PROJECT COMPLETION REPORT

TECHNOLOGIES FOR THE RURAL POOR

(386-0465)

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PROJECT COMPLETION AND POST PROJECT CONSIDERATIONS

TECHNOLOGIES FOR THE RURAL POOR (386-0465)

1. PURPOSE:

The purpose of the grant was to increase Indo-US collaboration in the testing and application of science and technology to India's rural development effort (with special emphasis being placed on technologies appropriate to the rural setting, i.e. culture, work force and skill base, economic system).

2. PROJECT DESCRIPTION

The grant was available to finance costs of subprojects and activities that supported the application of science and technology to India's rural development. These projects were within the priority areas established by the Indo-US Joint Commission and the priorities of the GOI. Towards this end the focus was largely on the development of system's that permit harnessing of non-conventional energy sources with small amounts allocated to activities in health and exchange of scientific visits.

3. AID INPUTS - PLANNED AND ACTUAL ('000 $)

	Inputs	Planned $	Actual $
a)	Technical Assistance	972.3	952.0
b)	Training	205.4	185.5
c)	Commodities	755.0	747.0
d)	Others	67.3	67.0
	Total	2000.0	1951.5

4. GOI INPUTS - Planned and Actual.

Planned $('000)	Actual $('000)
1,000	1,300

5. EXPECTED OUTPUTS: Upgraded or enhanced technical skills by Indian scientists and technologists including short-term training, scientific exchanges, workshops; available technical equipments; development of appropriate technology; implementation of pilot projects; socio-economic studies of new technologies acceptance and adaptation.

6. PROJECT STATUS - BACKGROUND

In 1977, the decision was taken jointly by the Governments of India and the United States to resume a bilateral assistance relationship. In considering what projects should be included as part of the

initial program, attention was focused on Indo-U.S. Commission activities where an interchange on subjects of mutual interest was already taking place. Discussions under these Subcommissions, particularly the Subcommission on Science and Technology, were consistent with AID's mandate to include technology transfer as an essential ingredient of the program planning. Thus the origins of the Technologies for the Rural Poor Project (originally entitled "Application of Science and Technology for Rural Development") grew from meetings held under the 1977 Science and Technology Sub-Commission.

As an early documentation (see primarily the PID) indicates, the focus under the AID grant was to be on non-conventional energy development, e.g., solar, biomass conversion, wind energy, etc., with a small percentage of funds reserved for possible activities in the agriculture, education and health areas. Besides specific sub projects, funds were also reserved for workshops, exchange of scientists, etc. An essential part of the purpose of any of the specific sub-project activities was to have as near a term impact as possible on benefitting the rural poor.

With the above background and parameters as guiding principles, a project design team including several scientists with specialities in the energy field and an AID loan officer was sent to India in February/March 1978 to develop a project paper incorporating these ideas and providing a criteria for project selection and approval, outlining GOI/USAID administrative arrangements and discussing an illustrative list of projects that might be eligible for financing.

The Project Agreement was signed on August 26, 1978 requiring as an essential condition that a GOI inter-departmental committee be established and chaired by DST but include members from a variety of ministries such as Agriculture, Education, Health and Finance. The committee was established in November 1978 and procedures and guidelines submitted to AID in January 1979 which were approved at that time. These guidelines were consistent with the project description and Project Paper and were written in a way to permit a somewhat broad range of activities that would benefit the rural poor, although always with the intention to exclude basic research. While the guidelines were somewhat broad, it is evident from the background papers, including an initial background by DST, the PID and certain other memorandum in the file that projects were intended to be essentially collaborative in nature and that the focus would be heavily on non conventional energy development.

Subsequent to the approval of the committee and its procedures in January 1979, a number of sub-projects were presented to AID over the ensuing months, ranging from small individualized research projects of about $ 10,000 to one or two very large projects costing more than $ 1 million each; none were very consistent with the type of project that was envisioned in the initial project design.

It became clear to USAID after reviewing a number of these proposals that it would be necessary to discuss the origins and intent of this project again with DST to determine the best means to get the project back on its original track.

As a result of a number of discussions during July and August on why the project appeared to be going astray, and on USAID's urging to consider the origins of the project again, DST came up with revised guidelines for the project which were far more specific and focused than the earlier guidelines. The salient points which were included were (1) that the grant should only support U.S. dollar costs of collaborative projects falling under priority areas under Indo-U.S. joint sub commissions; (2) that such projects should be designed in a collaborative fashion by Indian and U.S. institutions; and (3) that it was the intention of the grant to take up only a few large sized collaborative projects meeting the above criteria rather than too many smaller sized projects. These revised guidelines which had been informally discussed and agreed to by USAID were formally submitted to USAID in October 1979.

Early in 1980, three major energy related projects which had been discussed during the early thinking of the grant were put forward. They were subject to a comprehensive review and several redrafts were undertaken. Ultimately they were submitted and approved by the Inter Departmental Committee and USAID.

Between early 1980 and mid 1981 seven subprojects were submitted and approved by the Inter-departmental committee and USAID. The details are as follows:

1. Development and Application of Decentralised Energy Systems Utilising Non-Conventional Energy Sources.
2. Optimisation of Solar Drying Systems for Agricultural Produce.
3. Medium Temperature, high efficiency tracking and non-tracking Solar Energy Collectors for industrial applications.
4. Development of Micro and low head hybrid microhydel system.
5. Identification and development of collaborative research projects to be supported TRP project.
6. Comprehensive studies on prevention of nutritional blindness.
7. Field evaluation of Serological Tests of Malaria.

On account of the late start-up of the sub-projects the PACD was extended from September 30, 1981 to December 31, 1984. This was twice further extended to December 31, 1985 and finally to June 30, 1986. The last PACD extension was necessitated by the need to complete the erection and commissioning of two of the major energy projects (1. Development and Application of Decentralized Energy Systems using Non-Conventional Energy Sources, and 2. Medium Temperature, High Efficiency Tracking & Non-Tracking Solar Energy Collectors for Industrial Application. A brief description of the status of the sub-projects, project accomplishments, assessment of the extent to which purpose of the project has been achieved follows:

7. SUMMARY DESCRIPTION OF TRP SUB PROJECTS

7.1.1 Sub-Project Title	Collaborative Institutions
1. Development and Application of Decentralized Energy Systems Utilising Non-Conventional Energy Sources	Bharat Heavy Electricals Ltd. (BHEL)/ Central Electronics Ltd. (CEL) and Jet Propulsion Laboratory (JPL)

AID Grant Details					GOI Contribution (in equivalent $)
Date Approved	Agreement Signed	Amount	Duration	Amt Disbursed	
06/12/80	08/29/80	$ 770,500	3 years	$ 758,000	$ 885,000

7.1.2 Summary Description

The objective of the subproject was to design, develop and instal and test solar energy systems for the efficient utilisation of solar energy in Indian villages. The total system comprises two sub-systems: solar photovoltaic (PV)(7.5 kw_e) and solar thermal power generation (22 kw_e).

Solar photovoltaic-system description : The photovoltaic array comprises of two separate PV electrical generating systems. The first, a 200 watt PV array powers a community television and radio as well as four small flourescent lamps, has been operating continuously without problem since Feb. 1982. The second PV system, a 7.3 kw_e array comprises of both Indian (CEL) and U.S. (Photowatt) cells, has been installed since November 1983. It powers a distributed lighting system of 30 street lights and three irrigation pumps. The output of each PV sytem is run through a battery bank, which then provide power in the evening hours.

Solar Thermal power plant - system description : The solar thermal power plant incorporates 6 number of solar helio dish concentrators of 9m diameter each with $50m^2$ effective reflecting surface. Steam is generated at 500°C and 70 bar pressure through a focally mounted single pass cavity type receiver and is fed into a centrally located reciprocating steam engine which in turn drives an alternator. The load management and all other controls including double axis tracking is monitored and regulated by the computer system. The major sub-systems are: -

- Energy collection system
- Steam generation system
- Transportation and storage system
- Power conversion system
- Control system comprising of
  - i) Tracking controls
  - ii) Steam temperature controls
  - iii) Power generation controls
- Instrumentation and measuring system

The power plant has been designed to deliver 22 kw_e at 800 watts/m^2 direct normal insolation and starts working at 500 watts/m^2 insolation with 12 kw_e output.

Balance of System Description : - In addition to the above two power systems, a 60 m^3 floating dome type bio-gas plant has been installed which fuels a modified 3 H.P. diesel engine to run on bio-gas. The diesel engine runs on 80/20 mixture of bio-gas and diesel and operates a pump for lifting water from a 30 meter bore well to a 5000 gallon overhead tank connected in turn to several community water-taps.

7.1.3 Current Status (as on 6.30.86)

The two PV arrays which were installed in Feb. 1982 and Nov. 1983 respectively have been functioning well. This plant continues to operate successfully. A minor problem relating to burn-out of one of the three irrigation pumps in January '86 has been rectified. In order to augment the capacity of the borewells, additional wells have been dug.

The solar thermal plant has undergone extensive field trials and commissioning since Jan. '86. In March '86, four dishes were simultaneously tracked and the steam thus generated fed to the steam engine - generator. A power output of 3.3 kw_e was realised. Later this year, for the first time all the six dishes of the system were tracked successfully and a power output of 12 kw_e obtained.

The performance was low due to poor insolation and low efficiency of the engine generator at part load operation. Further tests are being carried out and it is confidentally predicted that the system design specifications for output will be achieved and the plant will be in daily operation. However, the system continues to face the following problems which are being solved.

While commissioning the two axis tracking system the shifting of Sun's image at the focal plane has been observed.

- Special welding techniques developed by the Welding Research Institute, Trichy was required for welding the small bore stainless steel tubing.

- Individual feed water pumps are being incorporated instead of a single reciprocating pump due to flow control problems.

- Image transverse created local hot spots on the receiver ring and this has been solved by covering the critical area by mineral wool insulation.

Besides running trials for incremental increases in load, the BHEL is evaluating the performance of the system and is engaged, with the assistance of JPL in preparing the detail report on the project. JPL is also assisting BHEL in providing information on equipments (primarily feed water pumps) for timely procurement by BHEL.

7.1.4 Project Accomplishments

The BHEL staff have gained tremendously, in terms of experience in the design and fabrication of the solar thermal dish systems. Two particular areas deserve mention. One is the competence and expertise developed by BHEL in the Optico-Mechanical design of heliodishes which can be effectively utilised in the designing of similar solar power projects. BHEL has documented this effort and is in a position to offer different types of helio-dishes for power generation on a commercial basis. The second is the development of cavity receivers for point focusing concentrators which is an important step in the design of efficient solar thermal power systems. There are other spin-offs as well. New welding processes and fabrication of structures had to be specifically developed; instrumentation and control systems for this unique operation required a thorough upgradation of knowledge and skills in control system design, installation and operation including familiarity with on-line computer networking.

The experience gained by CEL in installing photovoltaic arrays helped CEL gain valuable experience in the system development of PV arrays for rural lighting and pumping.

7.2.1 Sub-Project Title

Optimization of Solar Drying Systems for Agricultural Produce

Collaborative Institutions

Annamalai University (AU)/ Colarado State University (CSU)

A.I.D. Grant Details				GOI Contributions (in equivalent $)	
Date Approved	Agreement Signed	Amount	Duration	Amount disbursed	
12/04/80	05/13/81	$ 200,000	3 years	$199,900	$ 47,200

7.2.2 Summary Description

Annamalai University (AU) and Colarado State University (CSU)proposed to design and develop solar dryers for small farmers in India and for their possible application in the U.S. The project had four primary objective:

- Assessment of drying demands for agricultural products, including current practice and climatic factors;

- Use of this assessment by CSU to apply and modify current U.S. Crop drying technology, in conjunction with AU, to meet rural Indian needs;

- Construction of prototype units in India and the United States using CSU-generated design specification and methods; and

- A field monitoring program during the third year of the project to measure the effectiveness of the system prototypes.

In keeping with the above the project developed 1) portable solar dryers for rural farmers by AU; 2) a large scale stationary solar dryer by CSU.

7.2.3 Current Status

Both the universities have completed all major tasks for the project. Cost effective solar dryers have been developed, tested, and one is currently being demonstrated to rural farmers in Tamil Nadu. AU has taken several steps to popularise these dryers with the assistance of the State Government and their commercialisation is under consideration.

AU had designed, built and tested nearly a dozen solar drying units before deciding upon three units - ranging from a low cost single black polythene sheet dryer to a double layer polythene sheet system to a more costlier, sophisticated, large scale dryer with air blowing systems for use in rice mills. This dryer has an output of 1.75 tons of rice per day. It was installed at the Tamil Nadu Civil Supplies Corporation rice mill and has undergone extensive field testing. The system design has been optimised based upon laboratory studies, which were carried out using the instruments and the computer with data logger received from USA. It has conclusively proved that the suction type of collector is an efficient one when compared with other collector types, such as inflated plastic collectors. The CSU unit was developed as a stationary unit using higher cost yet more durable materials than the AU dryer. It has a capacity of one ton/day and uses motor-driver mechanical stirring devices.

7.2.4 Project Accomplishments

The sub-project has accomplished its objectives on time and under budget. The pre-design energy survey was carried out prior to committing resources to any particular design. Design and procurement decisions were essentially completed in the first year of the project (April '81 - May '82). Prototype performance testing proceeded in an orderly fashion throughout the project, as each design was laboratory and field-tested (using farmers' input) to provide design criteria for succeeding designs. The completion report of the sub-project was prepared by both AU and CSU and submitted to USAID in November 1985.

7.3.1 Sub-Project Title

Medium Temperature, High efficiency Tracking and Non-Tracking Solar Energy Collectors for Industrial Application

Collaborative Institutions

Indian Institute of Science,(IISC) Bangalore/University of Houston (UH).

A.I.D. Grant Details					GOI Contribution (In equivalent $)
Date Approved	Agreement Signed	Amount	Duration	Amount Disbursed	
12/05/80	05/05/81	$ 400,000	3 years	$ 399,200	$ 195,100

7.3.2 Summary Description

The sub-project envisaged production of medium-temperature steam through line focusing parabolic collectors, for use in the printing department of a silk mill, the Karnataka Silk Industries Corpn., Ltd., at Mysore. The project was designed to be completed in two phases, each of 3 years duration but with a year of overlapping activities to ensure orderly and smooth change over from design/development phase to the plant construction and installation phase. The goal of the sub-project were as follows :

i) Design and development of a cost-effective high efficiency tracking parabolic solar collector.

ii) Design of an experimental solar energy system for industrial hot water and steam production.

iii) Construction of an industrial process steam system for the silk factory at Mysore, as a retrofit to the existing boiler plant.

iv) Evaluation of the performance of the system and assessment of its suitability for commercialization.

The UH provided the technical expertise necessary for the computer design and simulation studies to size the system and its components, as well as to facilitate procurement of U.S. manufactured components such as the flexible glass mirrors and the tracking mechanism which were not available in India. The IIS worked on selective surface coatings for solar collectors, parabolic point-focusing dish collectors, prototype linear-focusing concentrators which was the subject of this project. Both UH and IIS activity collaborated in the design of the solar steam system. IIS major responsibility involved the project engineering, erection and commissioning of the system at the silk factory at Mysore.

7.3.3 Current Status

Because of the overall project delay which moved the subproject starting date back to December 1980, preliminary contacts between the counterpart organizations did not take place until May 1981. The U.S. principal investigator (PI) first spent one month in India, then the Indian PI spent three months touring U.S. research sites which were working on concentrating collectors. Other IIS personnel followed soon thereafter to complete their review of current U.S. linear concentrator technology. Collector and system design work on both the IIS and UH sides began soon thereafter.

As of mid-December 1984, all of the design and much of the procurement process had been completed. Three different prototype collectors had been constructed and installed on the roof of IIS for comparative technical evaluation. The selective black chrome surface coating (high- radiation absorptivity and low emissivity) and application techniques had been developed by IIS through the production stage. Absorptivity and emissivity measuring instruments were developed at IIS. With the assistance of Hindustan Aeronautics Ltd. (HAL), a GOI Public Sector Undertaking, a stiffened rib structure for the collector mounts was developed and was produced for the demonstration system at Mysore.

As of June 30, 1986, considerable progress in the installation of the demonstration system has been achieved. Construction and procurement of the demonstration system components such as collectors, piping, flash boiler, valves and instruments was completed in late 1985. Subsequently, in early 1986, work began on the erection of the parabolic collectors, steam networks comprising of flash boiler, boiler and instrumentation. All the civil works, such as control room feed water tanks, etc. have been completed. The system was commissioned on part load in June 1986 under manually operated controls.

7.4.1 Sub-Project Title
1. Development of low head hybrid micro-hydel system

Collaborative Institutions
Roorkee University (RU)/ Colarado State University (CSU)

A.I.D. Grant Details					GOI Contribution (in equivalent $)
Date approved	Agreement signed	Amount	Duration	Amount disbursed	
10/05/81	01/22/82	$ 166,765	3 years	$ 166,765	$ 85,600

7.4.2 Summary Description

The principal objective of the project was to demonstrate the utility of integrating low head hydroelectric generation, biomass processing, food processing and machine tool capabilities into a single cost-effective system. This main objective was to be accomplished through the development of economically viable and technically feasible system for energy production, energy storage and energy appliance integration with low head micro hydel systems.

System description : - The system consists of two components : a) Micro- hydel system consisting of i) a low head - 400 kw hydro plant on small canal drop at Kakroi and ii) medium head hydro plants in the hilly area of Manali and Jubbal b) hybrid system for integrated energy production, storage and commodity production. The major focus of the project was on demonstration aspects with emphasis on a) development of a low cost, microcomputer based controller and load management systems for low head hydro units b) comparing available systems and demonstration of most applicable hybrid systems.

7.4.3 Background

USAID financed the first year's requirments of $ 166,765 out of TRP Project. The remaining two year of the research project, estimated to cost $ 329,000 was provided from the Alternative Energy Resources Development (AERD) project.

The sub-project was originally planned to be a joint collaborative effort between CSU and RU. However, in October 1982, Professor Joel Dubow, U.S. Principal Investigator left CSU and accepted a position with Boston University (BU). Along with him, his chief research assistant also moved to BU. Therefore, USAID decided to i) transfer the project from CSU to Boston, ii) terminate the contract between CSU and Roorkee w.e.f. Dec 31, 1982 and iii) negotiate a fresh contract between Roorkee and Boston under the Alternative Energy Resources Development Project, to complete the remaining work. The contract between Roorkee and BU was initially for 2 years and extended for a further period of 2 years until December 31, 1986. This brief report on the status of the sub-project will confine itself to the sub-project activities performed under the initial contract between RU and CSU under the TRP project.

7.4.4 Current Status

During the period October 1981 to December 31, 1982 considerable progress was achieved towards realising sub-project goals. Among the important achievements were :

i) Definition and finalisation of the detailed scope of the subproject.

ii) Design considerations and hybrid system identification for integrated operation with micro-hydel systems to be installed at the three selected sites.

iii) Initial design of the controller system

iv) Detailed recommendations to USAID for modified budget for carrying out the work. Visits to sites in India to assess suitability of location and determine typical candidate hybrid plants. The following were some important recommendation.

a) That only commercially available hybrid system will be used and research work on hybrid systems will not be done.

b) That only one controller for Kakroi will be developed and controllers for other sites will be developed at Roorkee.

c) That prototype system for testing controller and laboratory facility for assembly of controllers will be set up at Roorkee.

v) That the project be transferred to Boston University and a new contract be entered upon by RU and BU under the AERD project.

7.4.5 Project Accomplishments

Since the sub-project is being currently supported under the AERD project its achievments and accomplishments will be documented when the PACD of the AERD project expires.

7.5.1 Sub-Project Title	Collaborative Institutions
Identification and development of collaborative research projects to be supported under the TRP project. The field of enquiry was primarily but not limited to that of energy from biomass	National Academy of Sciences (NAS), Contract No. ASB-0465 -C-00-1019-00

A.I.D. Grant Details					GOI Contribution
Date Approved	Agreement Signed	Amount	Duration	Amount Disbursed	
12/31/86	03/13/81	$ 81,738	thru	$74,637	None
	05/12/82 Am # 2		06/30/82		

7.5.2 Summary Description

NAS contract was signed on March 13, 1981 for $ 225,000 for identification and development of energy related projects for funding under TRP. Since the subprojects under TRP were already identified and approved prior to the completion of NAS services, it was decided to amend the contract (i) to revise the scope of work to include services for the planning of an energy conservation workshop proposed to be held under the Alternative Energy Project, (ii) to reduce the level of funding and (iii) to extend the termination date from January30, 1982 to June 30, 1982 revising the scope of work and reducing funding from $225,000 to $81,738.

7.5.3 Status & Accomplishments

Under the revised scope of work Dr. Dennis Wood and Charles Holt visited India during May 3 - 17, 1982 to have a preliminary survey of Steel, Aluminium, Industrial boilers and Industrial furnaces industries and to discuss modalities with the Association of Indian Engineering Industry (AIEI), the proposed Indian institution to implement the energy conservation component of the Alternative Energy Project.

Based on this visit NAS prepared a draft proposal for carrying out energy efficiency subproject in cooperation with AIEI. The draft proposal and brief report of NAS representatives visit was sent to DNES for review and comments in October 1982. Thus the work under NAS contract has been completed. The NAS study provided useful inputs in the design of the Alternative Energy Resources Development Project.

7.6.1 Sub-Project Title
Comprehensive Studies on Prevention of Nutritional Blindness

Collaborative Institutions
National Institute of Nutrition (NIN)/National Eye Institute (NEI)

A.I.D. Grant Details					GOI Contribution (in equivalent $)
Date Approved	Agreement Signed	Amount	Duration	Amount Disbursed	
10/19/81	04/28/82	$ 313,560	3 years	$ 293,800	$ 84,700

7.6.2 Summary Description

The National Institute of Nutrition (NIN), Hyderabad and National Eye Institute (NEI), USA, proposed to conduct a series of studies that will help to determine the adequacy of Vitamin A distribution in correcting Vitamin A deficiency and preventing nutritional blindness and also risk factors that may interfere with the effectiveness of India's Vitamin A distribution program in preventing blindness. Three studies were undertaken as part of this collaborative project :

i) Relationship between measles and heratomalacia

ii) Relative dose response for assessment of Vitamin A status

iii) Care control study of xerophthalmia.

AID also financed the costs of imported equipment and exchange of scientific visits.

7.6.3 Project Status and Accomplishments

The sub-project financed several sophisticated analytical equipments. All these equipments have been procured and installed at NIN. The equipments are all in good working condition and were extensively utilised in conducting the various studies under the collaborative program. Two NIN scientists visited USA during August 31 to October 8, 1982 to acquaint themselves of the developments in the field of collagon and retiroids and assess the technology with respect to immunological methods to be used in the project protocols. These visits were useful and instrumental in carrying out the project studies successfully. Visit by NEI scientists in October '82 and January '83 helped in reviewing progress of the project investigators and provided scientific inputs to studies on nutritional blindness. The subproject had quite clearly met the stated sub-project objectives within both budget and time limits set.

7.7.1 Sub-project title

Field Evaluation of Serological Tests of Malaria

Collaborative Institution

National Institute of Communicable Diseases Center for Disease Control

A.I.D. Grant Details					GOI Contribution (in equivalent $)
Date Approved	Agreement Signed	Amount	Duration	Amount Disbursed	
11/06/81	-	$30,842	2 years	$29,963	$14,000

7.7.2 Summary Description:

The National Institute of Communicable Diseases (NICD),Delhi and the Center for Disease Control (CDC), Atlanta conducted field research in the form of sero-epidemiological studies in support of an operational malaria control program. The aim of the project was to introduce, improve and evaluate antigen production and sero-epidemologic techniques for use in surveillance and assessment of malaria in India.

8. ASSESSMENT OF TRP PROJECT PURPOSE ACHIEVEMENT

The Technologies for the Rural Poor (TRP) project has no doubt resulted in significant technology transfer between U.S. and Indian scientific and academic institution in the area of renewable energy utilisation. This has fostered long term institutional relationships which ought to favourably influence future technology development and information. Further, it has assisted significantly in the establishment of Indian centers of excellence in several areas of renewable energy research and utilization. The quality of the technical research performed was high, and the technologies developed were technically sound, with high performance characteristics.

The project seemed to have suffered from a divergence between its initial conception, that of scientific exchange and scholarly research, and its stated purpose, which was to develop technologies for the rural poor. A number of the technologies that emerged from this project were scientifically interesting, but too expensive and too complex for remote site operation and maintenance. The complexity of several of the projects, combined with shifting research priorities in the U.S., led to serious project implementation delays.

It would be erroneous to assume that the technologies developed, atleast in three of the four renewable energy sub-projects, have immediate and cost effective application in the Indian rural energy sector. Rather, the developed technolgies have, in the main, little relevance to rural India, judging by their cost, complexity in operation and maintenance and the low to medium level of energy delivery. On all the above three counts and many more minor reasons, it is hard to visualize the penetration of these technologies on a commercial or even on a need basis. The Salojipally subproject is a case in point. Even the designers admit that this system of solar thermal dishes, steam engine and all the associated controls, motors and pumps, is totally inappropriate for a rural setting. Few trained engineers could step in and operate this system without a long training period, so one would hardly expect a rural villager to be able to undertake the task. The Salojipally sub-project provides an integrated set of services, such as street lighting, pumping of drinking and irrigation water, and entertainment, that are valued by people all over the world. However, it is doubtful that the Salojipally set of energy systems is the optimal or even an acceptable way of providing these services to the rural poor.

In terms of cost it is definitely not. The cost is $24,800 per kilowatt ($KW_e$) of the installed capacity at a rated output of 12 kw_e (the minimum figure against total maximum of 23 kw_e). In contrast, a diesel engine will cost $350-$500 per kw of installed capacity, a medium scale coal-fired power plant will cost $ 800-1500 per kw of the installed capacity, a micro-hydel unit $1000-4000/kw, and a Photovoltaic unit $ 10,000- 15,000/kw.

For quite similar reasons the IIS/UH subproject on line focusing solar concentrating collectors for production of medium temperature steam is inappropriate. The complexity of the solar steam generator makes it inappropriate for remote site operation. The use of medium temperature steam in a rural application is quite unlikely unless it is used for industrial process steam in a nearly industrial complex. This route of steam generation would be perhaps the last option even in a commercial undertaking, leave alone a rural setting. Infact one cannot think of a similar system in any industrial complex in India or any other developing country. 80kg/hr. of steam generation is relatively minor for an industry and is almost always met through fossil fuel fired boilers which are by comparison extremely cheap by a factor of over one hundred. In addition, the complexity of the solar system makes it an extremely unwise choice that can hardly ever be supported by techno-economic considerations.

The AU/CSU subproject on solar drying systems for agricultural produce, among the energy projects, has several features to be commended about. The choice of the sub-project was in keeping with the envisaged purpose of developing technologies appropriate to the rural setting. The sub-project accomplished its objectives on time and under budget. A significant lesson in this case was the usefulness of a pre-design energy survey which was carried out prior to committing resources to any particular design.

The rural poor have much to gain by the use of the low priced dryers developed during the project. The very low costs, the use of mostly locally available materials and the low levels of technical skills required place the small-scale dryers within the reach of many small farmers. Commercialization of the developed technology is on the cards. Upgradation of the developed designs is being undertaken to improve reliability and performance. All in all it has all the basic features of rural application, ease of manufacture and maintenance, low cost and potential for commercialization, including immediate economic gains to users that set this subproject apart from the others.

However, the above assessments should not detract from the very obvious scientific and technology development gains that this project has helped accomplish. In the case of the Salojipally sub-project, both the collaborating institution have gained significant relevant experience in the design and manufacture of the hardware.

Specifically the optico- mechanical design of heliodishes and development of cavity receivers are areas that BHEL views as important gains. Similarly the subproject on line focusing collection for medium temperature steam has provided useful opportunities to IIS for developing black chrome selective surfaces and in the design of collector structures using a innovative stiffened rib design. The TRP project has resulted in transfer of genuine skills between institutions and measurably assisted in the formation of several Indian centers of topical excellence that would not have existed without this project.

9. SUMMARY OF LESSONS LEARNT

Apart from the varied experiences encountered in the program related elements that encompass activities such as training and procurement, the lessons to be learnt from the TRP project are much more intrinsic and hence need closer examination. This brief report will confine itself to these concerns only and will not attempt to draw lessons or conclusion from actions relating to program elements. It is not as though timely or rather untimely procurement of supplies does not affect the tempo of a project; it certainly does and the lessons are generally clear in these cases.

But what generally passes unnoticed are the problems that impinge on the suitability of a particular project to a defined setting, the commercialization prospects of the developed technology which is quite distinct and apart from the scientific merit of the project and the ability of collaborating institutions to provide sustained and competent support. The major beneficiaries of this project were to be the rural populace with scientific and technological developments addressed to their needs appropriate to rural settings. Except for one sub-project, the other three sub-projects as a whole do not appear to have appreciably focussed on this primary purpose.

While one can hardly question the wisdom of harnessing energy (solar) for a particular application (drying, power, heat, etc) of rural importance, the appropriatences of the systems designed, engineered and erected is highly questionnable. They do not have relevance to the economic, conditions prevailing. Several of the tehnologies appear to be too complex and expensive for remote site operation and maintenance and appear to have been selected for their scientific interest rather than for their relevance to rural development. Several of the sub-projects funded under this project have only a tenuous connection with cost-effective rural development and appear to have been selected because they were expensive and involved very experimental techniques.

The criteria that were suggested in the project paper for sub-project selection, although quite adequate, should have been more rigorously applied to guard against the selection of what should have been perceived as inappropriate technologies.

The systems developed, complex as they are, may not find a ready market on account of their rather astronomical costs when compared to other competing energy generation systems. The sole exception is perhaps the solar driers, which are low cost using locally available material and labour in their construction. Control of costs through careful selection of technologies with the view to commercialize the developed energy system was not a consideration even at the periphery. Scientific institutions in both India and USA are hardly expected to seriously examine this problem critically.

Here is therefore a lesson to be learnt. Such projects may have had a better sense of urgency, focus and cost discipline not entirely divorced from the pursuit of the projects scientific and technological development needs, if at the early stages a well thought out plan was conceived to commercialize the development of the technologies. The involvement of private/public commercial entities at that stage may have provided the necessary impetus to commercialization.

The selection of universities and national laboratories as U.S. Collaborators probably increased unnecessarily the emphasis on high performance and reduced the emphasis on the commercial viability of the prototypes developed. The selection of counterpart Indian institutions ensured the joint pursuit of scientific development on one hand but on the other required a level of effort that Indian scientific institution do not normally possess, particularly erection and commissioning. The fact that BHEL was the collaborating Indian insitution for the Salojipally project was instrumental in its successful commissioning - it is unlikely that research institutions can draw upon its internal resources to successfully implement complex state of the art projects. In at least one case the inexperience of the Indian collaborator (IISC) hampered the progress of the sub-project.

The experience in the TRP projects have been instrumental in the design of the subsequent Alternative Energy Resources Development Project. It played no small a measure in the development of the concept for the proposed Program for Acceleration of Commercial Energy Research Project (PACER).

10. POST-PROJECT ACTIONS

Of the seven sub-projects in TRP, five have been completed satisfactorily.Only two of the solar sub-projects, namely the JPL/BHEL, Salojipally Solar electric power project and the IIS/UH Solar Steam project will require post-project monitoring responsibilities by the Mission until mid-1989. Considering that

the two sub-projects have been erected and commissioning is underway, no additional A.I.D. resources are deemed necessary except in monitoring. The JPL/BHEL sub-project is currently under commissioning and will take a while before it is fully operational. Currently BHEL is sending periodic reports on the progress of the sub-project to AID and a committee constituted by DNES to monitor the projects has been quite active and effective in expediting the sub-projects progress. USAID has been working closely with DNES in this matter and this cooperation would continue. BHEL plans to operate and maintain the system for a reasonable period and provide training to nodal agency of DNES's to takeover the responsibility of operating and maintaining the system. In the case of the IIS/UH Solar steam sub-project, the system commissioning has been completed on a manual operating mode and automatic operation with computer-assisted control systems is under consideration. The IIS plans to involve the staff of the local Mysore College of Engineering in the operation and maintenance of the system.

USAID will continue to monitor these specific decisions of DNES/ collaborating institutions. In January 1986 USAID officials visited the sub-projects under TRP project and checked end-use verification of USAID financed equipment. In general, the equipments were found to be in good working order and were being used for the purpose intended. Additional resources are not envisaged and it might be mentioned in passing that the mission has recruited a full-time Energy Officer responsible for its energy portfolios.

11. EVALUATION

A mid-term evaluation of the TRP project was conducted in December 1984. The evaluation was comprehensive and useful and helped USAID considerably in its management of the project. It also helped the collaborators to focus efforts on areas of tangible progress and lent urgency to their tasks. It has, in no small a measure, been instrumental for the successful conduct of the various sub-projects. Considering the mid-term evaluations success in identifying crucial issues and recommending a host of actions on various facets of the TRP projects, it can be considered as quite complete and authoritative. This report is an addendum to that and must be read in conjunction with it.

12. CONCLUSIONS AND RECOMMENDATIONS

A. Out of the seven sub-projects, there were four non-conventional energy system prototypes developed under this project. Of these four prototypes, only one (solar dryer) has been found suitable for commmercialization in rural areas. The other three prototypes are found to be complex in operation, expensive and inappropriate for utilization in rural set up. However, the experience gained from this project has been very useful to A.I.D. in development of a new project "Program for the Acceleration of Commercial Energy Research Project (PACER)" which is proposed to be financed by A.I.D. in Fy 1987.

B. All A.I.D. grant funds ($2,000,000) except for $48,500 have been disbursed. A.I.D. is taking necessary action for deobligation of this amount. The GOI contribution has been provided.

C. Of the seven sub-projects, five have been completed satisfactorily. The other two sub-projects viz solar electric power and solar steam are under an advance stage of commissioning. Post-project A.I.D. monitoring is therefore required on these two sub-projects upto mid-1989. Additional AID resources are not deemed necessary.

D. Based on the mid-term evaluation (discussed under item 16 above), A.I.D. has determined that the final evaluation is not necessary.

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