provide NEA the computer programs and LP models used. (In the event this analyses is decided to be carried out to the feasibility stage for the selected options, the necessary modifications to the consulting services will be discussed and finalized by the all concerned, viz., the UNDP, the NEA, the Consultants and the Bank).

c. Natural Gas

- Examine the available exploration drilling results and review estimates of gas reserves to determine the optimum offtake rates that comply with good reservoir maintenance practices. Also, determine the volume of gas reserves considered available for planning purposes at this stage.

- Consider possible feedstock and energy uses of natural gas consistent with the country's order of priorities in the field of energy and in the (area of) socio-economic considerations.

- Assess the potential for energy use of natural gas in Thailand for existing and planned industries and consider the most suitable mode for effecting it (e.g., pipeline and LPG distribution, conversion to power).

- Consider possible plant/process combinations for feedstock and direct burning applications.

d. Lignite

- Review and assess seismic data and other information presently available concerning Thailand' lignite deposits, including the Mae Moh mines and formulate guidelines for the planning of further development programs.

- Estimate the quantities of lignite that could be mined at Mae Sot for power generation at a kWh cost not exceeding that of a fuel-oil based kWh cost.

- Consider possibilities of non-power uses of lignite in the light of the experience of other countries (such as smokeless briquettes for cooking and heating purposes).

e. Imported Coal

- Consider the possibility of developing power generation facilities based on the use of imported coal for the purposes of diversifying the economy's import dependence on oil. In the light of experience of other countries, development of dual oil/coal-fired plants in the sizes of 600-1,000 MW may be considered.

f. Nuclear Power

- Review and update the various existing feasibility studies and technical investigations of nuclear power plants in Thailand in the light of recent technological changes and developments.

- Review the possible impact on system management and system stability of accepting nuclear power plant/s in sizes of 600 MW and 1,000 MW.

g. Geothermal Power

- Review the available data on geothermal investigations in Thailand with the object of determining its potential and to indicate the action needed to realize the same.

h. Oil Shale

- Review the existing or planned facilities and available technology in other countries for oil shale utilization, both directly and for oil extraction.

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- Review the available data on the Ma Sot deposits with a view to estimating the oil shale reserves by ranges of oil content and consider the prospects of their utilization.

i. Bagasse

- Assess the present practices in bagasse utilization with a view to improving its efficiency of use. Also, consider the possibilities for new applications obtaining improved efficiency.

j. Power Alcohol (Ethanol)

- Consider the possibilities of utilizing power alcohol as a complement to fuel in Thailand. In the light of these prospects, assess the various raw materials from which adequate quantities could be produced.

k. Non-Conventional Energy Developments

- Assess the status of non-conventional energy prospects with particular attention to the renewable energy resources and the assessment of relevant technologies. This will include consideration of small-scale hydropower, biomass utilization (especially agricultural and forestry by-products), solar, wind and geothermal resources. Based on work that may be available in Thailand in this field and taking into account the state of relevant technologies, develop estimates of the approximate energy supply potential of non-conventional energy sources, and indicate the timing of such development. In this context, the technical assistance in the field of non-conventional energy

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development expected to be undertaken under USAID assistance may make available to EMP considerable amount of relevant information. The consultant will fully coordinate his activities with these efforts so long as pertinent to the needs and the work schedule of EMP. In the event that findings of such studies do not become available to the consultant at the time required, the scope of work for this purpose may be revised in consultation with the National Energy Administration (NEA), UNDP and the Bank to meet the needs of the EMP.

D. Environmental Impact and Institutional Arrangements

16. Assess the environmental impact of the recommended energy development program. The assessment should include effects on air and water quality, and the effect of solid waste generation, including hazardous and toxic materials. The assessment should also address land use and population relocation issues.

17. Develop, using the assessment described above, a recommended set of environmental guidelines and regulations designed to minimize the environmental impact caused by implementation of the recommended energy development program. The guidelines and regulations will apply to air and water quality, solid waste, land use, and family relocation issues, and will be applicable to project site selection, design, construction, and operation, as appropriate.

18. Recommend and develop terms of reference for any environmental studies that should be performed in order to assure the achievement of an acceptable level of environmental quality during and following the implementation of the energy development sequence.

19. With the view to ensuring adequate analyses and monitoring of the energy sector issues(,)and programs to be undertaken and for formulation of appropriate sector policies

on continuing basis in the future, recommend the institutional arrangements and the framework that would be required. In making these recommendations, detail requirements of the institutional set-up proposed would be worked out in terms of the type and size of manpower required, expertise and training to be provided, computer facilities, scope and functions, etc.

20. The recommended sector development plan will require implementing a series of interrelated projects, demand management measures, pricing changes, etc. To ensure that these various actions are adequately coordinated, the consultant will review the existing institutional framework and arrangements of the energy sector and recommend changes and modifications as necessary.

E. Evaluation of Energy Development Programs

21. Taking into account the economic studies, demand analyses, and study of supply options referred to in A through D above, develop a computer program which will accept as inputs a number of selected economic growth scenarios, a set of demand forecasts, a range of demand management strategies, and several supply options. The computer program will be designed to produce as output alternative energy sector development plans based on different input configurations. These sector development plans will indicate the supply contribution by each energy resource, including imports, and also the form and sector in which energy will be consumed, the total energy costs, energy import levels and the preferred sequence of developing various investment projects, together with their timing, size, and costs.

22. Following development of the computer program, select the input configurations to be used, and run the program to obtain the outputs described above. The output format is to be designed to allow easy comparison to be made among different sector development plans.

23. Based on a review and comparison of the computer-assisted analysis, a program of action will be recommended for energy supply development and demand management projects in order to fulfill the stated objectives of the country's energy policy. The trade-off involved (if any) in the various objectives will be explicitly stated (e.g., rapid utilization of non-renewable energy resources may have different implications in the short run from those in the long run).

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24. The program of action developed above will identify further steps to be taken for the projects to be completed and/or initiated before 1991. This will require defining the specific technical investigations, engineering pre-feasibility type studies and similar other preparatory work prior to execution of the subject projects. The mode of accomplishing such requirements, their terms of reference and the likely costs will also be indicated.

25. The findings and the recommendations in the field of energy demand management and the energy pricing will be specific and the recommended policy measures will be designed realistically for effective implementation. The efficacy of the recommended measures would be clearly established in terms of increased efficiency in energy use, moderating energy consumption in general by reducing wasteful uses and judiciously influencing the growth of the energy intensive activities in the economy.

26. Complete documentation of the computer program will be provided to NEA so that future changes in basic data can be incorporated and the implications on the recommended program of action considered. The consultant will also indicate appropriate procedures and arrangements for periodic review of the analysis, so that the recommended programs can be modified in the light of changed future conditions.

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BIOMASS CONVERSION

A. Area Conditions

1. The Northeast

The Northeast is of special interest because it is the poorest region in Thailand. Mainly it is a rolling plain, the soil is not especially fertile and the organic content is low. The winds in the area appear to be moderate and the sky clear, at least during the dry season. There are perhaps 30 to 40 inches of rainfall each year, but the rains come over a short period during which (sticky) rice, the principal agricultural product, is planted. Since there is no opportunity for a second rice crop, except in lowlands near river bottoms where irrigation is possible, there is little need for mechanized agriculture. The result is a very large population of water buffalo and cattle. Since the animals are typically kept under the houses at night or penned nearby, there is also a large amount of dung that could readily be collected for biogas generation.

Ricehusks are currently used in a variety of ways, including the making of charcoal, the firing of brick and as a soil conditioner. While it is possible that some small fraction of these husks could be made available for energy uses through better utilization, the total energy potential is not great since present practices appear to be quite effective.

Rice bran is used as animal feed; each rice miller typically keeps several pigs. There also appear to be large chicken production facilities for urban needs which utilize the bran as a feed. The manures, however, produced from chickens, pigs, cattle and water buffalo are mainly ignored or, at best, used as a fertilizer. Some composting with the manures is done, but the practice does not appear widespread.

A second important activity is the Northeast is the production of cassava, which is exported as a cattle feed to Europe. Because production is rapidly expanding, even the stalks themselves are completely used for replanting and the leaves are sold as animal fodder. As a result, the soil is being mined with almost nothing returned to the land, and thus there is very little waste material that could be used

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for other purposes, except possibly in pelletizing the dried, pulverized chips.

Forest residues represent another potential energy product, since logging is a major activity in the Northeast. However, because much of the logging is done without permit and in remote areas, the residues are not currently utilized to a great extent. Individuals who might otherwise make charcoal from these materials are often apprehensive about the local authorities and further find it easier simply to cut down a tree closer to their village rather than go deep into the forest. As an additional energy source, sawmill wastes do not have much potential since, with the exception of about half the sawdust, they are currently being used for firewood andfor charcoal production. Thus, except perhaps for the sawdust currently being burned (about half), there is little real waste. It is estimated that the sawmills only recover about 40 percent of the input logs as sawn timber, and of the 60 percent residue perhaps 25 percent is sawdust. Therefore the sawdust available for other use may be less than 10 percent of the total mill input. While this waste, converted into substitutes for fuel, might locally have an impact, it is doubtful if on a region wide basis, it represents a major energy source.

Cooking in the Northeast and all over Thailand is done over open wood fires or over charcoal braziers. While variations in cooking patterns do exist between individuals and beween villages because of personal preferences and fuel availability, it can generally be said that wood is used mainly for boiling or simmering (rice) while charcoal is used most often for quick (stir) frying or boiling. Charcoal is typically made using wood from the forests which is first set afire and then smothered with rice hulls. While primitive, the practice is efficient and waste free. Some villagers claim up to 50 percent (by weight) charcoal grills; however 30 to 40 percent might be a more realistic estimate overall.

In the Northeast, villagers complain they have to walk too far and spend too much time gathering firewood. In particular, there are provinces to the east of Khon Kaen where the fraction of forested land is small and there are undoubtedly locations where there is a real problem. In ten years this may have become a crisis, since evidence of tree felling is everywhere and there is little indication that any trees are being planted to replace those taken down.

2. The North

The North is also of interest because its people lag behind all but the Northeast economically. It is a hilly land but with many valleys where upland rice and other vegetables such as peanuts, cabbage, maize, soybeans, cotton, tobacco, etc. are planted. The rains come only during a short period and so the planting practices are not unlike the Northeast. Because much of the land is forested, availability of firewood is not an overriding problem although fuel for industrial uses has increased in price from ฿40/m^3 to ฿130/m^3 in the last few years.

There are not so many buffalo and cattle in the North as in the Northeast to consume the biomass, but the otherwise available rice straw is widely used as a mulch to maintain soil moisture content during the dry season. Ricehulls have little use and are currently burned and the ashes used as a fertilizer. Therefore the rice hulls appear to be a significant potential energy source, and perhaps a not insignificant fraction of the rice straw could be used for fuel production.

There are considerable logging residues that could be recovered, but are currently left in the forests to rot. Perhaps up to 40 percent of the harvested tree is waste. There are also significant areas where clear cutting of the existing forests is practised with the result that large quantities of waste wood are produced. Both these activities offer the opportunity for large scale charcoal production. While some charcoal is made by Coops using in some cases portable metal kilns (FAO designed) - most of these residues are wasted. One major factor holding back the further development of charcoal production is the complex procedure involved in getting permission to follow the logging operations. In fact, there is little doubt that at current charcoal prices an amelioration of these regulations would probably result in a significant increase in this activity.

Sawmill residues in more remote areas are completely wasted, while around Chiang Mai the offcuts are used to fuel, for example, the many pottery and ceramic kilns nearby. However, the sawdust is perceived to have no value, while typically it represents enough energy to power the mills several times over. Therefore there also appears to be a potential in the utilization of sawmill wastes by either continuous pyrolysis systems which also allow recovery of the oils and off-gases,

simple kilns for charcoal production alone or through direct gasification to fuel engines to power the mills.

The Center

The large flat prosperous Center, unlike the North and Northeast, has sufficient water, due to a longer rainy season and the presence of numerous rivers and irrigation canals for two rice harvests each year. The result is an intensively cultivated area producing rice, maize, cassava, sugar cane, etc. Because the land preparation for the first rice crop must be done in the dry season, mechanized agriculture is widely practiced and only a small number of cattle and waterbuffalo are found. Thus large amounts of rice straw are unused and are typically burned in the fields. Likewise the great majority of the rice hulls are burned for fertilizer. Therefore a large potential exists in this area for energy conversion systems utilizing rice hulls and rice straw. In addition, because the swine population is relatively high, and since the pigs are largely fed the rice bran which is produced in abundance, there is also a limited potential for biogas production. There is some timber, but in remote areas, thus logging and sawmill residues do not offer an attractive source of energy. The corresponding lack of firewood in this area results in the highest charcoal/firewood prices in the country.

3. The South

This largely underdeveloped tropical area includes rubber plantations and mangrove swamps. There is relatively less agriculture practised and so the potential for energy recovery from residues is not as great as in other regions. The mangrove forests in the South already represent perhaps the major charcoal producing region, supplying Bangkok and the area to the North with the dominant fraction of its domestic fuel. Charcoal making here is perhaps the most advanced in Thailand with the frequent use of behive kilns. However, these kilns are not presently equipped to recovery the off-gas by-products of charcoal production and so a potential opportunity to upgrade this inustry exists.

B. Technologies

Considering that the primary focus of the program is to develop the use of renewable resources for small scale energy needs, the most apparent energy conversion innovations would be (1) through more efficient utilization of existing resources

and (2) through the development of alternate energy sources such as from currently wasted agricultural residues.

1. Improved Stoves

Since cooking represents perhaps 80 percent of the total energy consumed in rural areas a program to improve stove efficiency would be an especially attractive development area. Open wood fires typically are only five to 10 percent efficient, while wood stoves may be 25-35 percent efficient. Thus there is an opportunity to reduce firewood through better utilization. However, in any stove development program, the local cooking practices must be carefully studied and efficient stoves appropriate to these uses must be designed. Obviously cost will be a major factor and so it may be that a low cost, even moderately efficient stove may be superior, in practical terms, to an efficient but expensive one. Charcoal stoves also represent a major area for improvement, since they are currently only 15 to 20 percent efficient, but are widely used in both rural and urban areas.

Such a stove development program would be applicable to almost all of Thailand, rural and urban, and could possibly have a more immediate impact on the fuel wood situation than any other project conceived. While reforestation and fuel wood plantations are clearly long term objectives, the development and introduction of more efficient stoves can be accomplished in a matter of years - not decades. Thus such a program would provide a stop-gap measure that would be complementary to other renewable resource programs and would buy the necessary time for such projects to mature.

It should also be noted that while the need for identifying/developing the best equipment is apparent, there is also the necessity for making decisions and selecting hardware now that should be introduced at the earliest time. And this must be done with the awareness that rapid developments in technology will likely make early adaptations quickly obsolete. But to wait for the best system would be to lose the advantage that immediate improved conversion technology provides.

While much has yet to be learned about what a good stove is in terms of local cooking practices, etc., there is still a large amount of data available and/or being gathered today to support a program such as this.

2. Biogas

While all of Thailand faces - at least ultimately - a fuel wood crisis, the situation in the Northeast is certainly the most severe today. Hence a program to benefit this region has a special necessity. Of all the alternate energy schemes considered for the Northeast, there appears to be a particularly good potential in the production and use of biogas from animal wastes. Since successful biogas plants have already demonstrated the process locally and there appear to be few cultural restraints to its use, this would be perhaps a priority program in alternate fuel development for the Northeast.

However, because there are significant technical improvements in biogas production that have recently been developed, especially in the storage of biogas and avoidance of corrosion problems, any biogas program should take advantage of these new developments. In particular, the potential of community/neighborhood digesters should be investigated and new design concepts studied to avoid the maintenance problems associated with current designs.

While such a program would have an immediate impact on the Northeast, the North and Center, and to some extent the South - where in some areas, elephant dung is a serious disposal problem - would also benefit directly. Therefore such an effort would not just assist the Northeast, but all of Thailand.

As with the development of improved stoves, such a program could be implemented in shorter time than programs involving tree planting and hence offers the added advantage of an immediate impact.

3. Improved Charcoal Production

Since charcoal is utilized both in rural and urban Thailand and thus touches the lives of more Thai than any other fuel, a program to improve the conversion efficiency of charcoal kilns is an immediate need, since the present practice leaves considerable room for improvement. Further, the development of practical/economical means for recovering logging residues and reforestation wastes is a related special concern. Because charcoal making occurs both at a relatively small scale, using family size rice hull kilns, and at a larger scale applicable to logging/reforestation wastes, the program should involve efforts applicable to both of these widely different activities. Such a program would especially benefit the North and the

Northeast since it would provide an expanded revenue source. But indirectly it would benefit the entire country in reduced charcoal costs.

4. Pyrolysis of Agricultural Residues

While the Center is the most prosperous area, since the forests are most distant in this area, it faces the more immediate potential problem as firewood supplies dwindle. However, since charcoal is especially widely used in this region and can be produced by pyrolytic conversion of excess agricultural residues, there is a significant potential for the application of this technology in this region. Not only could the pyrolytic conversion of rice hulls and straw provide a source of charcoal, that could be briquetted for domestic uses or sold as an industrial fuel, but it could also produce an oil by-product for use as a kerosene substitute for domestic cooking or lighting. Moreover, excess oil could be sold as an industrial fuel. The pyrolysis off-gas could also be used to operate irrigation pumps or power village industry.

Undoubtedly the Center would be the principal beneficiary of this effort, but there are considerable agricultural wastes, especially in the North, which could also be utilized. Thus the advantages are not just limited to one region alone.

Currently US AID and the Government of Indonesia are involved in a technology development/demonstration program involving pyrolysis of rice hulls. This program should be well advanced by the time the projected Thailand work would be initiated. Since the similarity between the two situations (Thailand and Indonesia) is close, the work would basically involve transplanting the Indonesia convertor-almost without modification - to the Thai scene.

5. Energy Conservation for Small Industry

Throughout Thailand in the rural and urban areas there are numerous small industries providing jobs for many people and relying on petroleum, coal or firewood. In selected industries, such as ceramics, fuel costs represent 30 percent of gross income and profit margins run only 10-15 percent. In five years, some industries have seen increases in firewood costs from ฿40/m^3 to ฿130/m^3. The rapid escalation of energy costs is having an adverse impact on many of these small businesses. Thus there is a need for an energy conservation program applicable to these smaller industries. The program envisioned would pay for itself by charging the customers at cost from their fuel

savings. This would be at no risk since without fuel savings no charges would be made. While the program, once established, should operate at least on a break-even basis, the start-up and training costs represent a not insignificant factor. The program planned would therefore provide the initial training of qualified Thai engineers in the field of industrial energy conservation techniques.

6. Conversion System Integration

Finally, the potential of integration of various bio-conversion technologies applicable to Thailand should be at least investigated as part of any renewable energy program - since some techniques for fuel production such as ethanol cannot efficiently operate by themselves but require the use of waste heat, for example, available from other processes. Therefore a program to study the feasibility of such integrated systems and to perform economic analysis of these systems should be undertaken.

To illustrate such a system; it is observed that chickens are often grown in large houses supplying urban needs. The chickens are presently fed rice bran and wastes are only marginally utilized. Instead, a system is conceived in which the rice bran is first fermented to produce ethanol with a spent bran remaining and including the protein in the original feed but in a much more digestible form. This could then be used as a chicken feed. The chicken manure in turn could be fed to pigs and the pig manure digested to produce fertilizer and biogas. The biogas could be used to operate an engine-generator from which the waste heat could provide the energy for distilling the ethanol. The result would be a much more efficient utilization of the bran than is currently being made in terms of animal protein production, but also with significant amounts of additional energy produced.

Moreover, the interrelationships of all the methods of alternate energy production should be recognized and exploited in any program of energy from biomass. In so doing a significant amount of energy both as industrial and domestic fuels could perhaps be made available for use in the cities.

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C. Alternate Applications

1. Wood Stoves

Comments:

- represent major village energy consumer.
- open stoves are only 5-10 percent efficient.
- improvements in efficiency up to 15-20 percent easily/economically accomplished by enclosing heat (adding sides).
- present practice in Thailand - no social or cultural problems.
- simple stoves can be made at shops in villages using locally available materials.
- considerable literature available and improvements in design expected shortly.
- more suitable for boiling and simmering type cooking.
- more applicable where fuel can be obtained readily and where transportation costs are low.
- smoky fire, not good for indoor or urban use.

2. Charcoal Stoves

Comments:

- charcoal use represents village energy consumer.
- present braziers 15 to 20 percent efficient.
- efficiency could probably be raised to 20-30 percent relatively easily and economically, but above 30-40 percent cost increases might become excessive.
- can be made locally with available materials.
- fuel conversion efficiency intrinsically high even with poor stove design because radiation heating plays major role in heat transfer mechanism.

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- fuel source has high specific heating capacity and is thus well suited for cooking where transportation costs are important.

- is currently most popular cooking method - thus improved designs would face no social/cultural problems.

- clean burning - useful in urban areas.

- primarily used for quick boiling, frying type cooking.

3. Charcoal Kilns

Comments:

- probably twice as efficient as earthen kilns but only 30-50 percent more efficient than present practice using rice hulls.

- potential conversion efficiency up to 45-50 percent.

- makes fuel more usable and transportable.

- allows logging residues to be economically converted to high quality fuel thus reducing burden of firewood demand.

- can be made economically at large or small scale.

- can be made portable to allow for following logging crew.

- does not currently allow collection of oil-tars and off-gas but could be made to collect/utilize part of these by-products.

- produces a familiar product already used for cooking.

- charcoal intrinsically is 2-3 times as efficient as wood - for cooking - so even with conversion losses it still produces a fuel better than wood on a utilization basis.

- requires some skills in charcoal production.

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4. Pyrolytic Converters

Comments:

- utilizes agricultural residues.
- produces char, oil and gas whose amounts can be tailored to demand, thus system provides capability to meet wide variety of needs.
- char & oil easily stored and tranported.
- char can be easily briquetted for domestic uses or used directly with oil or by itself as industrial boiler fuel.
- oil can be used as kerosene substitute in lamps and stove.
- oil mildly corrosive, requires some care in handling.
- gas can be used to fire boiler, operate drier or fuel gasoline engine.
- can be made portable and self sustaining.
- requires certain level of crew training.
- requires access to capital in range of $1,000-$2,000.
- requires dry shredded or pulverized feed but this is no problem with most agricultural wastes such as rice hulls and straw which are already sun dried.
- fits well with sundried products such as rice; rice hulls are an ideal feedstock.
- economical over wide scale range and level of sophistication.

5. Biogas Digesters

Comments:

- wet, green or partially digested feed.
- Produces sanitary fertilizer, gas products.

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- easy to keep clean.
- 30-35 percent efficient energy conversion.
- Product gas can be used on site or bottled and used to fuel automobile tractors, etc.
- sensitive to scale economics - farm, neighborhood/ community digesters.
- economical - payback in 3-5 years but still requires significant capital.
- weeds constant maintenance and service.
- corrosion problems with materials, especially storage.
- may face cultural problems with use of dung or human wastes.
- can be made of locally available materials.

6. Fermentation

Comments:

- produces liquid fuel suitable for automobiles, tractors, etc.
- conversion efficiency of basic system poor, result is need for integration of fermentation system with other systems producing waste heat that can be recovered.
- this means fairly complex system with relatively high capital requirement.
- requires relatively high skill level for operation and maintenance.

7. Gasifiers

Comments:

- conversion efficiency runs 50-60 percent.
- single product is low quality gas that must be used at production site.

- can be used to run spark ignition engine.
- smallest economical/practical scale is probably in range of 40-60 horse power.
- applications most likely limited to small industry.
- can be used to fire a boiler.
- requires relatively high skill levels for operation and maintenance.

MATRIX OF ALTERNATE APPLICATIONS

	Conversion efficiency	Potential for Improvement or use in Thailand	Service/Maintenance requirement	Skill Level Required	Technology Availability	Economic Advantage	Comments
Wood Stoves	5-10	high	low	low	medium	high	
Charcoal Stoves	15-20	medium	low	low	medium	high	
Gasification	50-60	medium	high	high	medium	medium	
Pyrolysis	75	high	high	high	medium	medium	
Biogas	30-35	high	medium	low	medium	medium	
Charcoal production	40-50	high	high	medium	medium	high	

D. Program Implementation

1. Improved Stoves

The program would first involve a review of available literature for promising stove designs applicable to Thai cooking practices and assessment of applicable stove designs. From this effort would come the selection of perhaps five promising wood and charcoal stove designs based on current technology and perhaps the development of two or three improved systems which would then be fabricated.

Perhaps 100 of each design would be produced and placed in carefully selected villages, where the firewood problem is especially acute and therefore where interest in the project would be high. To ensure proper service and owner involvement, the stoves would not be given away, but sold at perhaps half the replacement cost of existing stoves. A control group for each type stove would be chosen and careful records of firewood/charcoal consumption would be kept for a period of each type. A follow up study of public acceptance, performance, maintainability, durability etc., would be made to determine response to the different designs. An evaluation of the responses would be made and an analysis of firewood use performed. A report would be prepared giving the results of the study, including detailed stove designs. Recommendations for further development would be made. Ideally, this would result in selection of a best wood and charcoal stove for Thailand or at least for regions within Thailand.

Roughly equal emphasis and funding allocations would be given to the development of improved wood stoves and better charcoal stoves. Consideration as to the social/cultural acceptance of the designs selected would also be made.

In addition to the demonstration aspects of the program in primarily the North and Northeast, a support training phase of this effort could be included. This would provide local technical training and assistance in fabricating, monitoring performance, and evaluation of stoves.

At the program end workshops would be held to discuss the results and to disseminate information regarding the recommended stove designs.

2. Biogas Producers

The activity would first involve review of the literature for digester designs applicable to the Thai situation, especially to the Northeast. This could be supplemented by visits to other countries to ensure that the most up-to-date digester information is obtained. This would lead to selection of several promising designs and perhaps the development of a new system where the emphasis would be given roughly equally to the needs for (1) improved construction materials using conventional designs (2) improved designs, and (3) utilization of neighborhood/community scale systems.

Perhaps 10 each of the selected systems would be fabricated and located in carefully chosen villages (in the Northeast) where firewood availability is low. Again a nominal charge for the system would be made. A control group would be chosen for each design and detailed records made of cooking energy costs and work requirements in each group. A survey of public response would be made and any problems noted. Full costs and labor requirements would be tabulated and an assessment of the performance and characteristics of the various systems chosen would be made. Ideally the selection of a standard best system could result form the work and a report prepared describing this system and the results of the study. At the end of the study a workshop will be held to present the results of the work and to disseminate information.

3. Improved Charcoal Production

A literature review, supplemented possibly by visits to other countries, would identify the most promising designs for (1) small scale charcoal production, (2) large scale production, and (3) modification of existing behive kilns to allow recovery of the pyrolytic oils. Perhaps two designs of each would be selected and up to five prototypes of each would be fabricated. Introduction of these kilns in the North, Northeast and South would be made at selected sites and villages. Careful monitoring of performance would be conducted and an evaluation of the various designs made.

Concurrent with this effort would be an investigation of the procedural problems hindering charcoal production from reforestation wastes and logging residues.

At the conclusion of the program, a report would be prepared and a workshop held to publicize the results of the study.

4. Pyrolysis of Agricultural Residues

The basic objective of this effort would be to transplant the pyrolysis technology developed in Indonesia to Thailand. To accomplish this RTG staff (preferably a mechanical or chemical engineer and two mechanics) would be sent to Bandung for up to two months to be thoroughly familiarized with the design, operation and maintenance of the converter there. On return to Thailand with blueprints of this unit, the engineer would supervise the fabrication of such a system, and its installation and operation at a selected rice mill located in the Central region. Performance tests would be conducted, and after training of local operator personnel, the unit would be turned over to private control at a cost to the miller approximating the original fabrication expense. Throughout the program, support would be available for troubleshooting in case of difficulties.

At the end of the training program, a report including an economic analysis of the system would be prepared and a workshop held to distribute information regarding the project.

5. Energy Conservation for Small Industry

This program would be directed toward improvement of energy utilization by small industry in Thailand. To accomplish this objective a team would review current literature on energy conservation techniques and make a preliminary assessment of industrial energy utilization in Thailand to determine where the greatest pay-off in energy conservation might be. This could be supplemented by travel to other countries to review at first-hand work in the field of conservation. Consultants with experience in energy conservation techniques would be engaged as appropriate.

The team, acting as consultants, would approach selected industries with offers of technical assistance on the basis that the actual costs of the assistance would have to be paid for and only from savings if these had resulted. Thus, except for start-up costs, the project should be financially self-sustaining and beneficial to Thai industry as well. Throughout the program, workshops involving local industry representatives would be held throughout the various Thai provinces. Self-help brochures and energy audit techniques would be devised and

distributed. Films on better energy use would be either located from outside sources or developed within Thailand and widely shown as part of this program.

At the end of the work, an assessment would be made and a report prepared. Out of this could be created a continuing NEA facility directed exclusively to energy conservation.

6. Conversion System Integration

The prime focus of this work would be to heighten the awareness of Thai engineers and industry with regard to the potentials from integration of energy conversion systems. The program itself is not seen an producing hardware; instead it would provide the feasibility analyses of promising system concepts which would improve energy conversion efficiency. In addition, the concept of co-siting industries whose inputs and exhausts are such that they could be combined to produce a more effective overall system would be studied. The study would not be limited to either particularly complex, capital intensive systems or simpler less expensive concepts. Much of the work would draw on the total of data assembled through the other components of this project to suggest improved energy utilization schemes.

It is expected that some computer modeling would be required in the study and substantial systems analysis involved. At the study's end, a report would be prepared to illustrate the various integration possibilities investigated and their potential pay-offs. A workshop to disseminate the results of the study would also be held.

Micro-Hydropower*

I. Resource Base and Needs

Extensive areas of the North and smaller but significant sections of the South, East-Central, and West-Central, have the necessary conditions for hydro-power: abundant rainfall transformed by underground storage into perennial flow in hill streams. Perhaps 100,000 km^2, or 20 percent of Thailand, is topographically, climatologically, and hydrologically attractive for development of small-scale hydropower. If it is assumed the average dry season flow is three liters/second/km^2 and the average drop in elevation of the smaller streams is 300 meters, then development of all the micro-hydro potential of Thailand would produce 800 megawatts of firm, dry season, unregulated power. This is equal to 25 percent of the present installed electric generating capacity.

Development of the full potential of such a dispersed resource is out of the question, however. But in areas where a need for power and a mini-hydro potential exist, the resource is attractive because:

1. it is renewable,
2. it can be developed with minimal environmental disruption (when no reservoir storage is provided),
3. it can be developed near the load,
4. it does not require imported equipment or expertise,
5. it can provide mechanical power for direct-drive of machinery, pump water, compress air, operate a heat pump, or generate electricity for local use or connection to a grid,
6. it can be a key component to a community development project, and
7. it can help meet basic needs by pumping water for drinking, animal needs, or irrigation; producing nitrogen fertilizer; producing heat for crop drying or small-scale industrial use; providing lights; running small machines and powering communications equipment.

* See note on page 10 for definition of micro-hydro.

II. Program Rationale

North Thailand's mountainous regions are experiencing rapid loss of forests as population pressure forces peasants either to (1) shorten swidden fallow cycles to environmentally unacceptable lengths or (2) extend valley-bottom rice cultivation upwards to include upland swidden cultivation. The tribal people who have been swiddeners for centuries are forced to alternative (1); Thais who have traditionally farmed the valley bottoms are forced to alternative (2). The consequencies of these moves to feed and support more people through extensive agricultural expansion are:

i) lower yields on upland soils that are poor in quality, structure, and water-holding capacity;

ii) smaller areas cultivated by a household because of difficulties of hand clearing and weed infestation;

iii) significant time consumed in traveling to new, upland crop areas;

iv) cultivation of steeper and steeper land with erosion the result;

(v) mining of soil nutrients by short-fallow cycles;

(vi) loss of tree cover to grass and shrubs, with attendant loss of rainwater infiltration to groundwater storage resulting in dry streams in the dry season.

Because of these phenomena, the hill peasant of the North is poorer than compatriots in many other parts of Thailand. In the Upper North, average holding size is less than half that for the nation as a whole. Recent agricultural development in Thailand has left these mountain areas relatively untouched. Real income between 1962 and 1976 for Upper North farmers not having access to irrigation increased only 27 percent compared to 70 percent for other Northern farmers, and 60 percent for the national average.

About 10 percent of the cultivated areas of the Upper North is accessible to wet and dry season irrigation; about 20 percent of households have this access. Such households can grow a cash crop in the dry season in addition to their traditional wet season rice. Incomes of such households are significantly higher than for those without access to irrigation.

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One possible solution to the tremendous natural resource degradation problem plaguing the mountains of North Thailand would thus appear to be irrigated intensification of agriculture on the better lands and management of uplands through improved swidden by tribal people, tree crops, off-farm employment, and out migration. Agricultural intensification and income improvement will require irrigation pumping, fertilizer, crop drying crop processing and in some cases mechanical power for cultivation. All of these activities/inputs require energy as does creation of off-farm employment and improved swidden. The most abundant potential form of energy for much of North Thailand is hydropower, a local, renewable resource.

According to PEA*, cost of electricity generation by isolater diesel generators (of which PEA has more than 400 ranging from 25 to 6000 KW) is from two to three Baht per KWH with the smaller diesel units experiencing the higher costs. Extension of rural electrification lines to remote villages is expensive but also uncertain where the fossil fuel supply must be transported large distances.

Development of small-scale hydroelectricity in Thailand should cost less than $2000/KW. At $2000/KW, a 12 percent capital recovery factor, and $400 plus $20/KW O&M cost, KWH costs will depend on load factor and capacity. For 20 KW:

load factor	B/KWH
.2	3.2
.4	1.6
.6	1.1
.8	0.8

Micro-hydro for electricity generation should be cost-effective therefore with diesel for any but the lowest load factors. Because there is no fuel cost, there is large incentive to increase load factors. (In effect, once the unit is built, staffed, and maintained, there is little additional cost to increasing KWH output; unlike diesel generators which consume fuel for every KWH generated). What this implies, however, is that utilization of power, especially off-peak power, for productive purposes is an important opportunity.

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* Provincial Electricity Authority

It should be noted, however, that hydropower and hydroelectricity are not synonymous. Electricity is often a convenient energy form, and because of its high quality it can perform a wide range of functions. Water power, however, can often be harnessed directly to perform the task. Examples are the hydraulic ram for water lifting, the trompe or hydraulic air compressor, direct-drive grain or lumber mills using waterwheels, and direct-drive heat pumps for heating or cooling. Such possibilities would also need to be considered in reviewing the options for cost development of specific sites in terms of local needs.

The projects now underway in Thailand (see Table 1) represent a range of agencies involved, scale of development, and technologies utilized. For example, Ang Kang uses a locally made impulse turbine; Nam Dang a locally made cross-flow turbine; Ban Yang two imported cross-flow turbines and one locally made Francis turbine; and Mae Kum Luang will use two imported Francis turbines. Heads range from about 10 to 400 meters.

The resources and need are there, the economics look reasonable, and experience is being gained.

III. Outline

1. Data Collection and Analysis

NEA has done a considerable amount of work collecting hydrological data, identifying potential sites (they have a list of over 100 sites), and doing pre-feasibility studies. These NEA efforts will continue to form the foundation of the RTG planning effort in micro-hydropower.

There are some issues remaining unresolved that require early effort.

a) Gauging stations tend to be located well downstream of micro-hydro sites. For example, the Huai Nam Dang project's closest gauging station is on the Mae Taeng between Chiang Mai and Chiang Dow, where the catchment area is 1711 km^2. The Haui Nam Dang catchment is 9 km^2. As would be expected, there is a discrepancy between the appropriate unit design flows (for example, the average or minimum flows recorded for the driest month). Because it is advisable to minimize cost, it

Table 1

Hydroelectric Installations

PROJECT	PROVINCE	AGENCY	KW	HEAD (M)	TURBINE TYPE	LOCAL OR IMPORTED	STATUS	UTILIZATION
Mae Hong Son	Mae Hong Son	NEA	800	40	Francis	Imported	Operating	PEA
Ban Yang	Chiang Mai	ECAT	112	67	2x50KW Crossflow 12KW Francis	Imported Local	"	PEA
Ang Kang	" "	RID	10	30	Pelton	Local	"	Village Lights
Mae Kua Luang	" "	NEA	3,000	116	Francis	Imported	Under Construction	National Grid
Huay Mae Pong	Phayao	NEA	900	400	Pelton	Imported	"	"
Huai Nam Dang	Chiang Mai	RFD	100	70	Crossflow	Local	"	Resettlement Village
Near Doi Pui	" "	WAT	5	17	Crossflow	Local	Was operating being modified	Village
In Mae Sa	" "	Private	1.5	10	Crossflow	Local	Under Construction	Home
Na Bon	Nakhon Si Tammarat	Rubber Organisation	150		Pelton	Imported	Operating	Rubber Processing
Mae Chon	Chiang Mai	RFD	5	17	Crossflow	Local	Under Rehabilitation	Forest Station

will be necessary to work from generalized unit design flows. This implies hydrological analyses based on rainfall, topography, and forest cover to relate gauging station data to upstream synthesized flows. It also implies investigation of the appropriate hydrological design criteria (lowest flow of record, average flow for driest month, lowest flow for driest month, flow percentile, etc.) to be applied in micro-hydro planning in Thailand.

b) Many sites can yield more power than can be paid for or productively utilized. This suggests several questions to be addressed.

i) What siting criteria (involving weir, headrace channel, penstock, transmission line tradeoffs) are appropriate?

ii) How can site development proceed in an incremental fashion, using standardized turbine - generator units?

iii) How can costs of civil works be reduced?

iv) What uses of power exist that can raise load factors and are productive and employment creating? Examples would be crop drying, cold storage, water pumping, kiln heating, water heating, and fertilizer production by the electric arc method.

c) There are many small-scale hydro sites that can economically be connected to a grid. There are also potential sites at existing dams and irrigation canals. These possibilities should also be explored.

d) The potential for use of hydropower in ways that do not require electricity generation should be investigated: hydraulic rams and air compressors, heat pumps, and direct mechanical drive.

This activity and related resources assessment* will support NEA's on-going efforts to identify sites, do reconnaissance investigations, make pre-feasibility studies, interact with the EMP study, and establish a priority list of projects balanced in each case against local needs and water resources.

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* See Annex VI.

2. Equipment Design, Testing, and Manufacture

Hydraulic turbines, at least below 100 kw and eventually considerably larger units, should be manufactured in Thailand. There will be essentially two types: cross-flow for intermediate heads and impulse for high heads. Examples of each of these types have been and are being manufactured by machine shops in Thailand.

There is a need to select a package of standardized units for manufacture on a less costly basis. It would be useful at the same time to review recent experience in the U.S. and elsewhere with use of modern fabrication materials and techniques. For example, Independent Power Developers, Noxon, Montana, build small, lightweight, durable and relatively inexpensive impulse turbines using epoxy-coated silicon aluminum alloy buckets. These may be especially suited to the sediment laden streams of Thailand where blade wear is already an observable problem.

NEA has the basis for a turbine test laboratory. Some equipment would help to put the laboratory in a position to do hydraulic testing of turbines.

A major cost item for hydroelectric generation from small-scale water sources is the cost of the governor. This cost can be reduced but the issues and design questions are complex enough to require an expert. These issues include the following.

i) Under what circumstances can DC be used, thus eliminating the need for a governor? Governor cost must be balanced against higher costs of transmission and appliances. Battery storage is easier, however.

ii) What mechanical governor designs hold promise of reducing costs?

iii) Electronic governors appear to hold promise of accomplishing the task at considerably lower cost than mechanical governors. These are of two types: essentially voltage regulators and load-diversion governors. The latter appear especially attractive where secondary power is being utilized. (ITDG of the UK have a load diversion governor that they propose to test in Thailand.

Nitrogen fertilizer manufacture by the electric arc process is a possible, low cost (except for electricity) process that can productively use large amounts of secondary power. The technology is not complex and a modest collaborative R & D effort with the Kettering Foundation Research Institute, Yellow Spring, Ohio, might be considered to develop the technology for use in Thailand.

3. Micro-hydro for Village Development

Hydropower can be put to use to save the forests, soils, and water of a significant part of Thailand. Villages where farmers are now forced to expand their activities from valley-bottom, monsoon season rice to include upland swidden, can use hydropower to:

a) irrigate a second (and third) crop on bottom lands,

b) improve village water supply and thus health,

c) dry fodder, monsoon-harvested rice, and cash crops,

d) increase crop residue production for fuel (by pyrolysis or other conversion technique),

e) power rice mills,

f) fire kilns,

g) supply hot water for textile-related activities,

h) lighting, and

i) manufacture fertilizer to increase crop yields and maintain soil fertility.

Hydropower can in this fashion help to relieve pressure on the forests and allow an opportunity for improved forest management, including spreading of fast-growing species for feed and fuel. If complemented by improved stoves, charcoal making, and small industry fuel efficiency; biogas for cooking fuel; and village woodlots, forest areas could increase while agricultural output and employment also should grow.

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The micro-hydropower project would propose to test these expansive claims. It would assist, under the technical direction of NEA, a maximum of ten villages to develop their hydro resource for productive purposes (and not only for electric lights). Villages would be selected both because the resource can be developed at a reasonable cost (tentatively: below $2,000/kw) and because there is an identifiable development need for the power. A pioneer village may generate electricity exclusively, but possibly other uses of hydropower will be developed, for a saw mill as an example.

Village participation in the pioneer projects is essential. Not only should the village be expected to repay part of the costs, but their investment contribution should be made in labor.

Villages would be selected according to the following criteria.

i) Village participation in project planning and construction and in designing utilization schemes looks broad-based and likely to be sustained.

ii) Unit cost of development is under $2,000/kw (including power transmission).

iii) Project involves plan to utilize power with a load factor in excess of 50 percent.

iv) Development (initial) is between five and 20 kw, electrical equivalent.

v) Project fits into a development scheme for the village. This does not require a formal plan but does require that sufficient thought has been given to the development impact of the power project so that cost-effectiveness in attacking an economic or resource degradation problem is assured.

The technical assistance requirements would probably include services of a hydrologist, utilization specialist, planner, design engineer (with manufacturing experience),

and governor specialist. They would work with NEA, and the program under this activity would be supplemented by the micro-hydro resources assessment activity.

In Thailand, the term "micro hydro" variously applied to units having a capacity up to 100 KW or as high as 500 KW. Larger units (above 100 to 500 KW depending on the authority) are considered to be "mini-hydro" units.

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Solar Drying & Distillation, Process Heat

A. Resource Base and Needs

Average solar radiation in Thailand is reasonably high, varying between approximately 440 cal/m^2 day in areas of the North and Northeast to 400 cal/m day around Bangkok. The climate of Thailand has a strong seasonal nature, with a wet rainy season from May to November and a dry season from December to April. There is, however, comparatively little variation in the amount of available radiation, varying about ± 15 percent from the norm (compared to ± 65 percent for New York City). Even during the rainy season, long unbroken periods of cloudiness are rare, with rain clouds often building up in the afternoon after a bright sunny morning. Thus there is usually adequate radiation over most of Thailand to run solar applications effectively.

Slash and burn practices in the North and Northeast during periods of the dry season can, however, cover large areas with a thick smoke haze that significantly reduces available radiation. In addition, the atmosphere in Thailand tends to be slightly hazy and to have a high level of absolute humidity, both of which make the diffuse component of solar radiation comparatively high. Thus, collectors designed for Thailand should try to take advantage of this diffuse component in addition to direct beam radiation.

Solar radiation's greatest advantage as an energy source is that it is available throughout the country, without need of a distribution system. It can be converted to usable energy directly where that energy is needed. Thus it offers potential for decentralized development. Currently, only 19 percent of Thai villagers have electricity available to them.* Gasoline and oil must be brought to the villages, necessitating the use of fuel for transport. In addition, occasional failure of the delivery system can make the supply unpredictable.

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* The Fourth Annual National Economic & Social Development Plan 1978.

The greatest disadvantage of solar energy is that it is intermittent, unavailable at night and during cloudy periods. The most economical uses of it are those which can accept this intermittent nature, and use it effectively when it is most available. Such uses include drying of crops or lumber, which can tolerate, or even benefit from, a rest period at night (to avoid case hardening stresses in lumber), pumping of irrigation water which is most needed during cloudless periods, and intermittent ammonia-water cycle refrigeration units which require a period to discharge heat.

The availability of solar energy can be extended with the use of storage systems, although these can add significantly to the cost. Solar energy can be stored in the form of heat (or cold), through electrical potential in a battery, or it can store against requirements by mechanical means, such as pumping water up to a storage tank. Solar hot water systems generally have efficient storage systems because once collected in the form of heat, the energy does not have to be transferred to any other medium. However, outside of simple hot water systems, there seems to have been little attention paid to developing inexpensive storage systems which would be appropriate to Thailand. Inexpensive storage systems would add greatly to the utility of solar energy in Thailand by extending its availability and allowing greater control in its use.

When a fuel is expensive in itself, as both oil and wood are increasingly becoming, then it must be used as efficiently as possible to keep the cost per unit of energy delivered low. This usually entails developing ever more sophisticated, and therefore expensive, equipment. The cost of solar energy, however, is solely in the cost of the equipment needed to collect and transform it. Therefore, inexpensive equipment is a far more important cost factor than efficiency. For this reason, solar energy can often be most economically used with the simplest of equipment, often technologically unsophisticated and comparatively inefficient from an energy standpoint. Thus once a few basic principles are understood, such as that black surfaces transform sunlight into heat or that heat rises, the technology for using solar energy can be fully within the skills of the average Thai villager. A solar crop dryer or solar still are both examples of technologies that could be crafted and used (and even refined) at the village level.

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B. Solar Drying and Distillation

Direct sun-drying of crops is currently the most common use of solar-energy in rural Thailand. Rice, fish and fruits are spread in thin layers on mats or concrete and dried with the heat of the sun's direct radiation. Considerable losses, however, are estimated to occur with natural sun drying, from rodents and birds, contamination with dirt or bacteria, and insect infestation. The level of loss has been as high as 50 percent in the case of fish.* In addition, as more farmers in Thailand have begun to double crop their land, there is the problem of drying the first rice crop during the ensuing wet season, when the grain has a very high moisture content.

Thailand plans substantial increases in second crop (monsoon season harvested) rice through expansion of irrigated area. When farmers in the Central part of the country were asked in 1977 by the Department of Agriculture what problems they encountered, they ranked moisture content and the resulting losses due to rice diseases, insect infestation, low recovery rates from milling, and low germination rates as of significant concern.

The same situation is true of cash crops, such as vegetables and fruits that are harvested during the wet season. Currently, these crops must be immediately consumed by the farm family or sold often at low market prices. The capability to preserve these crops would allow the farmer both a longer supply for family consumption and more control over when the cash crop is marketed.

Some bananas and chilis are currently dried with fuel such as charcoal and firewood. Food drying processes generally require low temperatures, however, that are easily delivered by simple flat-plate solar collectors. Using solar drying could conserve these fuels for other uses.

Thailand is very favorable to the development of solar dryers because even during the wet season there is a great deal of solar radiation available.

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* Post Harvest Food Losses in Developing Countries, National Academy of Sciences, USA, p.143. 1978.

Solar drying is also potentially applicable to use for distillation of water for salt harvesting. This is now done generally through use of charcoal or wood fuels, and the application of solar energy would simply be an extension of the heat principle but through a renewable resource. The adaptation for such uses should be relatively inexpensive, would save the cost of other fuel, and would be more convenient. The latter is particularly a factor where fuel supplies for salt harvesting are becoming more distant, for example in the coastal areas of the South.

1. Possible Types

The greatest need is for simple designs which can be easily built with inexpensive, locally available materials. If the small farmer is to be helped to gain more control over crop marketing, then such crop dryers should be directly available. The dryer or still should work without any additional inputs of energy (without dependence on high level technologies such as electricity or gas powered motors). The dryer should also lend itself to being able to dry a variety of crops to increase its utility to the farmer throughout the year.

Inexpensive sheets of plastic are readily available throughout the rural areas of Thailand, although they are of generally low quality and deteriorate quickly. All plastic is currently imported. Glass is less generally available and more expensive but it is made in Thailand. Researchers at KMIT* estimate that the economic pay-back is the same for both glass and plastic. Corrugated steel in sheets is commonly used for roofs even in the poorest of villages, and is therefore also available (although imported). An AIT project is also experimenting with the use of charred rice husks as an absorbing surface, and there may be potential there. Whatever the surface material used, any structures would be made of indigenous bamboo. In general, therefore, for surface and building materials, local availability at the village level should not be a problem. The same basic materials would be used both for drying and distillation.

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* King Mongkut's Institute of Technology.

2. Alternative Sources of Energy

Experiments have been done with developing a rice husk fired rice dryer. The cost of the fuel is attractive compared to conventionally fueled dryers. The cost of fuel per ton of paddy was estimated in 1974 as 8¢ for rice husks, 86¢ for kerosene, or 51¢ for coal.* However the capital cost of a rice husk dryer is considerably higher. Also, rice husks are not always available to the farmer, but must be bought back from the miller or saved from the previous season.

Technology for drying foods with fuels such as gasoline or oil is well-developed but involves the consumption of non-renewable resources. In addition, the high capital cost of the equipment generally excludes the process from the village scale and thus does not help the individual farmer gain economic control over his or her crop.

For salt harvesting, the costs and distances involved in obtaining currently used fuels are direct incentives for use of a solar alternative.

3. Description of Program

The technologies for solar drying of foods and for solar distillation of water have been proven and many designs exist which are appropriate and economically feasible for village scale use. For example, in Thailand at AIT, a prototype one ton natural connection batch dryer has been designed and built for an approximate cost of ฿1500 for materials. Also, a forced connection continuous flow dryer is being designed at Chulalongkorn University which is estimated to be affordable by a reasonably prosperous farmer (e.g., 25-30 rai) who owns a gas motor to power the fan.

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* FAO Bulletin #31

There is certainly room for further adaption to specific Thai needs and conditions, and this should be a direct component of this project. At the same time, however, since the basic technology is relatively simple and easy to understand, the villagers themselves will often be able to adapt the designs best to their particular needs. The main purpose then, is not so much to do extensive research of the technology, but to spread an understanding of the existing technology down to the village level.

Such a program of technology diffusion is already being carried out in Thailand in the area of family planning. Private organizations have created a birth control education and distribution network that has put one individual in charge of promoting and administering birth control for each village. This villager is fully instructed in the mechanics of birth control and has a medical and administrative support structure behind him or her to help with difficulties. The greatest effectiveness of the worker is direct contact and knowledge of the people in the village, thus minimizing the psychological distance between them and the new technology

Information about simple improvements in farm technology, such as solar dryers or stills, could perhaps apply a similar mechanism: using regional supervision of local people interested in the program and running day-long workshops to instruct them in the new technology. The workshops would need to be preceded by an information program and perhaps a series of demonstrations to arouse interest. This would begin the process of recruitment for the workshops themselves.

An important part of these workshops would be hands-on experience constructing one or more of the drying or distillation projects. Such a workshop would begin explaining the elements of a design: why a screen must be a certain dimension, why a fitting must be water tight, how to make it so and to test it to be sure that it is, etc. Participants might help in the purchase or preparation of materials, and then assemble the project themselves, under the supervision of the workshop leader. For a large project such as a one ton rice dryer, several participants could work on one piece of equipment, so that it is all built within a short time. For smaller projects, such as a still, each participant could build his or her own. The participant could pay some appropriate amount for attending the workshop, such as purchase price of materials for his or her project, in order to make the workshop a personal investment and have a tangible product at the end

4. Implementation

The activity would draw on the data developed through the solar resources assessment, as well as the work being done at KMIT, Chulalongkorn University and AIT. It would also include a review of solar energy technology experience elsewhere in the world, such a review perhaps supplemented by a trip to visit visit actual use sites. The data and literature review should then lead to design and selection of prototype solar drying and distillation models.

One approach could be to hold a competition for students to design such models.

Goal of Competition:

- no external power sources.
- easily duplicated by villager with readily available materials.
- appropriate scale (in operation and economics) for individual farmer or village co-op.
- more than one use (year-round utility).
- cheap.
- efficient.

After the designs are selected and the initial workshops organized and executed, there would begin the process of monitoring the program, testing and evaluating designs, noting innovations in design or training techniques, responding to new user needs, and analyzing the spread and effectiveness of the program.

The activity would conclude with a general evaluation and workshop at which the results achieved and potential indicated, with particular emphasis on the continuing role of NEA and the Regional Energy Centers (RECs), would be the agenda.

C. Solar Process Heat

Several industries in Thailand use hot water or hot air as part of their manufacturing process. The heat for these processes is currently fueled with either wood or fossil fuel, but might be easily be supplied with solar energy. Heat within the range of 40-90°c is generally found to be the most economical use of solar energy. A program of promoting the use of solar energy for industrial process heat has the potential for significantly reducing fuel consumption in Thailand.

Solar process heat also offers some promise of making it more economical for small scale industries to locate away from the centralized power and fuel sources of urban areas. Perhaps the best candidates for solar process heat are agricultural and food processing plants, such as tobacco curing factories, lumber kilns for export grade lumber, and noodle factories. Many of these are already located in rural areas, but the use of solar process heat could act to increase that number.

The technology for solar process heat is bascially simple and well established. Flat plate collectors are generally used, both for water and air systems. Flat plate collectors are already being commercially produced in Bangkok, having found a market for solar hot water, primarily for tourist hotels and large hospitals.

Solar hot water systems generally have a simple and economical energy storage system - the hot water produced can be stored in an insulated tank until needed. Air systems, however, generally require a more elaborate storage system, such as a bin of rocks.

The first target industries for an air system should probably not involve a storage system, as it would be preferable to get a simple system operating in order to gain experience with design and operation.

The tobacco industry of Northern Thailand could be a good candidate for the use of such a solar hot air system. The first tobacco crop is harvested in December, at the end of the wet season, and the curing goes on until April. Tobacco barns, which hold from 10,000 to 80,000 kg. of leaves, are generally fired with lignite or wood (although some barns are now being converted to gas). One batch of tobacco is cured in five days in which time five cubic meters of wood is burned per 1,000 kg. of leaves, or approximately 900 liters of gas per 1,000 kg. The barns are heated to temperatures between 45°c and 75°c over the course of the five days; humidity being controlled with venting from the outside and occasional wettings of the barn floor.

Description of Program

Two industries would be selected for a demonstration of solar process heat, one air system and one water system. Various companies in that industry would then be contacted and asked if they would be interested in co-operating in a demonstration program. A team

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would then design an appropriate system. The program would pay the costs of design and any tool up costs, while the company paid costs of materials. The company would also agree to let the system be monitored for a two year period. Government-owned industries might provide the most willing initial candidates. Probably 10 designs and systems would be carried out and installed. The emphasis would be on rural or rural-town located facilities.

During the construction of the systems and at the end of the first working season, workshops would be held for other interested industries. Evaluation would be continuous, the program would develop basic materials for spreading information about the practical application of the technology.

WATER LIFTING TECHNOLOGIES

A. Resource Base and Needs

In many parts of the country, water is available in abundance but a meter or so below the level of the cropland: e.g., in the Chao Phya Delta from the large network of streams, canals, and ditches; in the Northeast from farm ponds and shallow dug wells; and in the North from the rivers. This water can be used to help avoid the effects of delayed rains, monsoon droughts, and premature drying of rice fields toward the end of the monsoon. It can increase the gravity irrigation capacity of Chao Phya Delta irrigation works for dry season cropping; it can expand dry season irrigation from existing rivers and streams in many parts of Thailand, and it can provide modest amounts of irrigation for the Northeast.

The net benefits of irrigation pumping are high according to analyses using diesel pumps and high yielding rice.* Even supplementary irrigation alone, to improve monsoon season rice yields, is cost-effective.

Pump irrigation does not require dams, massive land acquisition, or complete canal systems. It can benefit a single household, a group of households, a village, or even larger groups, but it does not depend on establishment of a complex organizational structure for water management.

At the present time, however, pump irrigation is held back by the following disadvantages.

i) It consumes increasingly expensive, imported fossil fuels.

ii) It utilizes engine-pumps with relatively high maintenance costs.

iii) It is only economical at a scale (five horsepower and up; 70 rai or more) beyond the capability of the small farmer.

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*See "Water for the Northeast: A Strategy for the Development of Small-Scale Water Resources," Asian Institute of Technology for the Water Resources Planning Subcommittee, NESDB, September 1978, pp. 43-44.

B. Description of Program

Three technologies would be demonstrated for lifting water: wind, biogas, and solar photovoltaic. Encouragement would be given to dissemination of other technologies where appropriate: hydraulic ram, crop residue fired steam engine, animal power, and solar thermal, but emphasis would be upon the three most promising technologies unless changing conditions or data developed as a result of the testing of these technologies merited a shift in priorities.

Programs for demonstration of wind, biogas, and solar photovoltaic pumps would proceed as follows:

- Literature, data and experience review.
- Design selection based on resource conditions (e.g., wind velocities), for several alternative configurations if useful.
- Prototype units fabricated and tested.
- Villages and farmers selected for field testing.
- Devices installed in villages for operation and monitoring.
- Evaluation leading to further design selection and modification.
- Evaluation leading to design recommendations and to recommendations regarding appropriate and effective means of dissemination.
- Training of key personnel (entrepreneurs, voluntary organization field staff, agriculture or irrigation extension, or community development workers).

1. Wind Pumps

A 1974 AID report by William E. Heronemus, "A Survey of the Possible Use of Windpower in Thailand and the Philippines" is the basis for the program suggested here, as far as development of suitable windpumps for irrigation in the Chao Phya Delta is concerned. With the exception of some areas along the coast of South Thailand, the Chao Phya Delta is the most favorable area for wind development. The wind resource

even there is not tremendous but it is adequate for water lifting.

"It would therefore appear that a modern propeller type windmill or a modern fan mill type windmill of about 6 meters diameter with axis height of 10 meters, located at Don Muang, or between Don Muang and Sara Buri, could irrigate a family holding of at least 25 rai for rice culture during the dry season, provided it could take a suction from a ditch such that total head was of the order of 1.5 to 2.0 meters. It is possible that a dug well in that entire region might produce water fast enough to sustain that rate of withdrawal at that head. On the other hand, ... it may be more appropriate to locate wind pumpers along the main canals where they can draw from the "trickle" (but assured trickle of the dry season) in the canals and use their lift to fill the ditches whose turn-outs are high and dry above that trickle. The existing ditch system would then gravity-feed the fields." (p.34)

"More time could show exactly what the Lubing or the Aermotor might produce at Nakhon Sawan: it is suggested that it might still be quite adequate to serve a 25 rai farm with one 6 m diameter windpumper. So, it is concluded that there is an excellent possibility that windpower could be used to speed up the transition to double-cropping of rice in the extensive Chao Phya Delta. This might be accomplished by installing windpumpers at individual farms, ... each pump to take suction from a ditch or from a dug well. The water table is apparently almost at ground level throughout the entire region, but some experiments would certainly be appropriate before one could say that upwards of 2,725 cubic meters of water could be withdrawn each day from beneath a 25 rai farm on a continuing basis." (p. 36)

Heronemus then proceeds to outline design changes necessary to accomplish the desired task, be low cost, adaptable to home construction, and self-starting at 3-5 knots. Because there is currently underway in Thailand and elsewhere* a modest amount of research into improved, low-cost windpumps, it would necessary first to assess Thai progress toward achieving the objectives set forth by Heronemus.

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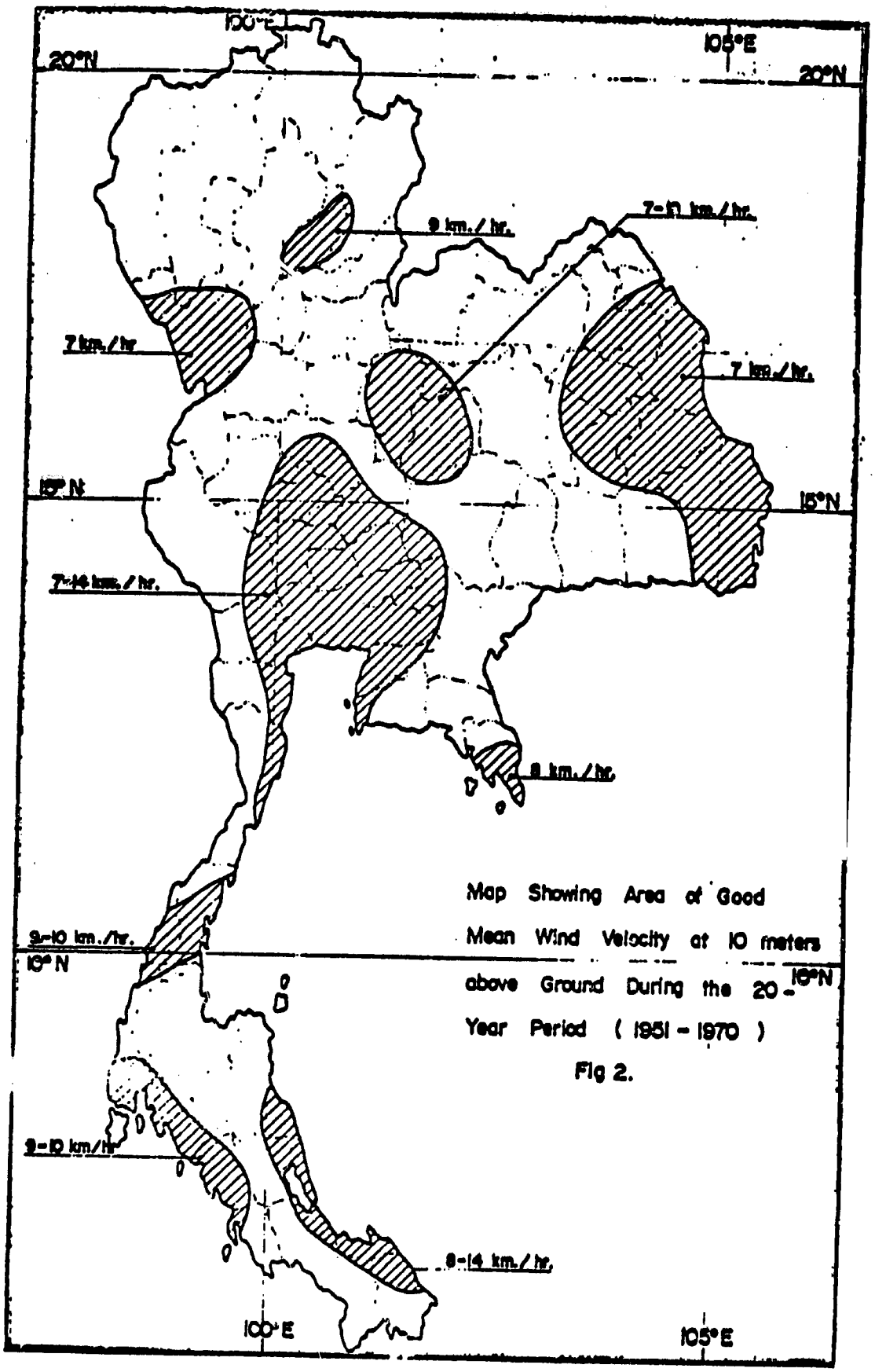
*See Marcus H. Sherman "Report on the Practical Application of Wind-Powered Water Pumps," ESCAP, Suva, July 1977.



Map Showing Area of Good Mean Wind Velocity at 10 meters above Ground During the 20-Year Period (1951 - 1970)

Fig 2.

SOURCE: NEA

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He concludes:

"A. There are several situations in which windpumped water could improve the yield of agricultural operation in Thailand:

1. Small windpumpers pumping from dug wells could alleviate the start-of-season and the end-of-season random droughts which reduce rice yields in the traditional one-crop rice culture.

2. Larger windpumpers pumping from irrigation canals and ditches in the Central Plain could improve Dry Season irrigation such that rapid expansion of double-cropped rice culture could occur.

B. Both small and larger windpumpers can probably be constructed in-country essentially from indigenous materials. The small windpumper can probably be owned by individual farmers if such farmers have wells or other sources on or alongside their land adequate to feed the pumpers. The larger windpumpers should probably best be located ... in harmony with ... improvements in systems for dry-season irrigation, and may therefore better be owned by collectives or governmental authority....

D. Small or large windpumpers pumping from dug well(s) or existing streams, or in some instances from deep bore holes, could accelerate the double-cropping of vegetables, upland crops and fruit in the central part of the Northeast, radiating outward from Khon Kaen." (p.66)

The following recommendations of Heronemus are endorsed, with minor modifications:

A. Assist the RTG expand its current excellent system for wind measurements so that accurate monthly velocity-duration curves can be prepared for areas of interest.

B. Initiate development of four meter diameter and six meter diameter wind machines of both the improved Thai two-bladed type and of the proposed wooden fan mill type.

C. Initiate the development of variable-throw crank mechanisms for windpumpers.

D. Initiate development of reciprocating pumps constructed of indigenous materials.

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NEA has a field station adjacent to AIT that is involved in wind machine testing. This would coordinate the R&D under this program and collaborate in development of improved windpumps.

2. Solar Pumps

In the great agricultural deltas of the world, where the sun shines brightly for long hours and where water is found not far below the land, ideal conditions exist for solar pumps. Already, diesel pumps are used in the Chao Phya Delta but these pumps are limited to use by larger farmers or by farm groups. Such groups have proven difficult to organize effectively to protect small farmer interests. Significantly smaller diesel pumps are not manufactured, and rural electrification cannot hope to reach the large numbers of tiny plots that require pumped water.

Solar photovoltaic pumps could possibly meet the need of the farmer with less than 20 rai of rice land, as well as the needs of the larger farmers. These pumps would be fuel free, have minimal maintenance requirements, be quiet and pollution free, modular in nature so that capacities could be easily be increased, would be adaptable to other uses besides pumping water, have high reliability (no problems of diesel fuel shortages, electrical system power failures, or load-shedding), and would offer protection against inflation and petroleum supply uncertainties.

Solar pumping systems could be particularly well suited to the pumping needs of Thailand. Because land parcels are small, limited quantities of water are sufficient, and because of low lifts, limited amounts of power suffice. Plants use water during the daytime, in direct proportion to incoming solar radiation which also drives the pump. No storage is needed (although under some circumstances a few hours storage can be cost-effective) because water is stored in the soil.

A photovoltaic pump to service one hectare for supplementary irrigation during the monsoon season and for a dry season non-rice crop would require about 100 watts (peak)*.

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*Peak month water requirement (at the pump) of 200 mm, lift of 1.5 m, pump efficiency 60 percent, motor efficiency 80 percent, 5.5 kwh/kw peak/day:

$$\text{kw}_{\text{peak}} = \frac{(2{,}000)}{(30 \times 5.5)\,\text{m}^3/\text{hour} \times 1.5\text{m} \times \frac{.746}{.6 \times .8} \times \frac{1}{272}} = 0.1$$

The pumpset costs $200, solar array costs would be about $900 at 1979 (early) prices. If the current pace in development of the technology continues, however, early 1980s projected prices for solar array could be on the order of only $200. Returns would be in excess of ฿400/ha or $200.* Inclusion of benefits from supplemental, wet-season rice irrigation would increase that benefit.

Thus such a pump will pay for itself in little more than a year at early 1980s solar cell prices and in less than six years at current prices.

In view of this favorable prospect, a solar cell demonstration program is recommended to design and fabricate two to three prototype photovoltaic pumpsets, to demonstrate these and monitor and evaluate the results. The program would include a data and literature review, including possible site visits in other countries, design and fabrication of the prototypes selection of villages, installation, operation, monitoring and evaluation. The program results would be the subject of a workshop, which would take into account the direct experience of the activity and the trend of photovoltaic cell prices in arriving at recommendations for dissemination of the technology.

Although the program aims specifically at developing photovoltaics for water lifting, a side benefit would be development of an RTG capability to work with solar cells in practical applications. This could include, for example, purposes other than lifting water: for communications facilities, health clinic refrigeration, lighting in remote areas, etc.

3. Biomass Pumps

There are several biomass pump possibilities that appear promising, including biogas and steam engines. To complement the biogas rural oriented technology program described at Annex VIII, a biogas pump program is proposed based on a community size biogas plant. This would involve a review of the technology data, design of engine modifications, selection of a village or tambon, construction of the biogas converter, operation, monitoring

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*Based on "Water for the Northeast," NESDB, September 1978, pp. 34 and 35.

and evaluation. The results would be subject of a workshop, which should develop recommendations on dissemination of the technology.

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VILLAGE WOODLOTS

I. Resource Base and Needs

Estimates of the size of the present forest estate of Thailand vary greatly according to the source and the time when they were made. The broad assessment of the forest resource was originally carried out in the late fifties and early sixties. De Backer and Openshaw did the most recent national survey, which was the basis for the 1972 FAO Report.

The natural forest of Thailand can be classified into three broad types: broad-leafed evergreen forest (40 percent of the area), mixed deciduous forest (22 percent) and dry dipterocarp forest (38 percent).

The forest resource, growing stock and increment of the country estimated in the FAO Report as of 1970 are summarized in the following table:

Table 1

Region	Area (mill.ha)	%	Growing Stock Volume (mill.m^3)	Vol/ha m^3	Annual Increment mill.m^3
North	11.28	42	599	53	11.74
Northeast	7.8	29	223	29	4.48
West Central	4.72	17	220	46	5.10
South	3.22	12	247	77	6.17
Total Country	27.02	100	1289	205	27.49

(Source: Present and Future Forest Policy Goals: A Timber Trends Study 1970-2000, Thailand; FAO, 1972)

(Note: Timber Trends Study - TTS for further references.)

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The above areas do not include areas of mangrove forest in the South of the country, or plantations of conifers, rubber and coconut trees. The area of 27.02 million hectares of forest in 1970 represented approximately 53 percent of the total area of the country.

In 1974 the total area of forest tree cover was estimated as being only 37 percent of the total land area, and recently estimates based on Landsat satellite imagery put the total forested area close to 25 percent of the total country's area. Despite the fact that the validity or precision of the more recent estimates can be open to question, they nonetheless are convincing evidence that the area of forest land is being reduced rapidly; how rapidly may be open to further definition.

North

The largest part of the forest area of Thailand is located in the North. The major part of the North is mountainous and over 60 percent of the region's area is designated as forest lands. These produce all the valuable teak timber in Thailand as well as other commercial species. Pressures of increasing population and scarcity of agricultural land have resulted in encroachment of the lower slopes of the forest land by the farmers and by the tribal communities. As a result, considerable areas of the forest have been destroyed. The economically significant area has been drastically reduced. Today it is estimated that only half of the area is reasonably productive. Illegal occupation of forest lands, followed by shifting (swidden) cultivation using slash and burn practices, is further aggravating the problem.

Tree covered land is spread in patches throughout the region including around villages. Great numbers of trees are also scattered all over the countryside. These trees or tree covered areas are used by the villagers as a source of fuel wood and building poles. However, the quality of this tree cover is deteriorating rapidly and the depletion is extensive.

Most of the logging operations take place in the more remote areas of the region and the distance to the market, either for sawlogs or fuel wood from the residue generated during logging, is often considerable. Most of the residue generated during harvesting of the natural forest is left at the logging site. Due to concerns about opening up the forests for general access, people are not permitted to collect the residue for use as fuel wood or conversion into charcoal. Since the

demand by the rural population for fuel wood and construction poles is strong, illicit felling and encroachment of more accessible forest areas results.

Northeast

The Northeast is considered one of poorer areas of Thailand. According to the statistics, the forest cover represented about 29 percent of the national forest area as estimated in the sixties. It is estimated that at the present time the forest area is smaller, but how much smaller is unclear. The distribution of the forest within the region is uneven with greater concentration of forests in the northern and western parts of the region. According to the information obtained from the Landsat program, the central, southern and eastern parts of the region are practically without continuous tree cover and contain only small scattered patches of degraded and depleted forest. There is evidence that the encroachment into the reserved forest and the conversion of the forest into agricultural land is much faster than in the North.

There are still areas of public land left used for livestock grazing and as a source of fuel wood around the villages. These are made up of only small trees and shrubs and this tree cover is under considerable strain and being rapidly depleted.

There is no reliable data available to estimate how much of this area is left as a fuel wood source; however, it is obvious that in the eastern parts of the region the tree covered area is small.

South

According to the Royal Forest Department (RFD) inventory data, the total area of evergreen forest in South Thailand was 26630 km^2 in 1972. This area in 1972 was only 83 percent of that in 1961. There can be no doubt that although the area of natural evergreen forest is being reduced rapidly, the region still has a large area under forest cover. The two other types which are of importance to the South are the mangrove forests, mainly located along the east coast of the isthmus, and actual tree plantations (conifers, rubber and coconut). The mangrove forests cover approximately 4000 km^2

and these are well managed and their exploitation is well organized. This also applies to plantation areas.

The situation regarding fuel wood and charcoal is not clear. Approximately 80 percent of fuel wood requirements are at present met from outside the forest reserves.

One fact which could influence the fuel wood situation is South Thailand is the rate of rubber replanting. It is estimated that by the late 1970s, "300,000 rai of overmature rubber will be replanted annually and this would provide approximately six million cubic meters of rubber wood each year" (Source: South Thailand, Regional Planning Study, 1975).

Fuel Wood Supply-Demand Picture

There are two major sources of fuel wood in Thailand: natural forests, and the tree covered areas around villages and scattered throughout the country. Wood fuel plays an important role in the life of the community as the principal cooking fuel in rural and urban areas.

Most of the wood fuel from the natural forest comes in the form of illegally cut wood from encroached areas, from land subjected to shifting cultivation, and from the residue generated during harvesting and sawmilling operations. Some charcoal is produced from these sources.

Most of the fuel wood requirements come from the tree cover scattered throughout the country. As the demand for fuel wood increases this source is being rapidly depleted.

There are no reliable estimates of wood fuel consumption and source of wood fuel. According to the FAO Timber Trends Study, 99 percent of the rural population and 87 percent of the urban population use wood fuel for cooking. The represents a national average of 97 percent. About 20 percent of the population use fuel wood for heating and about 10 percent use wood fuel for a number of other purposes such as curing fish, etc. The main use of course is for cooking.

The average consumption of wood fuel per capita is 1.23 m^3 with the range from 1.0 m^3 to 1.27 m^3.

The per capita consumption of wood fuel in 1970 was as follows :

	Per Capita Consumption Per Year m^3		
	Fuel Wood	Charcoal	Wood Fuel
Rural	0.76	0.51	1.27
Urban	0.11	0.89	1.00
Country	0.67	0.56	1.23

(Source: TTS.)

On the basis of the above estimates the total consumption of a household in the villages averages 7.26 m^3 per annum and in the urban areas the average represents 6 m^3/annum for a household. The data on annual consumption of fuel wood per household is presented in the following table.

Table 2
Household Consumption

Region	m^3 per Household 1/		
	Wood Fuel	Fuel Wood	Charcoal
1. Rural	7.26	4.36	2.89
N	6.75	4.26	2.49
NE	8.23	5.79	2.44
C	6.55	2.02	4.53
S	6.82	4.73	2.09
2. Urban	5.97	0.64	5.34
3. Total	7.08	3.84	7.08

Note 1/ This is the average for all households whether consuming wood fuel or not.

(Source: TTS.)

It should be noted that highest consumption of wood fuel per household and also per capita is in the Northeast. The total consumption of wood fuel for the country was over 44 million m^3 of which more than 50 percent was fuel wood. It is estimated that with increasing population and the higher cost of other fuel (oil, kerosene, gas), the total consumption is now probably higher than when this survey was done in 1970. Industry uses over 4 mill.m^3 of wood fuel annually. Fuel wood is used in the brick, earth-ware and cottage and steel industries, and in the preparation of agricultural products such as tobacco, rice and others. Many sawmills, especially small operations use the sawmilling residues to generate power. In many areas shortages of wood fuel are already occurring and the operators of many industries are looking for substitutes for fuel wood (as in the case of the tobacco industry which is using lignite), or are taking steps toward more economical and efficient use of fuel wood (e.g., earth-ware plants).

In addition to the household and industry consumption of wood fuel, over half a million cubic meters of wood fuel is used by hotels, restaurants, temples, etc.

In summary, over 49 mill m^3 of wood fuel was used in 1970. It is assumed the consumption is considerably higher at present and increasing. More than 90 percent of consumption is in households, mostly in rural areas.

According to the same FAO study, out of a total consumption of over 50 mill m^3 of fuel wood, 21 mill m^3 comes from the forests as a removal of standing trees (only about 2.5 mill. m^3 is officially recorded) and over 29 mill m^3 comes from farmers woodlots, rubber plantations, individually scattered trees in the countryside and from crowns, branches and felling of waste from the forests. This latter portion is unrecorded and it is believed that it is steadily increasing. The high portion of unrecorded use would also explain the rapid decrease in the area of tree covered land.

The demand for fuel wood from the forests, recorded in 1970 as 21 mill m^3, is expected to increase to a maximum limit of 34 mill m^3 in 1985. Meanwhile the supply from natural forests, in the form of increment, will decrease to the level of 14 mill m^3 in 1985 after which the demand will be met by drawing from the forest capital. It is expected that by the mid-eighties the demand on the national forests will reach excessive proportions.

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The effect of the increased demand for fuel wood on farmer woodlots and tree cover throughout the country is not known. However observations and interviews indicate a considerable deterioration in the quality and availability of the resource.

The following tables indicate the situation in the fuel wood supply-demand equation in 1970 and a scenario for 1985.

Table 3
Origin of Fuel Wood
unit: million m^3

	1970	1985
Total requirements	50	70
Production from:		
mangrove forest	5	5
felling losses off cuts	1.5	3
" " (crowns)	4	8
losses from pitsawing	2.5	2
removals by shifting cultivation	5	3
production from farmlands	8	11
rubber plantations	2.5	4
cane and bamboo	0.5	-
Total from alternative sources	29	36
Residual from standing forest trees	21	34

(Source: TTS.)

Table 4
Forest Situation

	1970 unit: million m^3		1985 unit: million m^3	
	sawlog size	small size	sawlog size	small size
Growing stock	1,225	600	1,020	400
Annual, growth rate	2.1%	3.5%	2.3%	3.5%
Annual increment	26	21	23.5	14
Removals: sawlogs	14	-	24	-
fuel wood	-	21	-	34
Surplus/deficit	+12	0	-.5	-20

(Source: TTS.)

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In 1970 there was a small surplus in sawlog size of timber and a balance in the small size timber. However in 1985 the drain in the small sized timber category, which is a base of future growth, could have reached alarming proportions On remedial steps, there are several ways to improve or stabilize the situation, and at the same time to increase the forest biomas for energy production. Without considering the economic aspects of supply, the major potential sources of tree biomass for energy include:

a) underutilized natural forest.
b) industrial forest plantations.
c) energy plantations-trees grown specifically for energy production.
d) industrial residues - principally logging waste and sawmill waste.

In biomass production for energy use, the most promising system is short-rotation forestry. In this management system the growth of tree species is three to eight years and the objective is to provide the maximum energy content at minimum cost. Within that objective the goals are to select and improve the most promising species, to minimize risks and cost of establishing growing stock, to determine the most efficient silvicultural and management systems and to obtain optimum yields. The biomass productivity and the quantity of energy produced in the short rotation forest system is considered high. Selected, rapidly growing species are planted at close spacing and the crop is harvested at appropriate intervals, i.e. by rotation, with the succeeding crops arising by coppicing, precluding the need to replant after each harvest.

As stated above, the forest tree cover in the Northeast in 1970 represented a total of 7.8 mill. hectares or 29 percent of the national total forest area. Despite the fact the present estimates are lower, the tree covered area in the Northeast is still larger than in the Center and South. However, in the rural areas the Northeast has the largest per capita consumption of wood fuel approximating 1.35 m^3 per year compared to 1.17 m^3 in the Central region. Also in the Northeast more fuel wood than charcoal is used.

There are varieties of ecological conditions prevailing in the Northeast varying from semi-arid to almost as humid as tropical conditions. The main forest types are Dry-Dipterocarpus and semi-evergreen.

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In the Northeast there are a number of provinces where the ratio of forest land to total land area is low, as indicated in the following list:

1)	Roi Et	3.5%
2)	Yasothon	3.5%
3)	Si Saket	7.68%
4)	Surin	9.44%
5)	Maha Sarakham	9.58%
6)	Ubon Ratchathani	18.58%
7)	Buri Ram	26.36%

Particularly in these provinces where the forest land area is small many villages are without a continuing source of supply of wood fuel. In the Northeast there are hundreds of villages which were once agricultural pockets surrounded by savannah forest. However over the last few decades more and more wooded areas have been eliminated owing to the encroachment of farmers searching for available land. The receding woodland has left many villages without easy access to wood supplies and the problem is becoming critical.

To obtain wood fuel the villager usually chooses the easiest way - he cuts wood illegally from the forest land and thus further aggravates the depletion of the forest resource. Since the alternative sources of energy for his consumption are either not available (electricity) or too costly (oil, gas) his actions are a logical means of survival.

Sacrificing woodland in this way often leads to erosion, may depress farm output and generally has a deteriorating effect on the environment. The steady disappearance of wood in the vicinity of the community also means increased social hardship. More of the time of the family members must be devoted to gathering fuel. As the situation deteriorates further and the family is forced to purchase its wood fuel, a burden is placed on the family budget. Yet, it is possible for a village family by scientifically farming and harvesting wood from its own trees or a small village tree lot to satisfy its annual needs and produce a small surplus for sale. Thailand is fortunate that the climatic conditions are favorable for growing a number of fast growing species which can yield a considerable amount of wood in a very short period of time. In the Northeast, as noted above, the conditions vary from tropical humid to semi-arid. However, conditions are not that severe that they would prevent successful tree growth. The candidate species may be chosen primarily on the basis of the following criteria:

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a) rapid juvenile growths.
b) ease of establishment and regeneration.

There are native or introduced species which can well adapt to such climatic conditions. Experience from Thailand and other countries shows that some of these species are particularly suitable for production of fuel wood.

However, there may also be constraints to establishment of village operated woodlots. The competition for crop or grazing land, delayed return from growing trees, seasonal shortage of labor force, unfamiliarity in tree growing techniques, etc., represent possible obstacles. Not all these would apply in the case of family lots, but the total production would probably be correspondingly less. The obstacles apply particularly to conditions in the Northeast where the competition for land is great. Nonetheless, the need for development of a woodlot resource in the Northeast is certainly clear. The effort to do so will attempt to find workable ways to overcome the constraints.

Proposed Tree Varieties and Their Characteristics

For successful adaptation to soil and climatic conditions of the Northeast, the following tree varieties, which have already been tested by the RFD, are appropriate for planting:

1) Leucaena Leucocephala has been introduced in Thailand over the last 5-7 years. Popularity among tree planting people began about two years ago (1977). Additional information on this tree is still required. However, a review of literature regarding its cultivation in the tropics, such as in Indonesia and the Philippines, is very encouraging. In the Northeast it is expected to achieve a volume increment of 25 m^3/ha/year over a five year rotation period. From the experiment conducted by the RFD a five-month old plant has achieved growth of four cm (d.b.h.) and a height of five meters. When considered in terms of attitude, soils, and amount of rainfall it can adapt well to the Northeast. In addition, it can be used in agro-forestry practices (inter-cropping). To date, the RFD is capable of producing 50-70 kg. of Leucaena seed per year from the stocking plant at Khon Kaen. Regrowth by means of coppice is very good. Both Salvador and Hawaiian type varieties could be planted to test the most suitable strain for woodlot needs. The Hawaiian type can also be used as animal fodder.

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2) Acacia Auriculifarmis is a small to medium shrub, about 10-15 meters high. It is widely adaptable to all types of topography, it is easy to propagate and highly resistant to drought and forest fire. Regeneration after cutting by means of coppice is very good. It is suitable for planting in sandy soil, laterite soil and even in forest.

3) Casuarina Equisitifolia is a medium to large size tree, about 20-25 meters high at full maturity. It has more branches than Casuarina Junghuhniana and propagates by seed. Suitable for planting in sandy loam at an altitude of 100-500 meters. Planting site is more limited than the other varieties mentioned. It requires moderate moisture and is resistant to drought. Growth constraint is laterite soil but it may do well in old alluvial soil. It is capable of regenerating by means of coppice.

4) Eucalyptus Spp. does well in almost all types of soil. There are several varieties. Some can grow in water-logged land, some are drought resistant. It propagates well. Seed orchards also exist in the Northeast. The most suitable species appear to be E. camaldulensis, E. resinifera, E. grandis and E. decaisneana.

5) Peltophorum Dasyrachis, a medium to large size tree; height 20-25 meters when fully mature; only 5-7 meters at five years of age. It is native to the Northeast and highly resistant to drought. This tree does very well in dry evergreen forest where soil type is loam - sandy clay loam. The Peltophorum dasyrachis is found in Surin, Si Saket, Khon Kaen, as well as in dry evergreen forest and upland areas adjacent to paddy lands. Collection of seed, preparation of seedlings, and planting can be easily handled. As a legume, it is suitable for planting in old alluvial soil, or even in mixed deciduous forest at a height from 100 meters to 1,000 meters.

6) Casuarina Junghuhniana is a medium to large size tree, about 25-30 meters high, introduced from Australia or Indonesia. In Thailand it does not produce seed. Thus, propagation is done by means of grafting. This tree is adaptable to all type of topography ranging from a height of below 100 meters to above 1,500 meters. It is highly resistant to drought and capable of growing even in laterite soil which is not suitable to agricultural practice. This tree also does well in sandy loam soil. The RFD has recently imported seed from Indonesia and the Forestry Research Section of the RFD has successfully found an appropriate grafting method by using a chemical to stimulate growth. It is expected to be successfully adaptable to the Northeast. Currently, it is very popular among private tree planters who are producing trees for fuel and poles used in construction. Since it is capable of producing coppice, a need for replanting is minimal.

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7) Acacia Catechu is a small to medium size tree, about 10-15 meters high, suitable for making fuel wood and charcoal wood. It is drought and forest fire resistant. Its propagation can be done by using seed or clone. This tree does well on fairly well drained soil and hilly areas. Planting is possible even on laterite soil. Its use is recommended for fencing. Results of the experiment conducted in the Northeast have proven a great potential for expansion. Acacia catechu is native to the Northeast.

Other Donor Assistance

The Northern Agricultural Development Project for which a $25 million IDA credit is soon to be signed includes two forestry elements. Village woodlots totalling some 4,000 hectares will be established in upland areas under the guidance of the Land Development Department with technical support from the RFD. In highland areas, the Watershed Management Division of RFD will manage forest rehabilitation, woodlot development, protection and track construction activities. Approximately 7,700 hectares is targeted for village woodlots or plantations.

The World Bank through its FAO Cooperative Program has just completed an initial survey for a major national forestry project. Under the FAO Cooperative Program (under 75 by the Bank and 25 by UNDP) FAO experts will be made available to the RFD to prepare a project proposal for World Bank assistance. Currently the project is viewed as a strengthening of the RFD, involving almost all divisions, with a variety of activities including forest village woodlots, reforestation, and rehabilitation, fire control, research, etc.

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II. Description

The optimum type of village program for retarding forest degradation, while at the same time providing villagers with a fuel source, is a community or village woodlot activity. At the same time, and as discussed at Annex XV, there are tangible constraints to the community based idea and other alternatives will be addressed and tested in the program. The basic long-term development to be encouraged, however, would involve the community as a unit. Accordingly, the program below sets forth this alternative as the proposed point of departure, and the main alternatives to be tested. The initial costs of this approach are probably among the higher of the alternatives, and with reasonably comparable yields, the economics of this approach should encompass the others.

In order to test the goal of safeguarding future fuel wood supplies to the predominantly rural population, villager operated woodlots will be established in or near the villages of the Northeast region. The objectives of the activity will be to a) provide a sustained supply of wood fuel for both woodlot owners and non woodlot owners, b) lessen the pressures on cutting of trees in the natural forests and poaching of trees on public land in general, c) creation of employment opportunities and increased income for rural families, d) develop techniques to be used as an important first step towards possibly country-wide schemes, and e) stimulate interest in tree farming by demonstrating the benefits which can come from such development.

The establishment of village operated woodlots is a new concept in Thailand. The scale of development will be limited to selecting 20 villages in two provinces of the Northeast. It is estimated that a total of 6,000 rai of land will be planted to various fast growing species over the five year period. This will benefit about 1000 rural families directly and many other families indirectly through easier access to wood fuel and through new employment opportunities. In each of the participating villages up to 50 families will be selected to join the program, with 10 the first year and 10 in each succeeding year through the five years of the project. Each family will grow trees on up to 10 rai of land. This total of 6,000 rai will increase to 10,000 by the ninth year based on planting by the 50 participating families.

Annex XV discusses some of the constraints in selecting land for the village woodlots activity as well as some of the opportunities for testing different approaches and applications on different types of land holdings. Accordingly, a combination of

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some of the approaches suggested in Annex XV will be taken depending on the situation in different villages and the interests of the villagers. Within the total of 20 villages a target distribution of the alternative approaches would be 8 in forest village land (2 in each of the 4 RFD districts in the Northeast), 6 on public land and 6 private land including marginal lands, backyard woodlots and shelter belts.

The villagers under the supervision of village woodlot technicians will clear the land, prepare it for planting, plant the seedlings, weed the area and provide fire protection.

The RFD will provide the villages with the planting stock from the nursery centers. If more families than planned join the program and a larger area is planted, village operated nurseries may have to be established to meet the demand for seedlings, but probably not for this project(see below).

It is expected that the average annual yield per rai will be 2.7 m^3 of wood after the initial five year period. A participating family, therefore, will be able to cut on continuing basis two rai of woodlot each year after the first five years of the program.

The RFD will employ two village woodlot officers and five village woodlot technicians. These officers will be responsible for the technical component of the project and will supervise and train the villagers in woodlot establishment techniques.

To assist in soil assessment of site suitability for planting of individual species, technical assistance from a soils sciences and forestry consultant will be provided in the initial phase. There will also be a long term Thai consultant assigned to the activity, as well as other technical assistance from US and Thai consultants as the need is identified.

Training of the village woodlot technicians will be an important part of the program. Some of the officers of the RFD participating in the program will be sent for study tours to a country having experience in tree farming (e.g., Philippines, Korea). Other training will also be included.

The phases of the woodlots establishment will be as follows:

1) Selection of the provinces and villages which will participate in the program.

2) Location of the necessary public, private or houselot land in or near the villages.

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3) Soil and site investigation.

4) Coordination of the activities of the RFD and villages.

5) Training of the village woodlot technicians.

6) Training of the villagers in woodlot establishment techniques.

7) Survey.

8) Nursery stock preparation.

9) Initial clearing and site preparation.

10) Staking.

11) Planting.

12) Weeding.

13) Fire control.

Constraints (See also Annex XV.)

a) Difficulty in making land available for woodlots.

b) Lack of experience in growing forest crops.

c) Limited numbers of trained RFD personnel to work with villagers.

d) Protection of tree crops from fire hazard and grazing.

e) Clash of woodlot and agricultural activities in the same season.

III. Technical Components

a. Site Selection

Site selection will consist of two main activities:

a) Identification of the public,village or private (houselot areas) land suitable for woodlot development (location of the land and suitability of the site for individual species). This will be carried out by representatives of RFD,

in coordination with other local officials, tambon and village representatives, etc., depending on local requirements and availability of responsible officials and land.

b) Surveying and marking of the land - this will be a separate activity. The cost should not exceed ฿90 per hectare or ฿15 per rai.

The subject of land availability and suitability warrants special consideration. These criteria for site selection will be followed:

1) Villages will be selected in those provinces of the Northeast in which the forest land to total ratio does not exceed 10 percent (see list above at page 9).

2) The average mean annual rainfall should be at least 1,200 mm.

3) A minimum of 1,000 rai of land must be available for the purpose of woodlots in or near the village (assumes expansion area will be needed, i.e.,beyond the initial 500 rai for the first 50 families).

4) Land presently covered by brush and used as a source of fuel wood should be selected. Heavily grazed areas should be avoided as much as possible.

5) The average elevation of the area should be no more than 600 m above sea level.

6) Laterite soils are usually constraints to the development of trees. Therefore they should be addressed as a special component, in the sense that experimentation with species that can grow in laterite soil should be part of the program, with the aim of eventually being able to use this land. But the main effort in working with the villagers in this project should be to locate land where good yields will be ensured from the outset.

b. Land Requirements to Satisfy the Needs for Fuel Wood Consumption in the Northeast

The average annual consumption of wood fuel in the rural Northeast was recorded in 1970 as 8.23 m^3 of wood per household (or 1.35 m^3 per capita). This is the highest consumption in the country. In the optimum situation, a family should have enough land available to produce wood fuel for their own needs and some surplus to sell to other villagers or villages.

There are several growing species with suitable properties for use in village tree farming (see list above). The RFD is interested in introducing fast growing and high yielding Leueaena leucocephala (giant Ipil-Ipil) in the areas included in the project.

According to information from other countries which have considerable experience with growing Ipil-Ipil, this species can produce 15 m^3 of wood per hectare annually on a four year rotation basis, or 25 m^3/ha/year on a five year rotation. Some estimates put the annual increment even higher.

Some other fast growing species (Eucalyptus, Casuariua spp., Acacia, etc.) have no such impressive increments but it is estimated that they can reach at least half the volume increment of the Ipil-Ipil during the same rotation. These are conservative estimates for growth increment.

Two growing alternatives will be considered for the woodlot requirement: a) fifty percent of the area will be planted to Ipil-Ipil and 50 percent to other species; b) eighty percent will be planted to Ipil-Ipil and 20 percent to other species. Rotations of four and five years will be considered. While the estimated annual increment and final yield are higher for the 80 percent Ipil-Ipil alternative, local climate or soil conditions may act as a constraint, also in the longer term there may be greater potential ecological benefit in a more balanced mix. While both percentages will be considered for the project, therefore, the project discussion which follows is based on the 50 percent mix. This also represents a more conservative yield projection, which is appropriate given the experimental character of the project. The five year rotation cycle is also applied as probably the preferred alternative where results of a demonstration project are important. The slightly longer cycle (five vs. four years) does result in a marked improved yield.

At 50 percent/five year rotation, the annual increment per rai is 2.7 m^3 or 13.5 m^3 over the five year term. Probably, therefore, one rai of land planted annually by one family would satisfy their wood fuel needs. An area of two rai planted annually would give the family enough yield to sell fuel wood to other villagers and generate income. The total would be correspondingly 5.4 m^3 per rai annually or 27.0 m^3 over the five years. Therefore the goal will be to have each family employ up to 10 rai of land, of which two rai will be planted annually.

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Assuming an average village consists of 100 families, the per village land required will be 1000 rai. It is expected that not all families in each village will participate in this program. However, if this program proves to be a success and other families choose to participate, a minimum of 100 rai should be potentially available in or near the village. This land does not have to be in one piece, clusters of land each consisting of about 150 rai would be preferable.

Some of the land which will be converted into woodlots is presently used as grazing land. An alternative source of fodder must be found. One of the possibilities is to use branching Hawaiian type of Ipil-Ipil as a source of this fodder. Experience from other countries shows that the Ipil-Ipil yields a considerable volume of forage. One system which deserves attention would be to allow the Ipil-Ipil plants to grow for about 18 months before cutting back to a height of one meter. Thereafter, the regrowth can be harvested at a three or four month period. This would consistently give forage yield to replace the fodder from the "lost" grazing land.

c. Payments to Villagers

The discussion below assumes for project cost purposes that the participating villagers will be paid for labor in clearing, site preparation, planting, weeding, etc. It is necessary in any event to establish a cost for economic analysis and project cost purposes, but the question goes beyond that (see also discussion at Annex XV under the social analysis of the woodlots scheme). The whole activity is a new untested idea which requires land work and time on the part of the participating villagers if it is to succeed. On technical grounds the project will require careful work at all stages, and motivation and interest are essential. The project benefits will not materialize if the whole activity is not done well right at the village level. These benefits in turn are essential to the spreading of the scheme. What is involved are the perceptions of the villagers, their motivation during the project and their recognition of proven benefits at the end of the five years.

Voluntary participation, which may be seen as work for the Government rather than for their own benefit, may not be adequate to carry the activity through the five years with the extent of work required. At the same time, payment for labor in a village scheme in which the benefits go to the participants should not in theory be necessary. Theory, however, is best tested in the project itself, while at the same time making provision for ensuring that the work and participation necessary for an effective program are nonetheless forthcoming.

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Accordingly some situations, e.g. plantings on private land, will test an approach where payment is not made to the villagers for some or all of the work components. In fact RFD regulations preclude payment to villagers for laboring on private land, Thus in the event an approach is to be tested involving any such payments, these would come from the AID funded portion of establishment costs. The RFD would compensate by picking up a larger portion at another site.

For the same reasons as reviewed above, seedlings will be provided without charge except for testing in selected villages of the cost alternative.

Since in most cases the project will bear the costs of establishment, the discussion below assumes this approach which from a cost standpoint covers the alternatives.

d. Site Preparation and Initial Clearing

The woodlots will be located in or close to a village, and may have considerable variation in vegetative cover. Some may contain only sparse vegetation, mostly grass, some may have an extensive cover of shrubs and others may be covered by degraded forest. The extent, difficulty and cost of site preparation will depend on the condition of this vegetative cover, and will affect the amount of work in terms of work days required to clear and prepare the land for planning. The average figure provided by RFD, taking these variations into account, is three work days per rai.

Site preparation includes cutting shrubby vegetation, small bamboos, etc., in fact anything that can be cut by a knife, and subsequent burning. Open grassland would be less difficult and take time. At an average of three work days per rai, the cost is estimated at ฿150 per rai for initial clearing and ฿90 for site preparation.

To assure success of a new program which has not been tested and which may be met with some skepticism from the villagers, it is essential that losses be kept to a minimum. Well prepared land for planting is one of the most important prerequisites for a successful establishment of a woodlot. The wood from the clearing operations will not be wasted and if feasible could possibly be used in lieu of some or all of any proposed payments to villagers.

e. Staking

Staking includes preparation of stakes. About three work days will be required at the cost of ฿90 per rai. This figure is based on spacing of 2x2 meters or 420 plants per rai. Wider spacing would decrease the cost.

f. Nursery Stock Requirements

The optimum spacing for a fuel wood plantation or for farmers woodlots is about 2x2 meters. Considering the inexperience of villagers in planting and tending trees, the probable destruction of many seedlings and consequent risk of high mortality, spacing 2x2 meters is appropriate. At this spacing, the required number of seedlings per hectare would be 2500, which represents 420 plants per rai (allowing some margin for losses). The cost of plants produced by the RFD nurseries is ฿0.5 per seedling. Therefore the cost of nursery stock for one rai will be ฿210 per annum.

g. Capability of the Nurseries to Produce the Required Stock

In the Northeast there are at present eight forest nursery centers operated by the RFD, each center producing about three million seedlings per year. The present production of seedlings is therefore adequate, and there should be no difficulties in providing necessary stock to the villages during the initial stages of the program.

Since the activity will be a pilot project from which experience will be gained for further expension only 20 villages will be selected. Accordingly, there should be no need for the establishment of new, village operated nurseries for this project. The increase required in the production of the existing nursery centers would be minimal. However if the program succeeds and proves to be attractive, and it then expands to a considerably larger area, there may become a need for local, village operated nurseries. This would be in a follow up phase to this project.

The nursery stock will be delivered to the villages by an RFD truck and distribution of the seedlings supervised by a designated village woodlot technician.

h. Planting

The productivity of a short-rotation woodlot using a given species on a given site will be a function of stand density and management. The more dense a stand the sooner crown closure takes place and thus full utilization of the growth potential of a site is achieved. As noted, it is believed that the most suitable planting spacing in the Northeast woodlots will be 2x2 meters. Properly and carefully executed planting is of great importance for the successful establishment of the woodlots.

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There is only limited information available on the planting costs in plantations of fast growing species. Estimates of the RFD indicate costs can be as high as ฿150 per rai. However in the teak afforestation project in the North the cost of planting teak stumps is as low as ฿60 per rai. It is estimated that a total of four work days will be required to plant one rai of land at a cost of ฿120.

i. Weeding

Weeding will be an essential part of the woodlot establishment. The survival chances for the planted stock and the subsequent productivity of the area both increase dramatically with proper tending. It is essential that the villagers not face a failure in the establishment of the woodlots in the initial phases of the program.

Weeding consists of hoeing a circular patch around the plants. The most important time for this is at the end of the rainy season, to reduce competition for water stored in the soil during the following dry season. More tree scheme failures are caused through insufficient weeding than from any other cause.

The cost of weeding varies according to site and type of species planted. It takes about three work days to weed one rai of woodlot. In the teak afforestation scheme, the cost of weeding averages ฿60 per rai. At least two weedings are required after the establishment of the woodlot. The first weeding should take place about one month after planting and the second should be carried out just before the end of the rainy season. Three work days will be required at a cost of ฿90 for each weeding or ฿180 per rai for establishment of each new rai.

If the villagers are allowed to grow cash crops in the space between individual trees for the first and second growing seasons, much of the weeding requirement will be eliminated. This would both reduce the cost and result in better growth of the trees. Also, as long as the crops are in the ground, trespass by grazing cattle is less likely to be a problem. At the same time, if this type of cropping is permitted, care has to be taken to guard against the cash crops, and not the trees, becoming the real point of the villagers efforts.

The weeding should be closely supervised by the woodlot technicians and advice given to the villagers on the techniques of the operation.

j. Fire Control

An estimate total of 100 rai of land per village will be required annually for woodlot planting. Such an area will require about 1600 meters of fire lanes five meters wide. The fire lane consists on the inside of a one meter strip completely cleared of vegetation, and a four meter strip on the outside on which the grass is cut and removed. This type of fire lane can be made at the rate of 30 meters per work day, requiring a total of 53 work days to complete. Using a wage rate of ฿30 per day, the construction of such a fire lane will cost approximately ฿1600. Maintenance of the fire lanes will require six months of work per year per village at the cost of ฿3600 (20 work days x 6 x 30 = 3600).

k. Transport

The Northeast has an adequate road network and therefore primary transport of seedlings by truck is no problem. No serious problems of access to the woodlot areas are expected. Vehicles for seedling delivery and for supervising staff will be procured.

Attached are the following summary project tables:

1. Planting Schedule by Village.
2. Predicted Volume Output.
3. Per Rai Establishment Costs.
4. Estimate Costs of Woodlot Establishment for One Village.
5. Estimate Budget for the Village Woodlots Program.

Table 1

Village Woodlots

Planting Schedule by Village

Families	Year	rai					Total	Area (rai)	Planted
10	1	20					20		
20	2	20	20				60		
30	3	20	20	20			120		
40	4	20	20	20	20		200		
50	5	20	20	20	20	20	300	at end of project	
	6		20	20	20	20	380	at end of year six	
	7			20	20	20	440	at end of year seven	
	8				20	20	480	at end of year eight	
	9					20	500	at end of year nine	

Note: Based on each family planting a total of two rai per year up to 10 rai.

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Table 2

Village woodlots

Predicted Volume Output

Basis: Total area planted would be 300 rai/20 villages for a total of 6000 rai at the fifth year end of project. This total would increase in the succeeding years through the ninth year to 500 rai/20 villages for a total of 10,000 rai.

Year	Area Harvested (rai)	Volume m^3
6	400	5400
7	800	10800
8	1200	16200
9	1600	21600
10	2000	27000

Note - Based on average yield of 13.5 m^3/rai over 5 year rotation.

- 50 percent of area planted to Ipil-Ipil.
- 50 percent of area planted to other species.

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Table 3

Village Woodlots

Per Rai Establishment Costs

A. Labor	Time Required (in work days)	Cost ฿	Cost $
Surveying and Marking	½	15	0.75
Initial Clearing	5	150	7.50
Site Preparation	3	90	4.50
Staking	3	90	4.50
Planting	4	120	6.00
Weeding 1	3	90	4.50
Weeding 2	3	90	4.50
Subtotal	21.5	645	32.25
B. Nursery Stock (seedlings)	420x฿0.5	210	10.50
Subtotal		855	42.75
C. Fire Lanes Per Village			
Each 100 rai requires 1600 meters of fire lane at ฿1600 ($80) for construction. At 300 rai planted per village		4800	240.00
Fire lane maintenance per year	฿3600($180)	3600	180.00

Table 4

Estimate Costs of Woodlot Establishment - One Village*

Year	Number Families	Area Planted	Estab.Cost ฿855/rai	Fire Lanes**	Total Cost ฿	Total Cost $
1	10	20	17,100		17,100	855
2	20	40	34,200		34,200	1,710
3	30	60	51,300	5,200	56,500	2,825
4	40	80	68,400	5,200	73,600	3,680
5	50	100	85,500	5,200	90,700	4,535
Total	50	300	256,500	15,600	272,100	13,605

* Assuming 10 new families participate each year, for a total of 50 families in the village at the end of five years.

** On the basis of each 100 rai requiring 1600 meters of fire lane at ฿1600 for construction and average ฿3600 per year for maintenance of the total length.

Table 5

Village Woodlots

Estimate Budget
($)

Item		AID	RTG	Total
1. Establishment Costs	- One village for five years at $13,605 x 20	136,000	136,100	272,100
2. Personnel Costs	- $14,500x1 year/$14,600x4 years		72,900	72,900
3. Non-expendables	- 2 trucks/2 jeeps/5 motorcycles (RTG cost)/other	72,000	15,000	87,000
4. Housing	- Village Woodlot Officers x 2 @$6000		12,000	12,000
	Village Woodlot Technicians x 5 @$4000		20,000	20,000
	Clerical Staff & Drivers x 4 @$2000		8,000	8,000
5. Office Building	- 2 @$10,000		20,000	20,000
Storage Sheds	- 20 @$100		2,000	2,000
6. Expendables	- Supplies, maintenance			
	Vehicles/Motorcycles @$100/month		24,000	24,000
	Other at $1000 per year		5,000	5,000
	Subtotal	208,000	315,000	523,000
7. Technical Assistance - US(10 mos. est.)		75,000		75,000
Technical Assistance - Thai (54 pm est.)		94,500		94,500
Support Costs (subsistence, travel, etc.)		41,000		41,000
Participant Travel			3,000	3,000
Training		18,000		18,000
		436,500	318,000	754,500

ECONOMIC ANALYSIS

Cost-Effectiveness of Technologies

Annexes III and IV set forth respectively the Thailand macro energy picture and an analysis at the village level in the Northeast. Part III of the text of the project paper is a general statement of the economic viability of the total renewable and non-conventional energy program proposed in this project.

This Annex includes a detailed cost effectiveness analysis for eight specific project activities. These are supplemented for the main rural oriented technologies in the specific technical Annexes (VIII - XII) in which these are discussed. See discussions of biomass, water lifting, solar drying, village woodlots and micro-hydropower. Micro-hydropower, which is not covered in this Annex, is discussed in total at Annex IV.

The specific analyses in this Annex XIII include the following:

1. Improved Stoves.
2. Village Woodlots.
3. Water Lifting.
4. Energy Conservation in Rural Industries.
5. Biogas.
6. Solar Drying.
7. Pyrolysis of Agricultural Wastes.
8. Improved Charcoal Production.

1. Improved Stoves

The benefits of improved stove efficiencies accrue on many levels, most of which are difficult to quantify economically. The immediate impact of the project will be reductions in use of fuel wood or charcoal and the accompanying reduction in fuel cost, wood collection time, or charcoal production time. The secondary effects of these reductions may be of large magnitude. These effects are benefits to the Thai people in terms of conserving a basic natural resource: forests. If managed properly the forests can provide valuable products on a continual basis to future generations. If the forest stock is depleted as is currently being done, the nation will lose a wide array of economic goods or crucial ecological protection services.

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The secondary effects also accrue to the individual as more free time and/or cash. In rural areas the primary benefit to the lower or poorer classes may well be in terms of avoided fuel collection and production time. It would most likely be the more well-to-do or urban wood fuel users who would reap the main cash benefits. Given the low average incomes in many rural areas, however, the cash benefits to even these groups could be significant. Although there is a significant amount of underemployment in many households, there will be direct benefits in ways besides gaining time (which has only potential economic value). Reduced wood fuel collection time during peak labor demand periods of the agricultural cycle would allow more time for agricultural work. Women who as a result of having both domestic and agricultural responsibilities are often faced with the most demanding work schedule, would be in most cases the beneficiaries of reduced collection time. For those who are fully employed there is a direct opportunity cost to collection time.

Analysis of the benefits of this program have been discussed on two levels: to society and to the individual. The initial candidates for this program will be households facing higher fuel costs. It is expected that the efficiencies of fuel wood stoves can be doubled, and of charcoal stoves increased by fifty percent. Using per capita levels of domestic wood fuel consumption reported in the FAO study, actual woodfuel savings can be estimated.

Annual per capita use presently (FAO, 1970) = $1.23m^3$ = (.67FW+56cc)

Use with improved stoves $0.71m^3$ = .5(.67)FW + .67(.56)cc

Percent fuel saving $\frac{1.23-0.71}{1.23} \times 100 = 40\%$

Assuming a household size of 6.5 persons, annual fuel savings of (6.5) ($.67m^3$)(0.5) = $2.18m^3$ of fuel wood and of (6.5) ($.56m^3$ roundwood equivalent) (.33) = $1.20m^3$ of charcoal i.e. are expected. Using the conversion factor used in the FAO ($6m^3$ i.e. per ton charcoal) study, this is a charcoal savings of 200 kg. of charcoal per household.

The cash equivalent of these savings will vary significantly with location in terms of proximity to wood fuel supplies. Furthermore, there does not appear to be any recording of regional wood fuel prices. In light of this, prices are only used to provide an order of magnitude estimate of possible savings. Using the following prices of ฿60 per cubic meter of firewood stacked

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and ฿1000 per ton of charcoal, the annual fuel savings are nearly ฿400. The savings are probably on the same order of magnitude as the cost of the improved stove and therefore the payback period for the stoves will be only a year or so. This period will decrease rapidly over time as wood fuel costs continue to rise and the cost of stoves decreases due to mass production techniques.

The benefits accruing to Thai society in general can be roughly examined from the perspective of forest land conserved. In 1970, the FAO study estimated that the domestic sector consumed 44.3 million m^3 of wood fuel. With an expected savings of 40 percent per individual, total acceptance of improved stoves would decrease wood fuel use by about 18 million m^3. This quantity represents the annual increment of about 9.6 million hectares or about 45 percent of the total forest area reported by the RFD in 1973. This quantity also represents over one percent of the total forest standing stock. Although these figures assume total conversion of existing stoves to the improved models, the ecological and economic implications of a much lower adoption level are still enormous especially in view of the relatively minor costs of the program.

2. Village Woodlots

The village woodlots program is described in detail at Annex XII and the costs set forth in that description are the basis for this analysis. Not included, however, in this analysis are the costs of consultant technical assistance and training. In view of the pilot and experimental nature of the activity, and the contribution which that assistance and training should register beyond the limits of the specific site program concerned here, it was considered appropriate that these costs not be a charge on this initial program.

In addition, although the proposed village woodlots activity will involve testing and adaptation of alternative approaches, the analysis in this section is conservatively based on application of the full program. Thus, the economics of the lesser cost alternatives (e.g., the household woodlots approach which will involve reduced RTG budgetary requirements for administration), are presumptively included given the same expected yield factors.

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The 20 village/6000 rai program engages costs in the following groups: (a) establishment; (b) fire lane construction; (c) housing office and storage; (d) non-expandable equipment, including vehicles; (e) expendables, maintenance requirements, etc.; (f) fire lane maintenance; and (g) RFD personnel costs. These, in turn, encompass both fixed and annual costs, as well as capitalized annual costs for the first five years. The life of the woodlot is assumed to be four rotations or 20 years; however, for the cost of fertilizer, at significantly less than the cost of establishment, that life could be extended.

All costs are at estimated market prices. Labor was costed at B30 per work-day reflecting current wages for hired agricultural workers; this rate is high but is acceptable as an average over the wet and dry seasons. The establishment of the woodlot, which is totally by village labor, should occur mostly at the beginning of the rainy season, thereby possibly overlapping with one of the peak labor demand periods of the agricultural cycle - land preparation and planting. If this occurs then the cost of labor could be significantly higher.

Part of this demonstration woodlot program will be experimentation with alternative woodlot establishment times which do not coincide with crucial agricultural work periods and to establish their technical and administrative feasibility. The productivity of the trees should not be seriously hampered nor should the cycle of nursery production be upset unduly by such variations. In order to work out schedules which are implementable, this issue of the seasonality of the woodlot labor requirement needs to be examined, most likely on a location specific basis in terms of the nature of the land to be used and the local supply of labor at various times. Due to the questions to be answered regarding this issue, the cost of labor was not shadow priced based on season because it may be necessary to avoid the present peak demand periods.

Table 1 summarizes the woodlot costs by the categories indicated above. It also sets forth the derived costs per rai and the annualized cost per rai. The total cost is $14.30 per rai/per year. Applying an average yield of 2.7 m^3 per rai over the second five year rotation, (i.e. beginning in the sixth year from the start of the program), the cost per cubic meter of wood yield is $5.30. The cost

Table 1

Village Woodlot Costs

($)

	Total Costs	Costs per Rai	Annualized Costs per Rai
I. Fixed Costs			
A. Cost of Establishment for 6000 rai	272,100	45.35	6.26 1/
B. Housing, Office, Storage	62,000	10.33	1.43 2/
C. Non-expendables	15,000	2.50	0.45 3/
II. Capitalized Annual Costs for First Five Years			
A. Personnel	72,900	12.15	1.67
B. Expendables, Maintenance, etc.	29,000	4.83	0.66
III. Annual Costs			
A. Personnel	14,580	2.43	2.43
B. Expendables, Maintenance, etc.	4,800	0.80	0.80
C. Fire Lane Maintenance	3,600	0.60	0.60
			14.30
At annual yield per rai = 2.70 m^3, the cost/m^3 =			5.30

1/ 4x5 year rotation life = 20 years annualized at 12.5%.

2/ Assumed 20 year life.

3/ Assumed 10 year life.

Table 2

Village Woodlots

Planting Schedule by Village

Families	Year	rai					Total	Area (rai) Planted
10	1	20					20	
20	2	20	20				60	
30	3	20	20	20			120	
40	4	20	20	20	20		200	
50	5	20	20	20	20	20	300	at end of project
	6		20	20	20	20	380	at end of year six
	7			20	20	20	440	at end of year seven
	8				20	20	480	at end of year eight
	9					20	500	at end of year nine

Note: Based on each family planting a total of two rai per year up to 10 rai.

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of non-woodlot firewood is not easy to ascertain for most people in the Northeast where this activity will be carried out. Most people collect their own firewood, and the costs are largely in terms of collection time or possibly rental of an ox-cart. Prices, however, have been recorded in both urban and rural areas of the Northeast at approximately $3.75 per cubic meter, 30 percent less than the estimated cost per cubic meter of wood under this program. Several observations, however, are in order on this point.

First, although this program is measured in terms of yield at the end of the five years of this project, in fact the planting begun by families joining after the first year will continue until the end of the ninth year. The 300 rai per village area planted at the end of year five, therefore, increases to 380, 440, 480 and 500 rai at the end of each succeeding year through year nine. The total area planted finally reaches 500 per village or 10,000 rai for the program. This would reduce the annualized cost per rai by $2.37 to $11.93 (adjusting for an increase of $9,600 in establishment costs for additional fire lane construction). See Table 2.

Second, the per rai cost calculated above is based on annualized totals which include significant fixed costs. These will show as already incurred in the second rotation, when the yields are calculated, and are not subject to inflation in the intervening period. The per rai cost, taking inflation into account up to the sixth year, should therefore probably not increase at the general rate to which the market price of wood would be subject.

Third, apart from the fact that as a pilot project the costs for technical assistance and training are not included in this analysis, it is also to be expected that this experimental program will result in alternatives and in the spread of the concept with both fixed and continuing costs which would be at substantially lower levels than in this program. In fact, a purpose of the activity is to test the feasibility and suitability for repetition of the whole principle of village woodlots, and the cost element must be part of that experiment. Higher initial costs are to be expected as part of the price of coverage and flexibility which such an initial effort must require.

Fourth, although it does not affect the cost per rai, the yield per family from the 10 rai planted, even at the ฿75 price above, will amount to ฿2,025 per year at an average yield of 13.5 m^3 per rai over a five year rotation (2.7 m^3 per year). At the end of the fifth year 10 families will have planted the full 10 rai, with 10 additional families reaching this acreage in each of the succeeding years through year nine. The income potential is, therefore, significant and if the program is successful in proving the feasibility of the concept, there is at least one potential cost reduction - in addition to the factors discussed above - which could make the economics of the concept more attractive even immediately. That savings could come directly from the participating villagers who benefit from the project but are also paid for their labor.

It is important to note that 38 percent of the per rai cost is solely attributable to the costs of village labor. To the extent that this results in income in rural areas of the Northeast, it already serves an RTG purpose. More than that, however, it can be expected that as the program succeeds and is repeated elsewhere, the demonstrated benefits will have the effect of reducing or eliminating the need for such payments, which are justified separately under this initial project (see discussion at Annex XV).

Finally, beyond the microeconomics there remains the larger issue of deforestation and the value of afforestation or of reducing the damage to natural forests. To the extent this experiment, notwithstanding its immediate costs, contributes to that purpose or to the technology and policies required to progress toward it, the cost should be worth it. Whereas the positive outcome of this microeconomic analysis should eventually become clear as suggested above, substantially larger costs will already have been incurred by Thailand in terms of forest degradation if overuse continues.

For specific review of the cost and technical factors for this project activity, see detailed discussion at Annex XII.

3. Water Lifting

Agricultural production is the primary sector underlying the Thai economy; however, in recent years this sector has exhibited some stagnation. Unit productivity or yields have remained relatively constant and in some cases have decreased. The growth in agricultural output is mainly due to the expansion of the land farmed, which in turn has contributed to the pressures causing deforestation as well as to use of land marginally suited to agriculture. In order to increase yields, a large increase of the inputs to agriculture has been attempted: high yielding varieties, mechanization, fertilization, irrigation, pesticides. Most of these inputs reflect or require the use of greater amounts of energy.

Irrigation can increase yields of agricultural production when applied separately as well as in conjunction with other new inputs. Irrigation can be achieved in many ways and scales ranging from large reservoir and irrigation canal systems supplying a large area to a single pump for a farmer. Irrigation from pumping has significant advantages over other methods involving reservoir or tanks in that it doesn't require dam construction, land acquisition, extensive canal systems, or the establishment of a complex organizational structure. Furthermore it can be scaled to most levels - household, village, etc. However pumping has several drawbacks, which are only recently being overcome. These problems are concerned the issues of high maintenance and operating costs, dependence on fossil fuels (whose costs are rising and whose availability is uncertain) and of minimum economics of scale.

With the advent of increased research into the use of appropriate small scale technologies and of renewable energy resources, significant advances have been made in developing low lift pumping systems which meet the needs of small farms. This section will compare the economics of the newer technologies - solar, wind and biogas with diesel. Then the costs of supplying irrigation water will be compared with the benefits due to increased production.

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Approximately one quarter of the agricultural households in Thailand farm less than two hectares of land. These farmers have the lowest incomes and therefore often the least access to inputs. In comparing the various pumping technologies, the setting will be a small farmer who harvests one hectare of rice during the wet season and one hectare of upland crop during the dry season. According to a study in the Northeast,* this cropping pattern will require 12500 m^3 water annually for one hectare. Although this pertains to the NE, the results of the analysis are generalized to other regions.

The conventional low lift water pumping technology employs a diesel engine. The smallest size generally available is about five horsepower and is quite easily capable of pumping 200 m^3 of water per hour. The estimated cost of pumping water using diesel engines is calculated in Table 3. The cost and lifetime of the pumps were obtained from local Thai pump distributers. The annual maintenance cost as well as the per hour fuel consumption figures are based on actual findings in other developing countries. In Table 3 several situations are examined. First (I.A.) the unit cost of irrigation water is calculated for the small farmer whose water requirements could be met by a two horsepower engine which is not often available. Because of the low capacity utilization rate, the cost per cubic meter of water is high: 2.8 US cents. The second case examines the cost when the use of pump is close to optimal in that it pumps about 1000 hours annually, which is sufficient to irrigate 16 hectares whose annual requirement is 200,000 m^3. Under these conditions the cost of a cubic meter of water is lowered by an order of magnitude to about .27 cent. A third option costed was based on one Bangkok pump store which marketed a two horsepower diesel pump. The initial capital cost of this pump, including 12 percent for spares, was about $365 with a five year-lifetime. Amortizing this cost over its lifetime at 10 percent p.a. (and assuming an annual maintenance cost of $100), the smaller engine can supply the small farm irrigation requirements at a cost of about 1.6 US cents per cubic meter of water.

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* Water for the Northeast: A Strategy for the Development of Small-Scale Water Resources prepared by Asian Institute of Technology for NESDB.

Table 3 : Costs of Irrigation Using Diesel Engines

I 5 horse power diesel pump

- initial capital cost ฿11,800
  + 1,400 12% for spares
  ฿13,200 $ 660
- annualized capital cost (7 year life at 10% p.a.) $ 135
- annual maintenance costs 200

Total Annual cost excluding fuel $ 335

A. Cost Of Water for small farm (1 ha.)

- annual water requirements 1250Q m^3
- down-rated pumping capacity. 200 m^3/hr.
- hours of operation required annually 63 hours
- annual fuel costs (1.0 liter diesel/hr)[a](63 hr.)(4 B/L)[b] ...$ 13
  other annual costs 335

Total Annual Costs $348

- Cost per M^3 of IRRIGATION WATER ($348 ÷ 1250 m^3) = $ .0278

B. Cost of Water for large farm (optimal use of engine)

- maximum annual output: (1000 hrs.)(200 m^3/hr.) ..... 200,000 m^3
  (equivalent to [illegible] requirement for 16 ha.)
- annual fuel Costs (1.0 L/Hr.)[a] (1000 hr.)(4 B/L)[b] $200
  other annual costs 335

Total Annual Costs $535

- Cost per m^3 of IRRIGATION WATER($535 ÷ 200,000 m^3)= $.0027

a - assuming down rated fuel consumption to be (.5 L/hphr)(2 hp)

b - average current dollar cost of diesel fuel over next 7 years assuming current price of 3 ฿/L and 10% p.a. real price inflation of fuel.

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The high annual maintenance costs used in this analysis attempts to reflect the actual expenses incurred rather than the low costs stated by pump manufactures to be about 2½ percent of the initial cost. In many cases, maintenance problems with diesel pumps result in total disuse thereby greatly reducing the actual life of the pump. Furthermore, inability to obtain fuel can also hinder the use of diesel pumps.

On the other hand, both solar and wind water lifting have very low maintenance and operating costs. Currently they also have higher initial capital costs. However in the near future this will no longer be true because of the ability to scale down both of these technologies to the actual pumping energy requirements of the small farmer and because of continuing technical developments. Solar pumping is based on the use of photovoltaics, which is a fuel-and pollution-free means of generating electric power. The technology is modular and can be adapted to any scale as well as being flexible and adaptable to other uses. It has very low maintenance costs and high reliability. The present costs of solar arrays are $8.00 per peak watt; however, by the early 1980s this cost is projected to be $1.50. In the past forecasted price decreases have been attained and in some cases exceeded. For the needs of a small farm (one ha.) where 1250 mm. is required annually, given a head of 1-5 meter and a monthly peak of 200 mm., the required solar array would need to have a capacity of 100 peak watts. Table 4 estimates the cost of irrigation water from solar pumping both at current prices and at those projected for the 1980s.

This Table also shows the estimated cost of pumping using wind energy. This cost presented is a rough estimate; the initial structure cost is based on batch production of at least 100 units. This wind mill was developed at the National Aeronautical Laboratory (Bangalore, India) both to meet the needs of small farmers and to have very low maintenance costs. Other wind mills are available which have lower initial costs.

A fourth pumping alternative would be to operate a diesel pump using biogas. This option requires only a few modifications to the existing engine, in particular to the carburetor. The main cost difference between a diesel pump and a biogas pump would be in fuel costs. The amount of biogas required can be estimated by substituting for the diesel fuel on the basis of heat content.

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Table 4 : Solar + Wind Pumping Costs for Small Farms

I. Solar Pump Costs for Small Farm (100 peak watts)

	Current Prices		Early 1980's Prices	
- initial solar array costs (including $100 support structive)	$ 900		$ 250	
annualized over 15 years at 10% p.a.		$118		$ 33
- pumpset cost	$ 200		$ 200	
annualized over 10 years at 10% p.a.		$ 33		$ 33
- annual maintenance costs		20		20
Total Annual Costs		$171		$ 86
Unit Cost of Irrigation Water				
- annual pumping requirement 12,500 m^3				
Cost per m^3 water		$0.014		$0.0069

II. Wind Mill and Pump Costs for Small Farm*
(these costs are for a 10 meter NAL windmill developed in India for high performance at low wind speeds. Its pumping capacity is somewhat greater than the small farm requirements being discussed here but the costs have not been scaled down)

	Total Cost	Annual Costs
- initial structure costs	$ 1038	
annualized over 28 years at 10% p.a.		$ 111
- Sails	47	
annualized over 2 years at 10% p.a.		27
- pump	95	
annualized over 7 years at 10% p.a.		19
Total Annual Costs		$ 157
Unit Cost of Irrigation Water		
- annual pumping requirement 12,500 m^3		
Cost per m^3 Water		$ 0.013

* adapted from Sherat K. Tewari "Economics of Wind Energy Use for Irrigation in India", Science, vol. 202, 3 November 1978.

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One liter of diesel fuel contains 9371 kcal whereas 1 m^3 of biogas contains 5000 kcal; therefore, 1.87 m^3 of biogas are required to replace 1 liter of diesel fuel. For a five h.p. pump on a small farm where 63 liters of diesel were required, the amount of biogas needed instead would be 118 m^3. This annual amount is equal to about 20% of the total annual production of a 5 m^3 digester (see biogas analysis, item 5 below). Based on the cost of biogas entimated is the section (₱1.1/m^3 or \$0.056/m^3, the annual biogas cost for the small farmer would be ₱130 or \$6.15 compared to ₱250 and \$12.50 for annual diesel fuel costs. The unit cost, however, of a cubic meter of irrigation water using biogas is only reduced to 2.7 U.S.cents from 2.8 U.S.cents using diesel. This is due to the low utilization rate of a 5 h.p. pump on a small farm. The same cost reduction would hold for the use of biogas with a 2 h.p. diesel pump. The unit cost reduction would be much greater if the 5 h.p. biogas pump was utilized at its capacity. Biogas could lower the unit cost of water calculated in Table 3 (I.B.) using diesel by about 15 percent, this level of operation would require a biogas plant which produced on average 5 m^3 of biogas daily and some gas storage.

Table 5 summarizes the costs of alternative pumping technologies available to small farms and also presents a sample estimation of the value of irrigation water. Even at current prices, solar and wind energy are the most economic means of providing water for a small farm. In the future they will become even more attractive whereas the diesel cost will probably rise over the next few years. The price of diesel fuel in the calculations was raised to reflect an average of its projected price over the next seven years. The cost of biogas should at the same time be decreasing; however, the appeal of the use will be handicapped by the minimum scale of pumps available. However if this can be overcome, the combined production of fertilizer and energy for irrigation from digesters should prove to be an even more attractive technology in the future.

It should be noted that the solar pumps in particular are costed to meet the requirements of a small farm whereas the diesel pumps have the capacity to supply water for a much larger area. Therefore in judging the attractiveness of diesel pumping in general, it should be recalled that at capacity the cost of water from diesel is only about U.S. cents 0.3 per cubic meter.

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Table 5 - Summary of Benefits and Costs of Low Lift Pumping for Small Farms

I. Cost per m^3 irrigation water for 1 hectare farm requiring 12500 m^3 annually

Pump	฿/m^3	U.S. cents/m^3
5 h.p. diesel *	0.56	2.8
2 h.p. diesel	0.33	1.6
solar (current costs)	0.28	1.4
(early 1980's costs)	0.14	0.7
wind	0.26	1.3
5 h.p. diesel using biogas *	0.54	2.7
2 h.p. diesel using biogas	0.32	1.6

II. Benefits per M^3 irrigation water (NE)**

		Value/m^3 With	/ Without Fertilizer
- wet season supplementary irrigation	5000 m^3	฿ .31	฿ .125
- dry season crop	7500 m^3	฿.42	
Average Value of Water at 20฿/$		฿ .38 U.S. cents 1.9	฿ . 30 / 1.5

* Based on meeting only the water requirements of a small farm. If used at maximum capacity unit costs would be 0.05 ฿/m^3 or 0.3 U.S. cents/m^3. Unlike wind or solar, diesel pumps are often not available at the scale of the small farm's use requirements.

** Based on Water for the Northeast: A strategy for the Development of Small Scale Water Resources prepared by Asian Institute of Technology in the NESDB (Volume1)

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As indicated in Table 5, irrigation would be quite beneficial to the productivity of a small farm. Cost-benefit analysis of irrigation investments can be quite complex, and the best perspective would require a systematic analysis of all agricultural inputs in order to develop the optimal package of water, fertilizer and seed inputs. For present purposes, however, this analysis only indicates the basic attractiveness of solar, wind and, to a limited extent, biogas as pumping technologies for small farms.

4. Energy Conservation in Rural Industries

Many rural industries, such as tobacco, pottery, brick, lime, salt and rice are very energy intensive operations. Production usually occurs on a rather small scale; and due to high fuel prices, energy costs may represent a large fraction of total costs, possibly 30 percent. As a result, these industries are being severely pressed economically due to rising energy costs.

The primary fuel for most of these industries (except rice milling) is fuel wood. According to the 1972 FAO Timber Trends Study by de Backer and Openshaw, industrial wood use amounted to about 9×10^{12} kcal (about 3.7 million m^3 wood) or nearly 25 percent of industrial fuel consumption excluding electric power use. An energy conservation program would provide benefits to society by reducing the use of forest resources and to the individual firm by reducing operating costs. Furthermore a fuel wood energy conservation program would hopefully aid the most needy - the small scale operators. In some industries, it seems that the larger operations have switched to other energy sources.

There appears to be room, however, for significant improvement in the efficiency with which energy is used by small industries as well. In some cases, the goal may be to redesign to varying degrees the equipment such as a kiln. In others energy conservation may translate into assisting the switch from one fuel to another. For salt production, using fuel wood for boiling off water is a common practice; however, in addition to a scarcity of wood in many salt producing areas, a very practical alternative source of energy is available - solar. It may also be feasible to meet some of the tobacco curing needs with solar energy.

In addition to conservation efforts aimed at wood fuel use, there is also potential for increasing the efficiency of energy use in lignite-fired tobacco barns and in rice mills. It is possible that the efficiency of lignite use for tobacco curing could be easily doubled if not tripled, although the cost of this effort is so far uncertain. Presently about one-third

of the tobacco crop is dried using lignite; therefore significant amounts of lignite could be saved.

With regard to rice mills, it is not known to what extent paddy husks are used to fuel rice mills; however, the use of husks in this manner probably would be one of the most efficient uses of this resource. This possibility is most likely not applicable to the majority of very small mills which are diesel powered.

In general the costs of increasing the efficiencies of energy use in rural industry are unknown. However in light of the potential benefits and the energy supply difficulties facing these industries and in order to determine the actual value of such an effort, energy conservation assistance would be very valuable.

5. Biogas

Economic analysis of biogas production is a complex undertakening because of the numerous present and alternative uses of the input (primarily animal manure) and the joint production of methane gas and fertilizer*. It is further complicated by the difficulties of quantifying increased health benefits and reduced nuisance from the collection and treatment of the manures. In addition, the social cost of introducing biogas will vary from place to place; in Thailand this cost does not appear to be high in that people are receptive to the idea of biogas.

In this analysis with regard to inputs for biogas production only animal manure will be discussed, leaving out agricultural residues and human excreta. Although most of the following discussion would apply to these other inputs, discussion of just animal manures which are the most common inputs will make the analysis easier to describe.

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* Much work has published on this issue for example see A. Barnett, L. Pyle and SK Subramanian, Biogas Technology in the Third World: A Multidisciplinary Review, International Development Research Center (IDRC-103e); Ottawa, Canada, 1978.

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Animal manure is traditionally used in many parts of the world as either fertilizer or fuel. In some places it is not fully utilized although the percent of manure which can be practically collected is a function of livestock management methods. In addition to biogas, a relatively "new" alternative use of manure is in scientific composting. In all of its uses except for biogas, the capital cost is negligible and the scale of use infinitely flexible. It can either be dried into bricks for fuel, applied to fields, mixed with other residues for composting. Biogas production, on the contrary, involves some initial capital and a minimum scale of production; therefore, prospective biogas users must have access to adequate supplies of each.

The availability of capital is a function of the availability of credit as well as the economic position of the household. At a present initial cost of about $150, a biogas plant could require as much as 10 percent of a farm household gross cash income*. The testing of ways, methods and materials to lower this initial capital cost will be a main effort in this activity. Although the economics of a biogas unit are quite favorable, for many families which collect fuel wood, its main cash benefit may be the value of increased agricultural production due to fertilizer produced. There may also be indirect cash benefits due to saved fuel collection time which can be productively used in agricultural work. Nevertheless, in order for biogas to be a feasible option for the poor, adequate credit availability is needed; furthermore, credit conditions could take into account the social benefits of biogas production - reduced fuel wood consumption, better sanitary conditions, and reliance on a renewable energy resource.

The availability of animal manure is another constraint. Data indicate that 58 percent of Thailand's 7.8 million households are primarily agriculturally employed and the average farm household has 0.97 cow, 1.27 buffalo, 0.67 pig and 11 chickens.

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* Based on a gross cash income of about ฿2100 for a household with 6-15 rai in the Northeast in 1970 (MOAC in World Bank report).

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Although the reported manure requirements for a family size biogas unit vary, the manure produced by these average livestock holdings is close to that required to meet household cooking needs. However in the Northeast, the average household livestock holdings are larger: 1.1 cows, 2.0 buffalo, 0.4 pig and 8 chickens; therefore adequate biogas production is possible for probably the majority of agricultural households in that region. However as the technology of biogas production develops, more efficient means will be developed which will lower the manure and capital requirements. Nevertheless the potential for widespread use of biogas does presently exist, especially in the Northeast. In light of the low average income levels in that region, the benefits of biogas plants to the average farm can be significant.

In evaluating the costs of biogas, determination of the initial capital costs and the annual maintenance costs is conceptually straightforward, although there is uncertainty in these estimates. As to the cost of dung, there are several options which need to be explored by determining the value of the manure as fuel, fertilizer or an input to scientific composting. In Thailand manure is rarely used as fuel. It is quite common that manure is used as fertilizer, most often by letting animals graze on the field during the dry season or by putting manure from the corrals on the fields or on small vegetable plots. The fertilizer value of this manure application is hard to assess because it is often left exposed for great langths of time and it offers both inorganic nutrients such as nitrogen and organic components such as humus which is difficult to value. Manure has a greater value as fertilizer when used in scientific composting. This opportunity cost would be based on the feasibility of properly implementing a scientific composting program.

For the purposes of this discussion, biogas will be analyzed on the basis of the value of the gas produced only and at the same time assuming the cost of manure to be zero. This simplification assumes that the value of the fertilizer co-produced with the biogas adequately counterbalances the opportunity cost of the manure in either its original form or use in composting. In fact the biogas slurry is a better fertilizer than original manure. Furthermore, it is equivalent in fertilizer value to the product of composting; therefore, in light of the effort required for composting, except for the initial cost, biogas will be a more productive means for producing an enriched fertilizer.

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Given the crucial need for fertilizer in many developing areas, the primary focus of the analysis of biogas can be fertilizer production. In analysis elsewhere concerning India, investment in biogas plants for nitrogen fertilizer has been quite favorably compared with investment in urea plants*. Analyzing the economics of biogas on the basis of energy only is therefore a strong test of its attractiveness.

Table 6 shows the results of estimating the generating costs of biogas. The capital cost is derived from the Fertilizer Research Station, MOAC** for a 5 m^3 digester**. The gas production figure is based the output of several currently operating plants. The maintenance cost is based on figures used in other analyses. The assumed lifetime of 10 years is meant to be a conservative figure and is less than what is used in other analyses. The resulting cost of biogas is quite sensitive to the lifetime of the plant; increasing it to 15 years would lower the generating costs by nearly 15 percent. Although the analysis presented is quite simplified, it does indicate that biogas is more economical than equivalent commercial fuels with the significant added benefits of being totally domestically produced and renewable, unlike both LPG and diesel fuel.

Analyses of biogas in the context of the village household is more difficult. The unit described in Table 6 is more than adequate on the average for supplying the required cooking energy for a large family. Biogas use is at least three times and possibly as much as six times (5 percent versus 30 percent) more efficient than fuel wood. Using a cost of B60 per cubic meter of stacked wood, the cost per 1000 kcal is B.0375/using 1.5 m^3 solid, o.6 tons per m^3 and 4000 kcal/kg wood). At one sixth the efficiency, the cost of wood for cooking is identical to that of using biogas.

However for families who collect wood, their decision would be based on the amount of collection time and the alterative use of this time. In this case it would be useful to evaluate the benefits from the fertilizer produced because a reasonable number of households purchase chemical fertilizer. The benefits from

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* See p. 87 A. Barnett et al., op.cit.

** MOAC - Ministry of Agriculture and Cooperatives.

Table 6. Economic Analysis of Biogas Production

Unit description	digester volume	5 m^3
	reported average daily gas product	1.7 m^3
	cost (not including household labor)	฿3000 or $150
	annual maintenance	$10
	lifetime	10 year

Generating Cost of Biogas (not including benefits of fertilizer production)

1. Annual Costs (operating labor and manure cost not included*)

annual capital cost (10 years at 10%p.a.)	$24.50
maintenance	$10.00
Total	$34.50

2. Annual Gas Production

(1.7 m^3 biogas/day)(365 day/yr)	620 m^3
at 5000 kcal/m^3 biogas	3.1×10^6 kcal

3. Unit generating costs $0.056/$m^3$ or ฿1.1/m^3

$0.011/1000 kcal or ฿.22/1000 kcal

Comparison with Cost of Other Fuels

Fuel**	$/1000 kcal	฿/1000 kcal
biogas	0.011	0.22
LPG***	0.025	0.50
diesel fuel	0.016	0.32

** Fuels with equivalent end use efficiencies.
* At ½ hr/day, total operating labor may be 23 person-days per year.

*** Assumed 15% price increase over 1977 price.

foregone or reduced fertilizer costs or increased yields may pay for most of the biogas plant. Overall, despite the attractiveness of biogas plants as both a renewable source of energy and fertilizer, it is still important to lower the initial cost in order to make it accessible to a greater fraction of agricultural households.

6. Solar Drying

The advantages of solar drying (as compared to open-air drying) are numerous both from economic and health perspectives. Solar drying is applicable to a wide range of products: grains, vegetables, fruits, seafood and tobacco. In some cases, solar drying would permit drying of products which are not presently dried. Solar drying compared to open air drying takes less time, produces a longer lasting more attractive and less contaminated product, and in many ways results in significantly less losses. In Thailand the major target products of a solar drying technology would be second crop rice, fish and vegetables and possibly tobacco.

The primary economic benefits of solar drying of monsoon-harvested rice are threefold: (i) reduction of crop losses due to spoilage, insects, birds and physical losses on the open ground, (ii) production of a better product (less moisture content) which can be sold for a higher price and (iii) increased flexibility of time of marketing due to increased storage life. Crop losses from open air drying and high moisture content are difficult to determine; however, estimates of crop losses are in the 5-15 percent of total production range, and for some crops high as 50 percent; fish for example. The higher value of better dried paddy derives from its better milling characteristics because of the greater yield of unbroken grains. Increased marketing flexibility enables farmers to avoid having to sell their paddy during harvest season when prices are lowest.

There are several types of solar rice driers which have been developed and used extensively in the field*. They range in capacity from 20 kg. to many tons per day and the initial cost of these devices ranges from $10 to $25,000. In this project low cost, farm size, natural connection driers will be demonstrated.

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* A very practical summary of the various driers and an assessment of their technical, economic and performance characteristics is available in the Proceedings of the Solar Drying Workshop (Manila, Philippines, October 18-21, 1978) Ministry of Energy of the Philippines and UNESCO.

One of the widely used and successful driers is the tent drier which is simply constructed from bamboo poles and clear polythene sheeting. Given the widespread availability of plastic in Thailand, access to construction materials will not be a problem. The cost of construction, excluding labor, may be as little as $10-20 for a small farm size version. The lifetime of this drier is maybe only six months to one year. The benefits from using the drier are expected to be a reduction of crop loss of five percent of the total paddy harvest plus a five percent higher selling price from better quality and timing. For the subsistence farmer harvesting a hectare of paddy land with a yield of 1.8 tons/ha, the increased production is equal to 90 kg of paddy at ฿2.5/kg or a savings of B/225($11). A five percent higher selling price would amount to another ฿225 ($11). Therefore the increased income from one hectare worth of paddy would be more than sufficient to recoup the cost of the drier. In this analysis both the reduced losses and the increased selling price figures are rough but conservative. To the extent that the dryer is used for other products: vegetables and fish, for example, the benefits from one year's operation will increase greatly. These economic benefits will be supplemented by health benefits from better nutrition because of consumption of more solar-dried fruits and vegetables and from reduction in insect infestation.

7. Pyrolysis of Agricultural Wastes

The pyrolysis program is aimed at the Central as well as possibly the Northern region of Thailand. In these areas there is a relative abundance of agricultural residue which could be economically converted to fuel thereby lessening the demand for wood fuel and petroleum products. This substitution of fuel use will both reduce the pressure on forestland and oil import costs. The basic technology for pyrolysis is quite simple and the materials readily available. A current program in Indonesia appears to be directly applicable, and the equipment and labor skills required are readily available in Thailand.

The costs and revenues of a pyrolysis unit are shown in Table 7; they are based on those in Indonesia. The unit presented can handle one ton per day of agricultural wastes such as rice hulls and can produce daily 0.25 tons of charcoal, 0.15 tons of pyrolytic oil and some gas. It was assumed to operate 150 days per year and require one shift of two workers. The design analyzed in Table 7 does not include the utilization of the off gas, and it is assumed to be initially flared.

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Table 7. Costs and Revenues of One Ton/Day Model*

(one ton of rice hulls input daily, one shift, gas flared)

Capital Costs		Operating and Maintenance Costs	
Production costs	$1850	labor (2 wks for 150 days at 40₱/day)	$600
Building & hull storage	600	Management overhead and maintenance	270
Contingency	100	Debt service (over 10 years at 12.5% annually)	245
Working capital	500	Depreciation (straight line over 10 years)	305
	$3035		$1420

Revenues

Charcoal: 0.25 ton/d for 150 days at 1000₱/ton	$1880
pyrolytic oils: 0.15 ton/d for 150 days at 1447₱/ton**	1630
Off-take gas: no revenues/benefits accorded at this time	n.a.
	$3510

Annual profits = $3510-$1420 = $2090

Return on investment = $\frac{\$2090}{\$3050}$ = 69%

Payback period = $\frac{\$3050}{\$2090}$ = 1.5 years

* Exchange rate of 20₱ = US$1.

** in proportion to heating value, two-third of the price of kerosene (NEA 1977).

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The potential of this gas has been estimated to be able to dry several tons of paddy daily or alternatively it can be used to run an engine if it is sufficiently clean. The materials required are several 200 liter and one 100 liter oil barrels, insulated ductings, an exhaust fan, etc. - all easily fabricated or available at middle sized metal shops and supply stores. The labor required does not need to be specifically skilled; some initial training and on-the-job experience will be sufficient.

The analysis presented in Table 7 is conservative in that the revenues are low estimates. In particular the price for pyrolytic oils, which have two-thirds the heating value of kerosene and with minor end-use adaptions can be used as a substitute, is based on the retail price of kerosene in Bangkok in 1977 from the NEA report, Thailand Energy Situation '77. The current price is undoubtably higher, plus it does not include any transportation cost which would be paid for kerosene to be shipped beyond Bangkok. However, on the other hand no costs are included for the input materials. Such costs would reflect either the fertilizer value of the straw or the fuel value of the paddy husks (see discussion below).

The applicability of a unit this size is quite widespread. A rice mill of only about 3-4 tons per day capacity would produce sufficient rice husks. Also based on production of rice straw, a group of 30 households farming 10 rai of paddy with a yield of 250 kg paddy or 500 kg straw per rai would also generate enough straw annually.

The potential benefits of widespread use of pyrolysis units are quite significant in the aggregate. Presently significant amounts of rice hulls and other agricultural residues such as rice straw are not fully utilized. By diverting a fraction of these residues for pyrolysis, their present opportunity cost is their value as fertilizer both for inorganic and organic nutrients. In most cases straw seems to be burnt in the fields and the ashes spread on the fields. This fertilization does not necessarily need be lost since the ashes from the use of the charcoal produced from pyrolysis can still be returned to the soil; however, there may be some distributional effects as to where the straw or residues are grown and where the ashes are used. In any case, the value of the organic matter in the residues will be lost, but this cost is difficult to calculate.

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In order to explore the potential benefits of pyrolysis on an aggregate level, it will be assumed that 5 percent of the total agricultural residue of Thailand are used in this manner. From Tables 5 and 6 above in Annex III (Energy Use in Thailand) it was calculated that these residues totaled 160×10^{12} kcal in 1976/77 of which about 75 may be required as animal feed; therefore this discussion is examining nearly 10 percent of the remaining residues or 8×10^{12} kcal (about 2.42 million tons) of residues. Based on the pyrolysis production figures in Table 7, these residues would be converted to .606 million tons of charcoal and .364 million tons of pyrolysis oils. The charcoal production would result in at least a 3.64×10^{6} cubic meter reduction in wood use assuming the standard but very efficient conversion factor of 6 m^3 of wood per ton of charcoal. This amount is equal to over eight percent of total domestic wood fuel use in 1970. It is also equivalent to the annual increment from nearly two million hectares of forestland which is nearly 10 percent of the total in 1973.

The magnitude of wood conservation is quite significant and is based on the eventual use of between one and two mill on pyrolysis units. The output of pyrolytic oil would be sufficient to replace totally the use of kerosene at its 1977 consumption level with a domestic renewable fuel that is produced on the local level.

8. Improved Charcoal Production

The benefits of improved charcoal production would be more efficient use of wood resources or, for a given supply of charcoal, reduced use of wood resources. For the individual charcoal maker, collection time and costs would be less or the output of charcoal greater. Charcoal is currently produced by several methods in Thailand. One general method is to smother the ignited wood stack with rice husks. Another one seems to be to cover the ignited wood with large leaves and then dirt. The former method is probably more efficient in that some of the husks also become char and the resulting charcoal is cleaner. It is projected that the efficiency of charcoal production could be increased by about 30 percent using different techniques.

One suggested improvement would be the use of oil drums as a combustion chamber; this would facilitate higher efficiencies through an air tight kiln as well as produce a cleaner product.

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Construction of this kiln would involve two 200 liter drums welded together and a support structure. The initial cost would include several days of a metal worker and welder. The actual cost of this device in Thailand is not confirmed but an order of magnitude estimate would be about US$30.

The profitability of this device is a factor of its initial cost and the amount of increased efficiency. An added factor is the availability of the initial capital requirement for the individual charcoal maker. If two 200 liter barrels are used, the internal area would be about 0.4 cubic meters. The average loading of wood would be about 0.25 cubic meters of solid wood. If a charcoal producer undertakes about 100 loadings annually, about 25 cubic meters of wood will be used to make about 4.2 tons of charcoal. This assumes a conversion rate of six m^3 of wood per ton of charcoal as opposed to a possible current rate of nine m^3 per ton. These rates are merely illustrative and do not reflect actual surveyed results, they do however serve to demonstrate the relative efficiency increases which can be expected. Table 8 shows the results of the analysis under two sets of conditions. In both cases the efficiency is increased by about 30 percent; however, the initial efficiencies are varied.

As can be seen, the increased charcoal production resulting from the higher yields is sufficient to pay for the initial cost of the device within the first year of operation.

On the aggregate level if the improved method was commonly used, the consumption of wood for charcoal production would decrease by about one third. According to the 1972 FAO timber study noted above (de Backer and Openshaw), in 1970 the total consumption of charcoal for residential or domestic use in Thailand was estimated to be 3.4 million tons or 20.3 million cubic meters of round wood equivalent, assuming six m^3 of wood per ton of charcoal. The FAO study did not at that time explore the efficiency of charcoal production, but assumed the standard conversion rate which assumes a high rate of efficiency. Current production methods require more than six m^3 of wood per ton of charcoal, more likely about nine or 12 m^3 per ton. Researchers in Africa have found that some traditional methods use as much as 18 m^3 of wood per ton of charcoal produced. The most efficient kilns or retorts achieve rates of five to six m^3 per ton.

Although the efficiencies of charcoal production probably presently fall between these extremes, a 30 percent increase in efficiency is feasible. Such an increase could result in as much as a saving of six million m^3 of wood according to the 1970 figures. The represents the annual increment of over three million hectares of forest and or about one-seventh of the forest area in 1973.

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Table 8.: Improved Charcoal Production

Initial Costs

- materials	two 200 liter barrels at ฿150 each*	- ฿ 300
	support structure	100
-. labor	three person-days, welder, ฿60/day	180
		฿ 580
	or at 20฿/US$ .....about	$ 30

Benefits:

	Case A	Case B
increased charcoal production from given amount of wood		
- production using improved charcoal device		
assuming 100 loading of .25 m^3 wood each loading		
and conversion of 6 m^3 wood to one ton charcoal	4.2 tons	
or " " 8 m^3 " " " " "		3.1 tons
- previous production yield from equivalent wood use (25 m^3)		
and conversion of 9 m^3 wood to one ton charcoal.....	2.8 tons	
or of 12 m^3 wood to one ton charcoal		2.1 tons
increased yield of charcoal	1.4 tons	1.0 ton
value at 1000 Baht/ton	฿1400	฿1000
at ฿20/US$	$70	$50

Net Benefits

1. Initial costs can be paid back within first year of operation.
2. Assuming five year life, total additional income during the period would be $320 at the higher efficiencies or $220 at the lower efficiencies. This income stream is not discounted because the future prices for charcoal are difficult to project but will be significiently higher than current prices.

* Bangkok price.

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PROJECT SOCIAL ANALYSIS

The purpose of this Annex is to place the rural energy program in the perspective of Thai society and culture. The objective is to identify and analyze the nature and relationships of the most important cultural and social aspects of rural energy.

Sociocultural Feasibility

The target group for the rural energy project are the farmers and villagers of the Thai countryside. Particular attention will be paid to the North and Northeast but no rural area is purposefully excluded. The "context" of this society is Buddhist and the countryside's social tempo and patterns grow out of that tradition.

Buddhist Values

Villagers as Buddhists believe in a hierarchy based on the ability to act effectively and be free from suffering. This includes not only mankind but all living things and heavenly beings. For example, an animal cannot knowingly alter the course of a river, a person must work very hard to divert a small stream, and all of this work can be undone by a flood. A heavenly being can change great rivers with a single word.

All living things stand in this universal order according to the merit accumulated. The more merit one gains the more effective one's actions and the less acute will be one's suffering. The same laws apply to the human social order. This world view means that villagers tend to consider that people of high social position stand higher in the moral hierarchy, because they suffer less and are blessed in many ways. Such people also have responsibilities. They are expected to show an attitude of benevolence to those below them in the hierarchy.

Two important social concepts grow out of this view of the world and its order. First, in a life of mutual relevance, one should be benevolent and compassionate towards others and offer as much assistance as possible. Benevolence and compassion are experienced as "merciful favors" by the

villagers, and the feeling of gratitude becomes an obligation to return the favor received. Each villager knows his position in this religious hierarchy and is expected to act accordingly.

The other concept is the value which is placed on harmony between individuals. One should not speak ill of others nor consider only oneself to be good. The philosophy of "an eye for an eye" is not condoned, because all actions rebound onto the doer.

These attitudes, while expressing the value attached to harmony, also express a theme of self-completeness of action in that actions rebound onto the doer. This criterion is important in forming interpersonal relationships. The principle of self-completeness means that an action, such as giving assistance, does not originate in the relationship with the recipient but, strictly, in the individual, and consequently it places the recipient under no constraint or obligation to return the action. In fact, to expect reciprocation is contrary to the principle.

Thus the result that rebounds upon oneself, rather than "obligation" incurred by others, provides the cultural motive for the exchange of actions. If both parties hold the same values in the exchange, the relationship will move along smoothly, but if the recipient does not sufficiently hold to the principle there is no guarantee that he will reciprocate. The absence of cultural devices to make the recipient feel it is his duty to return the favor indicates the fragility of social ties.

Village Culture

The village headman has authority through his position in the Government administration. He has the authority and the duty to act for the village. However, it is important to remember that his influence springs more from the respect the villagers feel in him, his character, than from any authority inherent in his office.

The typical Thai village leader calls meetings, assembles the villagers, and exhorts them to action but that can often be about the extent of his activity. Villagers are not organized into groups for manual labor. In this context it is important to remember that people who do not take part are

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not openly coerced except through continuing meetings. One of the major results of this collective behavior pattern is that community projects are carried out with considerable deliberation.

In general the headman acts as a middleman or a broker between the village and the Government. The various headmen of the sub-district (tambon) choose among themselves (subject to official approval' a sub-district headman who "has the duties of a headman, has the powers to arrest in specific cases, takes care of travelers, inspects public places, takes care of the census and encourages the inhabitants to pay taxes." He usually has a small staff of inspectors and sometimes others such as medical aids (to administer vaccinations). Both village and tambon headmen tend to be elected from a semi-hereditary group. They usually achieve sufficient power to dictate the appointment of their successors.

Another important village group involves religion. Most villages have a temple committee to comply with Government regulations and to satisfy local customs. Members are usually older men who have served in the temple. Some villages also have a village council. Villages in community development areas are supposed to elect a village development committee but these are often picked by the village headman from among the village elite.

It is often difficult to identify the locus of authority within a village. The headman has almost all the legal power but unless he is also from a prominent family, relatively, rich, and sufficiently pious, he may not be effective as a leader. In many areas, as land becomes more valuable under population pressure, land-rich farmers have gained power. Monks, although influencial, usually play limited secular roles.

Most authors raise doubts about the existence of cooperatime groupings within a typical village. Some single-purpose agricultural or credit cooperatives have been successfully established in some villages but they have limited objectives and immediate ends. Most also take a great deal of attention from community development professionals and cannot easily be considered locally generated groups.

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Leadership Capacity of the Village Headman

One of the most striking features of almost all rural development is that implementation of projects depends to great extent on the village headman and to lesser extent on his council or other committees. It is unlikely that any individual local leader in any society in the world could adequately cope with the scores of leadership demands (at least on paper) that are made of the village headman. It is not realistic to expect a part-time leader with limited education, training or exposure adequately to provide positive, enlightened and flexible direction to all the programs that could in theory filter down to the village.

Status of Women

The women of the regions of Thailand have different cultures, languages, food habits, and labor roles. Rural and urban women are part of significantly different societies. Attitudes and roles change as families move from subsistence agriculture to cash-crop agriculture or to an agriculture base augmented by seasonal work in a non-agriculture sector and so forth. To understand the role of Thai women with regard to a specific energy technology or in a specific locality, a detailed study of the effected community will have to be conducted. The following represents a limited general analysis of the status of women in Thailand.

Thailand's labor force is 45 percent women and 55 percent men which is the most equal percentage in Asia. Most women fill "unskilled" positions including heavy labor, raising animals, farming, various part-time jobs and/or factory work. They are the backbone of the rural family labor force having extremely productive roles as farmer, guardian of the family income, decision-maker, and are the principal persons responsible for the welfare of both children and parents. The women's roles are, in some cases different from men, but are not necessarily viewed as inferior.

There may be a greater gap between professional women in Bangkok and village women than between any other segments of the society of Thai women. Thai professional women are among the most liberated women in Asia while poor rural women are almost exclusively involved with managing their families with very limited resources. The bridge between these disparate groups will be the female rural elite:

the wives of village headmen, the rural well-to-do and the wives of subdistrict and district level Government officials. Many of these women have some leisure time and expanded horizons while still maintaining a rural perspective.

The daughter works in the home and has the responsibility for taking care of old and/or sick parents. Traditionally women keep the family's money. If the family has money left over after meeting basic needs, the women of the family can develop significant power. More often than not, however, there are not enough funds and the responsibility is to make the money stretch as far as possible to cover expenses.

Within the family, women are centrally involved in decision-making, but in the village outside the home they are not well represented. However, "equal rights for women" or "women's liberation" is not a concept to which most rural women relate because they are preoccupied with stretching limited resources to provide minimum food, clothing, education and security for their families. Major concerns are financial and therefore the most direct way to meet the felt needs of rural Thai women would be to improve their income earning capacity. Energy technologies can contribute to this effort both directly and indirectly.

The adaptation of such technologies, therefore, to the extent that they offer a reduction in domestic and farm labor, and lower costs, should appeal to and find support from village women. The challenge will more likely be the mechanisms themselves for diffusion of the technologies, to be sure that women are included. In terms of this project, this means that each activity needs to ensure that women are involved in the testing and adaptation of the technologies, and that women are specifically included in the response groups for the data gathering effort across the whole project.

Diffusion of Innovations

It is generally understood that innovations are transferred by a few technological entrepreneurs usually classified as "innovators", followed closely by a minority called "early adapters." These two groups are the opinion leaders in the community and therefore must be the initial

target group of any new technology project. The opinion leaders influence the majority of their community until an innovation has been generally adopted and adapted.

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At the center of the acceptance of an innovation is a personal and internal commitment to change. Here there is a large body of literature, but for the purposes of this paper a paradigm will serve to summarise the processes involved. Stated simply innovations are adopted when incentives to change outweigh inhibitors or disincentives to change which motivate individuals to retain their established behavior patterns.

Both change inhibitors and change incentives are present in most if not all social/economic settings.

Studies in Thailand indicate that rural people do not allow themselves to be influenced by outsiders easily. Visitors coming into villages do not usually have much influence unless they can establish themselves enough to gain the trust of the residents through frequent visits and demonstrated contributions to the community.

It seems that farmers adopt new agricultural technologies not so much because they were persuaded to do so but rather because they convinced themselves of its merits. Demonstrations of innovations perceived to be useful contribute more to the diffusion than the leadership qualities of those promoting any given innovation or technology.

Respect Counts

Changes in a village are often initiated by respected leaders or innovators who command influence and a measure of trust because of their positions. They are not agents of change in a promotional sense but contribute to diffusion by providing the demonstration of the value of the innovation which makes the other farmers want to imitate their actions.

Influential and formal leaders can be convinced by a new technology by more conventional promotion methods and in this way the classic innovative process takes place. Innovators are induced to try a technology. They "demonstrate" its usefulness and in turn influence others who trust and value their opinions. The farmers are very

quick to adopt and adapt new crops and products through this two-step informal demonstration process.

A strong sense of ownership seems to be needed to ensure proper operation and maintenance of projects. This seems to be a common finding of almost all development activities of the last decade. To develop this strong sense of ownership, villagers must participate in real terms. This will be particularly important for bringing about the receptivity of innovations to women. This means a more than nominal involvement in the planning, selection and initiation of projects, but also participation in labor and funding. In most successful efforts the villagers earn equity in these projects through their activity (sweat equity).

No matter how advanced a single technological element may be, its superiority will not guarantee its dissemination. A prominent example is the evaluation of the "green revolution" of high yield varieties of rice. If the yields obtained on experimental stations are to be duplicated in the villages of Asia, improved seed is not enough. Water control, large fertilizer inputs, disease and insect damage prevention, expanded credit, marketing and training channels must move ahead concurrently. Thus it appears that integrated, multi-disciplinary projects are the most appropriate development schemes.

However, innovations, particularly in agriculture, do not often become adopted in an integrated fashion. Single technologies and simple "packages" are included in the traditional cultivation and livelihood patterns at the personal discretion of innovative farmers. The point where an innovation is adopted will always be based upon personal choice under certain limited socioeconomic and environmental constraints.

Rural energy will be closely connected to agriculture in Thailand and natural conditions are the paramount constraint. Regional differences that might be trivial to industry are often critical in an agricultural setting. Rural areas will probably advance through the accumulation of piecemeal advances: village woodlots here, solar pumps there, greatly increased activity based on new crops, and conventional energy in another locality.

To promote a highly localized piecemeal advance of technology it is necessary to understand the regions involved (including all the elements to be integrated). It is particularly important to discover what factors might obstruct progress. Village studies need to be conducted and this will require discipline, dedication and patience.

Most of the "piecemeal" innovation will take place because villagers are actively involved in the search for an improved life. This may be particularly true with some energy devices. One of the major objectives of the rural energy project is the emphasis on testing out as many different mechanisms for spreading technologies as appear to be practical.

The goal is to tailor diffusion to fit the existing leadership, communication and motivation patterns within an energy demand segment and expand it as effectively as possible. Even the poor make choices based on a range of options and they adjust quickly when they judge conditions and risks are acceptable. For example, the spread of cassava as a cash crop has been rapid in the Northeast. With it has been a rapid expansion of mechanization in agriculture. This has been accomplished, for the most part, through traditional diffusion channels which include village and regional opinion leaders, and private sector entrepreneurs.

Social Consequences and Benefits

The energy technologies that are recommended in this project all hold the potential for bringing either increasing energy efficiencies or new supplies of useful energy to rural villagers. Since the people of rural Thailand are now very limited consumers of conventional energy the suggested alternative sources of energy will not even be in serious competition with this sector. In fact the suggested technologies may decrease the demand on these increasingly scarce energy sources while increasing the opportunity of rural people to participate in some critically important aspects of modern life.

As further evaluation proves the usefulness of these technologies the rural residents should have the possibility for a better life in terms of heat for drying crops, for domestic cooking and for other applications.

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Access

Any individual energy program will be very site specific, at least during the initial stages. For example improved stoves will serve only a single household but stoves will be available for purchase by every household in a village (after a successful testing and evaluation period). Solar applications can be communal but can also be scaled down to serve an individual family.

With each rural oriented technology, access will potentially be broad, once the demonstration and pilot projects have been completed. The technologies chosen are believed to be affordable by large segments if not all of the rural population. In some technology networks the access will be by individual household units (with generally all families being encouraged to participate). In the case of some other technologies the approach will be through cooperatives or other village-wide efforts like the village woodlot idea or pyrolysis or other technologies.

Employment and Rural Displacement

The energy technologies discussed are predominantly labor saving and opportunity increasing devices. Their widespread adoption would increase productivity and decrease drudgery, whether in the home or field.

Improved rural energy should make it possible for a generally improved quality of life for the participants in the program. There may be some small regional displacements (for example commercial charcoal makers) but most of these technologies will replace household and farm labor performed by the family members themselves with labor saving renewable energy.

The main social challenge is at the village level, where the innovation must take place. Basic attitudes and behavior may need to be adjusted in many of the technological applications. In every case the technologies will have to fit into the perceived needs of the villagers. Appropriately local management and leadership contributions are also an integral part of each technology application project.

Many of these technologies will fit easily with the rhythm of village life, (e.g. improved stoves or use of charcoal). All hold the potential for bringing labor and

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energy saving measures to the traditional work of the villagers. It is important to note that these projects will be particularly helpful to women because increased energy efficiency and convenience will help them most directly.

Alternative Pathways

Most innovation in the world takes place without benefit of a program. Farmers shift to a new seed variety, make an adjustment to a tool, women take part in a new commercial opportunity, etc., most often on their own. It is likely that pioneer projects will show that the fastest, most efficient way to spread some of the more simple or familiar technologies will be in a private, informal way. For example, fully tested, improved cookers or simple inexpensive solar-dryers are both likely candidates for this pathway because their functions are clearly understood, they will be easily manufactured (in some cases by the villagers themselves), most materials can be obtained cheaply and locally. Maintenance will also be simple and reliability should be high when final designs are accepted. The major barriers in this type of adoption pathway may be the non-technical issues and identifying these is a major segment of the pilot rural oriented activities.

Another of the most common pathways is business-induced change. In tractors, pumps, generators and many others, technological innovations are "marketed" for profit all over the world. Not only are the technologies often spread quickly, but maintenance service and other support can be a part of this change process.

Probable technologies that are likely to be compatible with this approach include pyrolytic conversion units, wind powered generators and solar pumps. Entrepreneural motivated innovation systems have a great many advantages but with some technologies the very poor would be neglected because of their limited buying potential. A fourth pathway could work to cover this gap from the non-Governmental sector.

Private community action agencies have a long and successful history in many parts of the world. In Thailand a good example of this type of innovation dissemination organization is the Population and Community Development Association (CBFPS). By the end of 1978 this community based

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family planning group had reached about 7000 villages in 75 districts. Over 16,000 village workers had been trained. This represents approximately 33 percent of all the villages in the nation. Recently a community-based technology and development service has spun-off from this group and is working in villages where the original family planning concept is successful. The village workers are local residents who receive training, support and carefully increased status within the village. They are rewarded financially only through their sales.

Governmental or other funding institutions pay the expenses, or at least subsidize this type of agency. It is important to note that the villagers also pay for goods and services received and are therefore likely to have a positive motivation toward the technology. The village workers are carefully selected and motivated by social progress in their position in the community and financially by their sales commission. With adequate management, and technical support this system has proven to be an effective pathway to specific village development programs. It is a scheme that will be tested in this project.

Community Development (CD) Workers

For the Government path, some of the most widespread RTG workers active at the village level are the officers of the Community Development Department, Ministry of Interior. The CD workers have the responsibility for directing and coordinating the village work of all RTG activity from whatever agency. The training the CD workers receive is the most thorough of any Thai Government village level representative and can be used as a yardstick when planning the role of the technicians for the rural oriented energy activities in this project.

There are presently 4000 Community Development Workers (CD workers) in the villages of Thailand. Another 1500 will be active within a year. Sixty-five percent are men and 35 percent are women. They usually work one or two years in an area and then transfer to another area within the same province. Most often they work near their own area of the country so there are only minor problems of isolation and loneliness. About 60 percent of the CD workers now own motorcycles and the Department is continuing to assist in the purchase of this type of transportation.

The country is divided into nine regions. Each province has a CD officer and staff. The District Officer has four to twelve village CD workers under his administrative control. Each village CD worker is located at the sub-district and is responsible for five to fifteen villages. Village workers receive four to six months training, depending on their background. The emphasis is on field work. After each segment of classroom work, there is an application period in the village (approximately twice the length of the classroom segment).

The general CD program has the following basic objectives:

1. Acceleration of production increases in family income from agriculture and village industries.

2. Improvement and construction of public facilities with active participation of the people.

3. Improvement of health and sanitation.

4. Promotion of formal and informal education for adults, youths and children.

5. Promotion of village culture, customs and traditions, welfare and recreation.

6. Fostering local government.

Underlying these goals is a more fundamental purpose of teaching villagers self-help through "non-directive" approaches.

Non-directive community development work, however, causes some special problems. Much of the ambiguity concerns status. Unlike other Government officials, CD village workers often do physical labor in the village. They are also often poorer than the village elite. Their ideology dictates that they encourage village leadership and initiative. They are to remain in the background as much as possible but in doing so they are denied behavior patterns that are part of a traditioned leader's role. At the same time, within their own organization the CD workers often feel handicapped as the lowest members of a hierarchical structure.

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Frustrations notwithstanding, the village CD workers represent one of the immediate resources for this project in working through the Government path. They should provide an effective means of outreach for each of the RECs and become a main vehicle for support of the NEA rural oriented activities, both in the testing and adaptation of the technologies and particularly in the development of techniques for dissemination.

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VILLAGE WOODLOTS SOCIAL ANALYSIS

The village woodlots component could pose important challenges to existing village social systems. The following is a list of the major social concerns and possible remedies to the barriers they represent.

Any acceptable land is sure to have some existing use and funds should be made available for the replacement or substitution of those benefits. In many cases this will involve replacement of animal feed for lost grazing. It will also include provisions for the fuel lost from the land while the tree crops grow to maturity (much of this will be very site-specific and will also have to include a land-use survey).

A cooperative village woodlot will place new demands on village leadership, and these demands are not trivial. First, as part-time leaders the village headman and the elites who serve on village committees are already over-extended in terms of additional time available for public service and their ability to absorb ever more detailed technical information. Second, cooperative forms of enterprise, with their broadly based equity, are among the most management intensive forms of business. When mass participation and access to responsibility and benefits are a main objective, as in this case, cooperatives are a desirable management form. However, they do carry a management burden particularly for accounting, control and communications.

Villagers will have to be mobilized to work in this activity. For example, much of the mass labor requirements will come in occasional short work periods requiring relatively intense combined activity. It is possible that this will initially be seen by the villagers as similar to past road building or canal maintenance projects. Villagers often view Government-initiated activities of this sort as being primarily something they do for the Government rather than for themselves.

Since four or five years will pass before significant benefits are realized it might be well to include interim benefits in this effort. The most obvious example is the use of leaves as fodder. Another possibility is the use of smaller trees for poles. A bit more risky is the option of inter-cropping among the young trees. The risk here will be that the quick-return alternative crops will be perceived as being more important than the woodlot.

Women as the principal wood gatherers and users will be most directly affected, particularly if the newly planted woodlot requires them for up to five years to travel farther to find wood. Perhaps the new fuel wood may also necessitate behavior charge. For example, will the new wood smoke more or less? Will food taste differently to those used to traditional woods and "require" more or less use of charcoal? Will possible changes in sparking characteristics require new fire control methods (a major village concern during the dry season). Certain traditional wood products will undoubtably remain valuable for tools and other applications. Will a new source have to be found? All of these questions will require testing in the woodlot activity.

While labor requirements for the woodlots do not appear to be extensive or prohibitive, optimal planting occurs at roughly the same time as most other crops are planted. Research needs to be conducted into the effects of transplanting trees after crop planting pressure has passed.

The estimated yields are purposely conservative, nevertheless significant surplus wood is anticipated. Since wood is priced at roughly the cost of the labor to gather it, the surplus (wood left over after domestic use) will probably be converted into charcoal which is both more valuable and lighter to transport. The effects of increased amounts of a basic commodity on the cash market system need to be anticipated. Transportation and marketing of charcoal is already well established. How will the market relationships be affected? What will be the response be of the traditional sector? Who will be dislocated and how will the traditional village charcoal makers react? All these concerns are questions to be investigated for each specific site.

In summary, the village woodlot objectives include a number of social and economic issues that involve traditional behavior. The impact may be felt in several farming and commercial sectors. Studies are required, therefore, on a number of technical and behavioral questions as part of each of the pilot applications of the activity.

The following are presented as alternative approaches to be tested as part of the activity.

One of the principal potential constraints to an expanded village woodlots activity is the jurisdictional question of Government land. It is legally difficult, if not virtually impossible, for the RTG agencies involved to alienate title

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to Government land for specific village use. There may be limited exceptions and these alternatives will be explored in the project. Associated with the use of Government land, however, would be the perceptions of villages. One, which is discussed further below, is the fact that Government land (forest or scrub) is often actively used by villagers already - and subject to degradation from cutting. Villagers could see a setting aside of this as a taking from them of a resource they already have, and not as a source of potential benefit to them. The risk of the project being perceived as labor for the Government, rather than for their own benefit, particularly given the long lead time for benefits, is also a substantive concern. The application of the public land alternative, therefore, will engage one of the most complex tests of this technology. The groundwork in carrying it through, and the assessment of its problems and potential, will be of importance to the whole concept.

A second alternative would involve the use of village owned public grazing land, of which there may be relatively little in terms of formal title. This approach also needs to be tested but with particular address to some of the social and economic constraints which it raises. These would need to be evaluated as the activity was carried out. Scrub or grazing land represents a total village resource, and the social and economic mechanics of removing it from common use for a long period need to be carefully addressed. The site specific character of any test of this alternative is obvious. The identification of economic costs where woodlots displace use for grazing or crops, and the equity in distribution of costs and benefits within the village, are critical in this approach. Many of these same factors, of cource, also apply in the case of the Government-owned land alternative above where use, although informal, may be nonetheless a real village economic and social fact.

A somewhat similar but more simple approach would be using village wat (temple) land as the woodlot. Such a scheme could have advantages, including less dislocation and avoiding the expense of compensation. Also, the land itself would probably be of higher quality, therefore more productive, and must more centrally located. Labor might also be more freely given as an act of merit.

A fourth alternative, and one which would specifically address the charcoal related objectives of the activity, might be to recruit and set up established charcoal producers as cooperative villages or simply as cooperatives using the woodlot concept. These enterprises could be located in more clearly defined forest reserves using un-contested land. Obviously, a great deal of community development work would be involved in the establishment of such new communities. If the charcoal producers lived in their original villages, however, and used the woodlots as a production unit, the new community stress would be lessened. Cooper tive management skill on the other hand would have to be even greater.

As a fifth approach, which addresses poaching of fuel wood and the charcoal problem, while also addressing other rural problems; marginal private land could be placed in a private woodlot program. Many farmers have a few rai of under-used land that might more economically be used in woodlots. It might take less labor and the payback period may not be as significant for these farmers. Management problems would be minimized. This would begin to directly attack the shallower non-commercial household poaching of forest land for heavy fuel wood.

A sixth alternative would be small back-yard woodlots in the form of a few trees as a supplement for family wood uses. This would be a good way to demonstrate the value of trees to a large number of villagers while eliminating the problems of land aquisition and Governmental cooperation. It would also provide valuable community development experience to village woodlot technicians. In addition very good land and close personal attention would be given to the trees.

Finally, the Northeast has need of windbreak and soil retention measures. Trees could be introduced as windbreaks and erosion control devices while providing a demonstration and training effect for both villagers and officials.

The goals of this activity are three: (a) a sustained supply of wood for village and home consumption, (b) a decrease in the present level of poaching of trees on public lands, and (c) increased income for rural development. These are complex and obviously long term goals, and this project can only provide a beginning through the testing and

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adaptation of alternative approaches to meeting these ends. There is clearly no best or simple approach, each will have to address site specific factors as well as the broader economic and social questions underlying the activity. The end of project should see a winnowing of methods and alternatives, and the development of data to provide the basis for longer-term address of the problem. Given the enormous impact of forest degradation on Thailand's environment, there is no question of the urgency of making the effort.

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ANNEX XVI

Financial Plans

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FINANCIAL PLAN

FOR NEIDCT

($1,000's)

AID $	PROJECT YEAR 1	2	3	4	5	TOTAL
Technical Assistance						
Consultants: (US - 6 mm)	15.0	15.0	15.0			45.0
Consultants: (AIT - 18 mm)	18.0	18.0	18.0			54.0
Travel	2.2	2.2	2.2			6.6
Local Subsistence, per diem	3.6	3.6	3.6			10.8
Equipment, Books, Materials	10.5	21.5	15.5	13.5	14.5	75.5
Sub Total	49.3	60.3	54.3	13.5	14.5	191.9
RTG: ฿ ($ equivalent)						
Salaries & Staff Related Cost	15.3	27.75	24.15	27.15	25.65	120.0
NSO Computer Support		5.0	5.0	5.0	5.0	20.0
EGAT Training/Extension		2.0	2.0	2.0	2.0	8.0
Sub Total	15.3	34.75	31.15	34.15	32.65	148.0
TOTAL	64.6	95.05	85.45	47.65	47.15	339.9

FINANCIAL PLAN

FOR Regional Energy Centers (6)

($1,000's)

AID $	PROJECT YEAR 1	2	3	4	5	TOTAL
Equipment						
Trucks		90.0				90.0
Jeeps		120.0				120.0
cameras, projectors, video tapes		36.0				36.0
Sub Total		246.0				246.0
RTG $ ($ equivalent)						
Salaries & Staff Related Costs	38.6	115.8	193.0	231.6	231.6	810.6
Facilities						
Land Acquisition & Development		60.0	60.0	60.0		180.0
Offices & Buildings		25.0	25.0	25.0		75.0
Staff Housing		110.0	110.0	110.0		330.0
Sub Total	38.6	310.0	388.0	426.6	231.6	1,395.6
TOTAL	38.6	556.8	388.0	426.6	231.6	1,641.6

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FINANCIAL PLAN

FOR Resource Assessment - Solar

($1,000's)

AID $	PROJECT YEAR 1	2	3	4	5	TOTAL
Technical Assistance						
Short Term Consultants (15mm)	75.0	22.5		15.0		112.5
Travel	6.6	2.2		2.2		11.0
Local Subsistence (per diem)	18.0	5.4		3.6		27.0
Training (33 mm)	13.5	27.0	108.0			148.5
Equipment	70.0					70.0
Sub Total	183.1	55.1	108.0	20.8		369.0
RTG ฿ ($ equivalent)						
Participant Travel	1.5	3.0	3.0			7.5
Salaries & Staff Related Expenses	11.25	6.0	6.0	6.0	6.0	35.25
University Assistance			4.5			4.5
Sub Total	12.75	9.0	13.5	6.0	6.0	47.25
TOTAL	195.85	64.1	121.5	26.8	6.0	416.25

FINANCIAL PLAN

FOR Resource Assessment - Biomass

($1,000's)

AID $	PROJECT YEAR 1	2	3	4	5	TOTAL
Technical Assistance						
Long Term Consultants(12mm)		90.0				90.0
Short Term Consultants(7mm)	7.5	45.0				52.5
Travel & Transportation	2.2	25.4				27.6
Local Subsistence	1.8	10.8				12.6
Equipment & Materials		50.0				50.0
Sub Total	11.5	221.2				232.7
RTG ₦ ($ equivalent)						
Salaries & Staff Related Costs	6.0	8.0				14.0
Local Subsistence (housing)		6.0				6.0
Support Costs		6.0				6.0
Sub Total	6.0	20.0				26.0
TOTAL	17.5	259.2				258.7

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FINANCIAL PLAN

FOR Resource Assessment - Micro Hydro

($1,000's)

AID $	PROJECT YEAR 1	2	3	4	5	TOTAL
Technical Assistance						
Short Term Consultants (5 mm)		30.0	7.5			37.5
Travel		4.4	2.2			6.6
Local Subsistence (per diem)		7.2	1.8			9.0
Sub Total		41.6	11.5			53.1
RTG ¥ ($ equivalent)						
Salaries & Staff Related Costs		13.5	9.0			22.5
Sub Total		13.5	9.0			22.5
TOTAL		55.1	20.5			75.6

FINANCIAL PLAN

FOR Resource Assessment

(lignite, tar sand, oil shale, geothermal)

($1,000's)

AID $	PROJECT YEAR 1	2	3	4	5	TOTAL
Technical Assistance						
Short Term Consultants (30mm)		90.0		120.0	15.0	225.0
Travel		8.8		8.8	2.2	19.8
Local Subsistence (per diem)		21.6		28.8	3.6	54.0
Training (36mm)			162.0			162.0
Equipment (instruments, computer services)				5.0	10.0	15.0
Sub Total		120.4	162.0	162.6	30.8	475.8
RTG ₱ ($ equivalent)						
Participant Travel			4.5			4.5
Salary and Staff Related Costs			11.25		11.25	22.5
Sub Total			15.75		11.25	27.0
TOTAL		120.4	177.75	162.6	42.05	502.8

FINANCIAL PLAN

FOR Energy Technologies Monitoring

($1,000's)

AID $	PROJECT YEAR 1	2	3	4	5	TOTAL
Technical Assistance						
Short Term Consultants (19mm)	7.5	45.0	45.0	45.0		142.5
Travel	2.2	6.6	6.6	6.6		22.0
Local Subsistence	1.8	10.8	10.8	10.8		34.2
Training (48 mm)		108.0	108.0			216.0
Equipment		40.0	10.0			50.0
Sub Total	11.5	210.4	180.4	62.4		464.7
RTG ฿ ($ equivalent)						
Participant Travel		6.0	6.0			12.0
Salaries & Staff Related Expenses		19.5	19.5	19.5	19.5	78.0
R & D at Thai Universities and RTG Depts.		5.0	5.0	10.0	10.0	30.0
Sub Total		30.5	30.5	29.5	29.5	120.0
TOTAL	11.5	240.9	210.9	91.9	29.5	584.7

FINANCIAL PLAN FOR

SUPPORT OF THE ENERGY MASTER PLAN

($1,000's)

AID $	PROJECT YEAR 1	2	3	4	5	TOTAL
Technical Assistance						
Long Term Consultants (16mm)	30.0	90.0				120.0
Short Term Consultants (14mm)		67.5	22.5	15.0		105.0
Travel and Transportation	9.4	16.0	4.4	2.2		32.0
Local Subsistence		16.2	5.4	3.6		25.2
Training (54mm in U.S. 54@AIT)		60.0	90.0	90.0	30.0	270.0
Equipment		2.0				2.0
Sub Total	39.4	251.7	122.3	110.8	30.0	554.2
RTG ₦ ($ equivalent)						
Salaries & Staff Related Costs	8.7	33.3	33.3	33.3	17.7	126.3
Participant Travel		1.5	1.5	1.5		4.5
Local Subsistence	1.2	3.3				4.5
Sub Total	9.9	38.1	34.8	34.8	17.7	135.3
TOTAL	49.3	289.8	157.1	145.6	47.7	689.5

FINANCIAL PLAN

FOR Rural Oriented Technologies - Biomass Conversion

($1,000's)

AID $	PROJECT YEAR 1	2	3	4	5	TOTAL
Technical Assistance						
Short Term Consultants (45 mm)	75.0	112.5	112.5	37.5		337.5
Travel	8.8	13.2	13.2	8.8		44.0
Local Subsistence (per diem)	18.0	27.0	27.0	9.9		81.9
Training (13 mm)	58.5					58.5
Equipment		25.0	30.0	12.0		67.0
Workshorp Costs			15.0	25.0		40.0
Reports	4.0	5.0	8.0	8.0		25.0
Sub Total	164.3	182.7	205.7	100.3		653.0
RTG ₱ ($ equivalent)						
Participant Travel	12.0					12.0
Salaries & Staff Related Costs	39.85	76.8	94.8	105.9	102.9	420.25
Special Monitoring/Evaluation		2.5	2.5	5.		10.0
Sub Total	51.85	79.3	97.3	110.9	102.9	442.25
TOTAL	216.15	262.0	303.0	211.2	102.9	1,095.25

FINANCIAL PLAN

FOR Rural Oriented Technologies Micro Hydro

($1,000's)

AID $	PROJECT YEAR 1	2	3	4	5	TOTAL
Technical Assistance						
Short Term Consultants (9mm)	22.5	22.5	22.5			67.5
Travel	4.4	6.6	6.6			17.6
Local Subsistence (per diem)	5.4	5.4	5.4			16.2
Training (3 mm)		13.5				13.5
Equipment						
Turbine components, fabrication		60.0	60.0			120.0
Laborator Equipment		25.	25.0			50.0
Workshops			13.0			13.0
Sub Total	32.3	133.0	132.5			297.8
RTG ₱ ($ equivalent)						
Salaries & Staff Related Costs	18.0	27.3	24.15	24.15	24.15	117.75
Participant Travel		4.5				4.5
Construction		40.0	40.0			80.0
Sub Total	18.0	71.8	64.15	24.15	24.15	202.25
TOTAL	50.3	204.8	196.65	24.15	24.15	500.05

FINANCIAL PLAN

FOR Rural Oriented Technologies - Solar Drying & Distillati
Process Heat

($1,000's)

AID $	PROJECT YEAR 1	2	3	4	5	TOTAL
Technical Assistance						
Short Term Consultants (9mm)	15.0	30.0	22.5			67.5
Travel	4.4	4.4	4.4			13.2
Local Subsistence (per diem)	3.6	7.2	5.4			16.2
Equipment and Materials		15.0				15.0
Sub Total	23.0	56.6	32.3			111.9
RTG ฿ ($ equivalent)						
Salaries & Staff Related Costs	7.8	14.1	11.4	9.9		43.2
Sub Total	7.8	14.1	11.4	9.9		43.2
TOTAL	30.8	70.7	43.7	9.9		155.1

FINANCIAL PLAN

FOR Rural Oriented Technologies - Water Lifting

($1,000's)

AID $	PROJECT YEAR 1	2	3	4	5	TOTAL
Technical Assistance						
Short Term Consultants (21mm)	7.5	52.5	67.5	7.5	22.5	157.5
Travel	2.2	6.6	8.8	2.2	4.4	24.2
Local Subsistence (per diem)	1.8	12.6	16.2	1.8	5.4	37.8
Training (12 mm)	27.0		27.0			54.0
Equipment and Materials		72.0	135.0			207.0
Workshops, Publications, etc.				10.0	10.0	20.0
Sub Total	38.5	143.7	254.5	21.5	42.3	500.5
RTG ¥ ($ equivalent)						
Participant Travel	3.0		3.0			6.0
Salaries & Staff Related Expenses	4.5	21.0	28.2	26.7	26.7	107.1
Other		3.6	4.8	4.8	4.8	18.0
Sub Total	7.5	24.6	36.0	31.5	31.5	131.1
TOTAL	46.0	168.3	290.5	53.0	73.8	631.6

FINANCIAL PLAN

FOR Village Woodlots

($1,000's)

AID $	PROJECT YEAR 1	2	3	4	5	TOTAL
Technical Assistance						
Long Term Consultants (42 pm)	10.5	21.0	21.0	21.0	-	73.5
Short Term Consultants (22pm)	18.5	37.0	22.0	18.5	-	96.0
Travel & Transportation	3.7	5.9	3.7	3.7	-	17.0
Local Subsistence (per diem)	5.1	8.7	5.1	5.1	-	24.0
Training (4 mm)	9.0	9.0				18.0
Equipement, vehicles	72.0					72.0
Other (Labor, supplies, etc.)	8.5	17.1	28.25	36.8	45.35	136.0
Sub Total	127.3	98.7	80.05	85.1	45.35	436.5
RTG H ($ equivalent)						
Salary & Staff Related Costs	14.5	14.6	14.6	14.6	14.6	72.9
Participant Travel	1.5	1.5				3.0
Facilities						
Buildings	11.0	11.0				22.0
Staff Housing	17.5	22.5				40.0
Equipment		15.0				15.0
Other (labor, supplies, maintenance)	14.4	22.9	34.05	42.6	51.15	165.1
Sub Total	58.9	87.5	48.65	57.2	65.75	318.0
TOTAL	185.2	186.2	128.7	142.3	111.1	754.5

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FINANCIAL PLAN

FOR Coordinating Consultant

($1,000's)

AID $	PROJECT YEAR 1	2	3	4	5	TOTAL
Technical Assistance						
Long Term Consultant (30mm)	45.0	90.0	90.0			225.0
Short Term Consultant (12mm)	30.0	15.0	15.0	15.0	15.0	90.0
Travel & Transportation	11.6	2.2	11.6	2.2	2.2	29.8
Local Subsistence (per diem)	7.2	3.6	3.6	3.6	3.6	21.6
Sub Total	93.8	110.8	120.2	20.8	20.0	366.4
RTG ₱ ($ equivalent)						
Salaries & Staff Related Costs	6.0	12.0	12.0	12.0	12.0	54.0
Local Subsistence (housing)	3.0	6.0	6.0			15.0
Support Costs	4.5	9.0	9.0			22.5
Sub Total	13.5	27.0	27.0	12.0	12.0	91.5
TOTAL	107.3	137.8	147.2	32.8	32.8	457.9

NATIONAL ENERGY AUTHORITY CHARTER AND ORGANIZATION *

NEA Charter

The following extracts from the National Energy Authority Act of B.E. 2496 (1953) provide a picture of the scope of NEA's authorities and responsibilities:

Definitions

"Energy" means the ability to do work obtained from natural sources, such as, water, wind, natural heat, sunlight, mineral or fuel, for instance, firewood, paddy husk, oil, coal, or natural gas.

"Controlled Energy" means the energy to be brought under control under the provisions of this Act.

"Energy Works" means works established by any person or persons so as to acquire energy, such as, electricity, steam, gas.

"Committee" means the committee of the National Energy Authority.

"Competent official" means the official of the National Energy Authority, and shall also include officials of Ministries, Dabuangs, Departments or Municipalities, Local Government or Officials of the Energy Organization prescribed by this Act as competent officials."

Overall Statement of Powers and Duties.

"Section 5. The National Energy Authority as established by law concerning the Organization of Ministries, Dabuangs, and Departments shall have the following powers and duties:

(1) To procure and to establish energy works for the development of the country and for the welfare of the people;

(2) To make researches, experiments, inspections, and surveys, and to compile statistics on localities suitable for establishing hydro-electric power work or places from which materials for the production of electric and other energies would be derived;

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* Name changed to National Energy Administration in 1977.

(3) To lay down policy of and devise control any production of energy, such as, electric energy;

(4) To provide, control, construct, purchase, sell, lease or close down any energy production works and the transmission or the distribution systems;

(5) To lay down regulations and to control for the safety from dangers resulting from the Energy Works;

(6) To establish standards and to prescribe rates for the sale of energy;

(7) To aid and promote the utilization of Energy, for economic developments such as, agriculture, handicraft, industry, commerce, and communications;

(8) To bring about other benefits jointly coupled with those accrued from the Energy Works, such as, irrigation, flood control, and navigation."

Board of Committee, Sub-Committees.

"Section 7. There shall be instituted a Board of Committee composing of the Prime Minister as President, the Minister of the Interior and Industries, as Vice Presidents, the Director General of the Public and Municipal Works Department, the Director General of the Royal Irrigation Department, the Director General of the Mines Department, the Director General of the Forestry Department to the Board of Committee as ex officio members, and the Secretary General as an ex officio Committee and Secretary, and not less than five and not more than nine other members, to be appointed by Royal Command, from persons qualified in electrical engineering, civil engineering, mechanical engineering, geology, finance, economics or law."

"Section 15. The Committee may appoint a Board of Sub-Committee to execute on its behalf any of its function as may be assigned."

Power to Summon, Enter Premises, Make Use of Property.

"Section 16. In the exercise of its powers and duties, the National Energy Authority shall have power to summon by letter any Ministry, Dabuang, Department, Municipality, Local

Government, Government Organization or any person to furnish information, or to deliver any documents or evidence or article relevant to Energy as may be necessary for consideration."

"Section 17. In the execution of business of the National Energy Authority the competent official shall have power to enter premises of Ministries, Dabuangs, Departments, Municipalities, Local Government, Government Organizations or any person between sunrise and sunset to inquire into facts or to check up any documents or things relative to Energy from persons residing on such premises in so far as it is necessary. In this respect, such persons shall render reasonable facilities to the competent officials."

"Section 20. The competent officials shall have power to make use of or to possess temporarily an immovable property of any person, which is not a habitation of any private individual under the following conditions:

(1) Such action is necessary for the surveys of site for energy development, energy production, distribution system; and for precaution against danger or damage that may arise from the production or distribution of the energy; and

(2) The owner or possessor of the immovable property has been notified of such action at a reasonable time in advance if practicable."

Power of Eminent Domain.

"Section 21. Should any necessity arise as to the acquisition of immovable property to be used for the production system, expansion of the production system or for distribution system, expropriation shall be proceeded with in accordance with the law relating to the expropriation of immovable property..."

Designation of Energy Areas and Controlled Energy.

"Section 30. When it is expedient to prescribe any locality as an Energy Area, notification shall be made by a Royal Decree.

There shall be a map or maps determining an Energy Area attached to this Royal Decree. Such map or maps shall be regarded to form part of the Royal Decree."

"Section 31. There shall be determined by Royal Decree as to what form energy, its capacity, method of production and use as well as its scope will be regarded controlled energy."

"Section 32. Within an Energy Area, no person is permitted to do any act that would hamper or decrease the controlled energy production."

Use of Raw Materials and Natural Resources.

"Section 33. The National Energy Authority shall have power to prohibit or limit the use of raw materials or natural resources which are necessary for any energy production; or to require any person desiring to use such raw materials or natural resources, to apply for permit from the National Energy Authority.

The National Energy Authority shall have power to permit or not to permit or to permit with any conditions."

Licensing of Energy Production.

"Section 34. No person shall carry out any production or extension of controlled energy in the Energy Area without permission from the National Energy Authority.

Application for and grant of permission shall be in accordance with rules and procedure prescribed in the Ministerial Regulations."

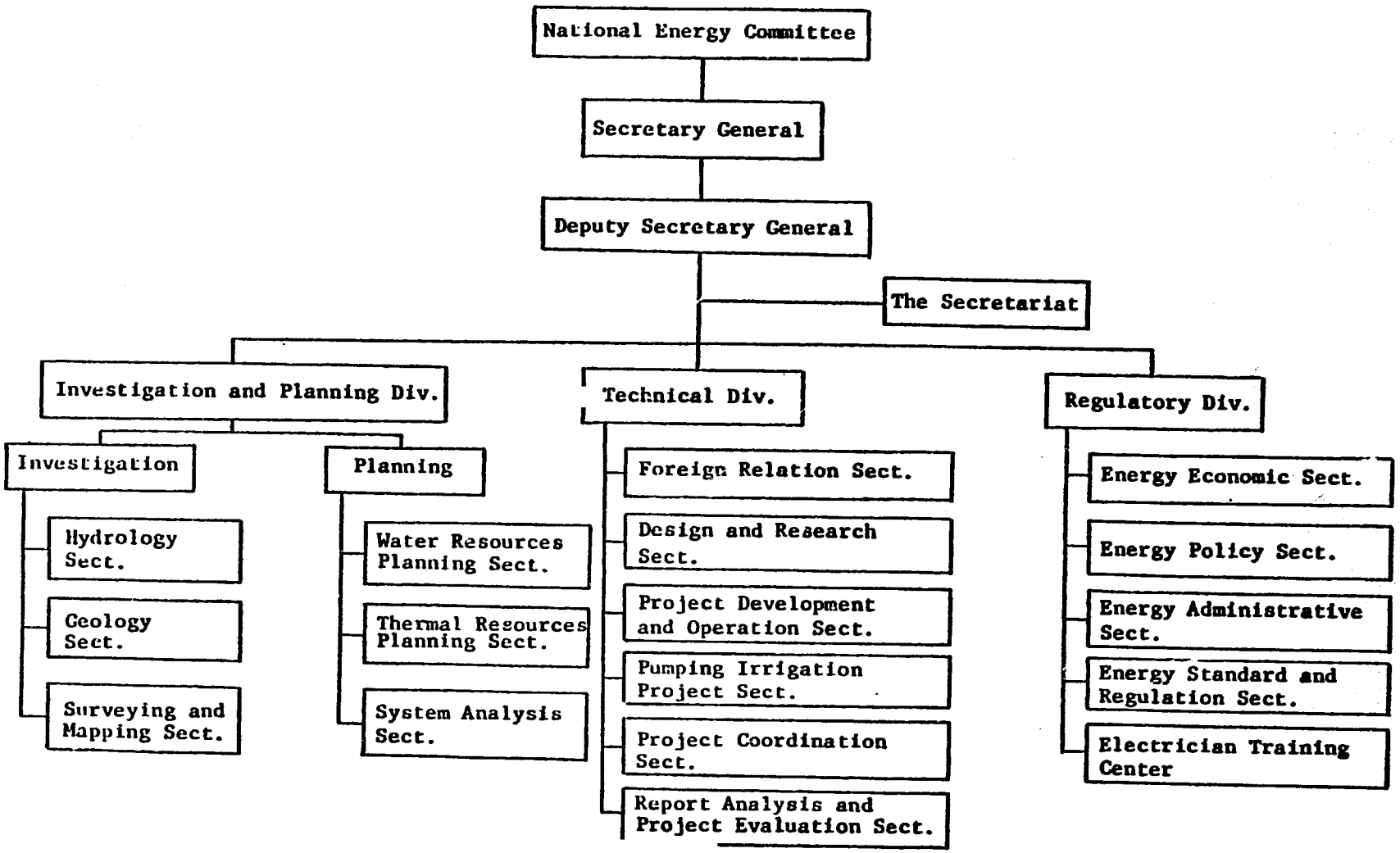
Power to Curtail Energy Production.

"Section 38. In case of shortage of controlled energy from time to time in an Energy Area, the National Energy Authority is empowered to order that the production, distribution or utilization of controlled energy be decreased to a reasonable extent, or to order that the type of raw materials or natural resources used in producing controlled energy be altered, irrespective of whether the production of controlled energy has been commenced before after the date of the coming into force of this Act."

Other sections of the Act expand on the above. They also deal with NEA's authority to redelegate its powers, to prescribe the location of, or install, energy lines, and to order changes in energy production for reasons of safety or national interest.

The Act also contains a separate part with sections on the establishment, management, and financial arrangements for "an Energy Organization to carry out the production of energy." One section provides that the NEA "shall have power and duty to exert a general supervision over the enterprise of an Energy Organization." Specific NEA approvals required are stipulated in other sections.

ORGANIZATION CHART OF NATIONAL ENERGY ADMINISTRATION (NEA)



ANNEX XVIII

Implementation Schedules	pageono.
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Resources Assessment - Solar	4
Resources Assessment - Biomass	5
Resources Assessment - Micro Hydro	6
Resources Assessment - Lignite, tar sand,oil shale, geothermal	7
Energy Technologies Monitoring	8
Energy Master Plan (EMP)	9
Rural Oriented Technologies - Biomass Conversion	10
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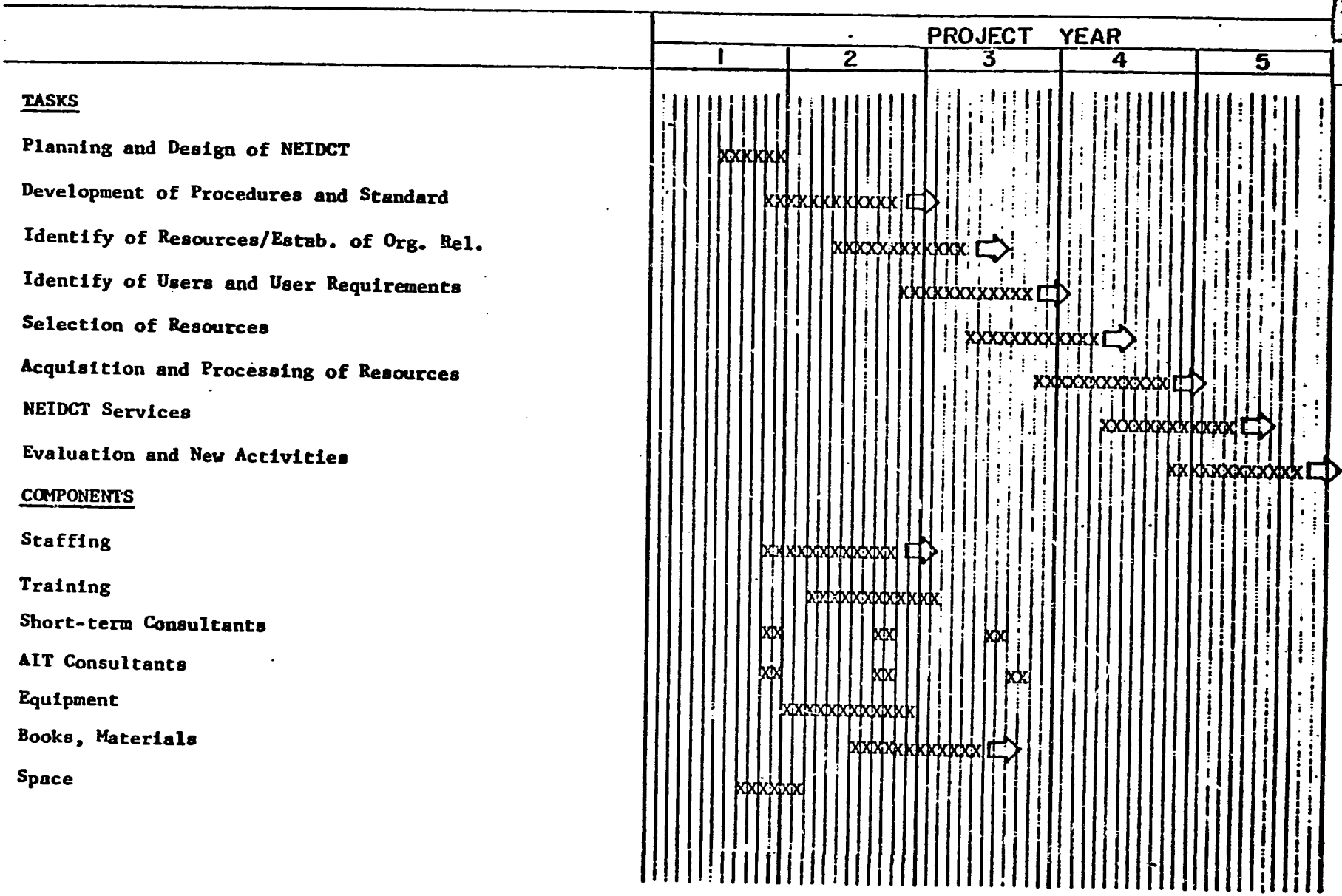
Rural Oriented Technologies - Solar Drying & Distrillation, Process Heat	12
Water Lifting Technologies	13
Village Woodlots - 10 Villages	14

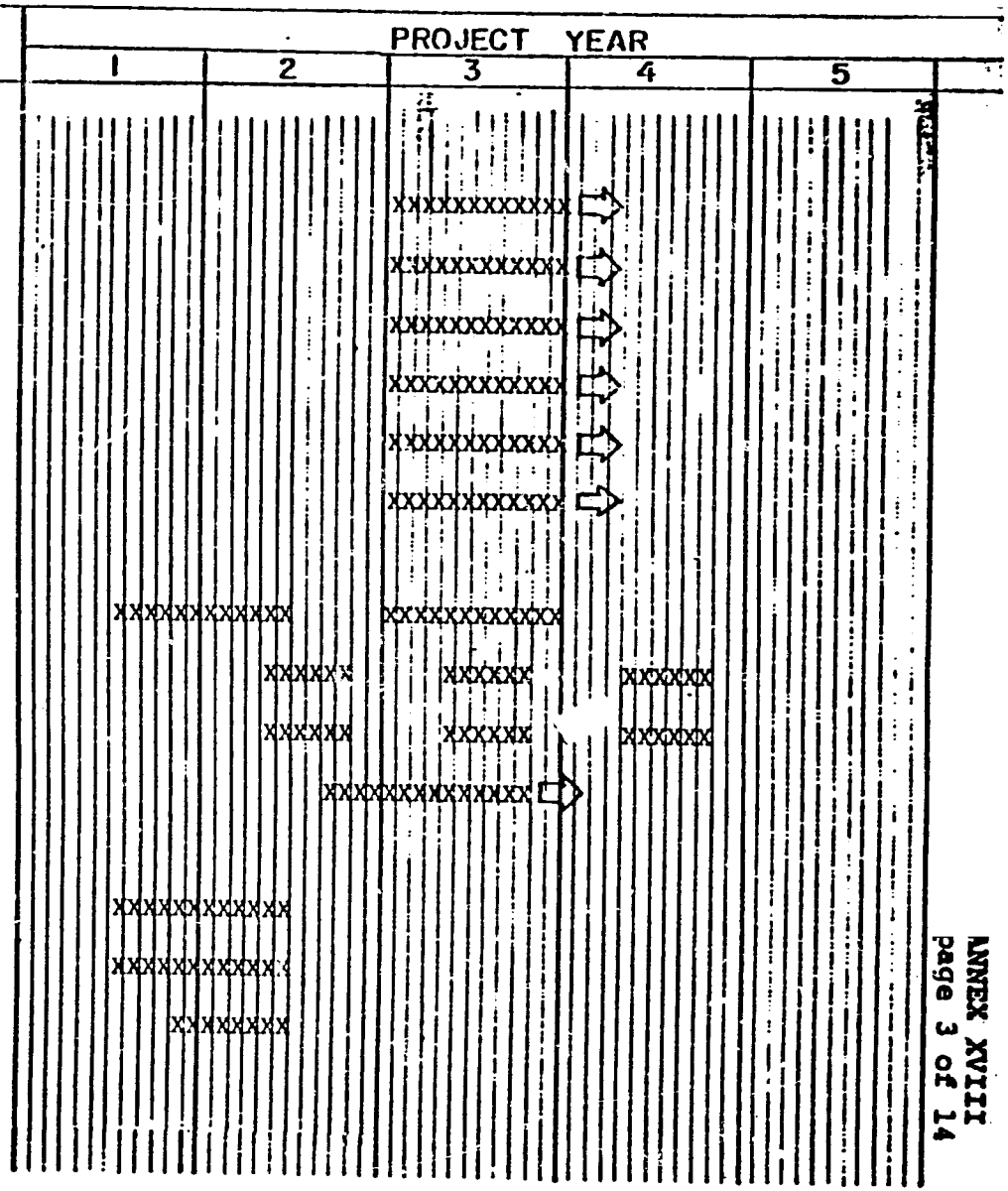
IMPLEMENTATION SCHEDULE

FOR NEIDCT



IMPLEMENTATION SCHEDULE

FOR RECs (Six Centers)



TASKS

NEA Extension Activities

Data Collection

Project Monitoring

Information Dissemination

Training

Coordination

COMPONENTS

Land Acquisition/Preparation

Office Space Construction

Housing Construction

Staff Assignments

Vehicles:

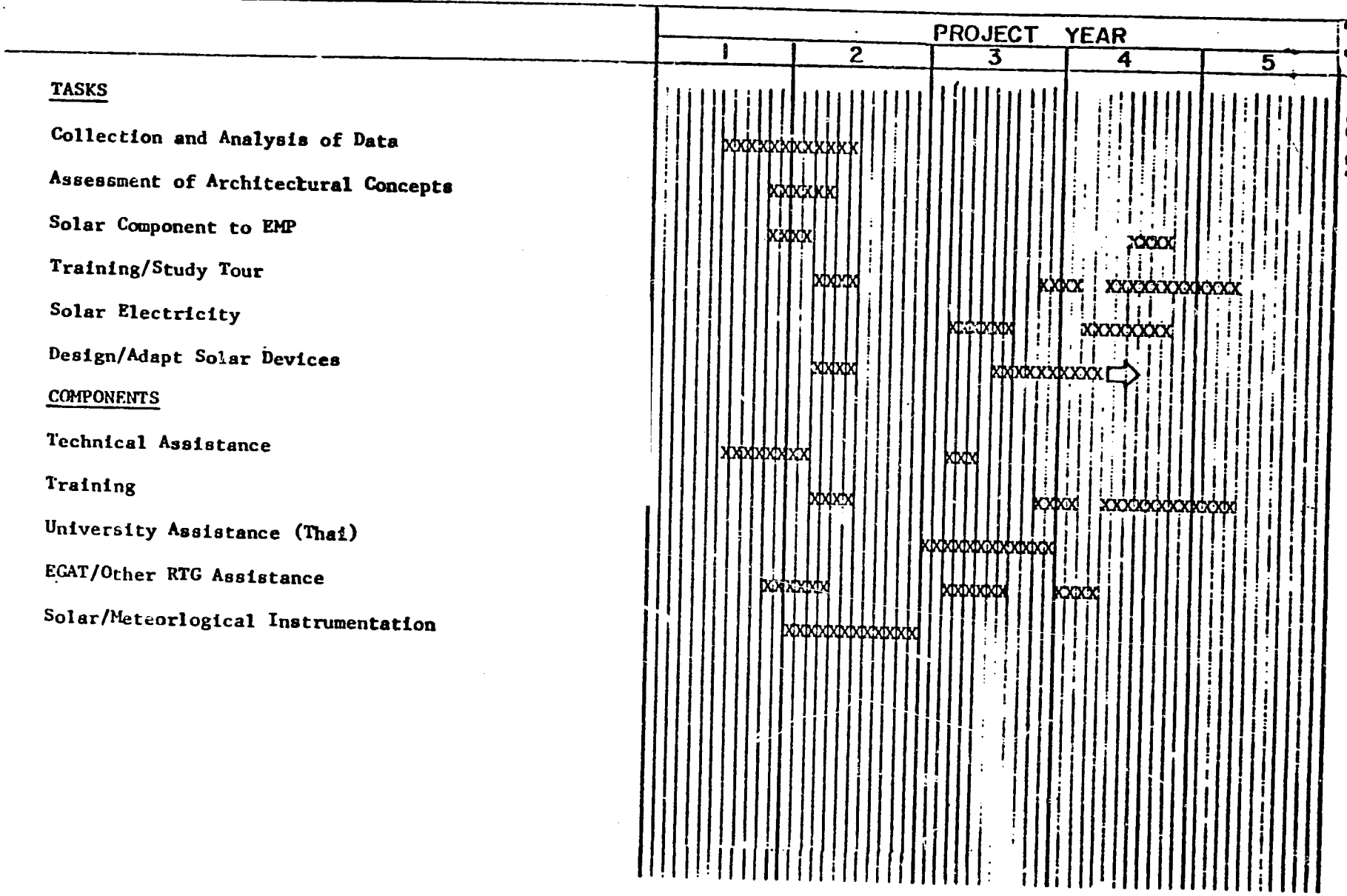
Trucks 6 2-ton trucks

Jeeps 6 (4 x 4)

Cameras, Projectors, Video Tapes

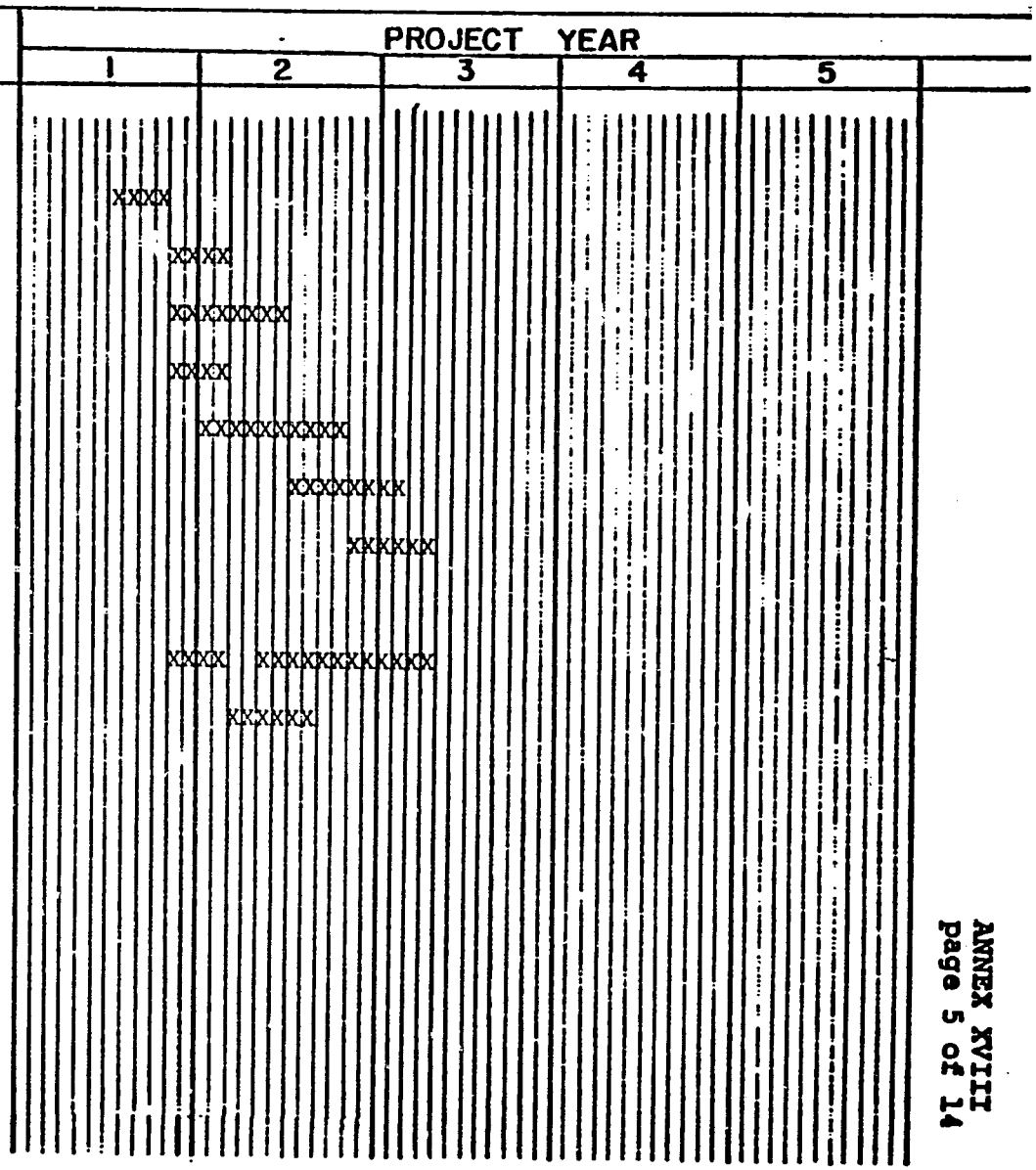
IMPLEMENTATION SCHEDULE

FOR Resources Assessment - Solar



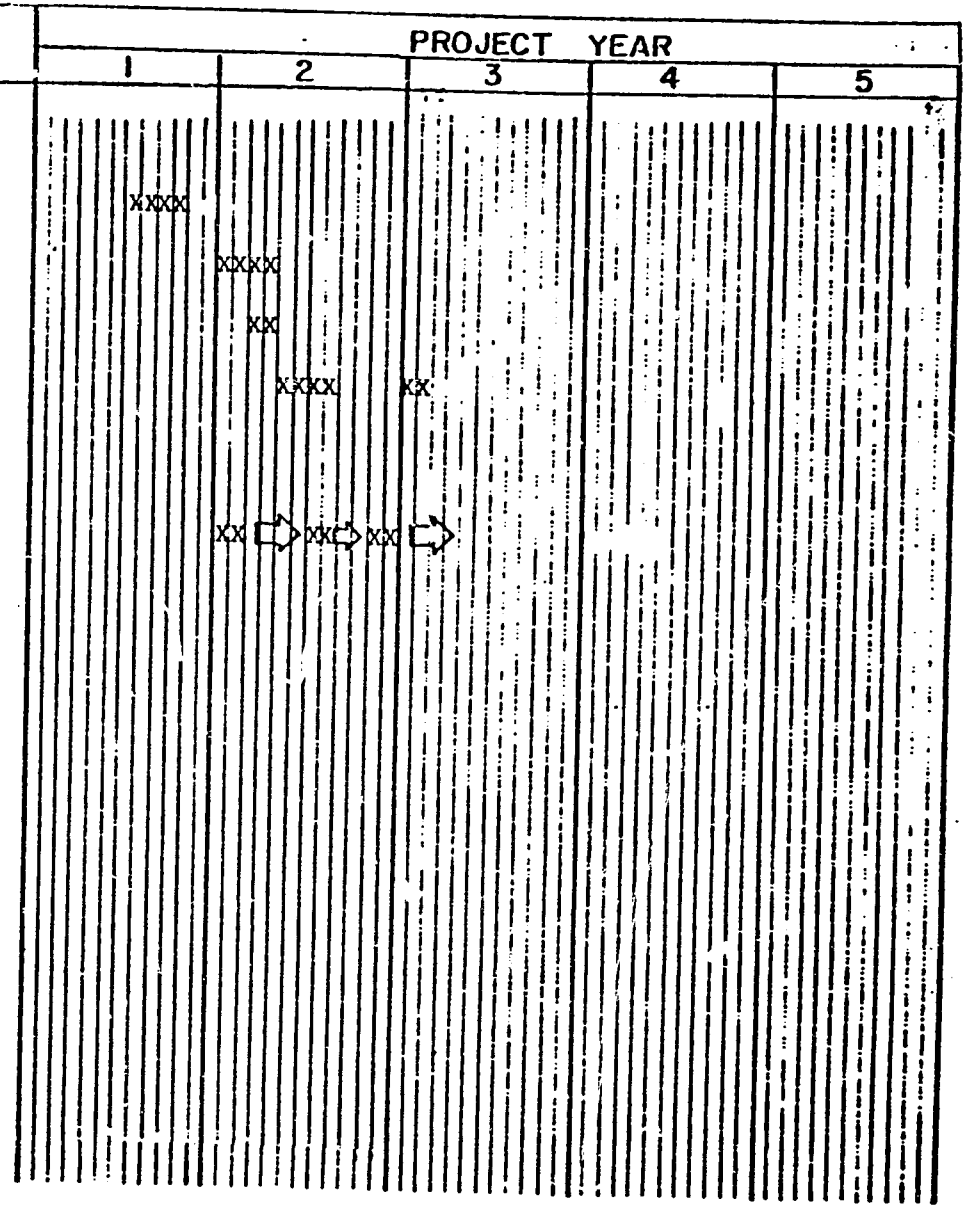
IMPLEMENTATION SCHEDULE

FOR Resources Assessment - Biomass



IMPLEMENTATION SCHEDULE

FOR Resources Assessment - Micro Hydro



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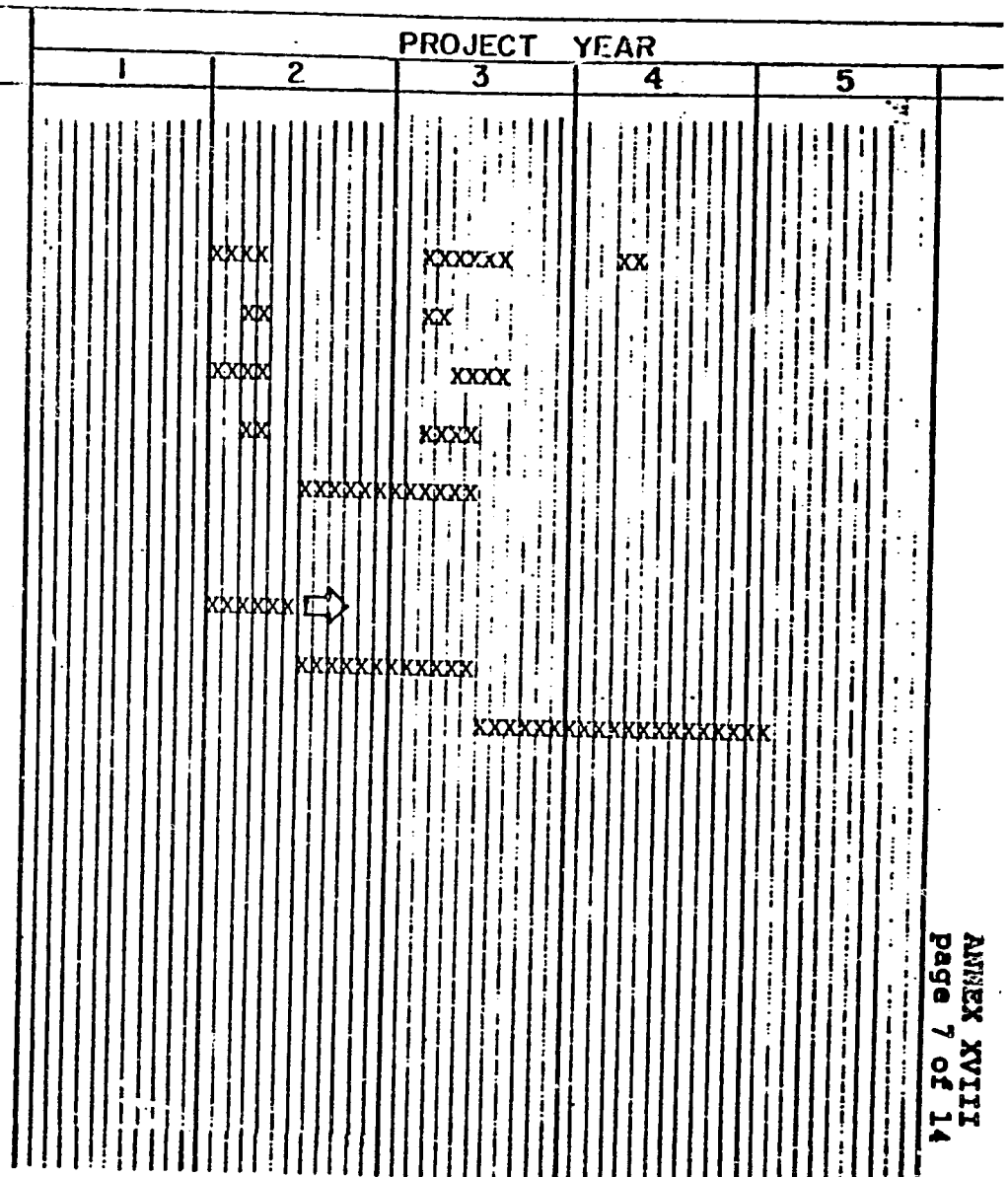
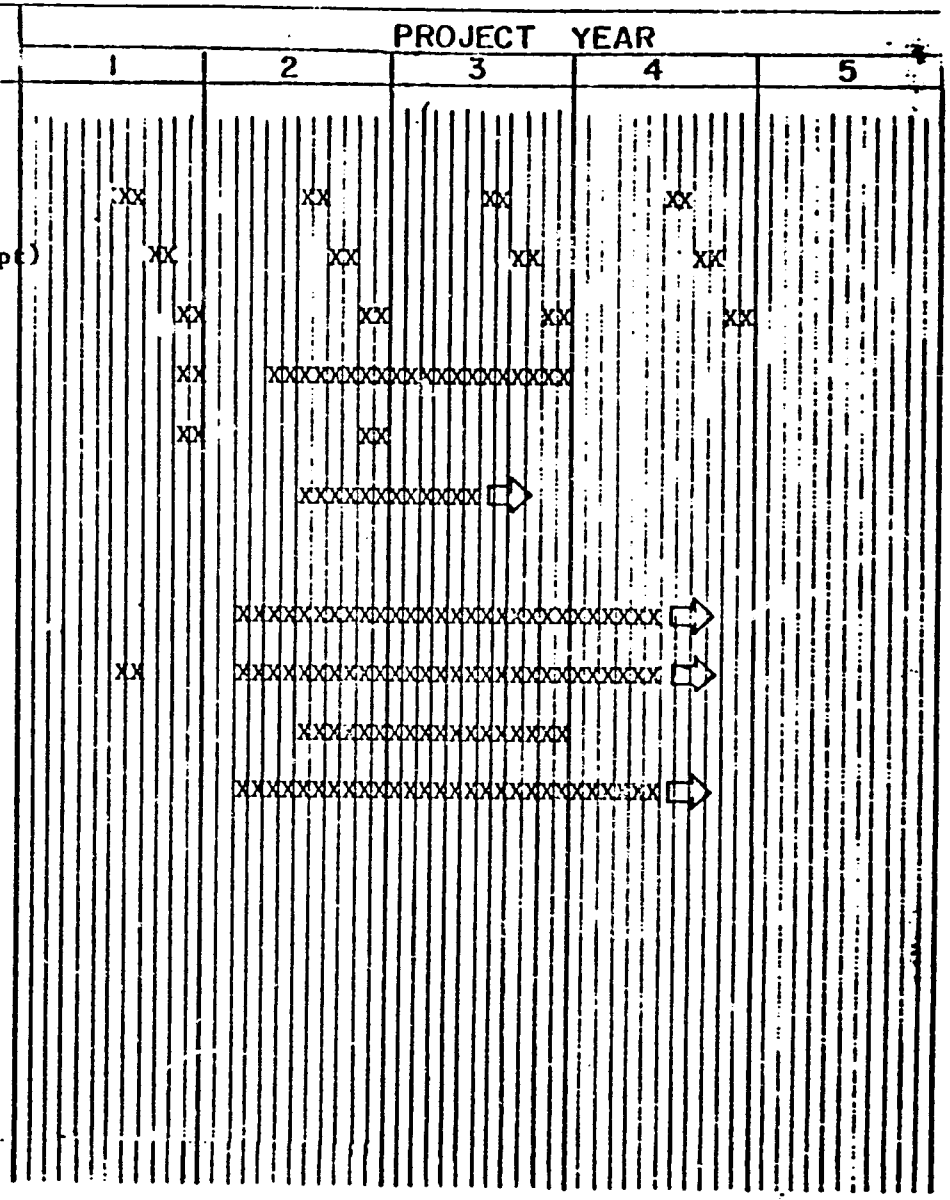
IMPLEMENTATION SCHEDULE

FOR Resources Assessment - Lignite, Tar Sands, Oil Shale, Geothermal



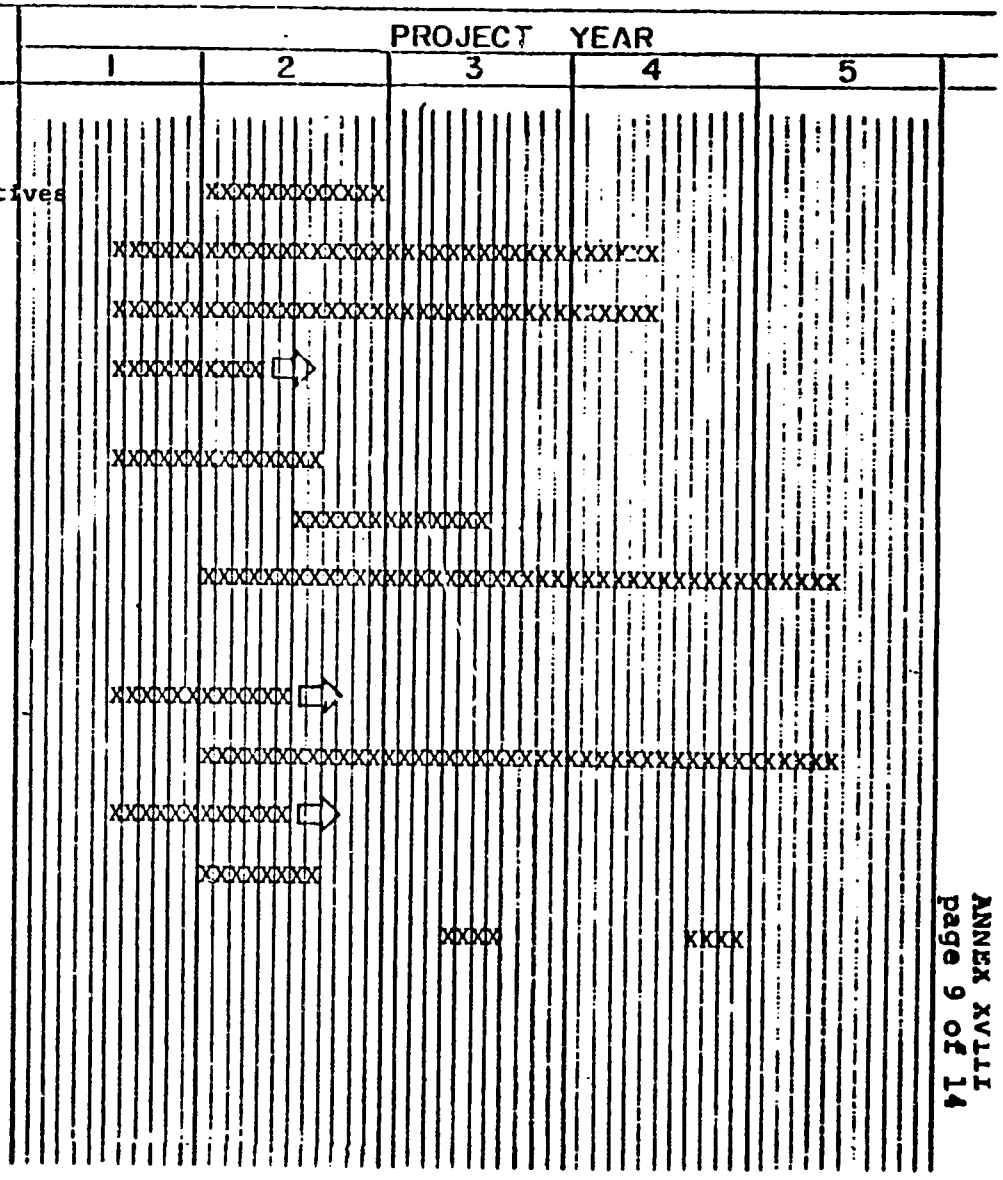
IMPLEMENTATION SCHEDULE

FOR Energy Technologies Monitoring



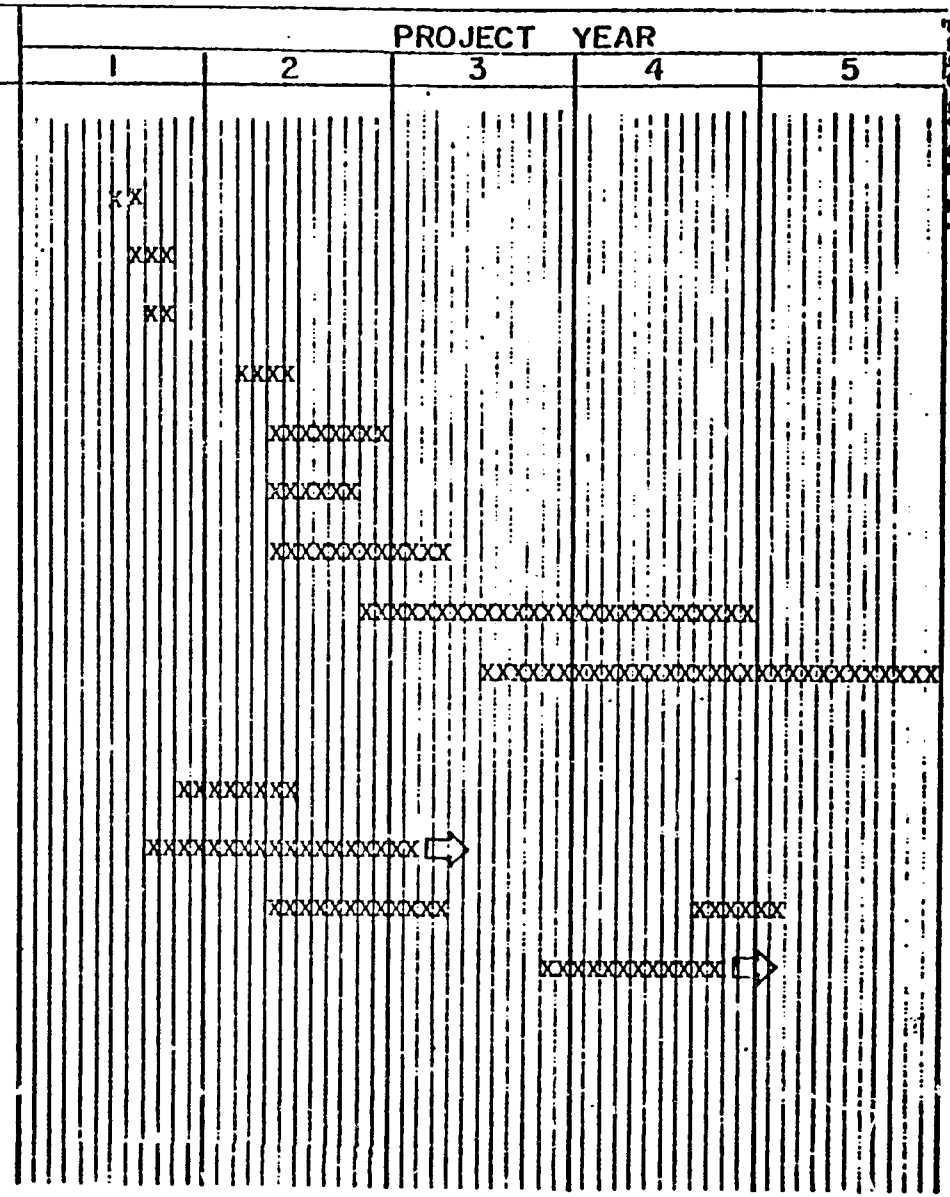
IMPLEMENTATION SCHEDULE

FOR SUPPORT OF THE ENERGY MASTER PLAN



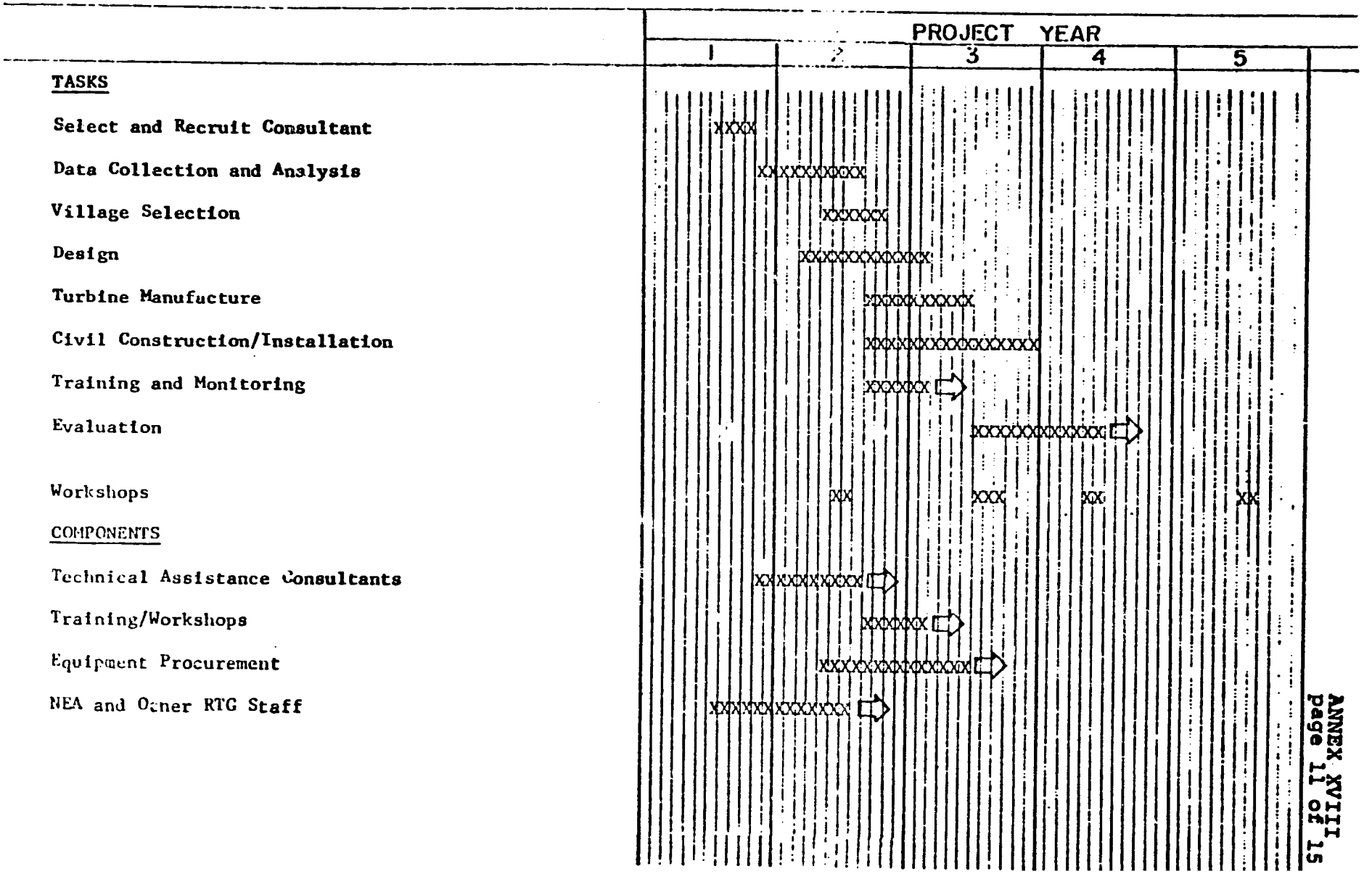
IMPLEMENTATION SCHEDULE

FOR Rural Oriented Technologies - Biomass Conversion



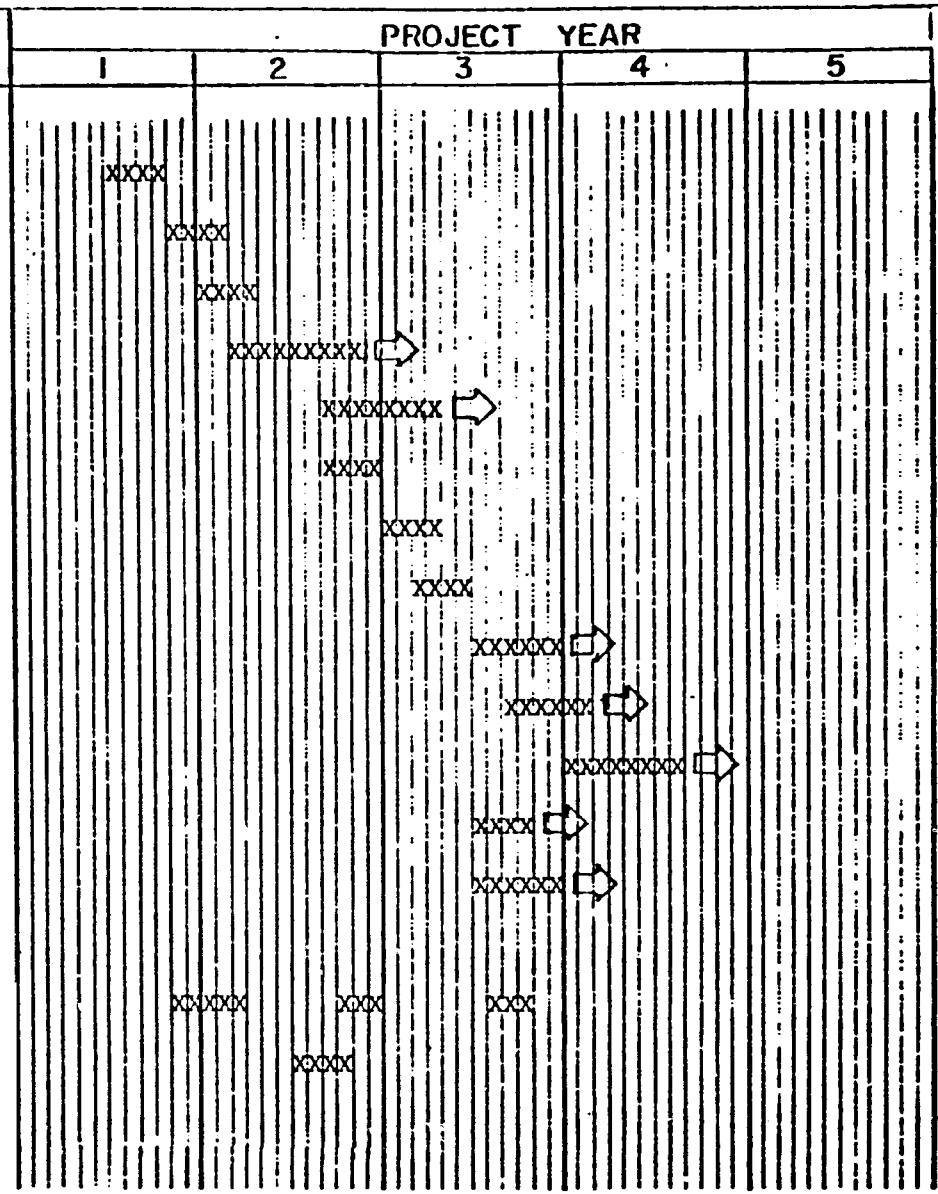
IMPLEMENTATION SCHEDULE

FOR Rural Oriented Technologies - Micro Hydro



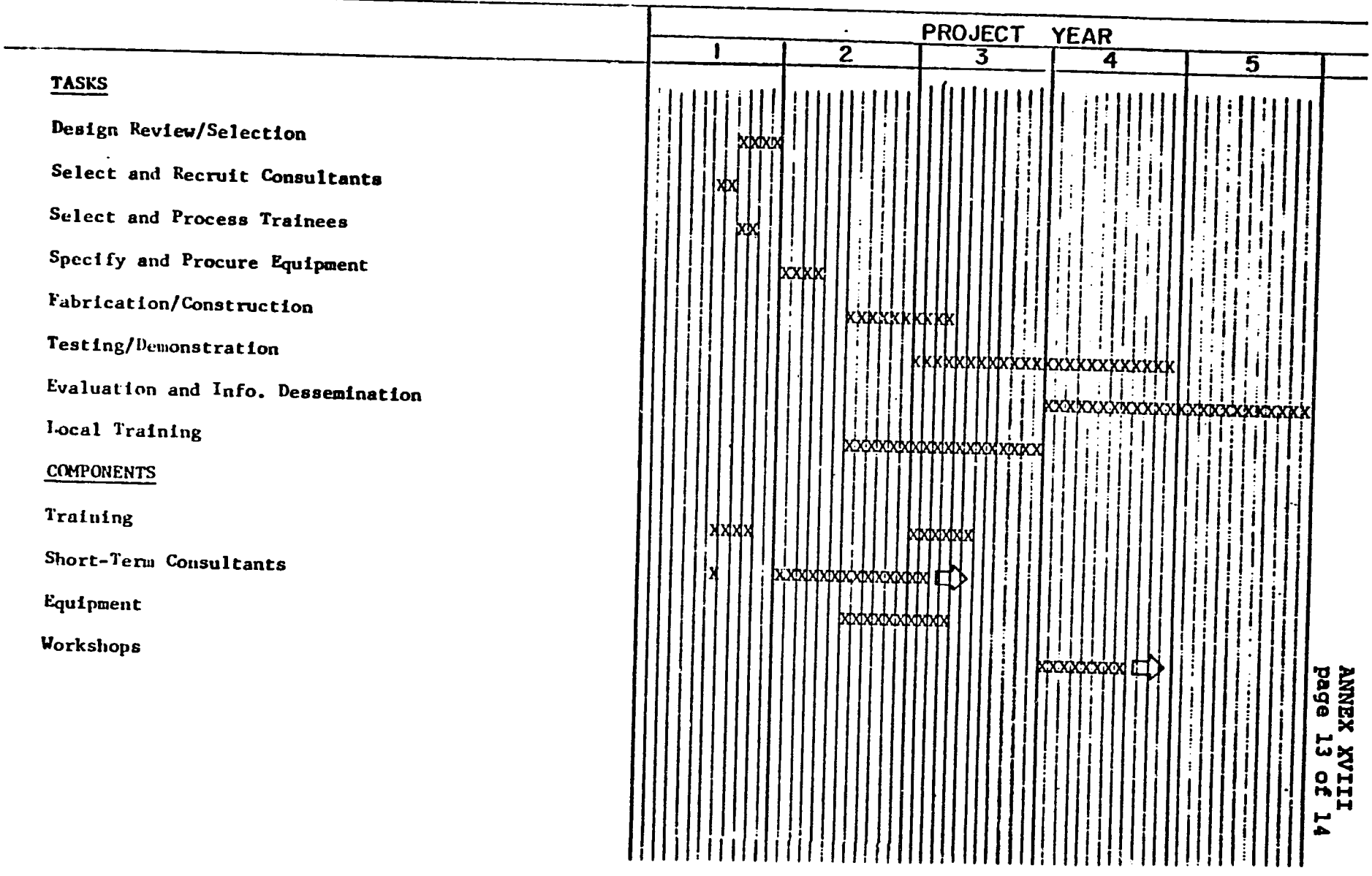
IMPLEMENTATION SCHEDULE

FOR Rural Oriented Technologies - Solar Drying and Distillation, Process Heat



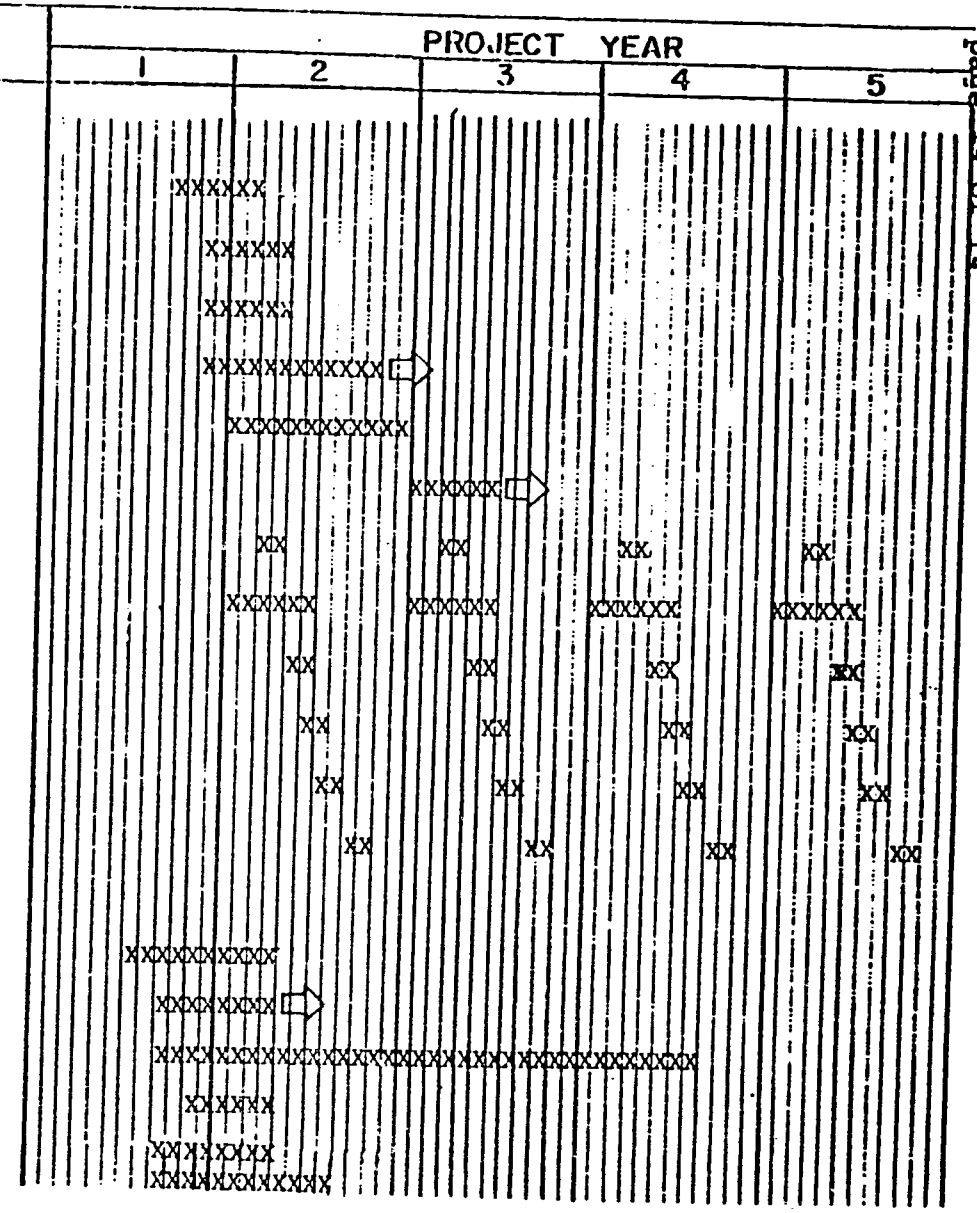
IMPLEMENTATION SCHEDULE

FOR Water Lifting Technologies



IMPLEMENTATION SCHEDULE

FOR Village Woodlots - 10 Villages



TASKS

Site Selection

Location of Land

Soil and Site Investigation

Coordination

Training (Technicians)

Training (Villagers)

Allocation of Land

Nursery Stock Preparation

Staking

Planting

Weeding

Fire Control

COMPONENTS

Staffing

Training

L-T Consultants

S-T Consultants

Housing

Equipment Procurement

AID 1020-28 (7-71)
SUPPLEMENT 1

PROJECT DESIGN SUMMARY
LOGICAL FRAMEWORK

(INSTRUCTION: THIS IS AN OPTIONAL FORM WHICH CAN BE USED AS AN AID TO ORGANIZING DATA FOR THE PAR REPORT. IT NEED NOT BE RETAINED OR SUBMITTED.)

Life of Project:
From FY 1979 to FY 1983
Total U.S. Funding $ 5.0 million
Date Prepared: 4/10/79

Project Title & Number: Renewable Nonconventional Energy (493-0304)

PAGE 1

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Program or Sector Goal: The broader objective to which this project contributes: (A-1)	Measures of Goal Achievement: (A-2)	(A-3)	Assumptions for achieving goal targets: (A-4)
To enhance Thailand's rural development by increasing the availability of energy from other than imported conventional fossil fuels for a variety of domestic, agricultural and industrial uses of the rural population. Subgoal: To reduce environmental degredation due to deforestation causedby the demand for wood for use both as fuel and in charcoal production.	An increase in the amount of energy consumed in rural areas from a variety of renewable sources, including village woodlots.	Evaluation of RTG data.	1. Increased availability of energy for domestic, agricultural and industrial use is an essential ingredient for rural development (and conversely development increases the demand for energy). 2. Importing of fossil fuels continues to increase in cost and to consume an increasing amount of foreign exchange, thereby providing a continued and growing impetus for the development of alternative energy sources.

ANNEX XIX
Page 1 of 4

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AID 1020-24 (6-74)
SUPPLEMENT 1

PROJECT DESIGN SUMMARY
LOGICAL FRAMEWORK

Life of Project:
From FY 1979 to FY 1984
Total U.S. Funding $5.0 million
Date Prepared: 4/10/79

Project Title & Number: Renewable Nonconventional Energy (493-0304)

PAGE 2

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Project Purpose: (B-1)	Conditions that will indicate purpose has been achieved: End of project status. (B-2)	(B-3)	Assumptions for achieving purpose: (B-4)
BY 1984: - To ready appropriate, cost-effective, and non-environmentally destructive energy technologies for dissemination in rural areas by testing and evaluating their technological, economic, and cultural feasibility in Thailand and by adapting them as necessary; - To develop and test methodologies and techniques for disseminating rural energy technologies throughout Thailand; - To develop the institutional capability and trained personnel to enable the RTG to engage in resources assessment and analysis, energy technologies monitoring and energy planning which includes consideration of rural needs.	1. A number of renewable energy technologies, including woodlots, tested and adapted for use in rural Thailand, 2a. Techniques and methodologies developed and tested for training appropriate public sector outreach workers or private voluntary agency workers to disseminate rural energy technologies. 2b. The private sector will have been made aware of those technologies with commercial applications or which are suitable for commercial marketing (e.g. improved wood burning stoves). 3. An institutional arrangement is being established for continued testing, demonstration, and training at the regional level, e.g. the six planned regional Development, Demonstration, and Training Centers of some alternative. 4. RTG decision makers and policy makers have been provided with training, information and data on resource analysis and assessment, surveying rural energy needs uses and resources, and on utilization technologies.	1. AID/RTG evaluations. 2. NEA and other RTG agency records. 3. Interviews and field visits to regional facilities to corroborate program records and document the availability of proven technologies and techniques for their dissemination. 4. Interviews with individuals trained to ascertain whether they are working in the fields in which they received training and whether their training is being utilized.	1. Timely RTG approval of annual operating budgets, staffing levels, and adequate policy support. 2. RTG implementing agencies will cooperate with and support the program, as well as work under the lead of NEA. 3. Renewable energy technologies prove to be socially acceptable and culturally feasible in addition to their being technically and economically feasible.

AID 1020-20 (7-71)
SUPPLEMENT 1

PROJECT DESIGN SUMMARY
LOGICAL FRAMEWORK

Life of Project:
From FY 1979 to FY 1984
Total U.S. Funding $3.0 million
Date Prepared: 6/10/79

Project Title & Number: Renewable Nonconventional Energy (493-0304)

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Outputs: (C-1)	Magnitude of Outputs: (C-2)	(C-3)	Assumptions for achieving outputs: (C-4)
1. Train policy- and decision-makers. 2. Increased energy information. 3. Pilot and demonstration facilities.	1. 257 person months of training provided to RTG officials in the U.S., Thailand and third countries. 2.a. 309 person months of consultant services have been provided in resource assessment and analysis, technologies monitoring and master planning, as well as rural energy technologies testing and adaptation. 2.b. One energy master plan for Thailand, including rural supply and demand considerations. 2.c. One energy information center functioning 3. 6 regional centers operating or alternative institutional arrangements functioning at the regional level for the purpose of establishing pilot/demonstration facilities in selected technologies.	1. Annual reviews, 2. NEA and other RTG agency records, 3. Participant training records.	1. Adequate RTG support for and coordination of the program. 2. Qualified technical advisors can be recruited on a timely basis. 3.a. Personnel qualified to take training can be made available, 3.b. Access to U.S. and other training facilities. 4. Availability of required commodities including publications at prices budgeted.

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ANNEX XIX
PAGE 4 OF

AID 1020-20 (7-71)
SUPPLEMENT 1

PROJECT DESIGN SUMMARY
LOGICAL FRAMEWORK

Project Title & Number: Renewable Nonconventional Energy - (493-0304)

Life of Project:
From FY 1979 to FY 1984
Total U.S. Funding $5.0 million
Date Prepared: 4/10/79

PAGE 2

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Inputs: (D-1)	Implementation Target (Type and Quantity) (D-2)	(D-3)	Assumptions for providing inputs: (D-4)
AID $5 million (grant)		**AID** 1. Project agreements 2. Periodic reports of advisors/monitors.	**AID** Funding and project monitoring capability will be available as planned.
RTG $3.4 million of support		**RTG** 1. Annual RTG budget 2. Staffing lists 3. National planning documents.	**RTG** Operating budget requirements will be met as planned and staffing levels will be approved as needed.
ADB/UNDP $950,000 of support for the energy master planning activity.		**ADB/UNDP** 1. Grant document with RTG committing funds for energy master planning activity 2. ADB/UNDP-funded staff in place.	**ADB/UNDP** Funding will be available as planned.

	80	81	82	83	84
AID					
T.A.	501	1138	629	398	74
Training	108	218	495	90	30
Equipment	152	556	276	30	24
Other	12	22	36	45	46
RTG					
Salaries, etc.	213	411	481	511	492
Facilities	50	279	235	195	-
Other	63	114	91	71	73
ADB/UNDP					
T.A.	700	310	-	-	-

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CERTIFICATION PURSUANT TO SECTION 611(E) OF THE FOREIGN ASSISTANCE ACT OF 1961 AS AMENDED

I, Donald D. Cohen, The Principal Officer of The Agency for International Development in Thailand, do hereby certify that in my judgement Thailand has both the financial capability and human resources capability to effectively maintain and utilize the capital assistance to be provided under the proposed Renewable Nonconventional Energy Project Grant. This capital assistance will be part of a project design which will utilize institutional development and the careful introduction of new technologies to assist the Royal Thai Government in its efforts to reduce imported energy resources and increase the quality of life and income opportunities in rural areas. In so certifying, I have taken into account, among other things, the soundness of the Thai economy, the competence and active involvement of officials of those departments and agencies of the Royal Thai Government directly concerned with the project in its planning and design, and the maintenance and utilization of projects in Thailand previously financed or assisted by the United States.

Donald D. Cohen
Mission Director

Date July 3 79

DRAFT

PROJECT AUTHORIZATION AND REQUEST FOR ALLOTMENT OF FUNDS

PART II

Country : Thailand

Project : Renewable Nonconventional Energy

Project No.: 493-0304

Pursuant to Part I, Chapter 1, Section 103 of the Foreign Assistance Act of 1961, as amended, I hereby authorize a Grant to the Kingdom of Thailand (the "Cooperating Country") of not to exceed Two Million Five Hundred Thousand United States Dollars ($2,500,000)(the "Authorized Amount") to help in financing certain foreign exchange and local currency costs of goods and services required for the project as described in the following paragraph:

The project (hereinafter referred to as the "Project") is designed to assist the Royal Thai Government ("RTG") in developing its institutional capacity to perform and sustain energy policy planning, in introducing and testing renewable energy technologies adapted for use in rural areas, and in developing and testing techniques for disseminating such technologies. These activities will be carried out simultaneously so that at the end of the Project there should coincide a tested selection of rural renewable energy applications and the data and institutional base to implement them within the framework of a broader energy policy for the Cooperating Country.

I approve the total level of A.I.D. appropriated funding planned for this Project of not to exceed Five Million United States Dollars ($5,000,000), including the funding authorized above, which will be entirely grant-funded, during the period FY 1979-84. I approve further increments during the period of grant funding up to $2,500,000, subject to the availability of funds in accordance with A.I.D. allotment procedures.

I hereby authorize the initiation of negotiation and execution of the Project Agreement by the officer to whom such authority has been delegated in accordance with A.I.D. regulations and Delegations of Authority subject to the following essential terms and major conditions together with such other terms and conditions as A.I.D. may deem appropriate:

a. Source and Origin of Goods and Services

Except for ocean shipping, goods and services financed under the Grant shall have their source and origin in the Cooperating Country or in the United States, except as A.I.D. may otherwise agree in writing. Training in the United States and in third countries shall be undertaken in accordance with the provisions of A.I.D. Handbook Number 10. Ocean shipping financed under the Grant shall be procured in the United States, except as A.I.D. may otherwise agree in writing.

b. Initial Conditions Precedent to Disbursement

Prior to any disbursement, or the issuance of any commitment documents under the Project Agreement, for any expenditure of funds, the Cooperating Country shall designate representatives to undertake the Project and to coordinate actions with A.I.D.

c. Covenants

The Cooperating Country covenants to provide continuing adequate budgetary and staff support for the Project.

d. Blanket Waiver to Code 941

On the basis that a portion of the goods and services related to unconventional, renewable energy technology is necessary for implementation of the Project and is not available in the United States or the Cooperating Country, goods and services financed under the Project may be procured from countries included in A.I.D. Geographic Code 941; Provided however, that the United States Dollar value of each such procurement does not exceed $500,000 and that vehicles are not procured under this waiver authority.

John H. Sullivan
Assistant Administrator
Bureau for Asia