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UNITED STATES INTERNATIONAL DEVELOPMENT COOPERATION AGENCY
AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D.C. 20523

APR 21 1989

ACTION MEMORANDUM FOR THE SENIOR ASSISTANT ADMINISTRATOR FOR SCIENCE AND TECHNOLOGY

FROM: S&T/EN, Jack Vanderryn

SUBJECT: Biomass Energy Systems and Technology (BEST) Project Approval

Problem: Your approval is needed for funding of the Biomass Energy Systems and Technology Project, 936-5737.

Discussion: On March 7, 1988, you approved the concept paper to design the Biomass Energy Systems and Technology (BEST) Project as a follow-on to the Bioenergy Systems and Technology Project (BST), 936-5709. At that time you authorized the Office of Energy to proceed with the project design process so as to achieve an orderly transition from the BST to BEST project prior to the PACD for the BST project on September 30, 1989. The BEST project as designed is a seven year, $25 million project with a total of $15 million in core funding from S&T/EY and an expected total of $10 million in Mission buy-ins over the life of the project.

The project was reviewed and endorsed by the Energy Sector Council on January 11, 1989. The following Missions have expressed interest in providing financial support for BEST project initiatives of value to their countries through buy-ins during the life of the new project: the Philippines, Indonesia, Egypt, Morocco, Malawi, Dominican Republic, Jamaica, Sudan and Kenya. Because the BST project could not routinely accept buy-in funds until very recently, written documentation of projected buy-in commitments by specific Missions for FY '89 has been limited. Nevertheless a high level of Mission interest has been expressed and funding commitments are expected as soon as the new BEST project is authorized. Given indicated interest, the level of Mission buy-ins has been projected to total $10 million over the life of the project.

Approval of the new BEST project will help establish a framework to reduce technical, financial, economic and institutional risks associated with bioenergy systems in A.I.D.-assisted target countries. Private interests (both U.S. and indigenous) require this type of assistance so that they can invest in commercially-proven energy conversion systems matched to readily available supplies of biomass feedstocks. Bioenergy systems produce electricity, process steam, liquid and gaseous fuels, and in some cases animal feeds and chemical by-products from processing residues such as sugarcane bagasse and field trash, rice husks and straw, wood wastes and commercial timber processing residues, and municipal or industrial wastes.

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Through the new project A.I.D. will be able to catalyze the private sector to invest in successful use of residues for the production of energy and other by-products to create new jobs in rural areas, improve natural resources management practices in an environmentally sound manner, reduce dependence on imported fuels, and create new product markets. Investments will be facilitated by identification of the full range of project risks, recognition of constraints preventing implementation, working with key personnel to reduce and/or remove constraints, helping U.S. private firms to work with developing country private and public sectors, and matching financial instruments and institutions with attractive project opportunities.

An Advice of Program Change was approved on March 20, 1989, CN #158, for this new project. The FY '89 OYB is $2,170,000, which will be obligated to initiate a Cooperative Agreement to support this program. We have programmed $1,800,000 in the FY '90 CP for this project.

Recommendation: That you sign the attached PAF authorizing the Biomass Energy Systems and Technology Project for seven years with life of project central funding of $15 million and estimated buy-ins of $10 million.

Attachments:
1. Approved Concept Paper
2. Approved Project Identification Document
3. Project Paper
4. Project Authorization Form
5. Project Data Sheet
6. Justification for Non-Competition Cooperative Agreement Memo

Clearances:

S&T/PO, DSheldon _____ Date: 4/25/89
GC/CP, STisa (subs) _____ Date: 4-14-89

Drafter: JSullivan:BST:4/19/89:0011T:875-4203

PROJECT AUTHORIZATION

Name of Country/Entity: Worldwide

Name of Project: Biomass Energy Systems & Technology

Number of Project: 936-5737

1. Pursuant to Sections 103 and 106 of the Foreign Assistance Act of 1961, as amended, I hereby authorize the Biomass Energy Systems and Technology Project, which will be centrally funded. Planned obligations of not to exceed $15,000,000 in grant funds over a seven-year period from the date of authorization, subject to the availability of funds in accordance with the A.I.D. OYB/ allotment process, to help in financing foreign exchange and local currency costs for the Project.

In addition, A.I.D. Missions, Offices, and Regional Bureaus may contribute up to $10,000,000 of funds authorized under Section 103, Section 106, the Development Fund for Africa (DFA), and the Economic Support Fund (ESF) to help in financing costs for the Project. The planned Life of Project is seven years.

2. The project consists of: 1) assessments in selected A.I.D.-assisted developing countries in order to identify specific agroprocessing industrial sectors and specific mills where opportunities exist for implementing profitable diversification investments to produce energy as a by-product; 2) brokering investment opportunities identified among plant/mill managers, utility executives, U.S. equipment suppliers, and commercial investors (both U.S. and indigenous); 3) a program of sponsored applied research; 4) technology analyses; and 5) project implementation activities in the field in a variety of countries in order to advance investment interest. Implementation of specific field projects designed to reduce perceived risks and to test working hypotheses is a key focus, within the overall aim of BEST to create new jobs in rural areas, improve resource management in an environmentally-sound manner, reduce dependence on imported fuels, and create new product markets.

3. The Project Agreement(s) which may be negotiated and executed by the officer(s) to whom such authority is delegated in accordance with A.I.D. regulations and Delegations of Authority shall be subject to the following essential terms and covenants and major conditions, together with such other terms and conditions as A.I.D. may deem appropriate.

4. Source and Origin of Commodities, Nationality of Services.

Commodities financed by A.I.D. under the project shall have their source and origin in the United States or the cooperating country* except as

* Each country in Code 935 in which project activities are conducted is deemed a cooperating country for the purpose of procuring goods and services required for the activity conducted in that country.

A.I.D. may otherwise agree in writing. Except for ocean shipping, the suppliers of commodities or services shall have the United States or the cooperating country as their place of nationality, except as A.I.D. may otherwise agree in writing. Ocean shipping financed by A.I.D. under the project shall, except as A.I.D. may otherwise agree in writing, be financed only on flag vessels of the United States.

No waivers are anticipated at this time.

Name	Office Symbol	Date	Initials
Clearances:			
A. JBSullivan	S&T/EY		
B. JVanderryn	S&T/EN	4/25/89	
C. DSheldon	S&T/PO	4-14-89	(subs)
D. SRTisa	S&T/CP		

Signature

N. C. Brady
Senior Assistant Administrator
for Science and Technology

Date: 5/4/89

AGENCY FOR INTERNATIONAL D LOPMENT

PROJECT DATA SHEET

1. TRANSACTION CODE: A (A = Add, C = Change, D = Delete)

Amendment Number

DOCUMENT CODE: 3

2. COUNTRY/ENTITY: Worldwide

3. PROJECT NUMBER: 936-5737

4. BUREAU/OFFICE: S&T/Office of Energy

5. PROJECT TITLE (maximum 40 characters): Biomass Energy Systems & Technology

6. PROJECT ASSISTANCE COMPLETION DATE (PACD): MM 09 DD 30 YY 96

7. ESTIMATED DATE OF OBLIGATION (Under 'B.' below, enter 1, 2, 3, or 4)

A. Initial FY 89 B. Quarter 4 C. Final FY 96

8. 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						
(Grant)	(2,170)	( )	(2,170)	( )	(15,000)	(15,000)
(Loan)	( )	( )	( )	( )	( )	( )
Other U.S. 1.						
2.						
Host Country Mission Buy-ins					10,000	10,000
Other Donor(s)						
TOTALS	2,170		2,170		25,000	25,000

9. SCHEDULE OF AID FUNDING ($000)

A. APPROPRIATION	B. PRIMARY PURPOSE CODE	C. PRIMARY TECH. CODE 1. Grant	2. Loan	D. OBLIGATIONS TO DATE 1. Grant	2. Loan	E. AMOUNT APPROVED THIS ACTION 1. Grant	2. Loan	F. LIFE OF PROJECT 1. Grant	2. Loan
(1) FN/	740	878		0		15,000		15,000	
(2) PSEE									
(3)									
(4)									
TOTALS						15,000		15,000	

10. SECONDARY TECHNICAL CODES (maximum 5 codes of 3 positions each): 850

11. SECONDARY PURPOSE CODE: 660

12. SPECIAL CONCERNS CODES (maximum 7 codes of 4 positions each)

A. Code

B. Amount

13. PROJECT PURPOSE (maximum 480 characters)

To reduce the technical, financial, economic, and institutional risks associated with biomass energy systems to encourage public and private sector interest (both U.S. and indigenous) to invest in commercially-proven energy conversion systems in target A.I.D. - assisted countries.

14. SCHEDULED EVALUATIONS

Interim MM 09 YY 93 MM YY Final MM 09 YY 96

15. SOURCE/ORIGIN OF GOODS AND SERVICES: ☐ 000 ☒ 941 ☐ Local ☐ Other (Specify)

16. AMENDMENTS/NATURE OF CHANGE PROPOSED (This is page 1 of a ____ page PP Amendment.)

This is a new program that was not originally proposed in the CP for FY 1989.

17. APPROVED BY

Signature: Jack Vanderryn

Title: Agency Director, Energy and Natural Resources

Date Signed: MM 02 DD 14 YY 89

18. DATE DOCUMENT RECEIVED IN AID/W, OR FOR AID/W DOCUMENTS, DATE OF DISTRIBUTION

MM DD YY

UNITED STATES INTERNATIONAL DEVELOPMENT COOPERATION AGENCY
AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D.C. 20523

MEMORANDUM

APR 21 1989

TO: M/SER/OP/W/R, Ed Thomas

FROM: S&T/EN, Jack Vanderryn

SUBJECT: Non-Competitive Award of Cooperative Agreement to Winrock International

I request that you consider only Winrock International for the subject cooperative agreement to: 1) utilize and enhance its resource base in biomass utilization diversification systems developed over past years; 2) expand the level and complexity of its collaboration with public, private, university, and foundation organizations, both U.S. and LDC; and 3) provide assistance to expand successful applications of biomass systems, with particular emphasis on energy systems.

Background: As part of the Office of Energy's ongoing program to encourage the development and use of indigenous, renewable energy resources and to encourage private sector participation in increasing energy availability as project developers and investors, a new project, the Biomass Energy Systems and Technology Project (BEST) has been designed to follow the Bioenergy Systems and Technology Project (BST), PACD for which is September 30, 1989.

During the nine years of the BST project a variety of mechanisms and institutional arrangements were tested for their usefulness and ability to attract and unite the various necessary project elements that must be accommodated during successful biomass energy project research, development, and application. Since the most innovative and financially sound biomass energy conversion systems are held by the private sector, since new and risky financial packaging is required in this arena, and since these projects require complicated participation by various entities from the agriculture sector, it is determined by S&T/EY that the management of the new BEST Project must be supported by an institution with a unique set of legal and operational characteristics in order to maximize the potential for success of the new A.I.D. project.

The characteristics deemed necessary for support of BEST are:

- Specialized expertise in energy systems, agroprocessing industries and post-harvest systems, agricultural and farming systems research, natural resource management (especially in the forestry domain), and a working relationship with the international environmental community.

- Staff with experience in technology and project screening; economic and financial analysis; technical and engineering analysis; project analysis; identification, selection, and monitoring of research activities; information dissemination and public relations; industrial outreach and networking; and investment promotion.

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- Established linkages with foundations; private companies; the academic community; and leading world experts on agriculture, energy, environment, forestry, and natural resource management.

- Commitment to continue expanding agricultural diversification institution under a cooperative agreement with A.I.D.

- Capability to procure private sector firms and private sector goods.

- Capability to manage a Competitive Research Grants Program.

- Ability to enter into and manage cooperative agreements with other institutions.

- Capability to maintain financial records in accordance with U.S. Government regulations.

- Office, library, and conference facilities.

On the basis of these requisites, a search for and an evaluation of various institutional possibilities were conducted by S&T/EY. The following were explored and rejected for the noted reasons:

- Private sector companies, both engineering and management type: Given the profit-making agenda of such companies, it would be difficult if not impossible to maintain the full attention to creation of the new institution required nor would a private company invest its own funds, attract foundation participation, and continue the activity beyond the period of S&T/EY funding. In addition most such companies have a more narrow focus than what is necessary for BEST and few of them have connections to resources in energy, as well as agriculture, environment, etc. Companies that S&T/EY considered included the ones that could be expected to be interested given past involvement in energy issues: Bechtel, EDI, Dames & Moore, Haigler Bailly, and IRG Systems.

- Several U.S. government institutions were also considered as possible recipients of RSSA/PASA type contracts. These included: DOE, the USDA, Oak Ridge National Lab, and the Tennessee Valley Authority. By and large all of these were rejected for one major drawback: inability to enter into flexible relationships with a wide variety of private, public, university, and foundation partners of the type most necessary to develop biomass energy systems potential. USDA, for example, has some highly innovative co-financing mechanisms that are of great interest to S&T/EY. These, however, are focused on what is still the agricultural production sector specifically. The Agency does not have experience with using these mechanisms in energy projects. Oak Ridge does not have adequate private sector experience, nor does TVA. DOE is too narrowly focused on the energy aspects of bioenergy systems.

- Universities themselves were considered as a primary home for the BEST project, particularly Louisiana State University which has both cane and rice expertise. Upon review it was seen that while this expertise is highly valuable to ongoing BEST work, it is also narrowly defined vis-a-vis the full import of BEST project development work. Further, university personnel do not have significant, nor particularly successful, relationships with the private sector of the type necessary to S&T/EY.

In the course of the search Winrock International, known for many interesting and successful endeavors both within and outside the A.I.D. purview, was considered. Beyond the well-documented field project management skills in the F/FRED work and agricultural projects in various A.I.D.-assisted countries, Winrock maintains a unique relationship with the U.S. foundation community and has long standing working relationships with universities both in the U.S. and in the Third World. Given the primary requisite that the new institution be focused on the co-mingling of financial and substantive support from the private sector as well as foundation and university communities, it is especially valuable to note the ongoing access to these universes resident in the Winrock Board of Directors. S&T/EY is especially interested in the emphasis of Winrock on farm systems, agroforestry and rural economic development and the ways in which Winrock has successfully created joint collaboration with the donor community, host country governments and the private philanthropic organizations. Winrock's track record in this area together with its application of this project development style to the post harvest technology arena makes it ideal for supporting S&T/EY in meeting the objectives of the new BEST project.

S&T/EY has determined that Winrock International of Morillton, Arkansas can provide all of the required connections and relationships necessary to the BEST project in effecting the necessary modus vivendi for biomass energy systems. Winrock is evolving in the same direction as that targeted by S&T/EY and is investing its own resources in the process.

The total funding obligation to the BEST Project over a seven-year period is $15,000,000. It is suggested that the cooperative agreement with Winrock be for the seven years of the project. A.I.D. will include in the agreement a possibility for canceling such agreement if that should be recommended in the mid-term evaluation.

Recommendation:

It is for the above reasons that the Office of Energy, the Directorate for Energy and Natural Resources, and the Bureau for Science and Technology recommend that the Office of Procurement award a new seven-year cooperative agreement to Winrock International without consideration of other sources.

Clearance: S&T/EY, James B. Sullivan James B. Sullivan date: 4-20-89
Shirley Toth Shirley Toth date: 4-20-89
S&T/PO, Douglas Sheldon [illegible] date: 4-25-89

[S&T/EY:BAmin-Arsala:mbs:04/19/89:0022T]

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Project Paper

BIOMASS ENERGY SYSTEMS AND TECHNOLOGY PROJECT (BEST)

Project Number 936-5737

Office of Energy
Bureau for Science and Technology
U.S. Agency for International Development
January 1989

Biomass Energy Systems and Technology Project (936-5737)

Project Paper

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BIOMASS ENERGY SYSTEMS AND TECHNOLOGY PROJECT (936-5737)

PROJECT PAPER

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Biomass Energy Systems and Technology Project (936-5737)

Project Paper

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1.0 SUMMARY AND RECOMMENDATIONS

1.1 PROPOSED FUNDING

The Bureau of Science and Technology's Office of Energy (S&T/EY) recommends the authorization of $25 million to fund the Biomass Energy Systems and Technology (BEST) Project, 976-5737. This is a world-wide program designed to encourage adoption of biomass energy systems that utilize readily available crop residues, wood wastes and municipal solid waste to generate productive energy. The project has been designed as a successor to the previously funded Bioenergy Systems and Technology (BST) Project, 936-5709, which will end on September 30, 1989. The S&T Bureau will provide $15 million in core funding for the BEST project with an additional $10 million in buy-ins expected from mission bilateral accounts and regional bureau accounts. The S&T Bureau funding is planned to be incrementally obligated as follow:

FY	SD/FN Funding (000)
89	2,170
90	1,800
91	2,000
92	2,500
93	3,000
94	2,530
95	1,000
Total:	$15,000

1.2 HOST COUNTRY, PRIVATE SECTOR AND COFINANCING CONTRIBUTIONS

It is expected that over the life of project in-kind, host country contributions will be encouraged and are expected to significantly assist in promoting private sector investments in

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innovative commercial bioenergy systems. In addition private sources of funding for pre-feasibility and feasibility analyses and for research will be tapped whenever possible. It is also expected that a number of private U.S. foundations will make contributions to the project during its active life. Finally, BEST project activities are likely to stimulate the obligation of a considerable amount of cofinancing for implementation of actual commercial bioenergy systems from such institutions as the World Bank, International Finance Corporation, Inter-American Development Bank, Caribbean Development Bank, Asian Development Bank, U.S. Ex-Im Bank, U.S. Trade and Development Program, and U.S. Overseas Private Investment Corporation. While a precise forecast of total co-financing to be stimulated from outside A.I.D. cannot be made, it is expected that outside financial investment may total $230 million during the life of the project.

1.3 SUMMARY DESCRIPTION

A.I.D.-assisted developing countries face major difficulties in meeting their burgeoning energy requirements, especially those of their rural economies. Even with declines in world oil prices, most developing countries face staggering demands for expanded energy supplies, particularly in the power sector where demand already exceeds existing generation capacity by over 10 percent. Based on current trends in demand, investment requirements could be as high as $2.6 trillion by the year 2008. This implies investment of more than $125 billion/year as compared to current expenditures of $50-60 billion/year (A.I.D., Power Shortages in Developing Countries, March, 1988).

Opportunities exist for the commercial production of electricity, liquid fuels and other products from the biomass commodities on which many rural areas depend such as sugar cane, rice and forest products. In the case of sugar cane, widely

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fluctuating prices and competition from other sweeteners has severely hampered development and discouraged new investment. National governments have developed few options for rejuvenating agroprocessing industries and have often resorted to subsidies because of the political importance of maintaining these agricultural commodity-based industries. The new BEST project proposes an innovative approach to this complex problem, namely developing energy production systems as one option to speed self-financing, diversification investments for key LDC industries such as sugar, rice and wood. The surplus energy generated as a result of these investments will generally be made available for export to the national grid where it can contribute to helping to meet overall national energy demand. BEST will also investigate the potential of other crops, such as palm oil, and of urban solid wastes as feedstocks for commercial energy production systems.

1.4 GOAL AND PURPOSE

The goal of the BEST project is to increase energy production in A.I.D.-assisted countries and improve natural resource management by using biomass wastes for power and liquid fuel production.

The purpose of BEST is to reduce the technical, financial, economic, and institutional risks associated with biomass energy systems to encourage public and private sector interests (both U.S. and indigenous) to invest in commercially-proven energy conversion systems in target A.I.D.-assisted countries.

1.5 PROJECT DESCRIPTION

The BEST project will undertake country and regional assessments in selected A.I.D.-assisted developing countries in order to identify specific agroprocessing industrial sectors and

specific mills where opportunities exist for implementing profitable diversification investments which can produce energy as a by-product. Such diversification options will be screened at a pre-feasibility and feasibility level of analysis through the BEST project in order to stimulate and catalyze the required private sector capital investments. Based on the experience gained through the predecessor BST project, such opportunities are greatest in the sugar cane, rice and wood processing industries. Such investments when made will help to diversify basic agricultural commodity processing industries into attractive new by-product markets while also helping to displace conventional energy fuels (in many cases imported petroleum) and generating electricity or liquid fuels which can contribute to meeting overall national energy demands. An important element in BEST project activities is the role the project plays to define and broker the investment opportunities identified among plant/mill managers, utility executives, U.S. equipment suppliers, and commercial investors (both U.S. and indigenous). The BEST project will actively seek opportunities to cooperate with the agricultural sector in all of its project activities. A primary focus of BEST is the creation of a multi-funded institution that will provide an infrastructure of support for biomass energy projects and will exist beyond the A.I.D. funding period.

The BEST project will also sponsor limited applied research, undertake general technology analyses, and guide project implementation activities in the field in a variety of countries in order to advance investment interest. Implementation of specific field projects designed to reduce perceived risks and to test working hypotheses will be a key focus, within the overall aim of BEST to create new jobs in rural areas, improve resource management in an environmentally-sound manner, reduce dependence on imported fuels, and create new product markets.

The technologies most relevant to the diversification options to be supported by the BEST project are commercially-proven energy systems that convert biomass to steam/heat, electricity or ethanol. The current BST project is emphasizing two cost-effective technologies, combustion and fermentation, which have been commercially proven in the marketplace. Other biomass utilization technologies still under development or in a non-commercial status in the United States include new types of gas turbines, hydrolysis, gasification, rotary kilns, and fluidized bed combustion. If these are demonstrated during the life of the project to be commercially viable when matched with locally available biomass residue resources, they may also be incorporated into project activities.

1.6 PROJECT IMPLEMENTATION

During the design process S&T/EY concluded that it needed a flexible host organization in order to accommodate the diverse types of activities called for in the BEST project. The implementation plan proposes to fund a cooperative agreement with a private non-profit organization that is committed to agricultural diversification and that can serve as the principal implementing body for the project. The non-profit organization will co-invest in BEST activities, mobilize non-government funding, and manage competitive procurements to select suitable private sector firms capable of providing specialized support services to the project, as agreed on by the non-profit organization and A.I.D.. The non-profit organization will also manage a competitive research grants program.

A number of other complementary cooperative agreements may be executed over the project's life between S&T/EY and selected organizations to provide support for specialized activities not found in either the lead non-profit organization or the private support contractors. To the degree required, additional project

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support will be obtained through agreements with other U.S. government agencies and non-profit organizations, IQC work orders, competitive procurements. The S&T/EY project manager and BEST's core staff will work closely together to ensure the coordinated and effective functioning of these contractual mechanisms.

1.7 SUMMARY FINDINGS

The BEST project is considered economically, administratively, and technically feasible and socially sound. Expected environmental impacts have been carefully reviewed and provisions made for environmental assessments as required under A.I.D. environmental regulations (22 CFR Part 216). The cost estimates are reasonable and all applicable statutory criteria have been met.

2.0 PROJECT RATIONALE

Developing countries must increase the supply of low-cost energy to local consumers in order to expand and diversify their rural and peri-urban economies. In many developing countries power demand already exceeds existing generation capacity by over 10 percent. Based on current trends in demand, investment requirements could be as high as $2.6 trillion by the year 2008 (A.I.D., Power Shortages in Developing Countries, March, 1988). This implies investment of over $125 billion/year as compared with current expenditures of $50- 60 billion/year.

The original BST project was designed to develop ways for using biomass feedstock for energy production. One approach was to develop new biomass feedstock production systems -- fuelwood plantations -- to produce a regular fuel supply for different kinds of energy conversion technologies. This was found to be complicated and uneconomic at that time, especially in view of the alternative approach, which uses "captive" residues that are already available in large quantities at existing mills from existing agriculture and forest production systems. Developing new biomass production systems will only be done commercially if operating plants establish a value for biomass as fuel.

BST project experience demonstrated that the most cost-effective sources of biomass feedstock are these residues found at agricultural or forestry processing plants. The project explored and evaluated the opportunities for commercial production of electricity, liquid fuels and other energy products using biomass feedstocks derived from sugar cane, rice and forest products since these three commodities contribute most to national agricultural economies in A.I.D.-assisted countries. [As shown in attached Figures 2-1 and 2-2 and Tables 2-1, 2-2 and 2-3]. One BST

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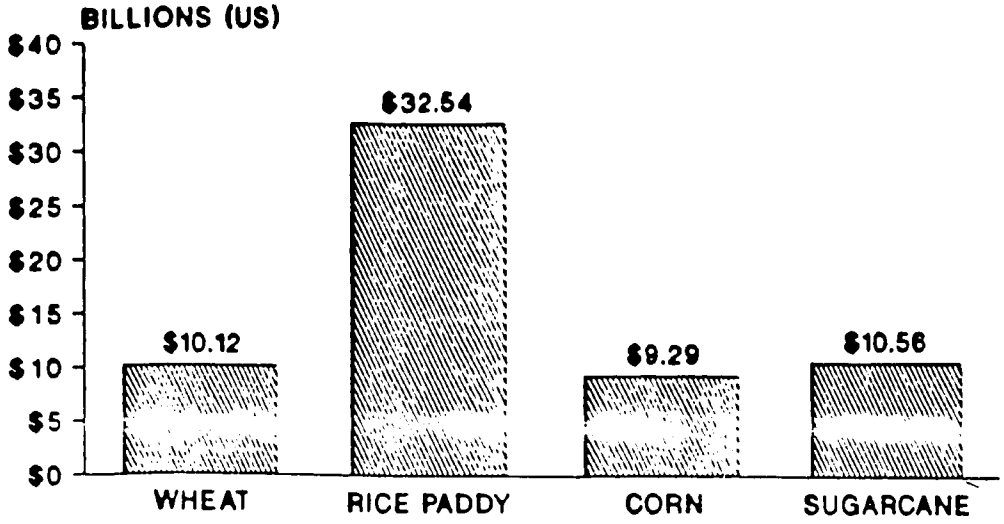
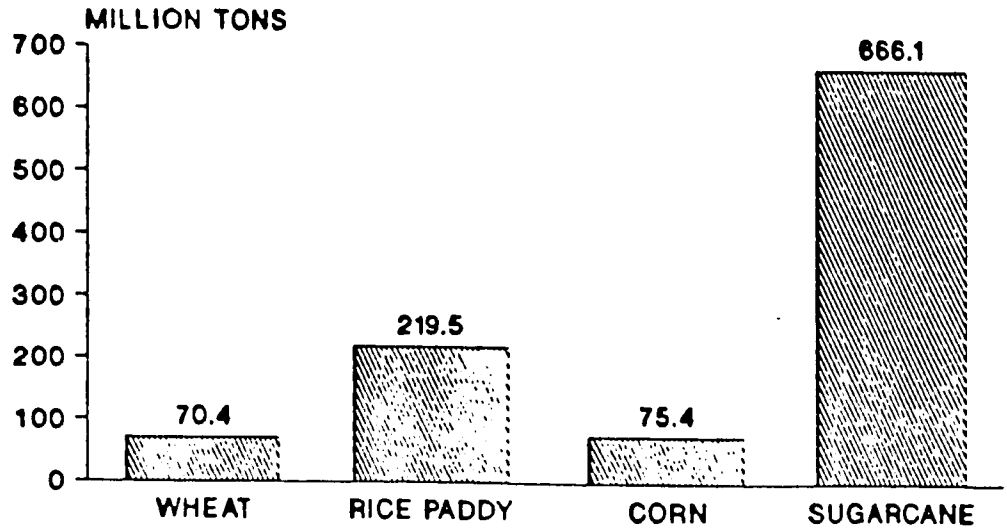
FIGURE 2-1

CROP VALUE IN A.I.D. - ASSISTED COUNTRIES (1984)



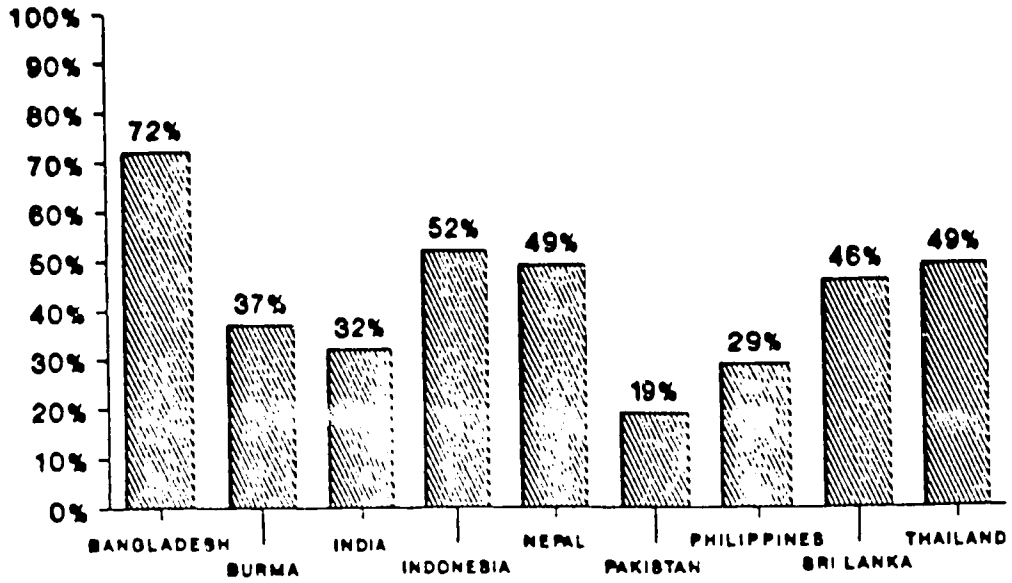
SOURCE: WORLD INDICIES OF AGRICULTURAL AND FOOD PRODUCTION, 1975-84, USDA: ECONOMIC RESEARCH SERVICE, STATISTICAL BULLETIN NUMBER 730

CROP PRODUCTION IN A.I.D. - ASSISTED COUNTRIES (1984)



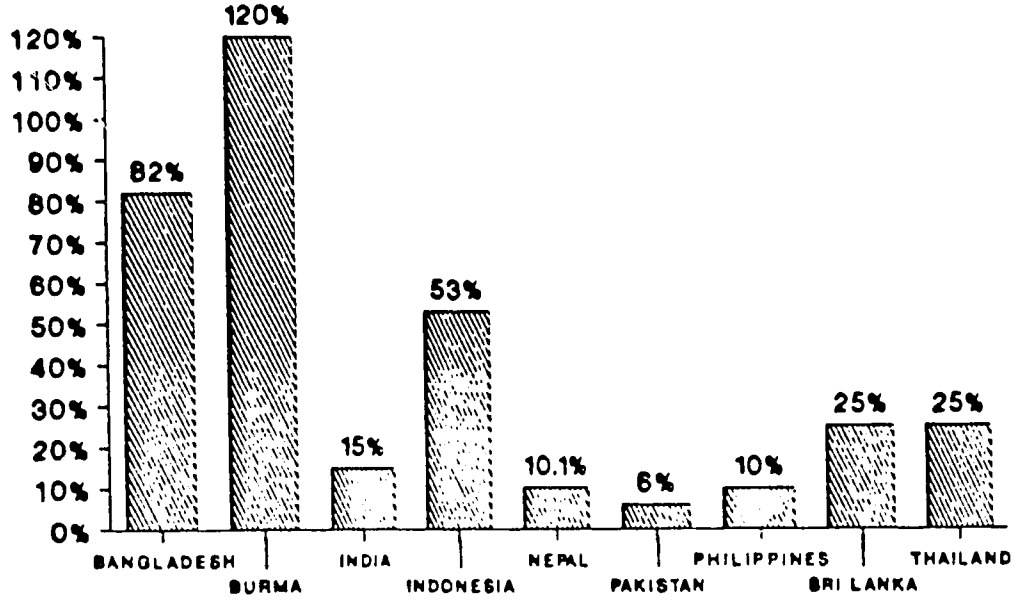
SOURCE: WORLD INDICIES OF AGRICULTURAL AND FOOD PRODUCTION, 1975-84, USDA: ECONOMIC RESEARCH SERVICE, STATISTICAL BULLETIN NUMBER 730

RICE AS % OF TOTAL AGRICULTURAL VALUE (1984)



SOURCE: DERIVED FROM WORLD INDICES OF AGRICULTURAL AND FOOD PRODUCTION, 1975-1984, USDA, ECONOMIC RESEARCH SERVICE, STATISTICAL BULLETIN NUMBER 730

GROSS NATIONAL MW POTENTIAL FROM RICE HUSKS AS % OF REQUIRED MW INCREASE (1982-2000) IN NET INSTALLED ELECTRICITY CAPACITY WITH NO PER CAPITA IMPROVEMENT



SOURCE: BASED ON DATA FROM WORLD DEVELOPMENT REPORT 1985, IBRD; ENERGY BALANCES AND ELECTRICITY PROFILES 1982, UNITED NATIONS; AND MW PRODUCTION/TON OF RICE HUSK ACHIVED BY U.S. BASE CASE PLANT FOR YEAR 1984. (i.e. ONE MW/8,491 TONS)

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Table 2-1

Potential Gas Turbine Capacity with Sugar Cane Residues as Fuel[a]

Region	1985 Cane Production (million tonnes)	Supportable Gas Turbine Capacity[b] [MW(e)]
SOUTH AMERICA	257.37	17,823
Brazil	211.30	14,633
Colombia	13.67	947
Argentina	11.88	823
Peru	7.10	492
Venezuela	4.70	325
ASIA	201.16	13,931
India	70.16	4,859
China	42.50	2,943
Thailand	23.93	1,657
Indonesia	17.05	1,181
Philippines	16.65	1,153
Pakistan	14.10	976
Taiwan	6.90	478
CENTRAL AMERICA	145.34	10,065
Cuba	78.89	5,463
Mexico	34.92	2,418
Panama	9.21	638
Guatemala	5.00	346
AFRICA	70.72	4,897
South Africa	25.40	1,759
Egypt	8.15	564
Mauritius	6.84	474
Zimbabwe	4.56	316
Sudan	4.50	312
Swaziland	3.96	274
Kenya	3.70	256
OCEANIA	38.38	2,658
Australia	34.39	2,382
Fiji	3.67	254
UNITED STATES	28.12	1,947
EUROPE	3.22	223
WORLD	744.31	51,544

a Regional totals include more than the sum for the individual countries shown.

b Based on Ref. 62, assuming a 206-day cane crushing season, factories operating 22 hours per day during the crushing season, gas turbines with performance characteristics of gasifier STIG units based on the LM-5000, and bagasse available from the cane crushing as fuel.

Source: "Aeroderivative Turbines for Stationary Power", by Robert H. Williams and Eric D. Larson, Princeton University, May 1988. (A BST funded research report)

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Table 2-2

Potential Gas Turbine Capacity with Corn Stover as Fuel[a]

Region	1985 Corn Production (million tonnes)	Supportable Gas Turbine Capacity[b] [MW(e)]
NORTH AMERICA	232.58	18,253
United States	225.18	17,673
Canada	7.39	580
ASIA	89.89	7,055
China	64.00	5,023
India	7.80	612
Thailand	5.15	404
Indonesia	4.55	357
Philippines	3.54	278
North Korea	2.30	181
Turkey	1.50	118
EUROPE	72.93	5,724
Romania	14.00	1,099
Soviet Union	13.50	1,060
France	12.30	965
Yugoslavia	9.89	776
Hungary	6.50	510
Italy	6.35	498
Spain	3.21	252
Austria	1.73	136
Greece	1.70	133
Bulgaria	1.50	118
SOUTH AMERICA	32.00	2,511
Brazil	19.00	1,491
Argentina	13.00	1,020
AFRICA	25.47	1,999
South Africa	8.50	667
Egypt	3.70	290
Kenya	2.65	208
Nigeria	2.25	177
Zimbabwe	2.25	177
Tanzania	2.07	162
Malawi	1.50	118
Ethiopia	1.45	114
CENTRAL AMERICA	11.13	874
Mexico	10.00	785
OTHER	15.69	1,232
WORLD	479.69	37,647

a Regional totals include more than the sum for the individual countries shown.

b Assuming 1/2 tonne of stover per tonne of corn (which represents about 2/3 of the total stover), an energy energy content of 15 GJ/tonne of stover, a stover-to-electricity conversion of 33% (HHV), and a 100% capacity factor

Source: "Aeroderivative Turbines for Stationary Power", by Robert H. Williams and Eric D. Larson, Princeton University, May 1988. (A BST funded research report)

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Table 2-3

Potential Gas Turbine Capacity with Rice Husks as Fuel[a]

Region	1983 Rice Production (million tonnes)	Supportable Gas Turbine Capacity[b] [MW(e)]
ASIA	416.74	16,781
China	172.18	6,933
India	90.00	3,624
Indonesia	34.30	1,381
Bangladesh	21.70	874
Thailand	18.54	746
Burma	14.50	584
Vietnam	14.50	584
Japan	12.96	522
Philippines	8.15	328
South Korea	7.61	306
Pakistan	5.21	210
North Korea	5.20	209
Nepal	2.74	110
Sri Lanka	2.20	89
Malaysia	2.00	81
Kampuchea	1.70	68
Iran	1.40	56
Laos	1.00	40
Afghanistan	0.65	26
SOUTH AMERICA	12.13	488
Brazil	7.76	312
Colombia	1.78	72
Peru	0.77	31
Argentina	0.65	26
Venezuela	0.51	20
AFRICA	4.59	185
Egypt	2.44	98
Madagascar	2.15	86
UNITED STATES	4.52	182
EUROPE	4.52	182
Soviet Union	2.50	101
Italy	1.06	43
CENTRAL AMERICA	1.31	53
Mexico	0.66	26
Cuba	0.49	20
OCEANIA	0.52	21
Australia	0.52	21
WORLD	449.83	18,113

a Regional totals include more than the sum for the individual countries shown.

b Assuming 1/4 tonne of husks per tonne of rice, an energy energy content of 14.8 GJ/tonne of husks, a husk-to-electricity conversion efficiency of 33% (HHV), and a 100% capacity factor.

Source: "Aeroderivative Turbines for Stationary Power", by Robert H. Williams and Eric D. Larson, Princeton University, May 1988. (A BST funded research report)

report concluded that electricity production from the sugar cane industry alone using advanced technology could have provided up to 236 billion kWh of power in 1986, equivalent to 20 percent of the total electric utility generating capacity of the developing world at that time (A.I.D., S&T/EY, Cane Energy Symposium, Volume II). BST fieldwork in Jamaica, Honduras, the Philippines, Costa Rica, Malawi, and Thailand showed that biomass systems are also economic. Sugar cane waste fueled power systems in Costa Rica, for example, can produce power at 2-4 cents per kWh which is competitive with current and projected utility production costs (A.I.D., S&T/EY, Electric Power from Sugarcane in Costa Rica, September 1988). Similarly, ethanol from molasses can be produced at 60-75 cents per gallon in Malawi, and used to extend gasoline which costs over $1.15 per gallon before taxes (A.I.D., S&T/EY, Ethanol Options for Malawi, October, 1988).

An evaluation of the BST project that was completed in February, 1988 recommended that the project continue to emphasize the use of agricultural wastes for energy production. A synopsis of the Evaluation Report's findings can be found in Annex H. The evaluation determined that the project was moving in productive directions in its two major components, Cane Energy Systems and the Rice Residue Utilization Program, and that wood combustion should be chosen as the next area of concentration. The evaluation identified some of the important lessons that were learned during the first nine years of the BST project. One important lesson was the realization that institutional factors, such as the type of project sponsor (foreign vs. indigenous) and an understanding of how to obtain project financing, are crucial for project success.

Another important lesson concerned how best to approach technology development. Developing technology without a clear understanding of specific applications and the market in which the technology competes does not yield positive results. One major

example that illustrated this problem was the attempt to develop gasification technology for remote applications, that failed because few commercially-proven gasifiers were available on the market and because certain complexities inherent in gasifier systems created technical problems when matched with biomass feedstocks that were not easily resolved in isolated locations especially when compared to diesel engines, the predominant competing technology in the market.

The new BEST project will continue the emphasis of BST on providing technical assistance to determine least-cost approaches to provide energy and to organize project components, matching commercially-proven technologies to available surplus biomass residues while adapting these energy production systems to meet specific local requirements in target countries. By meeting their energy needs with locally-supplied biomass power, developing countries save foreign exchange, free energy supplies for alternative uses, increase the value of agricultural commodities, and build the revenue base for investments in rural infrastructure. Agro-processing industries have been adversely affected by the depressed state of agricultural markets for their raw products, which has reduced income and limited capital investment. National governments with few options for rejuvenating such industries have increasingly resorted to subsidies to keep them operating. The BEST project provides a solution to this problem by developing energy production as a diversification option for processing industries. Commercial experience in Hawaii where sugar prices are supported by U.S. government policy, shows that net sugar mill revenues can be increased by 5-20 percent, depending on the level of cogeneration energy system investment selected.

It is critical for development projects to generate income and create jobs in rural areas. The agricultural sector in developing countries is evolving from an orientation based on basic commodity

production to one based on multiple higher-value products, thereby making better use of capital and human resources. A recent assessment by the BST project for Costa Rica determined that 2-10 MW cane cogeneration systems can add between $33,000 to $90,000 per mill in direct income to the rural economy each year (A.I.D., S&T/EY, Electric Power from Sugarcane in Costa Rica, September 1988).

As set out in current A.I.D. policy and the Program Plan of the Office of Energy, A.I.D. development projects seek to foster expanded roles for private enterprise and market forces in the development, management and distribution of energy. An increased participation of the private sector in rural economies is an important factor in the potential growth of new rural industries which require capital for their development. Biomass energy systems are an example of an exciting new investment opportunity which can be incorporated into existing rural agricultural sector industry while offering high potential returns on the capital investments required.

The goal of the BEST project is to establish a functional institution for mobilizing varied resources to increase energy production in A.I.D.-assisted countries and improve resource management by using biomass wastes for power and liquid fuel production. The expectation is that by the BEST PACD this institution will be supported by a variety of other participants and that the institution's program will serve the multiple needs and goals of university, government, private sector, and foundations in expanding biomass utilization. The purpose of the project is to reduce the technical, financial, economic, and institutional risks associated with biomass energy systems to encourage private and public interests (both U.S. and indigenous) to invest in commercially proven energy conversion systems in target A.I.D.-assisted countries. To stimulate wider use of

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biomass resources for energy production, the BEST project will offer a wide range of services and technical support to USAID Missions, host governments and private U.S. and indigenous firms including:

- PRE-PROJECT ANALYSIS (macro-screening, definitional missions, project-level pre-feasibility and feasibility studies, country assessments, and technical evaluations)

- PROJECT IMPLEMENTATION (project management, technical assistance, procurement of specialized equipment, conflict resolution, and assistance in obtaining project financing)

- APPLIED RESEARCH ACTIVITIES (field studies and biomass energy system research and design)

- INFORMATION DISSEMINATION AND INSTITUTIONAL SUPPORT ACTIVITIES (technical reports, policy dialogue, information dissemination, newsletters and workshops, training, and networking).

Over the life of the project, these project activities will have the effect of further reducing the technical, financial, economic and institutional risks presently limiting the wider adoption of biomass energy systems in many developing countries.

The project's core staff provided under the cooperative agreement will coordinate these activities through the A.I.D. Science and Technology Bureau's Office of Energy (S&T/EY). In addition to managing project operations, the duties of the core staff are to provide technical assistance, lead field missions, recruit and supervise cooperating institutions and consultants, develop linkages important to project success, identify candidate

projects for implementation, and facilitate private sector involvement. Project staff will also mobilize and coordinate resource networks of the host institution and focus them on the overseas opportunities in A.I.D.-assisted countries.

3.0 PROJECT DESCRIPTION

3.1 BACKGROUND

The Biomass Energy Systems and Technology (BEST) project is a seven year, $25 million follow-on activity ($15 million from S&T/EY and $10 million in Mission buy-ins) to the Bioenergy Systems and Technology (BST) project (#936-5709) which ends on September 30, 1989. The PACD for the BEST project will be September 30, 1995. The BEST project is directed at developing countries in Asia, the Near East, Latin America and the Caribbean, and Africa. The achievements of the BST project are described in greater detail in Annex C and a summary of a recent evaluation's findings concerning the BST project can be found in Annex H.

3.2 GOAL AND PURPOSE

The goal of the BEST project is to increase energy production in A.I.D.-assisted countries and improve natural resource management by using biomass residues (crop residues, wood wastes and municipal solid wastes) for power, gaseous fuel, and liquid fuel production. The purpose of the new BEST project will be to reduce the technical, financial, economic and institutional risks associated with bioenergy systems so that private interests (both U.S. and indigenous) will invest in commercially proven energy conversion systems in A.I.D.-assisted countries. A limited number of public sector projects will be developed where appropriate.

Under the new BEST project A.I.D. will sponsor feasibility and pre-feasibility studies, collaborative R&D, research networking and

field project development activities intended to build upon previous efforts and strong private sector support for biomass systems identified in the BST project. Implementation of specific project activities designed to reduce perceived risks and to test working hypotheses will be a key focus. The primary activity areas are as follows:

- Private sector stimulation - The new project will work with firms active in bioenergy to assess commercial experience, particularly overseas, in order to identify and eliminate key barriers to trade and investment. One key focus will be analysis and implementation of ways to divide and share risk among energy project participants. Another focus will be the identification of successful innovations developed by the U.S. private sector but not yet introduced internationally. The BEST project will work closely with the new S&T/EY PSED project to promote private sector involvement and investment in bioenergy systems in LDCs.

- Policy dialogue - The project will examine key energy and agriculture policy constraints to investment in bioenergy systems, especially crop residue utilization, least cost planning, utility contracting, forest management and private sector policies. The BEST project will relate to the ongoing S&T/EY EPDAC project on key policy issues and the BEST project will establish an Advisory Council to manage forestry policy and environmental issues associated with wood waste bioenergy projects. The BEST project will also actively develop and disseminate information to policy markers on the environmental impacts and benefits of biomass energy projects.

- Research - The project will fund priority applied research both in the field and in the U.S. through a competitive research grants program to reduce technical risks to the private sector associated with potential investments and to keep abreast of the potential impact of new technologies. PASAS with USDA, TVA and DOE will be used to help structure, guide and manage these applied research activities and also to conduct research where specialized capabilities have been developed by the U.S. government.

- Technical Assistance - The project's core staff will manage the services of specialists provided by a competitively selected contractor or through other contractual means to assess the technical, financial and economic feasibility of bioenergy systems in various LDC applications and to facilitate implementation.

- Pre-Investment Project Planning - The project's core staff will coordinate activities with lending, trade and development promotion, and investment organizations already identified as interested in including bioenergy systems in their project portfolios.

- Information - The project's core staff and contractor will collect, prepare and disseminate information on successful systems and new technical developments that affect planning for future systems.

Through the new project, A.I.D. can catalyze the private sector to invest in successful use of residues for the production of energy and other by-products to revitalize agricultural subsectors, create new jobs in rural areas, improve resource management in an environmentally sound manner, reduce dependence on imported fuels,

and create new product markets. Investments will be facilitated by identification of the full range of project risks, recognition of constraints preventing implementation, working with key actors to reduce and/or remove constraints, helping U.S. private firms to work with developing country private and public sectors, resolving conflicts by providing unbiased analysis, and matching financial instruments and institutions with attractive project opportunities.

3.3 IMPLEMENTATION STRATEGY AND PLAN

The BEST project will operate from a non-profit organization mutually committed to innovation in biomass systems. Project activities will be implemented primarily through a cooperative agreement with this non-profit organization. The organization will also manage competitive procurements of equipment and specialized services needed to carry out project activities and will manage a competitive research grants program for BEST. The non-profit organization will also enter into agreements with universities and other research institutions as appropriate.

During the project design process S&T/EY determined that a need for flexibility in accessing contractual processes existed in order to effectively implement the diverse types of project activities called for under BEST. In addition, one of the lessons learned during the predecessor BST project is that to achieve maximum effectiveness in its investment stimulation processes and field trials of emerging biomass energy production systems, the project must possess the organizational capability to cost-share development of innovative technologies with private companies, and be able to receive private foundation support as well as U.S. Government and other donor funds, and in-kind contributions from host country governments. The BEST project core organization must also maintain a mechanism for performing feasibility studies of proposed bioenergy system investments on a cost-sharing basis with

other S&T/EY projects such as the Private Sector Energy Development Project (936-5738), other S&T/EY projects such as EPDAC and REAT as appropriate, and private U.S. and indigenous firms. Given the context within which biomass energy activity is successful, the non-profit organization must also have extensive experience with agricultural systems.

During the past five years of project development under the Bioenergy Systems and Technology Project (BST) staff of BST have learned that the development of successful biomass energy systems requires creative combination of elements. Projects require a new set of relationships between and among government developers and private companies which permit joint funding of research, development, and project implementation elements. Biomass energy projects utilizing agricultural and forestry processing wastes, such as sugar cane bagasse, rice husk/straw, and wood, generally also produce additional non-energy by-products which have markets in the agricultural economy. These by-products can be significant importance to the financial/economic viability of the overall projects. At the same time, however, they necessitate the participation of non-energy partners. The institutional structure from within which biomass energy projects are to be developed must be one that has a mandate for this full range of products and participants. Even more importantly, the melding of funds to ensure risk reduction at the various stages of research and development can only be executed by an institution which is legally constituted to do these things and which has proven experience in this mixing of funds related to farm systems, agroforestry and rural development.

Biomass energy systems are rightfully a part of the "Post-Harvest System." Until quite recently the agricultural community itself held a narrow view of what this system encompasses. Increasingly, however, agricultural specialists are realizing that

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a wide range of options exists for increasing agricultural benefits during the post-harvest phase. These options which include the classical items such as better storage and transportation also include high-value processing, energy production from wastes, and by-product development and marketing. Private companies have been leading innovators in these areas and often own rights to proprietary processes. The BEST project intends to place itself in the center of this newly evolving network of ideas, institutions, and possibilities to maximize the potential of biomass energy systems' contribution to rural development in A.I.D.-assisted countries.

After a careful review of the capabilities of various institutions, government agencies and private firms, S&T/EY has decided on the following implementation strategy:

- A cooperative agreement with a non-profit organization or institute with an ongoing commitment to biomass utilization systems and with specialized expertise in integrated renewable resource use, agricultural and farming systems research, and agroindustrial/biomass energy systems. This organization would have primary responsibility for creating a supportive environment for the BEST project. It would provide: core staff; identification of candidate projects for implementation; management of specialized technical analysis; project administrative services; technical expertise in agroprocessing industries and biomass energy production systems; linkages with foundations, private companies, and government agencies (via Memoranda of Understanding as required or through other means); and office, library and conference facilities.

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- Competitively procured private sector firm or firms obtained under the non-profit organization's Cooperative Agreement to provide specialized support services including: access to permanent professional staff with suitable skills, specialized technical analysis, and financial analysis and packaging services.

- A number of other specialized cooperative agreements or Memoranda of Understanding (MOU) between A.I.D.'s S&T/EY and selected organizations will also be executed to obtain specialized expertise not possessed by either the private non-profit organization or the private support contractor. Likely cooperators include: TVA's Biomass Branch, TVA's Forestry Division, USDA's Agricultural Experiment Stations, the Resource Development Foundation, and the Hawaiian Sugar Planters Association. Justifications will be prepared prior to contracting with these organizations when required. A.I.D. may prefer to establish these relationships directly. In this case they will be managed by the non-profit once they are in place.

- A Competitive Research Grant Program will be used to focus on applied research investigations targeted as key risk areas in the project development process. The core organization will design, execute and manage this program.

- Any BEST project needs not met through the contractual mechanisms described above will be met through other means including: S&T/EY IQC work orders, and open competitive procurements if necessary.

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Given the complex nature of the proposed work under the BEST Project, the administrative entity required for the new BEST Project must have several specific charateristics. First all, S&T/EY is convinced that the core unit for the project must reside with a non-profit organization. Since a primary objective will be the mingling of public, private, and foundation monies, it is inappropriate to expect a profit-making organization to manage such an activity successfully. Resources to be mobilized under the BEST Project must not be biased by staff having any agenda other than the one at hand.

Second, the new parent organization for BEST must be willing to accommodate the historical memory on biomass energy system development which evolved over a ten year period beginning in 1979. Beyond a transitional period the non-profit organization in consultation with the S&T/EY Project Manager will develop an appropriate staffing plan that will maintain this historical memory.

The Cooperative Agreement partner must also have a proven track record in these very important areas:

- the management of U.S. government competitive procurements;
- the management of competitive research grants programs;
- overseas field project management;
- strong sectoral experience in the agriculture systems of both the U.S. and the developing world;
- established and wide access to top leadership of public, private, university, and philanthropic organizations.

Throughout the contractual process efforts will be made to obtain significant involvement by Gray amendment firms and Historically Black Colleges and Universities (HBCU's).

Besides strengthening the linkages with foundations, private companies and other organizations the core staff of the BEST project will be required to carry out and/or manage the following functions: economic and financial analysis; technical and engineering analysis; project analysis; identification, selection and monitoring of research activities; information dissemination and public relations; industrial outreach and networking; and investment promotion. Additional staff functions may be required as the project develops.

As shown in Figure 3-1, the BEST project's component activities will be managed and directed by the private non-profit organization which will: supply the project's core staff functions, perform administrative and budgeting functions, identify and organize candidate projects for implementation, develop linkages and networks with other organizations (foundations, private companies, U.S. government agencies and host country agencies), manage specialized technical and economic/financial analyses of candidate projects, administer a competitive research grants program, and maintain all project financial and other records. The selected private non-profit organization will be assisted by competitively procured private firms which will supply supporting specialized services in technical and financial areas.

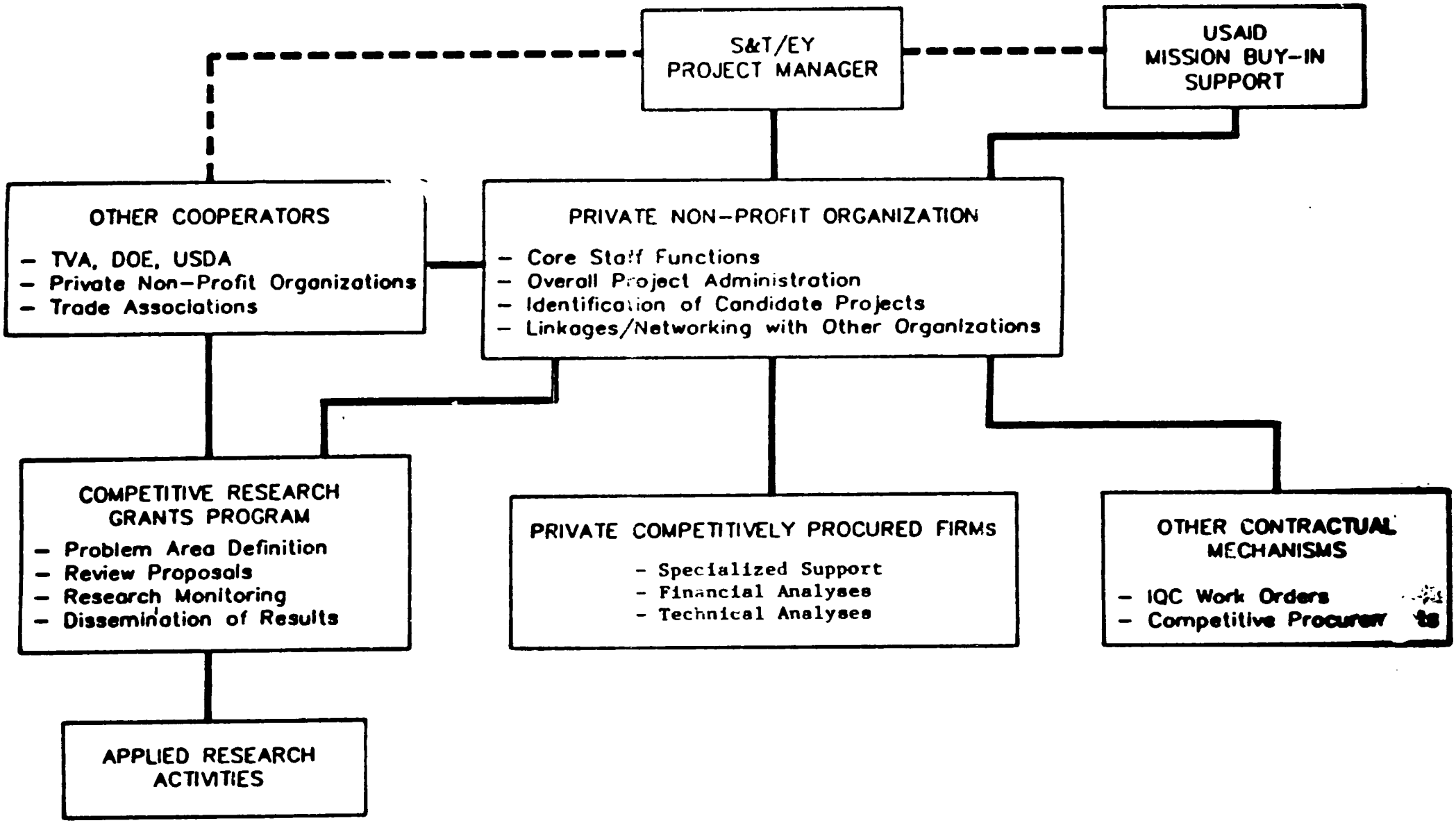

FIGURE 3-1
BEST PROJECT ORGANIZATIONAL STRUCTURE

The private non-profit organization will also administer cooperative agreements and other contractual mechanisms required to carry out project activities, work closely with USAID field Missions, and receive Mission buy-in funds for implementation of project activities.

The S&T/EY project manager will be responsible for the coordinated and effective functioning of these contractual mechanisms by working closely with the Project Director and core staff members to ensure development of a close working relationship among all project elements. To ensure effective project initiation, accountability and planning, S&T/EY's assigned project manager will receive a detailed annual work plan within the first month of the new BEST project and will chair project review meetings every six months over the life of the project. The BEST project's core staff will also be responsible for regular and frequent communication and coordination.

3.4 COST ESTIMATE AND FINANCIAL PLAN

The BEST project's activities will result in specific outputs such as country assessments, pre-feasibility and feasibility studies, research and implementation activities, workshops, conferences and newsletters. An estimate of the costs incurred to the project of producing these outputs in the first year is shown in the attached Table 3-1. This program plan summary also includes expected Mission buy-in funds and funds expected to be available from other sources. The figures in Table 3-1 also include salaries and administrative costs in addition to other project costs. A further detailed model budget for obligation levels during the first fully funded year of the BEST project in FY90 is shown in Table 3-2. Figures are based on available core S&T/EY funds and expected Mission buy-in levels.

Table 3-3 is a presentation of the annual obligations and expenditures programmed by S&T/EY for the life of the project totaling $15 million, broken down by year and major budget category. It also includes an estimated $10 million in USAID Mission buy-ins over the life of the project. S&T/EY core funds will be used to support all project activities while buy-ins will generally support specific field projects for implementation and specialized technical analyses and applied research for specific countries or projects.

The level of Mission buy-ins which has been projected to total $10 million over the life of the project, is not unreasonable given the level of Mission interest expressed to date. For FY89 slated buy-in levels include: Thailand - $115,000; Pakistan - $100,000; India - $100,000; and Costa Rica - $200,000 for a total of $500,000 in buy-in activity expected. Several of these Missions have indicated their interest in providing additional funding via the buy-in mechanism over the life of the BEST project. In addition, the following Missions have expressed interest in considering funding of BEST project activities in their countries through buy-ins during the life of the new project: the Philippines, Indonesia, Egypt, Morocco, Malawi, Dominican Republic, Jamaica, Sudan and Kenya. Mission documents supporting the projected level of buy-in activity expected during FY89 are contained in Annex L. Because the BST project could not routinely accept buy-in funds until very recently, written documentation of projected buy-in commitments by specific Missions for FY89 has been limited. Nevertheless a high level of Mission interest has been expressed and funding commitments are expected as soon as the new BEST project is authorized.

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3.5 EVALUATION PLAN

The BEST project will have two regularly scheduled evaluations over the life of the project. An evaluation budget has been included in the indicative project budget. The mid-term evaluation, to be conducted at the beginning of the project's third year, will address basic issues related to whether the project is being implemented as designed. This evaluation will occur early enough in BEST's implementation that corrective actions can be taken to re-orient project activities as warranted by the evaluation's results.

The mid-term evaluation will also review the efficiency of the core administrative mechanism to determine whether this form of project management is meeting the requirements of BEST as laid out in the Project Paper.

The final evaluation will take place eight to twelve months after the scheduled project completion date of September 30, 1995. It will determine what has been accomplished during the project both in terms of lessons learned and recommendations for future actions. It will analyze the sustainability and replicability of activities initiated under the project and determine what future A.I.D. roles or actions are appropriate.

A major reason for delaying the final evaluation so long after the PACD is to be able to better gauge the level of secondary investment in bioenergy systems stimulated by the BEST project. The principal focus of BEST project activities is to reduce the level of risk and uncertainty surrounding potential investments in bioenergy systems to stimulate investment. This will be the primary focus of the initial evaluation along with assessing the performance of the project mechanisms for implementation. Ultimate success of the BEST project can be measured by these investments

as well as by the actual impact of such investments in practical terms (i.e. additional megawatts of power production from biomass feedstocks; additional levels of rural income and jobs created; and amount of leveraged funding for applied research). To assist in tracking accomplishments, the BEST project will monitor the ongoing status of actual field projects which the project helps to bring to development through pre-feasibility and feasibility level analysis. This information, to be collected on a periodic basis, will be factored into the preparation of annual BEST project work plans as well as the evaluation reports.

Evaluations will be the responsibility of S&T/EY. Cooperating institutions, contractors, participating Missions, regional bureaus and host country governments are expected to participate in the evaluations as required. The evaluation teams should be composed of the following individuals: at least one A.I.D. energy planner or economist (possibly from one of the Regional Bureaus); one agricultural economist with extensive experience in and understanding of bioenergy systems; one energy engineer/agricultural engineer familiar with the technologies used in the bioenergy systems being developed through the project; one financial analyst/investment specialist knowledgeable of investment conditions in LDC's for small and medium-scale power systems; and one specialist in organizational dynamics and institutional relations. Specific questions to be addressed in the mid-term and final evaluations are listed in Annex K.

As discussed in the project implementation section, S&T/EY's assigned project manager will regularly evaluate BEST project activities. Annual work plans will be prepared and submitted by BEST's core staff to S&T/EY and project review meetings will be held every six months or as warranted over the life of the project to review the status of project activities. Annual internal reviews will be made by S&T/EY to assess project progress, and

these will serve as a basis to guide the development of successive year work plans.

The following table indicates expected year one project costs by specific components.

TABLE 3-1
COSTS OF PROJECT FIRST YEAR OUTPUTS (FY89)

Output	Total S&T/EY Core Funding ($000)	Mission Buy-ins Projected ($000)	Other Financing [Private Cost-Sharing,S&T/EY Projects,other] ($000)	Total Cost ($000)
I. Target Project Implementation				
A. Costa Rica Cane Energy	200	200	-	400
B. Thailand Cane Energy	180	115	-	295
C. Cost-shared Feasibility Study (Costa Rica or Thailand)	150	-	150	300
II. Potential Project Identification				
A. Cane/Rice/Wood residue power production potential analyses in selected countries	500	200	-	700
B. Organize Agri-Energy roundtable meetings	60	-	-	60
C. Site-specific Cost-shared Feasibility Study in another selected country	160	-	150	310
III. Applied Research Activities				
A. Collection/Storage of cane trash for combustion in powerplant boilers and bagasse drying/storage	245	-	-	245
B. Biomass combustion and ethanol production technologies	105	-	-	105

TABLE 3-1 (Cont'd)
COSTS OF PROJECT FIRST YEAR OUTPUTS (FY89)

IV. Institutional Development				
A. Creation and implementation of new mechanisms for private/ public partnership in funding research, development and commercialization of biomass energy systems	190	-	250	440
V. Information Dissemination				
A. Production/Dissemination of 3 Bioenergy Systems Reports	70	-	-	70
B. Production/Dissemination of 10 Bioenergy Reports or other Topical Materials	100	-	-	100
VI. Networking/Outreach Activities				
A. Develop Industrial Outreach Program	30	-	-	30
B. ISSCT Meeting participants' support	100	-	-	100
C. Develop user-friendly computer programs to assist in in analyses and selection of technically, financially and economically sound private cane energy power projects	40	-	-	40
D. Establish Advisory Committee to select sustainable, ecologically sound, commercial wood waste energy projects	40	-	-	40
TOTAL	2,170	515	550	3,235

The following table gives a model breakdown budget for FY 90 by basic cost categories.

TABLE 3-2
MODEL BUDGET BREAKDOWN (FY90)

			SOURCE OF FINANCING	
			Central	Mission
I.	Salaries of Core staff		$600,000	(200,000)
II.	Travel and Transportation		$100,000	(200,000)
III.	Office Management and Support		$200,000	
	A. Rent	50,000		
	B. Printing and Reproduction	40,000		
	C. Supplies and Materials	10,000		
	D. Equipment	5,000		
	E. Communications	30,000		
	F. Courier, Postage and Shipping	15,000		
	G. Management of Contract and Agreements	50,000		
IV.	Other Costs		$900,000	(1,600,000)
	A. Research	300,000		(300,000)
	B. Pre-Project Analysis	200,000		(1,000,000)
	C. Project Implementation	300,000		(300,000)
	D. Information	100,000		
			---	---
			---	---
	Total Financing		$1,800,000	(2,000,000)

Table 3.3 gives the same categorical budget breakdown for the life project.

TABLE 3-3
SEVEN YEAR PROGRAMMING PROJECT

	FY 89		FY 90		FY 91		FY 92		FY 93		FY 94		FY 95		FY 96*	
	OBL.	EXP.	OBL.	EXP.	OBL.	EXP.	OBL.	EXP.	OBL.	EXP.	OBL.	EXP.	OBL.	EXP.	OBL.	EXP.
I. Salaries	0.6	0.3	0.6	0.6	0.5	0.6	0.6	0.7	0.7	0.7	0.7	0.6	--	0.6	--	--
II. Travel & Transportation	0.27	0.2	0.1	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.4	0.3	--	0.2	--	--
III. Office Management	0.2	0.1	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	--	0.1	--	--
IV. Other Costs	1.1	0.6	0.9	1.3	1.05	1.85	1.4	1.9	1.8	1.9	1.06	0.9	1.0	0.6	--	--
V. Project Evaluation	--	--	--	--	0.15	0.15	--	--	--	--	0.17	--	--	--	--	**0.17**
Total (I-V)	2.17	1.2	1.8	2.3	2.0	3.1	2.5	3.1	3.0	3.1	2.53	2.0	1.0	1.5	--	**0.17**
Expect USAID Mission Buy-ins (Millions of Dollars)		0.5		2.0		2.0		2.0		2.0		1.0		0.5		--

*Final evaluation to take place 8 to 12 months after September 30, 1995.

4.0 PROJECT ACTIVITIES

4.1 APPLIED RESEARCH

The project will fund priority research both in the field and in the U.S. to help reduce the technical and economic risks associated with biomass energy systems and thereby increase the confidence of potential investors. Research is also intended to incorporate into the project any new technological advances in related energy systems or improvements in particular system components. The overall research strategy to be pursued through the BEST project will be to fund practical problem-solving research which will materially contribute to accelerating the adoption of biomass energy systems and thereby have an impact on development.

The administration of the BEST project's research activities will be through cooperation with ongoing research at other institutions and through a competitive research grant program. Appropriate topics for research will be determined by the needs of field projects and advertised annually along with criteria for selection. BEST will support applied research on specific subjects which tend to further advance the broader adoption of commercial biomass energy systems such as those utilizing cane, rice and wood residues. Some guidelines for selection of priority research topics and evaluation of proposals are contained in Annex G.

BEST will sponsor research in priority technical areas based on the previous BST project's experience. For example, some BST research funds are now being used in support of cane energy projects in Jamaica and Thailand. A more detailed account of current BST research projects can be found in Annex C. This research has focused on: (1) development of specialized field

equipment for collection and storage of cane field trash (tops and leaves) for off-season use as a boiler fuel, and; (2) research into adaptation of existing advanced combustion systems for use with biomass residues. The BEST project will primarily fund research related to the development of field projects in selected developing countries, and will attempt to incorporate research findings in ongoing projects.

At the outset of the BEST project a research advisory committee will be formed to help establish, oversee and administer the competitive research grants program. The members of this committee will be drawn from institutions and organizations knowledgeable of biomass energy systems and agroprocessing industries but without a direct financial interest in the research to be supported by the BEST project. Their role will be to monitor and participate as required with: research problem area definition, issuance of notices of grant availability to the research community, review of proposals received, selection of research proposals, budget allocation, research monitoring and dissemination of results. Allocation of research funds to specific applied research activities will only be made with the concurrence of the S&T/EY project manager. Cumulative funding of applied research over the life of the BEST project through this competitive research grants program will be limited to a fixed percentage of total core S&T/EY project funds and individual research grants will fall within a ceiling amount. These levels will be jointly set by the S&T/EY project manager and the BEST Project Director.

4.2 PRE-PROJECT ANALYSIS

The BEST project will provide technical assistance to assess the technical, social, financial, environmental and economic aspects of using biomass energy systems in various applications. Model field projects will, prior to implementation, undergo a

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process of analysis through BEST that will include macro-screening, country assessments, pre-feasibility and feasibility studies, and assistance in obtaining project financing. BEST will use a sectoral approach, comparing energy activities with other options in a particular sector of the economy.

The BEST project will initially define potential projects by undertaking macro-screening of large-scale issues in the agricultural subsector. The following issues might be raised at this stage of the analysis: What is the nature and extent of available biomass residues utilizable for energy conversion and what constraints to their use exist (i.e. seasonal availability, traditional uses, etc.)? What are the alternative and potentially competing uses for the waste residues? Are there other existing energy production systems that would compete with biomass energy? Is there any assurance that the local power company will purchase energy from a secondary source such as a sugar-processing mill? Is a biomass energy system a sustainable resource management option? What are the environmental implications associated with the proposed projects and specific country settings? How will a proposed BEST project activity work within the larger economic framework of the agricultural sector of a country (i.e. analyze production costs, comparative advantage, subsidies and import policies, etc.)?

Once the macro-screening process is accomplished, high-potential countries can be selected for more complete country and/or regional assessments which will determine whether further, detailed pre-feasibility or feasibility investigations are necessary and/or warranted. Often, countries will make a specific request to BEST to undertake an assessment or a specific feasibility study. After the feasibility stage, BEST will attempt to coordinate activities among donor agencies, multilateral lending institutions, private banks and other organizations interested in

including biomass energy systems in their project portfolios. Environmental Assessments consistent with USAID regulations will be incorporated into project analyses in a comprehensive manner.

The BEST project will work with U.S. and host country firms that have already demonstrated commercial biomass energy systems or a viable interest in such systems, and attempt to identify and eliminate key barriers to trade and investment such as transfer pricing arrangements. One key focus will be analysis and implementation of ways to divide and share risk among energy project participants.

BEST will guide the U.S. and A.I.D.-assisted countries' private sectors in evaluating alternative investments in biomass energy systems. Investments will be facilitated by identification of the full range of a proposed activity's risks, recognition of constraints preventing implementation, working with key actors to reduce and/or remove constraints, helping U.S. private firms to work with developing country private and public sectors, and matching financial instruments and institutions with attractive project opportunities.

4.3 PROJECT IMPLEMENTATION

The role of BEST in project implementation activities will be to support field activities by extending technical assistance, supplying prototype equipment, and assisting in locating and securing financing. As identified in the recent evaluations of the BST project, there is a need for greater attention to be paid to project finance in implementing biomass energy systems. The BEST project will become more active in bridging sources of project finance with indigenous project sponsors who are not familiar with the requirements and mechanisms associated with the range of public and private sources of project finance or equity investment. In

addition, the project will increase the participation of U.S. private sector firms in its activities.

The BEST project will focus its project implementation activities in areas where country assessments have already identified high-potential projects that are appropriate for BEST. Establishment of a project implementation mechanism that facilitates USAID Mission buy-ins will allow the BEST project to manage projects that are co-financed with Mission program funds. This mechanism will leverage the potential effectiveness and reach of the S&T Bureau's core funding for this project. Project implementation is the most important new component in the transition from BST to BEST, and the degree of activity in this area will partially depend on the level of interest among individual USAID Missions or initiation of new and complementary Mission projects.

The BEST project will take a proactive position regarding the assessment of potential negative environmental impacts resulting from its field project implementation. All proposed field projects will be scrutinized from an environmental assessment point of view and key issues such as sustainability, soil conservation and maintenance, and other pertinent issues such as air pollution impacts will be addressed. Environmental monitoring of BEST field implementation projects over an extended time period will be incorporated wherever feasible so as to establish a data base from which more conclusive environmental assessments can be developed. Such monitoring activities may be funded through the competitive research grants program as appropriate. This will ultimately yield valuable information which can be used by the scientific and policy-making community to inform future decisions concerning implementation of bioenergy systems.

For field activities in which BEST is not directly involved in implementation, short-term and intermittent extension-type support will be provided. Typical extension activities include: providing project managers and/or technical specialists with critical technical information to help resolve conflicts, advising system technicians on equipment trouble-shooting, and keeping key managers and technicians informed regularly of research advances and new applications. Dissemination of information to ongoing projects of "lessons learned" and the experiences of others working with particular types of biomass energy systems is a very important part of the proposed BEST project implementation activities.

4.4 PROPOSED FORESTRY ACTIVITIES

Forests, which are undoubtedly the most valuable biomass resource base in many A.I.D.-assisted countries, are seriously threatened due to the lack of effective forestry management policies and de facto economic incentives which promote deforestation or forest degradation. The resulting local, regional and global ecological impacts are increasingly serious and extend into many facets of global life. Therefore, the BEST project proposes to approach cautiously and within an environmentally sound framework the development of wood-fired and wood waste fueled bioenergy systems. Given the massive pattern of tropical forest destruction occurring in many A.I.D.-assisted LDC's due to agricultural land clearance, road-building, commercial forestry activities, and other forms of unchecked development, the complete environmental implications of any proposed additional wood or wood waste utilization schemes must be carefully scrutinized to ensure that only sustainable end uses and practices are encouraged.

The BEST project will investigate opportunities that exist in many A.I.D.-assisted LDCs to utilize wood wastes at existing timber processing industries (i.e. lumber mills, plywood factories, etc.).

These "captive" wood wastes, already discarded by existing industries, are an attractive development option using wood waste as a fuel for on-site power generation. For example, wood waste represents up to 50 percent of the total amount of raw lumber that enters a plywood factory studied in Indonesia. At present these wood wastes are typically piled in heaps and burned, used for land fill or dumped in rivers and the ocean in many developing countries. These wastes constitute a potential energy resource for on-site power generation.

Important environmental issues must be addressed at each stage of feasibility analyses for wood energy projects. Direct project-related environmental issues will be examined before proceeding to recommend BEST project funding of or support to such projects in A.I.D.-assisted countries. In order to ensure that wood energy projects to be supported are in fact sustainable, ecologically sound and commercially viable, the BEST project will establish an advisory committee to adequately review such considerations before project activities proceed further.

The proposed wood energy projects advisory committee will be composed of competent forest ecologists, foresters, conservation/protected area specialists, commercial timber product specialists, and wood energy system engineers. The initial task of this advisory committee will be to identify model wood energy projects that are sustainable and environmentally sound while offering suitable commercial potential. For example, the BST project prepared a Pre-feasibility Assessment of the potential of wood waste power systems for the Indonesian wood products industry (A.I.D., BST, November 1988) which identified sufficient stocks of unutilized wood waste at Indonesian sawmills and plywood factories to power 1,000 MWe of distributed small stream power plants for base- and intermediate- load power production. Once the BEST project begins, such projects will have to be endorsed by the

advisory committee before being further developed for actual implementation. In the final analysis, a proposed wood energy project must be acceptable environmentally and contribute to enhanced forestry management practices to be found acceptable for project support.

In developing its wood energy initiatives, the BEST project will draw upon the experiences gained through other S&T/FENR forestry projects and natural resource management activities. Innovative integrated approaches may offer new potential to simultaneously advance a number of complementary objectives. For example, establishment of working forests as buffer zones around protected natural areas (i.e. national parks or areas of high biological diversity) may be a valuable way of diminishing the pressures of agricultural encroachment into protected ecological areas. A "working forest" concept centered on management of existing forests or on short rotation tree plantations which yield forest products and wood wastes for energy production, may ultimately be more effective in promoting sustainable management of critical ecological areas requiring protection. These concepts have been discussed by the BST project with local conservation organizations, USAID Missions and commercial forestry interests in Costa Rica, Indonesia and Peru.

4.5 INFORMATION DISSEMINATION AND INSTITUTIONAL SUPPORT ACTIVITIES

Since biomass energy systems are a relatively new concept, it is essential that the project's information dissemination and institutional support activities work toward achieving a consistent and rationalized approach in the development of biomass energy systems. The BEST project will examine energy and agriculture policy constraints to investment in biomass energy systems, especially pricing and private sector policies. Because of the growing environmental concerns in A.I.D.-assisted countries, the

BEST project will devote attention in project information dissemination activities to highlighting environmental impacts and benefits of biomass energy systems. The BST project has already addressed a variety of key policy issues and institutional constraints during its preliminary consultations or country assessments so that the BEST project can focus on institutional support activities to relieve these constraints.

As documented in A.I.D.'s recent report to Congress, one of the important issues in energy development is the inability of the public sector to provide enough financing to meet growing demand for energy in developing countries ("Power Shortages in Developing Countries", March, 1988). BEST will promote further dialogue between the government, local and U.S. private sector sponsors as part of its pre-feasibility and feasibility studies. Promoting such dialogue requires constant facilitation of information flow between and among all participants involved in project development. BEST will also promote the adoption of national and local policies which help to ease or minimize existing constraints such as the lack of precedents in many countries for sales of electricity by private companies to utilities, which represents a major barrier to electric generation using biomass or other fuel sources. BEST will also continue to provide USAID Missions with information and resources they need to carry out policy dialogue with the government on biomass-related renewable energy matters (For example, supplying information on municipal solid waste to energy systems and a discussion of key technical and socioeconomic issues involved).

The project will collect, prepare and disseminate information on successful systems and new technical developments that affect planning of future systems, both through newsletters as well as published reports. Both host-country officials in A.I.D.-assisted countries and USAID Missions will be provided information on

research and development advances in practical application of biomass energy systems. Newsletters may also be distributed to U.S. equipment suppliers and project developers.

Networking is another important activity that can support interaction among the relevant institutions, private sector firms, government agencies and other donors. Participating in or sponsoring workshops is an effective way to bring together people with similar interests who can build relationships that may result in future successful project collaborations, with or without further input from BEST. Training activities will be included and coordinated with other S&T/EY and Mission training projects.

4.6 ACHIEVEMENTS AND ACCOMPLISHMENTS

The principal accomplishments of the BEST project will be the establishment of biomass energy systems in target A.I.D.-assisted countries. This will occur as actual biomass energy systems are developed, constructed and become operational in these countries. However, it should be recognized that BEST project activities may assist or support the process of developing such field projects at various stages in their implementation through such means as: assisting in establishment of a viable institutional and regulatory climate for investment in such facilities by private agro-processors; carrying out of prefeasibility or feasibility level studies; mobilizing private investors, equipment suppliers and sources of project finance; support for technical adaptations or innovations through applied research; and provision of specialized technical assistance. While A.I.D. funds will not be used to support a single project in every facet from conception to operation, the BEST project will share in the responsibility for successful start-up of biomass energy systems, even for those whose operations commence after the project's scheduled completion date.

Activities of the project will be organized under the four components described previously:

- Pre-Project Analysis;
- Project Implementation; and
- Applied Research Activities;
- Information Dissemination and Institutional Support Activities.

Successful accomplishment of these project activities should result in the following achievements, based on an assumption that a number of 2-25 MW biomass power plants (or energy-equivalent biomass conversion processes) are brought on stream either during the life of the project or will be on stream during an acceptable future time frame after the PACD. Project accomplishments should be measured at the final evaluation by the following achievements:

- The participation of private investment funds in biomass energy system ventures will increase. It is expected that $30 million of private capital will be invested in biomass power generation in target A.I.D.-assisted countries by both local and U.S. investors.

- Additional sources of public capital will be invested in biomass energy systems. Financial institutions, especially the Multilateral Development Banks, will make available over $200 million in project investment funds for biomass energy systems.

- Institutional structures or policy changes will be in place in developing countries that will facilitate continued investment in biomass energy systems.

- Additional rural income and increased employment will result from adoption of biomass energy. These income and employment effects will provide an incentive for LDC governments to adopt policies and formulate a regulatory environment that makes continued investment in biomass energy systems attractive to investors.

- Additional sources of research funds will be made available as the result of A.I.D. seed funding. It is expected that each dollar of BEST funding spent on applied research and biomass energy production system adaptive design will result in mobilization of an additional ten dollars in additional non-BEST funding that will be allocated for the development of biomass technologies and for technical improvements of existing systems.

- Additional energy supplies are created using indigenous fuels. It is expected that BEST will contribute to the creation of 150 MW of electricity generation capacity by power plants fueled with biomass residues.

4.7 CONSTRAINTS TO MORE WIDESPREAD USE OF BIOMASS ENERGY SYSTEMS

A number of practical constraints to the more widespread use of biomass resources for energy production exist in A.I.D.-assisted developing countries. Many of these have already been discussed

elsewhere in this project paper and its annexes. To summarize, the key constraints retarding broader adoption of bioenergy systems in LDCs are:

- o institutional constraints that limit acceptance of biomass energy production systems (i.e. lack of standard utility power sales agreements from private power producers);

- o financial and psychological constraints that limit investor interest in what are perceived as risky or unproven ventures;

- o limited knowledge of capabilities of and potential for bioenergy systems in LDCs;

- o lack of broadly disseminated, commercially available, LDC-proven technologies for biomass energy production systems;

- o lack of a clearly developed U.S. equipment supply industry or unified trade association to promote U.S. and indigenous private investor interest in commercially viable bioenergy production systems;

- o inability of bioenergy system projects to fit neatly into existing agency relationships and within sectoral boundaries; and

- o national economic and financial policies that inhibit investment in private power systems.

Through the BST project and biomass energy related components of other centrally-funded and Mission-funded projects, A.I.D. has

supported the development of commercial biomass energy systems using a variety of residue feedstocks. The BST project has undertaken sugar cane residues to energy country assessments in Costa Rica, Honduras, Jamaica, Thailand, the Philippines, Mauritius, Swaziland, Zimbabwe, Malawi, and Zambia. Rice residue energy potential has been studied in the Philippines, Indonesia, and Thailand. Wood residues have been examined in Indonesia and a wood-fired gasifier/engine/generator set field-tested in Costa Rica. Recently a report was prepared on energy production from urban solid wastes. These studies have documented the opportunities to develop biomass energy systems in developing countries as well as revealing the institutional and other constraints facing the broader implementation of such systems. The BEST project's proposed activities will help to systematically address these constraints in target countries receiving A.I.D. assistance.

5.0 RELATIONSHIPS WITH OTHER PROGRAMS, POLICIES, AND ACTIVITIES

5.1 RELATIONSHIPS TO THE AID ENERGY STRATEGY

As documented in A.I.D.'s FY 1989 Congressional Presentation, the Agency's energy programs are "specifically designed to help developing countries establish appropriate pricing and investment policies to stimulate the exploitation of domestic energy resources and the efficient use and production of all energy supplies whether imported or produced domestically." (A.I.D. Congressional Presentation, FY 1989, Main Volume, p. 103).

A.I.D. has provided nearly $1 billion in assistance for the energy sectors of selected developing countries over the past five years. A.I.D.'s basic approach to energy development conforms with the Agency's strategic plan, "Blueprint for Development", which identifies four major components of development activities: (1) policy dialogue, (2) institutional development, (3) technology research, development and transfer, and (4) reliance on the private sector and market forces.

The BEST project will contribute to policy dialogue by working closely with host government agencies and officials and USAID Missions in the field, encouraging host country policymakers to undertake the economic and policy reforms necessary so that biomass energy systems can be introduced into the energy sector where appropriate. Secondly, BEST will help to strengthen local institutions through training, technical assistance and information dissemination activities like workshops and newsletters which expand the base of knowledge of programs in biomass energy systems. Third, BEST will support technology transfer and applied research in priority technical areas associated with the implementation of biomass energy systems. Fourth, BEST will facilitate private

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sector participation in development by assisting U.S. and indigenous investors and equipment manufacturers in identifying and establishing commercially viable projects.

A.I.D.'s program support in the energy sector emphasizes increased energy efficiency. Part of this strategy is to attract private investment in energy supply systems to complement the strained and limited financial resources of central governments. The BEST project offers an approach to expand production of indigenous energy resources in agricultural processing and industrial subsectors traditionally unconnected with energy supply.

Realization of the purpose of the BEST project will result in a substantial increase in the amount of privately-financed energy generated at the local level. An average sugar mill, for example, can double, triple or even quadruple its existing power production, depending on the level of investment made. Since these new energy supplies will be made available in rural agricultural production areas, the benefits will be all the more valuable. For these reasons the new BEST project is clearly consistent with the current development strategy and energy programs of A.I.D.

5.2 RELATIONSHIP TO THE S&T BUREAU CPSS

The energy programs of the Energy Office of the Science & Technology Bureau are designed to help ensure that adequate supplies of energy are made available for economic growth by helping to alleviate underlying structural problems that inhibit energy development. S&T/EY projects also provide technical assistance to present and potential energy producers and suppliers in LDCs. Specific assistance activities are designed to: promote policy reform particularly with regard to energy prices and incentives for private investment; expand the role of the private sector in development, management and distribution of energy

supplies (including: conservation, fossil fuels, electric power and renewable energy resources); and to expand the availability of energy for rural and household needs.

S&T/EY energy projects support the objectives of developing new approaches to energy problems through research and adaptation of commercially-proven technologies applicable to LDC settings. The various elements of S&T/EY's energy program concentrate on activities to develop indigenous energy sources to substitute for imported or domestic conventional fuels and traditional fuels such as charcoal and fuelwood; to increase efficiency in existing energy systems; and to help LDCs make wise energy production systems choices and investment decisions. A prerequisite for sound energy development and investment decision-making is accurate and properly presented information about available options and the consequences of choosing specific options for investment purposes. The BEST project supports each of these programmatic objectives of the Office of Energy of A.I.D.

In particular, the BEST project will interact closely with S&T/EY's new Private Sector Energy Development Project (PSED #936-5738). While that project will focus on promoting private sector power development in LDC's, it is only concerned with possible development of bioenergy production systems as one among many power supply options to help meet the electricity shortfall in most A.I.D.-assisted LDC's. The BEST project will support and complement a number of other ongoing A.I.D. projects in addition to the PSED project including: Renewable Energy Applications and Training project (REAT #936-5730), Energy Policy Development and Conservation project (EPDAC #936-5728), Energy Training project (ETP #936-5734), the Conventional Energy Technical Assistance project (CETA #936-5724), and the Forestry/Fuelwood Research and Development project (F/FRED) and the Forestry Support project. Other relevant projects are agricultural diversification projects

and private enterprise development projects being carried out at the Mission level.

Throughout its proposed project activities, the BEST project will maintain strong linkages with the S&T/AGR Division and its ongoing project activities. While the BEST project does not propose to fund agricultural projects directly, it should be recognized that successful bioenergy production systems utilizing agricultural residues usually provide a range of complementary benefits to agroprocessing industries. These can include by-products such as animal feed, agricultural chemicals and fertilizer which enhance overall returns to investment in these projects. Therefore, it is important to view bioenergy projects from a systemic agricultural sector perspective and utilize existing expertise in or capabilities of S&T/AGR staff and projects whenever possible.

The BEST project will also take into account and incorporate whenever possible the agricultural sector strategies being adopted by the A.I.D. regional bureaus. This will allow BEST project activities to complement ongoing sectoral policy emphases which A.I.D.'s regional bureaus and country Missions will be implementing.

5.3 RELATIONSHIP TO OTHER AGENCIES AND DONORS

A major orientation of the BEST project is to encourage the involvement of other local agencies and donors in the financial and institutional support of biomass energy systems and technology. One major purpose of the networking activities of the project is to disseminate information to potential project sponsors concerning the existing procedures for obtaining financing from U.S. financial institutions, multilateral development banks, and other sources of project finance.

The BEST project will collaborate on a regular basis with the U.S. Trade and Development Program (TDP) and other organizations such as the Overseas Private Investment Corporation (OPIC), the Export-Import Bank of the United States (EXIMBANK), and other multilateral organizations which have complementary objectives such as the International Finance Corporation (IFC).

Numerous multilateral and bilateral donor projects focussed on various aspects of biomass energy systems in LDCs exist. In addition, many of these institutions have demonstrated a willingness to become involved in either co-financing or making loans to interested host country governments and private investors to advance the development of specific bioenergy system projects. Based on the experience gained through the BST project it is reasonable to expect a high degree of donor interest in actual field project activities developed through the pre-feasibility and feasibility level of analysis by the BEST project. The activities of the BEST project are likely to be crucial in stimulating a high level of co-financing and equity loans or investment on the part of other donors in actual bioenergy production system investment opportunities in selected A.I.D.-assisted developing countries. For example, as a result of the recently completed BST Costa Rica Cane Energy Study the Inter-American Development Bank is considering financial support to the Costa Rica cane industry.

The BST project actively participated in several donor coordination fora concerning bioenergy systems. For example, BST played an active role in activities of the Producer Gas Roundtable. This donor coordination group, recently renamed the Biomass Energy Roundtable (BERT), is widely acknowledged as an effective forum for promoting donor coordination and co-financing of biomass energy projects. Its member organizations include: the World Bank, FAO, UNDP, CIDA, JICA, and all of the European donor community.

In the private sector, BEST will continue to expand on the good working relationships that have been established with U.S. private firms during the BST project activities. Such firms include Cameco Industries, PRM Energy Systems, Agrilectric Power Partners, Ltd., Bechtel National, Inc., and Stone and Webster. Other organizations such as the Agri-Energy Roundtable will also be supported.

The BEST project will continue to coordinate different agencies and parties as required for implementation of specific model field projects. In the case of the cane energy project in Thailand which began under BST, the parties involved included: Electricity Generating Authority of Thailand (EGAT), the public utility; USAID/Bangkok; a privately-owned and operated sugar mill; the Government of Thailand's Office of Cane and Sugar Board; and the sugar cane growers surrounding the mill.

6.0 SUMMARY OF PROJECT ANALYSIS

6.1 TECHNICAL ANALYSIS

As described in greater detail elsewhere in this project paper and in Annex C, the BEST project represents a logical extension and continuation of activities carried out over the last nine years by the predecessor BST project. Drawing on available experience and commercial technology in the United States, the BST project gradually explored LDC market niches for biomass fueled energy production systems. The refinement and evolution of BST project activities reflects a convergence in three principal areas: sugar cane, rice and wood residue energy systems, both for electric power and for ethanol.

Designation of these three areas for intensive attention and investment of BST project efforts and funds resulted from previous explorations of other alternative feedstocks, conversion systems, and LDC country settings over a considerable time period. Sugar, rice and wood processing plants often operate at a scale where they generate significant volumes of "captive" feedstock in the form of biomass wastes. These agroindustrial concerns have extensive and usually costly energy needs which can be met by on-site power/heat generation. Available plant technical personnel can operate new cogeneration equipment and financial/capital investment requirements can usually be handled by the parent company. These mills have the added advantage of being located in rural areas so that excess power production can be fed to the national grid or local users. Increased energy availability in these rural areas creates new jobs, produces new income sources, and stimulates broader economic activities in areas where it is badly needed.

These benefits are of importance to both A.I.D. and developing countries.

Cane, rice and wood residues are targeted by the BEST project because these crops or commodities are often the most significant in developing countries assisted by A.I.D., either in terms of volume produced or product value. The BEST project draws upon years of successful U.S. experience with bioenergy systems research, development and application. This experience, detailed at greater length in Annex C, spans sugar cane electric power production in Hawaii, rice husk fired power plants in Louisiana and Arkansas, and a diversity of biomass-fueled cogeneration systems in California. There is also considerable U.S. experience in production of alcohol from biomass and other innovative biomass to energy conversion systems. In summary, the demonstrated activities of the BST project in A.I.D.-assisted developing countries has lain a sound technical foundation for undertaking the new BEST project.

6.2 SOCIAL SOUNDNESS ANALYSIS

In general, BEST project activities will be focused in agrarian-based rural economies where latent energy demand is high and economic development is dependent, among other factors, on increasing available supplies of energy. The lack of adequate supplies of electricity and other forms of energy in rural areas of many A.I.D.-assisted countries has significantly limited the social development of these regions. Social services such as health and education have tended to be underdeveloped and more limited, due in part to lack of adequate rural electricity supplies.

The developing countries best suited for biomass energy systems are those in which agricultural production generates large amounts of post-harvest wastes. Productive use of agricultural

residues can generate income and jobs for both direct and indirect beneficiaries in the local economy. For example, by using processing waste for energy production, the real cost to the processor of the agricultural commodity which has been purchased for transformation is decreased. Accordingly, this cost saving effectively increases the value of the agro-industrial residues, and both farmers and processors directly benefit from the increased income which accrues to the industry.

The utilization of agricultural residues for energy generation also contributes to the creation of new employment and extends periods of employment of seasonal laborers. An indirect benefit of this more efficient use of raw materials goes to the local agricultural producers in the form of more stable and often higher prices for their basic agricultural commodities. Politically, national governments may gain from improved rural economies which in turn help to stem rural to urban migration patterns.

Therefore, the primary beneficiaries of successfully implemented biomass energy systems at the local level include farmers, seasonal laborers, small-scale industries, mechanics and other skilled workers, and local entrepreneurs. Secondary beneficiaries will exist in all of the communities affected by installation of new biomass energy systems including those who will benefit from the new supplies of electricity or liquid/gaseous fuel, those whose economic well-being is enhanced by the multiplier effects of increased income made available within rural economies, and those who will benefit from secondary economic demands which result from the increase in economic activity associated with biomass energy systems. Providing additional supplies of power locally in rural areas at affordable prices will tend to support current efforts to promote microenterprise development, much of it dependent on small electrical appliances or other machinery. As women tend to be involved in many of these small-scale

manufacturing or service enterprises, the successful development of this project will likely have a positive effect on the status of women in those rural areas where biomass energy systems are adopted which produce surplus electricity available for local use.

Each pre-feasibility or feasibility level project analysis conducted by BEST will consider socio-cultural and socio-economic issues as a part of its overall technical and economic analysis. In terms of the sustainability of actual projects, biomass energy systems are generally self-financing and economically viable over the life of the capital equipment purchased. Depending upon the type of biomass energy system to be implemented, the system can often then be replicated in other locations with small modifications to account for differences in local conditions.

6.3 ECONOMIC AND FINANCIAL ANALYSIS

The primary contribution of this project will be improvement in agricultural and natural resource management and increasing local energy supplies through support to organizations, institutions and other private and public entities that are attempting to design and implement biomass energy systems to achieve their goals. The project will accomplish this by expanding host country institutional capabilities and by facilitating participation of U.S. technical specialists in the design and implementation of projects in appropriate developing country settings.

Some types of biomass energy systems will replace or substitute for other current sources of commercial fuels (i.e. electric rice mills, diesel-fueled mills, etc). Therefore, considerable potential savings in substitution of biomass residue-derived energy for other currently available commercial fuels or electricity will occur in many countries. This has immediate

economic benefits for the enterprises adopting these systems as well as generally making available greater supplies of these energy forms for other users. Many biomass energy systems also produce substantial surplus supplies of electricity that are exportable to the grid or available for local rural uses.

The project will also seek to mobilize private and public sector capital, equipment and human resources for projects that will create jobs directly in rural areas through development of biomass energy production systems. This will also have secondary economic impacts in terms of income, job creation, lower energy costs, and industrial development. In addition, scarce foreign exchange can accumulate through savings that are a result of increased use of indigenous energy production systems.

By stimulating and encouraging private sector involvement and investment, BEST will have a strong leveraging effect in promoting private investment in biomass energy systems in developing countries. It will also generate strong indirect economic benefits that will result from the installation of such systems on local energy supplies and the ancillary secondary economic benefits of expanded energy supplies.

6.4 ADMINISTRATIVE ANALYSIS

Implementation of the BEST project as proposed will not have any unusual requirements for A.I.D. administrative support capabilities. An expanded Administrative Analysis can be found in Annex E. The BEST project will be managed by S&T/EY, which will provide centralized project supervision and a mechanism for dissemination and interpretation of project results as needed in the broader A.I.D. policy and programming process. The Project Director and core project staff for the BEST project will report to the A.I.D. project manager appointed by the Office of Energy.

The BEST project as proposed will affect Mission workloads and may possibly affect staffing requirements. However, this will likely be minimized since the core staff and consultants will have considerable experience at operating within the A.I.D. administrative system. Project support services on the part of participating Missions are generally expected to be minimal. It is expected that this project can be successfully implemented and managed given present staffing levels within S&T/EY.

6.5 ENVIRONMENTAL ANALYSIS

Based on an Initial Environmental Examination (IEE) that analyzed project activities carried out under the BST project and the range of proposed BEST project activities, it appears that the majority of project activities proposed by the BEST project will not produce significant harmful effects on the environment. This would include BEST's analyses, studies, workshops, meetings, applied research, technical assistance, training and information dissemination activities. However, since the BEST project proposes to expand its activities in actual project implementation in the field analysis of project-related environmental considerations will be incorporated into the feasibility-level study of specific model field project activities to ensure that no adverse environmental impacts or irretrievable commitments of resources resulting from expenditures of A.I.D. funds occurs. In particular instances Environmental Assessments of proposed projects will be developed as per A.I.D. environmental regulations (22 CFR Part 216).

The expansion of electric power production in developing countries has the potential to produce significant environmental damage. Projections of power supply expansion indicate that large increases in hydropower and steam thermal facilities (mainly coal) are likely. Large-scale hydropower plants often require the

relocation of sizeable populations and alterations of river basin ecosystems. Coal-fired power generation has historically been associated with emissions of particulate materials, sulfur dioxide, oxides of nitrogen and other pollutants. However, the biomass energy production systems being encouraged through BEST project activities generally produce net environmental benefits or at least acceptable levels of negative environmental impacts when compared with other conventional types of power generation systems.

Most of the biomass energy production systems proposed for feasibility level analysis through BEST project activities and eventual investment as private power production schemes utilize efficient cogeneration equipment. These boilers and turbogenerators can be fueled with biomass feedstocks such as sugar cane bagasse and may also be fueled with supplemental boiler fuels such as No. 6 Fuel Oil (Bunker Oil). Emissions from bagasse boilers contain particulates, nitrogen oxides and, when oil is fired, sulfur dioxide. No sulphur is present in bagasse. Standard control technologies are available to control air emissions, especially of particulates and many of the new, fuel-conserving cogeneration units feature flue gas scrubbers or cyclones which tend to greatly minimize air emissions. Based on analysis available to date, most off-the-shelf commercial cogeneration systems will operate within acceptable environmental regulatory limits for air emissions (particulate emission standards), wastewater effluents (total suspended solids, oil and grease, and free available chlorine), and solid waste (flyash, bottom ash and wastewater treatment sludge) as established by U.S. and state laws.

At the present time the management of underutilized or unutilized agricultural residues by the agricultural processing industries in many developing countries often creates negative environmental situations. Under current practices in most countries residues that accumulate at processing facilities or that

are left in the fields are inefficiently burned or dumped in water bodies such as rivers. These present disposal practices may have serious negative environmental impacts resulting in high levels of localized air pollution or deoxygenation of surface water bodies. In some areas smoke produced in residue-burning areas has been documented as the source of traffic accidents (Gariboldi, International Agricultural Forum, Geneva, Switzerland, May 1988).

Careful analysis of possible negative environmental impacts associated with more widespread use of agricultural processing wastes as energy feedstocks indicates that the types of agricultural residues targeted by the BEST Project, namely sugarcane bagasse/field trash and rice husks, combined with the selected conversion technologies, do not generally produce significant harmful effects on the environment. This includes consideration of the specific agronomic impacts associated with residue removal from fields, possible air pollution impacts, and any unintended socioeconomic or sociocultural impacts on alternative consumers of the residues. For example, in Indonesia, it was discovered that even in areas with the greatest use of rice husks, no more than 10 percent is useful in other markets. New high-yielding crop varieties, while producing less biomass residue per plant, produce much more residue per hectare than traditional varieties. Over time these excess field residues are creating larger and larger disposal problems. Attempts to plow under all of this matter results in water percolation problems beneath the soil or are frustrated by farmers' lack of funds for reapplication to fields. (Gariboldi, International Agricultural Forum, Geneva, Switzerland, May 1988).

Similarly, while analysis of possible wood residue and urban solid waste energy utilization projects in the IEE shows that certain types of these projects can have negative environmental impacts, there should be no significant harmful effects on the environment resulting from the BEST project since the types of

projects being supported by BEST will focus on use of captive mill wood residues and environmentally beneficial landfill gas projects. Use of residues from forest management will only take place after consensus has been reached with environmental and conservation experts on the sustainability of the activity. In the event that these types of projects are developed further through the BEST project, environmental analysis will be incorporated into their pre-feasibility and feasibility-level assessments.

The IEE attached in Annex F provides the basis for a conclusion that the BEST project will have a negative threshold decision and thus does not require a full-fledged Environmental Assessment. However, as small-scale field energy projects are considered for implementation through the BEST project's activities during its seven year life, environmental considerations will be incorporated into the pre-feasibility and feasibility level analyses. If particular projects will be of a class or scale or occur in environmentally sensitive locations, further environmental analysis will be undertaken, including Environmental Assessments as required.

ANNEX A

LOGICAL FRAMEWORK

ANNEX A - LOGICAL FRAMEWORK

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	ASSUMPTIONS
GOAL			
To increase energy production and improve resource management in developing countries through the use of biomass wastes for power and liquid fuel production.	Increased utilization of biomass energy systems in developing countries and increased involvement of private interests in such systems.	• A.I.D. reports • World Bank reports on trends in use of biomass energy systems • Professional journals • Host Country reports • Private Sector studies/reports	1. Developing countries continue to increase demand for energy. 2. Biomass wastes are available in sufficient quantities for fuel use.
PURPOSE	**END OF PROJECT STATUS**		
To reduce the technical, financial, economic, and institutional risks associated with biomass energy systems to encourage public and private sector interests (both U.S. and indigenous) to invest in commercially-proven energy conversion systems in target A.I.D. - assisted countries.	• Private sponsors invest $30m in biomass energy systems ventures. • Financial institutions provide $200m for biomass energy systems. • $25m in leveraged research funding • Institutional structures in place to foster expanded investment in biomass energy systems. • Additional rural income and jobs created. • Energy systems using biomass residue as fuel add 150 MW to planned energy production.	• Office of Energy reports • USAID Mission reports • BEST reports and newsletter • Dollar investment levels in biomass energy systems by public and private sector. • Host Country investments • Private Sector investments • Multilateral Development Bank Investments	1. Developing countries' energy policies accommodate bioenergy systems and facilitate private sector participation. 2. Private sector investment in biomass energy systems results in biomass systems that are technically and economically feasible.
OUTPUTS			
APPLIED RESEARCH • Field Studies • Biomass Energy System Design PRE-PROJECT ANALYSIS • Macro-screening • Micro-screening • Definitional Missions • Country Assessments • Pre-feasibility and feasibility studies • Technical evaluations PROJECT IMPLEMENTATION • Assistance in obtaining project financing • Technical Assistance • Procurement of equipment INFORMATION DISSEMINATION AND INSTITUTIONAL SUPPORT ACTIVITIES • Technical Reports • Newsletters • Conference, workshops, symposiums, and training • Networking	• 10 research activities • 10 country assessments • 12 prefeasibility studies • 10 feasibility studies • 15 project implementation activities • 15 workshops • 10 quarterly newsletters • 2 evaluations	• Project reports • Field visits/trip reports • BEST office reports and memos • Evaluation reports	1. Developing countries and donor agencies actively support research and development of biomass energy systems and technology. 2. USAID Missions participation in BEST activities.
INPUTS			
1. A.I.D. funding 2. Mission buy-ins 3. Core professional staff 4. Outside technical assistance 5. Equipment	$15,000,000 (FY89 to FY94) in core S&T Bureau funds and $10,000,000 of possible Mission buy-ins for a total project of $25,000,000	• Vouchers • Programming budget • Evaluation reports	1. USAID Mission buy-ins.

ANNEX B

IMPLEMENTATION SCHEDULE

ANNEX B - IMPLEMENTATION SCHEDULE

1.	Project Paper Reviewed by Sector Council	Jan. 11, 1989
2.	Congressional Notification Prepared	Jan. 13, 1989
3.	PIO/T Prepared and RFP Drafted	Feb. 3, 1989
4.	Final Draft of PIO/T and RFP to Contracts Officer (M/SER/OP)	Feb. 17, 1989
5.	Prepare CBD Notice for RFP	Feb. 17, 1989
6.	Justification for Cooperative Agreement Prepared	Feb. 17, 1989
7.	CBD Announcement of RFP	Mar. 3, 1989
8.	Establishment of Technical Review Panel	Feb. 17, 1989
9.	Closing Date for proposal Submission	Apr. 4, 1989
10.	Cooperative Agreement executed with Private Non-Profit Institution	Apr. 7, 1989
11.	Review/Evaluation of Proposals	Apr. 10, 1989
12.	Contract Price Analysis	Apr. 24, 1989
13.	Contract Negotiation	May 8, 1989
14.	Contract Signed	May 22, 1989
15.	Other Cooperative Agreements/Memoranda of Understanding Established	September 1989 (and as needed)
16.	Mid-term Evaluation	January 1991
17.	Project Activity Completion Date	September 1995
18.	Final Evaluation	May-September 1996

ANNEX C

TECHNICAL ANALYSIS

ANNNEX C: Technical Analysis

BIOMASS ENERGY SYSTEMS AND TECHNOLOGY PROJECT (BEST)

SYNOPSIS

I. BACKGROUND

A. Traditional View of Biomass Energy
B. The New A.I.D. Approach to Biomass Energy

II. RATIONALE FOR BEST PROJECT FOCUS

A. Sugar Cane
B. Rice
C. Wood
D. The Energy Context

III. U.S. EXPERIENCE AND TECHNICAL CAPABILITIES

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Electricity Production and Sale to Utilities
Bagasse Dryers
Energy Efficiency at Sugar Factories
Louisiana
Puerto Rico
"Energy Cane"
Baling and Combustion of Cane Tops and Leaves
B. California Private Biomass Power Experience
Utility Contracting
Contractual Development
Electricity Prices and Payments for Alternative Energy Projects
Biomass Generating Facilities and other Alternative Energy Projects
C. Utilization of Rice Residues for Energy
Louisiana
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TVA Agrirefinery
USDA - Stabilization of Rice Bran for Commercial Oil Production
D. Production of Alcohol from Biomass
Background
U.S. Experience
E. Production of Electricity and Process Heat from Wood Residues
Forest Products Industry
Wood-Fired Base Load Power Plants
Short Rotation Tree Plantations

IV. BST TECHNICAL EXPERIENCE WITH FIELD APPLICATION OF BIOENERGY SYSTEMS

A. Electricity from Sugar Cane Residues
Costa Rica
Thailand

Jamaica
Philippines
Mauritius

B. Alcohol from Sugar Cane and Molasses
Honduras - Fuel Alcohol Production
Philippines - Sugar Industry Diversification
Malawi - Ethanol Expansion Feasibility
Future A.I.D. Role

C. Electricity and Process Heat from Rice Residues
India
Indonesia
Philippines

D. Electricity and Process Heat from Wood Residues
Indonesia
Costa Rica

V. RESULTS OF BST PROJECT ECONOMIC AND FINANCIAL ANALYSES

A. Cane Energy Systems - The Example of Costa Rica
B. Energy from Rice Residues - The Example of Indonesia
C. Energy from Wood Residues - The Example of Indonesia

VI. BST PROJECT RESEARCH INITIATIVES

A. Development of Off-Season Fuels for Sugar Mills
Bagasse Drying and Storage
Field Residue Collection Program
Development and Testing of Cameco Equipment
Testing and Adaptation of Ford New Holland Equipment
Field Trials in Jamaica
Thailand: Trial Year - Nong Yai Sugar Mill

B. Energy Efficiency in Sugar Factories
C. Advanced Biomass Conversion Systems
Steam Injected Gas Turbine (STIG) Cogeneration for the Cane Sugar Industry
Matching Biomass Gasifiers with STIG Units

VII. BST PROJECT INFORMATION GENERATION AND DISSEMINATION

A. Bioenergy Systems Report (BSR) Series
B. Technical Reports
C. Conferences, Meetings, and Workshops
Brazil Charcoal Seminar
Philippines Workshop
Support for Biomass Users Network (BUN) Meetings
Cane Energy Workshop in Hawaii
Workshop on Contracting for Private Power in Hawaii and California
Cairo International Biogas Conference
Cane Rice Energy Opportunities for the Philippines, Agri-Energy Roundtable
Rice Residue Utilization Technology Convocation: International Market Prospects for U.S. Industry

SYNOPSIS

The Biomass Energy Systems and Technology Project (BEST) is a new Agency for International Development initiative designed to follow the work begun during a previously funded A.I.D. project titled the Bioenergy Systems and Technology Project (BST). The new work will assist developing countries in utilizing biomass resources for the production of energy and related by-products. Effort will be concentrated on the agricultural and wood processing industries. BEST intends to:

- Draw upon U.S. experience and technical capabilities in biomass energy;
- Involve the private sector, both as project investors and as sources of commercial technology;
- Support priority research related to developing country bioenergy applications;
- Improve agricultural and wood resource management;
- Promote environmentally sound biomass energy systems as alternatives to conventional energy systems;
- Displace petroleum imports in developing countries;
- Stimulate economic development in rural areas; and
- Promote knowledge and understanding concerning biomass options for economic development, for use by farmers, processors, technology vendors, financiers, and bi-lateral and multi-lateral donors.

I. BACKGROUND

A. Traditional View of Biomass Energy

Biomass in the form of wood, animal waste or crop residues has for centuries been a basic source of energy. In developing countries over two billion people still rely heavily on biomass for cooking and heating fuel. These 'traditional' uses of biomass are often associated with the increasing scarcity of hand-gathered fuelwood as well as with the problems of deforestation and even desertification. New evidence indicates, however, that agricultural expansion to meet food needs of increasing populations is the largest contributor to the loss of forested land in developing countries. Furthermore, there is growing recognition that use of biomass energy in larger commercial systems based on sustainable, already accumulated resources and residues (as is done in the more developed countries) can offer a partial solution to some of these environmental and natural resource management problems.

When the oil crisis began in the early 1970s, bioenergy strategies were perceived as a panacea for developing countries' energy needs

because they tap indigenous renewable fuels to substitute for fossil energy and alleviate foreign exchange costs of energy imports. In addition to household fuelwood uses, biomass energy systems currently used in developing countries include the partial combustion of wood to produce charcoal; the combustion of sugar cane bagasse to produce process heat and electricity needed in sugar mills; the combustion of rice husks to produce heat for rice drying and mechanical power for milling; the fermentation of molasses to fuel alcohol for use as transport fuel and for blending with automotive gasoline; the gasification of wood and peanut shells for "producer gas" to run small engines; and small-scale conversion of animal and human wastes to make biogas in anaerobic digesters, producing gas for cooking and lighting. Some applications of these technologies provide low cost energy in a variety of rural and peri-urban settings. When successfully implemented, biomass strategies can be powerful and cost-effective ways to create rural employment, new income, and new marketable commodities from an already existing resource base. But 15 years after the first energy crisis, bioenergy systems and strategies have not been widely accepted nor commercially disseminated to the degree originally anticipated.

B. The New A.I.D. Approach to Biomass Energy

Beginning in 1979, A.I.D. began to target the possibilities of mobilizing biomass resources for energy production through the creation of a specific project titled the Bioenergy Systems and Technology Project (BST).

The evolution and efforts of that project over the past nine years have led to the initiation of an exciting new approach which mobilizes natural resources, private sector expertise, and financial support to integrate the conversion of biomass into marketable energy products at existing agro-processing facilities. The proposed BEST project will refine and continue these efforts to maximize the use of renewable, indigenous resources to stimulate energy availability and rural economic development.

BEST emphasis will be on private sector investment in sugar cane, rice, and wood residue energy systems, both for power and for ethanol. The Cane Energy Program was initiated four years ago and the Rice Residue Utilization Program two years ago, both under the BST project. The Wood Residue Energy Program is currently being designed. Designation of these three areas for intensive attention and investment of project time and funds resulted from previous years' efforts to identify the appropriate "niches" within which maximum results can be obtained from biomass energy systems. Sugar, rice, and wood processing plants often operate at a scale generating significant captive feedstock in the form of biomass wastes. These businesses have extensive and usually costly energy needs which can be met by on-site power/heat generation. The technical personnel are sophisticated enough to handle cogeneration equipment, and the financial requirements for capital investment can be managed by the parent company. These mills have the added

advantage of being located in rural areas so that power/heat produced in excess can be fed to either the national grid or to local users. Increasing energy availability in these rural areas creates many new jobs, produces new income, and stimulates economic activity in areas where badly needed. These benefits are of importance to both A.I.D. and to the host countries.

Under these programs, BEST will be involved in assessments of country potential as bases for policy and incentive innovations to encourage improved use of biomass resources for energy production. Each program is also vested in pre-feasibility analysis as well as extensive pre-implementation project set-up work. These efforts are designed to result in active field projects.

The ultimate objective is for A.I.D. to assist private sector investment in rural economic activity based on residue energy by reducing risks to the private sector inherent in applying new systems in new environments. To accomplish this, BEST must work with new institutions and organizations. New relationships in support of this will be established and will require additional nurturing to create the system required for full support of project identification - prefeasibility - feasibility - private financing.

II. RATIONALE FOR BEST PROJECT FOCUS

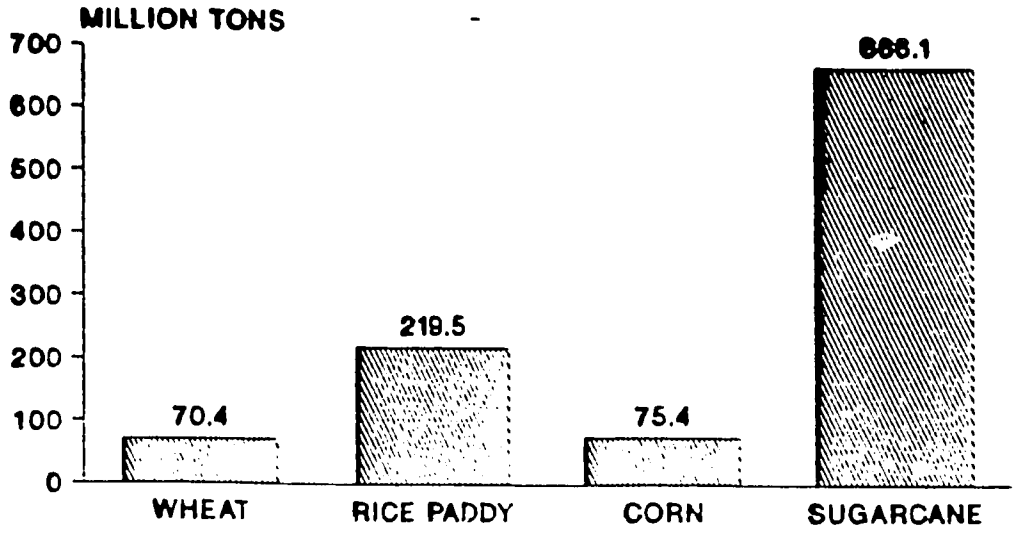
Cane, rice, and wood residues are targeted by BEST because these crops are the most significant in many of the developing countries assisted by A.I.D. Cane is the most significant in terms of volume produced and rice is most significant in terms of product value (Figures 1 and 2). In many A.I.D.-assisted countries sugar cane and rice are the basis of the agricultural economy and account for a very high percentage of rural jobs (Figure 3). Providing options to these agricultural industries is therefore crucial to maintaining national economic health.

A. Sugar Cane

The sugar cane industry worldwide suffers from oversupplied markets and historically low prices, with concommitant decreasing export earnings and trading power (Figure 4). The A.I.D. Cane Energy program offers the industry a diversification of products which will stimulate new revenue.

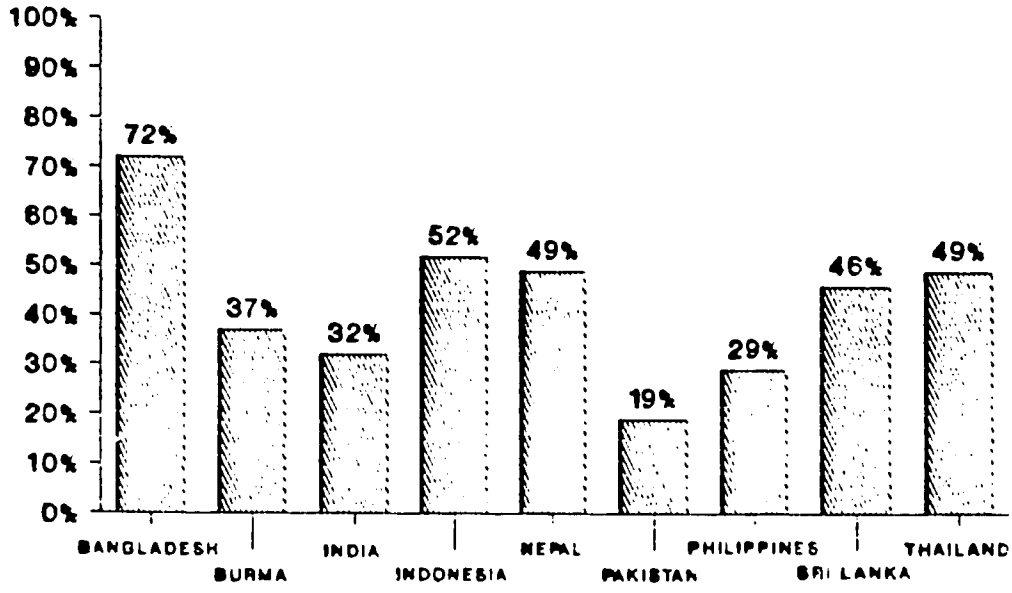
Many countries receiving U.S. foreign assistance rely greatly on the production of sugar to provide employment and earn foreign exchange. Among agricultural commodities in A.I.D. countries sugar cane is by far the largest crop; at 660 million metric tons annually, cane production is more than three times that of rice paddy and more than five times that of wheat and corn. Consistent employment data in the sugar cane industry is difficult to obtain, but some seven million people are employed full-time in A.I.D. countries, with over 30 million directly dependent on sugar industry income.

FIGURE 1: CROP PRODUCTION IN A.I.D. - ASSISTED COUNTRIES (1984)



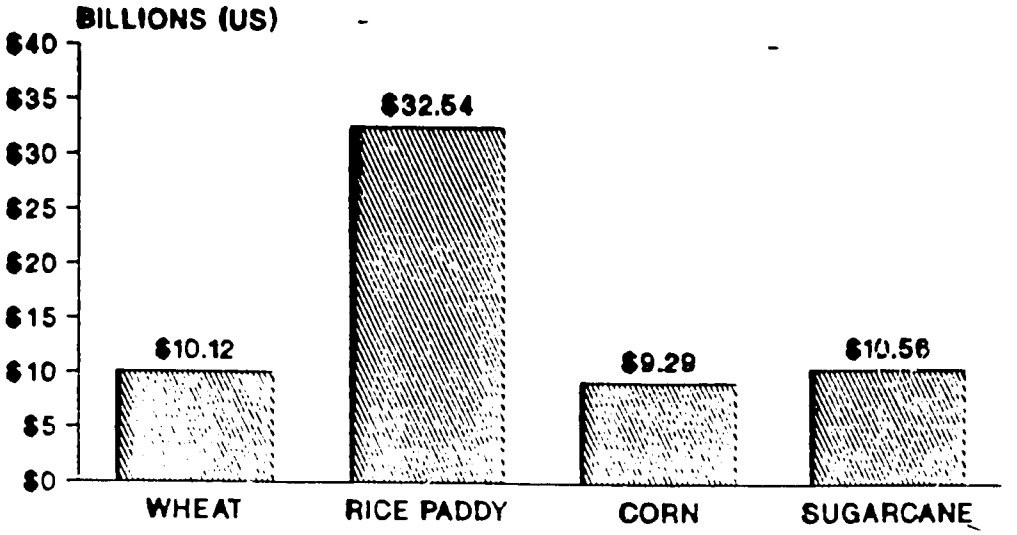
SOURCE: WORLD INDICIES OF AGRICULTURAL AND FOOD PRODUCTION, 1975-84, USDA: ECONOMIC RESEARCH SERVICE, STATISTICAL BULLETIN NUMBER 730

FIGURE 2: RICE AS % OF TOTAL AGRICULTURE (1984)



SOURCE. DERIVED FROM WORLD INDICES OF AGRICULTURAL AND FOOD PRODUCTION, 1975-1984, USDA, ECONOMIC RESEARCH SERVICE, STATISTICAL BULLETIN NUMBER 730

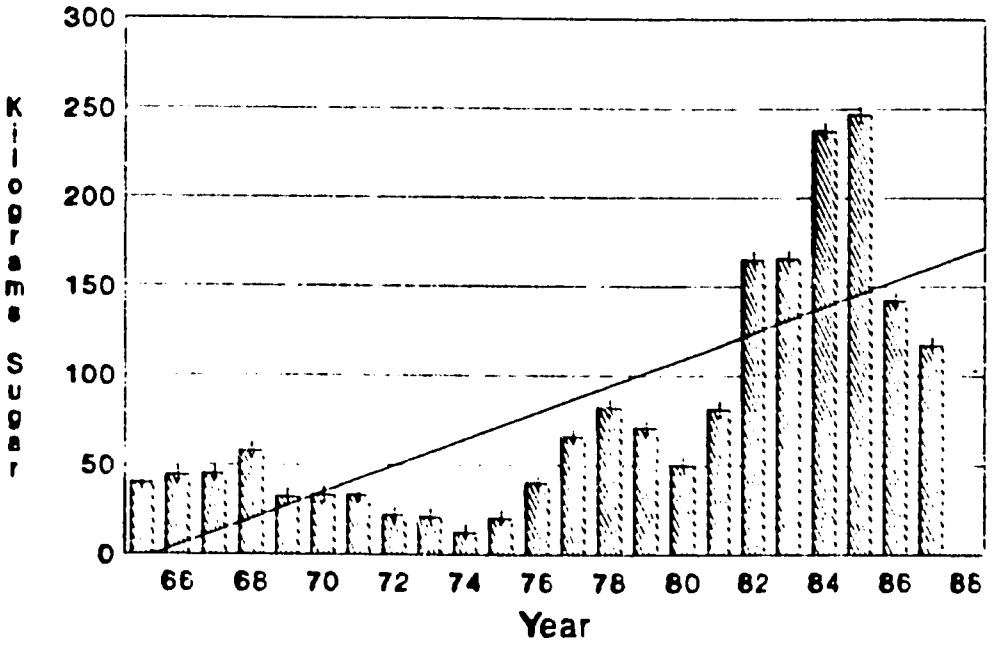
FIGURE 3: CROP VALUE IN A.I.D. - ASSISTED COUNTRIES (1984)



SOURCE: WORLD INDICIES OF AGRICULTURAL AND FOOD PRODUCTION, 1975-84, USDA: ECONOMIC RESEARCH SERVICE, STATISTICAL BULLETIN NUMBER 730

FIGURE 4: SUGAR/OIL TERMS OF TRADE

(Kg Sugar to Buy 1 Bbl Oil)



(Based on yearly average world market prices for sugar and crude oil)

The sugar industry's performance declined markedly in past years. Over-production of sugar in countries with price supports resulted in excess stock buildups worldwide and long term depression in world prices. While internal sugar prices in many countries have remained sufficient to cover costs, most industries rely on exports for substantial revenue and these prices have generally been well below production costs.

The situation is further exacerbated by shrinking U.S. and EEC sugar quota markets, neglible consumption growth during the past five years, state take-overs of heavily indebted private sugar companies in order to preserve employment, poor managment in many locations, and the lack of resources for maintenance and new investment. As a result, many sugar cane industries in A.I.D. countries have suffered consistent financial and employment losses, declines in foreign exchange earnings and government revenues, and reduced stability in agricultural regions.

Based on four years of effort in feasibility studies, research and field project development, A.I.D. views energy and new product markets as significant opportunities for exploitation by producers of sugar cane. The BEST program concentrates on commercial energy production from the sugar industry because of the importance of sugar cane to the economies of many A.I.D. countries and because of the increasing needs for energy in expanding sectors of these economies. Electricity sales to public utilities as well as possible alternative products such as fuel alcohol, boiler fuel, and animal feed appear to offer promise as new commercial avenues for the sugar cane industry. Figure 5 illustrates the cane electricity potential worldwide.

B. Rice

The rice industry faces a different but equally serious future. Increased demand for rice over the next 20 years will require modernization of rice mills to handle larger volumes of rice. Rice residue power systems will also create new revenue for millers which they can reinvest in the required modernization. The BEST program will stimulate development and implementation of systems to convert rice residue (husk and straw) into energy and other commercial products (steam, ethanol, lignin, gypsum, chemicals) to strengthen the rice processsing industry through diversification. (See attached Figure 6 outlining residue product possibilities.)

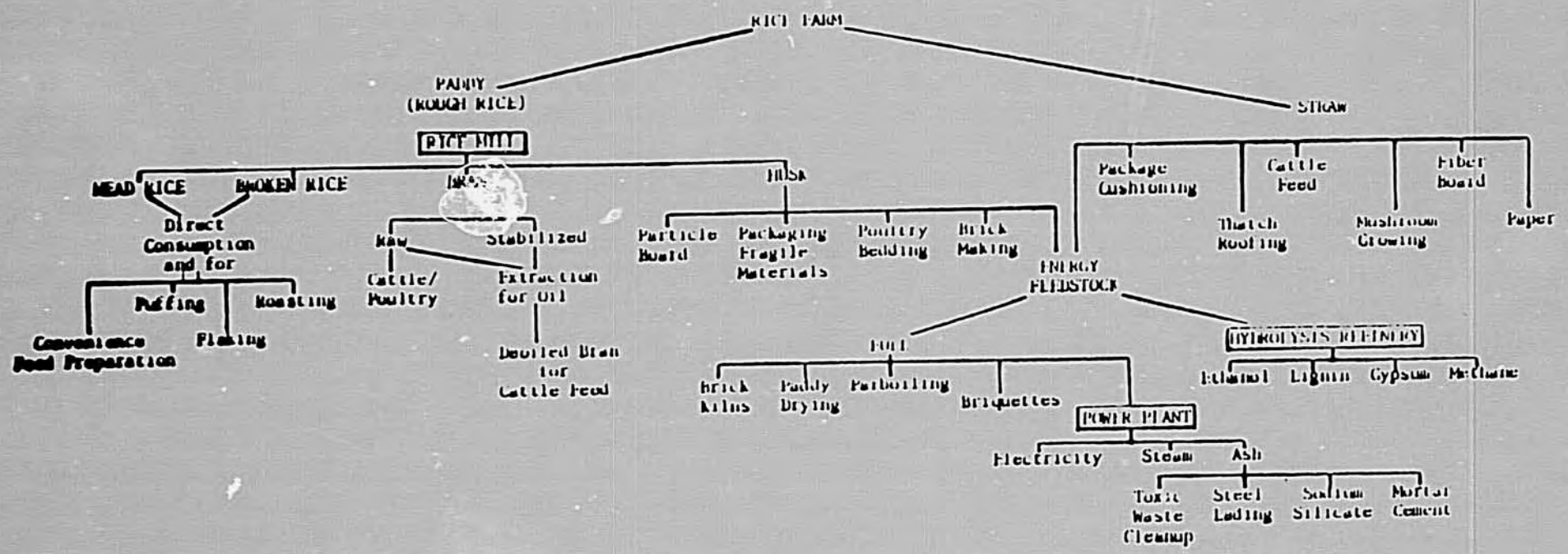
To meet projected rice demand beyond the Year 2000, both rice growing and rice processing will need to increase efficiency. Increased efficiency requires capital investment. Diversification of rice processing through the conversion of rice residue into energy products increases income and capital accumulation for re-investment. Creation of these new income streams will also result in new jobs, new rural infrastructure, and new economic activity in rural areas. Establishing products and markets for the entire rice plant stimulates improved and sustainable resource management. Ultimately rice farmers will also benefit as the value of rice husk and straw filters down to the rice producer.

Figure 5. Percentage of Actual Total Electric Utility Generation in 1982 that Could have been Produced by Gas Turbine Electricity Generated from Sugar Cane (Based on the 1985 Cane Production Level)

WORLD TOTAL (SUGAR PRODUCING DEVELOPING COUNTRIES)				27.05%
ASIA				14.86%
India	24.4%	Iran	5.1%	
China	5.8%	Vietnam	47.9%	
Thailand	66.7%	Burma	29.6%	
Indonesia	63.9%	Bangladesh	14.1%	
Philippines	42.5%	Malaysia	2.9%	
Pakistan	43.0%	Nepal	42.3%	
Taiwan	7.6%	Sri Lanka	3.4%	
CENTRAL AMERICA				65.00%
Cuba	328.7%	Jamaica	72.3%	
Mexico	21.4%	Panama	26.6%	
Dominican Rep.	176.5%	Belize	753.8%	
Guatemala	162.0%	Barbados	132.7%	
El Salvador	82.8%	Trinidad & Tob.	15.7%	
Nicaragua	116.4%	Haiti	65.3%	
Honduras	96.2%	St. Chris. - Nevis	n/a	
Costa Rica	41.3%			
SOUTH AMERICA				45.14%
Brazil	66.2%	Guayana	431.4%	
Colombia	28.6%	Bolivia	55.7%	
Argentina	15.2%	Paraguay	63.3%	
Peru	45.5%	Uruguay	6.6%	
Venezuela	5.4%	Suriname	28.6%	
Ecuador	42.1%			
AFRICA				19.16%
South Africa	10.5%	Mozambique	8.0%	
Egypt	21.5%	Somalia	320.0%	
Mauritius	968.8%	Nigeria	3.1%	
Zimbabwe	50.5%	Angola	15.8%	
Sudan	219.8%	Uganda	26.4%	
Swaziland	2400.0%	Congo	56.4%	
Kenya	92.5%	Mali	112.5%	
Ethiopia	140.8%	Gabon	9.4%	
Malawi	168.3%	Burkina Faso	40.7%	
Zambia	6.2%	Chad	61.5%	
Ivory Coast	29.4%	Guinea	14.0%	
Tanzania	65.3%	Sierra Leona	14.7%	
Madagascar	131.6%	Benin	125.0%	
Cameroon	14.9%	Liberia	2.6%	
Zaire	20.3%	Rwanda	15.2%	
Senegal	47.5%			
OCEANIA				200.00%

Figure 6. RICE RESIDUE AND BY-PRODUCT UTILIZATION

SCHEMATIC PERSPECTIVE



A.I.D. is in a unique position to play a critical role in developing the potential of rice residue energy systems. U.S. companies involved in successful rice residue system development and potential developing country users alike have little previous experience in either international technology transfer or international finance. A.I.D. can provide the institutional framework needed to identify and coordinate rice residue use opportunities. In collaboration with groups such as IRRI, TVA, TDP, OPIC, and the international business community, A.I.D. can establish these relationships and encourage their success.

C. Wood

Forests, the most valuable biomass resource in many A.I.D. countries, are seriously threatened due to the lack of effective forest polices and incentives for sustainable management. The wood products industry, while arguably not the primary cause, is often the catalyst for destruction through creating the infrastructure for agricultural development and using poor logging techniques to set the stage for environmental catastrophes. The overrriding theme of BEST's wood energy strategy is to work with the environmental, local, and wood products communities to further sustainable wood management practices. Through innovative planning and research, energy projects for the wood products industry can benefit all communities.

Interest in the forest products industry seriously waned over the last twenty years as the international donor community became involved in residential wood users, shifting away from industrial wood users. With global warming trends being linked to destruction of the world's major tropical forests, there is no longer the luxury to deal only with part of the deforestation problem. Innovative projects that provide incentives to local communities, the private wood sector, and governments to encourage responsible forest practices must be explored and implemented.

D. The Energy Context

The lack of energy in all forms (electricity, heat, steam, and liquid fuels) is increasingly recognized as the major constraint facing the developing world as it attempts to expand agricultural and industrial production, improve standards of living, and increase higher-value exports. In many developing countries power demand already exceeds existing generation capacity by over ten percent. Based on current trends in demand, investment requirements in the developing world for power systems could be as high as $2.6 trillion between 1988 and 2008. This implies an annual investment of over $125 billion, which is more than twice the current annual expenditure. (Power Shortages in Developing Countries, U.S.A.I.D., A Report to Congress, March 1988, p. iv)

Public funds from bi-lateral and multi-lateral sources are not available for the scale of investment required. In any case, the debt service that would be required on this amount of investment is

beyond the capability of most developing countries. As a result, increasing attention is being placed on the possibility of private investment/ownership/operation of power systems. To attract these new sources of funds for energy production requires a new orientation that is built upon sound technical evaluation, rigorous site-specific financial and economic analysis of opportunities, a supportive legal and institutional environment provided by both government and the utility, tax benefits and other incentives, as well as new skills in international project development. The BEST project is designed to mobilize the resources of all these elements in creating sound private power investment opportunities in A.I.D.-assisted countries.

Since many of the commercially proven biomass energy systems have been demonstrated in the U.S. experience, the BEST project also creates overseas business possibilities for U.S. companies. Integrating the proven technologies into the full system required for the success of a biomass energy project in an international situation will require unusual partnership between A.I.D. and the private sector, both in the U.S. and in the developing contries where these projects will develop.

III. U.S. EXPERIENCE AND TECHNICAL CAPABILITIES

The BEST project draws upon years of successful U.S. experience in biomass energy systems research, development, and application. This section summarizes that experience in cane, rice, and wood residue energy conversion systems for power, heat, and ethanol production.

A. Cane Energy Experience

Hawaii

Private companies in Hawaii historically have been an important source of electricity, particularly the sugar mills. The Hawaiian sugar cane industry remains the primary supplier of private power generation to outer islands' grids, averaging 10 percent statewide and from 20 to 40 percent of total generation on outer islands. Hawaii's cane electricity experience has seen a transition from producing only surplus or dump power to almost all mills providing baseload generation. Concurrently, with changes in the level and reliability of power coming from the mills to the utility, the mill-utility contractual mechanisms become increasingly sophisticated.

Electricity Production and Sale to Utilities

For nearly a century, the Hawaiian sugar industry has produced most of the steam and electricity needed to process sugar cane and to power its factories and irrigation pumps. It also played a major role in establishing electrical utilities on the three largest neighbor islands and produced much of the electricity those utilities distributed in their early years. The association continues; today Hawaiian sugar cane plantations

produce more than 775 million kWh annually, or about ten percent of all electricity generated in the state. As much as two-thirds of the electricity produced in some areas is generated by plantations, and in certain counties roughly one-half of the electricity distributed to the general public by the utility companies originates from the industry. About ninety percent of this electricity is produced by sugar factory cogeneration facilities (the remainder is produced by hydroelectric installations). Bagasse (the fibrous by-product of milled sugar cane) is the principal fuel burned to produce steam and electrical power, and represents nearly ninety percent of all boiler fuel burned (First Quarterly Report to A.I.D., Cane Energy Program, Hawaiian Sugar Planters' Assn., January 1988).

Power plants associated with the Hawaiian sugar industry first started generating power for sale to the utility in the mid-1970s. Of course, conditions in the sugar industry in Hawaii are different than they are in other countries which produce sugar. In Hawaii sugar cane is machine-harvested every 24 months because of the high cost of labor.

Notwithstanding the unique features of the Hawaiian industry, approximately 15 sugar mills in Hawaii now provide approximately 10 percent of the state's power (63 percent of the power on Kauai, 40 percent of the power on Hawaii, 29 percent of the power on Maui and two percent of the power on Oahu). Power plants at sugar mills run 24 hours per day and in some cases are the most reliable power plants serving the grid. Revenues from sales of power provide approximately 20 percent of the net revenue to the sugar industry.

In 1983 the sugar industry in Hawaii sold 815 million kWh to the utility and had a nameplate installed capacity of 213 MW. The capacity of the largest plant is 40 MW. The smallest plant has a 2 MW capacity. Six mills have contracts to provide firm power to the grid. Others provide power on an unscheduled basis.

The amount of power that can be produced in association with sugar production depends on the quality of fuel and the basic efficiency of the boiler and generator system. Most sugar mills today rely on low pressure boilers (200 to 300 psi) to produce steam for mill drives and electricity generation. Steam is exhausted from mill drives and steam turbines at lower pressures and sent to the factory to meet processing needs.

In the past many sugar mills have considered bagasse more of a nuisance than a resource. The average sugar mill produces only 10 to 20 kWh per tonne of cane processed, generally enough to meet mill and factory demands. In a surprising number of cases, sugar mills are foced to import large amounts of electricity from the grid to supplement the power they produce.

As demonstrated in Hawaii, it is possible to dramatically increase the amount of electricity produced in association with sugar operations. The more efficient Hawaiian mills produce some 70 kWh per tonne of cane. Hawaiian mills use turbo-pressure boilers (from 800 to 1250 psi) and separate sugar operations from power generation to enable power production to continue even if the mill or factory shuts down. The power plant provides all process steam needed for sugar processing.

To help examine the potential for the global sugar industry to produce electricity, A.I.D.'s Cane Energy Assessment Program developed a model to predict the quantity of electricity that could be produced by an efficient sugar operation using an 865 psi boiler and modern turbo-generator equipment. By using input parameters for a particular situation, the model predicts the technical and economic performance of a mill producing multiple products. For example, a hypothetical mill with efficient equipment grinding 4600 tonnes per day working 44 weeks per year could expect, after satisfying its own needs for electricity, to export an average of 10.5 MW of electricity. At $0.09/kWh, the revenues from electricity would equal $7.5 million annually.

If sugar mills add cane tops and leaves collected from fields after harvest to bagasse as discussed earlier, the quantity of electricity that could be produced jumps. For the hypothetical mill discussed above, adding 0.25 tonnes of cane tops and leaves to bagasse would increase the electricity produced per tonne of cane stalks processed to 200 kWh. The mill would be able to export an average of 27.5 MW to the grid and obtain revenues of $19.6 million annually.

Figure 7 summarizes Hawaiian cane mill electricity production. The Cane Energy Program is accessing the Hawaiian experience through a series of activities, including a cooperative agreement with the Hawaiian Sugar Planters' Association.

Bagasse Dryers

The Hawaiian Sugar Planters' Association is accumulating and evaluating data on the Hawaiian experience with flue-gas bagasse drying installations. In 1988 data was collected on the Waialua Sugar Company and Hamakua Sugar Company (Haina) boiler and flue-gas dryer systems. Detailed schematics of the bagasse drying and handling systems for the four installations have been prepared.

The preliminary data indicates that, in general, bagasse dryer systems offer a net energy gain, i.e., permit more electricity to be generated than consumed (e.g., three out of four of the systems analyzed have an electricity generation: consumption ratio of greater than 2.0, whereas only one system has a ratio of less than 1.5; in addition, at one factory, because there is no condensing stage in the turbogenerator system, supplemental low pressure steam (15 psig) is produced along with electrical power

Figure 7. Plantation and Utility Electrical Generation

ISLAND	ELECTRICAL GENERATION (10^6 kWh)							PERCENTAGE GENERATED BY PLANTATIONS
	Plantations[a]					Utilities and Others[b]	Total	
	Biomass[c]	Hydro	Non-fossil fuel	Fossil fuel[c]	Total			
HAWAII	204	1	205	36	241	449	689	34.9
KAUAI	146	55	201	18	219	177	396	55.2
MAUI	177	33	210	63	273	539[d]	812	33.6
OAHU	123	0	123	22	145	5,882	6,028	2.4
1986 STATEWIDE TOTAL	650	88	739	139	878	7,047	7,925	11.1
1985 STATEWIDE TOTAL	618	79	697	81	778	6,729	7,507	10.4

[a] Gross generation.
[b] Includes electricity imported by utilities from sources other than sugarcane plantations.
[c] Allocation of amounts of electricity generated by boiler biomass and fossil fuel sources based on fractional contribution of each source to total production of steam; islandwide steam and electricity figures used in computations.
[d] Includes 29×10^6 kWh generated on Molokai and 6×10^6 kWh excess electricity exported to public on Lanai.

(this should be considered as an additional energy product of the dryer/cogeneration system).

Drying rate (which affects installation and operating costs) and amount (which affects the magnitude of energy saved) vary directly with the temperature of the flue-gas used to dry bagasse. The flue-gas temperatures measured by the Station at the inlet of the four dryer systems analyzed averaged about 390°F, significantly lower than for most sugar factory boiler systems outside of Hawaii (typically greater than 500°F at the boiler exit); thus, the potential energy and cost advantages of flue-gas drying would be substantially greater for most factories outside Hawaii than for Hawaiian factories. The attached schematic (Figure 8) illustrates the Hawaiian system.

Energy Efficiency at Sugar Factories

U.S. experience in improving energy efficiency and increasing electricity production is clearly illustrated by the Hawaii sugar industry. Over the period 1960 - 1988, industry-wide average boiler capacities increased eight-fold (from 25,000 to 200,000 pounds steam per hour) and average boiler pressures more than tripled (from less than 200 to over 600 psi); at the same time, the average number of boilers per sugar factory fell from five to slightly over one. These indicators demonstrate important improvements in energy management in the sugar industry over a long period. In addition, the advent of new economic opportunities in energy conservation and power production can be seen in the acceleration of these changes after the energy price rises of the mid- and late 70s in oil-dependent Hawaii and the consequent opportunity to sell power to utility companies (see Figures 9 and 10).

Louisiana

Research on high-fiber cane (as opposed to the University of Puerto Rico's "high tonnage" cane) has been carried on for nearly a decade at the Audubon Sugar Institute (ASI) of Louisiana State University and a program of studies has recently been established at the West Indies Sugar Cane Breeding Station in Barbados (CBS). As noted earlier, sugar cane breeders have in the past sought to produce varieties with the most extractable sucrose per MT of harvested material, and thus discarded cane types with fiber content above about 15 percent. They also selected against canes with large amounts of leaves and tops.

Spurred by an interest in biomass production for energy, researchers at ASI crossed a commercial cane variety (CP-52-68) with a species imported from Argentina (Tinian 96). This produced a number of clones, two of which, L79-1002 and L79-1003, formed the basis of studies of production and processing alternatives.

Figure 8. **Bagasse Flue-Gas Dryer System**

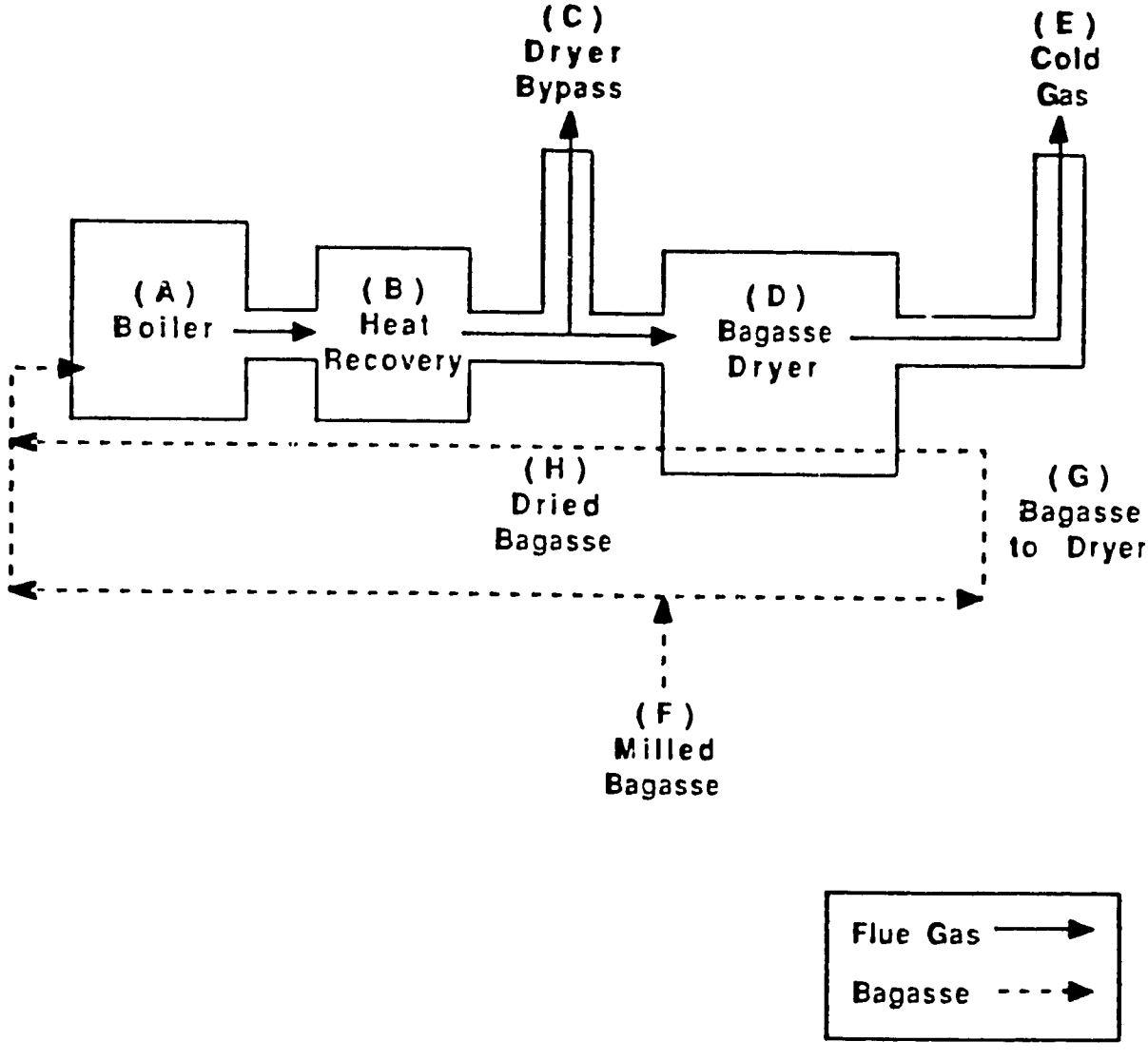


Figure 9. Average Boiler Capacity, Pressure, and Number of Units per Factory

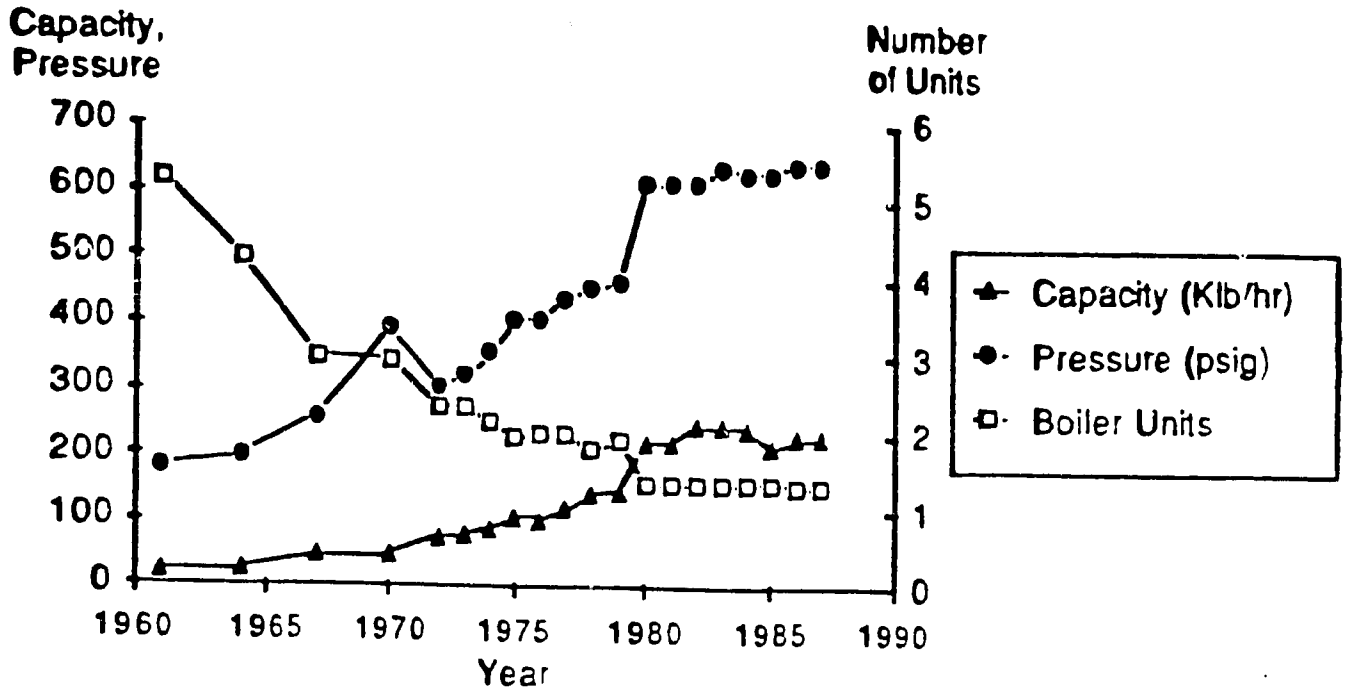
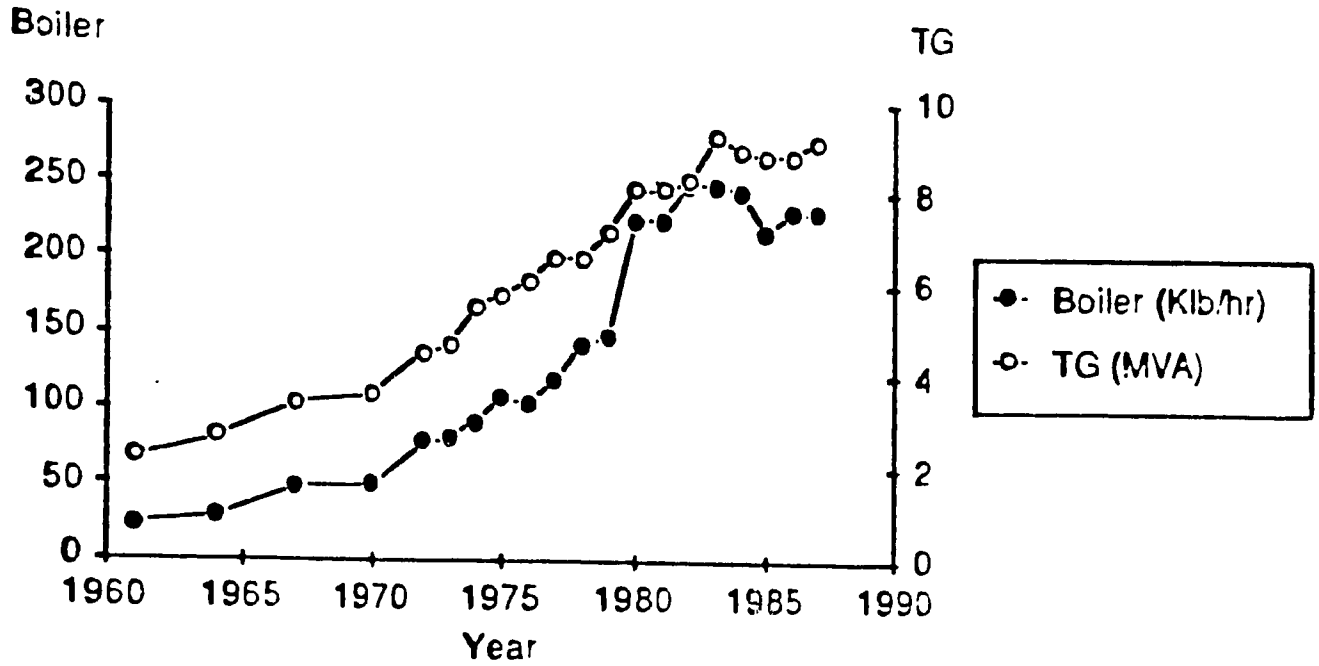


Figure 10. Average Unit Capacities of Boilers and Turbogenerators



Source: Hawaiian Sugar Planters' Association, "Review of Cogeneration in the Hawaiian Sugar Industry," Project #5500, (Draft), October 1988.

The varieties cultivated at Louisiana produced enormous quantities of biomass: green matter in excess of 89 MT per acre for five years in a row, or more than double the yields of standard sugar cane varieties. Because they also contained twice the fiber, they produced more than four times the amount of bagasse per acre. As might be expected, sugar percentages were lower than was the case in commercial varieties in use (8.6 percent sucrose in juice, compared to 14.3 percent), although the total quantities of sugars (11.1 percent soluble solids, compared to commercial levels of 16.1 percent) still make them interesting for the production of fuel alcohol.

Significantly, the high-fiber canes proved about half as expensive to produce per acre. While the plant crop cost about the same, succeeding crops required neither herbicides nor further cultivation to attain their higher yields, and continued to produce well for six or more ratoons. (Mike Giamalva, Stephen J. Clarke and Jeanie M. Stein, "Production of Saccharum Genotypes for Maximum Biomass Yield and to Determine its Potential as a Source of Fuel," Baton Rouge, Louisiana: Audubon Sugar Institute, p. 107.)

Researchers at CBS in Barbados tested a set of eight varieties. The fiber content of these ranged from 17.5 percent to 30.2 percent, and they, too, proved highly productive, with cane yields ranging from 62 to 86 MT per acre. Fiber yields increased 400 percent over those obtained from commercial varieties. Like the canes in Louisiana, these contained less recoverable sucrose per MT of cane. Overall yields of sucrose and reducing sugars per acre, of course, tended to be higher because of the tremendous amount of cane produced.

Although experimentation with high-fiber canes and energy grasses is just beginning, work to date has clearly identified an important resource base which has heretofore been ignored: the production of very large quantities of lignocellulosic material on a sustainable basis at a relatively low cost. From this research it is clear that lands currently used for sugar in the tropics and subtropics can continuously produce yields of more than 30 MT of dry biomass (60 MT of bagasse equivalent) per acre per year while at the same time producing five or more MT of fermentable sugars. If burned efficiently, this material could produce from 300 to 400 kilowatt hours of electricity. Put differently, 300 acres could be expected to generate one megawatt of electricity on a continuous basis.

Puerto Rico

"Energy Cane"

The most widely publicized research in the production of cane for energy purposes is that completed by Professor Alex Alexander and his colleagues at the University of Puerto Rico (UPR) between 1977 and 1982. Supported by a grant from ERDA and then the Department of Energy, the UPR team focused primarily on the effects of revised agricultural management on total biomass

growth. By providing generous fertilizer and irrigation water, researchers were able to obtain significant yield increases growing varieties in commercial use in Puerto Rico. Then they further revised cultivation methods, chiefly by much more intensive soil preparation, and at the same time included in their trials several known, but non-commercial, clones that had demonstrated great growth potential. Among the latter was the variety US 67-22-2, a cane with a normal fiber content and good sugar-producing qualities, but which also tends to produce large stool complexes and a generous foliar canopy. (A. G. Alexander, et.al. Production of Sugarcane and Tropical Grasses as a Renewable Energy Source, Final Report. Rio Piedras, Puerto Rico: Center for Energy and Environmental Research, 1982, pp. 58.)

Using this high-tonnage clone and the newly developed management techniques, the University of Puerto Rico team achieved yields of 113 MT of green matter (87 MT of millable cane) per acre per year in the plant crop under irrigated conditions. This measured a full 45.8 MT per acre of dry matter. The same crop yielded over seven MT of sugar per acre and 21.1 MT of trash.

These impressive yields were obtained under very carefully controlled conditions, and exceed the levels that could be expected by commercial cane operations. Nevertheless, they clearly establish the importance of cultivation techniques and varieties selection in producing prodigious quantities of biomass. They also appear to sustain the basic thesis of the UPR researchers -- viz. that well-managed commercial ventures should be able to produce cane in excess of 90 MT of green matter and 27 MT of dry matter, along with significant amounts of sugar, at a cost per MT lower than is normally incurred in conventional sugar operations.

Baling and Combustion of Cane Tops and Leaves

The biomass produced by sugar cane and related grasses is currently harvested in the form of "millable stalks", or that part of the plant that contains the highest concentration of sucrose. Where the cane is hand harvested, the trash is burned or left in the field. The tops are also cut and left behind. Machine harvesting manages this material in different ways, depending on the equipment used, but the general goal is to avoid milling material that does not contain a high percentage of extractable sugar. Because trash and tops were always considered a waste product, little attention was paid to the quantities of this material produced or to possible means of harvesting, transporting and processing it. As a result, this remains one of the most important areas of uncertainty in the cane/energy business.

Drawing on experience with varieties in Puerto Rico, Alexander estimates that on a dry-weight basis, each 7.2 MT of millable stems has associated with it 6.1 MT of green tops, attached trash

and detached trash. If we assume that 60 percent of this material could be harvested, we could expect approximately 3.65 MT for every 7.2 MT of millable stalks, or a ratio of just about one-half, again, on a bone-dry basis. (Alex Alexander, The Energy Cane Alternative. New York: Elsevier, 1985, 46.)

Alexander's theoretical calculations are supported in part by research in the field conducted by ABA, Inc., for the government of the Dominican Republic. ABA's research in a range of fields of different kinds, handcut without burning, suggests that in general 0.67 MT of trash and tops (at about 50 percent moisture) are available for every MT of cane harvested. Assuming, again, that 60 percent of this material could be harvested, this would leave 0.4 MT of trash and tops for every MT of green cane. A MT of green cane at 15 percent fiber produces approximately 0.3 MT of bagasse at 50 percent moisture. This means that, in terms of fuel, the harvestable trash and tops almost certainly have a fuel value greater than that of the harvested cane itself. The amount of material, of course, can be expected to vary considerably by variety. Barney Eiland and others at USDA in Florida have measured available trash in fields that have been burned and mechanically harvested. Their conclusion is that, in general, two to three tons of dry matter can be recovered from fields that yielded 20 tons/acre at harvest. This would be the equivalent of about five tons of green matter. Eiland also estimates that the burning removes another two to three tons per acre. Extrapolating these estimates, the Florida experience suggests that 10 tons of trash at 50 percent moisture may be available for every 20 tons of cane harvested by mechanical means. Again, since the 20 tons can be expected to produce between six and seven tons of bagasse, the fuel value of the trash exceeds that of the bagasse. As Eiland stresses, however, the challenge is in collecting the material at a cost that makes economic sense. (B. R. Eiland and J. E. Clayton, "Unburned and Burned Sugarcane Harvesting in Florida," Transactions of the ASAE, Vol. 26, No. 5, 1983).

The actual collection of field trash and tops presents a number of practical problems and few have had experience with this activity. The giant La Romana complex in the Dominican Republic collects field residues as a feedstock for furfural production, employing thousands of oxen to do so. University of Puerto Rico researchers have suggested that the best approach is to turn and field-dry the material and then bale it in large, circular bales for transport to storage areas near the boiler. Any separate entry to the field during harvest is both expensive and logistically difficult to manage, and it may prove easiest to harvest whole cane and separate the tops and attached trash at the mill site. Separators have been developed in the Hawaiian sugar industry (where whole, burned cane is harvested) that might be suitable for this purpose. Clearly this is an important problem area, and a great deal of experimentation is needed to determine the best way to take advantage of this very considerable resource.

B. California Private Biomass Power Experience

California has been a pioneer and leader in private power development in the United States, especially in contract negotiations, utility management, producer incentives, and financing. As a result of innovative financing, tax laws, and contract procedures, California represents one of the most forward looking states in the U.S. in terms of power issues. After systematizing its contract negotiations by the early 1980s under the Public Utility Regulatory Policies Act (PURPA), California has brought on line significant quantities of biomass-based electricity production.

Utility Contracting

Contractual Development

To systematize utility contracting, California developed four basic types of private power contracts: Standard Offers 1, 2, 3, and Interim Standard Offer 4. Generally, surplus or intermittent electricity is sold to the utility under Standard Offers 1 to 3, while Standard Offer 4 deals with firm or baseload power sales to the grid.

The Interim Standard Offer 4 was suspended in 1986 due to the excess of demand by private power producers resulting from setting very favorable fixed energy prices and California's oversupply of generation capacity. A new Standard Offer 4, based upon a bidding process by private producers, is being devised and will be implemented next year. Bidding is expected to increase competition to ensure that the least-cost producers are the first ones drawn into the grid.

Electricity Prices and Payments for Alternative Energy Projects

Electricity purchase prices paid by the utility to the private producer are based by U.S. law on the utility's avoided costs. Implementation of the avoided cost principle resulted in significant discussions between the California utilities, public utility commmission and private producers. Avoided costs typically are broken down into three componenets, according to the utility commission: 1) energy costs that account for the fuel savings by the utility from purchasing private power, 2) a capacity charge or payment that is based upon the amount of firm power the private producer agrees to sell to the grid, and 3) sometimes an energy-related charge which relates to the type of generation system that is displaced. (See Figure 11.)

The payments for which private producers are eligible depends upon the type of power sold to the grid or end user. Standard Offers 1 to 3 typically allow for energy or fuel charges only, since these contracts are for intermittent or surplus power sales. In contrast, Interim Standard Offer 4 (SO 4) originally set fixed capacity and energy prices to encourage banks to

Figure 11.

Average Cost of QF Energy and Capacity: 1980 - 1987 1/

5/23/88

Technology	1980 ¢/kwh	1981 ¢/kwh	1982 ¢/kwh	1983 ¢/kwh	1984 ¢/kwh	1985 ¢/kwh	1986 ¢/kwh	1987 ¢/kwh
Thermal 2/	4.7	6.8	6.5	6.8	8.2	7.5	5.6	5.1
Lg. Geothermal	0	0	0	0	7.6	7.3	5.1	4.2
Hydro	0	0	5.8	6.0	7.5	7.9	6.5	7.5
Wind	0	0	6.7	7.0	8.8	7.4	7.3	7.5
Solar	0	0	0	9.0	1.12	8.3	5.6	4.1
Average	4.7	6.8	6.5	6.7	8.1	7.5	5.8	5.4

1/ Source: Power Control 2/4/88 QF Program Statistical Report

2/ Thermal includes cogeneration, sw/biomass, and small geothermal

finance firm power producers. Based upon long run energy price forecasts, the energy prices set by SO 4 for the 1980s in retrospect were high relative to the actual prices of petroleum fuels during this period. This is one reason Interim Standard Offer 4 was suspended.

Payments to alternative energy projects grew dramatically from 1980 to 1984, then leveled off somewhat. Payments from Pacific Gas and Electric increased from $9.4 million in 1980 to $362.2 million by 1987, in nominal terms. (See Figure 12.)

Biomass Generating Facilities and Other Alternative Energy Projects

Alternative energy projects under contract or on-line in California have increased exponentially from 166 MW (only 5 MW on-line) in 1979 to 17,182 MW total (5,220 MW on-line) by 1987. Sixty-one percent of all private power generation is from cogeneration and 50 percent of all cogeneration in the state is from biomass. Thus biomass operating facilities contribute over 30 percent of all private power in the state (4,500 MW on-line and non-generating under contract). Over 90 percent of the 1000 MW in signed "solid waste/biomass" power contracts with Pacific Gas and Electric are for firm power, Standard Offers 4. In addition, some of PG&E's cogeneration facilities utilize biomass feedstocks although they are not classified as "biomass" contracts.

C. Utilization of Rice Residues for Energy

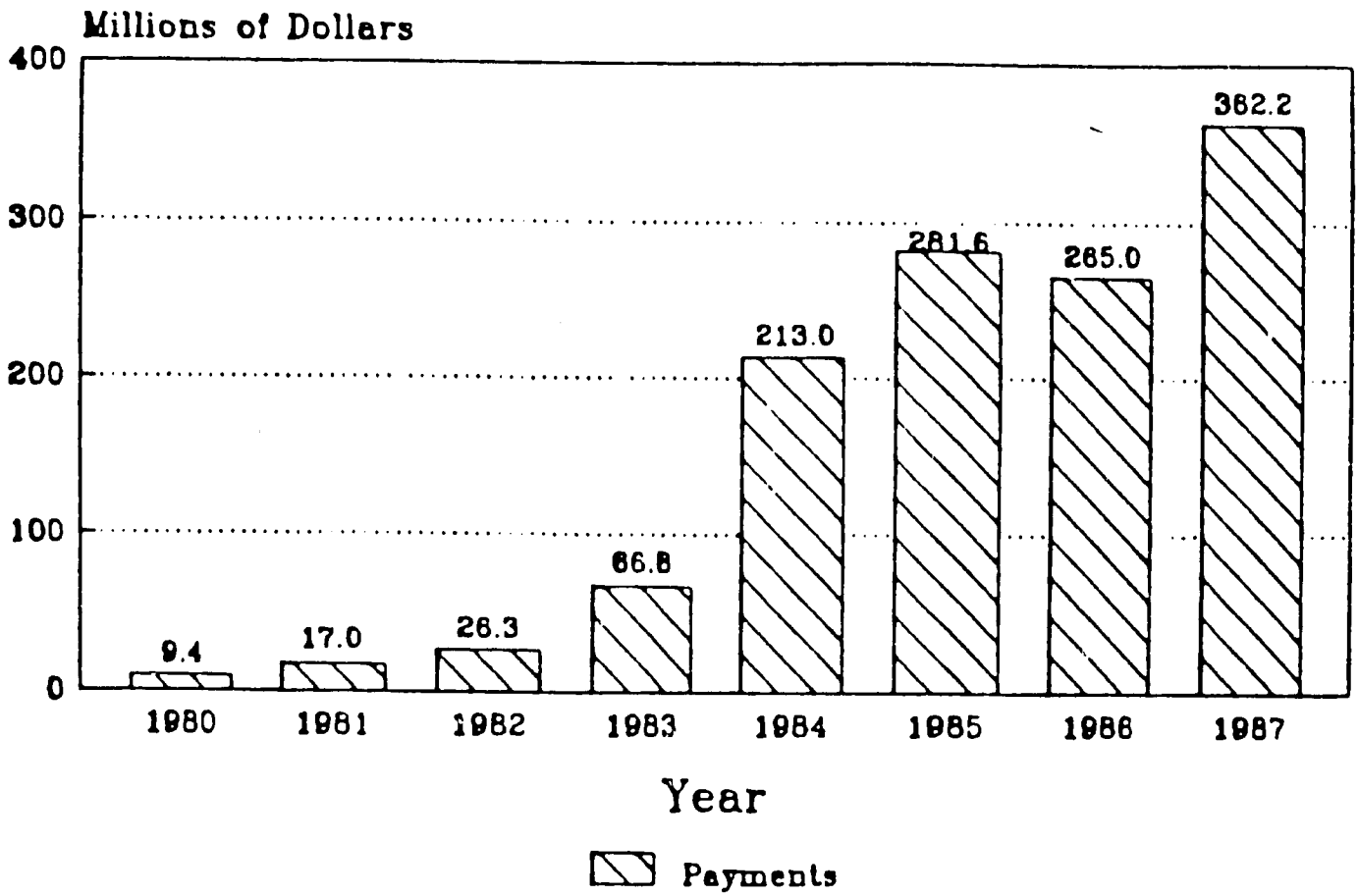
Louisiana - Agrilectric, Ltd., Lake Charles, LA

A steam power plant is producing more than 11 MW of electric power from rice husks at Lake Charles, LA. The Agrilectric plant uses all of the husks generated by the adjacent Farmers Rice Milling Company, which processes about 1,000 tons of rice per day in a 290-day season. In the non-harvesting season, it uses rice stored by producers or by the U.S. government. The power plant receives 200 tons of finely ground husks per day from the Farmers Rice mill via a pneumatic conveyor; up to 100 additional tons of husks are purchased daily from other large mills.

The husks are burned in suspension in a cyclonic furnace. The silica content of the ash must be kept high and the carbon content kept low to permit the sale of the ash to steel producers who use it as an insulating material.

The boiler island was installed by McBurney Corporation of Atlanta, GA. The watertube boiler was manufactured by Deltak Corporation of Minneapolis, MN. Erosion from the entrained ash in the combustion gases is minimized by the straight-through design of the tubes, superheater, evaporator, and economizer. The boiler has modular bundles of tubes that permit easy removal of the bundles and easy replacement of any bundle. The system produces about 112,000 lbs/hr (50,400 kg/hr) of steam at 650 psig and 750°F (398°C).

Figure 12. Payments to Qualifying Firms (Historical)



QF Contracts, PG&E

5/18/88

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The steam is used in a General Electric turbine-generator rated at 12.5 MVA. The turbine is often operated at five percent overpressure with valves wide open and produces from 11.2 to 11.8 MW. Exhaust steam from the turbine is condensed in a 22,000 gallons/minute (83,600 liters/minute) condenser. Cooling water is obtained from an artificial lake supplied by deep wells.

About 15 percent of the gross power output is consumed in the operation of the power plant and the adjacent rice mill. All of the net power output is sold to the regional electric utility company, Gulf States Power. Income from the export of rice husk ash to European steel mills also contributes significantly to profitability.

Agrilectric officials are preparing a feasibility study with TDP co-funding for a similar system in the Philippines.

Arkansas - PRM Energy Systems, Stuttgart, AR

A husk combustion system developed by PRM Energy Systems at the large Producers Rice Mill in Stuttgart, AR, burns 1.75 tons of husks per hour to provide 15,000 lbs/hr of steam for rice parboiling. A second unit uses 2.5 tons of husks per hour to produce hot gas for rice drying. The two units are saving a million dollars a year in natural gas fuel costs; sales of ash to steel companies at $100/ton generate another million dollars in revenue.

The PRM two-stage, gasifier/combustor is specifically designed for high silica, high ash, low grade waste fuels. The gasification process takes place on a fixed bed. A unique method of mechanical fluidization requires less underfire air and less power than a conventional fluidized system. Problems of glassing and clinkers experienced in most systems have been eliminated. Controlled combustion allows variable carbon burn-out as the ash is automatically and continuously discharged without need for drying. PRM's ash quality control system permits ash production to meet the ready market for the ash residue in U.S., Asia, Europe and South Africa. Second-stage combustion of the gases delivers a clean hot air stream at 2000°F that can be directed to any heat or steam application. The introduction of combustion air in the second stage reaction allows thermal cracking of tars and hydrocarbons to enhance the heating value of the combustible gases and to eliminate the need for expensive pollution control equipment. In steam raising applications, the boiler stack is clean enough to be used for drying paddy rice.

The PRM system accepts a wide variety of waste fuels including rice husks, rice straw, cotton stalks, cotton hulls, gin trash, wheat straw, wood chips, bark, coconut shells and husks, cane wastes, corn and sorghum waste, peat, low grade coal, etc. Minor adjustments in the unique control system allow seasonal switching of fuels to follow crop patterns and reduce inventory of fuel stocks. PRM has recently built systems in Malaysia for the Padi

Board to replace diesel and handle disposal problems. These three units have passed environmental scrutiny with flying colors (Ron Bailey communication, November 1988).

TVA Agrirefinery

TVA is developing a process that efficiently converts the cellulosic portion of feedstocks to sugars that can be subsequently fermented to ethanol. The process ia a two-stage sulfuric acid hydrolysis process which operates at low temperatures (less than 100°C) and low pressure (atmospheric). Results in laboratory tests with over 25 feedstocks have shown similar conversion efficiencies provided the feedstock is reduced to a size suitable for efficient processing. Support from BST allowed for the inclusion of rice hulls and straw in this R&D.

Conversion of hemicellulose to xylose has averaged above 90 percent, and conversion of cellulose to glucose has averaged above 85 percent. Sugar yields can be calculated using these efficiencies and the feedstock composition. For example, average compositions of four feedstocks which would be available in the Philippines for processing to sugars are shown in the table below.

Composition of Feedstocks on a Percent Dry Basis

Component	Rice Hulls	Rice Straw	Corn Cobs	Bagasse
Hemicellulose	11	16	40	19
Cellulose	37	38	38	38
Lignin	21	12	8	22
Ash	19	16	1	3
Other	12	18	13	18

TVA has also conducted extensive fermentation tests with hydrolyzates to optimize conversion efficiencies and determine ethanol yields. Theoretically, 0.51 pounds of ethanol can be produced from each one pound of sugar. Glucose hydrolyzates have been successfully fermented to ethanol at an efficiency of 85 to 95 percent of theoretical. Xylose hydrolyzates have been fermented to ethanol at efficiencies of 60 to 70 percent of theoretical. Using an average composition for the four feedstocks of 28-percent hemicellulose and 38-percent cellulose, about 70 gallons of ethanol can be produced per dry ton of feedstock.

Products of the processing facility would be ethanol, lignin for steam and electrical generation, gypsum, CO_2, stillage, and a waste effluent. Many of these products also have markets in A.I.D.-assisted countries.

USDA - Stabilization of Rice Bran for Commercial Oil Production

Rice bran oil demonstrates characteristics that make it highly valued among all other vegetable oils, in both the food and pharmaceutical industries. High in Vitamin E, rice bran oil also reduces cholesterol levels more efficiently than oat bran. In addition, because this oil has no odor or taste, it is a more suitable base for medicinal, cosmetic, and other applications.

Until very recently, however, rice bran oil could not be produced at a commercial scale because during the milling process bran is removed in such a way that it destabilizes and becomes rancid very quickly. Essentially, rice bran was disposed of as an animal feed. The U.S. Department of Agriculture Laboratory at Albany, CA has now designed an extrusion cooker which stabilizes the bran permitting it to be accumulated for use in commercial scale oil processing plants. Many of the large rice mills in California are installing extruders and will add bran oil to their product lines. As the result of the LSU Convocation designed and sponsored by the BST Project, the U.S. companies with the patents for commercial application of this technology are in discussion with the U.S. rice husk power system companies for the development of joint venture applications of bran oil and husk power integrated systems. Immediate targets for this work are India and Pakistan. The following table illustrates the current high value commodities that can be produced from rice bran oil.

RICE BRAN OIL USES (DECEMBER 1988)

	Price/Pound
Moderate Emulsifier	$0.75
Hypoallergenic Infant Formula Base	$1.00
Lowfat Milk Replacer	$1.25
Imitation Meat Paste	$1.00
Whole Milk Replacer	$2.50
Artificial Cream Cheese	$2.50
Artificial Egg Yolk Powder	$1.95
High Fat Emulsifier	$0.85
Ice Cream Base	$0.90
Rice Protein Isolate	$1.10
Malted Rice Milk	$0.75
Imitation Parmesan Cheese	$2.50
High Protein Emulsifier	$1.75
Skim Milk Replacer	$0.80
Artificial Whole Egg Powder	$1.25
Artificial Yogurt	$1.25
Hypoallergenic Products	$1.85
Protein-Lipid Dough Improver	$1.10
Rice Bran Oil	$0.60
Rice Bran Fiber	$0.60
Aquaculture Feed	$0.25
Chicken/Swine Feed	$0.125
Milk Replacer for Calves	$0.60
Oryzanol	$15.00
Inositol	$12.00
High Protein Baby Cereal	$0.80
Phytic Acid	$4.50

Information from Helix International, Baton Rouge, LA, December 1988.

D. Production of Alcohol from Biomass

Background

Since the mid-1970s, the production of fuel alcohol or ethanol from sugar and grain has achieved significant scale in Brazil, the United States, and in several African and South American nations. Expansion of ethanol has coincided both with massive increases in world agricultural production of sugar and cereal grains, which has produced large surpluses of these commodities, and with energy price shocks of the mid- and late 70s, which brought forth serious economic and energy security problems for energy importing nations. Like some other biomass energy sources, ethanol production has been able to substitute for imported high quality energy (gasoline) while offering a reliable market for indigenous products.

On a purely economic basis, ethanol requires a low cost fermentation feedstock and low production costs in order to compete with gasoline refined from crude oil. With oil costing $35 per barrel, this translates into corn at roughly $2 per bushel, molasses at $45 per ton, and sugar at 6¢ per pound (assuming wholesale gasoline @ $0.90/gallon, ethanol from corn @ 2.5 gal/bu., from molasses @ 70 gal/ton, and from sugar @ 185 gal/ton). With the relaxation of oil prices to $15 to $20 per barrel over the past two years, the economic justification for ethanol production has narrowed to fewer settings. For example, in developing countries this occurs where the delivered cost of gasoline and diesel is high, the value of feedstock such as cane molasses is low, and foreign exchange is at a premium. Beyond simple economics, however, ethanol production often has strategic importance and spin-off development, factors important to the ethanol programs in Zimbabwe, Malawi and Brazil.

U.S. Experience

In the United States, financial incentives established in 1979 to promote alternatives to petroleum-based fuels have stimulated the growth of a large and diverse fuel ethanol industry, with a present capacity of one billion gallons per year (compared to Brazil, 3.5 BGY). The rush to create a new industry provided opportunity for the installation of plants with a range of sizes, feedstocks and technologies. Corn (maize) is the dominant ethanol feedstock for economic reasons, stemming from continued large surpluses, but production from sugar, molasses, barley, wheat, potatoes and industrial sugar wastes has also contributed to provide a strong base of commercial and technological experience.

In technical areas, U.S. industry holds a leadership position in commercial scale batch fermentation, batch with yeast recycle, cascade systems, and true continuous fermentation. In distillation, the U.S. offers competitive azeotropic systems using cyclohexane, ethyl ether and benzene, as well as commercial applications with molecular sieves and corn grits absorbents.

There has been significant progress through the use of innovative process improvements, resulting in improved plant reliability, reduction of operating costs, and ethanol yield improvements. In new technology areas, U.S. industry and research institutions lead the way in development of alcohol from wood and other non-starch biomass through both acid and enzymatic hydrolysis.

Of particular relevance to energy-conscious developing countries, U.S. expertise with electricity cogeneration, anaerobic waste treatment with methane recovery, and maximum efficiency in process energy use has been successfully exploited by the ethanol industry and incorporated in its commercial approach. Further, the lack of support by the automotive and petroleum industries has forced the U.S. ethanol industry to develop comprehensive knowledge of the role and performance of ethanol in petroleum blends in order to achieve acceptance of the product. Combined with the wide variety of technologies applied in the expansion of the industry, the U.S. can provide proven process, engineering and project development options to the prospective ethanol producer.

E. Production of Electricity and Process Heat from Wood Residues

Utilization of the forest products industries' residues and production of short rotation tree crops for thermal and electrical use provide a multitude of benefits ranging from improved waste management, diversified and strengthened industry, increased local incomes and jobs, and if linked to proper cutting and management practices, sustainable forest use.

Given the massive devastation of tropical forests worldwide, the full environmental implications of any additional wood use must be carefully understood to ensure that only sustainable end uses are encouraged. Wood energy use from plant wastes material or short rotation tree crops if properly selected can provide environmental, local income generating, private sector and national benefits but such projects will require tradeoffs to, incentives for, and innovation by all parties involved in wood energy schemes.

Forest Products Industry

Biomass energy provides anywhere from 80 to 100 percent of the thermal and electricity needs for most of the U.S. and developed countries' forest products industry since the mid 1970s. Most plants use direct combustion of their wood wastes, with gasifiers being the exception rather than the rule in the industry. The commercial feasibility, technical capability, and financial advantages of wood combustion systems based on captive feedstocks are no longer major concerns for the industry. Rather, newer plants have adopted multi-fuel systems that give them the flexibility to shift between feedstocks, such as wood, coal and/or oil, based upon delivered fuel costs.

Wood energy projects in some A.I.D.-assisted countries make sense due to the environmental benefits from properly managing wood residues in conjunction with diversifying the wood products industry into additional stable markets. The forest products industry in developing countries has been slower in utilizing their field and site wood wastes for various reasons. In the past, sizing power plants to industrial peaking needs combined with a national prohibition on sale of excess electricity to the grid prevented the industry from efficiently managing their wood wastes. Recent development of multi-fuel systems changed these technical sizing limits, creating a broader range of economic wood power systems.

However, many developing countries still limit or prohibit private power sales. Further, until wood waste disposal becomes too costly or environmental regulations are mandated, companies have little incentive to invest in wood power systems if rural electricity rates are low and grid buyback sales prohibited. Finally, many stand-alone rural energy systems cannot absorb the energy production capabilities of the forest products industry, making investments in optimally sized power plants unattractive due to the lack of markets.

Where countries are changing their private power laws and additional rural energy is needed, industrial wood energy systems provide new options to the electricity sector. A recent Office of Energy prefeasibility study of wood waste power systems in Indonesia suggested installation of 3 MW systems based solely on waste residues for the plant's internal thermal and electric needs. Despite the availability of excess plant wastes, larger systems were not recommended due to the lack of surrounding rural demand. Even so, a preliminary first-cut analysis suggests that these smaller plants might be financially attractive, yielding 25 to 60 percent rates of returns and 6 to 2-1/2 year payback periods in a country where 30 to 35 percent yields and one year to six months paybacks are often expected by private entrepreneurs.

Wood-Fired Base Load Power Plants

Dramatic increases in wood-fired base load power plants have occurred in the U.S. since 1978. Currently, there are over 3,500 wood-fired plants in the U.S. producing steam or steam and electricity. Of this, almost 40 percent of these plants are producing electricity. In total, there are about 3,200 MW of electricity produced from these plants, with two-thirds of these plants selling electricity to the grid. The remaining one-third is produced primarily by the paper industry which consumes most of its electricity internally.

Growth in wood-fired power plants has been fairly evenly dispersed throughout the U.S., located in all major U.S. wood producing regions. All plants are under 80 MW, with a clustering of plants around 15 and 25 MW for the plants selling to the grid. In contrast, the paper industry tends to have larger systems ranging from 50 to 80 MW, sized to their internal steam/electric needs.

Most plants have come on-line since 1978 when tax credits and the institution of PURPA laws created financial and regulatory incentives for independent power systems. The U.S. wood products industry, as well as many independent power producers, have seen the financial benefits of shifting from fossil fuels, even with recent oil price trends.

Short Rotation Tree Plantations

Where the industries' on-site wood wastes are inadequate to meet an energy demand, short rotation tree plantations provide additional sustainable long-term supplies. Extensive research into the biological aspects of fast growing trees dominated the 1980s, with many A.I.D. projects, such as FFRED and country specific woodlot trials (e.g.,. India and Thailand renewable energy projects) demonstrating the advantages and limitations of tree plantations. While provenance and species trials are still important, greater emphasis must be placed on the economic and local incentives fostered by such plantations.

Knowledge gained from such species trials and community woodlots supports the concept that local communities must have a stake in the income and other long-term benefits of any wood plantation, or forest management, plan for the strategy to be successful. Short rotation tree plantations have failed notoriously where the local community has no gain from the schemes. The BEST Project will draw upon U.S. and overseas experience in short rotation plantations in developing its wood energy projects.

IV. BST TECHNICAL EXPERIENCE WITH FIELD APPLICATION OF BIOENERGY SYSTEMS

A. Electricity from Sugar Cane Residues

Current emphasis of the BST project on electricity from cane residues is in Costa Rica and Thailand. As a result of the country cane energy assessments conducted in these countries, implementation activity is being given high priority by government, utilities, and the cane industry. BST contributions to the success of these country projects are increasing and will continue during BEST. These two situations are described in more detail because of their high priority.

Costa Rica

The overall conclusion of the Costa Rica Cane Power Report (July 1988) is that the production and sale of electricity in the national grid could be an excellent investment opportunity for the sugar industry of Costa Rica and would provide important benefits to the national economy. Further, selected mills could commence electricity sales soon enough to help the national electric utility handle the surprising recent surge in demand that has materialized at the same time as hydropower reserves have been reduced by drought. Depending on the options selected, the industry could contribute from 17 to 500 million kilowatt hours of electricity

while creating additional jobs in rural areas, diversifying the sugar cane industry into attractive new by-product markets and (in the short term) displacing up to $7 million now spent for imported petroleum. However, there are important uncertainties or risk factors that need to be addressed. The availability and cost of supplemental fuels for energy production in the off-season is of critical importance. The attractiveness of investments in private power production and the amount of power that mills choose to produce also depend heavily on decisions by public authorities concerning matters such as loan rates, import duties, and the prices they are willing to pay for power.

The study team chose three existing mills (Quebrada Azul, El Viejo and Taboga) to form the basis for its analysis and developed technical projections for four levels of investment and for each level estimated capital costs, electricity production and sales, and fuel options. The technical projections range from the simple sale of surplus power, without any new investments, to the installation of entirely new boiler-turbogenerator systems for year-round electricity production. A key conclusion of the sensitivity analyses is the importance of domestically produced biomass fuel, principally sugar cane field residues (trash), in permitting mills to produce larger amounts of power at a cost that is competitive with other sources of electricity available to the country.

Extrapolating from surplus power scenarios analyzed in detail in the report, the Costa Rican sugar industry could, with minimal investment and little or no risk, produce some 17 to 19 million kilowatt hours per year (the equivalent of two to three megawatts annual capacity) for sale to the grid. But this surplus power production from bagasse (mill residue) would be available only during the dry season when the cane is being crushed. This timing is still advantageous to Costa Rica since the dry season is when there is the greatest need for additional generation capacity because of the reduction in ICE's hydro power output. This approach would result in annual petroleum savings from surplus power production of $120,000 to $165,000 per mill studied in this report.

For all-year electricity production, higher capital investments and additional off-season fuel supplies are needed. With supportive public policies on private power sales and larger investments ($9 to $20 million per mill), the industry might produce as much as 400 to 500 million kilowatt hours of power per year (the equivalent of 50 to 55 megawatts annual capacity), with several larger mills providing electricity on a firm basis for the entire year. The value of net national petroleum savings produced by each of these larger mills studied would range from $1.1 to $2.2 million per year, a substantial economic benefit to the country.

The precise pattern of production, of course, would depend heavily on local conditions and the investment decisions of mill owners and managers. In either case, the power produced could be sold at a

price at or below that available from alternative new sources of electricity (diesel, gas, geothermal), and would provide additional economic benefits to the nation. Among the latter are increased rural employment and farm income as well as the displacement of imported fossil fuels. The exact amount of power that can be produced and the extent of national economic benefits, however, both depend partly on the extent to which mills are able to harvest and burn cane field residues or identify other biomass sources of fuel - the major technical uncertainty affecting the prospects for cane power production in Costa Rica.

Figures 13, 14, and 15 summarize the power output and the financial and economic returns for the candidate mills under different technical projections using the "base" case assumptions set by the team. These figures also show four levels of investments with different power output options.

Thailand

In mid-1986, a team of cane energy specialists sponsored by S&T/EY examined a number of potential sugar industry products and their markets in Thailand. This study concluded that the most attractive option in the new term is the generation of electricity for sale to the national grid during the seven- to eight-month non-grinding season, when sugar factories do not use installed power equipment. National potential is estimated at over 200 MW using existing installed capacity in the sugar industry, thus requiring no new capital investment. Cane trash is the recommended fuel, which is already collected to a limited extent in Thailand for animal feed purposes. Projected electricity generation costs are less than four U.S. cents per kilowatt-hour, or about two-thirds current costs in Thailand. Once electricity markets are opened to the sugar industry, investments in more efficient power equipment will become attractive with a power generation potential over 1000 MW.

At this time U.S.A.I.D./Bangkok is sponsoring applied research in trash collection methods at the Nong Yai sugar mill as part of their project in Rural Private Sector Development. S&T/EY is collaborating with U.S.A.I.D./Bangkok in the design of this activity and development of private power generation in the sugar industry.

Jamaica

An in-depth feasibility study was completed in September 1986 by Bechtel National, Inc. and Ronco Consulting Corporation for a private sector 35 MW power project at the Moneymusk sugar factory in Jamaica that will burn sugar cane bagasse and trash. Based on the projected returns of the proposed project, Bechtel made a proposal to the Government of Jamaica (GOJ) in December 1986, and is in the process of discussions on private equity financing.

Figure 13. Technical Projections of Base Cases for Sugar Industry Power Production in Costa Rica

Option/ Mill (M US$)	Power Export	Days Produc- (M kWh)	Fuel tion	Technical System Type(s)*	Capital Cost Attributes	Financial NPV (M US$)
Level 1						
El Viejo 1	1.6	121	Bagasse	No changes, 455 psig	0.00	0.82
Q. Azul 1	2.5	142	Bag./hydro.	No changes, 200 psig	0.00	1.10
Level 2						
El Viejo 2	9.6	121	Bagasse	Topping Turbine	1.54	2.86
Level 3						
El Viejo 3	91.9	335	Bag./Oil	Topping Turbine, plus 3 condensing turbines	9.60	2.62
Level 4						
El Viejo 4	101.6	335	Bag./Oil	New System, 850 psig	17.31	-0.09
Taboga 4	104.0	335	Bag./Oil	New System, 850 psig	19.77	2.00

* Sensitivity analyses add trash (cane field residues) to extend electricity production or substitute cane trash or coal for oil as off-season fuels.

Figure 14. **Financial Net Present Value - Base Case**

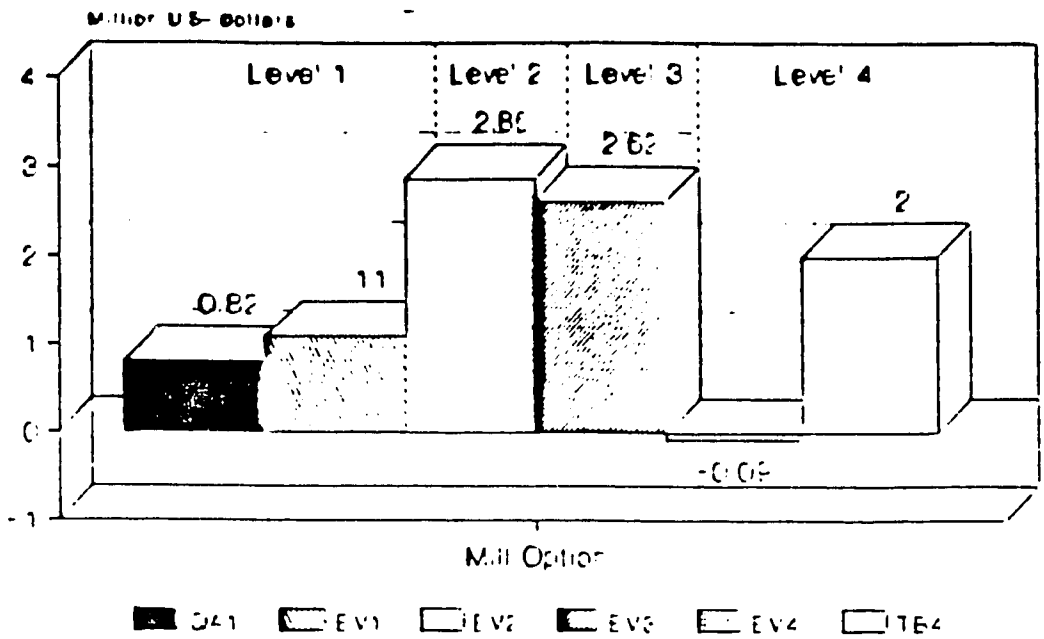
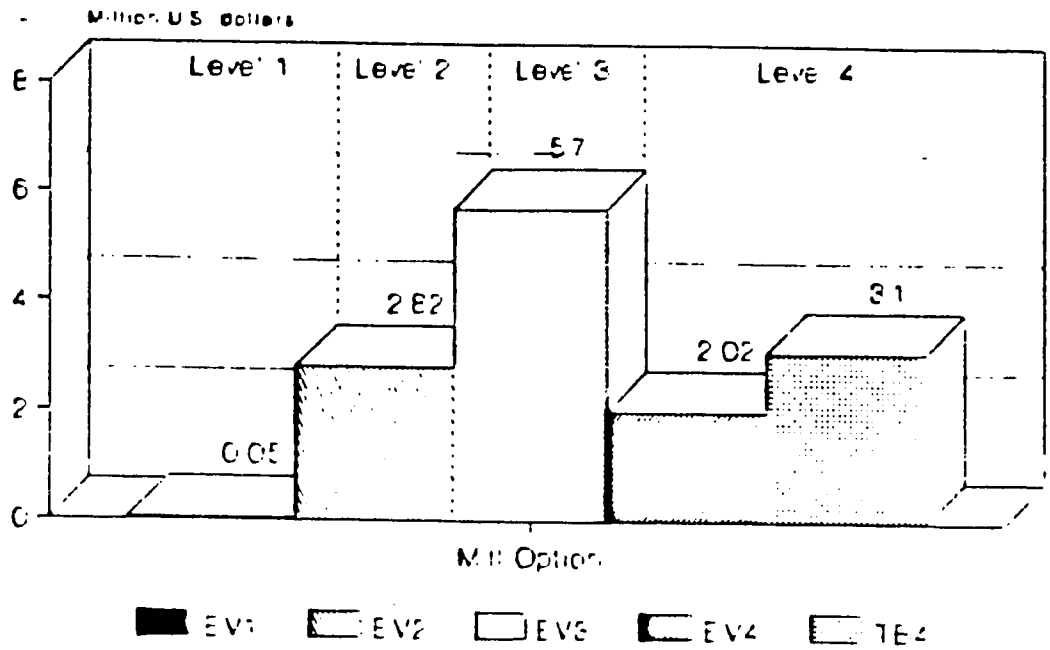


Figure 15. Financial Net Present Value with Trash Fuel



U.S.A.I.D./Jamaica and the A.I.D. Office of Energy (S&T/EY) in Washington collaborated in pre-feasibility analysis (Summer/Fall 1984) and contributed feasibility funding. A.I.D.'s funding for this work was augmented by funds from the Trade & Development Program (TDP) and Bechtel, and was crucial to bringing this innovative project to its current stage. The project will be important in boosting revenues, preserving employment and diversifying the problem-plagued Jamaican sugar industry into energy markets. It will also eliminate the large government subsidy to the sugar company, displace yearly 0.75 million barrels of oil imported to Jamaica to produce electricity, and should help pave the way for similar energy production and privatization projects in the sugar industry.

A major element of the Jamaica project is the development and testing of a prototype equipment system for collection and preparation of cane field residues (trash) for use as boiler fuel. The use of trash substantially improves the economic viability of the project, and requires commercial scale testing for integration with present project plans. This innovation is also important to A.I.D.'s worldwide cane activity, and a number of locations are anticipating field results from the Jamaica research.

Thus, Cameco Industries made a presentation to U.S.A.I.D., GOJ, and Jamaican sugar industry officials in February 1987, on conceptual and engineering design of a cane trash collection system. U.S.A.I.D., the Sugar Industry Authority, the Ministry of Mining, Energy and Tourism (MMET), and Jamaica Sugar Holdings, Ltd. (which manages Monymusk and Frome sugar companies, the two largest) endorsed the proposal to develop and test the cane trash system. A.I.D. has funded the procurement and testing of the equipment system.

Philippines

Potential for Sugar Mills to Generate Surplus Electricity

In a comprehensive analysis of the sugar industry in the Philippines, prepared for A.I.D. in the spring of 1986, a team of specialists reported on the potential for power generation and sale of excess electricity to non-mill end-users ("The Sugar Industry in the Philippines: An Analysis of Crop Substitution and Market Diversification Opportunities, Ronco Consulting Corp., August 1986).

Opportunities for the Philippine Sugar Industry to Sell Surplus Power

The potential market for surplus power from the sugar industry varies widely from one region to another. At this time power shortages only appear to be a problem on Luzon. Until the nation's economy picks up, the power shortages on Luzon will be limited to peak demand periods. However, an economic recovery could leave Luzon with baseload capacity shortages by 1990-1991.

Investment decisions made by 1988 would lead to plants able to deliver power at that time.

On Luzon much of the crop is burned prior to harvest and the efficiency of energy use in the industry is generally low. Consequently, a discussion of the possibilities for electricity production must assume certain changes in field practices and improvements in mill efficiency. Less burning of the crop can be induced by changing the incentives for cutters. In Thailand, for example, burned cane receives a substantially lower price than green cane.

Many of the Philippine mills rely on very old boilers. Replacing such units is desirable if the outside electricity sales can pay for the energy savings. The team found that new boilers and generators offer attractive rates of return at electricity prices well below the current wholesale levels in the Philippines.

One section of the report suggested ways in which cane trash could be collected to be used as fuel for power plants. Recent work in Jamaica suggests costs for collection of trash will fall in the range of $8-14/MT (about $4-7 boe).

Changes necessary to make electricity production a feasibile alternative with existing equipment are relatively minor. A study prepared by A.I.D. in Thailand found that relatively simple, low cost modifications of existing equipment could reduce the heat rate for electricity in existing boilers from 45,000 to 50,000 BTU/kWh to the 35,000 to 40,000 range. The major changes include reduced turbine backpressure and improvements to the boiler's performance.

The entire power output from a modified unit could be delivered to the grid for 175 to 200 days, the period when sugar mills in the Philippines are not grinding cane. Only relatively small amounts of power would be available during the crushing season.

In mills with efficient boilers, the retrofits required to produce commercial quantities of electricity are small. They range from about PO.03-0.06/kWh. The only equipment purchases needed are fuel handling systems for the cane trash and improved synchronization equipment for feeding the power into the grid.

Using the existing capacity of all the mills currently operating on Luzon would produce more than 130 MW of capacity additions for the Luzon system from the sugar industry. An additional 100 to 150 MW is available with investment in new boiler and generator units.

Before any definitive answers can be given on the desirability of using sugar mills to contribute to Luzon's power supply, several issues need to be investigated more closely. These issues are:

- the receptiveness of the NPC to large volumes of private power;

- cane trash harvest costs and required changes in agronomic and harvest practices, if any; and

- financial support for equipment purchases from external donor agencies or banks.

NPC has indicated a willingness to discuss power generation by the sugar industry. Modified existing units could be used to meet peak and intermediate loads since their capital costs are low per unit of output. Investments in new efficient power generation equipment can probably only be justified if units operate as baseload plants. In the Thailand case the authors found that upgraded plants needed to operate at a load factor of at least 50 percent before they were economic.

Mauritius

Almost 60 percent of Mauritius' total primary energy requirements are met with bagasse-fired generation of power and steam in the sugar cane industry. Most of this energy is consumed within the industry, but in 1986 15 sugar factories exported 115.3 million kWh (or Gigawatt-hours [GWh]) to the public grid, which made up 16.6 percent of total power sold by Mauritius' Central Electricity Board. Of this power, 72 GWh were from bagasse and 43 GWh from coal, including approximately 80 GWh of power from one plant, the Flacq United Estates Ltd. (FUEL) sugar factory. FUEL is a 21.7 MW bagasse-coal year-round power station which has been in operation since 1984 and has become the principal baseload facility for the CEB grid.

Government policy calls for increased use of indigenous fuels to meet a 12 to 14 percent annual growth in electricity demand and to lessen dependence on imported energy. As Mauritius' limited hydro resources are largely developed and the country has no fossil energy resources, greater cane industry cogeneration of power from bagasse represents the principal option.

B. Alcohol from Sugar Cane and Molasses

The attractiveness of fuel alcohol from biomass in A.I.D.-assisted countries depends to a large degree on world prices for petroleum and sugar, but also on local and regional economic factors and trade relationships. The recent fall in oil (and alcohol) prices and sugar price increases illustrate that the market outlook is by no means certain. In its technical assistance role, the BST Project has sought to perform careful analyses of the costs and benefits of alcohol production by sugar industries under various price scenarios and with a view toward promoting diversification of the sugar industry into a variety of commercial products. BST has conducted detailed alcohol assessments in Honduras, the Philippines and Malawi, and has provided advice to a number of other countries. These effforts are summarized below.

Honduras - Fuel Alcohol Production

BST collaborated with U.S.A.I.D./Honduras in the first half of 1986 to conduct an economic, financial and technology analysis of alcohol production for export by the sugar industry. As in other countries covered by the Caribbean Basin Initiative (CBI), interest in alcohol stemmed from the prospect of duty-free export to the growing US market. The estimated returns from alcohol, however, dropped as its price fell with the fall in oil prices, and alcohol was projected to be only slightly better than world market sugar over the short term, making major investments risky. The study recommended against a Honduran subsidy or incentives for domestic alcohol use, but recommended investment by the sugar industry in a 120,000-150,000 liter/day distillery to take advantage of subsidized U.S. alcohol markets when world sugar prices were poor. BST also examined applications for production of yeast, bagasse-based animal feeds and carbon dioxide for local markets from the sugar industry. The study became the basis for U.S.A.I.D./Honduras to provide policy advice on future directions for the Honduran sugar cane industry.

Philippines - Sugar Industry Diversification

In the second half of 1986, S&T/EY sponsored a comprehensive assessment of options for the severely depressed Philippine sugar industry for U.S.A.I.D./Manila. One of the studies examined alcohol potential at various sites, and the prospects for development of animal feeds in the sugar industry. It concluded that market potential for ethanol was not promising without subsidies or higher world energy prices, but that development of yeast-based animal feeds from sugar and molasses was quite promising and that investor interest appeared strong. BST recommended steps to capture that opportunity.

Malawi - Ethanol Expansion Feasibility

In late 1988, the BST Project sponsored a mission at the request of the Government of Malawi to assessthe feasibility of increasing the production and use of ethanol from molasses as a transportation fuel in Malawi, which has had blend program since 1982. Because of very high inland freight costs, the delivered cost of petroleum products is over $1.20/gal (Sept.'88) in Malawi and clearly justifies the conversion of low value molasses to ethanol, currently saving some $3MM/yr in foreign exchange. In its preliminary conclusions, S&T/EY determined that raising ethanol use in gasoline blends to the target 20 percent level, as well as new uses as a neat fuel (100 percent ethanol) in sugar cane estate tractors and some GOM fleet vehicles, are profitable and economically sound strategies which Malawi should pursue. The final feasibility analysis will propose a least cost expansion strategy, comparing two proposed sites for new ethanol production and recommending steps to continue private investment and management for a larger industry.

Future A.I.D. Role

While debate in the U.S., with lower oil prices, centers around the continuation of subsidies for ethanol, it is clear that there are A.I.D.-assisted countries where new ethanol development makes sense without the need for subsidies. Some of these are Zimbabwe, Swaziland, and Sudan; should world energy prices rise, other countries would become candidates for alcohol fuels from indigenous biomass. Further, as new technology becomes commercial, it is likely that feedstocks other than molasses will become cost-effective sources for conversion to high-grade fuels. The new BEST Project will continue A.I.D.'s technical assistance role in providing analysis and development advice on alcohol strategies, relating U.S. commercial and technical skills to this process, and monitoring new technology developments for their relevance to developing country settings.

C. Electricity and Process Heat from Rice Residues

India

The Punjab Agro Industries Corporation (PAIC) of northern India is proposing to establish a commercial scale (2.5 MW) biomass power plant fueled by rice straw. In partnership with PRM Energy Systems, Inc., of Stuttgart, AR, and supported by local engineers (ICB Private Ltd. of New Delhi), PAIC intends to demonstrate the commercial viability of power production from agricultural wastes using a system requiring collection, baling, storing, and processing of rice straw as a combustion fuel. Both the BST project and the PACER project of U.S.A.I.D./New Delhi are encouraging this activity.

Upon demonstration of technical and system viability, PAIC intends to replicate this project throughout the Punjab using 1.5 to 10 MW versions of the facility at an average cost of $5 million/plant and producing 1000 MW throughout the region. Anticipated steam and electricity sales from the first plant will average $2.5 million/year with ash sales profits of over half a million dollars/year. Annual fuel costs for straw @ 200 Rps/ton will average $900,000. Net profit before taxes should average over $1.0 million per year.

Given the extraordinary volume of agricultural wastes available in India, the success of this project could open the door for extensive mobilization of biomass resources for energy production in India.

Indonesia - Potential for Private Investment in Rice Residue Power Generation

Rice residue electric power systems can either be associated with a rice mill, utilizing the mill's captive feedstock, or stand alone as power plants that purchase part or most of their feedstock from

farmers or mill owners in the surrounding area. (See Figure 16.) A BST study analyzed the potential for both models in Indonesia, in terms of resource availability, costs, and policy impacts.

Commercially proven rice husk electric power systems in the U.S. depend primarily on captive feedstocks of 83,000 to 112,000 MT/year. With the exception of the few large mills on Java, the current average size of rice mills (1 ton paddy [gabah]/hr) in Indonesia does not allow for sufficient accumulation of captive rice husk feedstock for these mills to depend exclusively on their own feedstock for power systems of even 600 kW to 1.5 MW. Adequate surplus husk and straw, however, are available in enough rice growing/milling areas (even at a 25 percent availability rate) to suggest that collection-based systems are an option.

The analyses conducted in Indonesia suggest that rice residue power systems which incorporate efficient (higher ratio of kcal-in: kcal-out of the newly demonstrated commercially proven rice husk energy system) technology and use collected husk or straw (though not necessarily as mixed fuel) may be profitable over a wide range of feedstock costs - up to three times current market prices - given 1) dependable electricity sale prices of 90 Rp or more per kWh, 2) high load factors (over 75 percent) at the power plants, and 3) guaranteed ash markets. Private investment in collection-based residue power systems can be a viable commercial option, particularly for less capital-intensive systems, but will depend upon residue collection systems designed for and proven cost-effective at a particular site.

As shown in this prefeasibility analysis, potential benefits of rice residue power systems to the agricultural sector include waste utilization and ash sales, reliable rural electricity, additional farm and off-farm jobs, and increased "value-added" to the rural economy of Indonesia. Balanced against these economic incentives is the current high risk for investors in private power systems due to the lack of clear legal guidelines and institutional support in Indonesia. The chart in Figure 17 summarizes constraints and options.

Philippines

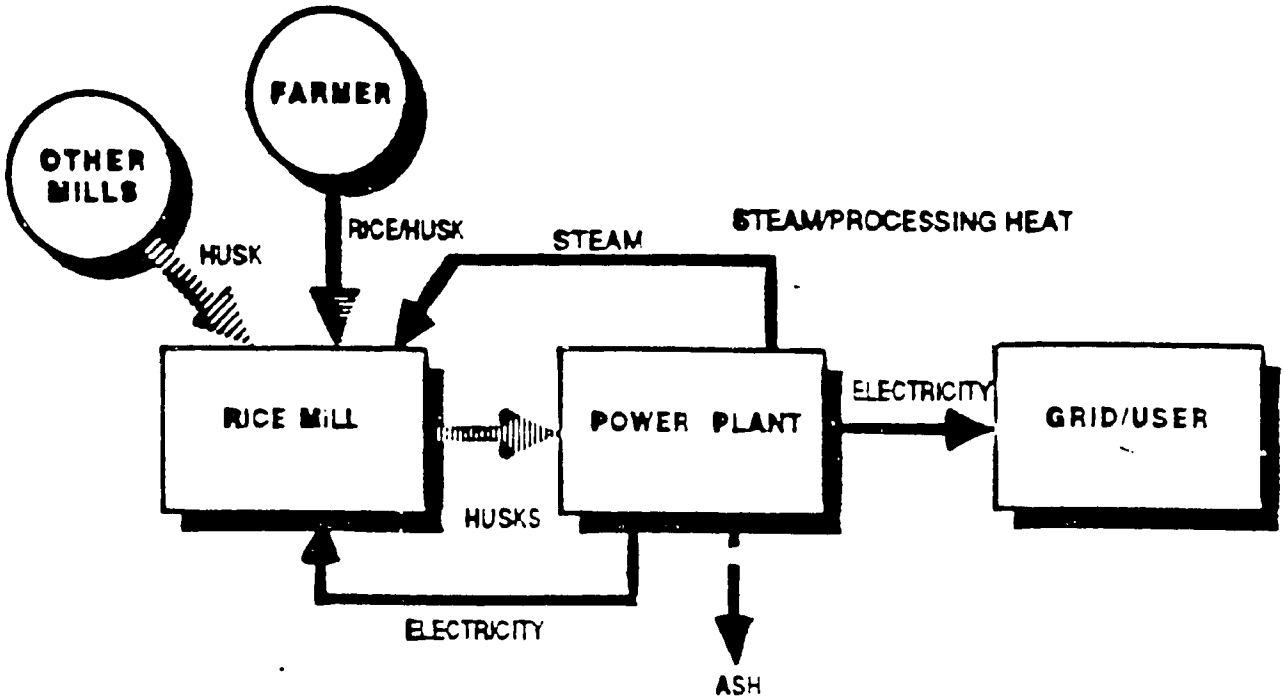
An analysis conducted in the Philippines by BST staff and rice power consultants indicates a strong opportunity for developing successful decentralized power generation plants utilizing rice residues for fuel because:

- The quality of education of local engineers is good and their background suggests they could be trained to be excellent operations supervisors.

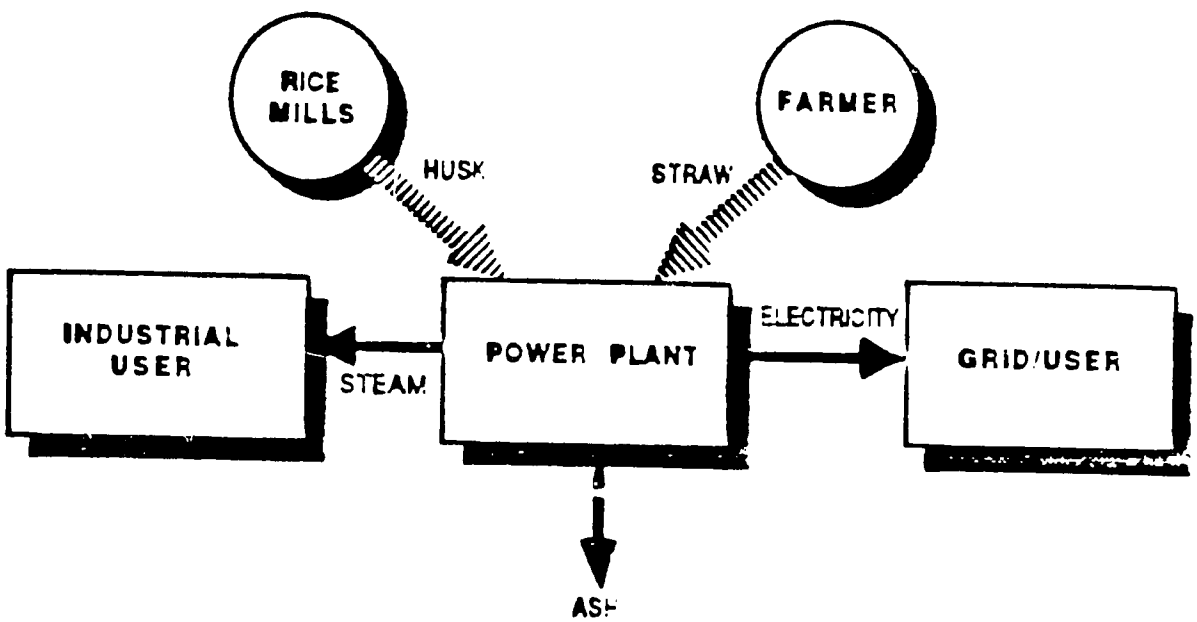
- There are many qualified engineers available for employment.

- There are several areas with extensive cultivation of rice and an infrastructure to support plants.

Figure 16. Integrated Rice Mill-Power Plant System



Stand-Alone Rice Residue Power System



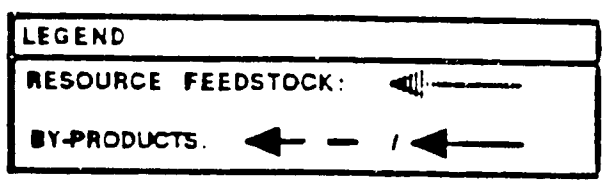


Figure 17.

SUMMARY

SITUATION/CONSTRAINT	OPTIONS
RESOURCE BASE	
Adequate husk available in several areas for small (600 kW to 1.5 MW) power plants but lack of adequate husk supply at most individual mills given decentralized milling capacity. Collection/transport of husk would be necessary to supply even small-scale plants.	Due to lack of alternative uses for husk and straw, energy systems could buy the residues but must create a reliable, low-cost residue collection and transport system. Seasonal and geographic production differences and logistics must be considered in plant location. Optimal initial sites may be on-Java.
Straw also in sufficient volume but like husks it is dispersed and would require a collection/transport system that does not exist in most regions.	
Given lower melting point of rice straw systems should not presume mixed fuel possibility.	
TECHNOLOGICAL	
Due to small mill capacity, the current size of commercial rice residue power systems is too large for Indonesia.	Downsizing of commercial power systems is needed, and is underway by some foreign firms. New smaller systems will still require commercial demonstration.
ECONOMIC	
Analysis of smaller model systems show positive returns over a range of feedstock prices and electricity purchase prices provided that: there exists a reliable residue transport system, high load factors and by-product (ash) sales. World markets for ash appear strong. Actual feedstock costs, while a small percentage of total costs, are highly uncertain.	Power plant owners would need to ensure a husk transport network by guaranteeing prices for the feedstock. Firm power contracts for electricity prices must be negotiated and enforceable. Government must guarantee contracts.
FINANCIAL	
Local investors require extremely short (1 yr) payback periods and high returns (35-45%) due to past instability and current conditions for alternative investments. Although firms invest in on-site captive energy use, most feed power generation has high risks due to tax and legal policies that discourage foreign and local ventures.	Provide incentives for private energy investment on a selective basis.
POLICY	
Rice Current government policy is to encourage small mills (1T/hr) because of employment and income benefits and food supply stability.	Production of rice residue power will require either large mills or substantial residue collection system.
Electricity New 1985 electricity law allows sale of electricity by private producer, but few cases of private power generation for sale currently exist. Private sector is uncertain of legal and government support.	Further laws or guidelines must be established to ensure both electricity sales and prices are guaranteed. Ongoing successes need to be publicized.

- The National Power Corporation has demonstrated its willingness and ability to contract for power purchase as is evidenced by its contract with Proctor and Gamble (5 MW coconut-shell fueled plant).

- There are experienced local contractors with a demonstrated construction capability.

- The cost of "doing business" can generally be pinpointed with some reasonable degree of accuracy.

- Local qualified partners seem readily available.

Private locals and the National Food Authority both seemed willing to cooperate and facilitate a proposed venture.

There is a definite need for additional generating capacity in the Philippines, particularly in Mindanao and Luzon. Projects in the Philippines have been delayed by recent events there. Currently, however, two U.S. companies are negotiating for feasibility studies: 1) a study funded 50/50 with the Trade & Development Program for power generation using rice husk on Luzon and 2) a steam/heat/power plant study for a private firm planning to install a rice husk energy system at a desalinization plant.

D. Electricity and Process Heat from Wood Residues

Indonesia

In 1987-88 BST, in cooperation with private industry and U.S.A.I.D./Jakarta and with the assistance of TEM Associates, carried out a prefeasibility study of the prospects for the use of wood waste produced at Indonesian forest product industry sites, especially plywood factories, to substitute for diesel fuel for on-site power generation. Presently the industry uses diesel fuel for primary or supplementary power generation at virtually all of its sites. In most cases outside of Java there is no local grid to provide power to the industry. The wood waste, which can constitute as much as 50 percent of the total raw lumber entering the factory, is either piled in heaps and burned, used for landfill, or dumped in rivers and the ocean. This waste constitutes a potential energy resource for on-site power generation within the Indonesian wood products industry and eventually for rural electrification as well. Its use as a fuel in generating power at plywood industry sites would also mitigate the environmental consequences of its dumping.

There is a significant associated potential market for U.S. industry to supply or provide equipment for small standardized multi-megawatt integrated wood waste-fired power plants and cogeneration plants to the Indonesian wood products industry. Over the next ten years the total market for U.S. equipment suppliers could be as high as $400 million. The technology is well suited

for private power initiatives by U.S./Indonesian joint ventures that would build, own, operate, and in some cases, transfer this technology at Indonesian plywood industry locations.

The use of wood waste power generation in Indonesia could address important social and economic development goals as well as benefit the Indonesian wood products industry directly. Wood waste currently produced at Indonesian sawmills and plywood factories is sufficient to power some 1,000 MWe of distributed small steam power plants.

The widespread use of this technology ultimately could provide significant power for economic and social development on Indonesia's outer islands; establish new private sector initiatives for the production, sale, installation, and maintenance of wood waste power systems, increase the stability of the private wood products industry; increase diesel fuel exports; and improve the environmental and health conditions of the plywood manufacturing industry.

Environmental impacts from possible future expansion of the Indonesian plywood industry are considered in this study. (The proposed project would make use of wood waste presently produced by the forest products industry; wood is far too valuable in the form of exported products to be used in its primary form as fuel.) The tropical forests of Kalimantan and of Brazil constitute the world's last great virgin tropical rain forests. While the Indonesian government has indicated that commercial forest concessions in Kalimantan will not expand significantly over the coming decade, the foreign exchange revenues of the Indonesian forest products industry may foster reconsideration of this. Yet reforestation in Indonesia can be difficult and the BST staff and consultants are exploring ways in which the proposed project could be used to stimulate effective private sector participation in sustainable forest management.

The work reported here indicates that even with the present 50 percent subsidy of diesel fuel in Indonesia, small (ca. 2.5 to 3 MWe) integrated standardized wood waste-fired power plants could be economically attractive. Joint U.S./Indonesian private sector initiatives could lead to establishment of an important new industry in Indonesia. Several U.S. and Indonesian companies participated in this study and have indicated a strong interest in establishing such an industry. The financial and economic analyses conducted as part of this study are discussed in some detail in section V.C. of this report.

Costa Rica

The BST project initiated a remote location biomass gasification project near the town of Horquetas, Costa Rica in 1983. The intention of the activity was to construct a 150 kW wood gasifier at the edge of a virgin forest being logged for the first time.

The gasifier would use wood waste from the lumber mill and produce power for the town of Horquetas. In addition, the project was to be coordinated with conservation efforts being promulgated by the Government.

After five and a half years, the Horquetas project has not proven itself on several counts. The commercially proven gasification equipment has not functioned according to specifications. Attempts to rectify problems have also met with failure. BST concludes that at the present time, remote location gasifiers are inappropriate for two main reasons:

1) There is only a small number of gasifier manufacturers, limiting the system possibilities and the necessary aspects of competition;

2) The operation and maintenance of gasifiers is not simple in any location and fraught with difficulty in remote ones. Qualified personnel are few in this area of application and even fewer in the remote areas where wood gasification can make sense from a wood waste to energy point of view.

V. RESULTS OF BST PROJECT ECONOMIC AND FINANCIAL ANALYSES

A. Cane Energy Systems - The Example of Costa Rica

To determine the attractiveness of cane power production in Costa Rica and to identify key factors influencing the commercial success of the systems, A.I.D. conducted an investment analysis, applying an investment model developed for sugar mill power investments (CANEPRO Version 1) to generate scenarios for the target mills based on varying capital investment and power output assumptions. The study conducted both financial and economic analyses to show the private and public sector incentives. Sensitivity analyses are made on key variables in the scenarios - electricity purchase price, loan rates, fuel costs, and power load rates - to determine the risk associated with each of these factors. Four investment levels were developed for the mills based on alternative technical options.

Present value analyses of the mills show cane energy production to be attractive at a variety of investment levels (Figures 18, 19 and 20). From a financial perspective, mills could expect to receive anywhere from U.S. $1 to $3 million in net returns before taxes. Only one option, EV4, loses money. Applying Costa Rica's business tax rate, the net present values fall by 50 percent.

In economic terms, at medium electricity prices, all low power levels of investment are attractive to the country but high power scenarios show negative NPVs due to their dependency on imported fuel oil. The highest economic returns are realized with extended electricity production at low power output, investment Level 2.

Beyond the net returns of the investment, the mills and country must compare the capital and foreign exchange requirements and amount of power exported for the various options. Levels 1 and 2 require little or no capital, and similarly have zero or low foreign exchange needs. In contrast, Levels 3 and 4 often have NPVs near Level 2, but require U.S. $10 to $20 million of capital and can draw off from U.S. $6.7 to $8.7 million in foreign exchange for 11 to 13 MW power sales. When comparing options, the low investment/low power and moderate investment/high power scenarios (options EV2 and EV3) may fare the best overall in terms of financial NPVs, foreign exchange and capital requirements when compared to power output.

Costa Rica's utility faces serious economic and timing issues in developing its generation expansion plan. ICE needs to select a least-cost expansion strategy that will keep its rates down. However, the most attractive least-cost options, such as geothermal or hydro, have long lead times and ICE is under pressure to invest immediately in additional baseload capacity. The utility is paying dearly for its reliance on expensive gas turbine and diesel power generation, while the country is in jeopardy of losing its competitive edge in attracting new export industries since local and foreign companies cannot be assured reliable and sufficient electricity by the utility.

Implicit in the fuel price sensitivity analyses for cane power systems (Figure 18) is a comparison to ICE's planned least-cost options. Currently, ICE must rely on diesel and gas turbine units throughout the dry season for meeting its peak and off-peak demand, and in the wet season diesel for peak hours but a mix of hydro and fuel oil for off-peak hours. The only systems ICE can develop in the short term are diesels or gas turbines. ICE pays seven U.S. cents per kWh based on its existing diesel/gas systems. Note that this is an average cost; it is not the cost of new or rehabilitated diesel units, i.e., not the short term avoided (marginal) cost.

Long run marginal costs reflect the integration of geothermal units into the grid. ICE's long term plans are to bring on sufficient geothermal, and possibly coal, to substitute for much of its diesel/gas turbine use. Due to quite recent delays in ICE's geothermal plans, such options are not expected to come on line until the mid-, not early, 1990s.

In the short term, sugar cane power investments at all proposed levels are the least cost option for the country. Further, unlike other options, they appear to be the only realistic indigenous fuel alternatives available to Costa Rica in the short term. When combined with the results presented in Figure 21 that show annual petroleum savings for each mill, power from sugar cane residues becomes even more attractive to the country as a serious generation option.

Figure 18. Direct Financial Benefits and Characteristics of Cane Power Systems with Trash (1988)

Mill*	NPV (M US $)	Capital (M US $)	Foreign Exchange (M US $)	Power Export (M kWh/yr)
Level 1				
QA 1	0.82	0.00	0.00	2.5
EV 1	1.10	0.00	0.08	1.6
EV 1T	0.05	0.00	0.08	3.5
Level 2				
EV 2	2.86	1.54	-0.33	9.6
EV 2T	2.82	1.54	-0.33	13.8
Level 3				
EV 3	2.62	9.59	-6.70	91.9
EV 3T	5.70	9.73	-5.94	91.9
Level 4				
EV 4	-0.09	17.31	-8.71	101.6
EV 4T	0.02	18.04	-8.17	101.6
TB 4	2.00	19.77	-8.23	104.0
TB 4T	3.00	19.77	-7.68	102.0

* Mill options followed by a "T" are ones utilizing cane field residues (trash) as fuel.

**Foreign exchange represents the total direct net foreign exchange requirements (without shadow valuing) of the investment option, i.e., the total foreign exchange saved from the displaced petroleum at a mill minus the foreign exchange needs for capital and operating expenditures. Negative values indicate net outflows to the country from an investment option. Note, however, this value does not include the indirect foreign exchange savings to the country from cane electricity replacing diesel-based electricity generation by the utility.

Figure 19. Financial Net Present Value - Base Case

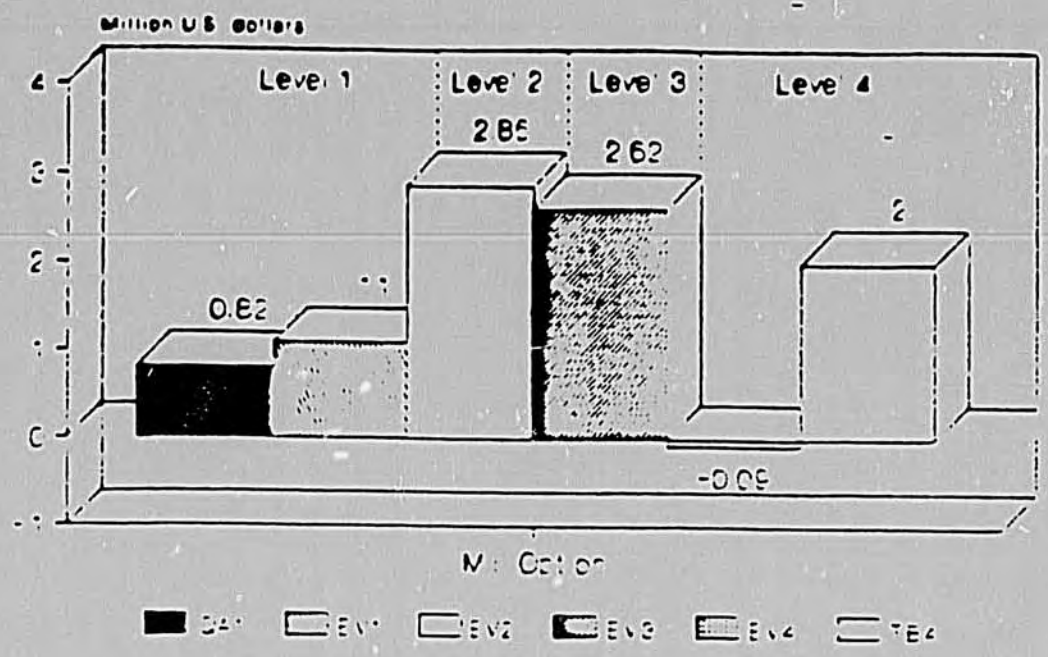
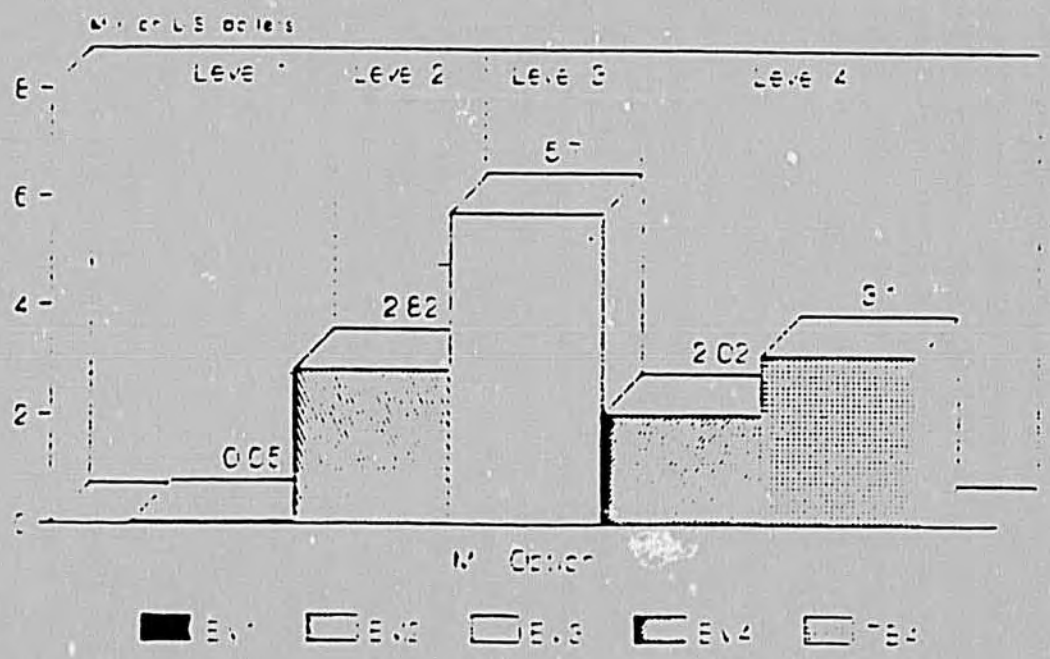
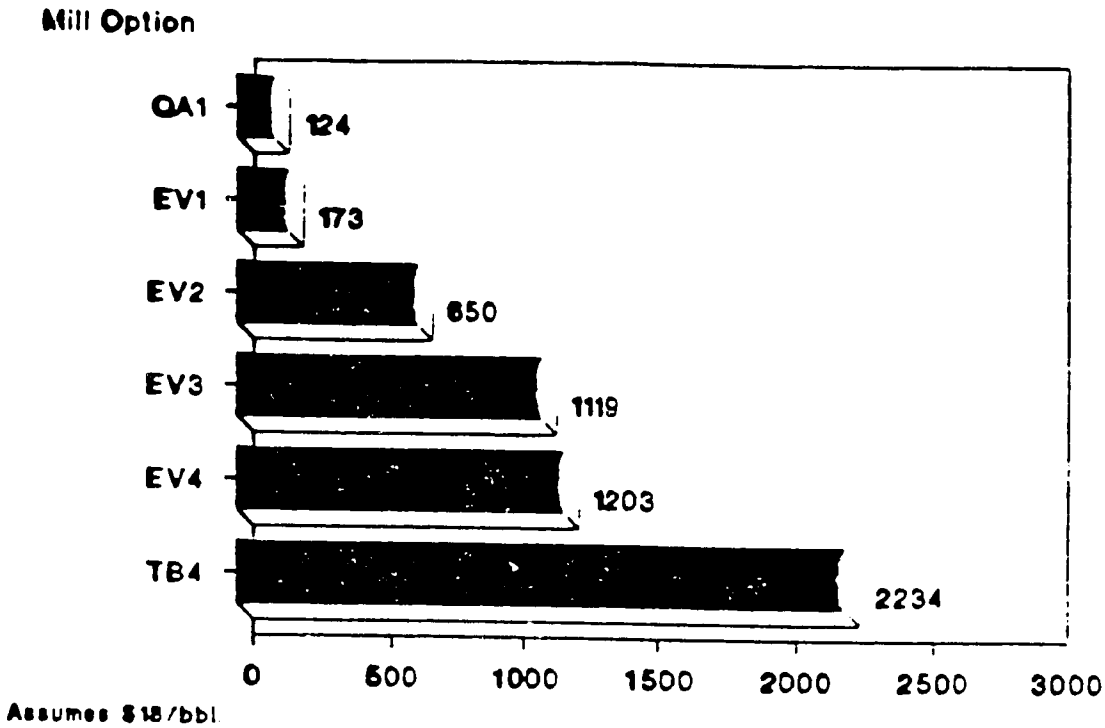


Figure 20. Financial Pet Present Value with Trash Fuel



Note: The addition of trash fuel reduces the net profits (while increasing power output) of Levels 1 and 2 because costs for the fuel increase total costs more rapidly than increased revenue from the new power sales.

Figure 21. Annual Petroleum Savings by Mill (Thousand U.S. Dollars Per Year)



B. Energy from Rice Residues - The Example of Indonesia

In Indonesia, the government commitment to rice production resulted in an astoundingly successful intensification program which carried Indonesia from the status of major rice importer to the attainment of self-sufficiency in 1984-85 with 3.4 million tons of rice in Government stocks.

Beyond its value as the most prominent source of calories for Indonesians, the rice industry is also important to the economy for the number of jobs provided. In addition to being a major employer of rural people in rice growing areas, the transportation, processing, and marketing of rice create many additional jobs. In Indonesia small farmers contribute 60 percent of the agricultural GDP and employ 54 percent of the labor force of the country. A majority of these are rice farmers responsible for rice cultivation on more than nine million hectares of land and for rice production of over 26 million tons (1985-87, milled basis). Rice is the mainstay of the Indonesian diet and as such, has received major dedication to national resources in the form of techniques to maximize productivity and to maintain local availability of rice to consumers.

Increased rice consumption in Indonesia is directly correlated with increased annual per capita income, both showing a 2.1 percent average annual growth rate between 1969 and 1985. The fact that the urban population is growing faster than the general population also implies expected future need for intensified production. Maintaining the health of the rice sector is a keystone to economic growth in Indonesia.

In financial analysis of a 600 kW rice residue power system conducted by BST, rice residue energy production was attractive over a range of reasonable electricity prices provided the system can operate a sufficient number of hours with an acceptable load factor, can obtain a steady supply of residues, and can find a reliable market for ash. Unit costs appear competitive even against current utility tariffs (103 RP/kWh). The 1.5 MW rice residue power system, in contrast, becomes competitive only if the national utility's purchase price reflects the high electricity costs (i.e., full avoided costs) experienced Off-Java.

The economics of both systems depend upon five key factors: feedstock cost, system load factor, PLN purchase price, ash price, and system conversion efficiency. Feedstock cost has less effect on the viability of the system than the other factors. In order to finance debt associated with installation of these systems, an established rice processing company will need to have firm contracts for purchase of electricity and ash.

At the macroeconomic level, production of electricity and other products from rice residues will strengthen rural economies by creating jobs, reducing energy imports to rural areas, and increasing revenues associated with production and processing of rice. It could also attract new investment to rural areas.

As shown in Figure 22, these basic cases demonstrate the absolute importance of ash sales to the viability of rice power systems, where the cases are:

1) a "base" or financial analysis case that uses the current or expected market prices for the systems' costs and benefits;

2) a "no ash" case, which is a variation of the base case but where no ash sales are included;

3) a "worse" case scenario where market prices are high for husk but electricity and operating days low and no ash sales exist; and

4) an "economic" case where higher feedstock and the full avoided costs of electricity are used in the models.

More detailed sensitivity analyses were conducted on capital costs, husk price, ash price, operating days and electricity prices. The findings support the following general conclusions:

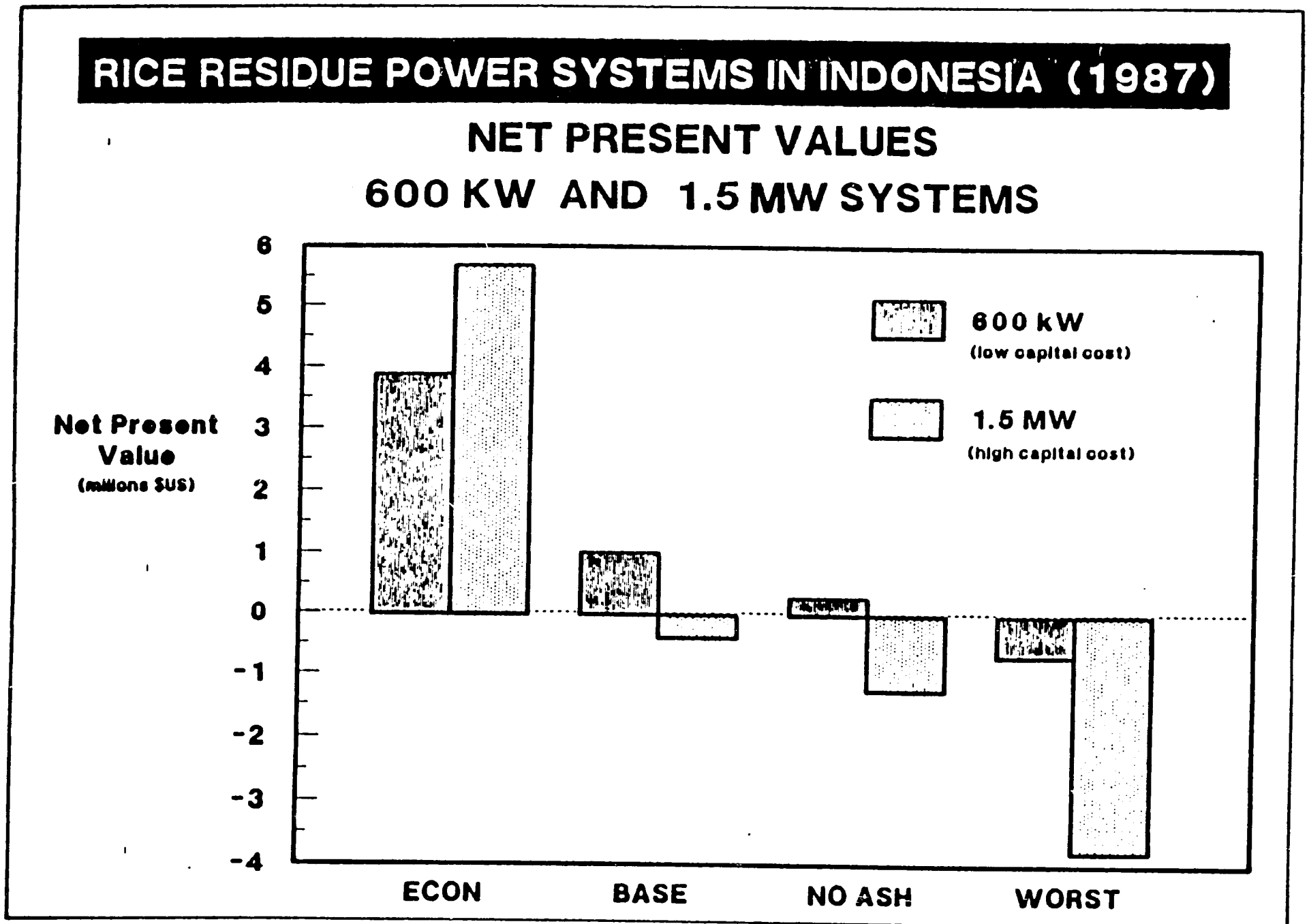
° The 600 kW (250 psig) systems are more financially and economically attractive than the 1.5 MW (650 psig) systems due to the formers' substantially lower capital costs. (In contrast, one expects scale economies to favor 1.5 MW over 600 kW systems. However, these plants are very different technically.) These costs are lower for the 600 kW systems primarily because they are run at much lower psig than the 1.5 MW systems and require less costly feedstock preparation equipment and other hardward.

° Assured sale of the ash to a guaranteed market is absolutely essential to the viability of all systems, particularly 1.5 MW power plants. This by-product market is the major factor that determines whether these systems are attractive investments.

° Ability to achieve high load factors at a rice residue power plant is fundamental to the viability, financial or economic, of any system. It is particularly important to the larger system, which must be run close to a full operating schedule, near 290 days per year if high capital costs are assumed and 240 days if low capital costs are assumed. In contrast, 600 kW systems have far less stringent operating day requirements.

° The level of the PLN electricity purchase price is less important to the 600 kW than the 1.5 MW system. It can range over a wider band for 600 kW systems to be financially and economically feasible but must be at or above the current tariff rates when low capital costs are assumed for the 1.5 MW system and at or near the full avoided costs for the larger 1.5 MW system when high capital costs are used.

Figure 22.


RICE RESIDUE POWER SYSTEMS IN INDONESIA (1987)
NET PRESENT VALUES
600 KW AND 1.5 MW SYSTEMS
Net Present Value
(millions $US)
6
5
4
3
2
1
0
-1
-2
-3
-4
600 kW
(low capital cost)
1.5 MW
(high capital cost)
ECON
BASE
NO ASH
WORST

- Feedstock costs have minimal impact on total costs and system feasibility for either system, since they represent a small percentage of total costs and negatively affect only the viability of systems that are at the margin.

- Because of the significantly lower pressure and capital needs of the 600 kW systems, unit costs for the 600 kW systems are almost always lower than the 1.5 MW systems despite the expectation that larger power systems would exhibit economies of scale.

In conclusion, the prefeasibility analysis of generic plants suggests that the smaller scale system (600 kW) can tolerate a wider range of variability than the larger 1.5 MW system in key cost and benefit streams over which it still remains competitive when compared to PLN grid electricity rates. The larger 1.5 MW system has a narrower band of values over which it is an attractive investment to the private sector. Critical factors for a 600 kW system are the sale of ash and capital costs, but it can be feasible over a range of operating days and certainly viable at a probable PLN purchase price of 90 Rp/kWh. Key to the success for a 1.5 MW power system is the absolute need for an ash market, high number of operating days, low capital costs, concessionary interest rates (10 percent), and high electricity purchase prices.

C. Energy from Wood Residues - The Example of Indonesia

Wood waste, which represents up to 50 percent of the total raw lumber entering a plywood factory, is typically piled in heaps and burned, used for landfill, or dumped in rivers and the ocean in many developing countries. This waste constitutes a potential energy resource for on-site power generation. A pre-feasibility study was made by S&T/EY of its use as a fuel in generating power within the Indonesian wood products industry at plywood industry sites to mitigate the environmental consequences of its dumping and displace diesel use at these factories. (This text comes from P. Jezek, J. Weingart, and G. Morris (1988) as published by BST/S&T/EY.)

The use of wood waste power generation in Indonesia addresses a number of important social and economic development goals for the country as well as benefits the Indonesian wood products industry directly. The wood waste currently produced at Indonesian sawmills and plywood factories is sufficient to power 1,000 MWe of distributed small stream power plants for base- and intermediate-load operation. Wood waste at the plywood plants would be sufficient to support ca. 150 MWe of distributed captive power which would be consumed entirely on site. Wood waste produced at sawmills would be more difficult to use as a fuel for power generation, but the resource could support ca. 800 MWe of distributed capacity, most of which would not be required for the sawmills themselves. A separate study is required to determine the opportunities and requirements for using wood waste at sawmills for private power generation.

There is a significant potential market for U.S. industry to supply or provide equipment for small (multi-megawatt) integrated wood waste-fired power plants and cogeneration plants to the Indonesian wood products industry. Over the next ten years the total market for U.S. equipment suppliers could be as high as $400 million. A major study conducted for the Asian Development Bank in 1984-85 has confirmed the potential significance of this market for Kalimantan, and by extension, for all of Indonesia.

The preliminary financial analysis of 3 MW wood waste power plants suggests (Figures 23 and 24) that even with the present 50 percent subsidy of diesel fuel in Indonesia, a 2.5 MWe wood waste-fired power plant could be fully paid for in six years or less, with a 25 percent return on equity. (These figures are preliminary and indicative; a detailed Indonesia-specific project financial analysis will be required using current data, as part of a full feasibility study. This preliminary assessment was conducted in order to determine the general financial characteristics of the project based on information available to S&T/EY at the time of the analysis.) This return primarily reflects the savings in diesel fuel costs, assuming that the wood waste is available at no cost for use as fuel. If operation, maintenance, and diesel generator replacement costs are included in the analysis, the effective payback time becomes even shorter. If the Indonesian government were to phase out the present diesel fuel subsidies over a five-year period (starting in 1990 - the projected first year of plant operation), the payback period would decrease to three years and the return on equity could be 60 percent.

Sensitivity analyses on diesel and wood feedstock prices demonstrate the importance of such prices on project economics. The conservative assumptions with the present diesel fuel price subsidy (Figure 25) and a fuel charge for wood waste ($3/cm) results in a negative annual net cash flow for the first six years of the project, with an associated payback time of 12.5 years and a 12.9 percent return on equity -- an unattractive investment environment. If the wood wastes are free, as they currently are, the cash flows are positive and the payback time is 6.25 years with a (before tax) return on equity of 25.2 percent.

Diesel prices are the key factor affecting project economics. By contrast (Figure 26), if the price of diesel fuel is at the world market price, the fuel price savings are so great that the payback time is relatively insensitive (1.0 vs 1.25 years) to whether or not there is a $\$3/m^3$ charge for the wood waste. The before-tax return on investment is well above 100 percent (the owner's equity is repaid in the first year!). For purposes of analysis, it also was assumed that the price would be gradually raised over a five-year period to the world market price. Under this condition, the payback time is 3.0 years (if wood waste is free) or 4.25 years (if wood waste costs $\$3.00/m^3$ to the plant operator), and the respective before-tax return on equity is either 60.7 or 44.3 percent.

Figure 23. **FINANCIAL SENSITIVITY ANALYSIS**

CASE	DIESEL PRICE ($/Liter)	WOOD WASTE PRICE[5] ($/ton)	PAYBACK TIME[1] (Years)	RETURN ON EQUITY[2]
1	0.13	5.43[3]	12.5	12.9 %
2	0.13	0.00	6.25	25.2 %
3	0.26	5.43[3]	1.25	> 100 %
4	0.26	0.00	1.0	> 100 %
5	Subsidy Phaseout[4]	5.43[3]	4.25	44.3 %
6	Subsidy Phaseout[4]	0.00	3.0	60.7 %

1. On equity.

2. Pre-tax internal rate of return on equity.

3. Equivalent to $3.00/m^3 of green wood (23% moisture content).

4. Present 50% subsidy phased out linearly over a 5-year period beginning in 1990.

5. It is assumed that all of the wood waste could be sold at this price. In practice only 5 - 30% of the wood waste is sold for firewood and as scrap for building huts.

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Figure 24. Wood Waste Power Generation Project Cash Flows
(. . Domestic Diesel Fuel Subsidy)

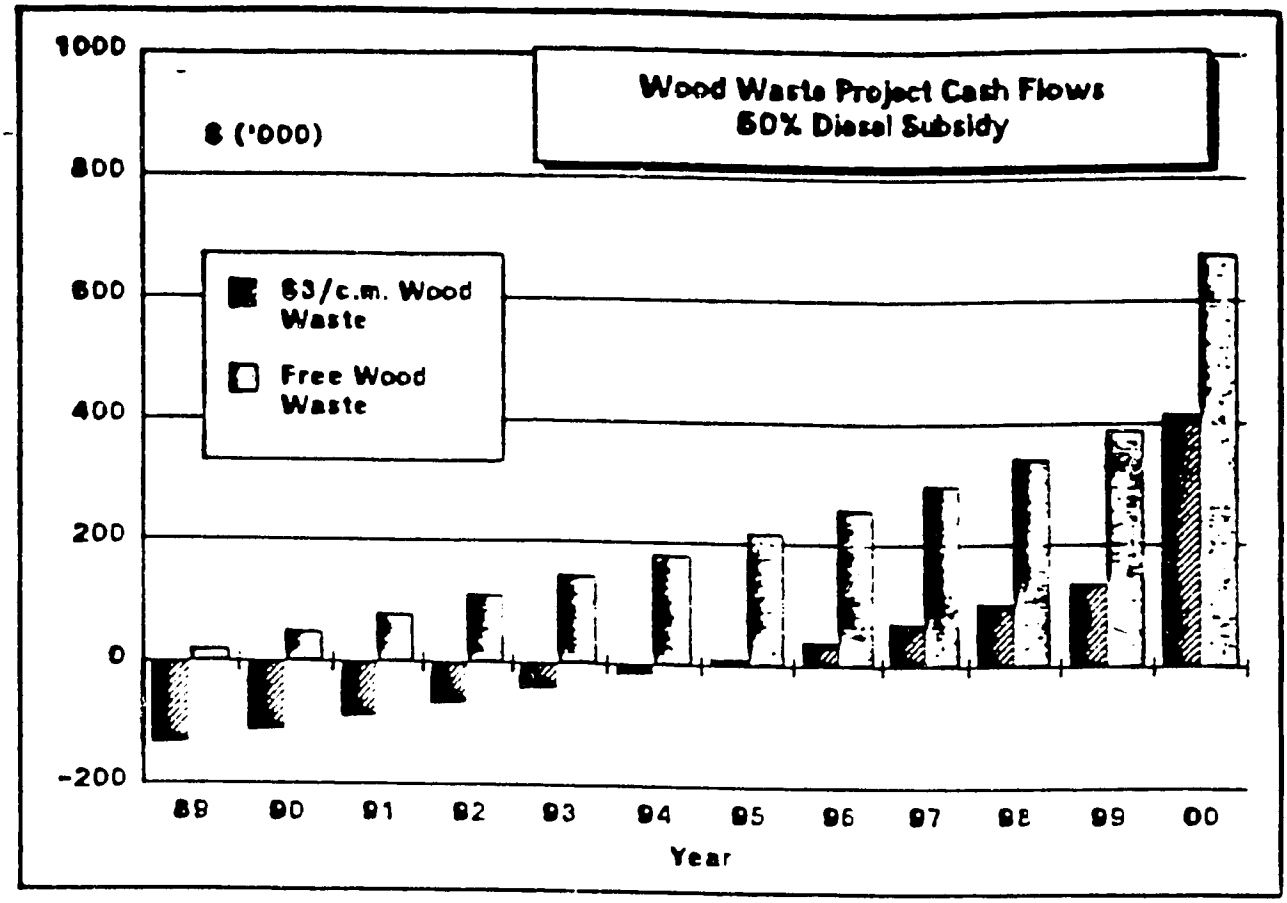


Figure 25. Wood Waste Power Generation Project Cash Flows
(No Domestic Diesel Fuel Subsidy)

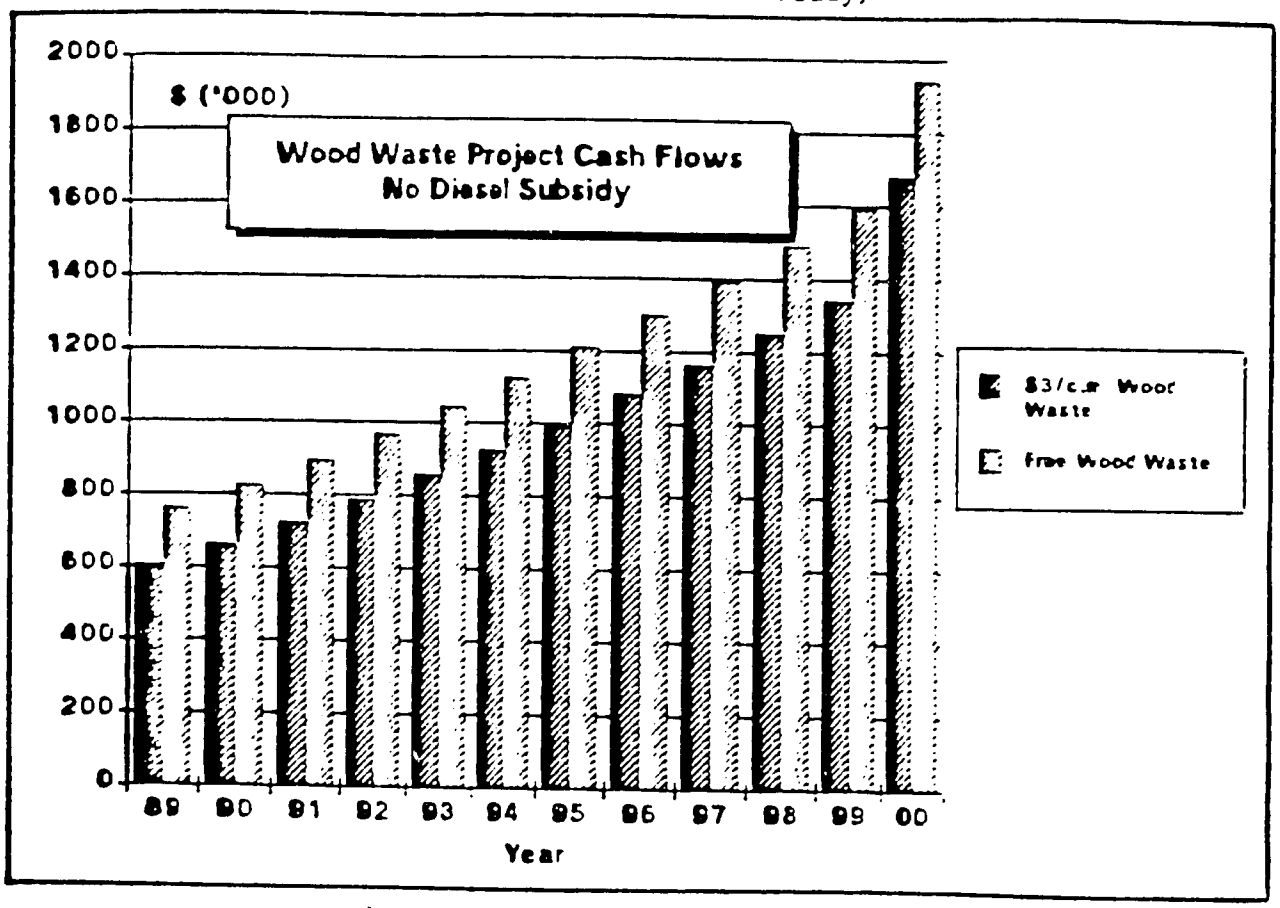
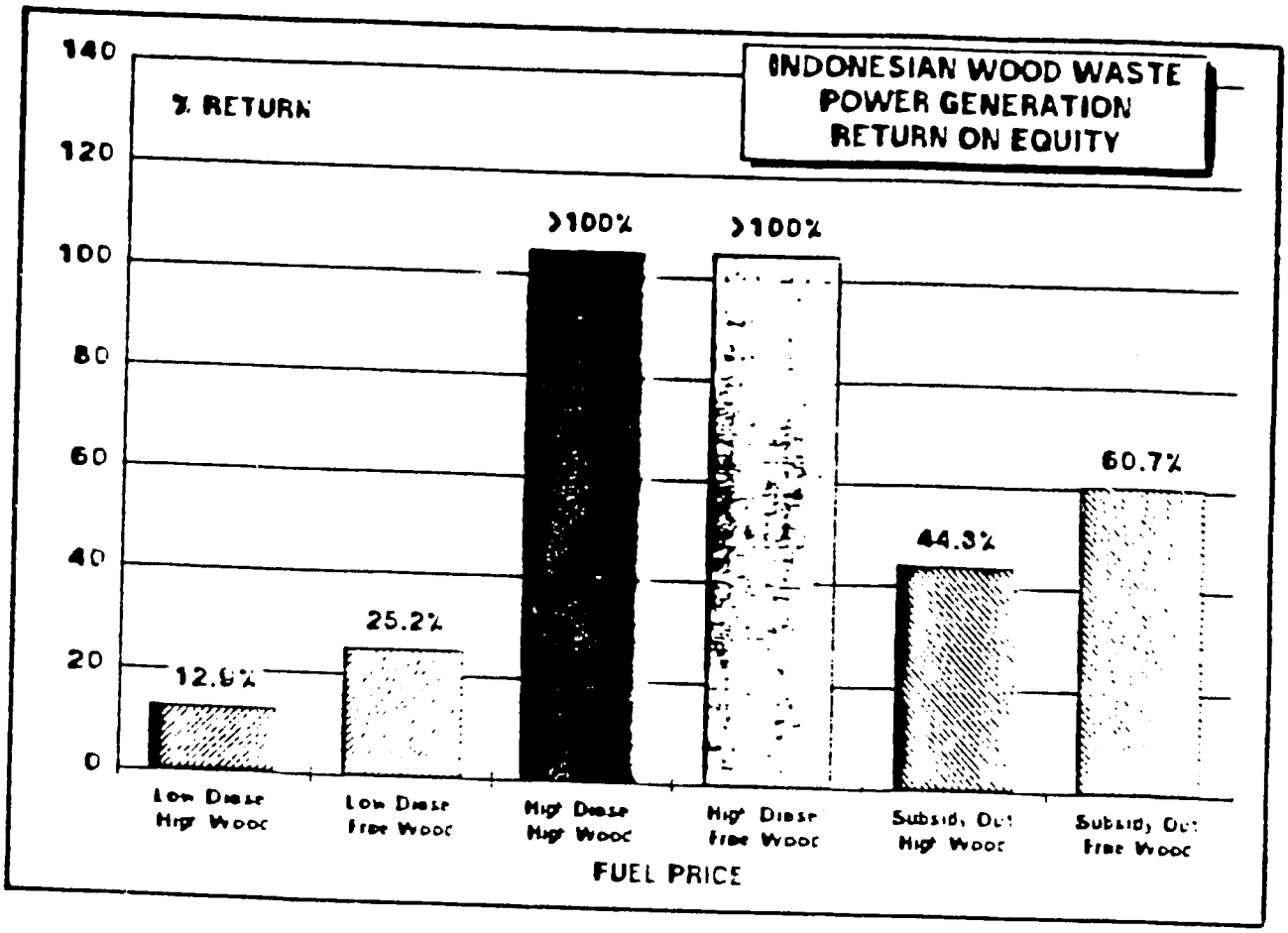


Figure 26. Return on Equity for an Investment in Wood Waste-Power Generation Systems in Indonesia



While some scenarios with high (25 percent) returns on equity would have little trouble attracting investors in the U.S., financial conditions in Indonesia dictate short payback periods (often two years or less) and high rates of return (at or over 25 percent). Attracting financing for the initial wood waste power plants in Indonesia will require some incentives and guarantees beyond those typically required in the U.S.

Important environmental issues must be addressed in any wood energy project. Direct project-related environmental issues include emissions to the atmosphere, discharge of waste water, and disposal of ash. The study proposed use of only wood waste currently generated at plywood industry sites, and would not use the wood from logging activities as fuel. The proposed plants will use debris and waste wood that currently presents disposal problems. Moreover the use of wood waste power generation in place of diesel power generation has the potential for a significant improvement in the physical environment of the plant and in worker health and safety. Carbon dioxide emissions are significantly reduced by biomass versus fossil fuel use. Since coal and petroleum fuels are the major contributors to global warming, wood fuel substitution could be a net gain provided the wood products industry practices sustainable forest management.

The most important long-term environmental consequence of the Indonesian forest products industry is damage to the unique and ecologically important forests of Kalimantan and Sumatera. Although at present the high rate of deforestation in Indonesia is attributable principally to clearing for agriculture, logging indirectly is a major factor since it often sets the stage for forest encroachment. At present Indonesian loggers pay $4/cubic meter to the government for reforestation and the government is responsible for implementing reforestation programs. However this program has not proceeded rapidly enough to inhibit the present rate of deforestation. Alternative innovative solutions must be explored to ensure sustainable forest management by providing not only the loggers, but also the local communities and government, with sufficient financial incentives for sustainable resource management. The responsibility for reforestation could be turned back, and closely monitored, to the local communities, governments, or to the wood products industry itself in order to accelerate and expand the reforestation area. This aspect will be considered in any detailed project feasibility assessment study.

VI. BST PROJECT RESEARCH INITIATIVES

A. Development of Off-Season Fuels for Sugar Mills

Bagasse Drying and Storage

Bagasse (the fibrous by-product of milled sugar cane) typically has high and variable moisture content. Reducing the moisture content of milled bagasse would improve its effective fuel value so that each unit of bagasse produced could generate more steam and

electricity, and would improve its combustibility and thus reduce operational difficulties and decrease opacity.

Several methods to reduce and stabilize the moisture content of bagasse have been proposed and/or used, most notably, drying bagasse with hot flue gas (as is being practiced at four Hawaiian raw sugar factories) and dehumidifying bagasse via chemical or biological treatment (as is being practiced in at least one sugar factory in Brazil). However, questions relating to these processes continue to be raised: Do these practices result in net energy savings when viewed on a total-system basis? Does induced drying (with chemical/biological treatment) substantially accelerate the natural drying process and improve recovery of the original fuel?

Although drying may help to extend the amount of bagasse available to the processor, many cane sugar factories throughout the world currently produce substantially more bagasse than is needed to process cane and sugar. Hence, any improvements in the net calorific value of bagasse by drying, which would increase the amount of excess bagasse generated, could compound an existing problem. Indeed, it would be desirable to be able to burn the excess bagasse during the mill off-season (when fossil fuels must often be used since no bagasse is being produced) to generate electricity. Unfortunately, typical bagasse/trash densities are relatively low, making storage of substantial amounts impractical. If one were able to densify bagasse to facilitate its storage and transport, and were able to retard deterioration of bagasse during storage, bagasse would become more valuable to the processor.

The Hawaiian Sugar Planters' Association in a cooperative agreement with BST will evaluate bagasse drying, densification, storage, and preservation practices. A detailed assessment of flue-gas drying and the use of chemical/biological treatment to accelerate drying and/or preserve bagasse will also be made.

Field Residue Collection Program

Because of the duration of cane harvest seasons, from three to seven months in most locations, sugar mills must identify fuels to supplement bagasse if they hope to generate electricity throughout the year. Year-round generation is necessary to receive higher prices for the electricity sold to public utilities and/or industrial customers, and to justify capital investments in new equipment with higher efficiency.

When sugar cane is harvested, the tops and leaves are separated from the millable cane and left behind in the fields. These tops and leaves are a large potential source of biomass fuel with combustion characteristics similar to bagasse.

In both Jamaica and Thailand, A.I.D. is sponsoring trial year programs to collect a reasonable quantity of tops and leaves to be used for boiler fuel to demonstrate the technical and economic feasibility of this technology under existing conditions in these

two locations. A major objective is to obtain cost and performance data that an investor will need before deciding to invest in a cane energy system based on the use of tops and leaves. Seven sets of baling equipment will be procured and operated in these programs.

The operations involved in the collection of cane tops and leaves are similar to the standard operations which have been developed to harvest forage crops (for livestock feed) in many areas of the world, particularly North America. Conventional forage harvesting equipment has been used successfully to harvest cane tops and leaves commercially at several locations, including the Dominican Republic and the Philippines. Using knowledge from these other applications, several of the most suitable equipment models will be selected and tested in Jamaica and Thailand during the trial year. These include a prototype high-performance system developed specifically for cane residue collection.

Development and Testing of Cameco Equipment

Utilization of sugar crane crop residue for biofuel is proposed to enhance the viability of the Jamaican sugar industry. A.I.D., with the assistance of the Hawaiian Sugar Planters' Association, is assessing whether cane residue normally burned during harvest operations can be collected and stored for deferred combustion as boiler fuel for electrical generation. The method proposed to collect sugar cane crop residue is to bale cane residue in-field with mobile field equipment. This equipment is being custom fabricated by CAMECO Systems in Thibodaux, LA. HSPA is evaluating the cane residue recovery methods for proof of concept testing. The data collected from the proposed procedures should: 1) determine the available cane residue resource base, 2) determine the CAMECO TRS system productivity and cane residue recovery performance in a production mode, and 3) evaluate the feasibility of storing cane residue bales and any effect on fuel value. Parameters determined from this study are to be used so that an economic evaluation can be made of cane residue recovery methods being considered in other sugar producing countries where transfer of this technology is appropriate.

Testing and Adaptation of Ford New Holland Equipment

As part of the ongoing field trials in Thailand (see next section of this report), currently available hay collection and baling equipment produced by the Ford New Holland Company will be tested for the collection and baling of sugar cane field trash (leaves and tops). (See Figure 27.)

Because of the short duration of the harvest season in Thailand, sugar mills must identify fuels to supplement bagasse if they hope to generate electricity throughout the year. Year-round generation is necessary to receive higher prices for the electricity sold and to justify capital investments in new equipment with higher efficiency.

Figure 27. Sugar cane Residue being Baled by Conventional Hay Baling Equipment

When sugar cane is harvested, the tops and leaves are separated from the millable cane and left behind in the fields. These tops and leaves are a large potential source of biomass fuel with combustion characteristics similar to bagasse.

During the proposed trial year a reasonable quantity of tops and leaves will be collected and used for boiler fuel to demonstrate the technical and economic feasibility of this technology under existing conditions in Thailand and to obtain cost and performance data that an investor will need before deciding to invest in a cane energy system based on the use of tops and leaves. Six sets of baling equipment will be procured and operated during the trial year.

The operations involved in the collection of cane tops and leaves are similar to the standard operations which have been developed to harvest forage crops (for livestock feed) in many areas of the world, particularly North America. Conventional forage harvesting equipment has been used successfully to harvest cane tops and leaves at several locations.

The field equipment to be used includes the following:

- Side delivery rakes, to align the cane tops and leaves into windrows in the fields after the cane harvest and loading operations are completed, and after the tops and leaves have been sun-dried to a moisture content below 30 percent mcwb;

- Round balers, which pick up the windrowed tops and leaves to form cylindrical bales which weigh approximately 0.4 tonne each. These balers are PTO (Power Take-Off) driven and pulled by standard tractors with 60 hp rating;

- Rectangular balers with a bale chamber size of 16 by 18 inches, PTO driven with windrow pickups. These machines are an alternative to the large round balers, making bales weighing less than 50 kg each that can thus be moved and loaded manually. The smaller bale size permits more flexibility in handling, but does not provide the feature of weather-resistant outdoor storage which the large round bales have;

- Bale movers and mechanical bale loaders for the big round bales. Loaders are locally available for use with tractor hydraulic lifts;

- Trucks for transporting bales from field to mill. Dimensions of standard care trucks are 4.5m x 2.5m x 3. high; and

- Equipment for fuel handling and preparation at the power plant. Bales can be disintegrated using a tub grinder that prepares the tops and leaves in a form ready for conveying into the boiler. Tractor-mounted hydraulic front-end loaders can be used to lift bales off the trucks and into the tub grinder.

The Machinery requirements for the field collection of tops and leaves can be calculated as follows:

Baler capacity	= 9 to 14 tonnes/hr
Field efficiency	70%
Length of working day	8 hours
Availability	80%
Length of season	100 days
Daily output	40 to 63 tonnes/baler
Productivity	4,032 to 6,272 tonnes per Baler per season

Field Trials in Jamaica

Field trials of the S&T/EY-sponsored cane field residue collection system have been conducted at the Moneymusk sugar estate in Jamaica in cooperation with Jamaica Sugar Holdings, Ltd., the Jamaica Sugar Industry Research Institute, and Hawaiian Sugar Planters' Association. Raking, baling, and bale handling operations of the system were proven feasible in Jamaica field conditions, and operators were trained to use and maintain the Cameco Industries (Thibodeaux, LA) equipment. Baled cane "trash" was used as boiler fuel in mixture with bagasse and wood chips at the Petroleum Corporation of Jamaica's (PetroJam) ethanol plant at Bernard Lodge, and proved satisfactory in handling and combustion operations. Both Jamaica Sugar Holdings and PetroJam are interested to continue testing the prototype system in the next harvest beginning December 1988, in order to obtain complete performance and cost data in extended trials. S&T/EY is currently discussing next year arrangements with these parties.

Thailand: Trial Year - Nong Yai Sugar Mill

BST has designed and is coordinating a one-year trial program for a cane energy project at the Nong Yai Sugar Mill in Chonburi, Thailand. During the trial year, cane residues will be collected, stored, and burned in order to determine the technical and financial feasibility of year-round electricity generation and sale by private sugar factories.

The trial year program was designed to involve the national utility, private investors, and individual cane farmers to clarify the circumstances under which each party could experience a net gain from a trial year activity. The program is agreed to by participants and approved by the Royal Thai Government. It was implemented beginning in December 1988.

B. Energy Efficiency in Sugar Factories

Under a research grant from BST, the Center for Energy and Environmental Studies at Princeton is studying cane mill energy efficiency. The following is taken verbatim from a September 1987 report titled "Steam-Injected Gas Turbine Cogeneration for the Cane Sugar Industry."

Regardless of the type of cogeneration technology installed, process-steam conservation appears worth considering because of the additional export of electricity this permits. To use the GSTIG technology steam consumption would have to be reduced from about 400 kg/tc, typically achievable at existing raw-sugar factories to about 300 kg/tc, a level that is probably readily achievable with commercially available technologies.

Additional export electricity could also be made available if factory electricity demands could be decreased, e.g., through the use of more efficient electric motors and variable speed motor drives. Industrial experience with such equipment is growing, although virtually no experience exists with such equipment in cane-sugar factories. However, given the extensive use of motors, pumps, and fans in the typical sugar factory, the potential savings may be substantial. As part of the present study an assessment of this potential is being undertaken, including on-site management of motor and motor-system performance in typical sugar factories.

To explore the costs and benefits of factory energy conservation, three end-use scenarios with decreasing levels of steam consumption are used as the basis for subsequent financial analyses. No new technologies for reducing electricity demand are considered, pending completion of the motors assessment described above. For all end-use scenarios, the design cane throughput is nominally 175 tonnes per hour.

With steam-conserving retrofits, the RORs for the CEST and IFGT systems do not change significantly, but for the GSTIG system, the ROR would be 18 to 32 percent. In addition, the GSTIG plant would export about 60 percent more electricity than the IFGT plant and about twice as much as the CEST plant. Conserving more steam by electrifying the factory would improve the ROR slightly in all cases, and lead to a small increase in export electricity production. Figure 28 shows financial rates of return and annual electricity exports for the three end-use scenarios considered.

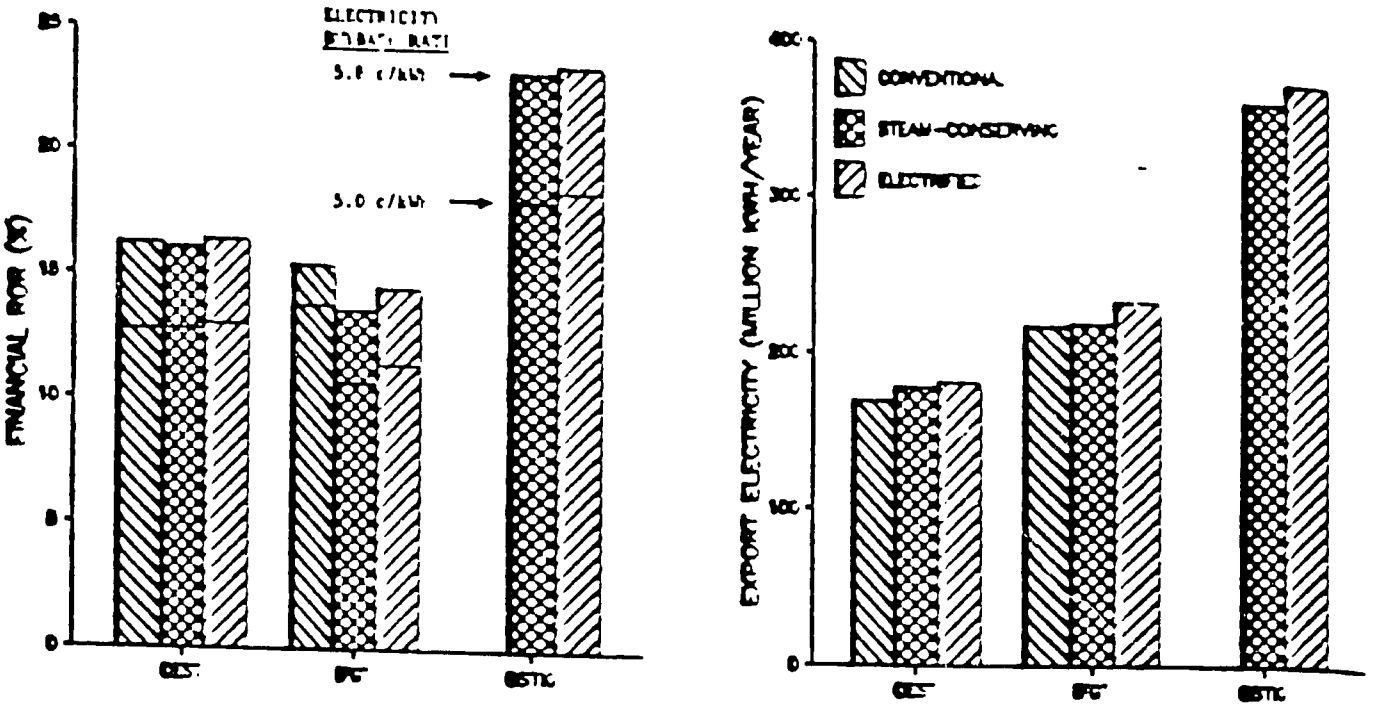
C. Advanced Biomass Conversion Systems

Steam Injected Gas Turbine Cogeneration for the Cane Sugar Industry

In research supported by BST the Center for Energy and Environmental Studies (CEES) at Princeton University is evaluating the impact cogeneration systems using advanced gas turbines could have on the cane sugar industry. Major improvements in the performance of gas turbines have come in the last decade largely from advances in jet engine technology. CEES has concluded that some 50,000 MW of gas turbines fired with sugar cane residues producing some 300 billion kWh annually could be supported globally with the 1985 level of sugar cane production.

The report prepared under the research grant reviews performance of an existing sugar factory in Jamaica as a basis for estimating potential for conserving steam. A typical sugar factory in the

Figure 28. Financial Rates of Return and Annual Electricity Exports for Cogeneration and Process-Equipment Investments at "Conventional," "Steam-Conserving," and "Electrified" Factories Crushing (Nominally) 175 Tonnes of Cane per Hour, 206 days/year, with 90 Percent Availability



world today produces about 20 kWh per tonne of cane crushed. Modern factories operating in Hawaii produce about 100 kWh per tonne of cane crushed. Advanced gas turbine systems could double this output at lower capital costs. In one analysis presented in the report, annual electricity revenues (at $0.05/kWh) equal sugar revenues ($0.23/kg) for an advanced gas turbine system.

ESTIMATED POTENTIAL WORLDWIDE GSTIG GENERATING CAPACITY AT SUGAR FACTORIES WITH THE 1985 LEVEL OF SUGAR CANE PRODUCTION [a,b]

Region	Potential Electrical Capacity (MW)
South America	17,800 [c]
Asia	14,000
Central America	10,100
Africa	4,900
Oceania	2,700
United States	1,900
Europe	200
Total	51,600

[a]Sugar cane production, assuming ten tonnes of cane are required to produce one tonne of sugar. Sugar production data are from the International Sugar Organization.
[b]Assuming a 206 day season, 24 hour/day operation, 90% plant availability, and a GSTIG fuel requirement corresponding to 180 tonnes of cane per hour for a 53 MW unit.
[c]Includes capacity that would be installed at alcohol production facilities in Brazil.

Matching Biomass Gasifiers with STIG Units

Research conducted by Princeton University with grant funds from BST has investigated the matching of biomass gasifiers with steam-injected gas turbines. The following reports their findings to date.

The steam-injected gas turbine (STIG), which to date has only been fired with natural gas or distillate oil, is a good candidate for firing with biomass. Biomass-fired power plants are characterized by their small size (5-50 MW), which results from the widely distributed nature of the fuel. In this size range, gas turbines are more efficient power generators than steam turbines, and their unit costs are lower and less sensitive to scale than those for steam turbines or gas turbine/steam turbine combined cycles. The STIG is a recently-introduced modification of the simple-cycle which improves further on these attributes. In a STIG, steam raised using the hot exhaust gases from the gas turbine is injected into the combustor or directly into one or more stages of the turbine, resulting in a significant increase in power and efficiency.

Among alternative biomass-fired STIG systems, the most promising in terms of high efficiency, low capital cost, and near-term commercial viability is one which couples the STIG to a gasifier. (Other biomass-fired gas turbine systems under development include ones in which pulverized biomass is burned directly in a modified combustor and in which biomass is burned in an atmospheric pressure combustor, with the heat being transferred to the gas turbine working fluid through a heat exchanger.) In the gasifier-STIG (GSTIG) system, biomass fuel is fed into a pressurized ractor, where it reacts with air and steam and is converted into a combustible gas (called producer gas), low-btu gas, or low-joule gas) having carbon monoxide and hydrogen as the primary combustible components. Contaminants are removed from the hot gas, which is then burned in the gas turbine combustor. Some of the steam raised using the exhaust gases from the turbine is used in the gasifier. The balance is injected. In cogeneration applications of GSTIG, some of the injection steam would be diverted to meet process needs.

The flexibility to use steam for process or for additional power makes the GSTIG well suited to cogeneration applications where process steam loads vary widely, as in biomass-processing industries that operate seasonally, and where excess electricity can be marketed, e.g., sold to a utility. The GSTIG would thus be a serious competitor to condensing-extraction steam turbines, the traditional workhorse for biomass-firing. A detailed case study for cogeneration in the cane sugar industry in Jamaica indicates that in the 5-50 MW size, GSTIG systems would be more efficient, less capital intensive, and have overall better economics than comparably sized steam turbines.

There are large potential markets for biomass-GSTIG systems. Initial applications might be for industrial cogeneration at biomass-processing facilities. Over 50 GW of capacity could be supported by residues available in the cane sugar industry alone. Considering additionally the residues from saw mills, pulp mills, and corn and rice production, over 250 GW of capacity could be supported worldwide. In the longer term, dedicated energy plantations might provide fuel for stand-alone GSTIG power plants.

Aside from fundamental chemistry, the past applications of biomass gasification are relevant for gas turbines only to a limited extent. Direct heat applications have exclusively utilized atmospheric pressure reactors and have generally been unconcerned with gas clean up. The development of gasifiers for engine applications has focused on small atmospheric-pressure reactors (less than 150 kW_e) producing a cool and tar-free gas. The previous application of gasifiers most relevant to gas turbine applications appears to be the production of methanol synthesis gas. The large scale and high pressure operation of the gasifiers, together with the requirement for a particulate-free gas are all relevant to gas turbine applications. The production of fuel gas for turbines would be simpler, however, because air-blown gasification could be used, and the gas would not be cooled, scrubbed of tar, or shifted to provide the requisite H2:CO ratio.

Pressurized gasification is required in gas turbine applications to avoid large losses associated with compressing the fuel gas after gasifying at atmospheric pressure. (For a gas turbine combustor pressure of, say, 35 bars, the extra compression work required would represent about 30 percent of the net output of the gas turbine. The result would be an overall cycle efficiency penalty of over 25 percent. An additional efficiency penalty of perhaps 10 to 15 percent would be suffered because the fuel gas would need to be cooled before being compressed. The sensible heat in the gas and the chemical energy of tars and oils would be lost.) The key concern with pressurized gasification is the feeding of the solid fuels into the reactor. The most commonly used system is the lockhopper. Lockhoppers are used on commercial Lurgi coal gasifiers that operate at over 30 bars pressure, and pilot-scale units have been tested at up to 80 bars. In single lockhoppers, a batch of fuel is fed at atmospheric pressure into a hopper which is then sealed and pressurized before it is opened to the reactor.

Cleaning raw gas of contaminants is critically important to avoid damage to turbine blades and other system components. Extensive development of cleanup systems has been done for both coal-gasifier gas-turbine systems and for gas turbines fired directly with coal, e.g., using pressurized fluidized-bed combustors. Much of this work is applicable to clean-up of biomass-derived gases. Clean-up of biomass gases is simpler than with coal gases, however, because sulfur removal is not required. The main contaminants of concern in biomass gasification products are tars/oils, alkali compounds, and particulates.

Tars and oils are problemmatic only if the temperature of the gas falls below their dew point, which ranges from 150°C to 500°C depending on their composition. In condensed form tars and oils foul surfaces, leading to increased maintenance costs and performance degradation. Tar and oil condensation is of greatest concern with updraft gasifiers, which produce the largest quantities and at the lowest gasifier exit temperatures. Fortunately, tar condensation can be avoided by insuring that the gas temperature is maintained above the tar/oil dew point until it reaches the gas turbine combustor. Such "close-coupled" arrangements have been incorporated into designs for advanced coal-gasifier gas turbine systems.

Oxides of alkalai metals in fuel gas (formed from potassium and sodium in the feedstock) are a concern because they can cause serious corrosion of the alloys used in turbine blades. The tolerable limit for alkalai metals in low-btu fuel gas is about 0.16 g/Nm^3. Based on clean-up tests with coal gas from a fluidized-bed gasifier, alkalai metals are removed with particulates in the temperature range 480-650°C. Thus, acceptable alkalai metal concentrations appear achievable if particulates can be removed at elevated temperatures. In biomass-derived gas, alkalai concentrations might be expected to be comparable to that in coal gas, since higher potassium and sodium levels in biomass ash would be offset by the much lower ash fraction in most biomass feedstocks. Measurements with biomass are needed to confirm this.

With any gasifier, some clean-up of particulates is required to prevent erosion of gas turbine blades, although the extent of required clean-up appears uncertain, as suggested by the wide range of published estimates for permissible loadings. Updraft gasifiers produce two orders of magnitude less particulate matter than fluidized-beds, because gas exit velocities are slower and the bed acts as a filter. In addition, the particles from updraft biomass gasifiers are much smaller than from either fluidized-bed gasifiers operating on biomass or updraft units gasifying coal.

As indicated in the above discussion, for gasifiers close-coupled to gas turbines, the only raw-gas contaminants of concern appear to be particulates. Extensive developmental work has been done on cleaning gas from coal, but relatively little on that from biomass.

Because of their simplicity and high efficiency updraft gasifiers have been popular both for coal and biomass feedstocks and appear to be good candidates for gas turbine applications. A key requirement is the close-coupling of the gasifier, hot clean-up system, and gas turbine, which would make the high tar/oil content in the raw gas acceptable, indeed desirable. The updraft gasifier is also attractive because of the lower particulate concentration in the raw gas compared to gas from fluidized-bed units. Their major drawback appears to be the requirement for relatively dense feedstocks.

VII. BST PROJECT INFORMATION GENERATION AND DISSEMINATION

A. Bioenergy Systems Report (BSR) Series

June 1982 - Thermochemical Conversion of Biomass for Energy
September 1982 - Biomass Fuels for Vehicles
December 1982 - Growing Trees for Fuel
December 1982 - Wood Fuels for Industry
March 1983 - Bioenergy for Agriculture
June 1983 - Bioenergy for Electric Power Generation
December 1983 - Bioenergy from Crop Residues
April 1984 - Innovations in Biogas Systems and Technology
September 1984 - Downdraft Gasifier/Engine Systems
March 1985 - International Conference on Biogas Technology
June 1985 - International Producer Gas Conference
March 1986 - Cane Energy Systems
April 1986 - Rice Husks Energy Systems
September 1988 - Prospects in Developing Countries for Energy from Urban Solid Wastes

B. Technical Reports

April 1986 - Fuel Alcohol Production in Honduras

This report presents a feasibility analysis of producing ethanol for export to the U.S. under a variety of sugar and oil price scenarios, using low-value world market sugar as the fermentation feedstock. The report both looks at the industry as a whole and compares individual sugar factory sites for ethanol production.

September 1986 - Jamaica Cane/Energy Project Feasibility Study

This report analyzes the technical and investment feasibility of producing power year-round in modern power facilities proposed for the Moneymusk sugar factory. Bagasse and cane field residues are the principal fuels for electricity production and sale of power to the national utility is examined under a variety of price conditions.

September 1986 - Electric Power from Cane Residues in Thailand

This study presents the findings of a team of specialists that visited Thailand early in 1986 to investigate ways in which the sugar cane industry might improve its prospects by selling new products. After examining a number of alternative products and their markets, the team concluded that the most attractive option for the Thai sugar industry would be the generation of electricity for sale to the national grid throughout the year especially during the off season when the mills are not grinding cane and can devote their boilers and turbines exclusively to power generation. For fuel, the team recommends the use of cane residues, the tops and leaves left in the field after the harvest.

The report contains a detailed analysis of the technical and economic consideration for five representative mills and extrapolates from these selected cases to project national impact. For many sugar mills as well as cane farmers, electricity sales appear to represent an attractive opportunity providing a welcome new source of income requiring only modest capital investments. Funds committed to this activity appear likely to earn a high rate of return. For the nation as a whole, generating electricity at sugar mills would provide new electricity supplies at a price that is equal to or lower than that which can currently be obtained. It would also permit the electric utility, by relying on private industry, to avoid spending valuable foreign exchange for as much as several hundred megawatts of new capacity.

December 1986 - The Sugar Industry in the Philippines

This report presents the findings of a team of specialists that visited the Philippines in late spring 1986 to review crop substitution and product diversification opportunities for the sugar industry. The team concluded that a variety of causes including chronically low world prices, reductions in U.S. quotas, corruption, poor policies, and inefficiency have forced the industry into a devastating depression from which it cannot recover without major adjustments. This means that some mills and factories must be closed and new uses found for the land and labor employed until recently in the production of sugar.

The work of the team focused on two issues: Identification of crops to be substituted on lands withdrawn from sugar production and identification of new products that can be produced from the

existing cane crop to supplement the income of producers and millers. The principal finding of the team is that crop substitution and market diversification are both difficult and expensive, and are likely to proceed slowly. There is no single crop or set of crops that form the ideal alternative to sugar.

The team felt there are several specific opportunities for product diversification significant enough to warrant further development. The first is production of electricity for the grid at sugar mills located on Luzon. A second is the collection and combustion of cane field residues to displace large quantities of fuelwood used by commercial facilities on Negros. The third is to produce animal feeds and feed ingredients from sugar, molasses and cane residues.

April 1987 - Cane Energy Utilization Symposium - Volume I

Energy production from cane residues offers developing countries the opportunity to utilize an important agro-processing industry for providing the public sector with additional energy resources. Representatives from the sugar industry in Asia and the Caribbean Basin, technologists, and researchers met to discuss new exciting uses of cane residues for energy production at this symposium. Volume I outlines the issues and summaries the topics discussed at the symposium.

April 1987 - Cane Energy Utilization Symposium - Volume II

Volume II includes the presented papers of the symposium participants. Papers include the latest technical research, economic/financial, policy and field experiences with cane trash use as boiler fuels for electricity or liquid energy production.

August 1987 - Trial Year Program Proposal - Nong Yai Sugar Mill

This report contains a proposal prepared in July 1987 for a one-year trial program for a cane energy project at the Nong Yai Sugar Mill in Chonburi, Thailand. During the trial year, cane residues would be collected, stored and burned in order to determine the technical and financial feasibility of year round electricity generation and sale by private sugar factories.

The proposal was designed to facilitate negotiations among the national utility, private investors, and individual cane farmers to clarify the circumstances under which each party could experience a net gain from a trial year activity. A modified program was agreed to by participants and approved by the Royal Thai Government. It will be implemented beginning in December 1988.

July 1988 - Electric Power from Sugarcane in Costa Rica

The conclusion of the report is that the production and sale of electricity for the national grid could be an excellent investment opportunity for the sugar industry of Costa Rica and the country. Depending on the options selected, the industry could contribute from 17 to 500 million kilowatt hours of electricity to the national grid. Besides many investments being quite financially attractive, particularly surplus energy production in the cane grinding season, the country also benefits significantly from additional rural jobs, diversification of the sugar industry into new attractive by-product markets, and displacement of petroleum imports of $7 million under some scenarios.

September 1988 - Electricity and Ethanol Options in Southern Africa

This report surveys economic development and U.S. trade opportunities for new electricity and ethanol facilities in the sugar industries of Mauritius, Malawi, Swaziland, Zimbabwe, and Zambia for potential follow-on work by A.I.D. and the U.S. Trade & Development Program. Numerous new energy sector projects are identified in each country, as well as opportunities in agriculture and telecommunications.

September 1988 - The CANEPRO Model: A Financial and Economic Micro-Computer Model for Cane Power Systems (Draft)

Investment opportunities by the sugar industry in steam/electricity systems require tools to assess the commercial and economic/national feasibility of power plant investment. CANEPRO is an IBM-compatible model that allows industry, utility, and government analysts to conduct first-cut assessments of a specific system for a mill. Results of the model include the net present values, internal rate of return, costs of electricity production, job generation, foreign exchange impacts and petroleum savings from a cane power system.

November 1988 - A Prefeasibility Assessment of the Potential of Wood Waste Power Systems for the Indonesian Wood Products Industry

C. <u>Conferences, Meetings, and Workshops</u>

Brazil Charcoal Siminar

Philippines Workshop

Support for Biomass Users Network (BUN) Meetings

Cane Energy Workshop in Hawaii

Workshop on Contracting for Private Power in Hawaii and California

Cairo International Biogas Conference

Cane Rice Energy Opportunities for the Philippines, Agri-Energy Roundtable

Rice Residue Utilization Technology Convocation: International Market Prospects for U.S. Industry

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ANNEX D

SOCIAL SOUNDNESS ANALYSIS

ANNEX D - SOCIAL SOUNDNESS ANALYSIS

The activities carried out under the BST project were evaluated from the standpoint of social soundness and appropriateness within the cultural and socioeconomic settings found in target LDC's. In addition the proposed activities of the BEST project were analyzed from the same set of perspectives. The overall conclusion of the social soundness analysis is that the BEST project can be a valuable addition to the rural agroindustrial sector in many A.I.D.-assisted LDC's and that its activities can be carried out in a sound manner from the standpoint of social acceptability and cultural compatibility. There will be a need to more carefully examine existing patterns of peasant utilization of biomass residues to ensure that proposed BEST project field activities do not disrupt viable existing social and economic relationships.

In general, BEST project activities will be focused in agrarian-based rural economies where latent energy demand is high and economic development is dependent, among other factors, on increasing available supplies of energy. The lack of adequate supplies of electricity and other forms of energy in rural areas of many A.I.D.-assisted countries has significantly limited the social development of these regions. Social services such as health and education have tended to be underdeveloped and more limited, due in part to lack of adequate rural electricity supplies.

The developing countries best suited for biomass energy systems are those in which agricultural production generates large amounts of post-harvest wastes. Productive use of agricultural residues can generate income and jobs for both direct and indirect beneficiaries in the local economy. For example, by using processing waste for energy production, the real cost to the processor of the agricultural commodity which

has been purchased for transformation is decreased. Accordingly, this cost saving effectively increases the value of the agro-industrial residues, and both farmers and processors directly benefit from the increased income which accrues to the industry.

The utilization of agricultural residues for energy generation also contributes to the creation of new employment and extends periods of employment of seasonal laborers. An indirect benefit of this more efficient use of raw materials goes to the local agricultural producers in the form of more stable and often higher prices for their basic agricultural commodities. Politically, national governments may gain from improved rural economies which in turn help to stem rural to urban migration patterns.

Therefore, the primary beneficiaries of successfully implemented biomass energy systems at the local level include farmers, seasonal laborers, small-scale industries, mechanics and other skilled workers, and local entrepreneurs. Secondary beneficiaries will exist in all of the communities affected by installation of new biomass energy systems including those who will benefit from the new supplies of electricity or liquid/gaseous fuel, those whose economic well-being is enhanced by the multiplier effects of increased income made available within rural economies, and those who will benefit from secondary economic demands which result from the increase in economic activity associated with biomass energy systems. Providing additional supplies of power locally in rural areas at affordable prices will tend to support current efforts to promote microenterprise development, much of it dependent on small electrical appliances or other machinery. As women tend to be involved in many of these small-scale manufacturing or service enterprises, the successful development of this project will likely have a positive effect on the status of women in those rural areas where biomass energy systems ar adopted which produce

surplus electricity available for local use.

Each pre-feasibility or feasibility level project analysis conducted by BEST will consider socio-cultural and socio-economic issues as part of its overall technical and economic analysis. In terms of he sustainability of actual projects, biomass energy systems are generally self-financing and economically viable over the life of the capital equipment purchased. Depending upon the type of biomass energy system to be implemented, the system can often then be replicated in other locations with small modifications to account for differences in local conditions. Opportunities will be examined to include further social science research into selected aspects of BEST proposed field project activities through the project's competitive research grants program and other A.I.D.-financed mechanisms such as the S&T/RD SARSA project.

ANNEX E

ADMINISTRATIVE ANALYSIS

ANNEX E - ADMINISTRATIVE ANALYSIS

Careful evaluation and analysis was made during the preparation of the BEST project paper to ensure that proposed project activities would not present an unnecessary administrative burden on USAID missions, the A.I.D. Science and Technology Bureau or the geographic bureaus.

Implementation of the BEST project as proposed will not have any unusual requirements for A.I.D. administrative support capabilities. The BEST project will be managed by S&T/EY, which will provide centralized project supervision and a mechanism for dissemination and interpretation of project results as needed in the broader A.I.D. policy and programming process. The Project Director and core project staff for the BEST project will report to the A.I.D. project manager appointed by the Office of Energy.

The BEST project as proposed will affect Mission workloads and may possibly affect staffing requirements. However, this will tend to be minimized since the core staff and consultants will have considerable experience at operating within the A.I.D. administrative system and have worked in many of the target countries previously. Project support services on the part of participating Missions are generally expected to be minimal. It is expected that this project can be successfully implemented and managed given present staffing levels within S&T/EY.

During the course of the predecessor BST project close liaison was maintained between S&T/EY, the BST core staff and Mission staff in the course of carrying out field activities. While the BEST project will have occasional logistical and in-country planning requirements, the BST project has demonstrated that these can be carried out by Mission staff in the course of their other responsibilities under related or complementary Mission-funded projects. A significant degree of mission

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interest has been expressed in the new BEST project's proposed activities and it is expected that these relationships can be administered in an efficient and cost-effective manner throughout the project.

September 1987 - Princeton University/CEES Report #217, Steam Injected Gas-Turbine Cogeneration for the Cane Sugar Industry

This report, prepared by the Center for Energy and Environmental Studies (CEES) at Princeton University, describes the impact cogeneration systems using advanced gas turbines could have on the cane sugar industry. Major improvements in the performance of gas turbines have come in the last decade largely from advances in jet engine technology. The authors conclude that some 50,000 MW of gas turbines fired with sugar cane residues producing some 300 billion kWh annually could be supported globally with the 1985 level of sugar cane production.

The report reviews performance of an existing sugar factory in Jamaica as a basis for estimating potential for conserving steam. A typical sugar factory in the world today produces about 20 kWh per tonne of cane crushed. Modern factories operating in Hawaii produce about 100 kWh per tonne of cane crushed. Advanced gas turbine systems could double this output at lower capital costs. In one analysis presented in the report, annual electricity revenues (at $0.05/kWh) equal sugar revenues ($0.23/kg) for an advanced gas turbine system.

January 1988 - Rice Residue Utilization Technology [in coordination with Louisiana State University, New Orleans, LA]

Summary of risks and constraints facing U.S. private sector as it considers Third-world marketing of residue recovery and use systems.

March 1988 - An Investment Case Study of the Lihue Power Plant (Draft)

This study traces the actual costs and benefits to all parties involved in a cogeneration investment at a sugar mill in Hawaii in the early '80s that involved financing from the equipment supplier. From a commercial perspective, all parties clearly benefitted from the investment arrangement; the mill since it found an outside source of capital and receives its internal steam/electricity needs free; the supplier (Foster-Wheeler) as a significant portion of electricity revenues goes to it in steady annual payments; and the utility which has additional 12 MW of capacity that it can draw upon from the private sector.

May 1988 - Potential for Private Investment in Rice Residue Power Generation: Indonesia

Evaluation of resource base, applicability of commercially proven systems and policy environment vis-a-vis private power generation from Indonesia's largest agricultural residue.

May 1988 - Princeton University/CEES Report #226, Aeroderivative Turbines for Stationary Power

ANNEX F

INITIAL ENVIRONMENTAL EXAMINATION

ANNEX F - INITIAL ENVIRONMENTAL EXAMINATION (IEE)

The Initial Environmental Examination (IEE) carried out in conjunction with preparation of the BEST project PID and PP carefully analyzed the range of activities carried out under the BEST project and their environmental implications. It also examined the range of proposed activities to be carried out during the course of the BEST project. The general conclusion of this IEE is that the majority of project activities proposed by the BEST project will not produce significant harmful effects on the environment. This would include BEST's analyses, studies, workshops, meetings, applies research, technical assistance, training and information dissemination activities. However, since the BEST project proposed to expand its activities in actual project implementation in the field, analysis of project-related environmental considerations will be incorporated into the feasibility-level study of specific model field project activities to ensure that no adverse environmental impacts or irretrievable commitments of resources resulting from expenditures of A.I.D. funds occurs. In particular instances Environmental Assessments of proposed projects will be developed as per A.I.D. environmental regulations (22 CFR Part 216).

The most appropriate mechanism to ensure that adequate environmental reviews are incorporated into BEST's proposed field activities is to develop at the earliest possible stage in the new project, a detailed set of environmental review criteria to be incorporated into pre-feasibility and feasibility level studies of proposed model field projects. Such environmental review criteria should be biomass residue type and combustion/conversion technology specific and should draw on the previous studies and field analyses carried out through the BST project. In this manner, continuing attention will be given to environmental issues throughout the process of field project formulation, activation and implementation. An important source

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of support within the BEST project to help meet its environmental review objectives will be the competitive research grants program. This program will provide a mechanism to fund environmental monitoring activities at actual field biomass energy projects. These efforts should help to develop an adequate data base with respect to better quantifying the actual environmental impacts of these types of biomass energy systems, particularly those for which little environmental data exists.

The expansion of electric power production in developing countries has the potential to produce significant environmental damage. Projections of power supply expansion indicate that large increases in hydropower and steam thermal facilities (mainly coal) are likely. Large-scale hydropower plants often require the relocation of sizeable populations and alterations of river basin ecosystems. Coal-fired power generation has historically been associated with emissions of particulate materials, sulfur dioxide, oxides of nitrogen and other pollutants. However, based on an analysis of available data and studies, it appears that the biomass energy production systems being encourages through BEST project activities generally produce net environmental benefits or at least acceptable levels of negative environmental impacts when compared with other conventional types of power generation systems.

Most of the biomass energy production systems proposed for feasibility level analysis through BEST project activities and eventual investment as private power production schemes utilize efficient cogeneration equipment. These boilers and turbogenerators can be fueled with biomass feedstocks such as sugar cane bagasse and may also be used with supplemental boiler fuels such as No. 6 Fuel Oil (Bunker Oil). Emissions from bagasse boilers contain particulates, nitrogen oxides and, when oil is fired, sulfur dioxide. No sulphur is present in bagasse. Standard control technologies are available to control air

emissions, especially of particulates and many of the new, fuel-conserving cogeneration units feature flue gas scrubbers or cyclones which tend to greatly minimize air emissions. Based on analysis available to date, most off-the-shelf commercial cogeneration systems will operate within acceptable environmental regulatory limits for air emissions (particulate emission standards), wastewater effluents (total suspended solids, oil and grease, and free available chlorine). and solid waste (flyash, bottom ash and wastewater treatment sludge) as established by U.S. and state laws.

At the present time the management of underutilized or unutilized agricultural residues by the agricultural processing industries in many developing countries often creates negative environmental situations. Under current practices in most countries residues that accumulate at processing facilities or that are left in the fields are inefficiently burned or dumped in water bodies such as rivers. These present disposal practice may have serious negative environmental impacts resulting in high levels of localized air pollution or deoxygenation of surface water bodies. In some areas smoke produced in residue-burning areas has been documented as the source of traffic accidents (Gariboldi, International Agricultural Forum, Geneva, Switzerland, May 1988).

Careful analysis of possible negative environmental impacts associated with more widespread use of agricultural processing wastes as energy feedstocks indicates that the types of agricultural residues targeted by the BEST Project, namely sugarcane bagasse/field trash and rice husks, combined with the selected conversion technologies, do not generally produce significant harmful effects on the environment. This includes consideration of the specific agronomic impacts associated with residue removal from fields, possible air pollution impacts, and any unintended socioeconomic or sociocultural impacts on

alternative consumers of the residues. For example, in Indonesia, it was discovered that even in areas with the greatest use of rice husks, no more than 10 percent is useful in other markets. New high-yielding crop varieties, while producing less biomass residue per plant, produce much more residue per hectare than traditional varieties. Over time these excess field residues are creating larger and larger disposal problems. Attempts to plow under all of this matter results in water percolation problems beneath the soil or are frustrated by farmers' lack of funds for reapplication to fields. (Gariboldi, International Agricultural Forum, Geneva, Switzerland, May 1988).

It is usually assumed that increased agricultural residue burning for energy purposes is diverting essential nutrients and organic matter that otherwise would be returned to the soil. Common sense might seem to suggest that increased agricultural residue utilization would automatically lead to reduced organic recycling and that as a result there will always be a direct negative impact on the soil. In fact this is not necessarily the case. The best summary of environmental and agronomic issues involving use of agricultural residues for energy purposes is the recent study by Geoffrey Barnard and Lars Kristofferson, "Agricultural Residues as Fuel in the Third World" (Earthscan Energy Information Programme, Technical Report No. 4, September 1985). This work clearly documents many cases where this simple, commonly-held assumption is wrong.

There are many examples where residue recycling is impractical, uneconomic and either harmful or only marginally efficacious to the soil or future crops. There is general agreement that the crop residues produced by centralized agricultural processing activities represent a special case which provides the greatest opportunities for increased use as fuels without adversely affecting alternate users or potential users of these crop residues or the natural soil characteristics. The

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BEST project's primary focus is on this comparatively small subset within the diverse pattern of agricultural residue production and use occurring in the developing world. BEST activities will focus on energy conversion of crop processing residues such as sugarcane bagasse/field trash and rice husks which are byproducts of agricultural processing operations and need to be disposed of by alternative means to those in use at present, generally by burning at centralized locations or within existing plant operations.

These residues are rarely returned to the soil under current agronomic practice due to the transportation costs involved and their low fertilizer value. In many cases, these materials are already being used to fuel boilers, dryers or other processes within a plant but they often represent significantly underutilized or inefficiently utilized resources. Thus there is no direct impact on soil fertility levels from the utilization of these residues. They usually are collected in large piles at the plant and unused surpluses may be periodically burned in the open air.

In addition, some of the residues used at a commercial scale through the BEST project are largely unsuited to use as household fuels. For example, rice husks make a poor cooking fuel and without proper treatment, such as briquetting into fuel pellets or burning in special stoves, are rarely used as a household fuel source. They are also physically light and fluffy making them difficult to collect, store and use. (Arnold and de Lucia, 1982, did, however, document two provinces in Thailand where rice husks and sugarcane stalks are used as a local fuel source.) Therefore, it can be concluded that broader adoption of such biomass residue energy systems is generally unlikely to adversely affect the availability of other types of agricultural residues to landless laborers or other rural residents who depend on access to such supplies for household fuels.

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The main threat to soil is where agricultural residues that were previously recycled start to be used instead as fuel. While the role of organic matter in soil is well known, both as a source of nutrients and as a key factor in maintaining the tilth or physical properties of soil (i.e. drainage capacity, water retention capacity, resistance to erosion and chemical capacity to retain nutrients), each residue's characteristics as organic fertilizer vary considerably.

In practice, it is often difficult to analytically separate and quantify the different effects of the organic matter that results from crop residue decomposition on soil fertility. It is largely dependent on local physical and environmental conditions. However, it is well-established that most crop residues are a fairly dilute form of nutrients, which are rarely fully available for organic recycling under conventional conditions in many developing countries, either due to field burning of residues or practical considerations related to the expense of turning them back into the ground. Thus the BEST project activities will not have an adverse environmental impact since the targeted residues are not generally utilized for recycling to the soil and they have inherently low value as fertilizer anyway.

In addition, it is traditional low-input agriculture that depends more on organic matter recycling than high-input modern agricultural systems. As most of BEST project activities are aimed at agricultural processing settings in which little agricultural recycling of residues is presently occurring and for which crops are grown with at least moderate levels of chemical fertilizers there is limited scope for negative impacts on soil fertility via this mechanism.

While modern high-yielding varieties (HYV's) of most field crops tend to produce as a rule a smaller proportion of residues

per plant than traditional varieties, they produce more residue per hectare, since the number of plants per hectare is greatly increased. This depends on the growth rate and productivity of the crop which in turn is a function of the agricultural methods used and the amounts of inputs supplied. Since HYV's normally are associated with high inputs of fertilizer and often benefit from irrigation, growth rates tend to be much higher than for traditional varieties and thus production of residues can be as high or higher than traditional varieties.

There are several other agronomic benefits of modern farming systems that tend to further obviate the soil structure/organic matter recycling issue. The use of chemical fertilizers tends to maintain the soil's nutrient availability. Modern high-input systems with several crops per year yield far more residues per unit area of cropped land than traditional rainfed systems. The higher crop growth rates in modern high-yielding varieties (HYV's) also results in increased root production which helps to maintain soil organic matter levels even when all of the above-ground crop is removed (for example HYV's of cereals generally yield as much as 1.0-2.5 tons of roots per hectare). For most agricultural crops the quantity of residue produced in a year generally exceeds the production of the crop itself. Rice is the most extreme case among cereal crops as deep water rice can produce as much as 14 tons of straw per ton of grain produced (Islam, 1983).

Thus there is no basis for concluding that BEST project activities involving agricultural residues will have any major negative environmental impact on soil conditions or negative social impacts on rural populations by preempting a fuel source. This appears to be generally the case for both of the two major agricultural residue types being considered for wider utilization under the BEST project, namely rice husks and sugarcane bagasse/field trash. Green sugarcane tops are used as animal

fodder, but have limited value since they are consumable only while green and may dry out very quickly. This has not, however, been an issue in any of the site-specific analyses of cane energy project undertaken to date by BEST's predecessor, the BST project.

One of the positive environmental benefits associated with BEST project activities is the reduction in the seasonal pollution caused by the uncontrolled burning of crop residues that occurs in many developing countries. Farmers burn residues to rapidly clear fields for replanting where multiple cropping is prevalent. Agricultural processing facilities also burn surplus quantities of agricultural residues that accumulate. When biomass energy systems are established that create a market demand for these agricultural residues, farmers and mill owners cease to burn them indiscriminantly, thereby reducing air pollution events. Generally, the combustion technologies being adopted for these biomass energy systems through the BEST project offer far more complete combustion of the residues thereby reducing pollution. Also pollution reduction and control is an integral part of many of these commercially-available combustion systems, both because they were originally designed to meet U.S. or European air quality standards, and because the most efficient systems offer possible additional by-product sales.

For example, uncontrolled combustion of rice husks results in releases of large amounts of entrained ash in the smoke. However, most commercially available rice husk combustion systems used in developed countries for generating process heat and steam and/or power, tend to incorporate cyclones or other devices to trap the ash. This is because the economic returns from sales of ash tend to be quite high, usually either to steel plants or cement plants.

Biomass energy projects thus present a generally much lower environmental burden than equivalent conventional energy facilities, both due to their smaller scale and their integration within existing agricultural production and processing systems. In general, the environmental impact of combustion or fermentation type biomass energy systems is much lower per kilowatt hour of electricity produced than equivalent fossil fuel systems. For example combustion of biomass releases no sulfur dioxide, no carbon monoxide or many other harmful air pollutants and does not release otherwise unavailable sources of carbon dioxide into the atmosphere as would be the case for fossil fuel-fired plants. Of course, the utilization of supplemental boiler fuels such as fuel oil will produce the air emissions normally associated with combustion energy facilities.

The environmental impact of expanded use of wood residues for energy in selected developing countries is chiefly dependent upon whether the residues under consideration for energy conversion represent wastes from wood-processing and paper pulping or whether they are logging residues. The application of energy conversion technologies in the former situation generally produces positive environmental impacts by utilizing bark, wood chips, sawdust and other unutilized energy sources (i.e. spent pulping liquor) to produce useful energy. In the case of harvesting of logging residues for an energy feedstock, the potential exists for both positive and negative environmental impacts depending on the nature of the forest or plantation and the previous manner of handling these residues.

In countries where wood residues (i.e. tops, limbs, and possibly leaves and understory) are routinely subjected to open burning, residue use for energy production may be environmentally beneficial by eliminating air pollution and destruction of the organic soil layer by fire. When logging residues are left in the forest, institution of residue removal programs will have

both positive and negative impacts, whose character and extent are largely determined by site-specific factors (such as: forest type, habitat considerations, slope, degree of harvesting, soil conditions, etc.). There may also be significant socioeconomic and land use impacts as residue harvesting is expanded to serve an established energy facility. It is not a simple task to analyze forestry residue project environmental impacts since stand thinning in a forest does often increase wildlife population and habitat diversity while clear-cutting can eliminate or destructively effect established forest. There is however a clear need to better explore the potential environmental impacts of proposed BEST forestry activities before promoting the widespread adoption of such systems. Recent studies by Repettro (1988) and others underscore the damaging and unsustainable nature of commercial forestry practices in many LDC's (i.e. Indonesia, Philippines, Ivory Coast and Gabon). Clearly the BEST project's proposed forestry/wood energy field project activities will need to be carefully scrutinized from an environmental standpoint to ensure that proposed BEST forestry/wood energy field project activities do not promote wanton tropical forest destruction, loss of biological diversity, or needless habitat destruction.

In the context of the forestry sub-sector, biomass utilization projects may be one tool to improve the management of tropical forests. Within the wood products industry in developing countries, sustainable biomass utilization projects may provide a way to generate energy and promote more efficient and ultimately more sustainable techniques of primary and secondary forestry management. Current forest management practices need to be further studied to identify where opportunities exist to realize sustainable uses of wood logging residues for biomass energy systems.

The BST project is currently helping to develop a wood

residue-based biomass energy system in Indonesia to convert captive mill wastes into electricity. This project will utilize on-site wood waste from the plywood industry. At the present time approximately 40% of the plant's raw log supplies end up as waste (bark, rejected chips, etc.). The project will involve installation of 2-3 MW power units at the plywood factory which will supply electric power for internal consumption thereby displacing diesel fuel. Given the sensitive relationship between tropical forests and the global biosphere, the BEST project will carefully analyze all wood residue utilization activity from an environmental point of view. However, since BEST wood residue projects are likely to focus largely on unutilized or underutilized captive mill wood residues (from milling, plywood production and pulp/paper operations), environmental impacts are likely to be of manageable or acceptable proportions, as long as the energy production activities do not promote non-sustainable patterns of wood resource exploitation. The convening of an advisory committee to review all BEST proposed forestry activities will help to ensure that wood waste to energy projects are ecologically sound and consistent with good forest conservation and management policies.

The BST project has also recently studied the prospects in developing countries for energy from urban solid wastes (Bioenergy Systems Report, September 1988). It concludes that there is an urgent need to reduce health and environmental problems arising from open dumping of these wastes throughout the developing world. This includes problems of odors, air pollution from smoke, water pollution, and the spread of diseases. However, many current systems do incorporate scavengers whose livelihood is gleaned from recycling of discarded goods (i.e. Zebaleen in Egypt). Several multipurpose technologies that could aid in ameliorating health and environmental hazards while also generating energy exist. These include both covered landfills designed for methane gas recovery and waste combustion systems

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generating steam and/or electricity.

The environmental impacts of landfill gas (LFG) systems are generally positive while those of waste combustion systems are mainly negative. LFG systems that incorporate sanitary landfills reduce or eliminate odors and smoke and can greatly minimize disease vectors. Leachate pollution of ground water can be prevented with a clay-sealed landfill or leachate collection systems.

The operation of waste combustion systems can have serious negative effects on air quality, water quality and water supply in adjacent areas and such plants in the U.S. are subject to stringent environmental regulations. The three key means of combatting these problems are emission controls, proper ash disposal techniques, and alternatives to conventional "once-through" condenser cooling using fresh water. All of these problems require costly engineering solutions that would appear to be inappropriate for developing countries.

Since commercial systems are not yet available that match the LDC waste streams, urban solid waste energy systems are not likely to be a focus of BEST project activities, and therefore, are not likely to pose a significant harmful effect on the environment as a result of this project. However, the BEST project should continue to carefully study the environmental impacts of such systems if they are considered for actual development through A.I.D. funding.

In general, any activities undertaken by the BEST project which tend to produce more effective natural resource utilization (i.e. more complete use of biomass residues) while also serving to augment rural incomes, offer economic diversification options to agricultural or wood processing industries, and increase available rural energy supplies, also contribute to the global

process of better management of the biosphere. Thus, A.I.D. support of the BEST project generally reinforces the linkage between more effective natural resource management strategies and an improved socioeconomic and biotic environment.

This IEE provides the basis for a conclusion that the BEST project will have a negative threshold decision and thus does not require a full-fledged Environmental Assessment. However, as small-scale field energy projects are considered for implementation through the BEST project's activities during its seven year life, environmental considerations will be incorporated into the pre-feasibility and feasibility level analyses. If particular projects will be of a class or scale or occur in environmentally sensitive locations, further environmental analysis will be undertaken, including Environmental Assessments as required.

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ANNEX G

APPLIED RESEARCH SELECTION GUIDELINES FOR
BEST COMPETITIVE RESEARCH GRANTS PROGRAM

ANNEX G - APPLIED RESEARCH SELECTION GUIDELINES FOR BEST COMPETITIVE RESEARCH GRANTS PROGRAM

The BEST project's competitive research grants program will need to develop a specific set of guidelines for the evaluation, selection and monitoring of research proposals received from research organizations interested in carrying out applied research related to biomass energy production systems. It is suggested that the administrative format of A.I.D.'s Program in Science and Technology Cooperation (PSTC) run by the Office of the Science Advisor (SCI) be used as a model for the development and administration of this component of the BEST project.

Once a research advisory committee is established, its first task should be to develop a set of research selection guidelines for the competitive research grants program. This group should use as a point of departure the applied research funded under the BST project and an evaluation of the research funded under the PSTC's "biomass resources and conversion" program module and any other relevant external research activities in biomass energy research (i.e. U.S. DOE, USDA, TVA, NSF, etc.) This will ensure that the set of research guidelines developed is appropriate to the goals of the BEST project, does not unnecessarily duplicate ongoing or previously funded research, and is properly coordinated with and gains benefit from other ongoing or recently concluded related research in the U.S., the industrialized world generally or LDC's.

A set of research selection criteria might include:

1. Does the proposed research focus on an important unresolved technical or scientific issue inhibiting further development of dissemination of commercial biomass energy systems in an LDC setting?

2. Does the proposed biomass energy system utilize surplus or available supplies of sugar cane, rice or wood residues?

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3. Is the proposed biomass energy conversion system technology consistent with or complimentary to technical and engineering approaches found to be economically viable in LDC settings?

4. Does the proposed research include LDC-U.S. in the research process?

5. Have end-users of the research results been adequately involved in the development of the research proposal and will they be involved in field tests and ultimately dissemination of research findings?

6. Has the research proposal been subjected to an adequate level of scientific or engineering peer review to ensure its viability and practicality?

7. Does the institution or institutions proposing to perform the research adequately staffed and funded and has it carried out similar research successfully and competently in the past?

8. Is the proposed research administration and grant management system adequate to achieve accountability and financial control?

9. Is any equipment specified for procurement actually needed and is such procurement an appropriate use of A.I.D. funds?

10. Does the research contribute to a better understanding of the environmental impacts of biomass energy systems in LDC's?

11. Does an adequate research backstopping and monitoring capacity exist in the BEST project, USAID Missions and S&T/EY, as appropriate?

12. Does the proposed research complement other A.I.D. or non-A.I.D. research programs?

13. Is the level of funding requested appropriate and adequately documented?

14. Is the schedule for the research acceptable and realistic?

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ANNEX H

A SUMMARY OF BIOENERGY SYSTEMS AND TECHNOLOGY PROJECT (BST) EVALUATION REPORT FINDINGS

ANNEX H-A SUMMARY OF BIOENERGY SYSTEMS AND TECHNOLOGY PROJECT (BST) EVALUATION REPORT FINDINGS

An evaluation of the current Bioenergy Systems and Technology Project (BST) was carried out in January and February 1988 by an IQC contractor, Energy/Development International (E/DI, Evaluation of the USAID Bioenergy Systems and Technology Project, A.I.D., Bureau of Science and Technology, Office of Energy, February 1988). The BST project was first evaluated in 1982. The most recent evaluation focused on BST project activities carried out since the 1982 evaluation. The evaluation report findings were utilized extensively in the design of the new BEST project. The evaluation report findings were particularly helpful since once important emphasis of the evaluation was on defining strategic options for the BEST successor project to BST.

This annex summarizes the main conclusions of the evaluation and its recommendations. The interested reader is referred to the evaluation report itself for a more detailed view.

Evaluation Conclusions

Conclusion 1: The current emphasis on agricultural waste is valid.

Conclusion 2: The greatest deficiency in the project is insufficient attention to issues of project finance.

Conclusion 3: There is a fundamental concern that technology is pushing the project, rather than development objectives.

Conclusion 4: BST still lacks concrete evidence of success but is moving in productive directions in its two major components

Recommendations

Recommendation 1: Wood combustion should be chosen as the next area of concentration.

Recommendation 2: Despite experience in Costa Rica, gasification technology should not be abandoned (experience in India is encouraging).

Recommendation 3: Need more formal and effective criteria for project selection such as macro- and micro-screening.

Recommendation 4: BST staff should include individual with strong private sector project development experience.

Recommendation 5: Coordinate with the Renewable Energy Applications and Training (REAT) project.

Recommendation 6: Emphasize institutional arrangements rather than technology.

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Recommendation 7: Learn more about 3rd party financing and how existing programs can be used (eg., OPIC guarantee program for third party equity investors).

Recommendation 8: Lean toward using indigenous sponsors versus the "entry" strategy.

Recommendation 9: Examine ways in which smaller-scale rice residue combustion power technologies could be made more economical.

Recommendation 10: Reinforce work in use of wood waste for energy production. Viable opportunities exist for both gasification and direct combustion.

Recommendation 11: The BEST project paper should develop a clear strategy for its work in wood to energy conversion (which should include consultation with A.I.D. Forestry staff).

Recommendation 12: The BEST project should provide support to Missions in area of renewable energy project identification, design and evaluation.

Recommendation 13: The BEST project core staff should include someone who is knowledgeable about procurement issues and the Office of Procurement should be consulted in the development of the BEST project.

Recommendation 14: If a PASA is used, an exemption from the provisions of OMB circular A-76 needs to be written so that it covers all anticipated Mission buy-ins.

Recommendation 15: The BEST project should include some type of

information dissemination activity.

Recommendation 16. The BEST project should play a stronger role in identifying and involving U.S. private sector firms for specific types of involvement in its activities.

Recommendation 17: The BEST project should formulate guidelines for interaction with the private sector.

ANNEX I

BST PUBLICATIONS

U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT
SCIENCE & TECHNOLOGY, OFFICE OF ENERGY
BIOENERGY SYSTEMS & TECHNOLOGY PROJECT
PUBLICATIONS

Bioenergy System Reports

June 1982	- Thermochemical Conversion of Biomass for Energy
September 1982	- Biomass Fuels for Vehicles
December 1982	- Growing Trees for Fuel
December 1982	- Wood Fuels for Industry
March 1983	- Bioenergy for Agriculture
June 1983	- Bioenergy for Electric Power Generation
December 1983	- Bioenergy from Crop Residues
April 1984	- Innovations in Biogas Systems and Technology
September 1984	- Downdraft Gasifier/Engine Systems
March 1985	- International Conference on Biogas Technology
June 1985	- International Producer Gas Conference
March 1986	- Cane Energy Systems
April 1986	- Rice Husks Energy Systems
September 1988	- Prospects in Developing Countries for Energy from Urban Solid Wastes

BST Project Reports

April 1986	- Fuel Alcohol Production in Honduras
September 1986	- Jamaica Cane/Energy Project Feasibility Study
September 1986	- Electric Power from Cane Residues in Thailand
December 1986	- The Sugar Industry in the Philippines
April 1987	- Cane Energy Utilization Symposium - Volume I
April 1987	- Cane Energy Utilization Symposium - Volume II
August 1987	- Trial Year Program Proposal - Nong Yai Sugar Mill
September 1987	- Princeton University/CEES Report #217, Steam Injected Gas-Turbine Cogeneration for the Cane Sugar Industry
January 1988	- Rice Residue Utilization Technology [in coordination with Louisiana State University, New Orleans, LA]
March 1988	- An Investment Case Study of the Lihue Power Plant (Draft)
May 1988	- Potential for Private Investment in Rice Residue Power Generation: Indonesia
May 1988	- Princeton University/CEES Report #226, Aeroderivative Turbines for Stationary Power
July 1988	- Electric Power from Sugarcane in Costa Rica. A Technical and Economic Analysis
September 1988	- Electricity and Ethanol Options in Southern Africa
September 1988	- The CANEPRO Model: A Financial and Economic Micro-Computer Model for Cane Power Systems (Draft)
November 1988	- A Prefeasibility Assessment of the Potential of Wood Waste Power Systems for the Indonesian Wood Products Industry

ANNEX J

GUIDING QUESTIONS FOR BEST PROJECT EVALUATIONS

ANNEX J - GUIDING QUESTIONS FOR BEST PROJECT EVALUATIONS

Specific questions to be addressed in mid-term and final evaluations include but are not limited to:

1. General Program Effectiveness and Impact

   a. To what extent is the BEST project meeting the objectives and goals of the original project paper? To the extent that the program has evolved in ways not fully foreseen at the time of project approval, have these changes enhanced the effectiveness of the program?

   b. Has the BEST project been targets to meeting the critical needs in the developing countries, capable of being satisfied through utilization of bioenergy production systems and existing biomass feedstocks? Have project activities been based on an adequate review of national energy problems, needs and priorities and by consultations with AID Missions and host government officials?

   c. Does the BEST project complement or duplicate any other programs? How is its support integrated with that of related projects?

   d. How is the BEST project promoting private sector involvement in LDC bioenergy system development? How have U.S. and indigenous private sector interests been involved in the implementation of the program?

   e. Is BEST responsive to U.S. foreign policy interests? How? How can this responsiveness be

improved?

f. How is the BEST project related to AID's interest in promoting institutional development and sound energy policies in the developing countries?

g. What levels of future funding are needed to ensure the project's efficacy in meeting stated goals and objectives? Should the project continue? Should current contracting arrangements be continued? If so, should some modifications be made in contractual requirements?

h. Given budgetary constraints, how can the effectiveness and impact of the BEST project be enhanced within current levels of financial resources? What level of Mission buy-in activity has been achieved? How can cost-sharing with Missions, other donors, host countries and other sources be further encouraged?

2. Biomass Energy Systems

a. How has the BEST project analyzed the overall LDC potential for biomass utilization? What criteria have been used to narrow the projects focus to a select group of A.I.D.-assisted countries? How have project activities been carried out in representative initial target countries?

b. Has the BEST project adequately identified the constraints to more widespread utilization of available biomass resources for energy production in LDC's? What action has the project initiated to address these constraints?

c. How has the BEST project integrated sustainable natural resource management approaches into its activities? How have the environmental issues surrounding expanded biomass utilization for energy production been analyzed and documented during the BEST project? What criteria have been used to ensure compliance with A.I.D. environmental regulations?

d. How have biomass energy production systems been selected and matched with available LDC biomass feedstocks? Have national and regional-level assessments of biomass energy utilization prospects been carried out with an appropriate degree of economics, technical and financial analysis? Have socioeconomic and sociocultural issues been adequately studied? Have project impacts on rural income generation and job creation been documented and substantiated?

e. How have applied research projects been selected for BEST project funding? What criteria have been used to ensure that only applied research activities supportive of expanded implementation of biomass energy production systems be undertaken? Has adequate external peer review of all research proposals been sought and utilized? What evaluations of completed research activities have been undertaken to apply lessons learned in future activities?

f. What activities has the BEST project carried out to promote dissemination of adequate information concerning biomass energy production systems and the support available through the BEST project to

appropriate audiences in LDC's and the U.S.? How have these activities aided increasing understanding of the project goals, accomplishments, the potential contributions of biomass energy systems, and the current status of worldwide implementation of biomass energy systems in other LDC's?

3. The Contractor's Program Administration and Staffing, AID Backstopping

   a. Are the contractor's and cooperating institution's key personnel working on the project of appropriate professional calibre and background? Are their individual responsibilities appropriate to their skills, and do they appear to be fulfilling their individual responsibilities effectively?

   b. Is the BEST core project staff effective as a team? How can the contractor's overall effectiveness be improved through reorganization, improved office automation, additional hiring or other changes? How can the cooperating institution's overall effectiveness be improved?

   c. Is there a need, as BEST project activities expand into a larger number of LDC's, to improve record-keeping systems for tracking project sponsored activities, measuring the level of follow-on investment in bioenergy systems generated by the project, and generally monitoring project budgets and expenditures? Can computerized monitoring systems (e.g., use of microcomputers with commercially available

software for spreadsheets and data base management) help in these areas?

d. How well are communications procedures (physical transport between the contractor and AID by messenger; editing, clearance and transmission by S&T/EY) working? What can be done to improve these procedures?

e. Are existing communication/consultation channels between the contractor and S&T/EY adequate? Are other AID entities (regional bureaus, S&T/IT, Missions, and PPC) brought into the communication/consultation loop at appropriate points?

f. Are changes needed in S&T/EY's backstopping and management of the BEST project. If so, what changes are recommended?

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ANNEX K

MISSION DOCUMENTS SUPPORTING PROJECTED BUY-IN LEVELS

AID 1350-1 (10-79)

PIO/T

UNITED STATES INTERNATIONAL DEVELOPMENT COOPERATION AGENCY
AGENCY FOR INTERNATIONAL DEVELOPMENT

PROJECT IMPLEMENTATION ORDER/TECHNICAL SERVICES

1. Cooperating Country: Thailand

2. PIO/T No.: 493-0343-3-60075

3. ☐ Original or Amendment No. _____

4. Project/Activity No. and Title: 493-0343, Rural Industries and Employment Project (Cane/Energy Trial Year Program for Thailand buy-in Bioenergy Systems and Technology Project) (936-5709)

DISTRIBUTION

5. Appropriation Symbol: 72-1161021

6. Allotment Symbol and Charge: QDAA8627493AG13

7. Obligation Status: ☐ Administrative Reservation ☐ Implementing Document

8. Project Assistance Completion Date (Mo., Day, Yr.): 09/30/96

9. Authorized Agent: AID/SER/OP/W/R

10. This PIO/T is in full conformance with PRO/AG 493-0363 Date 08/27/86

11a. Type of Action and Governing AID Handbook: ☒ AID Contract (HB 14) ☐ PASA/RSSA (HB 12) ☐ AID Grant (HB 13) ☐ Other

11b. Contract/Grant/PASA/RSSA Reference Number (If this is an Amendment): DHR-5709-C-00-8009-00

12. Estimated Financing (A detailed budget in support of column (2) is attached as attachment no. _____)

		(1) Previous Total	(2) Increase	(3) Decrease	(4) Total to Date
Maximum AID Financing	A. Dollars		$115,000		$115,000
	B. U.S.-Owned Local Currency				

13. Mission References

14a. Instructions to Authorized Agent: AID/SER/OP/W/R is requested to negotiate a buy-in to AID/ST/EY's Bioenergy Systems and Technology Project (No. 936-5709) contract with TEM Associates, Inc. (Contract No. DHR-5709-C-00-8009-00) to provide the services described herein. These services are estimated to cost $115,000 and should commence on 10/01/88.

TEM Associates, Inc.
1900 Povell Street
Suite 840
Emergville, CA 94608

ECN: P860507

14b. Address of Voucher Paying Office: Controller, USAID/Bangkok

15. Clearances—Include typed name, office symbol, telephone number and date for all clearances.

A. The project officer certifies that the specifications in the statement of work are technically adequate: PD/ENG, Mintara Silawatshananai — Phone No. — Date 9/8/88

B. The statement of work lies within the purview of the initiating and approved agency programs: PRO, Judith Wi[illegible] — Date 9/13/88

C. PD; Willy D. Baur — Date 9-10-88
ACO, Neil Edin — 9/12/88

D. Funds for the services requested are available: for CONT, Douglas S. Franklin — 9/14/88

E. PD/PE, Lawrence M.E. Brown — Date 9/8/88
PD/PERE, Craig M. Steffensen — 9/8/88
DD, Steven P. Mintz — 9/15/88

16. For the cooperating country: The terms and conditions set forth herein are hereby agreed to

Signature: Anuparb Sunananta — Date 9/23/88
Title: Asst. Secretary-General, NESDB

17. For the Agency for International Development

Signature: John R. Eriksson — Date 9/15/88
Title: Director, USAID/Thailand

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AID 1350-1 (10-79) PIO/T	1. Cooperating Country Thailand	2. PIO/T No. 493-0343-3-60075	Page 2 of 3 Pages
	4. Project/Activity No. and Title Rural Industries and Employment (493-0343) Cane/Energy Trial Year for Thailand buy-in to Biotechnology and Energy Project (936-5709).		

SCOPE OF WORK

18. THE SCOPE OF TECHNICAL SERVICES REQUIRED FOR THIS PROJECT ARE DESCRIBED IN ATTACHMENT NUMBER _____ HERETO ENTITLED "STATEMENT OF WORK".

19. SPECIAL PROVISIONS

A. ☐ LANGUAGE REQUIREMENTS (SPECIFY) None
(IF MARKED, TESTING MUST BE ACCOMPLISHED BY AID TO ASSURE DESIRED LEVEL OF PROFICIENCY)

B. ☒ ACCESS TO CLASSIFIED INFORMATION ☐ WILL ☒ WILL NOT BE REQUIRED BY TECHNICIAN(S).

C. ☒ DUTY POST(S) AND DURATION OF TECHNICIANS' SERVICES AT POST(S) (MONTHS)
Bangkok and Chon Buri, Thailand; and Aiea, Hawaii; for up to 12 months.

D. ☐ DEPENDENTS ☐ WILL ☐ WILL NOT BE PERMITTED TO ACCOMPANY TECHNICIAN.

E. ☐ WAIVER(S) HAVE BEEN APPROVED TO ALLOW THE PURCHASE OF THE FOLLOWING ITEM(S) (COPY OF APPROVED WAIVER IS ATTACHED)

F. ☒ COOPERATING COUNTRY ACCEPTANCE OF THIS PROJECT (APPLICABLE TO AID/W PROJECTS ONLY)
☒ HAS BEEN OBTAINED ☐ HAS NOT BEEN OBTAINED
☐ IS NOT APPLICABLE TO SERVICES REQUIRED BY PIO/T

G. ☐ OTHER (SPECIFY)

20. BACKGROUND INFORMATION (ADDITIONAL INFORMATION USEFUL TO AUTHORIZED AGENT)

21. SUMMARY OF ATTACHMENTS ACCOMPANY THE PIO/T (INDICATE ATTACHMENT NUMBER IN BLANK)

☒ 2 DETAILED BUDGET IN SUPPORT OF INCREASED FUNDING (BLOCK 12)

☐ _____ EVALUATION CRITERIA FOR COMPETITIVE PROCUREMENT (BLOCK 14)

☐ _____ JUSTIFICATION FOR NON-COMPETITIVE PROCUREMENT (BLOCK 14)

☒ 1 STATEMENT OF WORK (BLOCK 18)

☐ _____ WAIVER(S) (BLOCK 19) (SPECIFY NUMBER)

AID 1350-1 (10-79)

PIO/T

1. Cooperating Country: Thailand

493-0343-3-60075

4. Project/Activity No. and Title: Rural Industries and Employment Project (493-0343) Cane/Energy Trial Year for Thailand buy-in to Biotechnology & Energy Project (936-5709)

22. Relationship of Contractor or Participating Agency to Cooperating Country and to AID

A. Relationships and Responsibilities

The contractor shall report to the Director, Office of Project Development and Support, USAID/Thailand, or his designate, on all aspects of project implementation and shall submit for his approval a report on the results of the project.

B. Cooperating Country Liaison Official

C. AID Liaison Officials

Mr. Mintara Silawatshananai
Chief, Engineering Division
USAID/Thailand (251-1019)

Mr. John Kadyszewski
TVA/Bioenergy Systems and Technology Pro
Office of Energy, Rm.#508, SA-18
AID/W Tel: (703) 235-3470

LOGISTIC SUPPORT

23. Provisions for Logistic Support

A. Specific Items (Insert "X" in applicable column at right. If entry needs qualification, insert asterisk and explain below in C. "Comments")	IN KIND SUPPLIED BY: AID	IN KIND SUPPLIED BY: COOPERATING COUNTRY	FROM LOCAL CURRENCY SUPPLIED BY: AID	FROM LOCAL CURRENCY SUPPLIED BY: COOPERATING COUNTRY	TO BE PROVIDED OR ARRANGED BY SUPPLIER
(1) Office Space	X				X
(2) Office Equipment	X				X
(3) Housing and Utilities					X
(4) Furniture					X
(5) Household Equipment (Stove, Refrig., etc.)					X
(6) Transportation in Cooperating Country					X
(7) Transportation To and From Country					X
(8) Interpreter Services/Secretaries					X
(9) Medical Facilities					X
(10) Vehicles (official)					X
(11) Travel Arrangements/Tickets					X
(OTHER SPECIFY) (12)					
(13)					
(14)					
(15)					

B. Additional Facilities Available From Other Sources: N/A

☐ APO/FPO ☐ PX ☐ COMMISSARY

☐ OTHER (Specify, e.g. duty free entry, tax exemption)

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Attachment 1

STATEMENT OF WORK

CANE/ENERGY TRIAL YEAR PROGRAM: PHASE ONE

A. Introduction

In 1986 the Ministry of Industry, the Electricity Generating Authority of Thailand (EGAT), and USAID worked with the Thai sugar industry to examine the costs and benefits of having the sugar industry generate and sell electricity produced from sugarcane residues to EGAT. The study, published in May of 1986, found this option attractive and described in detail the likely benefits to the nation, to the farmers, millers and EGAT.

Following a request from the Ministry of Industry, USAID in the summer of 1987 provided a team of experts to assist in the design of activities for a trial year to demonstrate the technical and commercial feasibility of the approach recommended. Nong Yai Sugar Company agreed to cooperate with the Ministry of Industry in sponsoring the trial.

Early in 1988 the participants agreed that it would be best to divide the trial year activities into two phases. Phase One, to be conducted during the 1988-9 harvest season, will determine the costs of collection, storage, and transport of cane tops and leaves and estimate the amounts that would be available as fuel. During Phase One the collected fuel will be test burned by the participating mill to determine combustion properties, but only for the mill's internal power requirements. Phase Two, to follow, will demonstrate the feasibility of steady, controllable generation of electricity by the sugar industry both during and outside the processing season. Division of the trial year into two phases will allow the mill to test the response of cane farmers and determine fuel quantities and combustion properties before committing itself to the capital costs required for power export.

Nong Yai Sugar Mill currently buys cane through approximately 530 "quota men" representing approximately 15,000 farmers who farm approximately 32,000 hectares. During the harvest season, approximately 16,000 cane cutters are employed to harvest cane for the mill. Most cutters come from the northeast for the harvest season. Cane cutters are paid according to how much cane they cut and average approximately 70 baht/day.

The mill receives approximately 650 trucks of cane per day. During the season when cane is not being harvested, there is significant underutilized trucking capacity. The field manager for the mill did not feel it would be difficult to organize collection and delivery of cane tops and leaves to the mill.

Projected Project Benefits

From the data collected during the visit, it is possible to project benefits for a minimum of 31,900 workers that currently depend on the sugar mill for income. Actual benefits will depend on the system developed for paying farmers and for harvesting cane tops and leaves. But if the results of Phase I are favorable and Phase II is implemented as planned, farmer income could be expected to increase by 500-1,500 baht/hectare. Additional labor would be needed during the harvest season to collect cane tops and leaves or alternately the period of employment for cutters could be extended. The trial year will try to determine the optimum system for collection and use of cane tops and leaves and to collect cost data.

The mill will derive income from converting surplus bagasse into electricity for sale to EGAT and could buy surplus bagasse from other mills during the trial year to help meet fuel supply needs while the system to collect, store and use cane tops and leaves is developed specifically for Thailand. The mill has already purchased equipment to upgrade the performance of its boilers which it would install if power sales were permitted.

EGAT expressed interest to receive and review a proposal for a trial year of operation at a particular site. Positive results from the trial year may stimulate EGAT to alter its policy on purchase of power from private generators that use process wastes for fuel.

B. Objective

The objective of this contract is to provide managerial and technical support for the cane/energy trial year program to be implemented of the Nong Nai Sugar Mill in Thailand.

C. Tasks

This scope of work describes activities to be performed in support of a Phase I trial year program of cane residue collection agreed to by USAID, the Nong Yai Sugar Mill, and the Ministry of Industry of Thailand. The goal of the program is to determine the costs and agronomic impacts of collection, storage, and transport of cane tops and leaves in Thailand, and to estimate the quantities that might be collected and the properties of this fuel when burned in Nong Yai boilers.

To assist in the accomplishment of this goal, TEM will provide: (1) a program manager for up to fifty days; (2) a power plant engineer who will spend up to twelve days assisting Nong Yai mill; (3) a project analyst who will spend seven days evaluating the data produced by the trial year; and (4) a full-time local-hire engineer who will serve as assistant program manager and coordinate the overall program. The work of the local-hire assistant program manager will be supervised jointly by the USAID Mission and the trial year program manager. The assistant program manager will work a total of 220 days on the project.

TEM will provide the following support to the cane/energy trial year program:

1. Trial Year Program Manager: 50 days

   The Trial Year Program Manager will have overall responsibility for the provision of technical assistance to the Nong Yai mill, which will be conducting the trial year activities. Among other things, he or she will assist the mill in planning and scheduling the residue harvest activities, assist in the off-loading and transport of harvesting equipment, work with technical specialists in preparing the equipment for the harvest, and help coordinate the collection of technical data during the harvest activities. He or she will insure that the various parties involved in the program, including the Nong Yai mill, USAID/Bangkok, AID/Washington, and various interested agencies of the Royal Thai Government are informed of the schedule and progress of the trial year. Jointly with the designated officer of USAID/Bangkok, he or she will supervise the work of the local-hire Assistant Program Manager.

   The person selected for this position should be experienced in the sugar industry in the United States and be qualified to manage a complex set of activities. Because the collection, storage, and transport of field residues is likely to be the most complicated part of the program, experience in field management in the sugar industry is especially desirable. The individual should, if possible, have experience with USAID developing country activities. Proficiency in the Thai language is not required as the Assistant Project Manager will interpret for the Project Manager when necessary.

2. Power Plant Engineer: 12 days

   The power plant engineer will assist the Nong Yai mill in preparing for and actually conducting combustion tests using the residues collected during the trial year. He or she will also assist in planning Phase Two of the program. The power plant engineer should have experience in the sugar industry, preferably in one or more factories which have exported power to an electrical grid. As in the case of the Program Manager, proficiency in the Thai language is not required.

3. Project Analyst: 7 days

The project analyst will utilize the data from the trial year to estimate the financial and economic costs and benefits of cane/energy production from the Nong Yai mill. He or she will analyze the distribution of benefits and help estimate the benefits to be received by participants in the second phase of the trial year program. Proficiency in the Thai language is not required.

4. Trial Year Assistant Program Manager: 220 days

The Assistant Program Manager (APM - Thailand), under the direction of the program general manager, will coordinate the various components of the program's operations plan in Thailand during its several phases (planning and preparation, sugarcane harvest and processing season, and during the "off-crop" period directly following the up-coming campaign of December 1988 to April 1989). The program's operations are to begin in October 1988 and are to be completely by September 1989. The program objectives, not in order of importance, are to: (1) demonstrate the technical feasibility of adapting modern forage raking, baling and bale handling techniques to recover sugarcane tops and leaves as a biofuel following conventional hand cutting and loading of millable canes; (2) establish the financial and economic feasibility of the recovery, storage, transportation and biofuel preparation operations that will be required to utilize this crop residue as an "off-crop" boiler feedstock in lieu of fossil fuels; (3) determine the agronomic impacts (i.e., ratoon damage, soil compaction, reduction in moisture retention and weed suppression, crop nutrition, and tilth) of residue recovery operations; and (4) evaluate the fuel quality of the baled, sun-dried cane tops and leaves and the effects of field storage conditions and time on that quality.

The APM - Thailand, to be hired locally, will be required to coordinate the receipt and custom clearances of six sets of hay raking, hay baling, and bale handling attachments, specified spare parts and materials from Ford-New Holland beginning in October 1988.

There will be evaluations of two rake types, two baler types and two bale handling attachment types. Assembly and pre-operational servicing, delivery to the operational sites, operator and mechanic training, and repair and maintenance support is to be provided by Anglo-Thai Tractors Limited. USAID will be providing the test attachments to the Ministry of Industry's Office of the Cane and Sugar Board (OCSB). Nong Yai Sugar Mill has been designated to participate in this program by the OCSB and is to provide up to twelve tractors, the required bale transport units, equipment operators, field labor and a designated residue recovery operations supervisor. The mill has indicated that it plans to operate the

demonstrated machinery at its centrally managed sugarcane farm and as selected sugarcane farms affiliated with its operations. Bales produced under the program are to be stored in waste areas on the farms for possible "off-crop" transport to the power station of the sugar factory. The baling and storage of cane field residues is expected to be performed at the test site for 100 campaign days from mid-December to early-April. The APM - Thailand will be required to coordinate and oversee these operations for the program.

Concurrent with the baled residue recovery operations, the APM - Thailand will provide operational coordination with a research plan developed by and to be executed by the experiment station - the Hawaiian Sugar Planters' Association (HSPA) - in conjunction with the Eastern Regional Research Facilities and staff of the OCSB, Kasetsart University's Department of Agronomy, and the National Agricultural Machinery Center at the Kamphaeng Saen Campus. This plan for data gathering will develop the operational performance, biofuel quality and agronomic impact information required to perform the financial and technical evaluations of the techniques demonstrated.

Upon the successful completion of the initiating phases of the demonstration, with its objective to produce a significant quantity of good quality of biofuel, the APM-Thailand may be called-on to coordinate for the program the test firing of the cane residue-boiler feedstock in the mill's facilities. A limited research plan would then be concurrently coordinated by the APM - Thailand during this period.

A major work requirement for the APM - Thailand would be the recording and transmission of program management information on a periodic basis to the Program Manager.

Limited field office space is to be arranged at the mill and twenty-four hour telephone communications is to be established from the APM - Thailand's residence in the Chon Buri area. Telex and facsimile arrangements will also be made to and from Chon Buri for in-country and international coordination and communication.

A program field car is to be provided on an "Official Use Only" basis to the APM - Thailand. The vehicle is to be secured at the residence each night and during the weekends when there is not scheduled operations. Personal use of the vehicle by the APM - Thailand is not to be allowed.

The APM - Thailand should be fluent in both English and Thai and should agree to provide translation services for the Program Manager, Power Plant Engineer, and Project Analyst as deemed necessary by them.

D. Time

The activities under this contract will commence on or about October 1, 1988, and will continue for one calendar year, or until September 30, 1989.

E. Deliverables

The Trial Year Program Manager will be responsible for preparation of a final report that evaluates the test year and assesses the prospects for cane/energy production at Nong Yai Sugar Mill. To the extent that the data resulting from the trial year allows, the report should include suggestions on the steps the various implementing agencies might undertake to further develop this approach to power generation in Thailand. Five copies of a final report in English acceptable to USAID should be submitted to the Director, O/PDS, USAID/Thailand, not later than December 31, 1989.

F. Costs

The costs for the personnel in the Trial Year Program are attached. The production cost contingency fund will be used as needed for anticipated costs in Thailand during Phase One of the trial year.

Attachment 2

Cane/Energy Trial Year Program
Budget Statement

Personnel

Occupation	Assistant Program Manager	Power Plant Engineer	Program Manager	Project Analyst	
Salary Total	$13,000	$6,000	$13,500	$1,890	
Rate/day	59	500	270	270	
Days in field		14	70	8	
Days of work	220	12	50	7	
Days outside cap	60	9	50	1	
Fringe (25%)					
Allowances Total	$2,040	$841	$3,740	$783	
Moving					
Per diem	2,040	841	3,740	783	
DBA Insurance					
Quarters					
Post diff. (25%)					
Other					
Travel Total	$9,920	$2,200	$8,000	$2,200	
International	2,000	2,000	6,000	2,000	
Local	7,920	200	2,000	200	
Other Costs Total	$1,965	$430	$2,174	$131	
Medical exam	50	50	50	50	
Equipment	500				
Supplies	100	25	50	0	
Communications	800	100	1,500	0	
DBA	515	255	574	81	
Sub-total	$26,925	$9,471	$27,414	$5,004	
Overhead (33%)	$8,885	$3,126	$9,047	$1,652	
Fee (8.5%)	$2,289	$805	$2,330	$425	
TOTALS	$38,099	$13,402	$38,791	$7,081	$97,373

Assumptions
Bangkok per diem: 107
Chon Buri per diem: 34

CONTINGENCY	$17,627
	$115,000