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Office of Energy
Bureau for Science and Technology
United States Agency for International Development

RICE RESIDUE UTILIZATION TECHNOLOGY INTERNATIONAL MARKET PROSPECTS FOR U.S. INDUSTRY

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ABBREVIATIONS

A.I.D.	United States Agency for International Development
ARS	Agricultural Research Service, U.S. Department of Agriculture
BST	Bioenergy Systems and Technology Project
LSU	Louisiana State University
IRRI	International Rice Research Institute
OPIC	Overseas Private Investment Corporation
TDP	Trade and Development Program
TVA	Tennessee Valley Authority
USDA	United States Department of Agriculture
WRRC	Western Regional Research Center, U.S. Department of Agriculture

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SECTION 1: SUMMARY

Interest of the U.S. Agency for International Development

In 1979 the Office of Energy, Bureau for Science and Technology, of the U.S. Agency for International Development (A.I.D.) created a specific project (the Bioenergy Systems and Technology Project [BST]) to encourage the use of biomass resources for the production of energy in A.I.D.-assisted countries. Since 1984 BST has concentrated its project efforts on the processing wastes of the three agricultural commodities which contribute most to Third World economies: sugar cane bagasse, rice husk, and wood.

A specific program to target energy production from rice husk uncovered the success of several U.S. rice mills in designing combustion systems which efficiently convert husk into large amounts of electricity or steam/heat. The success of these systems, together with other new possibilities such as production of ethanol, animal feed and chemicals from processing wastes, raises the question of whether or not conditions exist in the developing world under which the vast amounts of wasted rice husk, particularly in Asia, could be converted to energy and other by-products increasingly needed to fuel the economic development effort.

Role of the U.S. Private Sector

Private U.S. companies are the holders of commercially proven systems that convert rice husk to marketable commodities. In addition, some newer systems for stabilizing rice bran that permit commercial scale rice bran oil production for the pharmaceutical and food industries are being developed by the private sector. Recognizing that these companies are the primary actors in future successful technology transfer efforts, BST commissioned the Postharvest Technology Division of Louisiana State University Agricultural Center (LSU) to organize a convocation of U.S. interests from the rice residue utilization industry. Several of these companies have already begun intensive efforts to market their systems in rice producing Third World countries. Others are poised to begin such efforts.

Purposes and Agenda for the Convocation

The convocation as designed had four specific purposes:

* Creation of an opportunity for private companies and other support groups such as finance houses, etc. to meet with each other, to learn about commercial efforts, and to consider each other as potential partners in joint marketing situations;
* Discussion of currently available commercial rice residue utilization technology systems;
* Discussion of promising conversion systems still in the research/development stage;
* Identification of the constraints and risks U.S. companies face if they attempt to commercialize their systems internationally.

To achieve the purposes of the convocation the agenda focused on the dynamics of creating consortia and joint ventures. The main participants in these exercises were the Chief Executive Officers of U.S. companies that are the key players in possible integrated projects with overseas replicability. Additional resource personnel were invited as observers from A.I.D., the Overseas Private Investment Corporation (OPIC), the U.S Trade and Development Program (TDP), LSU and private consulting firms that have put together successful international ventures. The conversation in these sessions targeted risks and constraints that impede successful overseas investment in biomass energy systems.

The sixty-four convocation participants also heard presentations on the energy market in the developing world, the developing country business environment, and the status of technology system performance. Participants represented a full range of expertise and experience in the field of rice residue utilization and included: rice husk power companies, rice millers, food processors, engineering consultants, project developers, researchers, and university faculty.

Findings of the Convocation

Following are the findings of the convocation:

* A tremendous opportunity exists to market power systems in developing countries.
* Commercially proven rice husk power systems are available from U.S. companies.
* On-going research and development efforts promise additional commercializable systems: acid hydrolysis plants to produce ethanol from husk; gas turbines; stabilized bran oil processors yielding high value chemicals as well as pharmaceutical and food/feed products.
* The economic, institutional, and policy environment in developing countries is complicated and must be understood by project developers before successful investment and/or system transfer projects can be realized.
* Based on the current set of risks and constraints identified by participants, the consensus was that U.S. rice husk power companies are not yet in a position to invest in rice residue systems in developing countries. Main concerns included: high costs associated with project development, high level of up-front project risk, the need for project developers to ensure their own fuel supply, the sometimes missing guarantee of repatriation of U.S. dollars, inadequate or unsure project financing, and the need to protect designs in the international arena. More promising initial effort can be expended on overseas sales rather than on investment projects.

What Needs to Be Done Next

Various suggestions made by participants focused on what their industry needs to do to develop systems offerings to the point where overseas investment can become a viable business opportunity.

* More complete packaging of U.S. technology to suit the conditions and needs of developing countries;
* Formation of consortia/joint ventures in the U.S. that bring together all the necessary project elements;
* Development of specific insurance products to protect against loss of contract and loss of development costs;
* Investigation of new sources for project financing, including the possibility of P.L. 480 soft loans and equity swaps in Latin America and the Philippines;
* Completion of project design and coordination of project elements such as technical soundness, local partners, supply and performance guarantees, etc., prior to requests for actual project funding.

Outcome

Participants agreed that it was very useful to call together the rice residue utilization industry. New contracts were made, new sources for project related information identified, and the realities of overseas business development made clear. As a result of the convocation, several new rice residue projects are developing which include new participants. Some convocation attendees have requested annual rice residue meetings to further promote development of this industry.

SECTION 2: BACKGROUND: A.I.D. RICE RESIDUE UTILIZATION PROGRAM

2.1 Origins of the Rice Residue Utilization Program.

Background of A.I.D. Involvement.

A.I.D. increased assistance to developing nations in the area of renewable energy systems after the 1973 oil embargo. In 1979, the Office of Energy at A.I.D. created a specific project termed the Bioenergy Systems and Technology Project (BST) to focus on biomass energy systems. Over the past several years, BST has evaluated options world-wide. In 1983, BST began to focus on the food processing sector which produces large amounts of residue or wastes with little commercial value. BST noted that sugar cane and rice provided the livelihood for a large majority of rural communities in Asia and contributed the most to the economies of many A.I.D.-assisted countries. Thus, rice residue utilization technologies and their useful application became a priority for full evaluation.

Rice-Production and Trade.

Over 90% of the world rice crop (471 million metric tons, rough rice basis for 1986-1987) is grown in Asia where it contributes significantly to the agricultural income. Earnings from the rice crop as a percentage of the total agricultural value in 1984 ranged from 20% in Pakistan to 73% in Bangladesh (Amin-Arsala, et al., 1987). The average figure for 1984 was 42% in nine of the A.I.D. assisted Asian nations. Trends show that some Asian countries have doubled their annual production in the last twenty five years largely through increased acreage, use of high yielding varieties etc. The scenario in the world rice trade, where only a small fraction (less than 10%) of the rice produced is handled, has undergone many changes in the recent past. Countries that previously imported rice have reached or are close to self-sufficiency. This fact together with others, such as the drop in prices prior to 1986, has tightened the situation for many rice exporting nations including the United States. Exporting nations have long looked to new market openings in countries including those in Africa and the Middle East. Recent exigencies of the weather have caused prices to rise again. All these factors indicate to exporter nations that there are new players in the export business and competition has increased. As a result, both importers and exporters have had to rethink on several fronts. One obvious way to reduce costs is by increasing efficiency of both production and processing. To those that have the means to utilize wastes from the rice crop such as the straw and husk, a waste disposal problem can be turned into creation of additional revenue by the sale of energy and marketable products.

The Energy Option.

Energy is a major driving force in most developmental programs in the less developed nations. This was clearly brought forth at the convocation. A.I.D. has estimated that for every 2% real increase in per capita income, energy use will increase 6 to 8%. As far as power generating capacity is concerned, the developing nations are nearing a crisis situation. Inadequate power restricts productivity and development. Despite recent low oil prices, many developing nations remain heavily burdened by the cost of importing fossil fuels. As a result a huge potential market opportunity estimated at up to a trillion dollars exists in the power sector in these countries. Using the current per capita consumption rates in developing countries (approximately 100 kWh compared with U.S. rate of 3000 kWh) and their population growth rates, it is reported that just to maintain current per capita usage, some nations must increase electric power by as much as 66% by the year 2000 (Shields, 1988).

The above constraints have long made these nations look to alternate local sources for their energy. Biomass is an attractive choice since agricultural wastes are already available in these countries. If the technologies can be successfully implemented, the estimated megawatt potential of the rice husk available in certain A.I.D. assisted countries looks promising. In this context, it is worth noting that U.S. exports now represent less than 10% of the total exports of power generation, transmission and distribution equipment and services to developing nations. This is a decrease from the 17% figure 5 years ago and down from over 20% in the late 1970's (A.I.D., 1988). The situation could be improved if the U.S. targets technology systems and services where U.S. suppliers have an edge, such as rice husk conversion technologies.

2.2 The Focus of the Program

From the harvested rice crop, rough rice constitutes nearly 45% of the dry weight of the plant while the straw percentage is nearly 30%. From the dry rough rice, 20 to 22% is husk. This indicates the enormous volume of residue that is generated from the production and processing of the rice crop. In 1984 the total amount of rice husk, generated in nine Asian countries assisted by A.I.D. was 44 million tons. Presuming an ability to mobilize this resource, the annual estimated energy potential from rice husk in these same countries was over 5000MW (Amin-Arsala, et al., 1987).

Although rice husk and rice straw have found minor uses in the past (Chart 1), by far the most promising utilization appears to be for the production of energy and energy related products. Over the past several decades, however, efficient conversion systems for rice residues were not practical due to problems caused by the inherent characteristics of the residues. The highly abrasive property of the silica contained in the rice husk and the rapid build up of rancidity in the rice bran were major deterrents. In addition, procedures adopted to mill the rice did not result in the production of pure residues. For instance the single pass steel huller mill used extensively even today does not produce pure bran. During the convocation it was pointed out that perhaps only 25% of the bran produced today is suitable for oil extraction or production of other high value food and chemical products, the balance being contaminated with ground rice husk which makes the new processes available today impractical as well as uneconomical.

Rice husk has been used for many years as a source of energy in the rice industry, primarily as heat energy for the parboiling of rice. Rice mills use simple husk burners to produce steam for small scale rice parboiling systems. Use in furnaces with step grate systems for husk burning has also been adapted to bigger boilers to generate steam to drive steam engines for mechanical power. The advent of efficient husk conversion systems in the United States utilizing the steam turbine-generator combination solely for the production of electric power, and the potential for other methods such as the acid hydrolysis process have narrowed the focus for looking at rice residue utilization technology applications. In this context, it is important to evaulate the rice industry in the developing nations. First, the husk generated is largely under-utilized and causes a serious disposal problem. Second, many mills in developing nations need replacement and are being replaced with those that are electrically powered, creating a situation in which (a) the husk disposal problem is increased and (b) a greater demand is placed on electrical needs in these countries. Third, as discussed under 2.1 'The Energy Option,' developing nations are under increasing pressure to look to renewable sources such as biomass to supply their energy needs.

2.3. Impact on Rural Development

Nearly 90% of the rice crop in the world is produced and consumed in Asian countries. Improvements to the rice economy will greatly benefit rural development in these countries. In addition, since energy is the driving force in most developmental processes, meeting energy needs with rice residues can produce several benefits in the rural setting. Some of these are enumerated below:

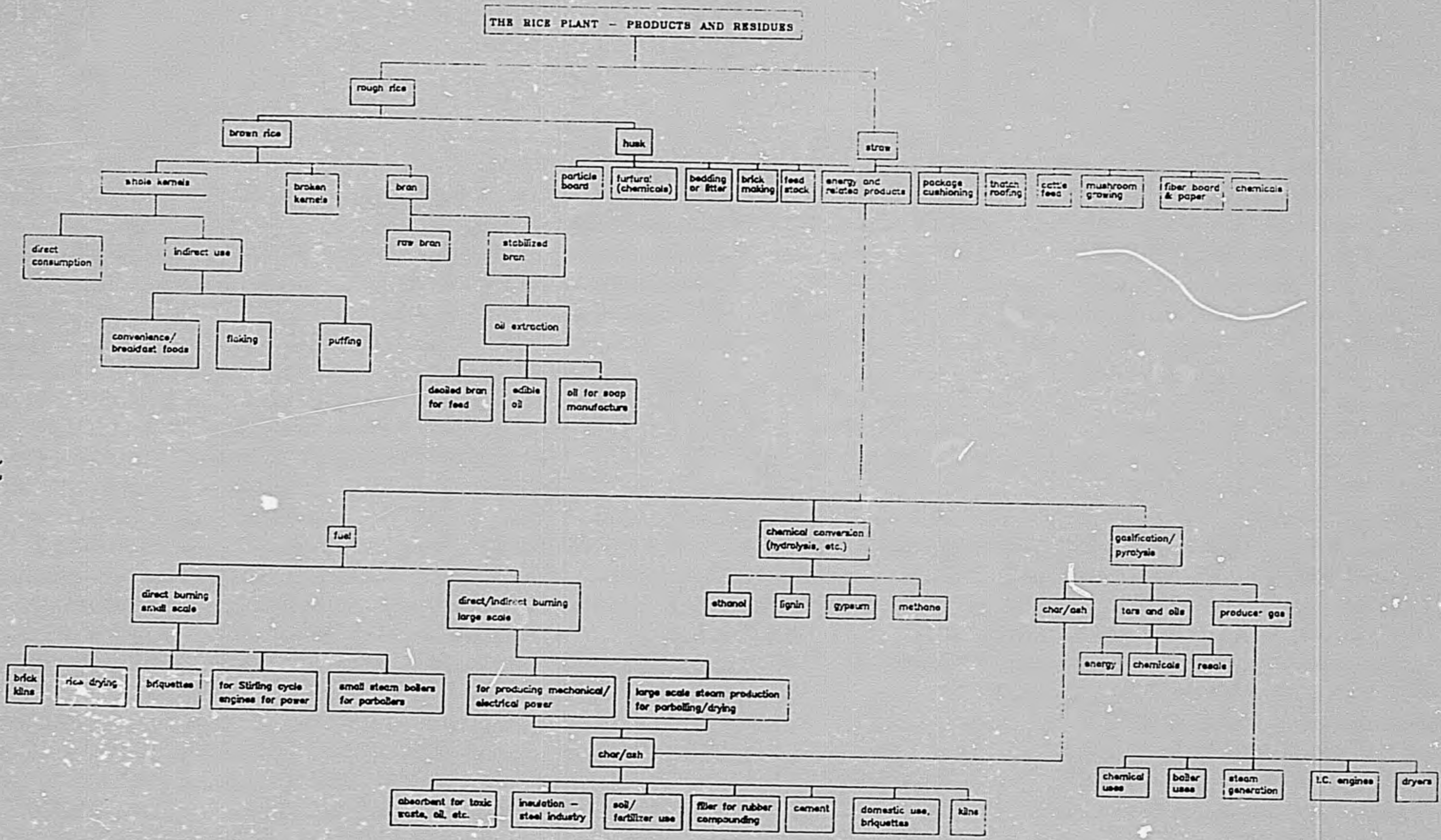


Chart 1. Uses for Rice Residues.

* Provision of reliable rural electrical power for development projects, irrigation, household use, etc.

* Additional on-farm and off-farm employment.

* Provision of new revenue from hitherto unused or under-utilized farm by-products, effectively increasing "value-added" to these products. These include earnings from the sale of straw and rice husk as well as the sale of the products (energy, fuels, chemical, etc.) and by-products (ash) from these conversion systems.

* Elimination or reduction of the disposal problem associated with rice husk in an environmentally sound manner.

* Rice residue conversion systems are clearly linked to, and require improved milling systems. Improved milling methods not only provide the rice residues in a suitable form for conversion but also, more importantly produce a higher rate of recovery of improved quality rice, thereby increasing a processor's earnings. To the rural producing sector this increase is brought about without additional production/field inputs to the rice crop.

2.4 Role of the U.S. Private Sector.

In recent years, the U.S. private sector, mainly from the rice processing industry, has taken the lead in developing and commercializing rice husk conversion systems. Companies developed these systems initially for waste disposal. As a result of the economic success of the systems (savings in fuel substitution and profits from ash sales), the original companies formed subsidiary energy system companies. If the full potential of the contributions these and other companies in the U.S. can make to the developing nations is realized, then both parties will benefit. Developing and marketing systems creates a diversification of the agricultural industry in the U.S. The outflow of conversion systems will provide new jobs and income both in the U.S. as well as in the developing country bringing about improved balance of payments for both nations. It is recognized that the dynamic approach adapted by the U.S. private sector offers management and financial capability and skills to bring about greater efficiency and productivity.

2.5. Potential role of Louisiana State University Agricultural Center and its Postharvest Technology Division.

In addition to performing the normal functions of a U.S. Land-Grant University, the Louisiana State University Agricultural Center, offers unique contributions in the area of rice production and processing. The Center operates the oldest Rice Research Station in the United States with an excellent track record of contributions to the rice industry. Other departments at the Center including the Agricultural Engineering Department and the Food Science Department actively contribute to the development of the rice postharvest system. Recognizing the mutuality of benefits in working internationally in agricultural development work, the Center established the International Programs component in 1979. This component, headed by one of the three Vice Chancellors of the Center, is active in the development and management of agricultural development projects in third world countries. As a commitment to the postharvest systems development effort, the Center established the Postharvest Technology Division in 1985. Several areas of emphasis (identified below) are of mutual benefit to the rice residue utilization program and the mission of the Louisiana State University Agricultural Center:

* Development and maintenance of the proper information base required by researchers, the private sector and government agencies. At present the Postharvest Technology Division has compiled a 15-year bibliography of research in the field of rice residue usage.

* With the proper collaborative arrangement, the Center is able to provide research support. Examples include evaluation of the products developed by the industry from rice bran, feed trials for aquacultural products, design and testing of pilot demonstration plants, bran product development in concert with cogeneration, and other product/process development research.

* Technical support and management skills in the design and development of national as well as international projects, especially in developing nations. International Programs of the LSU Agricultural Center has many years of experience in this area as outlined in Appendix C.3.

* The design and implementation of effective short term training programs both for the U.S. personnel and overseas participants. The Postharvest Technology Division is currently actively involved in this important phase of a typical developmental/technology transfer effort.

SECTION 3: PURPOSE AND AGENDA FOR THE CONVOCATION

3.1. Purpose

As outlined in Section 2 of this report, the utilization of rice residue can result in generation of additional revenue and the elimination of costly disposal problems in the rice industry all over the world. Through the use of the proper technology package and careful management, rice residue can be converted into energy, chemicals, edible oil and feed. At present, rice residues are not utilized to their fullest potential. There is also a tremendous unmet market opportunity of up to one trillion dollars in the energy sector in developing nations. Harnessing the technology systems available in the United States to successfully implement a rice residue utilization program requires the complete identification and coordination of all resources: the technology systems, the companies that can construct and manage them, the financial institutions that can provide the capital for investment in developing nations, and the newer developments in technology that are not commercialized but hold much promise. An environment was needed to allow identified resources to combine, establish contacts and relationships and discuss impediments preventing the U.S. industry from stepping out into the developing nations with the technology systems. The Rice Residue Utilization Convocation was designed to meet this important need.

A.I.D.'s intention was to highlight the stages necessary in creating successful developing nation applications of rice residue utilization systems and to identify *RISKS AND CONSTRAINTS* which prevent actors from moving ahead. Aspects to be carefully addressed included residue resources; mobilization; conversion technology; scale; as well as economic, financial, policy and institutional prerequisites. The exercise would identify which institutions and actors are currently available/willing to assume the identified risks and/or reduce them.

The ultimate goal was to define specific actions and programs which A.I.D. can mount or create in other institutions to assume the risks which no one currently is willing to assume.

At the stage of identifying U.S. resources, it was necessary to develop an information base to include not only resources (people, companies and institutions) but also information on the state of the art in the technologies for presentation to the participants at the convocation. The latter was addressed via: a literature review of research in the rice residue utilization area (last 10-15 years); a video production of the currently commercialized technologies in the U.S. as well as new technology which will be on-line in the short term for use overseas; and short technical presentations to the industry on new and promising technologies which could make a difference down the road, including bran stabilization/product development, gas turbine applications and gasification of rice husk.

3.2. Agenda

The agenda design for the one and one-half day convocation provided maximum opportunity for participants to combine/interact through information exchange, discussions, establishing relationships etc. One morning session allowed for presentations while the heart of the program concentrated on the dynamics of creating a joint venture/consortium. Exercises were formulated so that two lead companies who now have commercialized rice husk power systems would initiate a discussion with "partners" from consulting firms, banks, financing and insurance agencies etc., to form joint ventures/consortia. The actors for this role-playing exercise were chosen to represent the necessary elements of a project to venture overseas. The exercises were conducted separately: one for joint ventures and one for consortia. The opportunity in this format was to discuss and negotiate with actual people showing the real concern that each element of an overall project brings to such a proposition. Through such an exercise the actual risks and constraints were brought out and ways and means were suggested to remove or minimize them.

The objective of this main event was to encourage companies, institutes, and individuals who are involved in the utilization of rice residue to identify obstacles preventing formation of viable partnerships where each entity's talents, technology and strengths complement each other. The joining together of these resources is for both national and international markets.

AGENDA

Thursday, January 28, 1988

Morning Session: "U.S. Technologies and the Scenario in Developing Nations"
(Session Moderator: Dr. Lakshman Velupillai, L.S.U.)

8:30	Welcome Address	Dr. H. Rouse Caffey, Chancellor, L.S.U. Agricultural Center.
8:45	"The university role in integrating residue utilization into postharvest systems"	Mr. Macon D. Faulkner, Vice Chancellor and Director, International Programs, L.S.U. Agricultural Center.
9:00	"How does the U.S. private sector interact with the goals of the U.S. foreign assistance program?"	Dr. James Sulivan, Director, Office of Energy, Science and Technology Bureau, A.I.D., Washington, D.C.
9:30	"The potential of agricultural residue utilization technology in improving economies"	Mr. John Shields, Manager, Office of Agricultural and Chemical Development, Tennessee Valley Authority, Muscle Shoals, Alabama.
10:00	"Rice Residue Utilization - The U.S. commercial offerings and new resources"- A Video Presentation.	Postharvest Technology Division, L.S.U. Agricultural Center.
10:30	Coffee Break	

10:45	Technologies in the Making - New Possibilities	
	a) "Rice bran as a potential source of higher value chemicals"	Dr. Robert Sayre Research Chemist, Food Quality Research Unit WRRC,ARS,USDA, Albany, California.
	b) "Gas turbine cogeneration with agricultural residues"	Dr. Eric Larson Princeton University, New Jersey.
	c) "Gasification of rice hulls"	Dr. John Goss, University of California, Davis, California.
11:15	"The Developing Country Environment - Risks and Constraints	Dr. Marcia Gowen, Bioenergy Systems and Technology Project, Office of Energy, Science and Technology Bureau, A.I.D., Washington, D.C.
11:45	Discussion.	
12:00	Lunch.	

Afternoon Session: "The Dynamics of Creating Consortia/Joint Ventures"
(session moderators: Dr. Joseph Roetheli, TVA and Ms. Betsy Amin-Arsala, U.S.A.I.D.)

1:30 Group Discussion

<u>Consortium group</u>: Spokesperson - Mr. Willis Noland,
Facilitator - Dr. Lalit Verma

<u>Joint Venture group</u>: Spokesperson - Mr. Keith Lanneau,
Facilitator - Dr. John Nye

The two groups will participate separately, one as a consortium and the other as a joint venture, addressing the following issues:

a) What the U.S. industry has to offer in terms of technology?
b) What is promising in the research areas?
c) What are the international markets?
d) What are the risks and constraints?
e) How do we finance and support international ventures?

4:30 Preparation of summary of findings by group spokesperson and the facilitator.

5:00 Reception - L.S.U. Agricultural Center.

Friday, January 29, 1988

Morning Session: "Group session findings, next steps?"

8:30 Presentation of "consortium" group summary - Mr. Willis Noland, President, Agrilectric Power Partners, Ltd., Lake Charles, Louisiana.

8:50 Presentation of "joint venture" group summary - Mr. Keith Lanneau, President, Helix International, Baton Rouge, Louisiana.

9:10 General Discussion:

a) Summary of risks and constraints.

b) What are the next steps?

10:15 Coffee Break.

10:30 Summary Comments — Mr. Jack Williamson, Acting Director, U.S. Trade and Development Program, International Development Cooperation Agency, Washington, D.C.

10:50 Summary Comments — Mr. Michael Stack, Spokesperson for the Director for Government Affairs and Business Development, Overseas Private Investment Corporation, Washington, D.C.

11:15 "Options for Future Use of PL480 Funds" — Mr. Robert Bostick, International Affairs Specialist, PL480 Program, Office of Management and Budget, Washington, D.C.

12:00 Conclusion.

SECTION 4: THE OVERSEAS OPPORTUNITY

The objectives of the Office of Energy at A.I.D. in assisting the decentralized power sector of developing nations clearly complement the market opportunities and the resources available in the U.S. to meet the needs in these nations. Given below are the components of this scenario:

* To reduce the trade deficit the U.S. must play a larger role in international markets.

* There is a power crisis (impeding development) in developing nations. Increasing involvement of the private sector will be necessary given the budget problems of government agencies. Power demand however will increase as economic growth proceeds. This provides a huge potential market at least for the next 20 years.

* The U.S. has technological leadership in rice residue utilization systems and also possesses needed financing and management skills.

* The export of power generation and transmission systems from the U.S. has declined in recent years; the present low value of the dollar presents an excellent opportunity to reestablish these exports.

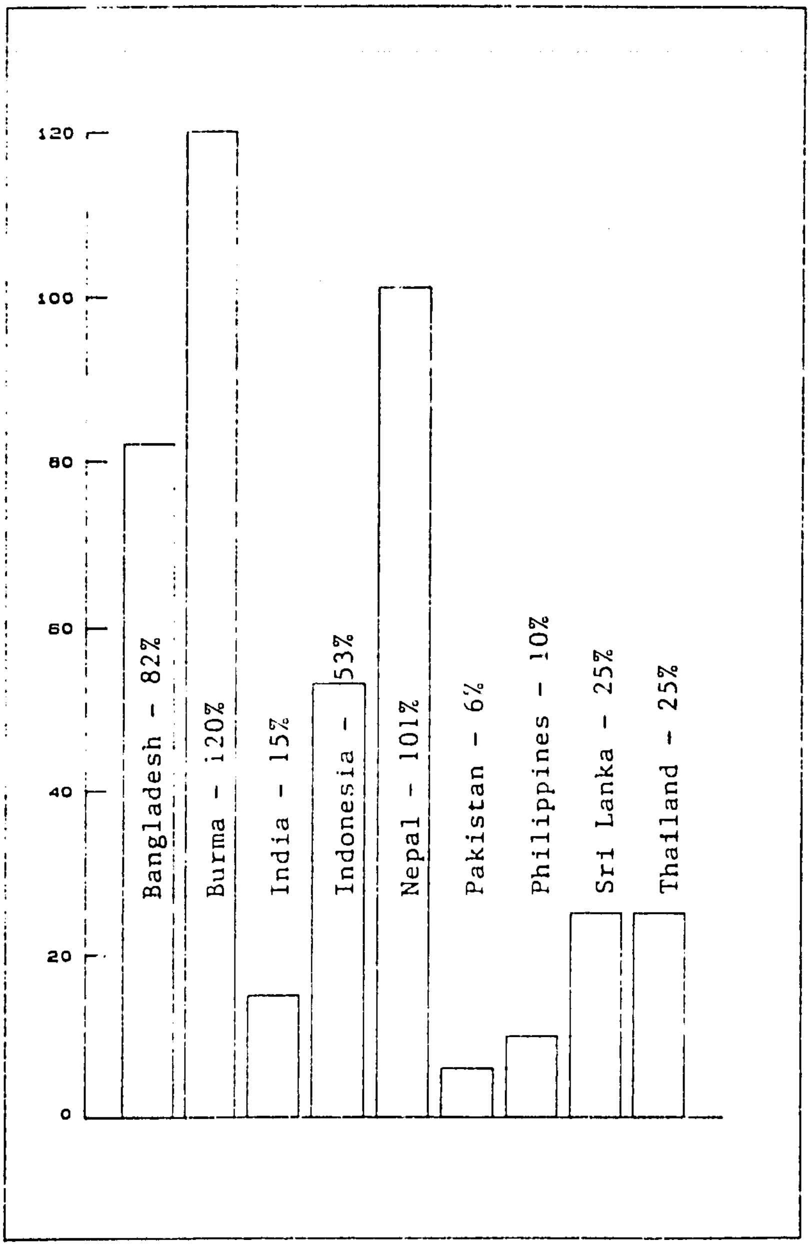
The Rice Residue Convocation was designed partly to find answers to the questions:

(a) How can U.S. businesses be better tailored to tap this 'power/energy' market?

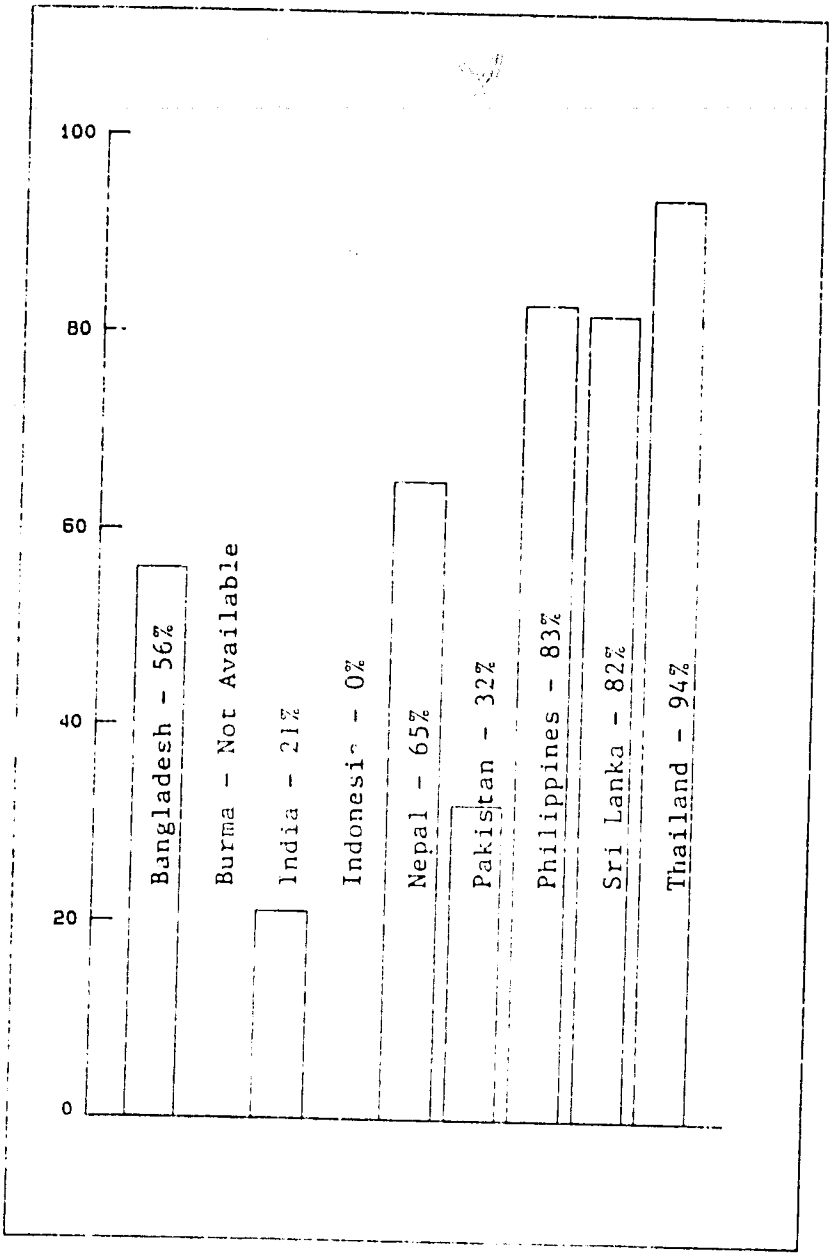
(b) Where and how must initiatives be taken?

The logical starting point given the scenario presented above is analysis within the developing countries where these opportunities are available. Typically a developing nation, in which the rice crop contributes significantly to the agricultural economy and where a demand for electricity exists, is a prime candidate for investment (Graph 1 and 2). If in addition to a need for decentralized electrical power, a market for fuel products such as ethanol exists, then a number of options are available. The Bioenergy Systems and Technology Project of the Office of Energy at A.I.D. has in fact published information on nine A.I.D. assisted countries where the rice crop plays an important part of the agricultural economy and rice husk is theoretically available for power generation. Table 1 indicates the role of rice in these economies and the gross megawatt potential of available husk (Amin-Arsala, et al., 1987). A rice residue utilization team consisting of A.I.D. and U.S. private sector personnel has evaluated the possibility of decentralized power need in East Asia. This team made a survey in Indonesia, the Philippines and Thailand, and confirmed that private sector involvement in decentralized power generation using rice husk was possible. A more recent study of Indonesia highlights the potential for private investment and clearly identifies the scope of project risks.

Project feasibility for rice husk power systems or bran oil/product development systems in developing countries is highly site specific. The benefits of power generation and related product development from rice residues on a commercial scale is a relatively new area, and the important players in a country are often not familiar with the implications and benefits. Thus embarking on a venture under these circumstances becomes a highly individualized and challenging undertaking. Companies in the U.S. have already paved the way both in rice husk power systems and rice bran utilization systems by successfully marketing these technologies. Despite country specific characteristics, however, there still are some common features in these markets:



Graph 1. Gross National MW Potential from Rice Husk as Percent 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 achieved by U.S. Base Case Plant for year 1984.)



Graph 2. Percent of Commercial Energy Derived from Imported Fuel (1980). (Source: The Energy Transition in Developing Countries, World Bank, 1983.)

Table 1. Rice Husk Power Generation Potential in Asian Economies

U.S.A.I.D. Assisted countries in Asia	Rice as % of Agricult-ural value	Year-1982 Net installed electrical capacity per capita (MW)	Year-2000 required net installed capacity with no improvement (MW)	Annual husk available at 22% husk (x1000tons)	Annual estimated gross MW potential of rice
Bangladesh	72.39	1,025	1,706	4,750	559
Burma	36.96	635	942	3,124	368
India	31.65	38,755	54,040	19,655	2,315
Indone[illegible]	51.75	5,016	6,877	6,355	985
Nepal	49.25	139	209	607	71
Pakistan	19.47	4,239	6,575	1,122	132
Philippines	29.37	5,155	7,336	1,754	207
Sri Lanka	45.57	562	776	440	52
Thailand	48.49	5,057	6,994	4,070	479

* The resource - rice husk, straw, and rice bran.
* The technology system.
* Economics.
* Financial implications.
* Policy and institutional factors.

These and other factors specific to the country of interest and within countries to the sites of interest must be carefully analyzed as part of project feasibility.

The A.I.D. program in support of rice residue systems replication seeks new mechanisms for 1) accessing the needed information, 2) identifying local companies and resources necessary as project components, 3) creating opportunities for communication between U.S. and Third World companies, 4) coordinating available financial resources and 5) publicizing the opportunity to mobilize competitive U.S. industry as a partner in development initiatives in countries assisted by the Agency.

SECTION 5: SUMMARY OF CONVOCATION

5.1 Participant Profile

At the outset the convocation was planned to bring together identified U.S. resources in the area of rice residue utilization. The main targeted participants were the private sector companies that have developed and commercialized husk energy systems and companies that have developed commercial systems for the extraction of bran oil and other bran products. In addition, people from allied fields including rice farmers, researchers from universities, private and government agencies, rice millers, power generation equipment manufacturers and private consultants were invited. Due to the fact that the main thrust of the convocation was to identify risks and constraints in investment and technology transfer to the A.I.D. assisted developing nations, finance and insurance agencies, A.I.D. personnel, and companies with overseas experience in project development and management were also in attendance.

The actual attendance at the conference, as shown in the participant list in Appendix A, was a good mix of the categories outlined above. Due to this good representation the process of identification of risks and constraints as well as the discussion of other pertinent issues received excellent coverage for the benefit of all present. Many of the issues exposed were controversial, and the discussion - both public and private - reflected the frustration which exists among those actors who can see that an opportunity exists which is not yet matched by coordinated action.

5.2 Program Format

The convocation design provided an environment for the identified U.S. resources to interact and flush out what the U.S. industry can and cannot do with respect to overseas investment and technology transfer. As a result over 60% of the time was devoted to exercises and discussions, with one session providing the audience with information on the new technologies.

The 'consortium' and 'joint-venture' groups were both given a similar set of guide lines to initiate the exercise of identifying risks and constraints to overseas investment. Resource persons from OPIC, TDP, and A.I.D. as well as university representatives were made available to both groups. As the exercise unfolded, the groups took slightly different approaches and produced results which were complementary in content and critical to the final decisions reached. The consortium group devoted much discussion to the risks in the developing nation, while the joint-venture group identified what needed to be done here in the U.S. prior to stepping out and what suitable climates are needed to successfully implement technology transfer projects overseas. Foreign competition was given much thought by both groups but these discussions were aimed only at the developmental and initiating phases of a project and not at the technological advantage/disadvantage of foreign companies. It was noted that successful investment by U.S. companies in the Third World has generally been preceded by selling goods and services for a period of at least five years. From this companies gain experience in doing business in a developing country which is a crucial prerequisite to good investment. Again the notion of involving a partner in the initial stages of project development here in the U.S. was suggested as an alternative by the joint venture group. Complete and proper packaging of the technology system, proper U.S. evaluation, and adaptation to Third World market/country needs were touched upon. The identified risks and constraints are summarized below.

5.3 Identified Risks and Constraints

A large number of risks were identified at both the development stage and at the overseas implementation stage, with various ways and means suggested to minimize these. To put them into proper perspective as well as to assemble all of the pertinent information, the authors felt it necessary to categorize them into the sections that follow.

U.S. Technology

In the area of U.S. technology the general conclusion reached by the participants was that only the properly packaged, commercially proven systems must be utilized to minimize not only the technical risk but also to present a system capable of winning a contract and being successfully operated. In addition, several areas of concern and need were expressed. These centered around the proper packaging of the technologies and what needs to be done in the U.S. first; protection of the technology overseas; fuel constraints for power plant operation, and others. In this context it must be stressed however, that the convocation brought out the fact that the U.S. does possess the leading edge not only in the technical area but also in the management area. Some of these capabilities are summarized in Chart 2. The identified constraints in the area of technologies are provided below.

Technology Packaging

The participants at the convocation felt that, although there were still some gray areas, the husk power systems were fairly well packaged and structured. The bran related technologies, however, are felt to be in the development and commercialization stage. Stabilization (Brady extruder) and bran oil extraction are now available on a commercial scale, but the food/feed and high value nutrient and chemical product development technologies must be fully packaged to work in concert with cogeneration. In this context a generic diagram of the elements in a technology package are illustrated in Chart 3. Elements 'B' and 'C' in this chart appear to be the weak links that need to be looked into prior to embarking on a full fledged project overseas. Again the sentiment was expressed that some gaps appear to exist in what the U.S. technology package can offer and what a particular developing nation may need. This is particularly true in the area of bran products. Food and fiber products as well as introducing protein from rice bran into the food chain appear to be preferable to the production of high value pharmaceuticals and oils. In terms of developing country needs, these countries are also looking to export the products or by-products of rice residue technologies. Ash and related products appear promising and the current U.S. technology packages can meet this need. Some countries require less sophistication of control equipment as well as maximum employment opportunities at the plant site.

Some valid answers were presented to the question: Why aren't these technology packages fully developed? In the rice husk-to-power area, only those rice mills that had a thermal power need (only about 15% of the U.S. mills - ones that parboiled rice) felt the need to invest in husk conversion systems. The others which processed 'white' rice did not have this need. In the bran area, not only was there a suitable outlet to the feed industries, but also there is a glut in the vegetable oil market, and at commodity rates bran oil does not compete well. On a positive note, it was pointed out that new technologies of bran conversion to food/feed products and other high value products are already available 'on-the-shelf' in Federal Labs, in private research companies, universities, etc. All that is required is the use of these technologies and packaging after complete evaluation and testing.

Considering elements 'B' and 'C' cited earlier as the major weak points, the storage (and transportation) aspect and the need (if any) to preprocess the residues prior to use in the U.S. technology systems are two areas that have to be carefully assessed. The moisture content and purity of rice husk for example could be crucial in obtaining the efficiency of conversion as well as the heat output in a power system. It may be necessary to plan on storage of residues (as discussed in the next section) in quantities and for periods greater than required in the U.S.

With respect to the availability of bran, it was pointed out that only a fourth of the bran processed in the developing world is produced in an manner suitable for economical extraction of oil and other products.

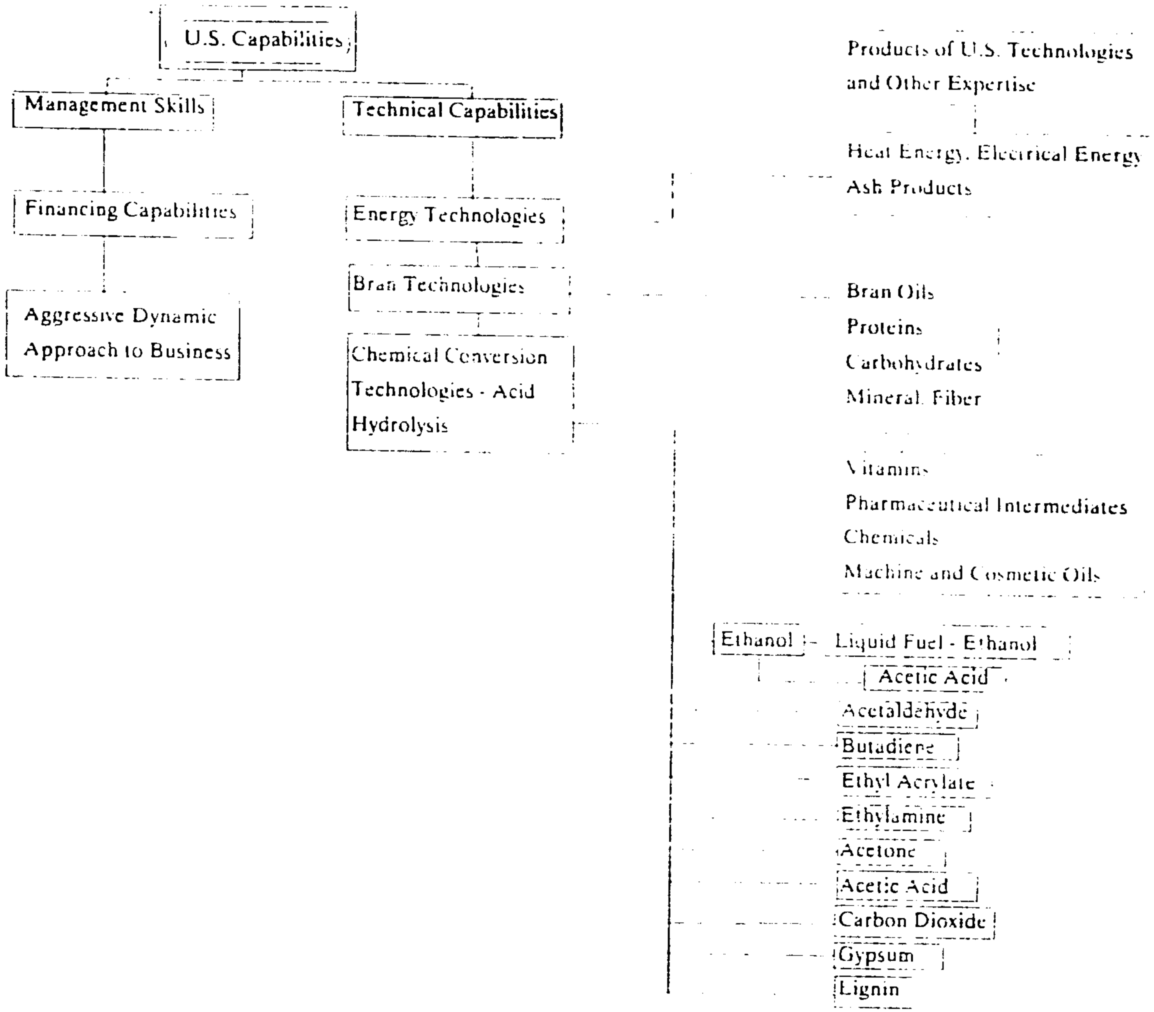


Chart 2. U.S. Capabilities and Expertise in Rice Residue Utilization.

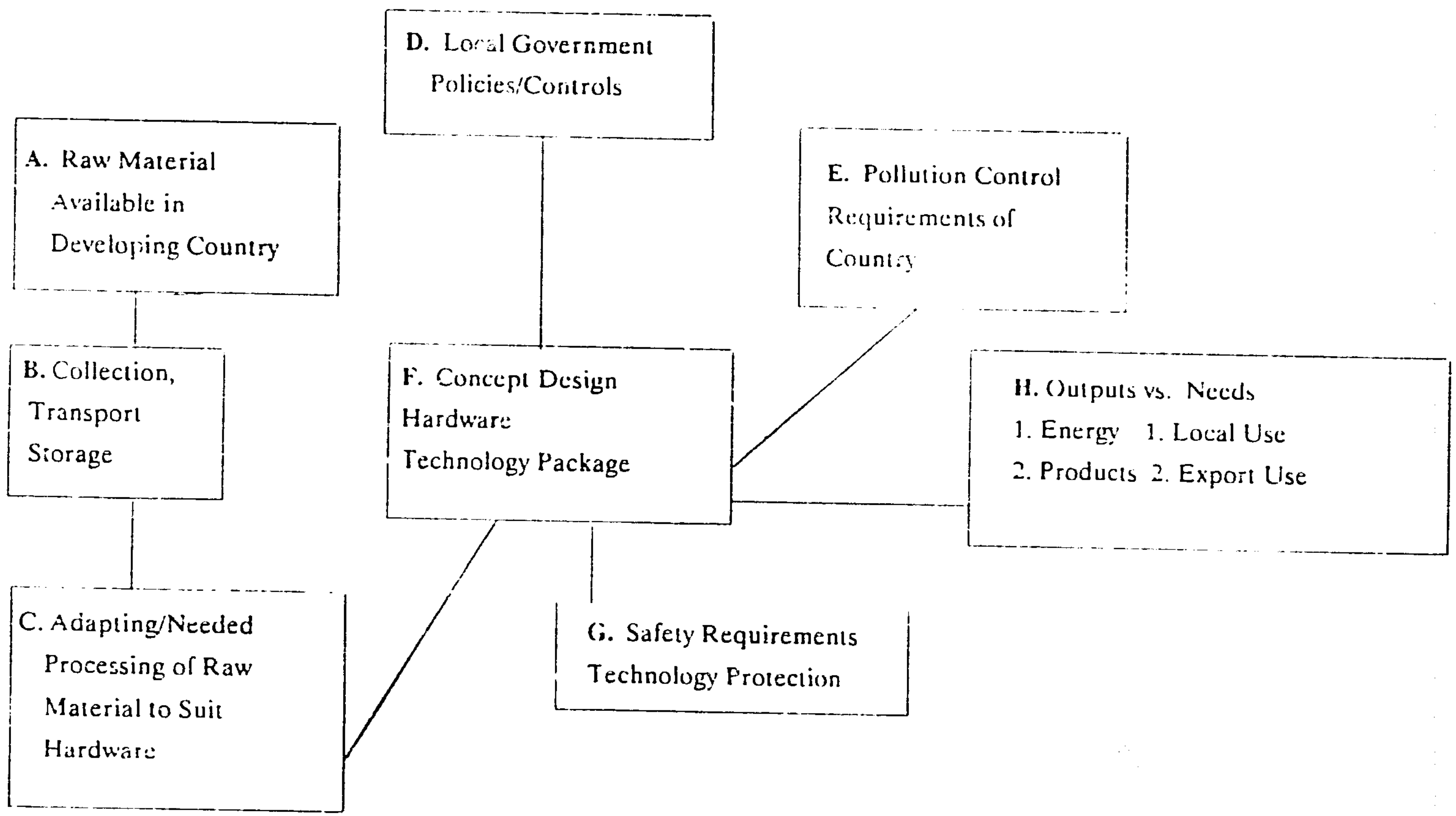


Chart 3. The Technology Package - Implications/Needs in a Development Country Scenario.

This points to the need for modernizing the milling practices and/or offering price incentives for better quality bran.

Fuel constraints for power plants

Quite appropriately a great deal of discussion was devoted to the question of fuel supplies for the operation of power plants. Fuel supply breakdown is identified as a major risk. Rice husk is the by-product of an agricultural crop and hence is also subject to the vagaries of weather as well as to social and political influences. Two recommendations were made to overcome this problem: (a) plan the project to have a minimum 45 day supply at the plant site and (b) size the plant to use only 10 to 15% of the husk supply available in the area of interest.

Next, the seasonality of the supply was discussed. In some areas husk is produced for only 7 months (arising from the 7 month milling season) of the year. Could rice straw and other crop residues be adapted for use during this off season? This is a very important question the private sector needs to address. As a first step some suggested that a project be located nearer to a few large mills rather than a cluster of several small mills to minimize the fuel availability and transportation risks.

Protection of U.S. technology

The protection of the technology when investments are made overseas is deemed important both to compete effectively and to ensure participation in a market with replication potential. On the other hand participants felt that mere duplication of a piece of equipment does not guarantee that the operation of the same will be successful. The U.S. company that developed and produced the system could maintain its uniqueness and hence hold competitiveness in the following areas:

* electrical/electronic controls and their proper settings

* equipment/component life as a reflection of the proper materials and processes of manufacture

* 'the whole is greater than the sum of the parts' effect where the original manufacturer/supplier can get and maintain rated capacities and efficiencies

Exclusive licensing and international patents are other alternatives that could protect technology systems and should be explored more actively by technology holders.

Project Development and Operation

In investing overseas in the area of rice residue conversion systems, the major risk identified at the convocation was the up front funds needed for project development, feasibility study and allied developmental costs. This was an area of concern for several reasons including the fact that the total value of a project often cannot justify the expenditure of the up front money needed (For example, a \$5 million total investment in a project cannot justify development costs of \$1 million.). There is also the risk of spending the initial funds only to loose the contract to a competitor. Companies that evaluated this risk felt that the U.S. rice husk power companies were too small to afford developmental costs and were willing to do so only if the possibility of replication existed in a country.

Several approaches to locate the funding for the development of the projects were discussed. Foremost among these was the assistance sought from U.S. Government Agencies such as TDP and A.I.D. Participants were also keen to access local currencies presumably accumulated in host countries as a result of the P.L.480 program. Considering the market potential for the next 20 years, the private sector felt that assistance from the U.S. government agencies for the initial feasibility monies could be a valuable investment. This would place U.S. companies in an advantageous position as well as assist them during this costly and risky phase. Another source of funding was proposed through collaboration with local partners who will have long term interest. A funded corporation consisting of U.S. and local partners was suggested as the most likely to attract feasibility money, while a contractually linked cooperative group was said to have the least likelihood.

Beyond locating project funds, the next area of concern was the lack of any guarantee that the U.S. company would be assured of the contract. In this context, exclusivity agreements with the local government was suggested as the best form of protection. A memorandum of understanding or a letter of intent from the local government, with limits and requirements as well as milestones (specifying obligations of both parties), was suggested as a mechanism for accomplishing what is needed.

Another important issue is that in planning and developing a project, a U.S. company may not be familiar enough with the local socio-political and economic environment. Therefore, it becomes difficult to quantify or assign risk factors, such as the electricity demand projections in a country. The company that wants to develop the project, whether it be the power company or not, must form joint ventures with the local government agencies or with local private sector partners. A model was suggested as shown in chart 4. Local entities are important in partnerships because:

* They understand the local culture.
* They know the local 'codes', environmental requirements and will know how to work through the local 'maze'.
* They will have the required credit worthiness.
* Due to the partnership arrangement, they will have a financial stake in the project.

There is also a need to convince local authorities that discouraging subsidies on energy will not only save much needed foreign exchange but also enable the country to better manage and benefit from the available biomass. Given the proper environmental controls incorporated in the U.S. power generating systems, the environmental improvement available should also encourage local and national support for these power projects.

If the possibility of replication of a project exists in a country of interest, another means of spreading the initial risk is to attract the U.S. manufacturing companies that supply the boilers, turbines etc. These companies seeing future sales outlets for their products might also take an equity position.

Fuel supply and transportation was considered an important component by the participants. Interruption of fuel supply and transport can seriously affect a power generation company's operations. Rice husk is a residue from an agricultural operation, thus supply side risks are higher. Several suggestions were presented earlier: maintaining a 30-45 day supply, planning the project to only use 10-15% of the husk produced in the area of interest, and joining with local transport companies and mills. Again contracting with local partners for these supplies and services should include price guarantees for specified periods. At initial stages the project must be scaled according to these constraints so that the likelihood of success is high.

Equally important to rice husk supply is the necessity of guaranteed sale of the generated power. New competition, failure on the part of the local government to buy the power, and breakdown of transmission equipment are some causes of business interruption. Protection in this case both for the initial financing

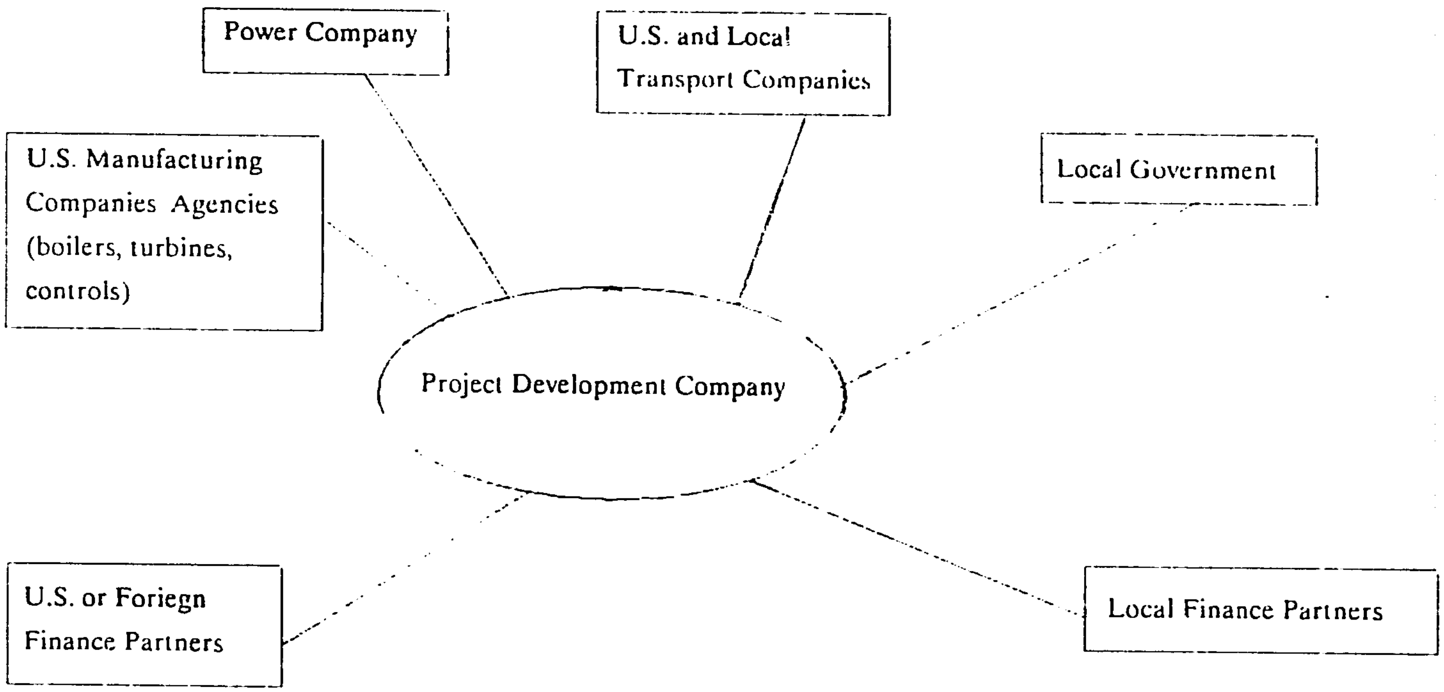


Chart 4. Project Partners.

requirement as well as for the uninterrupted operation, is a purchase contract with price guarantees. Local vested interests as partners can also help ensure uninterrupted sales.

Participants also discussed a less expensive approach to project development in a country: formation of a local partnership to merely sell the power systems for a period of time. This approach permits learning thoroughly the needs and features of the local climate, reduces or minimizes most of the political and other risks, and could serve as a first phase of foreign business development prior to actual investment later.

Project Finance and Insurance

The necessary finance and insurance for developing and operating a power project overseas received much attention at the convocation. The two primary issues that emerged from these discussions were:

(a) What is needed to be in place prior to approaching a financial institution?

(b) What are the potential sources of financing?

In this context, many risks and constraints were identified:

* Lending institutions will only entertain technology systems that are proven and commercialized. This places the burden on the projec' developer to properly package the technology (preferably in the U.S.) and provide sufficient data on performance and capability.

* Banks (especially U.S. lending institutions) will be comfortable only if foreign expertise in building, managing and running the plants to capacity are involved.

* Project completion risk and performance guarantees. The banks will have to be convinced that the plant is completed on schedule and its performance is guaranteed. In this context, a good record of management and operation at required capacity are of paramount importance to satisfy a lender. A sales contract for the product must first be negotiated.

* Various insurance policies (discussed later) will have to be in place.

To summarize the requirements for a lender to review a power project, the following were deemed important and necessary:

(a) Fuel supply contract (includes transport)

(b) Performance and operation guarantees

(c) Purchase contract for product (output)

(d) OPIC insurance

The discussions at the convocation also dealt with sources of finance for power projects in developing nations. It was pointed out that American banks are very reluctant at the present time to make loans for projects in developing nations. In the case of international development banks, such as the World Bank, there appears to be not much recourse as these institutions deal with governments and not with private entities. OPIC, IFC, the ADB commercial window and local banks and local equity partners were other sources mentioned. In the case of South America and the Philippines, since these countries owe a large amount of money to U.S. commercial banks, the possibility of converting these loans into equity was discussed as a source of local currency for these projects.

Structuring a project to use local sources of funding (banks, local businesses) was thought to be a good possibility to finance projects. A local partner who already has a stable business operation would not only know the business climate but also have the required credit worthiness to persuade local banks. The possibility of in-country manufacture was also suggested to minimize dollar investment. In this case many participants cautioned that the manufacturing technologies (casting, machining, etc.) may be lagging behind the level of the U.S. technology creating a new difficulty to ensure soundness of the components.

The question of insurance for power projects revolved around the protection of developmental costs (initial risk) and the protection against business interruptions once the project gets underway. The private sector specifically requested that OPIC sell an insurance product that will cover risks associated with developmental costs. This was considered essential by the small U.S. power companies as they felt unable to provide up front capital. Although the project developer would ensure that sales contracts and price guarantees are in place, the risks involved in nationalization, failure on he part of local governmental agency to buy the generated power, and similar occurrences would still remain. Currently available OPIC insurance against political risks would protect against some exigencies. However, OPIC insurance does not protect against risks due to natural disasters. These could be covered by commercial insurance products, but the project developer needs to evaluate the cost very carefully. Other relevant insurance products and financial sources are discussed in Appendix B.

SECTION 6. RECOMMENDATIONS

Based upon the discussions held at the convocation and from the feed-back obtained through a post-convocation questionnaire, several recommendations and requests were made regarding the future needs and direction of the U.S. rice residue utilization industry. These covered the areas of project development, financing, and insurance requirements among others and are given below:

1. U.S. government support is needed to develop an integrated rice husk power/bran products system. This could serve as a demonstration project as well as meet the needs of the private sector in properly packaging the technologies.

2. The private sector feels that U.S. government/agency support is needed in the area of technology protection in the developing nations.

3. The private sector needs information on rice residue availability and potential as well as the nature of the competition in the countries of interest.

4. Initiation of dialogue with developing country governments/agencies for environmental policies will enhance the attractiveness of U.S. rice residue systems which already incorporate pollution controls.

5. The private sector specifically requests that OPIC provide an insurance product that they can purchase to protect against development risks including loss of development investment. This request was made for protection against loosing a project when the developing nation client takes the developed project and hands it to a competitor.

6. The private sector recommends development of a program to guarantee repatriation of U.S. dollars.

7. Government support is also needed for financing project development and actual project funding - through sources such as P.L. 480 funds as soft loans.

8. Creation of a small group to coordinate a private-government approach to marketing rice residue systems abroad is recommended.

9. The rice residue utilization systems, especially those that use rice bran, need more complete packaging. Experience in adapting U.S. systems to developing country requirements and operating them under these conditions was deemed necessary.

10. The private sector was encouraged to form consortia within the U.S. to include all areas of expertise (technical, project development, financing) prior to investments abroad.

11. The private sector, as the project developer, was encouraged to explore and analyze all aspects (local partner, financing, technical soundness, fuel supply) and then present the proposal to obtain project funding through TDP, Eximbank and other banks.

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Many participants recommended that future meetings, perhaps on an annual basis, be sponsored by A.I.D. In this context, they recommended that the following be included:

1. People who have successfully developed projects overseas in the rice residue area to share their views and experiences.

2. Bankers to describe their actual requirements for projects.

3. Representatives from client country enterprises including rice millers in Asia to learn of their needs and how business is conducted in their environment.

4. Participants with experience in economic analyses related to complete systems in rice residue utilization.

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APPENDIX B

B.1 The U.S. Trade and Development Program

The U.S. Trade and Development Program (TDP) is a component agency of the International Development Cooperation Agency together with the Agency for International Development (A.I.D) and the Overseas Private Investment Corporation (OPIC). TDP exists to help promote the economic and development objectives of the United States. TDP finances the planning of projects in developing nations which result in export markets for U.S. goods and services. The TDP seeks to assist U.S. companies in meeting foreign competition and increasing exports. Projects funded by TDP have led to at least $600 million in exports from the U.S. It is stated that these projects are likely to generate exports totalling another $13 billion. TDP works closely with the Department of Commerce, the Department of Agriculture, the Department of State, OPIC, A.I.D., and the U.S. Export-Import Bank.

The following are some of TDP's functions as described in a TDP brochure:

* Financing feasibility studies and other planning services for major public sector projects in developing nations. Through this method, TDP seeks to increase the likelihood that U.S. goods and services will be used in implementing these projects.

* Co-financing on a reimbursable grant basis, planning services for projects where a private U.S. investor intends to have equity participation.

* Coordinating and authorizing the provision of government-to-government technical assistance on a fully reimbursable basis.

* Facilitating, through specific statutory authority, access to natural resources of interest to the U.S. This broadens opportunities for U.S. investment and export of goods and services needed in the development and the diversification of foreign sources of supply of strategic and critical minerals without adversely affecting domestic U.S. production.

The following is a summary of comments made by the TDP officer at the rice residue utilization convocation with specific reference to overseas investment in rice residue power/chemical or food products development projects:

* TDP is a small organization with limited personnel resources. Hence to better use the TDP, the project developer generally should perform all necessary steps including the tie up with a local partner, assigning risks, verifying the technical soundness of the project, etc.

* Project development should include the formation of consortia/joint ventures with the technical specialists, banks, universities, local partners and others to increase the likelihood of success.

* TDP's investment in time and resources is about the same irrespective of project contract volume. It generally favors projects that have a greater capacity to generate exports as well as jobs in the U.S.

B.2 Overseas Private Investment Corporation

The following is an overview provided by the Overseas Private Investment Corporation (OPIC) to describe its mission and functions:

The Overseas Private Investment Corporation (OPIC) is a self-sustaining, U.S. government agency whose purpose is to promote economic growth in developing countries by encouraging U.S. private investment in those nations. By doing so, OPIC can help American companies remain competitive in the international marketplace.

OPIC assists U.S. investors through two principal programs: 1) insuring investment projects against a broad range of political risks, and 2) financing investment projects through direct loans and/or loan guarantees.

All of OPIC's insurance and guaranty obligations are backed by the full faith and credit of the United States of America, as well as by OPIC's own substantial financial reserves.

OPIC assistance is available for new business investments and expansions in more than 100 developing countries and areas around the world. However, OPIC will not provide assistance for any project that adversely affects the U.S. economy or domestic employment, is financially unsound, or does not promise significant benefits to the social and economic development of the host country.

The Overseas Private Investment Corporation was established by Congress in 1969, and began operations in 1971. Structured like a private corporation, it does not receive Congressional appropriations. Moreover, OPIC has recorded a positive net income for every year of operations, with reserves currently standing in excess of $1 billion.

OPIC's professional staff, recruited primarily from the private sector, is dedicated to responding quickly to investor needs and to developing creative business solutions for furthering U.S. private investment in the developing world.

The programs and services offered by OPIC are described below:

Political Risk Insurance: OPIC can insure U.S. investments overseas against the risks of political violence (war, revolution, insurrection, civil strife); expropriation; inconvertibility of local currency; and/or loss of business income due to political violence or expropriation. Specialized insurance coverage is also available for U.S. investors involved with certain contracting, exporting, licensing, or leasing transactions to be undertaken in a developing country.

Financing: Medium- to long-term financing for overseas investment projects is available through loan guarantees and/or direct loans. OPIC's all-risk loan guarantees, issued to U.S. lending institutions, typically range from $1 million to $25 million, but can be as large as $50 million. OPIC's direct loans, reserved for overseas investment projects involving small and mid-sized companies, typically range form $250,000 to $6 million. In general, OPIC's finance commitments do not exceed 50 percent of the total project cost.

Investment Missions: OPIC traditionally conducts periodic investment missions to developing countries offering excellent investment opportunities for American businesses. Such missions are designed to introduce senior U.S. business executives to key business leaders, potential joint-venture partners and high-ranking government officials in the host country. Mission participants pay their own travel and accommodation expenses, as well as a pro-rata share of the administrative costs.

Opportunity Bank: This computer data system "matches" a U.S. investor's interest with specific overseas opportunities. American firms seeking joint-venture projects overseas submit a description of their company, the type of investment sought and the developing country or countries of interest. Upon request, the information is "matched" against similar information submitted by foreign businesses seeking American investors. Registration is free, with a modest fee charged for "match" requests. OPIC accepts registration for this service without detailed check of the accuracy or reliability of the information submitted.

Investor Information Service: This information clearinghouse provides U.S. companies and individuals with basic economic, business and political information and data on 110 developing countries and 16 geographical regions. The information is packaged in country-specific and region-specific kits, available for a nominal fee.

Specific comments were made by the OPIC officer present at the convocation to the U.S. private company representatives involved in the area of rice residue utilization. These are summarized below:

* OPIC has a mandate to assist small U.S. business - on that are not Fortune 1000 companies.

* OPIC's finance programs generally favor linkages (joint ventures, etc.) with a local partner in a project. The many reasons for this arrangement were discussed in Section 5.

* There are two legislative proposals currently: one provides for OPIC to make equity investments in African and Caribbean projects, and the other favors loans to assist technology adaptation in a country.

APPENDIX C

C.1. United States Agency for International Development, Office of Energy, Bioenergy Systems and Technology Project (BST)

Resulting from the 1973 oil crisis, interest in renewable energy sources increased world wide. At this time A.I.D. increased assistance to developing nations in the area of renewable energy systems. Due to the fact that biomass systems for the production of energy are quite different from other renewable energy sources, in 1976 the Office of Energy, Directorate for Energy and Natural Resources of A.I.D. created a specific project named the Bioenergy Systems and Technology (BST) Project. BST thus became the vehicle through which A.I.D. is developing the potential of biomass systems for the production of energy and marketable by-products in developing countries.

Concentrating efforts in the biomass resource area, BST began focussing in 1983 on the food processing industries which traditionally create large amounts of 'wastes' with very little value. An analysis of revenue and job generating sectors in A.I.D. assisted countries showed that the two most significant commodities are rice and sugar cane. A large majority of rural people in Asia depend on these crops which also account for the largest agricultural earnings in these countries. In addition to the crop residues from the food processing industries, BST also evaluates residues from wood resources. These efforts are designed to help developing nations lower their dependence on imported energy, explore ethanol and chemicals production possibilities from agricultural wastes, and to increase supplies of electricity from indigenous resources. In addition, BST's efforts help in not only diversifying the agricultural processing industry through involvement in the generation of power and saleable products but also in eliminating an often costly disposal problem associated with these residues. The BST Project is managed by the Tennessee Valley Authority through an interagency agreement with A.I.D. BST's main efforts are in the areas of:

* cane energy systems
* rice residue/ energy systems
* advanced combustion systems
* wood waste energy systems

With respect to the rice residue program that is of interest to the reader of this report, BST has initiated programs in A.I.D. assisted rice-growing countries to expand the efficient use of rice husk and straw. Production of energy and valuable marketable products from rice husk and straw are the objectives of these efforts. BST recognizes that commercially proven technology systems exist today in the U.S. and hopes to harness these as well as other processes currently being developed in the U.S. to achieve the above objectives.. More specifically, BST has been responsible for the following developments:

* A survey-study of two Asian countries - the Philippines and Indonesia - to evaluate investment feasibility for rice husk powered generating systems.

* Through a contractual arrangement with the Tennessee Valley Authority at Muscle Shoals, Alabama, the potential for converting rice husk to ethanol and co-products using the acid hydrolysis process has been investigated. Findings from this activity have shown great potential for commercialization. More details are provided under Appendix C.2 of this report.

* Identification and coordination of all U.S. resources in rice residue utilization technologies. This report outlines the findings in this area. This project activity was completed through a contract with the Postharvest Technology Division, International Programs of the Louisiana State University Agricultural Center in Baton Rouge, Louisiana.

* BST is also exploring ways to facilitate U.S. investment in rice residue energy projects by stimulating the complete packaging of the available technologies and accessing the in-place U.S. government mechanisms such as OPIC and TDP.

C.2. Tennessee Valley Authority, Office of Agricultural and Chemical Development, The Biomass Branch, Muscle Shoals, Alabama

Since its inception in 1933, the Tennessee Valley Authority has been involved in research, development and demonstration of systems to develop agricultural and forestry resources. The Biomass Program is oriented to develop comprehensive, biomass resource and processing technology systems. The program includes basic research, evaluation at laboratory and pilot scale, technology transfer and assistance services. Work is conducted both nationally and internationally. Technology developed by the TVA Biomass Program is directed toward the production of fuels and chemicals from biomass sources including agricultural crops and residues, wood, forestry and industry wastes primarily for commercial application. In implementing this program, the Biomass Branch has been supported by the experience and expertise of TVA's fertilizer program.

The TVA biomass program staff consists of about 40 employees. Projects are conducted by multi-disciplinary teams consisting of engineers, chemists, biologists, microbiologists, economists, and foresters. Capabilities include applied chemical and biological research, process development, resource assessment, process engineering, economic and marketing analyses, environmental studies, design engineering, technical and economic evaluations, technical monitoring and reporting, and forest management. The biomass program staff cooperates closely with universities, State and Federal agencies, private sector companies, and other institutions and organizations.

Facilities have been built at TVA to support the various phases of biomass research and development projects. Research laboratories and bench-scale facilities contain equipment for development of processes for hydrolysis of feedstocks to sugars, bio-conversion of these sugars to ethanol and other chemicals, and waste utilization/co-product production. Large-scale test facilities allow verification of process conditions and product yields and optimization of equipment designs required for commercialization.

Laboratory work on the acid hydrolysis process was begun at the TVA facility in 1983. Following laboratory evaluation, a four ton/day test facility was designed and built. Tests were conducted at this facility first on corn stover and more recently on rice husk. Conversion rates in excess of 90% were possible with corn stover. During this period of testing and evaluation the process was modified several times to increase acid efficiency and reduce the number of handling steps. As a follow up to these studies, A.I.D. in December of 1985 commissioned TVA to evaluate the two-step hydrolysis process for conversion of rice husk. The results showed that the conversion rates for the hemicellulose and cellulose were promising, at 79% and 95% respectively. Subsequently, a one-step acid hydrolysis process was tested. The rationale was that a simple, acid efficient process is more feasible as well as attractive for small scale conversion plants. Again, such tests conducted on a large scale could also provide valuable information on the economic feasibility of the process. As a result of these tests, not only were important technical questions answered, but also new constraints of commercial scale operations identified. Conversion rates for the rice husk into fermentable sugars was satisfactory. Erosion of vessels and pipes and rapid dehydration of the material were not present. However, reduction of acid consumption, increase of sugar concentration and simplification of hardware for the process are identified as needed refinements. In conjunction with this project, TVA performed preliminary economic analyses for rice husk to ethanol conversion. Findings reported are preliminary due to the fact that information on local conditions including availability of husk, cost of input items, market for the products and co-products must be incorporated in an analysis of this type. The TVA staff has performed cost calculations for plant sizes in the 4-27 tons/day range. A base case of a 5 million gallon/year ethanol producing facility was used. Input factors such as feedstock, capital requirements, acid, lime, labor, construction time and power requirements were considered. Included in the output variables were ethanol, biogas, lignin, and carbon dioxide. This analysis indicated a total operating cost of $1.62/gallon of ethanol assuming free feed stock and excluding credit for the by-products produced in the process. Although highly site specific, TVA estimates that the value of the by-products from this process could reduce the cost by $0.25 to $0.50/gallon of ethanol. Capital investment cost used in these estimates was $5.00/annual gallon for plants from 4 to 11 tons/day capacity and $4.50 for plants from 14 to 27 tons/day capacity. TVA is striving through research to reduce production cost by process modifications, acid recycling and recovery, and by-product utilization. For the overall production process the economic feasibility becomes much more attractive when all of the segments are fully in place. These include the development and sale of the various high value co-products (the use of lignin, for example, to provide part of the energy requirement for the conversion etc.). TVA is currently actively addressing these possibilities (Integrated Fuel Alcohol Project, TVA, 1986).

C.3. Postharvest Technology Division, International Programs, Louisiana State University Agricultural Center.

During the last several decades, Louisiana State University (LSU) has been involved in world-wide agricultural research, training and extension programs associated with rice and other sub-tropical crops. To strengthen this ongoing commitment the LSU Agricultural Center established the Postharvest Technology Division in 1985 to develop institutional and human resource skills in the area of rice and other subtropical crops. This division complements the well established programs in the production of these crops by concentrating its activities on the postharvest aspects of rice, cereal grains and forages, crops common to Louisiana and many developing nations.

The LSU Agricultural Center is one of eight campuses belonging to the LSU System, the land-grant university in Louisiana. Statewide agricultural research and extension are responsibilities of the LSU Agricultural Center. International Programs is one of the principle units of the Center, along with the Louisiana Agricultural Experiment Station and the Louisiana Cooperative Extension Service. The University has more than 30 years experience in international agricultural development. The Center has been involved internationally in institution building, participant training and technical consultations. The Center's scientists have served countries in Asia, Africa and Central and South America. A large qualified staff has been committed to service programs aimed at international agricultural development.

The main thrust of the Postharvest Technology Division's programs and activities is to strengthen the capability of personnel who are involved in grain and forage postharvest operations, to reduce losses, improve the quality of their crops and better utilize agricultural residues. The structured training and research programs are tailored to specific needs of participants so that they may better solve postharvest problems in their own environment.

The faculty includes full-time scientists in the area of processing, with emphasis on rice and forages, and several cooperating specialists from various departments and research stations. The Division draws upon the experience of personnel in the LSU Agricultural Center and others with broad international experience for its short- and long-term training programs.

Facilities for research and training in postharvest technology are available at the Department of Agricultural Engineering and other units of the LSU Agricultural Center. A complete laboratory for grain quality work is available. This laboratory is equipped with processing, grading and moisture evaluation equipment; precision apparatus for testing mechanical properties, and cooking, texture and color evaluation apparatus. A complete integrated 1/2 ton per hour rice mill will be installed during 1988.

Training programs vary in duration from a few days to graduate study programs which may last 3 years. The graduate study programs are structured according to the university graduate school requirements and conducted by various departments of the LSU Agricultural Center leading to the M.S. and Ph.D. degrees. The Postharvest Technology Division conducts several programs annually. These are for trainees mainly from developing nations sponsored by various agencies including the A.I.D., USDA, Rice Council, FAO and others. The Division staff are also involved in research in cooperation with the Department of Agricultural Engineering at LSU.

Experience gained from previous research and training programs in addition to the current (1987-88) involvement with the Rice Residue Utilization Project places the Postharvest Technology Division in a position where it could be of service both to the industry as well as government agencies. The Division is able to act as a catalyst for the development and transfer of technology through research, training, and extension. The vast potential for the utilization of rice residues warrants active participation of the university in providing an information base in the technologies; management skills in developmental projects nationally and internationally; and training and extension programs to apply new technologies.