Annex A

XD-AAT-871-A

46122

Panama

An evaluation of USAID's alternative energy sources project

NRECA Small Decentralized Hydropower (SDH) Program

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Panama: An Evaluation of USAID's Alternative Energy Sources Project

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September 1985

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I. EXECUTIVE SUMMARY

Although alternative and renewable energies receive less emphasis now than in the late 1970s, it was and is important that capabilities in these technologies be strengthened in Panama. Governments and development agencies should not assume that the present easing of oil prices will continue. Therefore, the purpose of the project--to strengthen the capability of the Water Resources and Electrification Institute (Instituto de Recursos Hidráulicos y Electrificación, IRHE) to develop alternative energy resources--was both valid and worthwhile.

Challenges in the Alternative Energy Sources Project were compounded by its ambitious scope. Originally, project activities were to include training and institutional strengthening, feasibility studies, demonstration projects, preparation of an alternative-energy master plan, and evaluation. Several changes were made during implementation--the most important being the introduction of seven micro-hydropower demonstration projects to replace the cancelled Yaviza biomass plant. This change had a positive effect on achieving the project purpose, since micro-hydropower is the most developed of the technologies under consideration. This evaluation addresses itself primarily to the micro-hydropower component of the project.

IRHE staff benefitted from extensive training activities funded under the project. Although other institutional strengthening targets in the areas of information generation and dissemination and planning were not entirely met, IRHE's capabilities were improved in these areas. The National Energy Commission (Comisión Nacional de Energía, CONADE) is drawing heavily on this experience.

Demonstration projects for solar water heating and photovoltaics were successfully completed, together with one of the two biogas projects. Cancelled activities included biomass feasibility studies and solar air-conditioning demonstration projects, in addition to the Yaviza biomass plant.

The major conclusions of the evaluation of micro-hydropower activities can be summarized as follows:

- In quantitative terms, the target of 40 feasibility studies has been achieved and two of the seven demonstration projects have been completed; the five remaining demonstration projects are nearing completion.

- In qualitative terms, achievements have been less than optimum:

  The 40 project studies should be considered as prefeasibilty, rather than feasibility analyses, due to methodological flaws.

  The two completed projects achieved only about 20% of their intended output, due to low turbine efficiency.

  Social and economic benefits are minimal at one completed project and limited at the other, due to capacity limitations, community underdevelopment, and the absence of productive-use promotion.

- The following would have had a positive effect on the outcome of the micro-hydropower component:

  adequate technical assistance, as originally planned;

  increased attention to project details and direct supervision by IRHE staff;

  greater attention to procurement procedures, supplier performance, and corrections of turbine performance; and

  a concerted effort to develop a local management structure for completed projects.

- While IRHE staff have undoubtedly gained experience through the projects, achieving maximum institutional benefits would have required greater commitment to activities and more effort to learn lessons. Although the micro-hydropower projects were built consecutively over a period of 5 years, common design flaws persist.

- Notwithstanding these shortcomings, significant benefits may now be realized through a limited expenditure of funds and effort, directed specifically to civil works, turbo-generating equipment, and community management structures. If the recommendations are followed, significant improvements can be made in all areas of shortcoming at very little cost.

- The evaluators recommend a number of corrective measures at the two completed demonstration projects, including replacing the turbine at Buenos Aires and the electronic load controller at Chitra. These measures would cost about $10,000 in materials and equipment, but would significantly increase benefits to the two communities. The evaluators also identify potential technical problems at the five projects to be completed.

An action plan is proposed for the formation of cooperatives to provide an effective management structure and promote productive uses of electricity at six of the seven projects. This activity will cost approximately $30,100, including the training and technical assistance.

This experience illustrates a number of general points:

- Large utilities are not necessarily the most appropriate organizations to identify, plan, implement, and administer micro-hydropower schemes. This is especially true in developing countries. The assumption that experience gained through large hydropower equips utilities for micro-hydropower implementation is erroneous.

- Appropriate, high-quality engineering work must be complemented by effectively decentralized, community-based management structures. Similarly, productive uses should be either built into the project or actively promoted in conjunction with it. Technology-driven approaches to micro-hydropower should be avoided by both development assistance agencies and implementing organizations.

- USAID should ensure that the specialized technical expertise required that is unavailable in-house is obtained elsewhere. Technical assistance should receive high priority throughout the course of the project. Care is needed to ensure that it is both of high quality and appropriate to the local context.

Micro-hydropower projects represent a relatively high initial investment that results in power availability on a continuous basis. So far, energy use at the completed projects has consisted mostly of household and public lighting. Socio-economic impacts are especially high when productive activities make use of the power during off-peak hours. Unfortunately, technical defects at the two completed projects have prevented high project utilization. Care should be taken to avoid repeating the design and execution errors made in implementing the first two projects.

In addition to the quality of the engineering work, two key factors will determine the long-term success and impact of the projects: effective administration and maintenance and productive-use promotion. These aspects have suffered from a lack of attention to date. Forming and supporting rural electric cooperatives in the communities would facilitate both. The Autonomous Panamanian Cooperative Institute (Instituto Panameño Autónomo Cooperativo, IPACOOP) is willing and able to do both, given the financial support and technical assistance outlined in this report.

By producing reliable and inexpensive power, micro-hydropower projects can contribute to the development of productive activities. This is evident at the two completed projects. At Chitra, relatively minor corrections would facilitate the operation of a cooperative coffee-processing facility that is under construction, thereby increasing the local producers' selling price from B/. 40 to B/. 60/q and stimulating production. In Buenos Aires, minor corrections would enable the school to use existing refrigeration equipment, increase lighting for expanded evening activities, and save on the cost of operating a pump for the village's water supply, which is under construction.

II. INTRODUCTION

At the request of the U.S. Agency for International Development Mission in Panama (referred to as USAID in this report), the International Programs Division (IPD) of the National Rural Electric Cooperative Association (NRECA) undertook a final evaluation of the Alternative Energy Sources Project.

The purpose of the Alternative Energy Sources Project was to improve IRHE's capability in the field of alternative energy. Activities included institutional development, feasibility studies, demonstration projects, and preparation of a master plan for developing alternative energy in Panama.

The evaluation was conducted by Guy Stallworthy, an economist and institutional advisor with the Small Decentralized Hydropower (SDH) Program of IPD, and Craig Murphy, a micro-hydropower specialist. Work was carried out in Panama from August 21 to September 9, 1985.

As requested by USAID, special attention was paid to the micro-hydropower components of the Alternative Energy Sources Project, because they came to constitute its major emphasis. The project embraced a wide range of technologies and applications, including biogas, biomass, and a number of solar-energy applications, as well as micro-hydropower. Both USAID and NRECA recognized that thorough analysis of the other technologies was not possible during the evaluation, given the budget available.

The evaluation methodology consisted of interviews, a review of records and reports, and a field trip. The team also benefitted from previous NRECA experience with micro-hydropower in Panama. The team interviewed USAID, IRHE, and IPACOOP staff, as well as numerous members of the communities involved in demonstration projects. (See Annex A for a list of contacts.) The team also visited the micro-hydropower demonstration projects already completed at Chitra and Buenos Aires, together with those under construction at El Cedro and San Juanito.

This report begins with comments on the original design of the project. Changes in project activities and inputs during the implementation period are summarized, together with comments on the effects of those changes. Project outputs are assessed in relation to objectives. The micro-hydropower components are assessed in detail, beginning with the Project Paper (PP), technical assistance, and feasibility studies. Technical, social, and economic aspects of the demonstration projects are then assessed and recommendations made. A separate section deals with options for community management of the projects and proposes an action plan.

The references used in the report are listed in Annex B; throughout the text, the number corresponding to the reference cited is noted in parentheses. Finally, two additional annexes provide the PP Project Summary and IPACOOP's budget for cooperative formation.

III. PROJECT DESIGN

SUMMARY OF ORIGINAL PROJECT

The purpose of the Alternative Energy Sources Project was to improve the capability of IRHE "to identify, analyze and develop renewable energy sources and applications with emphasis on rural areas (9, p. 12). This was to be achieved through staff development and training, feasibility studies, demonstration projects, and the development of an alternative-energy master plan.

The goal of the project was to improve the standard of living of low-income rural and urban families and to further Panama's economic development. It was recognized that a small number of target beneficiaries would benefit directly and that the project was to achieve its goal through long-term and indirect impact. (See Annex C for the summary of the PP.)

Table 1. Summary Financial Plan (9, p. 3)

Project activity	USAID ($000)	GOP ($000)	Total ($000)
Institutional development activities	95	230	325
Feasibility studies	175	50	225
Demonstration projects	355	270	625
Master plan	150	0	150
Evaluation	50	0	50
Total	825	550	1375

OBSERVATIONS

This evaluation does not provide an exhaustive critique of the PP. The design of individual project activities is dealt with later in this report, particularly in the chapter on micro-hydropower. The following are selected observations of a general nature:

- The project was overly ambitious in its scope. It included a wide range of technologies and applications, some of which were relatively unproven. This placed a heavy burden on USAID staff.

- The project budget was inadequate for the activities initially envisioned. This reflects a lack of experience with alternative energy on the part of the project designers.

- The implementation schedule was unrealistic and was largely responsible for the need to extend the Project Assistance Completion Date (PACD) four times. Furthermore, individual component activities had no implementation schedule at all.

- There is some confusion over the purpose of the project. The statement quoted earlier in this report is taken from the project description. The statement in the PP summary omits the reference to rural areas, while that in the logical framework adds the element of information dissemination. This confusion has consequences for the scope of the project. If the emphasis was to be on technologies and applications with maximum potential for rural areas, elimination of solar water heating and air-conditioning projects would have made the program more manageable without detracting greatly from this purpose.

- The circumstances under which the project was conceived are also worth noting. The project was a reaction to the surge of interest in renewable and alternative energy throughout the world, which resulted from the oil price increases of the 1970s. That interest has now faded significantly, within both IRHE and USAID. Insofar as it was intended to establish a capability and begin a process of technology transfer that would lead to follow-up and benefits over the long term, the project was a victim of changes in development thinking. Furthermore, the first assumption in the logical framework, that the price of oil would continue to rise, was erroneous.

IV. EVOLUTION OF PROJECT CONTENT

SUMMARY OF MAJOR CHANGES AND REASONS

The Alternative Energy Sources Project was authorized in August 1979, and conditions precedent were met in November 1979. The most significant changes in project activities over the life of the project are discussed below.

During negotiations with the University of Delaware in early 1980, the $150,000 originally allocated for technical assistance in the preparation of an energy assessment and master plan was found to be inadequate. Therefore, the contract awarded in July 1980 was for $230,820. In order to cover this, funds for the agricultural wastes feasibility studies were reduced from $100,000 to $50,000, and those for the evaluation were reduced from $50,000 to $19,180.

In September 1980, IRHE and USAID decided to implement two micro-hydropower projects at rural training schools. These schools were being established under a USAID project with the Ministry of Education and would otherwise need to operate diesel generating sets. As a result, $25,000 from the budget for technical assistance to conduct the micro-hydropower feasibility studies was allocated to purchase equipment and, subsequently, hire construction manpower.

In May 1981, after extensive feasibility analysis, IRHE and USAID decided to implement the Yaviza biomass plant. Cost estimates were substantially revised and the USAID-funded component increased from $325,000 to $375,000. As a result, the budget for the agricultural wastes feasibility studies, already reduced in July 1980, was eliminated.

In April 1982, construction of the Yaviza plant was cancelled. Apparently, the cheapest and most appropriate equipment could not be purchased because it did not meet "source and origin" requirements. Instead, $313,200 was reprogrammed to procure equipment for four more micro-hydropower projects at La Tronosa, La Pintada, El Cedro, and Entradero de Tijera. The $23,200 already spent on technical assistance for feasibility studies on the Yaviza project was accounted for under the line item for agricultural wastes feasibility studies, which had been eliminated in May 1981. USAID's contribution to the biogas demonstration projects was reduced from $30,000 to $10,500, and minor changes were made in the budget for institutional development. Finally, $61,000 was allocated to implement an additional solar air-conditioning project.

In November 1983, the budget for micro-hydropower projects was increased from $313,200 to $439,000 to correct deficiencies in the equipment at Chitra and Buenos Aires and to procure equipment for a seventh micro-hydropower project at San Juanito. San Juanito was added because it lay within the Integrated Rural Development Project of the Sur de Veraguas, which would have major responsibility for the micro-hydropower project. Funds for training and the biogas demonstration project were increased slightly .

Funds had been made available for these changes by cancelling the extra solar cooling project, reprogramming an additional $47,000 from the budget for micro-hydropower feasibility studies, and reducing funding for courses under the institutional development line item from $25,000 to $2,300.

COMMENTARY ON CHANGES

The near elimination of technical assistance for the micro-hydropower feasibility studies had a serious negative impact on the quality of two key areas of expected outputs--the feasibility studies and the micro-hydropower demonstration projects (see Chapter VI).

Reducing the evaluation budget from $50,000 to $19,000 had a negative impact on achieving the project purpose. Alternative energy was a new area of activity for both IRHE and USAID/Washington. The project was intended to establish a new capability within IRHE that would then serve as a foundation for further activities. The "learning process" was thus central to the whole endeavor. Futhermore, as noted above, the project was very ambitious in its scope, embracing a wide range of sophisticated technologies. By reducing the budget for evaluation to just $19,000, USAID assured that many of the activities would have only a superficial review, and that the socio-economic impact of demonstration projects could not be comprehensively surveyed.

Elimination of the Yaviza biomass demonstration project was a necessary change insofar as its implementation would have incurred unjustifiable costs for less than optimal equipment.

The eventual introduction of seven micro-hydropower demonstration projects had a positive effect insofar as the technology is the most developed of the renewable-energy technologies under consideration and one for which there appears to be considerable potential in Panama (see Chapters VII and VIII).

The speedy elimination of the agricultural wastes feasibility studies suggests that this subcomponent was given low priority by IRHE and USAID. To the extent that their elimination streamlined an overly complex project, the change was positive. On the other hand, it meant that this potentially significant alternative-energy resource was not studied.

The increase in the master plan budget from $150,000 to $230,820 was necessary. That the master plan nevertheless was not fully developed suggests that the allocation was not sufficient to ensure that project objectives were met.

Table 2 shows that total accruals and disbursements as of the PACD were $752,400. As a result, up to $72,600 will be deobligated; the exact amount is not yet available because of delays in receiving vouchers from IRHE.

Table 2. Evolution of the USAID Budget for the Alternative Energy Sources Project ($000)

Activity	PP	7/80	9/80	5/81	4/82	11/83	6/85 (PACD)
Institutional development	95	95	95	95	92	64.5	71.1
Training	50	50	50	50	43	45.2	45.1
Information generation/ dissemination	45	45	45	45	49	19.3	26.1
Sun/wind measurement	20	20	20	20	24	17.0	
Courses	25	25	25	25	25	2.3	
Feasibility studies	175	125	100	50	73.2	26.2	26.2
Agricultural wastes	100	50	50		23.2	23.2	23.2
Micro-hydropower[a]	75	75	50	50	50	3.0	3.0
Demonstration projects	355	355	380	405	409	484.5	405.6
Yaviza wood	325	325	325	375			
Solar							
Air conditioning							
Hot water					61		
Photovoltaics							
Biogas	30	30	30	30	10.5	13.5	13.5
Micro-hydropower							
Chitra/Buenos Aires[a]	25	25	25	25	25	25	25
Five others					313.2	446	367.1
Master plan	150	230.8	230.8	230.8	230.8	230.8	230.8
Evaluation	50	19.2	19.2	19.2	19.2	19.8	18.6
Total	825	825	825	825	825	825	752.4

[a]These line items differ from those in USAID records. Construction and equipment for the first two micro-hydropower demonstration projects at Chitra and Buenos Aires were partially funded by $25,000 from the budget for micro-hydropower feasibility studies. (An additional $35,000 was allocated from a USAID project with the Ministry of Education.)

V. ACHIEVEMENT OF PROJECT OBJECTIVES

SUMMARY OF PROJECT TARGETS AND ACHIEVEMENTS

Table 3 summarizes how project achievements compare with programmed outputs. To the extent possible in this evaluation (see Chapter II), the following comments make an initial qualitative assessment of project outputs and suggest reasons for apparent successes and shortcomings. This section does not deal with the micro-hydropower components of the project, which are discussed in detail later in this report.

Table 3. Summary of Project Targets and Achievements

Activity	PP target	Revised target	Achieved PACD	Comments
Institutional development				
Internships	4	2	2	
Courses	15	15	33	
New IRHE staff members	12	10	10	
Documentation center	1	1		Partly achieved by CONADE
Newsletter	1	1		
Sun/wind measurement program	1	1	1	
Seminars	3	1	1	
Feasibility studies				
Agricultural wastes	1	X[a]		
Micro-hydropower	40	40	40	Prefeasibility level
Demonstration projects				
Biomass	1	X		Feasibility analysis
Solar air-conditioning	2	X		
Solar hot water	5	5	5	
Photovoltaics	1	1	1	
Biogas	2	2	2	One never worked
Micro-hydropower		7	2	Partial output; five in progress
Master plan	1	1		Activity adopted by CONADE
Evaluation	1	1		In progress

[a]X = eliminated.

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OBSERVATIONS[1]

Eliminations

As noted in Chapter VI, a number of initially programmed activities were eliminated. The feasibility of utilizing agricultural wastes, such as bagasse and rice hulls, to generate energy was never investigated under the project. Similarly, biomass and solar-assisted air-conditioning technologies were never demonstrated.

The agricultural wastes feasibility studies were eliminated, when cost overruns occurred in other activities, because they were given low priority. The biomass demonstration project was cancelled because the design, developed with extensive technical assistance, was too complex. As a result, equipment that met the design could not be procured within the budget. The cancellation of these activities had the positive effect of simplifying an overly complex project (see Chapter III), but it is unfortunate that the apparently promising potential of both these technologies was not investigated, particularly given the availability of simpler biomass designs.

Elimination of the solar air-conditioning component, because of equipment costs, had the positive effect of simplifying the project and did not significantly detract from its purpose (see Chapter III).

Institutional development

Institutional development is the area least affected by changes in project design. The evaluators believe that the large number of training activities attended by IRHE staff under this project contributed to the institution's capabilities in the field of alternative energy, however difficult it may be to document such a qualitative change. It should be noted, however, that some of those trained have not continued to work on this project, or even on alternative energy within IRHE.

Although the documentation center and alternative-energy newsletter did not come about as envisioned in the PP, the project did contribute to the partial realization of these objectives under CONADE. The information gathered under the project has contributed substantially to CONADE's database, which is now computerized, and CONADE publishes a bimonthly newsletter on energy, Boletín Informativo.

To the extent that there were shortcomings under this project activity, they seem to have been due to the fact that IRHE was unwilling or unable to devote sufficient funds to those elements for which it had responsibility. For example, IRHE had some problems in fulfilling the staffing plan due to the difficulty of recruiting qualified people for the salaries allocated.

Those elements for which USAID funds were available, such as the training activities and procurement of sun- and wind-measuring equipment, were those where targets were reached or exceeded.

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[1]This section draws on reference 4.

Biogas demonstration projects

The first biogas demonstration project, at the Asentamiento of La Colorada in Santiago, never became operational. This was apparently due to faulty design of the plastic collector bag.

The second project, at the Ciudad del Niño orphanage in La Chorrera, was inaugurated in May 1985 and is reportedly operating successfuly. IRHE apparently concluded from the failure of the first project that a different collector bag was necessary and that such projects should be implemented only where prospective users have sufficient technical knowledge to operate and maintain them correctly.

The failure of the first project was thus reportedly due to faulty technical assistance, while the success of the second project can be attributed to an effective learning process on the part of IRHE. Note that the evaluators were unable to independently verify these conclusions (see Chapter II).

Solar conversion demonstration projects

Five solar water-heating projects were implemented as planned, all of them at public institutions. A small photovoltaic array was also installed, to power a repeating station for rural radio communications.

Master plan

Despite increasing the budget for this activity, the objective of developing a master plan for alternative energy in Panama was not met by the PACD. A large amount of information was gathered under the energy assessment phase of the activity, however, and a preliminary plan was developed.

CONADE had been set up in 1975 with its Secretariat within the Ministry of Commerce and Industry. In 1980 it was transferred to the Energy and Tariffs Department of IRHE's Development Division. CONADE has now been elevated to the level of Directorate General (Dirección General) within IRHE, but the staff is essentially made up of those who worked on the USAID project in the Alternative Energy Sources Section. Furthermore, CONADE drew on the experience gained in the Alternative Energy Source Project, including the master plan, in developing the document, Strategies for the Development of the Energy Sector.

Thus, although the plan as specified in the PP has not been developed, the project has certainly contributed to progress in alternative-energy planning activities.

An overly ambitious project design can be held partly responsible for shortcomings in this activity. The master plan suffered from being made partially dependent on the successful and rapid completion of other project activities, such as training, feasibility studies, and demonstration projects. USAID and IRHE staff also questioned the contractor's performance, although the evalutors were not able to investigate this in depth.

CONCLUSIONS

The foregoing discussion suggests that, although the results of individual projects were mixed, success was achieved in the objective of strengthening IRHE's capability to "identify, analyze and develop renewable energy sources and applications with emphasis on the rural areas." IRHE staff benefitted from a large number of training activities, participated in studies for the Yaviza biomass project and the master plan, and implemented demonstration projects for biogas and solar energy. Progress has been made, albeit slowly, in the objectives of information generation and dissemination and alternative-energy planning.

As noted, the project was ambitious and somewhat unrealistic. Nevertheless, more appropriate technical assistance would have led to greater achievement of the project purpose, particularly with the biomass and biogas technologies.

VI. MICRO-HYDROPOWER COMPONENT

PROJECT PAPER

The original project design did not provide for the implementation of any micro-hydropower systems. It was envisioned that IRHE would assign two full-time engineers to identify potential project sites and prepare feasibility studies on the 40 most promising sites. Once the feasibility studies were completed, it was assumed that they would attract financing from the Municipal Development Fund (Fondo de Desarollo Municipal, FODEM), IRHE's own resources, agricultural development projects funded by USAID or the Inter-American Development Bank (IDB), or the potential follow-up loan from USAID.

The project plans assumed, incorrectly, that IRHE would take full responsibility for the micro-hydropower projects, from planning to construction, operation, and management (9, p.40). In fact, decentralized community management of completed systems was later a major concern of both USAID and IRHE.

Other aspects of the PP regarding micro-hydropower were much better planned. In particular, the PP identified three areas in which IRHE would need technical assistance (9, p.18):

- site selection and evaluation of technical alternatives in carrying out the feasibility studies;
- development of IRHE's own capacity to manufacture and service small turbines; and
- proper construction and installation techniques.

The USAID-funded portion of the budget included $75,000 for this technical assistance.

Secondly, as indicated in the technical assistance package, attention was given to the possibility of manufacturing turbines locally. The PP identified a number of substitute demonstration projects should changes become necessary during project implementation. In addition to micro-hydropower plants, these included establishing a local turbine manufacturing capability, at an estimated cost of $150,000 (9, Annex H2).

The Alternative Energy Sources Project PP thus identified three of the four areas where most problems would later arise in the micro-hydropower component: the methodology for feasibility studies, turbine procurement, construction standards and processes, and community management of completed systems. With the exception of designing an appropriate management structure, it made adequate provision for technical assistance to deal with these problems. That these provisions were not followed during project implementation must be seen as a shortcoming of management rather than design.

TECHNICAL ASSISTANCE

Initial attempts were made to provide the technical assistance inputs identified in the PP. In October 1979, IRHE presented a scope-of-work to USAID for technical assistance in: site selection, feasibility analysis, preparation of a manual for design and technical-economic evaluation, counterpart training, and preparation of a work plan. The assistance was to cover a period of 15 months beginning in January 1980.

At the same time, the Energy Office (S&T/EY) of USAID/Washington was negotiating a cooperative agreement that would create a resource base for small, decentralized hydropower within the NRECA. In March 1980, a consultant carried out a 2-week assignment with IRHE to assist in developing plans to carry out the assessment and feasibility studies. He was contracted under the cooperative agreement between S&T/EY and NRECA, although USAID specifically requested him.[1]

Both USAID and IRHE were pleased with the consultant's initial work and requested his assistance throughout the project. A scope-of-work was drawn up, and USAID contracted directly with the consultant. In July 1980, he spent 2 weeks in Panama to prepare an outline of the micro-hydropower feasibility and design manual, plan a series of training seminars for the following year, and assist in preparing equipment performance specifications for the Chitra scheme. He failed to provide a draft of the manual by September 1980, as required by the contract, and his contract was terminated by mutual consent in October 1980.

The scope-of-work of the unfulfilled contract included the following activities:

- complete the manual, which IRHE would translate into Spanish;
- train IRHE personnel to present seminars on micro-hydropower for community representatives and later act as an observer during the seminars;
- review load information for prospective micro-hydropower sites;
- complete performance specifications for the Buenos Aires project;
- inspect equipment for the Chitra project;
- assist in the design of the Chitra scheme and supervise its construction;
- assist IRHE in project assessment, feasibilty studies, and bid documents; and
- prepare a final report.

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[1]Telex of February 27, 1980, from USAID to NRECA.

The technical assistance plan represented a step back from that originally envisioned in the PP because the option of fabricating turbines locally had apparently already been dropped. Moreover, the only technical assistance for micro-hydropower that was funded under the project was the consultant's 2 week preparation mission in July 1980.

Had USAID pursued its search for a replacement consultant, the planned activities would have had a positive impact on the outcome of the micro-hydropower component. USAID failed to make full use of NRECA's SDH Program that had been set up, under a cooperative agreement with USAID/Washington, for that very purpose.

FEASIBILITY STUDIES

Objectives

The PP set a target of 40 micro-hydropower feasibility studies. While the purpose of the studies was not explicit, it is normally assumed that a feasibility study will address the major technical issues so that final designs and construction may proceed, should the projects be funded. The study should also include sufficient analysis of financial viability and socio-economic impact for the project to be approved or rejected by potential funding agencies.

Achievements

The Projects Section of the Studies Department in IRHE's Directorate of Development conducted studies on 40 sites selected from some 240 that had been identified. This represents a significant level of effort by a small staff. Furthermore, the studies did indeed attract funding--from a USAID project with the Ministry of Education and from within the Alternative Energy Sources Project when other activities were cancelled. The fact that the studies had been carried out was instrumental in attracting the interest of the IDB, resulting in a preinvestment mission in 1985, in which one of the evaluators participated, to prepare a $500,000 package of micro-hydropower development. That mission found, however, that the studies were an inadequate basis on which to recommend funding, for the reasons described below (3).

Shortcomings

The methodology for calculating minimum streamflows was flawed. Since none of the sites had been gaged over time, it was necessary to estimate minimum flows by extrapolating from neighboring gaged basins--a valid technique. In the IRHE studies, however, this was done by taking average monthly flows at a nearby basin over a number of years, taking the average of those figures, and then extrapolating to the basin under study. Actual minimum flows for a given month can be expected to be significantly lower than average daily flows for that month. As a result, plants were sized on the basis of overestimated flow-duration curves.

In most cases, turbo-generating equipment was sized so that the plants would not be able to operate at all during the dry season. A more conservative definition of plant capacity would have resulted in a much greater probability of obtaining year-round power. IRHE assumed that the communities would purchase and operate diesel generating sets to make up for this deficiency, although there is little evidence for this in such poor communities. This assumption was partly based on an overestimation of potential demand (see discussion below).

Virtually all of the studies include photocopies of the same standard designs for the intake structure and powerhouse. Aside from the stream profile, there are no site-specific designs or layout maps. Even the stream profile is of little use because there are no benchmarks noted and there is no indication of where the intake is located.

The economic analyses were conceived as "least-cost" comparisons between two alternative means--diesel and small hydropower--of supplying a hypothetical demand at a given community. This is common practice and valid, if one remembers what the results indicate--if correctly calculated, a B/C ratio greater than unity means that the hydropower plant is more cost-effective, or perhaps less of a misuse of scarce resources, than the diesel set. It indicates nothing about whether either would be the best thing to do in the community.

With the exception of Chitra and Buenos Aires, where diesel sets were actually to be installed at the schools if the hydropower projects were not built, the analyses did not compare the hydropower projects with the "actual" alternative.

Even given the goal of comparing the hydropower project with a hypothetical diesel generating set, the methodology confused economic with financial analysis. Present values were calculated by applying interest rates of 2%, 4%, and 8%, instead of discount rates of 10% or 12%. The terms of financing made available to a project, although central to its financial analysis, are of no relevance to its economic analysis.

The choice of discount rate has a very significant effect on the economic comparison of hydropower projects with diesel sets because the former are characterized by high initial capital costs and minimal recurring costs, while the latter have relatively low initial capital costs and high recurring costs. For example, if the project at Chepo had been analyzed using a discount rate of 12%, as is used by the IDB, instead of 8%, the B/C ratio would have been reduced from 1.2 to 0.96.

Demand assumptions made in the feasibility studies were also unrealistic. For example, analysis of five of the studies for the IDB in 1985[1] found that forecasts of household consumption ranged from 34 kWh/month to 234 kWh/month, compared to 54 kWh/month used in IRHE's revised feasibility study for the Five-Year Rural Electrification Plan (Plan Quinquennial de Electrificación Rural, PQER). The analysis found that, given the relative poverty and underdevelopment of the villages in question, 30 kWh/month would be a more appropriate estimate of average household consumption in the first year.

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[1]Feasibility studies for Chepo, Bajo Grande, El Nanzal, El Rascador, and El Cortezo.

These assumptions are critical in the economic comparison of hydropower (with negligible marginal generation costs up to full capacity utilization) and diesel (with nearly constant unit generating costs). IRHE's feasibility studies seem to pay more attention to constructing scenarios that make maximum use of power available than to assessing actual energy needs and realistic potential uses in the communities.

Conclusion

The 40 studies carried out by IRHE cannot be used as feasibility studies, but rather as prefeasibility or project identification analyses.

Reasons for shortcomings

The challenge of conducting a series of micro-hydropower feasibility studies lies in streamlining and simplifying the methodology, without using faulty techniques or unrealistic assumptions, so that sound analysis may be carried out at a cost and level of effort proportionate to the value of the projects. A number of such methodologies have been published and could have been utilized by IRHE. Although both the PP and IRHE's management recognized the need for technical assistance in this field, very little was actually provided (see section on Technical Assistance). The fact that this assistance was not forthcoming had a serious negative effect on the quality of the studies produced.

Recommendations

Since IRHE may be called upon to assess the feasibility of micro-hydropower projects in the future, it should obtain the available methodologies and adapt them for its own use, requesting technical assistance as necessary.

IRHE should approach NRECA's SDH Program, if necessary, for assistance in obtaining a selection of published methodologies for micro-hydropower site selection and feasibility analysis.

VII. MICRO-HYDROPOWER DEMONSTRATION PROJECTS

BUENOS AIRES

Technical analysis

Introduction

Buenos Aires was one of the first two installations to be completed and has been operating for about 4 years. The team inspected the plant August 28, while it was shut down to clean the intake.

With the exception of details at the intake, the civil works were well designed and executed. The powerhouse machinery is properly installed. Although rated at 10 kW, the plant has yet to produce over 2.5 kW because of the factors described below. Left as is, the facility is of little value to Buenos Aires. Replacing the turbine will increase the plant's capacity to a level which will benefit the community.

Conditions

Although the powerhouse is well constructed and the penstock installation was well executed (especially considering the difficulties imposed by the site conditions), the design of the intake works requires revisions. The present installation requires that the plant be shut down daily to allow the attendant to clean the intake screen. This inconvenience could be substantially reduced with proper design.

The pond behind the dam must be drained periodically at irregular intervals during periods of high runoff when silt and gravel accumulate behind the dam, and to meet other service requirements. The attendant currently drains the pond by removing several sandbags that plug a hole at the base of the dam. The sandbags, however, provide a poor seal and allow water to escape from the pond. At times of low streamflow, this water could be used for generation purposes. Equally important is the danger to the attendant, who must complete this task while balancing on wet rocks at the top of a high waterfall. Again, this situation could be remedied by better design.

The turbo-generating equipment has not produced over 2.5 kW capacity, although the generator is rated at 10 kW. Output has been measured by IRHE and by a representative of the manufacturer, but information on the methodology used for output measurement is unavailable. This deficiency can be attributed to the fact that:

- o the turbine--a Pelton type--is somewhat inappropriate to the site; and
- o the turbine is poorly designed and constructed.

Although professional opinions vary somewhat, Pelton turbines are rarely recommended for a site with a head of less than 40 m. Buenos Aires operates under a head of about 21 m, and turbine efficiency suffers as a result.

This compounds deficiencies caused by poor turbine design as the following indicate:

- The turbine case is substantially smaller than necessary to effectively discharge the water which flows through it. Discharge water interferes with the jets and the turbine runner.
- The nozzles almost certainly operate well below the optimum coefficient of discharge.
- The intake manifold induces losses due to the short-radius bends and inline concentric reducers.

The manufacturer's performance claims, made at the time of purchase, have never been met. The manufacturer's agent, sent to Panama on two occasions, failed to make any noticeable improvement. Based on activity reports filed by the manufacturer's agent,[1] it appears that he was unqualified to perform the task at hand--to discover reasons for and correct the plant's low output. The manufacturer also appears to have failed to supply turbine operation and maintainance manuals, mechanical and electrical drawings, and parts lists.

At the time this equipment was purchased, the U.S. small-hydropower industry was still very young. There was probably only one established manufacturer (James Leffel and Co.) that could have supplied a turbine for this site, albeit at a much higher cost. Similar turbines were available from a few other "Mom and Pop" manufacturers at the time, but there is no reason to assume that any of the others would have supplied substantially better equipment.

According to the local operators and IRHE personnel, the plant operates within a range of 58-62 hz. While this may be acceptable at present, it could present a problem if future output and loads increase. Because the present loads are minimal, the electronic load controller's full-load performance is unknown.

IRHE has considered moving the intake upstream, thus gaining additional head. This task would involve substantial effort and additional expense and add to the difficulties of access to the intake.

Corrective options

To reduce maintenance requirements, the existing concrete intake box could be abandoned or modified. Options discussed with IRHE include:

- abandoning the box and installing a new steel catchment on the face of the dam, connected to the existing penstock;
- abandoning the existing box and constructing a new one, of different design, adjacent to it; or

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[1]Memoranda to G. Riley (USAID) from J. Hanson (SHSE) of October 12 and December 7, 1981.

- constructing a new concrete intake baffle with a screen on the upstream side of the existing box; debris would then flow around, rather than into, the intake box.

The problems of safety and convenience in draining the pond may be addressed by installing a pipeform penetration, at the base of the dam, equipped with an upstream slidegate with screw operator.

Increasing turbine output will require:

- discarding the existing turbine case and replacing it with a redesigned case sized to allow discharge;

- fabricating and installing the redesigned nozzle assemblies and manifold; and

- replacing the entire Pelton turbine with a crossflow turbine.

Implementation of either of the first two options would improve output. However, performance would still be compromised due to the hydraulic characteristics of a Pelton turbine operating at a low head. Replacing the Pelton turbine with a crossflow turbine will yield better overall efficiencies under the head and flow conditions at Buenos Aires. The cost appears to be competitive with that of modifying the Pelton turbine.

Recommendations

IRHE should carefully analyze options to improve the intake and select that which best meets the demands imposed by site conditions, the abilities of the construction crews and maintenance personnel, and the cost. The action chosen should be implemented during next dry season. These options have been discussed in detail with IRHE and sketches have been provided.[1]

A sluice gate should be installed as described. Convenience and safety will be improved because the gate can be operated from on top of the dam.

IRHE should replace the Pelton turbine with a crossflow turbine. The latter could be fabricated locally, obtained from the United States, or obtained from sources at the University of San Jose in Costa Rica. The existing generator and electronic load controller can be adapted to a crossflow with little effort.

Raising the intake elevation cannot be justified because the existing head and flow conditions are adequate for approximately 10 kW output, assuming installation of turbo-generating equipment with a combined efficiency of 60%.

Because this installation provides very little benefit in its present condition, expending additional funds--presently estimated at less than $7000--to implement these recommendations is prudent.

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[1]During discussions with Ing. Wong and Vargas on September 2, 1985.

The existing turbine should be retained for possible installation at another site, which would indirectly recover part of the cost of the improvements. If reinstalled, the turbine should operate under a minimum head of 40 m with no more than two nozzles.

USAID should, if possible, make an effort to recover the cost of the turbine replacement from the manufacturer. The manufacturer has, in a past meeting with IRHE, indicated a willingness to make a cash contribution to assist in corrective measures.[1] Failing this, USAID should consider the possibility of seeking funding from IRHE and the Guaymi Project.

Socio-economic analysis

Demand and consumption

The major beneficiary of this project is the school, which has 110 students and 11 teachers. The teachers and 60 boarders live at the school during the school year, from April to December. The present benefits from the project are limited to lighting (four fluorescent lights) and refrigerating perishable food intermittently. The school has two refrigerators, but can operate only one at a time <u>or</u> the lights, because of the low power output from the plant. Workshop equipment that was to be installed was reportedly redirected elsewhere when it became apparent that insufficient power would be available.

Besides the school, the only other direct beneficiaries are the 12 houses that have been connected, each with a single 40 W light bulb. It is important to remember that this is an extremely poor community, with family cash income estimated to vary between $100 and $300/year in 1981 (10, p. 68). Even with more power available, one should not expect a large number of household appliances to be installed.

Potential

There are a number of potential benefits that could be realized if the plant's output were increased to 8 kW:

- The school would immediately be able to operate its two refrigerators and lighting simultaneously. This will be particularly important since a new primary school building is under construction and funds have apparently been earmarked for the construction of a new dormitory.
- Increased output would renew the possibility of installing workshop equipment at the school. This would enable the community to develop new skills, which are greatly needed because local agricultural potential is limited. Furthermore, the reforestation carried out by the Directorate of Renewable Natural Resources (Dirección de Recursos Naturales y Renovables, RENARE) will make wood available for handicraft industries within the next few years.

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[1] During a meeting with Ing. Cedeño in May 1982.

- The potable water system, currently being installed under a civic action program of the Panamanian Defense Forces, will reportedly require pumping. This is an ideal load for off-peak hours, such as between midnight and 8 a.m. A 5 hp diesel motor, for example, would cost approximately B/. 0.48/hour just for fuel,[1] would require more maintenance and repairs than an electric pump, and may have a shorter life span.

- Extending the distribution system within the village would enable up to 20 additional houses to be connected, as well as the health center. The latter currently stores medicines in a refrigerator that runs on kerosene, which costs approximately B/. 10/month and is often unavailable. Lighting would also greatly facilitate service at night.

Realization of the above benefits would significantly increase the social and economic impact of the hydropower system, which is currently minimal. Even if the plant's output is increased, however, USAID should not expect any but the first of the above benefits to follow spontaneously.

Community management

The system is administered by the Junta Comunal (village council), a seven-member elected body. The present committee was elected in June, but the secretary was unable to provide any books, records, or other information on the administration of the electric system because the committee has yet to be sworn in by the Representative. Outgoing committee members were not available to be interviewed. The 12 household consumers are supposed to pay B/. 1/month for system operation and maintenance, but it was not possible to verify the extent to which this is carried out.

Administration of the electricity system is clearly rudimentary. It cannot be relied upon to generate any contingency reserve, or even funds for ordinary maintenance costs. It would benefit from outside support and regulation.

Formation of a cooperative to manage the system should not be attempted for the following reasons:

- The Guaymi community is isolated from the rest of Panamanian society and resistant to impositions on its own culture and customs (10).

- The system has already been built and administered for 4 years, albeit badly. Rural electric cooperatives should ideally be formed in conjunction with project implementation in order to facilitate a sense of ownership, participation, and responsibility on the part of the members.

- There are only 12 consumers, whereas Panamanian law[2] sets a minimum of 20 members for cooperatives.

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[1] 0.3 gals/hr at B/. 1.60/gal.
[2] Cooperative Legislation (Legislación Cooperativa), República de Panamá, 1983.

Recommendations

USAID should actively investigate funding options for the technical improvements outlined above. Possible sources include the Guaymi Integrated Rural Development Project, the equipment suppliers, IRHE, and other projects in the area.

IRHE should stengthen the ability of the Junta Comunal to administer the system, possibly working with the Directorate General for Community Development (Dirección General para el Desarrollo de la Comunidad, DIGEDECOM) or the National Office for Integrated Rural Development (Oficina Nacional de Desarrollo Rural Integrado, ONADRI). At a minimum, IRHE should ensure that basic operations and maintenance tasks are carried out adequately, that tariffs are collected and accounted for, and that a reserve is created for maintenance.

The following recommendations are contingent on obtaining increased power output:

- USAID should investigate the possibility of the Ministry of Education providing workshop equipment to the school.
- USAID should immediately investigate plans for the potable water project at Buenos Aires and recommend, if necessary, the installation of an electric pump to operate during off-peak hours.
- IRHE should investigate the possibility of extending the distribution system at Buenos Aires to include the health center and nearby houses.

CHITRA (PUEBLO NUEVO)

Technical analysis

Introduction

Chitra was one of the first two installations to be completed and has been operative for about 4 years. The team inspected the plant on August 28, when it was operating with an output of less than 10 kW.

The natural features of the site are well suited to micro-hydropower development and the project was well executed. The site will require some work to correct conditions caused by a change in the course of the stream. Although the generator is rated at 50 kW, the site has only achieved an output of 26 kW.[1] The electronic load controller is inoperative, as is the safety shutdown device.

Although turbine efficiency can be improved, it is unlikely that the plant will gain more than 10% in capacity. The electronic load controller should be replaced. The village has already benefitted from the installation and will benefit more once the recommendations are implemented.

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[1]The output claimed by the manufacturer's agent after on-site inspection.

Conditions

The dam and intake apparatus are well constructed and rationally designed. This site is typical of many micro-hydropower schemes where waterborne silt and gravel represent an ongoing maintenance problem. At the time of inspection, the stream was flowing through a break in the far end of the dam. According to the local villagers, the stream had changed course during a period of high runoff. This resulted in a lower than optimum headpond elevation. Adequate flow is available, however, to meet the turbine's present requirements.

The intake box is properly screened and requires little maintenance, due in part to design features and in part to site characteristics. The entire penstock length is buried and leakage at end-joint connections (reported in a previous evaluation) has been corrected. The powerhouse is well designed and constructed and the turbo-generating and electrical equipment is properly installed.

The same manufacturer supplied the turbo-generating equipment for both Chitra and Buenos Aires. The Chitra equipment, although rated at 50 kW, has yet to produce over 25 kW. Furthermore, it is not likely that it will ever reach its rated capacity because of turbine-design and construction deficiencies.

Theoretical power available at Chitra is 45.9 kW.[1] An output of 26 kW indicates an overall efficiency of 57%. The method used to determine the output is not known. Assuming a part-load generator efficiency of 85% and a drive efficiency of 98% results in a turbine efficiency of 69%. This figure is lower than industry standards and results from a number of causes:

- The nozzle design leads to a low coefficient of discharge.
- When operating with two nozzles, it is likely that there will be interference with the lower jet.
- The runner is a standardized design and efficiency is, therefore, compromised.

The overall layout of the turbo-generating equipment frame assembly is rational and acceptable. The lack of quality in turbine manufacture is evidenced by the following:

- A faulty seal on the turbine shaft allows water to escape from the case. As a result, the bearing nearest the turbine case is wet during operation and the powerhouse floor has a puddle of water.
- Faulty seals on the deflector shafts allow water to drip on the outside of the case.

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[1]Source: Discussion with Ing. Wong of IRHE.

- o The lower deflector shaft is bent and/or misaligned, which results in increased effort to operate the deflector. If this is a result of shipping damage, it indicates negligence in packaging. If it is a result of operation, it indicates poor design and/or execution.

- o One of the turbine bearings is without a grease fitting. As a result of efforts to lubricate the bearing, the grease seal has failed. It is not clear if the bearing was supplied without the fitting or if it was broken or removed after installation.

The manufacturer's agent was sent to Panama on two occasions to correct the above (see section on Buenos Aires). The results of his efforts were limited.

Various evidence[1] indicates that the electronic load controller either failed shortly after commissioning or never functioned properly at all. The electronic circuitry was removed from the unit by IRHE in an attempt to replace it that proved prohibitively expensive. The safety shutdown device, likewise, has never functioned properly. The plant has been manually regulated throughout its operating history.

Operating the facility using manual control is not only impractical but represents a risk because loss of load may result in plant overspeed and consequent damage. At present, the output is adjusted to meet existing loads. The operating range is 58-62 hz. If a large load (i.e., a coffee-processing machine or other motor over about 3 hp) were added to the system at this time, the system would not meet its demand unless manually adjusted. When that load was turned off, the voltage and frequency rise would be unacceptably high and would most likely damage other loads and/or the generator itself. The lack of a governing apparatus, therefore, substantially reduces the benefits available from the facility since a full-time attendant to regulate the plant is impractical.

Corrective options

The proper headpond elevation should be restored. Under present conditions, the penstock submergence is adequate. When flow to the turbine is increased, a siphon-vortex may occur, allowing air to enter the penstock. Increasing pond elevation will prevent this. Raising the pond elevation will require blocking the present course of the stream by extending the concrete dam. Alternatively, this task may be accomplished by using dam sack or sandbags.

Turbine efficiency may be improved, although probably not substantially. Efforts required to realize improvements are not prohibitively costly, however, and can largely be accomplished on site. They include:

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[1]Memorandum to G. Riley (USAID) from J. Hanson, Report on Contracted Activities, Buenos Aires and Chitra; and interviews with plant operator, Ing. F. Vargas (IRHE) and G. Riley (USAID).

- modifying the nozzle assemblies using an orifice-plate design that allows easy change of orifice diameter. Design sketches were provided to IRHE;[1]

- enshrouding the lower jet to reduce interference from discharge water;

- replacing the turbine housing with a wider version, thereby providing greater clearance for discharge water; and

- inspecting the runner for quality of surface finish and alignment with jets. Unless gross imperfections are present, improving surface finish yields little improvement. The proper spatial relationship between the runner and jets is important for efficient operation.

Deficiencies in construction quality may be improved upon by:

- replacing the existing shaft-seal assembly with another seal better suited to the task;

- replacing the shaft seals on the deflector shafts;

- repairing or replacing the lower deflector shaft; if the bearing is damaged, a substitute will be required because this bearing is no longer available; and

- repairing or replacing the deflector linkage to assure smooth operation.

Recommissioning the electronic load controller, or replacing it, is essential to the plant's operation and is affected by the following factors:

- The electronic circuitry appears to have been removed from the load controller case; repair is therefore impossible. The value of ordering a replacement from a supplier who has shown poor performance in the past is also doubtful. The manufacturer is believed to be out of business.

- Replacement with a unit from another manufacturer would require an estimated 3-month manufacture/delivery schedule at an estimated cost of less than $2000. Installation would require an IRHE engineer and electrician for 1 day.

Recommissioning the safety-shutdown device is subject to the same concern regarding the previous supplier as mentioned above. Replacement options include:

- utilizing equipment from the supplier of a replacement electronic load controllor; or

- fabricating a suitable device designed and built by IRHE. An approach similar to that used by Axel-Johnson on its equipment for the five new projects would be valid in this case.

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[1] In a meeting with Ing. Wong and Vargas on September 2, 1985.

Recommendations

IRHE, directing local labor, should raise the level of the headpond as indicated above. The cost would be low--estimated at less than $1000--and would be justified by the consequent benefits to the community.

IRHE should give full consideration to implementing actions to improve turbine efficiency. With the exception of replacing the turbine housing, the corrective actions noted above require reasonable effort and expenditure, and would be justified by the resultant improvement in performance.

The existing shortcomings in construction quality should be addressed as indicated above. Again, costs would be reasonable and work could be mostly done on site.

Both turbine bearings should be replaced with new bearings of double-roller type, either spherical or double-taper, self-aligning. Care should be taken to assure that shaft centerline remains located relative to the nozzle center lines. An IRHE engineer should first examine the turbine to determine if the shaft is of adequate diameter relative to the work required of it.

The load controller should be replaced. A supplier source list is available from NRECA.

IRHE should examine options regarding the safety shutdown system and consider its own capabilities in selecting a means by which the safety shutdown system may be made operative. The load controller manufacturers can provide this type of device as an integrated part of their device.

Socio-economic analysis

Demand and consumption

Table 4 provides estimates, in the absence of meters, of electricity demand and consumption at Chitra.

Table 4. Electricity Demand and Consumption Estimates for Chitra

Item	Load (W)	Demand (W)	Consumption (kWh)
Household lighting	(38 x 3 x 60)	6,840	8,500
Televisions	(8 x 120)	960	1,200
School lighting	(30 x 40)	1,200	1,000
Street lighting	(6 x 150)	900	4,000
Refrigeration	(4 x 240)	960	4,200
Radio/telephone	(1 x 1000)	1,000	unknown
	Total	11,860	Up to 20,000

This estimated annual consumption represents a capacity utilization factor of 4.5%, using the intended installed capacity of 50 kW, and of 9.0% on the apparent present capacity of 25 kW. Capacity utilization factors of at least 30% are considered normal for feasible small-hydropower projects. The capacity utilization factor would be substantially improved by the addition of a coffee beneficio motor load (see discussion below).

The greater consumption at Chitra than at Buenos Aires is due to several factors:

- The plant, although inefficient, can generate at least 10 kW and up to 25 kW.
- The village has a more developed economy, which leads to greater disposable income and an increased ability to pay for electric appliances and energy.
- The community obtained a radio-telephone from the National Telecommunications Institute (Instituto Nacional de Telecomuniciones, INTEL) which was installed in 1984 and is reportedly used quite extensively. No data on usage or energy consumption are available, however.

Electricity consumption, and therefore project benefits, are also directly limited by the following factors:

- It has not been possible to operate potentially productive loads. On two occasions, residents have reportedly attempted to connect small motors (a coffee huller and a block maker), but were unsuccessful. This may have been due to problems in the system, lack of electrical knowledge on the part of the users, or both.
- A multipurpose cooperative, Renacer Chitrano, was formed in 1981, but progressed slowly. Efforts to establish a cooperative store and, in particular, a coffee-processing facility had been unsuccessful until very recently (see discussion below).

Potential

IPACOOP regional staff in Santiago have worked closely with the Renacer Chitrano cooperative since its foundation. In 1983, IPACOOP developed a feasibility study for a project that would provide the cooperative with a small store, a small coffee "beneficio" (processing facility), and a vehicle. IPACOOP believed that major benefits would result from the coffee beneficio, which could process 3000 qq of coffee per season and enable growers to improve their selling price from approximately B/. 40/q to B/. 60/q. Furthermore, IPACOOP believed that in the future the quality of the coffee could be improved to the point of obtaining an export quota, and an average selling price of approximately B/. 96/q.

The project was submitted unsucessfully to the IDB; but IPACOOP continued to work with the cooperative and obtained a grant of $15,000 for the beneficio from a Canadian source in 1985. IPACOOP obtained the services of a builder with experience in such projects, who will be joined by two masons provided by the Agricultural Development Ministry (Ministerio de Desarrollo Agropecuario, MIDA). Construction had begun the day before the evaluators' visit on August 29 and is expected to be completed by mid-November 1985.

The motor loads that will be associated with the beneficio are shown in Table 5.

Table 5. Motor Loads for the Coffee Beneficio

Equipment	Load (hp)
Pulper	1
Pump	3
Huller	7.5

Since only one of the machines will operate at a time, the maximum load will be 7.5 hp. In addition, the beneficio, storeroom, and office will require lighting of 500 W.

The nearest electricity pole is just 226 m from the beneficio. Despite lower costs associated with installing electric motors at the beneficio, the builder is understandably mistrustful of the reliability of the village electric system. Indeed, reliable operation of the beneficio's equipment using the village electric system would require, at a minimum, installing an adequate load controller (see technical analysis). Unless assured that the electric system can handle the beneficio's motor load, including during evening peak hours if necessary, the builder will probably opt for one of a number of costlier and extremely difficult hydro-mechanical options.

The operation of a small coffee beneficio, particularly if the costs of a diesel motor can be avoided, will have a significant impact on the villagers' cash income by realizing more of the value added and stimulating increased production. This, in turn, will provide the villagers with a greater ability to pay for electrical appliances and energy.

Potential productive uses that are unplanned at present include workshop equipment for the school and the eventual construction of a health center.

Community management

As at Buenos Aires, the system has been managed in a rudimentary fashion by the Junta Comunal. Monthly tariffs are shown in Table 6.

Table 6. Monthly Tariffs at Buenos Aires

Type of load	Tariff (B./)
Light bulbs	0.50
Television	1.00
Refrigerator	3.00

Since public services are not charged, monthly system revenues should be approximately B/. 70. Compared to the plant at Buenos Aires, the system at Chitra appears to be in slightly better administrative and financial order because of the greater power available, the greater size of the community, and the higher disposable income of its members. Nevertheless, as in Buenos Aires, the management structure cannot be relied upon to effectively generate revenue, account for it, or provide contingency reserves.

Renacer Chitrano, on the other hand, has the potential for providing a sound administrative service to the community. The case of the beneficio provides a striking illustration of the importance of the institutional support structure provided by IPACOOP over the long term. This link resulted in funds and technical assistance leading to the realization of a project that will in turn stimulate the cooperative's development: the IPACOOP staff reports that the membership of Renacer Chitrano has already increased as a result of the beneficio. Furthermore, IPACOOP has received MIDA funding for the services of a full-time cooperative manager who will live in Chitra.

The electric system would benefit greatly from the concerted administrative and organizational support provided by IPACOOP to Renacer Chitrano. Transfer of the system to the cooperative would require care in attracting the handful of consumers who are not yet members, and attention by IPACOOP to ensure that the electric system accounts are kept separate from those of the coffee operation.

IPACOOP is willing to accept the latter task and believes it will be made easier by the fact that the Junta Comunal officials are all members of the cooperative, as is the Representative. The result--administration of the electricity system within a sound organizational framework that has access to outside assistance and resources--will be worth the effort.

Recommendations

USAID should investigate the possibility of obtaining funds from the manufacturer of the equipment to install an electronic load controller, thus enabling a significant productive benefit to be derived from the hydroelectric system.

Should this fail, USAID should coordinate with IPACOOP and IRHE to assure tha a load controller is procured and installed as soon as possible. IPACOOP has indicated that it would be prepared to fund the acquisition of the load controller under these circumstances.

Contingent on the successful completion of these improvements, IPACOOP should ensure that electric motors be installed at the coffee beneficio, rather than an independent hydro-mechanical system.

IPACOOP should establish a cooperative electric service within Renacer Chitrano, working in conjunction with the Junta Comunal and the Representative. (See action plan in Chapter IX.)

VIII. MICRO-HYDROPOWER PROJECTS UNDER CONSTRUCTION

TECHNICAL OBSERVATIONS

<u>El Cedro</u>

Introduction

This plant is one of a group of five under various stages of construction. The team inspected the plant on August 27.

The civil works are substantially completed but will require changes to be serviceable. The powerhouse equipment is not yet installed; IRHE did not indicate an installation date.

Conditions

The dam and intake works have been in place for 2 years. The silt accumulation over this period would render the plant inoperable were it functioning. Because of the design of the structures and the nature of the watershed, silt will continue to cause an ongoing maintenance problem.

No provision has been made for sluice gates in the dam or intake box, substantially increasing the effort required to remove debris.

The penstock is 775 m long and is buried for part of its length. It crosses several small ravines with long runs which are unsupported. The penstock elevation rises and falls at several locations resulting in at least two spots where the elevation is at or near the elevation of the intake. These high spots will tend to collect air and prohibit full flow through the penstock.

A few hundred feet below the dam, the penstock makes a 90° turn using a close-radius elbow fitting. There are also three 45° close-radius elbows in the line. The accumulated effect is a head loss that in this case is not significant.

The powerhouse is located creekside at the bottom of a steep-walled canyon. Construction is of poured concrete and concrete block. Construction quality is well below that seen at other sites. The building was designed and constructed before the equipment contract was awarded. A large portion of one wall will have to be removed to install the turbo-generating equipment. This represents a substantial effort.

Access to the powerhouse is very poor. Workers must walk along the penstock, which is both difficult and inconvenient. A heavy lift helicopter is required to carry the machinery to the site. Removing equipment for repair in the future will require removal of the roof and a helicopter for lifting and transport. The turbo-generating equipment weighs almost 5 tons. IRHE could not identify a means of installation if a helicopter were not available.

Based on the manufacturer's tests, the turbo-generating equipment will not achieve its rated capacity. Differences in conditions between the test stand and the field may result in a further reduction in output, but this can only be determined after installation. The equipment and controls were supplied by a manufacturer with an excellent reputation for quality and can be expected to provide several decades of dependable service.

The control/protection system provided is well designed, although somewhat sophisticated. The manufacturer has supplied excellent instruction manuals, but villagers will require training in plant operation and maintenance.

Corrective options

Accumulated silt and debris must be removed from behind the dam and around the intake area. Several possibilities were discussed with IRHE[1] which would improve operation and maintenance:

- excavating and protecting the banks on the upstream side of the intake box and using dam sack and concrete instream diversions to redirect silt and debris;

- modifying the intake box, including installing screens in series, baffles, and a sluice gate to reduce cleaning requirements; and

- installing one or two sluice gates in the dam to facilitate removal of silt by using the action of the water being drained when the gates are opened.

Plastic pipe manufacturers provide information regarding the maximum allowable free span for their product. This distance, although not specifically known, is obviously exceeded in several places at El Cedro. Support for pipelines is commonly provided through use of:

- suspension cables with slings through which the pipe passes; or

- columns or trestle structures of concrete or wood construction.

Installing penstock vents at appropriate locations will allow entrapped air to exit the penstock. Installation may be accomplished by:

- using glued saddle-tee fittings with a valve or vacuum breaker in the standpipe; or

- drilling and tapping the pipeline to allow installation of a threaded standpipe with a valve or vacuum breaker in it.

Head loss resulting from bends may be reduced by increasing the radius of the bends with new metal or plastic fittings or plastic/fiberglass fittings fabricated on site.

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[1]Discussion with Ing. Vargas.

There is no apparent way to eliminate the need to remove a portion of the powerhouse wall for turbine installation. The cost of building a road to the powerhouse would probably have rendered the project uneconomic. IRHE appears to have undertaken the project with no assured method of installation. Fully assembled, the equipment's weight will require a helicopter with a lift capacity of 5 tons, although the equipment could be disassembled and lifted in pieces by a smaller helicopter if necessary.

It is unlikely that turbine efficiency can be improved. The Pelton turbine to be installed is operating below its ideal head range, which results in compromised efficiency. Using a standardized runner and/or runner hydraulic design may also contribute to low efficiency, although this is speculative.

Recommendations

IRHE should reexamine the civil works at El Cedro and develop and carry out new construction. At the least, the new work should include:

- installing one sluice gate (with screw operator) in the dam;
- installing a screen and baffle in the intake box; and
- installing a sluice gate in the intake box.

Based on the abilities of labor and the availability of local materials, IRHE should use wood or concrete support columns where necessary in the penstock.

Penstock venting is a simple task and essential to proper operation. IRHE should assure proper completion of this requirement.

IRHE should take no action regarding replacement of short-radius elbows in the penstock because the gain in head and resulting power output would not justify the expense.

The disadvantages of undertaking powerhouse construction prior to machinery design are obvious and addressed elsewhere in this paper.

IRHE should immediately attempt to make arrangements for installing the equipment, because this may take more time than assumed necessary and therefore cause further delay.

To meet the challenge of successfully operating and maintaining the plant, the local operators will require adequate training. The chief operator and two alternates should attend. The program should use and include IRHE personnel, manufacturer's representatives, and outside technical assistance.

<u>San Juanito</u>

Introduction

This facility is one of a group of five under various stages of construction. The team inspected the plant on August 29.

The dam and part of the intake apparatus are complete, as is the powerhouse foundation. The penstock has not been installed, and there appears to be no target date for completion.

Conditions

The dam/intake is well sited and takes advantage of natural geographic features. Construction quality is good. However, as is often the case, waterborne silt and gravel appear to be a potential maintenance problem, although not to the degree at other sites inspected. The dam was designed without provision for sluice gates or other means of easy draining. Silt/gravel deposits are already apparent upstream of the intake area. At the time of inspection, the intake apparatus was choked with vegetation. Silt accumulation was also apparent behind the full length of the dam and could impede proper plant operation.

The powerhouse is designed to the turbine manufacturer's drawings. Foundations are nearly complete and appear well constructed.

Access is by dirt road, which is often impassable during the rainy season. There is adequate room around the powerhouse to allow for handling the turbine and other equipment.

Corrective options

As elsewhere, the problem of silt deposits can be tempered by installing sluice gates or similar apparatus in both the dam and intake box. Because of the length of the dam, at least two gates are required.

The wingwalls that form the intake box could be extended upstream and include a long screened opening on the wet side. This would allow the currents in the pond to carry floating debris away from the intake. The extensions could be poured concrete or dam sack. The intake box should also have a sluice gate.

Recommendations

IRHE should implement the above suggestions or take similar action to deal with the problem of silt, gravel, and waterborne debris. Several options were discussed on site with IRHE.[1]

SOCIO-ECONOMIC OBSERVATIONS

El Cedro

This community appears to have a somewhat higher standard of living than many of those visited. Coffee and cattle provide cash income. Nineteen of the 30 coffee growers joined together to obtain loans for planting an improved coffee variety that has led to increased production, but prices remain low. The growers are receiving long-term technical assistance from MIDA and have

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[1]During discussions with Ing. Vargas.

discussed the possibility of organizing to process their coffee and improve its selling price.

A 2 kW diesel generator, property of the Ministry of Education, is operated from 6 p.m. to 10 p.m. and serves the school and eight houses. The load is made up of televisions and lighting. The consumers contribute for diesel and oil as necessary, although, at the time of the visit, the plant had been out of service for a few days because of a lack of oil. A small privately owned rice mill used to operate with a diesel motor, but is out of service.

The community seems to have good organizational potential. There are committees for water, health, Holy Week, and electricity--the latter composed of the 43 residents who contribute labor for the micro-hydropower project. The daily work schedule is posted on the wall of the small general store. The Representative lives in the community and has been a moving force behind the project.

Expected electricity usage will consist of extensive household lighting, some televisions, a few refrigerators, and street lights. If 50 houses are connected, evening peak demand may reach 20 kW.

Potential productive uses include coffee and rice milling, as well as a small cheese factory to process the local milk production that cannot be marketed due to poor roads. While a few individuals, such as the Representative, may have the resources to initiate such activities, it is more likely that they would develop if promoted through institutional support from outside the community. The feasibility of forming a coffee cooperative with a small beneficio deserves further analysis.

San Juanito

Domestic consumers in San Juanito are likely to number only about 30. The apparent level of economic development suggests that average consumption will be minimal: probably two or three lights per home and very few electric appliances. Peak demand, including street lighting, is unlikely to exceed 10 kW.

A pre-cooperative group was established at this community in March 1984, in anticipation of forming an electric cooperative to manage the system. There has been no follow-up, however, and the group has functioned as a committee since then.

Potential socially productive uses include lighting for an adult literacy class, which currently uses kerosene lamps. Productive uses of electricity cannot be expected to develop spontaneously in communities such as San Juanito. The community's rice production could be hulled on a cooperative basis, although this would require active promotion and would compete with the Representative's business in nearby Soledad. Over the long term, it is possible that the Sur de Veraguas project will result in increased productivity and income in the area, enabling greater benefits to be realized from the hydroelectric system.

Other projects

Maximum demand at the remaining projects can be estimated as shown in Table 7 (note that estimates are very tentative, in the absence of visits to these communities):

Table 7. Demand Estimates for Remaining Projects Under Construction

Community	Houses	Lilely connections	Likely household demand (kW)	Likely total demand (kW)
Entradero de Tijera	80	50	15	18
La Pintada	46	30	9	12
La Tronosa	46	30	9	12

Only in relatively prosperous communities can productive uses be expected to develop spontaneously. Rudimentary village organization can be expected to be present, and all the communities have worked voluntarily on system construction for more than 2 years.

The development of productive uses will be influenced by factors such as the productivity of the area, the size of the community, the ability of the community to leverage outside assistance, etc. The prospects for effective community management will be influenced by such factors as the size of the community, the degree of local leadership, the degree of cohesion among community members, and past experience with working together.

Both productive uses and effective community management would be facilitated by the formation of cooperatives to administer the electric systems, together with strong and continued support from IPACOOP.

Productive uses and effective commmunity management will be impeded if the plants are unable to generate power year-round, if system capacity is significantly less than planned, and if the systems are unable to function for extended periods due to technical problems.

Recommendations

IPACOOP should form and support rural electric cooperatives at the five communities where micro-hydropower systems are under construction, given the assistance specified in the action plan for community management. Promotion of the cooperatives should begin as soon as possible.

In the course of its work with the cooperatives, IPACOOP should identify and analyze potential productive uses at each of the communities. The cooperatives should be encouraged to develop productive uses and provide services to benefit the communities.

IPACOOP should develop feasibility studies for small cooperative development projects, and pursue funding for them. IPACOOP should also maintain close contact with NRECA throughout, and request assistance as necessary. IRHE should remain available to provide technical assistance to the cooperatives after plant installation and start-up.

FURTHER OBSERVATIONS

Civil works

A common design flaw appears in all projects inspected, and, it can be reasonably assumed, in those not inspected. The dams and intake structures all show a lack of consideration for maintenance. As mentioned, waterborne silt/gravel and flotsam is a common problem in small-scale hydropower projects. This is usually due to the nature of watersheds in catchments characterized by high instantaneous runoff. Accumulations of silt/gravel can allow abrasive materials to enter the turbine, causing undue wear or damage. Flotsam will restrict flow through the intake screen, reducing power output.

Suitable designs can substantially lower maintenance requirements. Various types of diversion structures, stilling baffles, sluice gates, and trashracks can contribute to lower maintenance requirements. IRHE's experience with large projects apparently did little to prepare it for this situation. The availability of technical assistance would have had a positive impact throughout the design process, particularly at the intakes.

Powerhouses for four of the five projects were constructed before the drawings from the equipment manufacturer were received. Therefore, parts of all four powerhouses will need to be demolished and reconstructed. Early construction of the powerhouses was an error in management. The equipment manufacturer could have been required to provide powerhouse construction drawings within 30 days of the contract award. Equipment delivery usually takes at least 6 months, which would have allowed adequate time to construct the powerhouse to proper design.

The following observations are taken from a recent review of USAID-funded micro-hydropower projects in Panama (3):

> At most existing and planned schemes, the weir and intake structures are placed within a stream and the penstock is laid along the edge of the streambed. Some of the subsequent problems which have already been experienced in the brief history of the projects are the following:
>
> landslides and falling trees destroying supports and portions of the penstock;

erosion and undermining of penstock supports and weirs;

undermining of the streambanks supporting the penstock; and

weirs and intakes completely filled with stones and sediment

Any one of the problems mentioned above occurring after a plant has been put into operation could jeopardize that project. Potentially a large part of a year could pass before the streamflow has reduced sufficiently for repairs to be effected.

Turbines

The feasibility studies of all five sites recommend use of a crossflow turbine (although one recommends a Pelton or crossflow turbine). This recommendation was not included as part of the tender document. The advantages of a crossflow turbine in these installations include: higher efficiency because of the projects' low heads (especially La Pintada, 17 m); smaller size, which reduces powerhouse requirements and installation challenges; and relatively easy repair in the field. The evaluators could find no valid reason for not requiring, or at least stating a preference for, crossflow turbines in the tender documents.

The contract for the first two sets of turbo-generating equipment, awarded to Small Hydropower Systems and Equipment (SHSE), contained no provision for testing prior to delivery, expressed no preference regarding the type of turbine, and provided no clear guarantee of supplier liability for inadequate performance. Instead, USAID requested the assistance of NRECA's SDH Program in inspecting the equipment prior to shipment. The SDH Program's Principal Engineer certified that the equipment appeared well constructed, but pointed out that it had not been possible to perform any operational test and that equipment performance would only become apparent in the field. Inadequacies were immediately apparent after installation, and USAID made repeated efforts to have the supplier correct the equipment, but to no avail.

Preparation of tender documents for the lot purchase of four turbo-generating sets took 15 months. The equipment shared common specifications and standard procurement procedures. There is no apparent technical reason that would require 15 months of preparation time. Evidence suggests that USAID procedural requirements, particularly at USAID/Washington, were largely responsible for the delay.

The contract for the latest projects benefitted from prior experience by including a test requirement and penalty clause in the event of poor equipment performance. There was still no preference as to the type of turbine, however--and, once again, the less appropriate Pelton turbine was supplied.

IRHE evaluated equipment bids for the five projects in April 1984. The evaluation committee consisted of:

- Lic. Julio Cedeño, Controller General, Rep. of Panama;
- Sr. Manuel villalaz, labor union representative, IRHE; and
- Ing. Jorge Cedeño, Chief, Projects Section, IRHE.

The committee's evaluation of the efficiency for the equipment offered was affected by its use of a set of graphs published by the Latin American Energy Organization (Organización Latinoamericana de Energía, OLADE). The graphs show flow vs. efficiency for four turbine types. This graph should have been used in conjunction with a similar graph representing the effect of head on efficiency at various flows for various turbine types. An experienced turbine engineer, or technical assistance from outside IRHE, would have been an appropriate addition to the evaluation team.

Turbine efficiency is an area of ongoing concern. Comments on Buenos Aires and Chitra are included elsewhere. All other projects also use Pelton turbines. These turbines are, in fact, fully standardized; that is, any one turbine could be installed in any of the five sites with no mechanical alteration or difference in performance. Standardization offers the benefit of manufacturing economy and convenient replacement of parts. It also results in compromised efficiency. This effect is not important in some installations; however, the lower the capacity of the site, the greater the potential impact of this compromise. The efficiency which has been proven by the manufacturer's testing program does not ensure the same efficiency in the field. The tender document properly required a guarantee of turbine efficiency and provided for penalties. Axel-Johnson Engineering, the turbine manufacturer, paid a $45,000 penalty to USAID.

In conclusion, much was clearly learned about tender documents and contracting for micro-hydropower equipment during this process, but at great cost.

Costs

Table 8 shows the costs of the micro-hydropower demonstration projects as of June 31, 1985.

Table 8. Costs of Micro-Hydropower Demonstration Projects

Projects	USAID ($)	GOP (IRHE) ($)	Total ($)
Chitra/Buenos Aires	60,000	201,300	261,300
Five under construction	367,100	158,200	525,300
Total	427,100	359,500	786,600

The GOP expenditures are incomplete because counterpart costs for San Juanito are budgeted under the Sur de Veraguas Project and could not be obtained from IRHE and because the five latest projects are still under construction. It i not known how IRHE calculated its costs. USAID expenditures may also be incomplete because additional vouchers are expected to be submitted by IRHE.

Micro-hydropower projects in developing countries typically cost between $150 and $4500/kW installed. Comparison with these figures is difficult, however, because costs are largely determined by site-specific features and because th seven projects under consideration were considered demonstration projects.

On the basis of the planned installed capacity at Chitra and Buenos Aires (60 kW), they have cost $4350/kW installed. Since available effective capacity is approximately 15 kW, aggregate cost per kilowatt installed is really $17,400. Activities recommended in this report would cost around $10,000 and increase available capacity to approximately 35 kW, reducing the aggregate cost per kilowatt installed to $7750.

Similar calculations for the five remaining projects are not possible since neither the final cost nor the effective capacity are known.

<u>Alternative approaches to micro-hydropower</u>

This experience should not be considered necessarily representative of micro-hydropower in developing countries. The technology has had widespread success in countries such as China, Nepal, and Pakistan (2,1). Micro-hydropower plants are also found throughout the rural areas of Central America, and local capabilities, including turbine manufacture, are well established in Guatemala and Costa Rica.

A few characteristics of these success stories are worth noting since they shed light on the Panamanian experience. In all cases micro-hydropower is recognized as a well-established, even traditional technology; it is closely linked to productive uses; local communities are heavily involved at all stages; maximum use is made of local skills and materials; equipment is fabricated locally where possible; and outside development assistance takes the form of long-term efforts by highly committed organizations and individuals. As a result, costs are minimized and benefits are maximized.

IX. COMMUNITY MANAGEMENT OF MICRO-HYDROPOWER DEMONSTRATION PROJECTS

BACKGROUND

As noted above, the PP assumed that any micro-hydropower project that was implemented would be planned, constructed, and managed by IRHE's Isolated Systems Office. This assumption proved to be unfounded. IRHE management acknowledges that it cannot assume responsibility for small isolated systems. Its role throughout was to be limited to technical assistance for projects that would be the primary responsibility of others. In practice, the two completed projects, although built primarily for the benefit of vocational training schools, have been managed by local village committees.

The latest project, at San Juanito, is located within the Sur de Veraguas Integrated Rural Development Project. The possibility of forming a rural electric cooperative to manage this system was raised by USAID, IRHE, IPACOOP and the Ministry of Planning and Economic Policy (Ministerio de Planificación y Política Económica, MIPPE). In March 1984, a representative of NRECA, together with staff from these institutions, visited San Juanito to assess the potential for forming a rural electric cooperative. The issue was discussed with the villagers at a meeting, and a pre-cooperative group was formed. IPACOOP subsequently developed a work plan for the formation and support of a cooperative at San Juanito, and submitted a budget to MIPPE for funding under the Sur de Veraguas Project. No funds have been made available, however, and the issue has not been pursued.

OPTIONS

As of this evaluation, five micro-hydroelectric systems are nearing completion. There appear to be two alternative forms of decentralized community management of the systems. If no action is taken, the systems will become the responsibility of village committees, as at Chitra and Buenos Aires. Otherwise, rural electric cooperatives could be formed at each of the communities.

Village Committees

Juntas Comunales and Juntas Locales are a common form of decentralized community organization in Panama. They frequently administer isolated water systems and have been responsible for the hydroelectric systems at Chitra and Buenos Aires for 4 years. They are similar to cooperatives only insofar as they are nonprofit service entities elected by the community. They are political bodies, however, constituting an arm of the government. Their advantage is that they would be readily accepted; indeed, this administrative structure would require no effort on the part of USAID, IRHE, or any other organization.

The main disadvantage of village committees is that they cannot be relied upon to effectively operate and manage the systems. Internal accountability cannot be assured, bookkeeping systems are minimal or nonexistant, and external control and support structures are ineffective. Furthermore, the committees are active in a broad range of services, such as roads, health, water, and education, which may take priority over the electric system.

Cooperatives

Cooperatives contrast with village committees in that they are private enterprises that are operated as businesses to the benefit of all the members. They have constituted a successful institutional framework for rural electric services in the United States, the Philippines, Thailand, Chile, Brazil, Argentina, Bolivia, and Costa Rica. In Bolivia, the Santa Cruz Regional Development Corporation (Corporación Regional de Desarrollo de Santa Cruz, CORDECRUZ) provides technical and organizational assistance to 138 small public service cooperatives, most of which are in isolated villages. Some 60 of these cooperatives operate electricity services, and one is in the process of completing a small-hydroelectric project. Many of these electric cooperatives are in villages of less than 100 families with social and economic characteristics not unlike those of the communities benefitting from the USAID-funded micro-hydropower projects in Panama.

Although Panama has no rural electric cooperatives, it has a total of 298 cooperatives of various types, with a membership of over 79,000.[1] IPACOOP is charged with the formation, support, and regulation of all cooperatives in Panama. In 1985 an IDB-funded mission assessed the potential for micro-hydropower and rural electric cooperatives in Panama. It found that there is no legal obstacle to the formation of rural electric cooperatives and that, given some technical assistance, IPACOOP is fully capable of administering and carrying out such a program. In addition, IPACOOP is motivated and eager to do so (3). IPACOOP's institutional capacity is being further strengthened by an ongoing marketing project with USAID.

Ultimate authority in a cooperative is vested in a General Assembly of all the members, which meets at least once a year. In addition, rural electric cooperatives in Latin America are typically made up of the following committees, which meet monthly:

- Board of Directors (Consejo de Administración); 3-5 members;
- Oversight Committee (Consejo de Vigilancia); 2-3 members; and
- Education Committee (Consejo de Educación); 2-3 members

The staff of these cooperatives is expected to be limited to one part-time operator, and is paid by the cooperative. Two alternates should also be trained.

The constitution of cooperatives with close ties to IPACOOP ensures that there is a well-defined management hierarchy, with formal accountability both internally, to the members, and externally, to IPACOOP. Periodic audits will be carried out and contingency reserves established. IPACOOP will provide regulation and assistance over the long term to ensure efficient administration and to promote participation and a sense of responsibility on

[1]As of December 31, 1984. Source: IPACOOP.

the part of the members. Furthermore, IPACOOP provides a link through which to garner outside support in the form of funds and technical assistance, both for the hydroelectric system itself and for the development of activities that utilize the available energy to the benefit of the community. These advantages are illustrated by the case of the Renacer Chitrano cooperative (see Chapter VII).

The disadvantage of this option is that it requires inputs, in the form of funds and technical assistance, as detailed below.

PLAN OF ACTION

IPACOOP has a model plan for the formation of cooperatives. This involves a 7 1/2 month period of promotion and organization, followed by 17 months of intensive support. (See Annex D for IPACOOP's plan and budget.) The plan involves a total of 550 man-hours at a cost of $3160 (this covers per diem, transport, and materials). Beyond this 2-year period, IPACOOP will continue to support the cooperatives through its normal operations.

One of IPACOOP's primary functions will be to facilitate communication between the cooperatives and IRHE. IRHE should be prepared to commit itself to providing technical assistance to the cooperatives in a conscientious fashion. It should provide an intensive training program for three members of each community (an operator and two replacements) in all aspects of effective system operation and maintenance. IRHE should visit each system at least once every 6 months in order to provide IPACOOP with a written report on technical conditions. Finally, IRHE should be available to provide technical assistance on an as-needed basis, when requested by IPACOOP.

NRECA will be available to provide guidance to IPACOOP and IRHE as requested, and will establish contacts between IPACOOP and CORDECRUZ to prepare for the work-study period. NRECA has provided IPACOOP with a brief guide to the formation of rural electric cooperatives in developing countries, together with model electric cooperative statutes.

TECHNICAL ASSISTANCE

On the basis of consultation with IPACOOP, the following technical assistance will be required:

- Selected IPACOOP staff should undertake a short-term period of work and study with CORDECRUZ in Bolivia. The president of CORDECRUZ welcomed the suggestion when it was discussed with him in March 1985.

  IPACOOP staff would work with the departments of cooperatives and engineering to observe and participate in such functions as: tariff setting, billing and collection, accounting, record keeping, audits, and basic system maintenance. At the end of the period, they will have a thorough understanding of the functioning of a small rural electric cooperative in a developing country and be in a position to adapt the policies and procedures of CORDECRUZ for use in Panama.

It is suggested that three IPACOOP staff members participate in the program: one from the Directorate of Cooperative Promotion, and one each from the regional offices in Santiago and Las Tablas. The estimated cost per participant (including air fare, per diem, and miscellaneous expenses) is $2500. CORDECRUZ should be provided with $1000 to compensate for its increased operational costs.

- Working with USAID, IPACOOP should request the assistance of the organization Volunteers in Overseas Cooperative Assistance (VOCA) to obtain the services of a Spanish-speaking rural electrification specialist, preferably with appropriate cooperative experience in developing countries. VOCA has demonstrated its interest in providing this assistance in the past.

  The volunteer would work with IPACOOP for a period of at least 3 months immediately before and after system startup, in order to help IPACOOP staff provide assistance to the cooperative, establish a work plan, and lay the basis for IPACOOP's support over the long term. The cost to IPACOOP would be $1000.

BUDGET

The estimated cost for carrying out this plan is $30,110, as detailed in Table 9.

JUSTIFICATION

The cancellation of the technical assistance services originally programmed was partly responsible for subsequent problems throughout the micro-hydropower program (see Chapter VI). As of the PACD, up to $72,000 had not been spent (see Chapter IV). Coincidentally, this is equal to the unspent portion of the original budget for technical assistance in micro-hydropower.

These projects must be considered incomplete without an effective local management structure. The program outlined here is a cost-effective means of providing such a structure, especially since USAID has contributed at least $430,000 to the micro-hydropower program to date[1]. In addition, it would lead to the establishment of a base of experience in rural electric cooperatives for further isolated energy projects in Panama (such as those under consideration for IDB funding), which is particularly important at a time when attention is being given to the question of decentralized utility management in the country.

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[1]Including $35,000 allocated to the Chitra and Buenos Aires projects from an education project, but not including disbursements still to come (see Table 1).

Table 9. Budget for Cooperative Formation[a]

Item	Cost ($)
Increased IPACOOP operational costs over 2 years	
6 x 3160	18,960
10% contingencies	1,900
IPACOOP staff work/study in Bolivia	
3 x 2500	7,500
10% contingencies	750
CORDECRUZ costs	1,000
VOCA volunteer	
Cost to IPACOOP	1,000
Total	30,110

[a]IPACOOP's staff and administrative costs are not included, and would represent its counterpart contribution.

RECOMMENDATION

Since the five new hydroelectric systems are expected to be energized within the next few months, the above activities, to form rural electric cooperatives at the communities benefitting from micro-hydropower projects, should be initiated as soon as possible.

X. SUMMARY OF RECOMMENDATIONS

TECHNICAL ASPECTS

Chitra

1. The electronic load controller should be replaced as soon as possible.
2. Corrective actions should be taken to improve turbine efficiency.
3. The headpond elevation should be restored.

Buenos Aires

1. The present turbine should be replaced by a crossflow turbine, adapting the existing generator and electronic load controller accordingly.
2. The intake box and weir should be modified to facilitate maintenance.

COMMUNITY MANAGEMENT

1. Electric cooperatives should be formed to operate and manage the systems under construction at San Juanito, El Cedro, La Tronosa, Entradero de Tijera, and La Pintada.
2. At Buenos Aires, community management should be strengthened by working with the existing Junta Local, rather than attempting to create a cooperative.
3. At Chitra, operations and management responsibilities should pass to the Renacer Chitrano multiservice cooperative, which should be assisted to that effect.
4. IPACOOP should take part in training activities and receive technical assistance, as detailed in the action plan, in order to form and support the six cooperatives. The total cost of this activity will be approximately $30,100.
5. IRHE should remain available to provide technical assistance for the micro-hydroelectric systems.

PRODUCTIVE USES

1. The new coffee beneficio at Chitra should operate electric motors, powered by the village hydroelectric system.
2. The new potable water system at Buenos Aires should operate electric motors, powered by the village hydroelectric system, for any pumping requirements.

3. At the remaining communities, IPACOOP should investigate, in conjunction with the cooperatives, the potential for productive activities that benefit from the hydroelectric systems. IPACOOP should develop feasibility studies for these activities and seek funding for them.

PROJECTS UNDER CONSTRUCTION

1. In completing the five remaining projects, IRHE should pay particular attention to civil works designs and construction standards, in order to minimize maintenance problems and ensure a long project life.

2. Operating performance of the turbo-generating equipment should be closely observed after installation. If insufficient power availability prevents the realization of full benefits to the community, corrective actions should be taken (such as replacing the Pelton turbine by a crossflow turbine).

3. IRHE should provide a full training program in system operations and maintenance for at least three members of each community.

FUTURE PROJECTS

1. If IRHE is called upon to study or implement further micro-hydropower projects, it should draw upon the experience gained in this program and seek qualified technical assistance as necessary. Particular attention should be paid to hydrologic analysis, economic evaluation, civil works design and construction standards, and equipment procurement.

2. Funding organizations should consider the capabilities of other groups and organizations in the area, such as universities and agricultural-engineering firms, for micro-hydropower development.

3. Future micro-hydropower project designs should identify the most appropriate type of turbine for the site and consider local fabrication, particularly of crossflow turbines.

4. Special attention should be paid to establishing adequate, community-based management structures and to integrating projects with productive end uses.

IRHE'S INSTITUTIONAL DEVELOPMENT

1. IRHE should obtain methodologies for small-hydropower feasibility analysis and design, adapting them for its own use.

2. IRHE should plan a training seminar in all aspects of small-hydropower analysis and development, seeking qualified technical assistance to conduct the seminar and develop training materials. The seven demonstration projects should serve as case examples.

ANNEX A. CONTACTS

USAID/PANAMA

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Jose Sanchez	Office of Engineering
Guillermo Riley	Office of Engineering
Michael Hacker	Chief, Office of Development Resources, ODR
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Paul Tuebner	ODR
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Kermit Moh	Private enterprise
Aurita Othón	Training
Stella de Patiño	Finance

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Sra. Aixa de Hime.	Asistencia Técnica, Region Central

OTHER

Glenn Dewey	Faculty of Mechanical Engineering, University of San Jose, Costa Rica

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ANNEX C. ALTERNATIVE ENERGY SOURCES PROJECT PAPER SUMMARY

Panama depends on imported oil for approximately 71% of its energy needs. Barring unforseen developments, the amount of oil needed to fuel Panama's economic growth and development is expected to increase over the remainder of this century. Given the rapidly increasing price of oil and the high cost, technological difficulties, and negative environmental consequences of switching to other non-renewable fuels, the development of renewable energy sources will be increasingly vital to Panama's orderly growth and development.

Concern for developing alternative energy sources is evident in all sectors of Panamanian society, and the Government of Panama (GOP) is especially interested in their development. One GOP institution--the Water Resources and Electrification Institute (IRHE)--has recently created an office whose major purpose is to develop alternative energy sources. While this action represents a very modest beginning in the face of an enormous development problem, it is a start.

The purpose of this project is to improve IRHE's capability to identify, analyze, and develop renewable energy sources and applications. Through the project, IRHE's institutional capability will be strengthened by staff development, generation and dissemination of information on alternative energy sources and applications, feasibility studies for promising applications, demonstration of available energy conversion technologies, and development of an alternative energy master plan. Six demonstration projects which utilize biomass, solar, and biogas resources in practical applications will be carried out. These applications include electric energy production for rural communities, water heating, air conditioning, and water pumping. The institutional capability developed and the experience gained with alternative energy conversion technologies will facilitate production of additional energy in rural areas through IRHE investments and technical advice to the private sector.

The basis for replication of the project will be further developed through preparation of a master plan for alternative energy sources. This plan will utilize the results of an energy assessment, feasibility studies, evaluations of the demonstration projects, and the data generated through other project activities to identify sites for additional applications of renewable energy sources, develop institutional mechanisms which will facilitate their replication, and recommend policies to encourage their development.

The demonstration projects illustrate a small number of specific applications of biomass-, solar-, and biogas-fueled energy technologies in rural settings. These technologies have been matched with a specific (and therefore, limiting) set of engineering, economic, social, and environmental performance requirements. Once technological feasibility is demonstrated, they can be adapted for additional uses as these requirements become less limiting due to technological advances, broader utilization of the technology, and greater experience on the part of IRHE and potential users.

The purpose of the demonstrations is to:

- collect and disseminate data on the engineering, economic, social, and environmental aspects of the use of alternative energy technologies;
- introduce alternative energy technologies to Panama in a series of appropriate uses which provide direct or indirect benefits to poor people and others in Panama; and
- prepare Panamanian energy planners and engineers for the time when new alternative energy technologies will be economically competitive with other energy sources and technologies.

The demonstration projects include appropriate applications of the following technologies:

- conversion of wood wastes to produce electric energy in rural villages;
- solar hot-water heating in rural and urban health centers;
- solar air-conditioning in a hospital and a fish culture laboratory; and
- the use of methane from animal waste digestion to pump water and supply cooking fuel on rural farms.

Each of these technologies can be replicated a large number of times in Panama. Each of them will be new to Panama although the particular technology-use matches can be found in other parts of the world.

The energy conversion processes demonstrated through the project will utilize already available and, in most cases, simple technology. Most of them are economically feasible right now, and others are expected to be feasible in the near future, given expected advances in technological development and the probability of continued rapid increase in oil prices. The sites that have been selected offer good prospects for successful demonstration of the technology. The community groups and organizations who will be involved in developing them and who will be responsible for their operation and maintenance are known to IRHE and the Mission as responsible, hard working people who are desirous of both improving their living conditions and learning new skills.

Ultimately, the benefits of the project will accrue to all sectors of Panama's population, including the poor. Most of the energy conversion technologies that will be demonstated hold potential direct or indirect benefits for AID's major target group in Panama--low-income rural families. However, due to the very limited scope of this largely experimental technology-transfer project, actual benefits for this group will be somewhat limited during the life of the project. The project is expected to create the basis for diffusion of appropriate low-capital technology under a subsequent project (planned FY81 Alterntive Energy Sources II Loan). It is expected that significant target group benefits will result from that project.

The cost of the present project is estimated at $1,375,000. This will be financed by an AID Grant of $825,000, and a GOP counterpart contribution of $550,000.

Summary Financial Plan ($000)

	AID	GOP	Total
Institutional development activities	95	230	325
Feasibility studies	175	50	225
Demonstration projects	355	270	625
Master plan	150	0	150
Evaluation	50	0	50
Total	825	550	1375

ANNEX D. IPACOOP'S PLAN AND BUDGET FOR COOPERATIVE FORMATION AND SUPPORT[a]

Preliminary stage (2 months)	9	136	720.00	373.00	190.00	1,283.00
Visit and community acquaintance	3	48	210.00	292.00	40.00	542.00
Meeting with community	(1)	(8)	(10.00)	27.00	-	(37.00)
Coordination for the preparation and carrying out of the socio-economic survey	(2)	(40)	(200.00)	265.00	40.00	(505.00)
Basic cooperative orientation	6	88	510.00	81.00	150.00	741.00
Promotion	(2)	(24)	(150.00)	(27.00)	(50.00)	(227.00)
Orientation and motivation presentation	(2)	(24)	(150.00)	(27.00)	(50.00)	(227.00)
Basic cooperative seminar	(2)	(40)	(210.00)	(27.00)	(50.00)	(287.00)
Organizational phase (3 1/2 months)	9	272	665.00	379.00	30.00	1,074.00
Preliminary meeting	2	24	150.00	27.00		177.00
Pre-cooperative committee tasks	4	240	500.00	325.00	30.00	855.00
Constitutional meeting (assembly)	3	8	15.00	27.00		42.00
Legal processing (2 months)						4.00
Follow-up stage (17 months)	1	136	470.00	459.00	170.00	799.00
Total	9	544	1,555.00	1,211.00	390.00	3156.00

[a]Costs are given in U.S. dollars.

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SUPPLEMENT 1

PROJECT DESIGN SUMMARY
LOGICAL FRAMEWORK

(INSTRUCTION: THIS IS AN OPTIONAL FORM WHICH CAN BE USED AS AN AID TO ORGANIZING DATA FOR THE PAR REPORT. IT NEED NOT BE RETAINED OR SUBMITTED.)

Life of Project:
From FY ________ to FY ________
Total U.S. Funding ________
Date Prepared: ________

Project Title & Number: ALTERNATIVE RENEWABLE ENERGY SOURCES (525-0207)

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Program or Sector Goal: The broader objective to which this project contributes:	Measures of Goal Achievement:		Assumptions for achieving goal targets:
To improve the standard of living for low-income families and support Panama's economic development.	Reduction in oil purchases resulting in increased private sector profits and GOP revenues available for economic and social development programs. Decreased energy costs and/or higher disposable incomes for rural poor. Increased profits for asentamientos and cooperatives; initiation of new productive activities which use alternative energy technologies.	IRHE calculations Project evaluation Data from Dept. of Census & Statistics.	Price of oil continues rise. Efficiency of alternative energy capture and transmission mechanisms continues to increase. Energy produces from renewable sources has important non-quantifiable social and economic benefits. Panama is not hit by another economic recession.
PURPOSE: Improve IRHE capability to identify, analyze, develop, and disseminate information on renewable energy sources and their applications, with emphasis on rural areas.	Operating budget of Renewable Energy Office (RESCU) increased to $200,000/year. RESCU staffed with 12 professionals skilled in alternative energy applications. Collaborative relationships with public and private sector agencies developed. 50 additional applications identified and resources mobilized.	IRHE data. Project Evaluation	Continued high level support from IRHE management. Support from newly formed Energy Commission

AID 1020-28 (7-71)
SUPPLEMENT 1

PROJECT DESIGN SUMMARY
LOGICAL FRAMEWORK

Life of Project:
From FY ________ to FY ________
Total U.S. Funding ________
Date Prepared: ________

Project Title & Number: ALTERNATIVE ENERGY SOURCES (525-0207)

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Outputs:	Magnitude of Outputs:		Assumptions for achieving outputs:
RESCU staff trained in alternative energy sources development.	4 internships for project managers	Project records	Timely inputs
	15 training courses attended.		
Alternative Energy Sources information and dissemination capability operational.	Alternative Energy Documentation Center equipped with up-to-date reference file, periodicals, and books on alternative energy sources.	Project records	
	Newsletter on Alternative Energy Sources being distributed on a quarterly basis to a minimum of 500 individuals and organizations.		
	Minimum of 3 courses and seminars completed on alternative energy for interested private and public sector employees sponsored by IRHE.		
	Complete set of updated information on solar radiation and wind direction and velocity available through IRHE. Data being published yearly.		
6 demonstration projects and 2 feasibility studies of alternative energy applications successfully carried out.	Biomass, direct solar conversion and biogas applications completed and functioning effectively.	Project evaluation	
	Data available on technical, economic, and social feasibility of micro-hydro and agricultural waste applications.		

AID 1020-28 (7-71)
SUPPLEMENT I

PROJECT DESIGN SUMMARY
LOGICAL FRAMEWORK

Life of Project:
From FY ________ to FY ________
Total U.S. Funding ________
Date Prepared: ________

Project Title & Number: ALTERNATIVE ENERGY SOURCES (525-0207)

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Master plan for alternative energy sources completed.	Plan (a) identifies projects to be carried out between 1982 and 1986 including needed technical and financial assistance; (b) analyses institutional mechanisms for developing alternative energy applications; (c) proposes additional demonstration projects; and (d) recomends GOP policies and incentives to promote adoption of alternative energy sources.	Project evaluation.	
INPUTS	($000)		DS/EY Energy Evaluation Specialist when needed.

INPUTS	AID	GOP	TOTAL
Institutional Development	95	230	325
Feasibility Studies	175	50	225
Demonstration Projects	355	270	625
Master Plan/Evaluation	200	0	200
TOTAL	825	550	1,375

6C

Alternative Energy Sources

Project Evaluation Review Committee

USAID/Panama

José Sánchez	Project Manager	Chief, Engineering Division
Paul Tuebner	Loan Officer	Office of Development Resources
Stella de Patiño	Finance Officer	Controllers Office
Kermit Moh	IDI	Office of Development Resources
Frank Pope	Evaluation Coordinator	Office of Development Resources

IRHE

Vicente Rios	Project Manager	Chief Projects Division
Fernando Vargas	Project Staff	Microhydro Development
Domingo Wong	Project Staff	Microhydro Development