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Agenda

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AID Evaluation of the Small Decentralized Hydropower (SDH) Program
April 6, 1982

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The Cooperative Agreement

The following is a brief summary of Cooperative Agreement No. AID/DSAN-CA-0226--Small Decentralized Hydropower Program (see Appendix A--Tab B). A copy of the Program Description from the Cooperative Agreement is attached to this briefing book.

The Agreement was signed May 1, 1980, for an initial amount of $1,223,590. FY81 funds added an additional $1,000,000 in November 1981.

The purpose of the Cooperative Agreement is to provide technical assistance to developing countries in the development of small-scale decentralized hydropower projects, generally of 1 MW capacity or less. This assistance covers a broad range of services and involves experts and specialists in many fields. Funding for capital costs are not authorized by USAID under this agreement.

There are 5 major agreement activities:

Administration. Manage all contractual and travel arrangements; carry out program planning and support; plan and manage workshops; work with individual consultants and specialists from NRECA member institutions and carry out field support activities.

Project identification. Through collaboration with USAID, identify potential sites for development; carry out prefeasibility studies; provide recommendations for each site to include alternatives--

Hydro generation as sole source

Hydro generation as supplement to planned or existing remote diesel generation

No construction (wait for grid extension)

Site selection. Conduct final site selection in collaboration with USAID and host government; where necessary carry out feasibility studies and, where required, conduct planning and institutional assessments for system integration into the country's development plans.

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Development of SDH data base. Survey existing small decentralized hydro facilities and develop a state-of-the-art report; evaluate equipment manufacturers; assemble an inventory of skills; assemble manuals, resource directories describing small decentralized hydro technology, application, economics and implementation methodologies.

Training. Develop a training program in small decentralized hydro for engineers at university centers and government institutions that will provide both academic and hands-on training.

Cooperative agreement goals

In the first 22 months of the Cooperative Agreement we have carried out a number of activities. These activities have included and even exceeded the first year goals stated in the Cooperative Agreement.

1. "Identification of individuals or organizations able to provide SDH support services to the mission/bureaus"--NRECA has developed a talent bank of over 100 people with expertise in some aspect of SDH development--engineering, economics, management, etc. This talent bank continues to grow and also includes many people from our Member Systems with specialties in engineering, power system planning, productive use and management.

2. "Identified projects in LDCs with attendant prefeasibility studies underway"--NRECA has conducted resource surveys in 13 countries in Latin America and the Caribbean, Africa and Asia. Based on the NRECA survey report at least half of these countries are planning to go ahead with one or more projects in SDH.

3. "Workshop conducted in Andean countries and distribution of proceedings"--NRECA held a workshop in Quito, Ecuador for roughly 100 attendees from AID host countries in Latin America and the Caribbean. Fifteen hundred copies of the proceedings were printed and distributed. Twelve hundred of these have been to national agencies, information centers, AID missions, universities, and technical and financial institutions in almost 90 countries. Because of the success of the Quito workshop and because of the strong interest in both the Asia and Africa Bureaus as well as in many missions, other workshops were developed.

A workshop was held in Bangkok, Thailand for 106 attendees from Asian countries.

A third workshop was held in March, 1982 in Abidjan, Ivory Coast for 93 attendees from West and Central African nations.

It is anticipated that proceedings from these last two workshops will also receive wide distribution.

4. "Completion of a proposal for a training program in SDH"--

NRECA has developed and submitted to ST/EY a proposal for a comprehensive, and therefore unique, SDH training program using SDH staff, NRECA Member System personnel, university faculties and other specialists as needed to train developing country planners and engineers at locations in the U.S. and in-country.

5. "To strengthen, refine and broaden the expertise and capabilities of the recipient to participate in and contribute toward the resolution of energy problems in developing countries"--from NRECA's perspective, this is one of the most important objectives of the Cooperative Agreement--one measure of the success of NRECA in achieving this last goal is the success of the program activities to date. Another measure that both reflects an outside recognition of expertise at NRECA as well as creates the dissemination of acquired knowledge are the following activities--

Participation of SDH staff in planning or actually carrying out many of the country surveys and other required field work--Zoellner to Tunisia; Jackson to Rwanda, Togo, Panama, Dominica, Zaire; Inversin to Morocco, Pakistan, Nepal; Boyle to Ghana, Panama.

Provision of services (at mission request) in miscellaneous technical assistance--review of electrical design for two sites in Panama by Jackson; critique of electrical design and bid specifications for site in Liberia by Jackson; development of itinerary for Panamanian engineers to tour U.S. manufacturers by Boyle.

Provision of planning assistance--Ecuador for workshop plans by Zoellner; Thailand and five other Asian countries for workshop plans by Zoellner and Clark; Bangladesh and Indonesia to develop scopes of work for country surveys by Zoellner; Ivory Coast for workshop plans by Clark, Jackson, and Graham.

Participation (paper delivery and panel discussions), by sponsor invitation, in workshops and conferences--OAS Conference in Brazil on Energy in Latin America, Panel on Agricultural Use of Renewable Energy, Zoellner; UNITAR Conference (in Los Angeles) on Small Energy Resources, Jackson and Zoellner; USAID/Caribbean Development Bank Conference (in Dominica) on Mini-Hydropower, Boyle; USAID Conference (in Nairobi) on Energy Resources and Technology, Inversin; National Academy of Sciences (BOSTID) Panel (in Washington, D.C.) on Mini-Hydro Development--Issues and S-O-A, Boyle.

Submittal, by editor invitation, of articles to magazines (see Appendix B--Tab C), journals and newsletters--SDH article to Agenda, Graham; description of small hydro development in Pakistan to Water Power, Inversin; S-O-A in electrical equipment to RERIC (Asian Inst. of Tech.) Journal, Jackson.

Development of original documents designed for both field use as well as program implementation--methodologies for countrywide survey, for prefeasibility assessment, for hydrologic analysis and for environmental assessment; inventory of U.S. and developing country turbine mfrs.--equipment performance and cost; special study reports on topics of finance, evaluation criteria and management approaches; development of state-of-the-art micro-hydropower sourcebook to be used for facilities design and operation of civil works, equipment, site layout, resource assessment, system management and finance.

Summary

The cooperative agreement calls for NRECA to develop its capabilities in Small Decentralized Hydropower and to make that expertise available to Lesser Developed Countries. The agreement also calls for NRECA to compile a talent bank of resource people and firms with SDH expertise that can be called upon to assist LDCs.

NRECA has come along way in Small Decentralized Hydropower. We have compiled a talent bank of individuals from our member system and other source to meet most of the request from AID missions. We have some 100 individuals in our resource file, and approximately 60 firms. We have conducted resource assessment work in over 12 countries, using 22 individuals in additional to our own staff members. In most of the resource assessments, a report was produced with specific recommendation. About 90% of the recommendations have been accepted and carried out, or plans are evolving to carry them out.

Services Offered

Our technical assistance has primarily focused on performing the front-end work of a small hydro project; that is, conducting the necessary studies for the host country to attract project funding. Once the project is financed, then the AID Mission, or other institutions, can make funding arrangements for project management and implementation. We have categorized the front-end assistance we provide into four general types; country assessments, prefeasibility study, feasibility, studies, and project paper assistance.

Many countries where we have worked have not carried out overall energy planning - assessing their needs against resources, and planning a supply for the difference. As part of overall energy planning, a country may want to know their potential for small hydropower. The purpose of the Country Assessment is to answer this question. By assessing the hydrology and topography of a country, we can make some estimates of the number of small hydro sites their typical characteristics, approximate cost, and make recommendations for a national program in small hydro development. The Country Assessment can also identify a number of candidate sites.

If the results of the Country Assessment is positive, then the host country should consider which of the candidates sites are best for development. The prefeasibility study ranks sites using a common set of assumptions and criteria based upon the needs of the country. The result of the prefeasibility study is ranking of

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the sites with a recommendation of sites suitable for detailed feasibility study.

The feasibility study is a document that can be used to attract capital financing. It essentially answers all the technical, economic, financial, environmental, social and institutional questions that impact the viability of the project.

The level of effort in all of these studies is scaled to potential output. One would not for example, expend the effort for a 100kW installation that would be necessary for a 1MW installation. Many, if not most, engineering firms are familiar with the needs of a 1MW installation, but generally have difficulty in making recommendations for smaller units without the supporting studies normally done for installations 1 MW or larger.

Conducting these studies requires a general knowledge of numerous subjects ranging for the hydrology of the drainage basin, to the social structure of the target communities. Since it is impractical to send experts in each of these fields, we have developed methodologies, written by experts, to assist the team in carring out their assignments. Four of these methodologies, Hydrologic, Country Assessment, Environmental and Prefeasibility are available for general distribution.

In addition to the above Small Hydro Assessment assistance, we have provided assistance to AID missions for writing project papers, developing scopes of work and carrying out fact-finding studies.

Talent Bank

NRECA has compiled a file of experts in fields related to Small Hydro power who are available for short, or long term assignments through the cooperative agreement.

An important source of individuals in our talent bank comes from our U.S. member cooperative systems. These include system managers, engineers, and operators.

Through our member systems, and the IPD Division, we have several other sources of talent. NRECA has a long and close working relationship with the Rural Electrification Administration, the Cooperative Financing Corporation, the Electric Power Research Institute, and the Cooperative League of the USA. Member systems have used most of the major engineering firms in the country providing us with a source of recommendations for small hydro assistance. The experience of the IPD has given us access to numerous private consultants. Through professional and other contacts, hydropower specialist with developing country experience are placed in the talent bank.

The content of the talent bank is approximately made up as follows:

Association	Number
NRECA System Members	35
Individual Consultants	32
Individuals with Firms	27
Firms involved with SDH	60

Discipline of Individuals in the talent Bank

Civil Engineers	10%
Electrical Engineers	30%
Other Technical	10%
Economist/Accounting	20%
Management/Institutional	20%
Other	10%

Example resumes of the types of individuals we have used are included in Appendix C--Tab D.

We are in the process of putting all the resumes on a word processor for quick reference. We can then automatically list candidates according to position requirements such as discipline, language ability, LDC expertise, or educational level.

Services Completed

The NRECA Small Decentralized Hydropower Program has provided technical assistance to over 12 AID missions. Summary sheets of the work and present status of those projects follow on a country-by-country basis. A summary of the activities is given on the following table. Also indicated on this table are the AID missions that have expressed an interest in future SDH assistance.

Small decentralized hydropower

Technical assistance activities

REGION COUNTRY	COMPLETED	PLANNED OR EXPRESSION OF INTEREST
Latin American		
Peru	Assistance with PP	
Panama	Technical Assistance	Tour of U.S. Manufacturers
Dominican Republic	Assistance with PP	Site Development
Dominica	Prefeasibility	
Ecuador		Prefeasibility
Honduras		Country Assessment
Africa (Sub-Sahara)		
Togo	Country Survey	
Zaire	Program Assessment	Project Paper
Liberia	Recommendations on Peace Corps project	Training
Ghana	Regional Assessment	
Cape Verde	Country Assessment	
Rwanda	Preliminary Design	Construction Management
Burundi		Program Recommendations
Lesotho		Country Assessment
Sudan		Country Assessment
Asia		
Thailand	Prefeasibility	Project Paper
Bangladesh	Country Assessment	Prefeasibility/Feasibility
Indonesia		Country Assessment
Pakistan		Country Assessment
Near East		
Morocco	Preliminary Engineer	Detail Design Engineering
Egypt		Prefeasibilty
Tunisia		Country Assessment
Portugal		Country Assessment

Cape Verde

NRECA was requested to conduct a country survey of SDH potential in Cape Verde. Since the potential was so doubtful, this study was conducted in Washington and forwarded to the AID mission.

The study concludes that there is insufficient surface water in Cape Verde to economically develop small scale hydropower as part of Cape Verde's overall energy development program. This conclusion is based on the economic analysis of a hypothetical site in Sao Tiago Island, Cape Verde.

After the Mission has completed the wind energy portion of their renewable energy project, it may be worthwhile investigating a wind-hydro hybrid system.

Requesting cable	-	Letter 6/18/81
Response cable	-	Letter 7/28/81
Team member	-	David Rubin
Duration in country	-	0
Mission contact	-	Hugh Smith
Product	-	Country survey report
Future needs	-	None

Dominica

In September, 1981, at the request of the AID Mission in Barbados, the SDH Program's Principal Engineer travelled to Dominica to develop a scope of work for a small hydro team. The three-man team, including a small hydro engineer, a civil engineer, and an economist, evaluated the potential for small hydro development in Dominica during their three-week stay in November. The team identified several possible sites and conducted on-site prefeasibility studies to assess potential for providing decentralized rural electrification.

Requesting cable	- Bridgetown 5357
Response cable	- State 276619
Team members	- Walter Lawrence - Keith Oberg - Jeff Folts
Duration in country	- 3 weeks
Mission contact	- Alex Sundermann
Product	- Prefeasibility analysis
Present status	- Caribbean Development Bank is funding the installation of six stream-gauging instruments in accordance with our recommendations.
Future needs	- Possible technical assistance with site development

Dominican Republic

NRECA/SDH sent a team to the Dominican Republic for five weeks during June and July, 1981 to assist the USAID Mission in preparing the small hydro component of its Energy Conservation and Resources Development Project. The team consisted of a small hydro engineer, an institutional advisor, and a socio-economic analyst.

The small hydro component focused on consolidating and building existing institutional capabilities in designing, constructing, and operating small hydroelectric plants in the Dominican Republic. The team developed a country-specific methodology to set priorities and select suitable candidate sites for AID funding as demonstration projects.

The team wrote a report providing the information necessary for AID funding for a project. The report included technical, economic, financial, social, environmental, and institutional analyses of the sub-project. In addition, it contained two site-selection studies conducted by professionals from the Dominican Republic using the methodology developed by the team.

The team found that small hydro is an extremely attractive option for the Dominican Republic now for both oil displacement and new capacity additions. There are approximately 40 potential sites identified in the Dominican Republic with the possibility of many more as the Government begins to seriously consider the future role of small hydro in its overall energy picture.

Requesting cable	-	Santo Domingo 2651
Response cable	-	State 132303
Team members	-	Donal O'Leary
	-	Cora Shaw
	-	John Bogart
Duration in country	-	5 weeks
Mission contact	-	Allen Merrill
Product	-	Project Paper--Feasibility Methodology
Present status	-	Energy project approved to include the construction of three or four SDH installations.
Future needs	-	Possible assistance with site development, both long-term and short-term.

Liberia

NRECA was requested to evaluate progress to date on a Peace Corps micro-hydro project in Liberia, to estimate additional costs which would be incurred, and recommend a course of action. Two engineers from NRECA visited the Yandohun site on their way to the Abidjan Small Hydropower Workshop. The engineers found that since commitments had been made, work should continue, but that additional technical assistance was essential.

Requesting cable	- Letter from Eilers 1/20/82
Response cable	- State 310670
Team members	- Allen Inversin - Walter Lawrence
Duration in country	- 1 week
Mission contact	- Fred Hagel
Product	- Site evaluation (draft complete 3/30)
Future needs	- Provide the project with continued technical assistance through correspondence, literature, and contacts with the equipment manufacturers. - Operator training.

Morocco

In August, 1980, AID/RABAT requested the immediate services of a small-scale hydro specialist to assist the Mission in reviewing the Moroccan country assessment performed by a large engineering firm. The Mission felt that the firm was oriented toward large-scale civil works and needed to be guided toward smaller-scale projects. Within a week, NRECA/SDH provided the services of a mini-hydro specialist in Morocco.

The large, "Grand Coulee" types of civil works were deleted from the project which improved the economic feasibility of the hydroelectric program. Three potential sites were identified for development and site data was collected. In November, 1980, NRECA sent an engineer to Morocco to supervise a survey team which developed the site profiles and preliminary layouts.

In October, 1981, NRECA sent two small hydro engineers to work with Moroccan representatives in prospecting for additional sites in Ouarzazath Province and to review any potential interference of a proposed small hydro scheme at Argbalou-N-Kerdous with the existing irrigation system.

Requesting cable	- Rabat 7318
Response cable	- Telcon A. Jacobs--G. Bricker
Team members	- Allen Inversin - Ken Grover
Duration in country	- 2 weeks
Mission contact	- Mark Ward-Gary Bricker
Product	- Site assessments/trip report
Present status	- Three sites are funded. ONE is doing the preliminary engineering.
Future needs	- The Mission is funding three installations and wants to provide ONE with assistance in preparing the machinery specifications, and reviewing the civil engineering drawings. Hopefully, ONE will continue developing small hydro sites. - The Mission is also interested in sending one or more ONE engineers on a tour of U.S. equipment manufacturers.

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Panama

In November, 1980, the SDH Program's Principal Engineer travelled to Panama to review the status of two micro-hydro demonstration sites. He provided technical advice on the electrical distribution design, project schedule, and program management.

Requesting cable	-	N/A--request from Lynn Sheldon to Jack Fritz
Response cable	-	
Team members	-	Bard Jackson George Erskine
Duration in country	-	1 week
Product	-	Trip report; two micro-hydro installations
Follow-up	-	U.S. tour

Rwanda

In November, 1981, a two-man team, including the SDH Program's Principal Engineer, travelled to Rwanda to conduct a detailed study on one micro-hydro site at Kaviri Falls and initial assessment of nine undeveloped sites. This work was performed through the AID Mission for Rwanda's Center for Energy Research.

Requesting cable	- Kigali 02927
Response cable	- State 298664
Team members	- Bard Jackson - John Topik
Duration in country	- 3 weeks
Mission contact	- Gene Chiavaroli
Product	- Preliminary engineering
Follow-up	- Conduct site rehabilitation
Future needs	- Technical assistance with plant start-up, if the Nkora site is rehabilitated. - Operator training.

Thailand

The AID Mission in Bangkok requested NRECA/SDH technical assistance for prefeasibility investigations of potential small hydro sites throughout Thailand. There were 25 sites identified for consideration.

The 25 sites were characterized according to physical characteristics and potential demand structure. From this ranking, six sites were chosen for prefeasibility studies according to the following criteria: a. priority of area development; b. potential for productive uses; c. replacement of existing diesel-generating sets; d. lack of potential for grid connection; e. favorable benefit to cost ratios; and, f. potential for co-financing.

The NRECA/SDH members of the team included a small hydro engineer and an institutional advisor who manages one of NRECA's member rural electric systems. The team conducted prefeasibility studies on six selected sites. The studies were conducted in such a manner that they could be incorporated in the Mission's project paper and be proposed for financing through AID.

NRECA/SDH also provided the services of an electro-mechanical engineer whose duties included working with engineers from the National Energy Administration and helping them select appropriate equipment. Of particular concern was the selection of appropriate governors (mechanical or electronic) and determining the potential for their manufacture in Thailand.

Team members	- Jack Hicks - Charles Lusk - Everett Hoskings
Duration in country	- 3 weeks
Mission contact	- Rod McDonald
Product	- Governor selection report
Present status	- PID done and Project Paper in preparation.
Future needs	- Possible assistance with the Project Paper.

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Togo

In April, 1981, NRECA/SDH sent a three-man team to conduct a major, country-wide feasibility survey of small hydropower potential of Togo. The team, including a hydrologist, a small-hydro electrical engineer, and a socio-economist, selected a number of potential sites and evaluated them based on technical and economic criteria. The NRECA/SDH principal engineer assisted in on-site team coordination and field evaluation.

Tasks accomplished by the team during the survey included: a. hydrological study of drainage basins; b. identification of sites with appropriate hydrological and topographical features; and, c. comparison of sites based on potential capacity, annual energy production, proximity to grid and/or advantageous loads, social considerations, and problems in site development.

Based on the above activities, the team concluded that mini-hydropower will not play a major role in Togo's energy profile. Nonetheless, out of ten potential sites, two with favorable conditions were chosen for detailed prefeasibility studies including preliminary cost estimates and calculation of their internal economic rate of return. In addition to these sites, others not visible from the documents used might be worthy of further consideration and development.

Requesting cable	-	Lome 5579
Response cable	-	State 042665
Team members	-	Walter Lawrence
	-	Tobie Lanou
	-	Paul Kirshen
Duration in country	-	3 weeks
Mission Contact	-	John Lundgren
Follow-up	-	None
Future needs	-	None

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Peru

In July, 1980, NRECA/SDH sent a team of Spanish-speaking specialists to Lima, Peru to assist the AID Mission in formulating its project paper for a program in small-scale hydropower development. The program was designed to promote rural and regional social and economic development through reasonably-priced hydro-generated electrical energy and to provide technical assistance to the mini-hydro program within the Ministry of Energy and Mines.

The NRECA/SDH team consisted of an economist, a social scientist, an engineer, and two environmental specialists. Their task was to develop the following sections of the project paper: a. project activities; b. prefeasibility methodology; c. feasibility methodology; d. economic analysis; e. institutional analysis; f. social analysis; and, g. environmental analysis. In addition, the team helped supervise preparation of feasibility studies for two mini-hydro sites that ELECTROPERU, the Peruvian national electric authority, proposed to develop.

The team worked for more than five weeks in Peru. Based on the information provided by the team, the project was approved for FY80 funding. The project proposed to lend the Government of Peru US$9 million to finance feasibility studies, civil works, equipment, and local distribution systems for approximately 28 small-scale hydroelectric installations in the 100 to 1,000 kW range. In addition, a grant of US$1 million was included for institutional assistance, prefeasibility studies, and a program for productive uses of electricity.

Requesting cable	-	Lima 4393
Response cable	-	
Team members	-	Donal O'Leary Cora Shaw Willy Flores Glen Cada Frank Zadroga
Duration in country	-	5 weeks
Product	-	Project Paper
Present status	-	ELECTROPERU has met the conditions precedent for the loan funds. RFP's for the long-term technical assistance are being prepared. The German government is interested in funding additional small hydro sites and the British government is considering a $50 million loan for medium hydro installations.

Bangladesh

At the request of the AID Mission in Dacca, NRECA/SDH sent a two-man team, including a hydrologist and a small hydro engineer, to Bangladesh in October, 1981. The team assessed the potential for small hydro in Bangladesh and looked at particular applications of low-head installations during a three-week stay. The team visited four areas where small, low-head hydroelectric projects are feasible and should be pursued, recommended six sites for prefeasibility studies, and conducted a prefeasibility study on one barrage.

Requesting cable	- Dacca 3924
Response cable	- State 01219
Team members	- John Topik - Al Mercer
Duration in country	- 6 weeks
Mission contact	- Dennis Zvinakis
Product	- Country assessment report
Future needs	- Mission wants to pursue the follow-up recommendations in the assessment report to include six prefeasibility studies and at least one feasibility study. - Requested NRECA provide follow-on services.

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Zaire

NRECA/SDH provided technical assistance to a group of individuals from the northwestern United States that raised money to install a small hydro unit in Nundu, Zaire for a church hospital. In addition, the staff located possible sources of additional funding for the project.

In March, 1981, NRECA sent two engineers to Zaire to assist the AID Mission in evaluating several proposed small hydro projects. Their assessment was aided by the SDH principal engineer who assisted in coordination and field evaluation. The engineers visited sites throughout the country, which were generally found to be feasible, and assessed the possibilities for a national small hydro program. At the end of the assignment, the team left a report with the Mission outlining options available to AID for a small hydroelectric project. The options ranged from financial assistance at selected sites to a massive, multi-donor program involving institution building, training, and introducing productive uses of electricity.

Requesting cable	- Kinshasa 02263 (3/3/81)
Response cable	- State 031340
Team members	- Joseph Howe - Song Omkar
Duration in country	- 4 weeks
Mission contact	- Lee Braddock
Product	- Project recommendation report
Follow-up	- Project Paper
Future needs	- Writing assistance with the project paper - Institutional assistance with SNEL, and setting up rural distribution systems - Operator training.

1. Summary

The cooperative agreement stipulates that NRECA, as the primary contractor--
"Shall carry out a survey of existing SDH facilities in both developed countries to determine the state-of-the-art. This survey will require the recipient to review the literature and perhaps visit appropriate SDH sites. Descriptions shall include system performance, economics, implementation procedures and management. Manufacturing of turbine/generator equipment will also be identified and their capabilities assessed.

"An organized data base consisting of hydropower resources, available technology and skill will be assembled. Manuals, bulletins and resource directories will be prepared in appropriate languages describing SDH technology, application, economics and implementation methodologies.

"A training program plan in SDH for LDC nationals will be developed in collaboration with AID. The training programs will provide SDH training for graduated engineers at university centers and at Government institutions. Both academic and hands-on training will be considered.

"Goals to be attained during the first year shall include...(a) workshop conducted in the Andean countries and distribution of proceeding (sic); completion of a proposal for a training program in SDH; (and) to strengthen, refine and broaden the expertise and capabilities of the recipient to participate and contribute toward the resolution of energy problems in developing countries.

To fulfill the obligations of NRECA under the broad area of informational services, the SDH program staff has conducted numerous activities which for the purposes of this evaluation briefing document are presented in two sections--

1. Documentation
2. Technology Transfer

The first of these sections includes three subsections--
a. library, b. special studies, and c. state-of-the-art surveys and other publications.

The second section, Technology Transfer, includes
a. information dissemination, b. workshops, and c. training.

In carrying out the activities required under Section III of this briefing document as described in the foregoing portions of the Cooperative Agreement, NRECA has engaged the services of a number

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of consultants and subcontracting organizations in addition to drawing from personnel within NRECA, its member coops, and the SDH program staff. These activities are described below.

2. Documentation

Informational services under the SDH programs can be viewed as having an input function and an output function; the collecting of relevant materials, documents, and information, and getting this information into the hands of USAID mission personnel and the appropriate host-country nationals, as the Cooperative Agreement stipulates. This section, Documentation, describes the input side of this effort. The next section will describe NRECA's efforts to transfer the technology, the output function.

Despite the strong and widespread interest in and potential of SDH in the developing countries, the availability of an SDH resource base from which to draw up-to-date technical expertise, information, and training assistance which is specifically targeted to developing country conditions and needs was limited up until AID's establishment of the SDH program with NRECA. As a first step toward filling this need, NRECA has conducted a world-wide search of existing documentation of technical and non-technical information pertaining to SDH technology and related subjects.

As a second step, NRECA has undertaken to supplement this data base of existing documentation with special studies and other technical publications addressing issues of particular importance to developing countries. For example, the established technical documentation does not include anywhere a simplified methodology for making hydrological surveys in remote rural regions of developing countries where hydrologic data is scarce and standard data-collecting techniques are not readily applicable. NRECA has produced such a methodology to fill this need. Traditional power mangement approaches, to give another example, may not offer workable solutions for SDH administration in many parts of the developing world, so a special study has been done to examine institutional issues that can be used to explore innovative managerial approaches to SDH development under a variety of socio-economic, political, and cultural conditions.

A third, and final phase of the documentation effort has involved actual field surveys of operating sites, manufacturers, and research and development centers, both in the United States and in the developing countries. These surveys, to assess first-hand the technical, economic, and institutional aspects of SDH development--particularly overseas--have served an essential purpose in the documentation of the state-of-the-art, and have permitted a cross-fertilization of different technical and institutional solutions to SDH developmental problems worldwide for use in developing countries seeking to apply SDH technology in practical ways.

A. Library

As part of the information dissemination task outlined in the Cooperative Agreement, the SDH Program has established perhaps one of the most complete and up-to-date libraries on small hydropower in the world. In gathering this valuable resource and reference material from around the world, the SDH Program staff has sought to establish a world-wide information network informally linking the SDH Program with appropriate technology groups, (e.g. Volunteers in Technical Assistance, Intermediate Technology Development Group), development institutions (e.g. World Bank, United Nations Industrial Development Organization), U.S. government agencies (e.g. National Academy of Sciences, Peace Corps), regional information centers (e.g. Renewable Energy Resources Information Center, Commonwealth Regional Renewable Energy Resources Information System), universities (e.g. The PNG University of Technology, Colorado State University), and training centers (e.g. Water Resources Development Training Center, University of Roorkee). A more complete list of these organizations is listed below. In this way the SDH Program acts as a clearinghouse for information on small hydro with particular emphasis on small hydro in developing countries.

More than 3,000 separate items which comprise the SDH library include books, periodicals, and journals, maps, articles, proceedings of workshops and seminars, methodologies, directories and organizational charts of development institutions, and country files.

The library contains information on technical, economic, social, management, environmental aspects of small hydro as well as documentation on training, end-uses, and site evaluation. Other renewable energies are documented, although not nearly as completely, and include wind, solar, biomass, and geothermal energies. In addition, the library contains considerable documentation on development policy and on rural electrification in the U.S. and in developing countries. We have developed very comprehensive files on small hydro equipment manufacturers both in the U.S. and in developing countries. This information includes promotional brochures, performance specifications, technical data on operating characteristics, dimensions, and ordering information. This information was collected in large part and formed the basis for the SDH directory of manufacturers.

Groups, Organizations, Institutions with Which We have Exchanged Information

Swiss Center for Appropriate Technology (SKAT)
United Nations Industrial Development Organization (UNIDO)
Volunteers in Asia
Volunteers in Technical Assistance (VITA)
East-West Center (Hawaii)
Intermediate Technology Industrial Services (ITIS--U.K.)
Intermediate Technology Development Group (ITDG--U.K.)
Appropriate Technology Development Association (ATDA--India)
Appropriate Technology Development Organization (ATDO--Pakistan)
Appropriate Technology Development Institute (ATDI--PNG)
Yayasan Dian Desa (Indonesia)
Regional Center for Technology Transfer (RCTT)
German Appropriate Technology Exchange (GATE--Fed. Rep. of Germany)
Swiss Association for Technical Assistance (SATA)
International Project for Soft Energy Paths
TOOL Foundation
Renewable Energy Resources Information Center/Library and Regional Documentation Center, Asian Institute of Technology (RERIC--Thailand)
Peace Corps
National Academy of Sciences
Creative Associates (USAID contractor)
Colorado State University
University of Auckland
Chiengmai University (Thailand)
The PNG University of Technology
National Energy Administration (Thailand)
University of Missouri-Rolla
University of Minnesota
Appalachian State University
Environmental Liaison Center (Kenya)
National Energy Administration (Thailand)
National Engineering Research and Development Centre of Sri Lanka
Center for Energy Research, University of Rwanda
Water Resources Development Training Centre, University of Roorkee, India
University of Southern California
National Institute for Technological Research (Cape Verde)
Worldwatch Institute
Nova Scotia Research Foundation Corporation
Finnish Association of Electricity Supply Undertakings
Commonwealth Regional Renewable Energy Resources Information System (CRRERIS--Australia)
Khonkain University (Thailand)
C.CH.LG.Ltda.
Institute Nacional de Energia
World Bank
Asian Development Bank
African Development Bank
Caribbean Development Bank
Inter-American Development Bank

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This documentation process is an on-going effort. NRECA keeps in constant touch with other development institutions, and regularly receives copies of World Bank and U.N. publications, policy statements, program funding information, and country reports. In addition, the library contains directories and organizational charts for most of the major development institutions.

Perhaps the most useful documentation however, particularly for the SDH teams departing for the field, are the country files. More than 50 developing country files have been opened. Typically, a country file contains general background information on the country, maps, environmental and economic characteristics, previous energy surveys (particularly surveys of existing hydropower), hydropower's role in rural development within a specific country, alternative energy technologies in use, and impact studies of development institution's activities in the energy sector. Reading through the country file, an SDH team preparing for the field can begin to draw some conclusions about the country, its hydropower program, and develop a good feel for different approaches to a country's energy problems.

As part of its information gathering process, the SDH Program subscribes to numerous periodicals. These include hydropower newsletters (HydroWire, Small Hydro Newsletter) water resources journals and newletters (U.S. Army Corps of Engineers Information Exchange Bulletin, Water Source and Dam Construction), development institution periodicals (U.N. Development Forum-Business Edition), AID publications (AID Resources Report, Agenda) energy publications (Alternative Sources of Energy, Canadian Renewable Energy News), and engineering journals and magazines (Modern Power Systems, Power). These periodicals assist the SDH staff in staying abreast of developments in these fields and become part of our permanent resource material. They are regularly scanned for information about books, reports, and other publications which should be included in the SDH library, training programs, and upcoming conferences and workshops.

B. Special studies and methodologies

NRECA has undertaken special studies in three important topic areas pertaining to SDH development and four technical methodologies designed to fill gaps in the existing literature on the development of SDH projects in developing countries. These publications are being used as field tools for survey teams assigned to assess small hydro potential in the LDC's and as general resource documents for wide distribution to AID missions and host-country agencies, and other SDH practitioners world-wide on an information-exchange basis.

Special studies

Management. A four-volume study was prepared under a subcontractural agreement with NRECA by the Washington Institute for Social Research to examine key issues involved in the management of small scale energy systems in developing countries. The study consists of (a) an analytic report of management approaches, (b) a compedium of institutional case studies on SDH programs, (c) an annotated list of relevant publications in the existing literature on the subject, and (d) a management guide for SDH practitioners and planners, which is an attachment to this briefing document. As the principal theme to this work, the dichotomy between centralized and decentralized management approaches is analyzed in the context of actual case studies to present various options including hybrid local/national institutional approaches, for carrying out SDH projects and programs.

Site evaluation. Under subcontract to NRECA, AMARU IV Cooperative of Washington, D.C. has prepared a field guide to be used in evaluating the effectiveness of SDH systems to meet local needs in developing countries. This study looks at a number of economic and socio-cultural factors that tend to govern the success of SDH projects, and includes a framework with which relevant data can be collected as part of a general feasibility study of prospective sites.

Economic planning. NRECA is in the process of developing a general economic feasibility and planning manual for SDH program and project development. A number of in-house studies and working papers have been completed that will be combined in a four-part economic planning guide including (a) socio-economic feasibility, (b) end-use planning, (c) costing methodologies, and (d) financing strategies and resource directory. Work has already begun in all four of these areas, and preliminary reports have been completed for the end-use planning and financing sections. A final document is planned for the Fall of '82.

End-use planning. One part of this document, a planning tool for SDH end-uses emphasizing the development of productive uses of energy, is complete. Specific information is presented on end-uses of energy--and specifically hydropower--in rural areas, including an audio-visual on the importance of productive uses of electricity, papers which discuss the demand for energy in rural areas of developing countries, the role of hydro in meeting these energy demands and special applications of hydropower which can serve the needs of rural locales with unique problems. Guidelines for establishing promotional and educational programs aimed at integrating rural electrification projects into overall development objectives of a region, based on the U.S. experience, are also presented.

Financial strategies and resource directory. Three separate reports have been prepared that will form the basis for this section. The first examines the range of private, bi-lateral, and multi-lateral financing that is available for SDH development and the general lending and economic feasibility criteria associated with each. Work has also begun on a directory of public and private financial sources in the SDH field. A second study was prepared to make an initial survey of possible means for private sector participation in SDH development programs in LDC's. Finally, and related to the private sector study, is an analysis of the PURPA model of development that has been introduced in the U.S. with a view to applying this approach, under certain requisite conditions which are discussed, in developing countries.

Methodologies

Country assessments. Based on the unique survey approach developed by NRECA for its SDH field services, a methodology for conducting country-wide surveys of SDH potential has been prepared for wide distribution. The survey methodology outlines team make-up, a timetable, and elements of the study necessary to make a general assessment of the potential for going ahead with an SDH program in a developing country. These elements include hydrologic and topographic characteristics, institutional resources, and alternative energy options.

Prefeasibility studies. Following a country assessment, prefeasibility studies of selected sites is the next step. A methodology for completing a prefeasibility-level study, focusing on costs and benefits, has been prepared for wide distribution.

Hydrologic methodology. In most remote regions of developing countries accurate records of rainfall, peak flow, and streamflow duration do not exist. A simplified methodology for making such estimates has been prepared for wide distribution.

Environmental studies. Also at the pre-feasibility level, a methodology has been prepared for assessing environmental conditions and potential impacts of a small hydro project.

C. State-of-the-Art Surveys and other Publications.

Resurgence of interest in small hydropower is relatively recent, and new hydropower schemes are being installed without the benefit of years of experience. Many of those implementing schemes are beginning from scratch and repeating the mistakes of others. The result is schemes which are often expensive, problematical, and

be learned. But with all these installations, there is very little documentation. Much of what there is has already been included in the library. If one is to be more effective in implementing small hydropower programs, there is a need to gather data on existing sites and present it in usable form so that future work can build on past experiences and thereby be more cost-effective. A number of field visits both in the United States and overseas have been undertaken with this objective in mind as summarized by the following chart.

U.S.

State	Size (kW)	Number of sites
Alabama	2,000-5000	2
Alaska	3,000-15,000	3
Colorado	500-7,000	3
Idaho	1,200	1
Michigan	500-1,200	2
Minnesota	8,000	1
Missouri	3,000	1
New York	1,000	1
Virginia	300-3,000	3
Wisconsin	1,000-5,000	2

Overseas

Country	Size (kW)	Number of sites
Ecuador	75-250	2
Indonesia	75-575	7
Kenya	1	1
Nepal	1-1000	13
Pakistan	5-15	5
D.N.G.	1-100	14
Rwanda	100	2
Thailand	12-3,000	4

Not only must data be gathered but it must be available in usable form. The following represent some of the efforts undertaken to accomplish this--

Preparation of case studies of interesting approaches to country small hydropower program to raise an awareness of those options which are being used to develop hydropower potential. The first case study, Micro-Hydropower Schemes in Pakistan, is a 37-page, illustrated study of villager-implemented rural schemes in Pakistan, unique because of its low costs, use of local resources, and use of power both for electricity generation and direct coupling to equipment used in village industries. The second study, Butwal's Experiences with Micro-Hydropower Schemes in Nepal, nearing completion, describes a private sector approach which, over the last few years, has resulted in the installation

of over 60 non-subsidized hydropower plants in rural areas of Nepal.

Gathering a unique collection of over 1000 slides on small decentralized hydropower installations around the world. These have been used in workshops, seminars, and training sessions to raise the awareness of existing experiences in the field. These are also being used as illustrations of the technology in both NRECA and USAID publications, as well as others, including the National Academy of Sciences, and technical journals (e.g., International Waterpower and Dam Construction).

Gathering of actual design and operational experiences in the form of a Micro-Hydro Sourcebook. There has been interest expressed by a number of USAID missions in hydropower plants in the micro range (less than 100 kW). In addition, the cooperative agreement explicitly states that "Special attention will be given to units of 1 to 100 kilowatts." Since sending consultants and SDH Program staff around the world is much too costly for projects at the lower end of the power scale, this sourcebook will provide a cost-effective means of addressing requests for assistance and technical guidance. There is at present not a single publication which covers all the aspects of the design and implementation of micro-hydropower plants. The only publications which are available only cover various aspects to a range of departments. Most of these do not benefit from experiences gained in the field, experiences which can easily make or break new projects. This sourcebook, a longer term project, will be useful both as a reference text for design as well as for training purposes.

There is also a need by those undertaking small hydropower projects to become aware of hardware which is available as well as recent system design trends. Though there are scattered references to various manufacturers of small hydropower equipment in the literature, these are sketchy, incomplete, and often not up-to-date. To fill this need, the Directory of Sources of Small Hydroelectric Turbines and Packages has been prepared. Now in its second edition, it provides a description of companies supplying small hydropower equipment, indexed according to the operating characteristics of their turbines, and their line of equipment. This publication, also available in French, presently includes ten US and three developing country suppliers whose equipment satisfies US source requirements. It is updated as new information becomes available and new manufacturers enter the field.

3. Technology transfer

The principal target for the SDH program's information dissemination effort is, of course, the AID missions interested in small hydro development and their host-countries. In the course of documenting the information, however, NRECA has become keenly aware of the importance of promoting information exchange among

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the diverse resource organizations world-wide which are working in the field of small hydropower, such as multilateral banks, universities, and energy technology development organizations. Thus, in developing its mailing lists and communications network, NRECA has made a special effort to share its findings and publications, on an exchange basis, with other resource organizations working on small hydro development, both in the developing countries and in other parts of the world. In a similar sense, NRECA has attempted to draw in representation from some of these other resource organizations when holding workshops and seminars. It is the bringing together of diverse technical experience in its documentation and dissemination activities which has made the SDH Program uniquely valuable to developing countries seeking practical methods of utilizing their SDH resources.

This technology transfer process has taken place in three modes: (a) information dissemination (principally by mail); (b) workshops, and (c) training.

A. Information dissemination

The SDH Program receives about 10 requests for information each week either by mail, telephone, or personal visits. These requests may be very general ("Please send me any information on small hydropower.") or may be very specific in nature such as a request for information about the specifications of a turbine built by a U.S. manufacturer of hydro equipment. The requests come from AID missions, U.S. and LDC universities and training centers, U.S. and LDC private consulting or A&E firms, development institutions and organizations, and NRECA member systems among others.

Typically a request can be responded to in a matter of days. Someone requesting general information for instance is often sent a package of materials including the following--
Country survey methodology
Prefeasibility methodology
Quito proceedings
Pakistan report (part of sourcebook described in the previous section)
SDH Program Status (see Appendix D--Tab E)
SDH brochure

For such a general request, the materials sent provide only a very basic background. Therefore, in responding to the request for general information, the SDH staff asks that the recipient supply us with more details about the exact information required and what it will be used for so that we can send more specific information based on their response directed to his needs.

To assist in our information gathering and dissemination, the SDH Program has developed a comprehensive mailing list of individuals, groups, and institutions with which we correspond which is

currently being input into our word processor. Once complete, this list of approximately 1,000 names and addresses could prove invaluable not only because it will bring together in one easily accessible place all of the myriad people and institutions we work with and will therefore facilitate our information dissemination and gathering process, but because it can be accessed to share with other individuals, groups, and institutions active in the development of small hydro particularly in developing countries for their own information gathering and dissemination purposes, starting a chain reaction. In addition, each document in the library (its title, author/editors, and subjects) is being put on the word processor as well. Frequently, we receive requests for bibliographies on a given topic.

More specialized requests may require additional time for a response. When the information is not available in our resource library, but is available elsewhere, we provide the information necessary to obtain it and, if the document is of more general use, order a copy for our permanent library for future reference.

With all the documents listed and their subjects cross-referenced on the word processor, not only will the time taken to respond to such a request be greatly reduced, but the list will be more complete.

The SDH library is often the starting point for reports and background papers the SDH staff and its consultants prepare and as such is a valuable resource and reference library. Large portions of two of the special studies developed by outside contractors under the SDH Program's guidance (the WISR study and the AMARU study) were based almost entirely on case histories found in the SDH library.

Finally, the SDH Program distributes its publications as well through its own regional workshops and through conferences it attends where selected publications are made available in quantity and others are sent to participants upon request.

Through its information dissemination efforts, NRECA has distributed nearly 1300 copies of the Quito proceedings, and approximately 200 copies each of the prefeasibility methodology, country survey methodology, Pakistan report (part of the sourcebook), and the directory of manufacturers.

As part of the information network discussed above in Section III, the SDH Program as a matter of routine sends copies of its publications (the methodologies and special studies described in the previous section as well as copies of reports and reprints of articles written by SDH staff) to selected AID missions, in countries with substantial hydropower potential, appropriate technology groups, development institutions, regional information centers, and universities and training centers. This serves the purpose not only of disseminating information but often serves to

motivate the recipients to send us copies of their latest publications as well.

In addition to its own publications, the SDH staff has also found several other publications of particular interest and value for those interested in more technical aspects of hydro. Two of these, Simplified Methodology for Economic Screening of Potential Low-Head Small-Capacity Hydroelectric Sites (Electric Power Research Institute) and Reconnaissance Evaluation of Small, Low-Head Hydroelectric Installations (Tudor Engineering for U.S. Department of the Interior) are useful technical documents which we send out routinely.

The SDH teams sent to different countries take full advantage of their access for the SDH library before their departure for background briefing materials. Particularly useful are the country files discussed above, although the other reference materials are also valuable resources for the teams. Once again, the library is often the starting point for a background search--if the information is not in the library, there are usually good leads at least about where the required information can be found.

B. Workshops

NRECA has organized three regional workshops on SDH technology that have been attended by over 300 participants from 53 countries, 48 of them developing countries. The main purpose of these workshops has been to introduce the technology on a wide range of topics to the key individuals involved in small hydro program implementation in the countries of the three main geographical areas of the developing world--Latin America and the Caribbean, Asia and the South Pacific, and Africa and the Near East. The workshops also provided opportunities for the SDH practitioners to exchange ideas and experiences; for U.S. manufacturers and private engineering firms to get exposure to potential Third World markets; and for the SDH Program staff to make contacts with program managers and AID mission personnel from developing countries new to the SDH Program. Finally, the proceedings from the workshops have proved to be valuable publications for information dissemination purposes, and have been used in several instances as texts for training courses. Summaries of workshop evaluations submitted by the participants can be found in Appendix E--Tab F. A chart summarizing the vital data of the three workshops follows:

	Quito, Ecuador August 19-21, 1980	Bangkok, Thailand June 6-12, 1981	Abidjan, Ivory Coast March 1-5, 1982
No. of participants	108	108	93
No. of countries and names	16 U.S.,Ecuador,Peru, Panama,France, England,Honduras Costa Rica,Uruguay Haiti,Guatamala, Guyana,Nicaragua, Dominican Republic, Jamaica,Bolivia	16 U.S.,Austrailia, Fiji,Papua New Guinea,Thailand, Burma,India,Sri Lanka,Malaysia, Pakistan,Nepal, Bangladesh, Indonesia, People's Republic of China, Western Samoa, Philippines	30 U.S.,England, New Zealand, Malaysia, Indonesia, Pakistan, Ecuador,Colombia, Ivory Coast,Gohm, Liberia,Senegal, Benin, Morocco, Tunisia, Algeria, Upper Volta, Mali,Cameroon, Rwanda,Burundi, Togo,Ghana, Sao Tome,Principe
Papers presented (topic areas)	19 Country case studies (3), Hydrology,Load Determination,Environmental Assessments,Economic and Financial Studies,Turbines,Civil Works, Site Selection,Distribution	17 Country case studies (5), Water Resource Planning, Hydrology,Turbine Design Civil Works,Electrical Design,Operation and Maintenance Financing	20 Country case studies (6), Hydrology,Micro-hydropower,Site Development,Equipment Design, Economic Feasibility, End-uses,Financing,Cost Implications,Management, Institutional Issues.
Panels (topic areas)	2 Management Issues; Other Aspects of Small Hydro Development	2 Centralized Approaches to SDH development; Decentralized Approaches to SDH Development	2 Rural Mini-hydro Case Studies;Centralized vs. Decentralized Approaches to SDH Development
Workshop groups	None	4 Resource Assessment; Site Development; Economic and Financial Issues; Management and Social Impacts	4 Resource Assessment and and Site Selection; Site Development and Equipment; Economic Feasibility and End-Uses; Costs and Financing
Field trip	No	No	One-day trip to Aboisso; 4 groups assigned to study 4 design options and report findings and recommendations in session later in the week.
AID missions represented	2 Ecuador,Panama	3 Thailand,Indonesia Bangladesh	1 REDSO,Ivory Coast
U.S. firms represented	5 1 manufacturing firm (Leffel) 1	4 2 manufacturing firms (Allis-Chalmers)	2 1 manufacturing firm (General Electric)
Proceedings	1500 copies printed; 1300 distributed to over 70 countries	1500 copies scheduled to be published June, 1982	Planned

C. Training

As in any technical assistance program, training is essential. The real challenge to this training, of course, is assuming that it be effective in meeting the immediate and long-term needs of the developing country. To be truly effective, the training must be managed by those who are familiar with the project or program in which the training is carried out. NRECA's function in this training effort is to provide this essential link between understanding the nature of the developing countries' small hydro programs, their objectives and needs, and the actual management, planning, timing, and scope of the training program.

NRECA, through its years of experience in providing electricity to remote rural areas of the world is uniquely qualified for this management function. NRECA's Management Services Department has provided effective training for its member systems for more than 25 years in the areas of problem-solving, accounting, planning, institution building, and organized management structure.

In addition, NRECA's International Programs Division has developed a training program to expose those from developing countries to solutions to problems associated with rural electric system operation organization, and management. Similarly, the SDH staff has the requisite expertise and accumulated first-hand knowledge of the small hydro programs in many developing countries to assure that the training is effective. Through its member systems, its in-house staff, and its talent bank of engineers, consultants and academicians, NRECA can tap resources to effectively plan, promote, and manage a training program that meets the needs of developing countries.

In December, the SDH Program submitted a training proposal to the Office of Energy, a copy of which appears in Appendix F--Tab G. This two-phase, intensive, multi-disciplinary proposal outlines a training program to be initially conducted at a U.S. based university with a long-term goal of helping developing countries achieve self-sufficiency by training trainers--those who will be ultimately responsible for training engineers, planners, and others within their own countries in the field of hydro. The initial six-week training program includes an overview of all aspects of SDH development (data collections, economics and financing, civil engineering, management, hydraulic and electrical equipment, end-uses, hybrid development, and applications), and a choice of electives in selected topics to better tailor the training to the individual's needs, with an emphasis on hands-on training. The training is geared toward mid-level engineers, planners, and project managers intimately involved in their country's hydro development programs. The SDH Program recommended the University of Minnesota as the location for this training because of the exceptional small hydro equipment as its St. Anthony Falls Hydraulic Laboratory, its video-equipped classrooms, well qualified faculty from a multiplicity of

disciplines, its proximity to nearby small hydro sites, and its accessibility.

Although the SDH Program has not conducted any formal training courses in the traditional sense of the word, training is an element of virtually all its efforts. Each time an SDH team is sent to a developing country to assist with a country's hydropower program, the AID mission is responsible for selecting appropriate host country nationals to work with the team. These host country counterparts, primarily engineers, but occasionally sociologists, economists, or planners, representing an appropriate Ministry of the host country government or a university research program, are chosen prior to the team's arrival to work with the team because of their familiarity with the hydro program in their country. They work side-by-side with the SDH team through the planning and information-gathering process, as well as in the field assessment of the country's hydro potential, in conducting prefeasibility studies, and selecting sites--in short, learning techniques for resource assessments, site selection, economic feasibility studies, social impact analyses, preliminary design, and ordering equipment. In addition to this field training, there is a continuing need to train engineers and planners in developing countries on the latest developments in small hydro technology. Until adequate, well-staffed regional training centers are established, NRECA envisions sending small teams to developing countries on an as-needed basis to provide on-going and follow-up training to engineers in the developing world. These teams would be comprised of people drawn from the SDH talent bank, as well as from the SDH staff, NRECA member systems, and the Management Services Training Division.

In April of this year, several SDH staff members will focus on still another form of training as they conduct several engineers from the Panamanian Institute for Hydraulic Resources and Electrification (IRHE) on a study tour of U.S. hydro manufacturers. The four groups will visit seven separate U.S. manufacturers, the St. Anthony Falls Hydraulic Laboratory at the University of Minnesota and a number of small hydro sites during the two-and-one-half-week tour. The tour will acquaint the Panamanians with the U.S. manufacturers and their equipment lines, provide a first-hand look at turbine manufacture and assembly, and will permit them to see the equipment in operation. We anticipate that the equipment for several of the sites IRHE now has under development will be purchased from U.S. manufacturers. Morocco has conveyed its initial interest in the SDH Program developing such a tour for several engineersm, as well.

The publications developed by the SDH Program have themselves served as training tools and have been widely distributed. The proceedings from the Quito workshop have, for instance, been used by Appalachian State University as the text for its small hydro training course. The Quito proceedings were also used to train host country nationals in the Dominican Republic in a training

course on small hyro jointly sponsored by USAID and Volunteers in Technical Assistance (VITA). The Asian Institute for Technology, a cosponsor of the Bangkok workshop on small hydro, has indicated that the proceedings of the workshop will be used in its classroom training as well.

The sourcebook described above will be an even more effective tool, bringing together, in one document, up-to-date "how-to" information useful in implementing micro-hydropower schemes.

In addition, the teams the SDH Program sends into the field generally take with them several of the methodologies developed by the SDH Program as background training materials for AID mission personnel and host country engineers.

The training aspect of the three regional international workshops the SDH Program has organized and conducted thus far in Quito, Bangkok, and Abidjan is also significant. As the Cooperative Agreement notes, the workshops are designed to disseminate information on a regional basis on the latest developments in the technology of small hydro and its application, the economic and financial considerations in its development, and the management and institutional issues essential to creating sound hydro programs in developing countries. The workshops have actually evolved into mini-training sessions. In the Abidjan workshop, for instance, the 93 participants were organized into smaller working groups and were given exercises to complete as teams analyzing site, hydrologic, and cost data to determine whether a given site was economically and technically feasible to develop. The resultant high level of enthusiasm and participation throughout the workshop week were due in large part to this training element which intrigued and motivated participants. They were not merely recipients of information, but were active participants in a challenging training exercise. Any future workshops the SDH Program develops will have a similar, strong training element.

A. Observations

By virtue of our program activities we have made a number of observations about many aspects of these activities--successes, shortfalls, problems, biases, and so on, and we would like to share some of them with you.

USAID Missions. We see a substantial interest within many missions in proceeding with SDH programs based on the preliminary survey work of NRECA. In some cases this means engineering activities, such as system design and layout, bid specifications and eventually construction supervision. In other cases this may mean institution-building kinds of activities such as aiding the Mission to assist the host country in finding financing for one or more sites, developing a PID or PP for a mini-hydro program, carrying out one or more detailed site feasibility studies, etc. Some missions may have funds for a PIOT to carry out these next step activities, others may not.

We have a vested interest in seeing these efforts continue both from the standpoint of seeing our Program progress from the planning stage to the site development stage as well as from the fact that only so many resource assessment surveys can be carried out before there are no more to be done--and then what?

Follow-up contact is important in all phases of our work--planning for workshops, developing scopes, etc. In countries where we have been able to work in-site with the Mission and the host country staff in planning for upcoming work for the next stage--whatever it may be--we have had a successful project.

System scale. In our country surveys, many of the sites ranged in capacity from 500 kW to 1 or 2 MW, however most were under 500 kW. This is due in large part to the type of terrain the team was working in--low elevation and high flows tend to yield larger sites than high elevation sites with lower flows. Other factors governing the selection or identification of particular sites include: familiarity of the team with a particular size range; sites preselected by host government; duration of survey--access to sites; conventional or nonconventional approach to development

Another question has been that of the purpose of developing small decentralized hydropower sites--is it to increase national generation capacity or it it to provide rural energy? Increases to national capacity often are designed to have maximum national economic impact, such as oil displacement, system reliability, peaking power and so on. Providing energy to rural areas results in local and regional benefits, which may be directly economic but are also geared heavily to a higher quality of life. In many

cases an elevation of sites with development potential in the lower range would turn out to be negative when economic justification depended upon national criteria. The rural impact of rural electrification provided by these small isolated hydropower systems will have a significantly stronger effect than a national energy impact from these same small units. Development of these smaller, isolated sites will be expensive unless a different approach is taken to small hydropower development. There is no question that these smaller sites have a constituency, albeit an often inarticulate, widely dispersed and frequently uninfluential one. Sites would serve far flung villages, government outposts, farms, communes and cottage industries, to name a few. Government agencies that focus on rural development rather than power supply or energy resource development do not have engineers and planners with expertise in power development and supply. Yet both rural development and power development planners alike are hard-pressed to come up with energy solutions for these remote areas. This may call for a "re-definition" of rural electrification, as one of the Bangkok workshop participants described it, to promote inexpensive technological approaches that may be less reliable and durable, but nevertheless feasible for poor, undeveloped and energy-starved rural areas of the developing countries. We should be able to assist this micro-hydropower constituency without compromising our assessment of the larger small hydro sites and vice versa.

Demonstrations. Many questions surround the development of small hydropower. Principal among these are issues of equipment--suitability of control devices, particularly electronic load control, appropriateness of other electrical equipment (generators, etc.); approach to site development--local orientation vs. centrally planned programs; costs for development and operation, management of systems; end-use planning; integration--with development of other sectors, designed to demonstrate solutions to some of these technical and managerial challenges to small hydropower development. Without good data to resolve uncertainties, solutions to the above issues will remain in the category of conjecture.

Funding. There continues to exist a strong element of uncertainty as to the future of USAID funds for continuing the Small Decentralized Hydropower Program. We understand that it is impossible for USAID to guarantee funding for several years to NRECA, in spite of the wishes of ST/EY. There is a need therefore for NRECA to begin developing other funding sources as a hedge against possible loss of USAID funding.

It seemed that the original wish of USAID as stated in the Cooperative Agreement was to eventually develop an expertise within NRECA that would ultimately provide small hydro development assistance to developing countries and other entities independent of USAID support. We assume this is still the long-term USAID policy.

B. Future activities

On the basis of these observations, as well as on discussions among the SDH staff, we would like to propose some selected topics of our discussion as we try to come to an agreement on the new directions for the NRECA Small Decentralized Hydropower Program. The principal aim of the SDH program as we see it, is in providing a broad continuum of services in the field of rural energy with the purpose of establishing rural energy in the proper context within the national energy picture of a given developing country. To carry this aim out special efforts will be made in the areas of institution building, power system planning, technology transfer and training.

Continue with information exchange. We would maintain such activities as--respondents to requests from missions and host countries for information on small hydro; developing special small hydro publications (inventories, manuals, methodologies, etc.) for wide distribution; drafting, upon request, articles for journals, magazines and newsletters; making presentations on small hydro upon invitation to conferences, seminars and workshops.

Develop and manage a substantial training program. NRECA would design, help staff and be responsible for managing a long-term training program in small hydro topics ranging from resource assessment, site development, operation and maintenance to productive use planning and system management. In addition to small hydro specialists wide use will be made of the substantial training expertise within NRECA and its member systems. Training services would be provided initially in the U.S., but ultimately would include in-country assistance as well.

Continue with resource development surveys. We would continue with resource surveys for as long as requests come in and would respond to whomever asks. For missions with no funds for site development, we would assist, as part of the survey, in identifying funding sources for site development. We would encourage co-funding (mission and NRECA/ST/EY) of surveys to make SDH money go farther. We would restructure surveys to include more U.S.-based work by SDH staff and survey team before sending the team in-country. In come cases we may design a survey for longer than the usual 3 to 5 weeks. Given the in-country difficulties that we have experienced--weather, logistics, rough countryside, host country cooperation, vehicle availability, lack of data-maps-reports, misinformation, biases and so on, it is essential to (a) have the team get as clear a picture of the country before going and (b) for NRECA to control the scope of the team's activities personally--meaning visiting the mission to design the service to be provided, collect information, develop contacts, etc. An additional point is that we would attempt to maintain a somewhat continual presence in-country once a project is begun, for example, to keep the activity moving through the

various stages--survey to feasibility to PID to PP to funding to implementation.

Continue to offer assistance in micro-hydropower development. We would help missions, countries, or development organizations construct an approach to implementing micro-hydro systems that is cost effective and practical. This activity would include finishing the micro-hydro sourcebook to be used as a manual for system planning, design, construction and management. This activity may also include working directly with USAID missions or other divisions of USAID to integrate micro-hydro projects into other development programs--rural water supply, agriculture, housing, small scale industry and the like, rather than make micro-hydro units the center piece or even an element of an energy program.

Increase upper limit of system capacity. We would attempt to enhance the total energy program approach by (a) providing energy for rural development in which micro hydropower and isolated small hydro power systems are capable of providing rural electrification and (b) providing a renewable energy contribution, via small hydropower units, to the national energy picture. In this latter case, we would raise the capacity limit of potential sites to include those up to 10-15 MW, or larger as appropriate. These would be conventionally developed, grid-connected sites in most cases, though not exclusively, and their purpose would be either system expansion, oil substitution, or both. Human resources for this assistance would come from NRECA member systems, from U.S. small hydro specialists and from a sub-agreement between NRECA and a source of "bigger" small hydro design and construction expertise such as TVA or an engineering firm.

Increase institution building services. In this service a strengthening of the total host country program would be provided. Longer term assistance to support follow-through efforts would be emphasized. We would provide management-oriented services in addition to the already-stated resource assessment, training and engineering services. These management-oriented services would be designed to develop or improve the organization responsible for small hydro development, financing and management. These organizations may be local, regional or central in planning and management focus. The objective of this effort is to build in-country capability for hydro planning, development and management and to therefore eventually eliminate the need for the host country to continually rely on outside assistance. Examples of those to be assisted are small hydel development boards, local cooperatives or regional offices of the national utility.

Begin to reachout with skills and knowledge developed. We would attempt to develop other sources of funding for the small hydro program at NRECA. We would also continue to disseminate our knowledge and increasing experience through expanded contacts with other development and/or research organizations such as the UN,

OECD, World Bank (and other development banks), NAS and others. This activity would also include developing interest in private sector involvement in small hydro development via contacts with government agencies who would promote this kind of effort as well as with private developers, investors, and so on.

Begin to work with missions. In close coordination with ST/EY begin to accept requests of assistance to work directly for missions in activities related to follow-on to previous work. Payment for NRECA services can be made by Mission PIOT directly to NRECA or to ST/EY for transfer to SDH Program funds. This activity would include contact of mission by NRECA via correspondence as well as in person to get work moving. Example countries (not comprehensive) are Peru, Dominican Republic, and Zaire. An important activity with missions, particularly those who will be funding hydro programs partially or totally, will be provision of training services. Funds for this could also be provided by the host country (national utility, for example), or by another development organization with mission role as coordinator.

Develop a program capability to field-test the technology. As noted above, there is a universal agreement--whether you are listening to development institutions with a financial focus (WB, other development banks) or a technical assistance focus (UNIDO, AID bureaus and missions)--to study the performance of SDH technology under actual LDC conditions. These may serve a R&D purpose (e.g. to see how different regions of the world can adopt to new technological approaches to SDH being developed in places like Nepal, Pakistan, China and Peru), or alternatively to serve as pilot projects for country or region-based SDH programs that are being proposed in W. Africa, the Caribbean, or S.E. Asia. We would propose to address this need by both: conducting a methodological survey of existing technological applications in certain countries (we have already begun this in places like Pakistan, Indonesia, Thailand and Nepal), and actually participating in pilot phases of programs now envisioned by AID in places like Zaire and the Dominican Republic. It is particularly noteworthy that several U.S. manufacturers are also keen to participate in this sort of activity, and we would encourage the utilization or adoption of U.S. equipment and engineering techniques that are now being aggressively developed by firms like G.E. and Allis-Chalmers.

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

Mr. Thomas A. Quirk, Jr.
Assistant Administrator
International Programs Division
National Rural Electric Cooperative
Association
1800 Massachusetts Avenue N W
Washington, D. C. 20036

Subject: Cooperative Agreement
AID/DSAN-CA-0226
Amendment No.: 1

Dear Mr. Quirk:

Pursuant to the authority contained in the Foreign Assistance Act of 1961, as amended, and the Federal Grant and Cooperative Agreement Act of 1977, the Agency for International Development hereby amends the subject Cooperative Agreement, effective the date of this letter, as follows:

A. Cover Page - Accounting and Appropriation Data

Under Amount Obligated delete "$1,000,000" and insert in lieu thereof "$1,223,590."

B. Schedule, Article I - Cooperative Agreement

Delete Paragraph "A" in its entirety and insert in lieu thereof:

"A. Pursuant to the authority contained in the Foreign Assistance Act of 1961, as amended, and the Federal Grant and Cooperative Agreement Act of 1977, the Agency for International Development (hereinafter referred to as "AID") hereby enters into a Cooperative Agreement with the National Rural Electric Cooperative Association (hereinafter referred to as "Recipient").

C. Article II - Special Provisions

Paragraph E. Alterations to Standard Provisions - Add the following:

"Standard Provision 10 - Limitation of Funds is hereby deleted in its entirety and the attached Standard Provision 27 - Limitation of Cost is inserted in lieu thereof."

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D. Article III - Budget

Delete paragraph 1 in its entirety and insert in lieu thereof:

"The Total Estimated Cost and the Total Obligated Amount of this Agreement is $1,223,590. This is the total amount authorized to be expended by the Recipient. Expenditures exceeding this amount will not be reimbursed. Adjustments among line items are unrestricted."

Except as expressly amended herein, the Cooperative Agreement remains in full force and effect in accordance with its terms.

To acknowledge your acceptance of this amendment, please sign and return the original and eight (8) copies.

Sincerely yours,

Donald N. Lake

for Morton Darvin
Grant Officer
Agriculture/Nutrition Branch
Central Operations Division
Office of Contract Management

Accepted

National Rural Electric Cooperative Association

BY: _____

TITLE: _____

DATE: _____

Fiscal Data

Amount Obligated by this Amendment:	$223,590
Total Obligated Amount:	$1,223,590
Appropriation No.:	72-1101021.6
Allotment No.:	043-36-099-00-20-01
Project No.:	936-5715
PIO/T No.:	3606346

8/17/79

AGENCY FOR INTERNATIONAL DEVELOPMENT

COOPERATIVE AGREEMENT - NON-EDUCATIO INSTITUTIONS

NO. AID/DSAN-CA-0226

PROJECT TITLE: Small Decentralized Hydropower Program

PROJECT NO. 936-5715

AWARDED PURSUANT TO SEC. 635 OF THE FOREIGN ASSISTANCE ACT OF 1961, AS AMENDED, AND THE FEDERAL GRANT AND COOPERATIVE AGREEMENT ACT OF 1977

ISSUING OFFICE

Agency for International Development
Office of Contract Management
Washington, D.C. 20523

Cognizant AID Scientific/Technical Office
Office of Energy
Development Support Bureau
Agency for International Development
Washington, D.C. 20523

RECIPIENT National Rural Electric Cooperative Association

Name

1800 Massachusetts Avenue, N.W.

Street Address

Washington, D. C. 20036

City State Zip Code

MAIL VOUCHERS (original and 3 copies) TO

Agency for International Development
Office of Financial Management
Washington, D.C. 20523

FM/PAD

EFFECTIVE DATE: May 1, 1980

EXPIRATION DATE: October 31, 1981

ACCOUNTING AND APPROPRIATION DATA

Amount Obligated: $1,000,000
Appropriation No: 72-1101021.3
Allotment No: 043-36-099-00-20-01
PID/T No: 3606346

The United States of America, hereinafter called the Government, represented by the AID Grant Officer executing this Agreement, and the Recipient agree as follows: That the entire Agreement consists of: The Cover Page; the Schedule, consisting of 4 pages; Attachment "A", Program Description, and Attachment "B", Standard Provisions.

Best Available Document

SCHEDULE

ARTICLE I - COOPERATIVE AGREEMENT

A. Pursuant to the authority contained in the Foreign Assistance Act of 1961, as amended, and the Federal Grant and Cooperative Agreement Act of 1977, the Agency for International Development (hereinafter referred to as "AID") hereby enters into a Cooperative Agreement with the National Rural Electric Cooperative Administration (hereinafter referred to as "Recipient"). Funding in the amount of $1,000,000 is presently available for expenditure by the Recipient. Recipient expenditures exceeding this funding will not be reimbursed. Subject to the availability of funds and the mutual consent of AID and the Recipient, additional funding in the amount of $223,590 may be added to this Cooperative Agreement at a later date.

B. This agreement is effective as of the date indicated on the cover page and shall remain in effect until 10-31-81. Funds made available hereunder shall be used in furthering the program objectives during the period 5-1-80 to 10-31-81.

C. This Cooperative Agreement is made with the Recipient on condition that the funds will be administered in accordance with the terms and conditions as set forth in Attachment A entitled "Program Description," and Attachment B entitled "Standard Provisions."

ARTICLE II - SPECIAL PROVISIONS

As soon as possible after the effective date of this cooperative agreement the Recipient with the concurrence of AID project office will recruit an individual to occupy each of the following three key positions:

1. SDH Program Director
2. Principal Technical Officer
3. Information Officer

Prior to replacing an individual in any of the three key positions the Recipient will notify the AID Project Officer of the reasons therefor, the impact on performance under this agreement, and the intended replacement. The replacement will be acceptable if consented to by AID and the Recipient.

B. Consultants

No compensation for consultants will be reimbursed unless funds for such consultant effort are included in the budget of this agreement, or such consultant effort has the specific prior written approval of the AID Grant Officer. Unless approved in writing by the AID Grant Officer compensation to the consultant shall not exceed, (1) the current compensation or the highest rate of annual compensation received by the consultant during any full year of the immediately preceding three or (2) the maximum daily salary rate of a Foreign Service Officer Class 1, whichever is less.

Note: The daily rate of a Foreign Service Class 1 is determined by dividing the annual salary by 260 days. The maximum daily salary rate of a Foreign Service Officer, Class 1 as of the effective date of this Cooperative Agreement is $192.

C. Overhead Rates

Pursuant to the standard provision entitled "Negotiated Overhead Rates - Noneducational Institutions" a final rate(s) shall be established for the period beginning 1-1-80 and ending 12-31-80 . Pending establishment of final overhead rate(s) for the initial period, provisional payments on account of allowable indirect costs shall be made on the basis of the following negotiated provisional rate(s) applied to the base(s) which are set forth below:

Rate	Base	Period
24%	Direct Salaries and Wages	FR: 1-1-80 TO: Until Amended

The Recipient will use the above provisional rate for reimbursements under this coomperative agreement until such rate has been superseded in accordance with the standard provision entitled "Negotiated Overhead Rates-Noneducational Institutions."

D. Title to Property

For purposes of the standard provision entitled "Title To, Use, and Care of Property" title to nonexpendable property vests in the Recipient.

E. Alterations to Standard Provisions

The following Standard Provision contained in Attachment B of this Cooperative Agreement is hereby deleted in its entirety as being non-applicable:

9B Payment - Periodic Advance

Program Description

A. Purpose of Cooperative Agreement

The purpose of this cooperative agreement is to strengthen the technical capacity of the recipient in the identification, design and implementation of small scale, decentralized hydroelectric power projects generally of one megawatt capacity or less. The recipient organization, under this agreement, will assemble a group of small decentralized hydroelectric power specialists, social scientists, economists, and other specialties and make them available on a case by case basis to Developing Countries and Governments; provided there is mutual agreement between the host country, AID and recipient.

The size of the hydroelectric facilities anticipated under this program generally will be one megawatt or less. Special attention will be given to units of 1 to 100 kilowatts. Funding for the capital costs (i.e., construction facilities and equipment) including pilot projects, demonstrations or adaptation tests, are not authorized under this agreement. These costs, may or may not be funded by U.S. Government.

B. Program Background

Small Decentralized Hydropower (SDH), a mature and proven technology, is among the most promising renewable energy technologies available. In LDCs the hydropower potential is only beginning to be tapped and as oil and gas prices continue to rise, hydropower produced electricity appears increasingly attractive, especially in remote rural areas where fossil fuel transportation costs are prohibitive. SDH systems are currently being developed in the People's Republic of China, Peru, Indonesia and several other LDCs as a means of reducing diesel oil consumption. AID activities in SDH have been limited. As a result of current mission requests, it is clear that a centrally funded SDH skills base, resource assessment and training program are necessary for broad based implementation. Through this program activities will be carried out to create a skill resource within NRECA and make it available to outside organizations and LDC Governments.

C. Specific Activities

(1) Administration

Carry out all administrative activities of the cooperative agreement and conclude contractual arrangements with SDH specialty individuals and organizations to respond to requests for services from AID and host countries for long and short periods as necessary.

The recipient will carry out activities in collaboration with AID. Specific program activities will be jointly formulated. The recipient will formulate subprogram priorities, subcontract specific components of the work to NRECA member institutions, arrange workshops and/or seminars, identify and work with individual consultants drawn from the ranks of NRECA member institutions and carry out field support activities as necessary.

It will be the responsibility of the recipient to carry out a program that is well conceived technically, economically, and socially sound.

Reporting procedures will be established to keep AID informed of all activities being carried out. Specifically, monthly progress reports will outlined up-to-date progress, the need for decisions and actions and up-to-date technical information. DS/EY will monitor the program for conformance to AID's overall development goals. Reports will be submitted to project office in DS/EY.

(2) Project Identification

The recipient may collaborate with AID to identify potential hydropower sites in LDCs for development. Projects will not be undertaken unless they enhance the capability of the recipient.

During the initial months, a coordinated program will be undertaken by the recipient, to identify opportunities for SDH development through collaboration with AID. Prefeasibility examination and studies carried out by the recipient, will enumerate flowing water bodies suitable for SDH development of one megawatt or less which are untapped and near existing or potential future load centers in the candidate LDC's. This prefeasibility examination will focus on existing and future national energy development programs to determine the role of SDH in the country's rural electrification plans and overall energy strategy.

The prefeasibility examination would include the technical, financial, economic, sociological, institutional and environmental aspects of the project, and should be sufficiently complete to permit AID and the host country to make independent judgments of the project's soundness on the basis of the facts submitted and assumptions used. Specific recommendations for each site should be provided to the AID and the host country. Recommendations may include, but not be limited to, the following alternatives for each selected site: (1) construction of a hydro generation system as the sole source of electric power; (2) construction of a hydro generation system as a supplement to planned or existing remote diesel generation; (3) construction of nothing at all until grid power has been extended.

(3) Site Selection and Project Design

As a result of the project identification work, final site selections will be made by the recipient in collaboration with AID and host government participants. General criteria for AID's approval of the proposed project are:

- Consistency with AID's energy strategy for the proposed country or region.

- Anticipated availability of financing for project implementation.

- Existence of a local skill base which can be trained to operate the facility.

- Existence of a current or future local demand for electrical power.

- Existence of a mechanism to pay for operation and maintenance costs through the sale of electricity.

- Cultural acceptance of the concept of hydropower.

- Existence of other development projects which could benefit by the availability of electric power.

- Favorable economic and financial rate of return based on benefit cost analysis.

- Host government support and encouragement.

- No adverse social, political, economic or environmental impacts.

- Suitable physical characteristics such as the availability of stream flow, head and flow duration.

- Replacement opportunities for diesel/generator sets.

These criteria as well as others suggested by AID will form the core of a site selection criteria.

It is expected that at least one site in each of the geographic regions will be selected. Site selection may involve a analysis and design of a new project or the analysis and design of a SDH component of a renewable energy project. The amount of additional feasibility analysis required will therefore depend on how much has already been done, and that in turn will determine the extent to which the tasks anticipated below will need to be carried out. The team of specialists from the recipient may then develop specifications and prefeasibility studies and possibly detailed feasibility studies.

Feasibility studies for each of the candidate sites must include the following:

(a) <u>SDH Potential Determination</u>

For each of the designated SDH sites determine what the mean head and flow rate is for each month of the year and calculate the resulting potentially useable hydropower output for each month. State whether or not head and flow rates meet the minimum required to justify a hydro electric power installation. This analysis will be supported by stream runoff records, available period covered, and locations of gaging and meteorological stations. Based upon this hydro potential data, describe potential and projected system characters such as voltages, frequency, phases, and power factor. Project the firm or dependable small hydro KW and peaking KW capacity, and the annual KW energy output categorized as dependable and secondary energy for normal, wet, and dry years. Investigate, water and land rights peculiar to each site and determine what legal steps must be taken to acquire any necessary titles, rights-of-way, building permits, licenses, or water use permits. Estimate how long it will take to acquire such rights for each site. Determine whether or not projects are feasible based upon reasonable ease of acquisition of all necessary rights. Particularly include

in this judgment any competing use of the water for irrigation or other purposes that might inhibit or preclude its availability for power generation. Present a definitive, written recommendation for each site as to whether or not water characteristics and land and water availability justify further investigation and development of the project.

(b) Demand Forecast

For each site for which a positive hydro potential determination has been made, forecast power demand. Review and comment on present or potential power consumers; projects power consumption patterns for home and productive uses; prepare a demand forecast. Describe projected load factors, daily and seasonal demand variations, and peaking characteristics.

(c) Preliminary Design

Prepare preliminary designs for SDH and distribution systems for each approved site. Describe the basis of facility locations design, type and size of major elements, e.g., type and height of dam, size of reservoir, number, size and type of turbine - generating units, capacity of spillway, diversion tunnels, penstocks, gates; other major features of the project; capacity - are curve for the reservoir; extent and results of reservoir sedimentation and downstream channel effects that will result from project operation; required acquisition of land, reservoir clearing, relocation of roads, etc.; design allowances for flood, earthquake, and special local conditions; availability of materials for construction. If tunneling, dams or canals will be required, include reference to pertinent geological studies and site borings.

(d) Investment Cost Estimate

Prepare an estimate of the capital cost of the hydro project, specific to each site, in U.S. dollars and local currency. The cost estimate should be carried to a point which will insure that all significant factors that will determine the total investment cost of the project have been taken into account. Include land; site preparation; preliminary engineering services, including preparation of equipment; freight and insurance; construction and erection services, construction supervision, start-up assistance, training, initial spare parts and materials, license fees, other payments related to pre-operation costs, and escalation and contingency estimates. If back-up diesel generation has been determined to be required to supplement hydro generation during dry seasons, its investment cost will be included. Include the cost of distribution systems. Imported equipment will be of U.S. source and origin.

(e) Operating Cost Estimate

Estimate the average annual cost of operating each of the hydro systems, including operation, maintenance and administrative costs, labor, materials and spare parts, fuel, taxes and insurance, and depreciation charges based on the estimated useful life of various project elements.

(f) Technical Soundness Determination

Based upon the information presented and comparisons made, present definitive conclusions concerning the technical feasibility of each proposed SDH plant. The project will be considered technically sound if all pertinent technical aspects have been included in the analysis and each is positive; if the planned project preliminary designs conform to accepted engineering standards and practices; if the estimated discounted, 20-year, investment and operating cost of the project is as low as that of other alternatives that would produce the same result; (1) remote diesel generation; (2) extension of grid power. For this comparision, prepare order-of-magnitude 20 year investment and operating cost estimates for both alternatives for each proposed hydro site; describe present and planned extension of the grid in the vicinities of the proposed SDH sites.

(g) Financial Analysis

Estimate the amount of power generated by each plant to be sold during each of the ten years after start-up. Based on current laws and regulations governing rate schedules, classification of consumers, return on power investments, and local incomes and capability to pay for power, estimate the annual gross revenues resulting from power sales of this project during the first ten years after start-up. Analyze these financial projections to determine whether or not anticipated revenues would provide an adequate return on the investments and would compensate operation and maintenance costs. Provide conclusions concerning the financial soundness of the projects. A project will be considered financially sound if resulting revenues will be sufficient to amortize the investment, cover fixed charges, maintenance, administration, and operation costs, and provide an adequate return on the investment.

(h) Economic Analysis

Describe the total economic benefits of the project, including the economic value of the new power that will annually be generated, utilization of domestic labor, import substitution or reduction, foreign exchange earnings, stimulation of increased agricultural output, reduced emigration, benefits to consumers, etc. Assign monetary values to benefits to the greatest practicable degree. Compare costs and benefits and determine if the project's expected internal rate of return is adequate and at least as high as would be the case for technically feasible alternatives; i.e., (1) remote diesel generation; (2) immediate extension of grid power (3) other feasible technologies (e.g., wind, photovoltaic).

(i) Sociological Inquiry

Investigate the sociological aspects of each proposed hydro site, including: population and its growth rate, emigration factor; agriculture, commerce, local economy; family incomes, capability and willingness to pay for electric power; existing local infrastructure; community priorities for utilization of the proposed power generation; anticipated affect of electric power on the lives and production of the communities. Make a definitive conclusion concerning the social

soundness of the project for each SDH site. The project will be considered sociologically acceptable if: there is indication that an inequitable financial burden will not be placed upon the users of the project; user communities will be able to provide, or to adapt to, the new institutions that will be required to operate, maintain, and administer the facility to be placed in their midst; the local community will be involved in the design and development of the project sufficiently to assure its willingness to participate.

(j) Environmental Analysis

Investigate the environmental effects of the projects for each site and make definitive conclusions. Particular attention will be given to health problems that may result from water impoundment. The project will be considered environmentally acceptable if all pertinent and reasonably foreseeable effects of the project on the human environment have been included in the analysis and either; (1) no adverse environmental effects are projected: or, (2) those that have been identified are considered, when weighted against the anticipated benefits of the project, to be acceptable; or, (3) a way to amliorate the foreseen environmental impact has been devised and its cost has been included in the project design.

(k) Implementation Plan

Recommend methods and procedures for project execution, including: preparation of final designs and specifications, equipment procurement, contracting, engineering supervision; project execution schedule in bar chart format; related manpower requirements; availability of local construction materials; any special project execution problems; e.g., heavy lift requirements at port of entry, transport of equipment to site, etc.

In addition, during the feasibility study phase, the recipient may do comprehensive planning and institutional assessments with the goal of successfully integrating the SDH power resource into the country's overall development plans.

(4) Development of SDH Data Base

The recipient shall carry out a survey of existing SDH facilities in both developed and underdeveloped countries to determine the state-of- the-art. This survey will require the recipient to review the literature and perhaps visit appropriate SDH sites. Descriptions shall include system performance, economics, implementation procedures and management. Manufacturers of turbine/generator equipment will also be identified and their capabilities assessed.

An organized data base consisting of hydropower resources, available technology and skills resources will be assembled. Manuals, bulletins and resource directories will be prepared in appropriate languages describing SDH technology, application, economics and implementation methodologies.

(5) Training

A training program plan in SDH for LDC nationals will be developed in collaboration with AID. The training program will provide SDH training for graduated engineers at university centers and at Government institutions. Both academic and hands-on training will be considered.

D. First Year Objectives

Goals to be attained during the first year shall include the following:

(1) Identification of individuals or organizations able to provide SDH support services to the mission/bureaus.

(2) Identified projects in LDCs with attendant prefeasibility studies under way.

(3) Workshop conducted in Andean countries and distribution of proceeding.

(4) Completion of a proposal for a training program in SDH.

(5) To strengthen, refine and broaden the expertize and capabilities of the recipient to participate in and contribute toward the resolution of energy problems in developing countries.

E. Performance Evaluation

Individuals selected by AID will conduct an evaluation, following the first year of project activity, to determine the effectivenes of this cooperative agreement in enhancing the capability of the recipient.

F. Staffing

To carry out the objectives of this cooperative agreement, the recipient will assemble at least the following key personnel stationed at its headquarters:

SDH Program Director

The Director administers all SDH program activities as outlined in the scope of work.

Principal Technical Officer

The Technical Officer is responsible for the technical substance of the program.

Information Officer

The Information Officer will be responsible for all published materials related to the SDH Program as well as the organization of seminars and conferences.

G. Reports

The recipient will provide AID with the following reports as a minimum:

1. Monthly progress reports
2. Trip reports
3. Prefeasibility
4. Feasibility studies

When the oil crunch hit, Pakistan turned to small hydropower.

Thinking Small

by Allen R. Inversin

Worldwide shortages of energy, spiralling fuel costs, and the concomitant havoc they wreak on national economies have focused international attention on developing alternate, particularly renewable, sources of energy. This is particularly true in oil-importing developing countries where hard-earned foreign exchange resources are being-depleted to meet increasing demands for energy.

Hydropower is the most reliable and, potentially, least costly renewable energy technology for generating electricity. However, many developing countries have not tapped this potential, especially in remote areas where high costs and management problems are stumbling blocks.

In Pakistan, however, the Appropriate Technology Development Organization (ATDO), under the Ministry of Science and Technology, has overcome these obstacles by developing appropriate designs that cater to the conditions of a site and by involving the local community in installing, operating, and managing their own systems. Such efforts have resulted in very cost-effective installations in the 5-15 kilowatt (kW) range with costs between $350 to $450 per installed kilowatt. Since the high cost of most small hydro installations is often used as an argument against their appropriateness, this is a particularly significant accomplishment.

The 1973 oil crisis triggered interest in Pakistan in developing appropriate solutions to dependence on imported oil. One was to develop hydropower. In the remote rural areas of northern Pakistan the potential was greatest. There are two readily apparent alternatives to electrifying far-flung rural areas: extension of the national grid and on-site autogeneration of power. Each presents problems. Demographic problems from great distances separating villages, and between villages and the national grid, to the lack of income-generating activities made extension of the national grid uneconomical. When a village, even one only several kilometers from the grid, is electrified, the average cost is $50,000. On-site autogeneration of power proved too costly as well because it meant reliance on commercially-produced equipment and conventional designs. In the early 1970's, Pakistan's Ministry of Water and Power installed small hydropower schemes which, at $5,000 to $6,000/kW, were still too expensive.

To address the energy needs in these rural areas and to improve the quality of life of the villagers by providing some of the basic amenities already available to city dwellers, ATDO developed a less costly approach using available hydropower resources. The organization designed equipment suitable for local fabrication, adopted civil works' de-

A small village hydropower scheme.

signs that used local materials and local labor rather than costly machinery, and developed a less costly, decentralized management structure.

Appropriate design of individual components and the entire system is the key to low cost. Construction costs for civil works are negligible since villagers supply the necessary labor and maximum use is made of locally-available materials such as wood and stone. ATDO holds down administrative costs through its emphasis on decentralized, local management by the villagers themselves. When possible, equipment, particularly the turbine, is fabricated locally. The entire system is appropriately designed for local operation and maintenance and requires no full-time operating staff. The system is designed to require a minimum of expensive technical expertise and supervision to install it.

To generate interest in this technology, ATDO originally met with village leaders in areas with plentiful hydropower potential. Although some dismissed the idea outright, others agreed to make nominal contributions of cash and labor. The first sites developed provided impetus for growing awareness of microhydropower development potential and, requests for ATDO's assistance followed. The idea has taken hold and ATDO has helped villagers put into operation about two dozen hydropower plants. In addition, more than three dozen plants are currently under construction.

Originally, ATDO anticipated the need for a team to install each of these plants. However, after working with villagers in many communities, ATDO found a high level of enthusiasm among the villagers, and that they could learn to install the plants themselves. As a result, ATDO assigns only a coordinating team to help the villagers when necessary.

When ATDO receives a request for assistance, it determines whether there are plans to extend

NRECA: Helping to Light the World

In May, 1980, AID's bureau of science and technology implemented a technical assistance program under a cooperative agreement with the National Rural Electric Cooperative Association (NRECA) to provide a wide range of technical, economic, managerial, and training services to developing countries in the field of small decentralized waterpower. This effort, the Small Decentralized Hydropower Program (SDH), is one of the number of similar alternative energy programs.

The purpose of the SDH Program is to develop and strengthen a permanent capability within NRECA's International Programs Division (IPD) to help developing countries identify and design practical small waterpower sites and implement local, national, and regional management structures capable of effectively developing this promising rural energy technology. The SDH Program's services include providing country resource surveys, conducting regional workshops, developing assessment methodologies (particularly useful in areas where hydrologic and other data are deficient or non-existent), providing training services specially designed to meet Third World needs, and other forms of technical and institutional assistance.

NRECA, a private organization formed in 1942, is dedicated to protecting the interests of member rural electric systems and to strengthening and improving rural electrification in the United States.

With passage of the Rural Electrification Act of 1935, which enabled residents in rural areas of America to organize and borrow money through the U.S. Department of Agriculture's Rural Electrification Administration, electric cooperatives were established to serve rural areas with adequate, dependable, and low-cost electricity.

Since its inception in 1961, IPD has aided developing countries establish rural electrification projects in cooperation with AID, the World Bank, and other sponsoring donor organizations. To date, NRECA/IPD has carried out more than 300 assignments to assist in the planning and implementation of rural electrification and renewable energy development programs including cooperative rural electric programs. IPD has assisted in making 1.8 million electric connections reaching 12 million of the world's poor.

An additional 10 million people have benefitted indirectly from NRECA/IPD's work through improved public health, food production, educational and recreational opportunities, employment opportunities, and other indirect benefits which come with electrification.

IPD's services include identifying areas for development; assessing the potential for, and impact of rural electrification; helping plan the institutional framework for successful projects; completing economic feasibility studies; preparing project loan applications; serving as advisers and trainers until local personnel are ready to assume responsibility; and consulting with systems and institutions involved in overseas rural electrification programs. In addition, NRECA/IPD hosts trainees from developing countries.

the national grid to the area. Based on visits to the village, ATDO assesses available potential at the site, gauges villager interest in developing the potential, and instructs them in what will be expected of them, explaining all phases of the process.

Only after it is assured that the entire community will share in the benefits accrued from developing this potential, will ATDO approve a project. If there is any doubt, ATDO withholds or delays assistance which generally serves to encourage mutual cooperation among the villagers.

Once assured, approved, the project begins. After discussions with ATDO personnel, villagers buy materials such as cement or steel that are not available locally, and build the intake structure, forebay, canal, penstock, and powerhouse.

Villagers follow small wooden models in place of blueprints. Canals to bring water to the powerhouse are similar to those which have been used in village irrigation systems in Pakistan for centuries and, therefore, villagers are familiar with them and construction presents no problems.

When a specialized skill, in electrical work for example, is needed, the villagers must find the electricians in the towns or cities.

In designing the various components of the plant, there is a tradeoff between cost and labor. ATDO's approach suits local realities well, since labor is generally more readily available than capital. Once the villagers complete the site works, ATDO provides guidance in installing the turbo-generating equipment. The electrical generator is purchased, generally from China; this is the single largest cost associated with installing the plant. To reduce costs, ATDO has organized efforts to manufacture generators locally, and several units are being field tested.

A villager designated by the community operates and maintains the plant on a daily basis. He runs it with ATDO supervision for several days, mastering the needed skills. Since there is no automatic governor, one of the operator's major tasks is to manually govern the equipment during the night. The electrical load does not vary greatly and the largest change in load occurs as villagers retire for the night. The load remains at a fairly constant, low level through the night and the operator shuts the plant down at dawn.

Now that the technology is more widely accepted, government financing, originally used primarily to promote development of hydropower, is being phased out. ATDO is presently providing technical support and fielding about half the expense of the generator. The provincial government is assuming the balance of the cost of the generator and some distribution costs as well. Local villagers are responsible for civil works and the distribution system.

High costs are a stumbling block in remote areas.

The financial assistance from the government is not repaid. Once the plant is operational, it becomes the property of the village which is then responsible for all costs associated with operating and maintaining it.

The village leaders, or other influential individuals from the village, working in league with the community, manage the system and make operational decisions such as setting the tariff or determining the hours of operation of the plant. Although it is not formalized, there is usually an equitable arrangement based on mutual trust developed over the years. Generally this fee is not based on units of electricity consumed, thus avoiding the need for meters and meter readers. Instead, the villagers are charged a monthly rate, based on the number of light bulbs in a user's home. Village homes commonly have three or four 40 to 60 watt incandescent bulbs and are charged a monthly rate of about $0.40 per bulb.

At most sites, hydropower is used both to generate electricity and to drive machines. When electricity is generated, it is mainly for domestic consumption and is generally used for lighting. However, a number of cottage industries, many housed right in the hydropower plant's powerhouse, also directly tap the mechanical power from the turbine. This power is used to operate rice-hullers, woodworking equipment including saws and lathes, flour mills, and grinders.

The real beauty of ATDO's strategy in implementing these plants is its flexibility and, therefore, it holds promise for wider application. The low cost can be achieved even in larger plants using some, particularly technical, aspects of this approach. Plants of all sizes throughout the world use locally-available materials. And nearly all countries can find people with skills needed to fabricate equipment.

Villagers in remote rural areas often live at subsistence level and may be intolerant of change and reluctant to embrace new ideas. But ATDO's low-cost, villager-implemented plants seem to be catching on. Consumers have demonstrated a willingness to pay a monthly fee to electrify their homes and consumer interest remains strong. It may well take 50 years to provide electricity from the national grid to the 30,000 villages still not electrified in Pakistan. But ATDO has demonstrated an effective alternate means to help meet these energy needs. □

Allen R. Inversin is a micro-hydro engineer with the National Rural Electric Cooperative Assoc. This article was adapted from his "A Case Study: Micro-Hydropower Schemes in Pakistan" by the staff of NRECA's small decentralized hydro program.

small hydro

Rural power schemes in Pakistan

By M. Abdullah and A. R. Inversin
Professor and Head of Department* and Micro Hydro Engineer**

Although hydropower resources exist in remote, rural areas of many developing countries, high costs and the difficulties of operating micro-hydro schemes in these areas often discourage such efforts. However the Appropriate Technology Development Organization in Pakistan has found that when villagers install, operate, and manage their own schemes, and the turbines are built locally, installations in the 5-15 kW range can cost from US$250 to $400 per installed kilowatt.

TAPPING THE WATER resources in remote, rural areas with micro-hydro plants appears an attractive alternative to the costly extension of the national grid or to transporting increasingly expensive and scarce diesel fuel to those areas which rely on diesel generation of electricity. In addition, the potential contribution which micro-hydro plants make to rural development in these and other areas is out of proportion to the quantity of energy which can be delivered.

Problems

Of all the popular renewable energy technologies for electricity generation, including hydro, solar, biogas, and wind, hydro is the most proven, most reliable and potentially least costly to date. But hopes for using this technology in remote areas can be quickly dashed by the realities generally encountered in such efforts around the world—excessive costs and unwieldy management requirements.

With the exception of some schemes installed by private groups or individuals, implementation of small hydro schemes has often followed the conventional pattern used with large schemes—several levels of feasibility and engineering studies, conventional capital-intensive designs, imported hardware, construction firms and labour from outside the area, and overseas consultants. Working under this premise, economies of (large) scale are inevitable. Small hydropower schemes therefore are bound to be too expensive.

In addition, to have a significant impact on a nation's economy, a large number of these small schemes need to be implemented. But, if this is to be undertaken by a centralized, national utility, the vast logistical and managerial complications in implementing, operating, and maintaining these would be formidable.

Alternative approach

If any of the potential for micro-hydropower is to be developed, these problem areas must be addressed with a new approach. The Appropriate Technology Development Organization (ATDO), under the Pakistan's Ministry of Science and Technology, has been tackling the problem since the mid-1970s. There are already 22 5-15 kW micro-hydro schemes operating in the mountainous regions of northern Pakistan, and it is now being demonstrated that electricity can be generated at low cost and that schemes can be successfully managed and maintained by the local villagers.

This approach is proving contagious. In Lillonai, the first village to have an ATDO installation five years ago, four plants are now operating. In a small valley around Bishband, only accessible by foot, three plants have been installed. A dozen schemes with outputs of up to 50 kW are under construction at present.

Generating equipment for the Lillonai plant; the penstock is made of oil drums, and the turbine is located under a wooden cover.

With the increasing number of installations around the countryside, there is a growing awareness among villagers of the potential of hydropower. The ATDO is receiving an increasing number of requests for assistance. In each case, if no extension of the national grid is planned for the area in the foreseeable future, one or two individuals from the ATDO micro-hydro team visit the village and assess its potential for hydropower development. The team discusses all aspects of the project with the village leaders to make them aware of their obligations and understand their role. If villagers' interest is widespread and genuine, the project goes ahead.

Construction of the civil works and purchasing the necessary materials are undertaken by the villagers. No engineering drawings are prepared. Small wooden models have been used to convey the design of some of the components. No critical dimensions or designs are included in the overall plan. The villagers are already familiar with the technology since irrigation canals and traditional water-powered flour mills have been used in

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The Bishband powerhouse. Note the dry-rubble masonry forebay structure and wooden penstock.

the area for generations.

During the course of the site work, the ATDO provides technical guidance when necessary, while the turbine is being manufactured in a town. The turbo-generating equipment is installed by the villagers under the guidance of the ATDO. If the villagers apply themselves and no disputes over the land arise, a project can be completed in 3-4 months. Village leaders hire an individual from the village to operate and maintain the scheme. Decisions such as those regarding the tariff structure and the operating hours are made by the villagers.

Designs

For the civil works, designs which minimize cost and maximize villager labour inputs have been adopted. Local materials are used whenever possible.

The intake structure is a replica of the innumerable intakes to small irrigation canals dotting the region. A low stone weir is constructed to deflect the flow into the unlined headrace. An advantage of this type of intake, in addition to low cost, is that it can be washed away in times of floods, letting the water and river-borne debris pass downstream unhindered, and then can be easily replaced.

The penstocks are usually 5-15 m long and, to facilitate manufacture, no bends are included. Conventional steel pipe is used for heads of over about 6 m, and a valve is included just before the nozzle. For lower heads, non-conventional but more readily available materials such as wood or oil drums are used. In this case, flow is

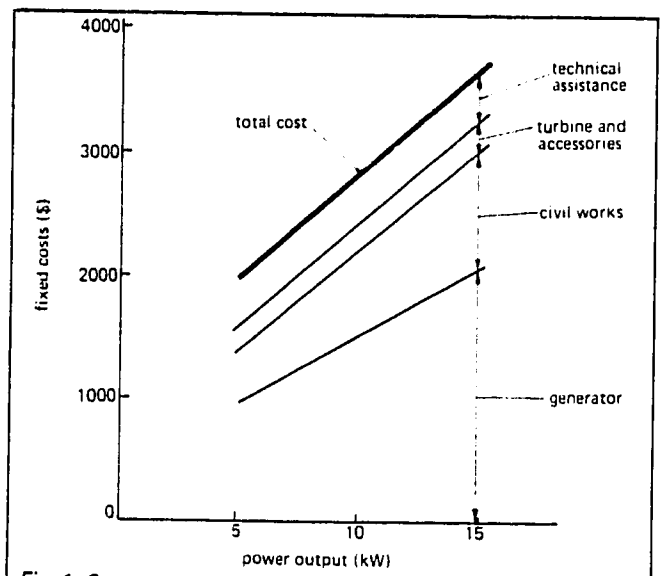


Fig. 1. Cost breakdown and ATDO schemes installed to date.

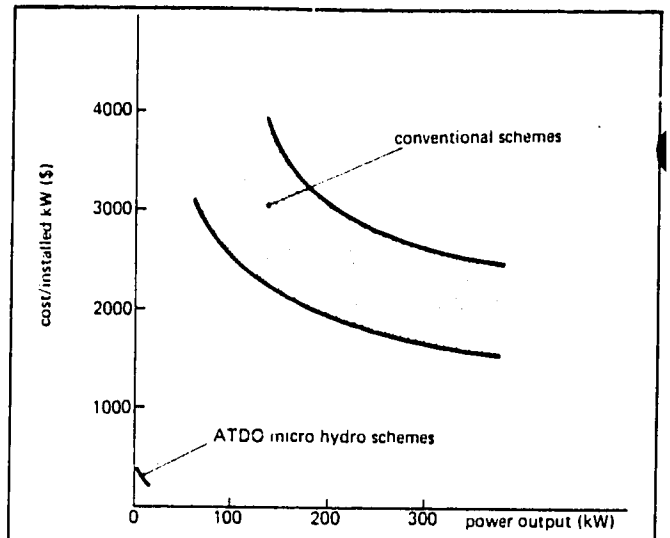


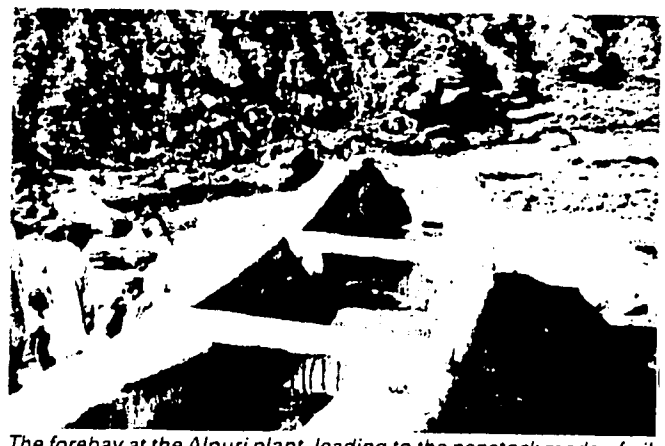
Fig. 2. Comparison of costs of conventional schemes with those installed with ATDO assistance.

controlled by placing boards across the inlet to the penstock. The penstock ends with a rectangular nozzle. To minimize penstock length and avoid bends, the forebay, often built of dry-rubble masonry lined with concrete, is built as close as possible to the point directly above the turbine.

The turbine is a cross-flow type, made of vanes shaped to the proper curvature by hammering strips of steel. With some units, vanes cut from suitably sized pipe have been used. These are then welded to circular end-plates mounted on the shaft. Turbine efficiencies of 50-60 per cent have been measured in the laboratory as well as in the field. Shaft bearings are secured on concrete below the floor level of the powerhouse. The nozzle is fixed independently of the turbine, with clearances of up to about 2 centimeters between the two. No governor is included in the design. Instead, the power input is manually controlled with a gate or valve along the length of the penstock.

The generators commonly used are made in the People's Republic of China, generating 220/380 V, three phase at 1500 rev/min, and are the most costly item. The University of Engineering and Technology at Lahore, under a grant from the ATDO, is at present designing and testing generators for local manufacture in an attempt to reduce costs, and savings of about 25 per cent are now anticipated.

Electrical power distribution is at the generating voltage. Most of the electrical load is for lighting, with three or four 40-60 W incandescent bulbs in most homes. A monthly tariff of about US$0.40/bulb is charged. At



The forebay at the Alpuri plant, leading to the penstock made of oil drums.

one site, an arc-welding unit is used; at another, an electrically driven wheat thresher/corn sheller is operated in the fields. It is moved to convenient locations around the village and electricity is tapped from a nearby distribution pole. Besides the generation of electricity, cottage industries have been established which use direct mechanical power from the turbine to drive a variety of tools. These include flour mills, rice hullers, band saws, wood lathes, cotton gins, corn shellers, and workshop grinders.

Costs

A breakdown of costs for micro-hydro schemes installed to date is given in Fig. 1. The unusually low cost per installed kilowatt (Fig. 2), ranging from US$250-$400, arises from several factors:

- low administrative costs;
- contribution by the villagers of most of the labour;
- maximizing the use of local materials;
- local fabrication of some of the equipment;
- appropriate system design (that is, no attempt to maximize system efficiency, no governor, no full-time operating staff); and,
- minimal use of costly technical expertise and supervision.

At present, the ATDO and provincial governments share the cost of the ATDO's technical services and turbogenerating equipment. The ATDO is working with the provincial department of cooperatives so that loans can eventually be advanced to village groups. Based on a plant life of 25 years, interest at 13 per cent, a plant factor of 30 per cent and distribution losses of 5 per cent, costs/kWh delivered range from 20-40 mill. Consequently, with the tariff structure now in general use, it is possible that schemes could be installed with virtually no government subsidy if loans could be arranged. This would be a break with the prevailing worldwide trend of cumbersome and costly government management. □

small hydro

Small and low-head hydro in the USA

By R. W. Gillette
Director of Hydropower Engineering*

The recent history of hydropower development in the USA and a review of how different projects have been pursued demonstrate how the country is working to decelerate the rate of increase of the cost of energy and reduce its dependence on foreign supplies.

TO ENCOURAGE new hydroelectric power generation projects in the USA, a variety of federal programmes have been instituted to provide incentive grants and loans as well as other inducements. The main intent of such legislation has been to demonstrate the opportunities in small hydroelectric power generation and to serve as a catalyst, encouraging the development of this resource.

Specifically, 12 bills dealing with small or low-head hydropower were introduced during the 95th Congress (1977-1978). Key provisions of these bills become part of the National Energy Act in 1978.

Partially as the result of this supportive legislation, commitment to hydropower development is growing. In addition to the studies sponsored by such federal funding programmes, projects are being pursued that derive their financing from other sources, usually utilities or municipalities. Regardless of where the money comes from, energy planning projects around the country are considering the benefits of generating electricity using hydropower wherever possible.

The Lake Redding project

Redding, California, is a rapidly growing community of 42 000. It has distributed electrical energy since 1921, but does not now have any generating capability. Electricity for the city's customers is bought from the Western Area Power Administration. By the mid-1980s, however, this will be surpassed by the needs of Redding's increasing population. To meet its load growth, Redding will then either have to buy electricity from other sources or develop its own generating facilities. So, faced with this predicted shortage, the city investigated several possibilities, one of which involved the development of a small hydroelectric generating plant.

A survey was conducted in 1976 to evaluate 19 potential

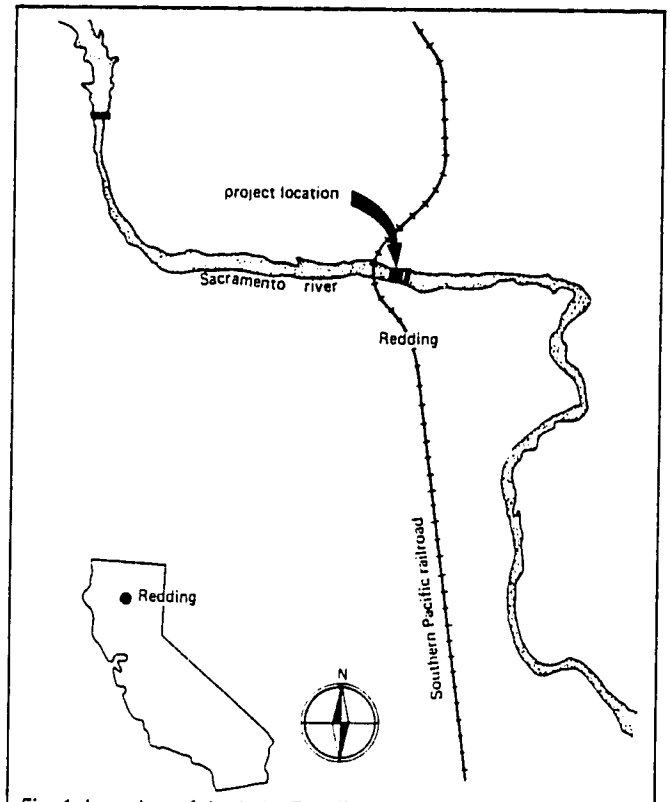


Fig. 1. Location of the Lake Redding power project

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Artist's impression of the proposed Lake Redding project.

small sites in the Redding area. One of these, Lake Redding, was selected for further study and development. The lake is formed by the Anderson-Cottonwood Irrigation District (ACID) dam, on the Sacramento river. This dam creates the water drop that will be used by the Lake Redding project, see Fig. 1.

Project details. The Sacramento river at the ACID dam is subject to regulation by the Shasta and Keswick dams and receives inflow by interbasin transfer from the Trinity river. Flows vary widely in response to the operation of the Shasta and Keswick dams. The mean annual flow is 300 m^3/s (10 800 ft^3/s) with a minimum of 71 m^3/s (2536 ft^3/s) and a maximum of nearly 2300 m^3/s (80 000 ft^3/s) since 1964, when the Trinity river project began operation. Summer season flows average approximately 340 m^3/s (12 000 ft^3/s) for the same period.

The district diverts up to 11.3 m^3/s (400 ft^3/s) at the site for irrigation of bottom lands on the west side of the valley between Redding and Cottonwood. The dam, constructed in 1916, is a 137 m- (450 ft)-high structure consisting of two abutments and 69 concrete piers on which removable steel A-frames are mounted to support timber stoplogs.

Each spring, at the beginning of the irrigation season, usually in March or April, the stoplogs are installed to raise the upstream water level and activate the diversion. In November, the stoplogs are removed to allow passage of winter flood flows with minimum damage to the structures and adjacent properties.

With the stoplogs in place, the dam creates a head of about 2.4 m (8 ft). This does not produce optimum economic power generation for this site. Studies were made of increasing the head by raising the forebay elevation, by lowering the tailwater elevation or by both. It was determined that the amount of head to be gained by either action alone would be limited, but that together they could be used to advantage.

Raising the upstream water level will require construction of a new higher dam to replace the existing structure. This will consist of four 4.3 m × 35 m (14 ft × 115 ft) bascule gates on a concrete sill. The gates, under continuous monitoring and capable of being opened by remote control, will enable the water to be used for power generation even during winter months, except during periods of flood. In the down position, the gates will offer minimal resistance to flood flows.

Aesthetic considerations enter significantly into the selection of this type of gate. Because the waterfall and pool created by the existing dam are focal points of a city park and recreation complex, it is essential to retain the appearance of the waterfall.

Two factors limit the elevation to which the forebay may be raised. Damage to structures along the river banks could result if the forebay is raised above el. 150 m (492 ft), which is the established high water

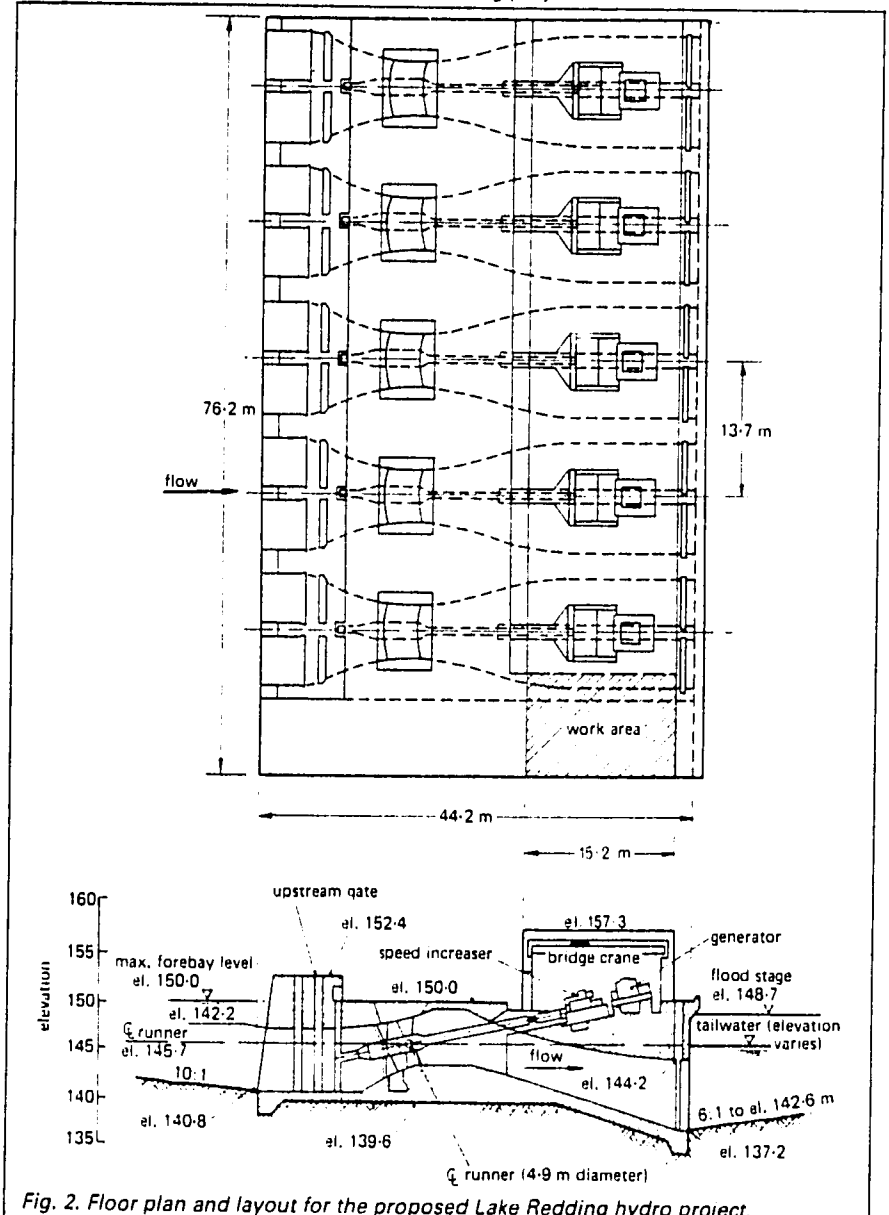

Fig. 2. Floor plan and layout for the proposed Lake Redding hydro project.

NRECA'S SMALL HYDRO ACTIVITIES IN DEVELOPING COUNTRIES

By

Bard Jackson, Principal Engineer
Small Hydro Development
NRECA

The National Rural Electric Cooperative Association (NRECA) and the United States Agency for International Development (AID) entered into a Cooperative Agreement to enhance NRECA's capabilities in small hydropower technology and to make the expertise available to developing countries. This paper will summarize NRECA's experience with small hydropower in developing countries under the Cooperative Agreement. Another paper, by Dr. Zoellner, will generalize from our specific country experience, to present an overview of small hydro potential in the third world.

NRECA INTERNATIONAL PROGRAMS

The National Rural Electric Cooperative Association is a service organization for nearly 1,000 rural electric systems serving more than 25 million consumers in the United States. In addition to the management and technical assistance it has afforded the rural electric systems in the United States, NRECA has provided assistance in 36 countries of Asia, Africa and Latin America installing nearly 1.8 million electric connections, serving 12 million consumers. More than 160 Rural Electrification Specialists have helped develop more than 196 rural electric systems overseas. In addition, they have provided specialized assistance to existing systems and have participated in the creation of several national rural electrification programs

since 1961. During this same period, more than 360 representatives of 34 countries have received organization and management training tailored to meet their needs.

AGENCY FOR INTERNATIONAL DEVELOPMENT (A.I.D.)

A.I.D. began its energy program development effort in 1978 offering technical assistance to developing countries to contend with their energy needs. The centrally funded program has systematically evolved into a comprehensive program aimed at helping developing countries increase their energy supplies and better manage their energy resources. The programs require specialized and intensive efforts requiring AID to seek U.S. private and public sector involvement in energy assistance activities.

Training is a significant portion of their energy program. The scarcity of personnel to plan, implement and manage energy activities is recognized by AID, the World Bank and other donors as a major impediment to effectively contending with energy problems.

THE SMALL DECENTRALIZED HYDROPOWER (SDH) PROGRAM

In May of 1980, the International Programs Division of the National Rural Electric Cooperative Association (NRECA) entered into an cooperative agreement with AID to enhance NRECA's technical capabilities in the area of small (1 MW or less) decentralized hydropower and to make this expertise available to developing countries.

The SDH Program has been funded for an initial eighteen month period (May 1980 to October 1981). As the SDH base grows and study methodologies are developed and refined, it is hoped that the program may be expanded to include other funding sources.

In order to facilitate the application of SDH technology throughout the world, teams of specialists have been assembled to provide in-country consulting services in areas such as plant siting, project design, economic and technical feasibility studies, environmental/social impact analysis, and institutional development. A wide variety of informational and instructional programs have been developed by the SDH/Washington staff.

SDH PROGRAM ACTIVITIES

The main provisions of the cooperative agreement are:

1. Program Identification: identification of potential hydropower sites in developing countries, determining the role of SDH in a country's over-all energy development program, examination of technical, economic, sociological, institutional and environmental aspects of SDH projects.

2. Site Selection and Project Design: development of analyses and designs of new projects or of the SDH component of renewable energy projects including evaluation of hydrologic potential, demand forecasting, preliminary design of generation and distribution facilities, technical feasibility studies, sociological inquiries, and environmental analyses.

3. Training and Information: development of training programs, workshops, and conferences on SDH for engineers, planners, and technicians from developing countries. These activities include classroom as well as hands-on training.

4. SDH Data Base: surveying of existing SDH facilities in both developed and developing countries to provide descriptions of

system performance, economics, implementation procedures and management. The SDH staff is also identifying and evaluating equipment manufacturers; developing a "skills bank" of qualified SDH specialists and compiling a library on SDH technology.

Since May, 1980, NRECA has completed small hydro assignments in Asia, Africa and Latin America. The following is a brief summary of projects that we have undertaken.

LATIN AMERICA

Peru. In July, 1980, we sent a team of Spanish-speaking specialists to Lima, Peru to assist the AID Mission in formulating their Project Paper for a program in Small Scale Hydropower development. The program was designed to promote rural and regional social-economic development through reasonably priced hydro-generated electrical energy and to provide technical assistance to the mini-hydro program within the Ministry of Energy and Mines.

The NRECA team consisted of an economist, a social scientist, an engineer, and environmental specialists. Their task was to develop specific sections of the AID Project Paper and supervise the preparation of feasibility studies for two proposed mini-hydro sites being developed by ELECTROPERU, the Peruvian national electric authority. The approved Project will lend to the Government of Peru US $9 million to finance feasibility studies, civil works, equipment, and local distribution systems for approximately 28 small-scale hydroelectric installations in the 100 to 1,000 kW range. In addition, a grant of US $1 million was included for institutional assistance, prefeasibility studies, and a program for productive uses of electricity.

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Panama. NRECA sent a micro-hydropower specialist to Panama in June 1980 to assist the AID Mission and the Institute of Hydraulic Resources and Electrification (IRHE) in planning a country-wide micro hydropower program.

In November 1980, I traveled to Panama to review the design and status of two micro hydro demonstration sites and arranged for the purchase of a 10 kw and 50 kw turbine generator sets.

Approximately 100 rural communities in Panama have expressed strong interest in having a mini hydroelectric unit installed in their area. AID is working with the Panamanians to identify the 40 most feasible sites.

Other. We have made some lesser efforts in Dominica, Ecuador and Bolivia and are beginning a large program in the Dominican Republic.

ASIA

Thailand. The AID Mission in Bangkok requested NRECA technical assistance with prefeasibility investigations of potential small hydro sites throughout Thailand. Thirty-nine sites were identified for consideration.

The NRECA team characterized the thirty nine sites according to physical characteristics and potential demand structure. From this ranking they choose six sites for prefeasibility studies according to the following criteria:

A. Priority of area development;

B. Potential for productive uses;

C. Replacement of existing diesel generating sets;

D. Sites with no potential for grid connection;

E. Sites which appear to have favorable benefit to cost ratios; and

F. Potential for co-financing

NRECA also provided the services of a small hydro electro-mechanical engineer. He worked with engineers from the National Energy Authority and help them in selecting appropriate governors and determining if they could be manufactured in Thailand.

Other. Additional work is starting in Bangladesh and Indonesia. NRECA is also supplying information to Papua New Guinea, Philippines, Nepal and Burma which all have active on-going small hydro programs.

AFRICA

Togo. In April NRECA sent a 3-man team of specialists to do a major country-wide feasibility survey of small hydropower potential of Togo. The team included a hydrologist, a small-hydro/electrical engineer, and a socio-economist, identified a number of potential sites.

They found very little potential for small hydro in Togo.

Liberia. The Government of Liberia in cooperation with AID/Monrovia has requested NRECA assistance in setting up a training program for small hydro electrical maintenance staff for a small hydro project at Yandohun, Liberia. We will soon send a team of specialists to begin preparations for implementing this request.

We also proposed a rewriting of the bid specifications for Yandohun to insure that high strength materials be used and that the electrical equipment be appropriate for tropical, remote location. In addition, NRECA suggested that the Mission not proceed with their underground distribution plan as future operational and maintenance problems would likely be unmanageable.

Zaire. In March 1981, NRECA sent two engineers to Zaire to assist the AID Mission in evaluating several proposed small hydro projects. The engineers visited sites throughout the country and generally found them to be feasible, worthwhile projects. They discussed the projects with officials from the Government of Zaire to assess the possibilities of a national Small Hydro Program. At the end of the assignment, a report was left with the Mission which outlined several options open to AID for a Small Hydroelectric project. The options ranged from financial assistance at selected sites to a massive multi-donor program involving institutional building, training, and introducing productive uses of electricity.

Also, a group of individuals from Northwestern United States raised the money to install a small hydro unit in Nundu, Zaire for a church hospital. NRECA provided technical assistance to the group and located some possible sources of additional funding for the project.

Morocco. AID/RABAT requested the services of a small-scale hydro specialist to assist the Mission in reviewing the Moroccan country assessment performed by a large engineering firm.

NRECA provided a small-hydro specialist to review the large "Grand Coulee" type of civil works in the project. Smaller structures improved the economic feasibility of the hydroelectric program and were incorporated into the program. Three potential sites were identified for development and site data collected. In November, NRECA sent an engineer to Morocco to supervise a survey team which developed the site profiles and preliminary layouts.

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PROBLEMS ENCOUNTERED

The problems encountered are classified as either technical, socio-economic, institutional or financial.

Technical Problems - The technical problem we faced most often is trying to size mini-hydro turbines with almost no stream flow data. The lack of records has forced us to rely heavily upon interviews with local residents and visual evidence of high water levels. Such methods are not dependable and expose the project to high risk either from inadequate flows or inadequate spillway capacity during floods. We've dealt with these problems by sizing the unit conservatively, and designing the intake structure such that if it get washed out, it can be replaced easily.

Another techical problem with every project we have worked with that has gone into the construction phase, is underestimating the time required for construction; particularly the purchase and shipping of materials. While waiting for one material, other on-site materials start disappearing and the problem compounds into major delays, cost overruns, and lots of finger-pointing.

NRECA has been asked to review projects that had started with a poor design. These units were under 50 kW making it difficult to justify consultants to review the design. The high engineering cost per kW for mini-hydro is a major roadblock, and the reason most large engineering firms don't know mini hydro technology. A good mini-hydro handbook does not exist that shows the non-specialist good designs and explain why they must be followed. We're starting to put one together.

Socio-Economic Problems - The basic economic problem we run up against is that the local rural people generally can't afford the cost of electric service. This means someone has to subsidize projects that have a rural electrification component. Unless rural people have the credit to purhcase electrical equipment, the output power usually will not be put to uses where a direct economic return can be seen. A project that just supports residential and street lighting will have a hard time gaining financial independence.

We have run across an interesting problem in developing countries that have their own oil or gas resources. They held their internal energy prices so low, that small hydro couldn't compete with the diesel-generator or gas-turbine alternatives. The alternatives must use the opportunity cost of selling the oil, or natural gas to make small hydro option attractive.

The major social problem we have encountered is that electrification is only one part of a development package, and many other parts are needed before and after electrification in order for development to progress. Many parts of Africa are socially not ready for electrification, even though enormous potential for small and mini hydro projects exist.

Institutional Problems - Our Institutional involvement with mini-hydro programs has been primarily in the initial organization phase of projects. We are just beginning to get into the actual operation and maintenance phases.

The problem we've encountered is in selecting the appropriate institutions to carry out a national mini-hydro power program. In some instances more

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than one agency wanted the mini-hydro program, and in others, no one wanted it. Most countries have the equivalent to a Department of Energy, a national utility, a rural development agency, and an "Appropriate Technology" type of organization; all which might be implementing agencies. Our Management Study is a tool for Institutional Advisors that we send to do institutional planning. The Study has looked at numerous SDH installations and has attempted to typify successful programs, and management structures, as a function of the country characteristics. The Advisor will be able to survey local characteristic, find the recommended management structure, and look for the institution that best fits.

Usually, the national utility is the only agency set up to operate and maintain the units. However, in one instance, they were not interested in managing units under 100 kW. One solution was to create a new department within the utility for small decentralized energy systems. In another instance, the utility had such a bad track record of poor management that donors wanted to avoid loans with the national utility all together.

Financial Problems - Obtaining financing is one of the biggest problems facing developing countries with small decentralized hydro potential.

Due to the economic problems of rural electrification, some sort of central government support usually is necessary. Then the government generally looks to development banks or institutions for funding. Development banks generally don't look at projects under $5 million so potential mini-hydro sites must be grouped into a loan package through the central government. This means the institutional problems discussed earlier must be resolved before funding takes place.

Lending institutions have had many years of experience in funding large hydro sites and have developed their set of requirements for feasibility studies. The same concerns exist with small hydro installations, but it is not reasonable to demand the same degree of studies and field investigations. On mini-hydro sized sites, the cost of doing the feasibility studies, as they are now done, can kill a project.

Small communities that don't want the central government controls that come with central government funding, generally don't know where to turn for financing. In our Financial Study we list possible sources and their loaning criteria.

One financing problem faced in most countries where AID works is coordinating a substantial small hydro program between several different donor institutions.

As an example, we don't know what the UNDP is doing in small hydro, and I don't think they know all that we're doing. Each donor agencies wants to fund the most feasible sites - rather than sharing the risk with a mix of less feasible sites. Each donor also has strings attached to loans which often contradict a good program. As an example, donors will require purchasing equipment from the donor country, when the mini hydro program is trying to standardize their installations with equipment from another source. Coordination among the donors and the development banks needs to be formalized.

CONCLUSION

We have attempted to learn not only from the problems we have encountered, but from those encountered by organizations installating and operating SDH units. We have conducted several case studies of successful and un-

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successful installations worldwide and can draw upon those studies when designing future programs. The problem encountered and lessons learned from our case studies could be the subject of another paper.

There are hundreds of locally controlled, decentralized auto-generating systems currently in operation worldwide. The exact number is unknown and documentation on most of these units is nonexistent. Many small hydro units have been in operation for decades with apparently excellent results. We hope our program will expand the number of these systems and make a significant impact on the fuel usage profile of numerous developing countries.

SMALL HYDRO POTENTIAL IN DEVELOPING COUNTRIES

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INTRODUCTION

Flowing water has been used for centuries as a source of energy. Water wheels of various types launched the industrial age by contributing energy other than human and animal muscle power. Hydropower is a well established, proven technology. Reliable performance expectations can be made, with efficiencies of site specific equipment now reaching as high as 95%.

The technical simplicity of small hydropower systems is a primary advantage. Moving parts are few in number and many can be fabricated locally. This is significantly important for the successful introduction of small hydropower systems into remote, rural areas of developing countries.

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A large, yet unexploited, hydropower potential exists worldwide. This renewable energy resource is one of the most promising energy options for developing countries, which on the average have developed less than 7% of their potential. (Armstrong, 1980).

Relative to other renewable energy sources, mini-hydropower is more immediately available and converts directly and easily to mechanical, electrical, and thermal energy. Wind power, while more widely distributed than hydropower, yields relatively low amounts of energy and requires large structures. At isolated sites, storage facilities must also be provided to make up for high variability. Harnessing solar power through photovoltaic cells requires no moving parts but only produces electricity, and storage needs must be met. Photovoltaic cells and other solar hardware are still expensive and cannot be produced locally. The caloric energy value obtained from biogas production from dung is actually greater than burning an equivalent portion of dung, and a valuable fertilizer is also produced. But this energy source relies on often touchy biological processes and requires a large feedstock to replenish the digestor and receptive social conditions in order to implement it. Biomass is the most conventional renewable energy source and is one which can be developed with the least capital and technological inputs. It is potentially accessible to all at virtually no cost. But in many less developed countries, the natural ecosystem is suffering from overuse of this once-plentiful resource. Problems of deforestation, top-soil erosion, and heavy silt deposits in riverbeds and behind dams are pointing out the need to reforest large areas and to find a rural energy source which can be, at least partially, a substitute for biomass until the forests can again be harvested under properly managed schemes.

Small-scale hydropower is also a wise alternative to petroleum and other imported fuels. Foreign debts of many developing countries are being aggravated by escalating prices brought about by a dependence on limited and increasingly expensive supplies of

petroleum fuels. On the other hand, the initial investment required for small hydropower schemes can be quickly repaid because recurring costs are low, and the fuel, available in the rural as well as urban areas is virtually free.

The underlying concern for developing rural hydropower systems is the need for an indigenous, reliable energy source that is affordable. Such an energy base can act as a catalyst for the development of other local resources and the creation of productive opportunities, breaking the poverty cycle so common in rural areas of developing countries. This leads to potential improvement in the well-being of the rural poor on a long-term basis, rather than short-term "band-aid" development approaches that treat symptoms only and must be repeated over and over again.

EXPERIENCES TO DATE

With an increasing awareness of the effect of a dependence on imported petroleum-based fuels on a nation's economy on the one hand and the potential of small hydropower plants on the other, a number of countries have recently begun considering this power source in earnest. Previously, it was often individuals from the Western countries who, because of their access to financial resources or possession of specialized skills, first installed such plants in the developing countries. One finds, for example, numerous mission stations as well as old gold mining sites throughout Papua New Guinea, all installed and operated by expatriates and utilizing expensive turbo-generating hardware available decades ago. In Colombia can be found a number of small foundries which have been casting runners for decades as well as numerous skilled and resourceful individuals, generally of overseas origin who have installed their own plants.

More recently, national governments have taken an increased interest in exploiting their hydropower potential by means of small plants. The People's Republic of China is the first and only country to undertake this on a large scale. To date, more than 50,000 plants under 500 kW capacity have been installed, most of them built by the people's communes at the county level and used by the commune members, supplying electrical power for local industries and small workshops. Whereas virtually all hydropower generating sets were previously imported, China began local manufacture of a wide range of turbines in the early 1950's. In the early 1970's, standardization of turbo-generating equipment with outputs 12-12,000 kW was undertaken. Recently the Tianjin Electro Driving Institute has developed small compact turbo-generating sets from below a kilowatt to 20 kW. Thousands of these are produced annually. In the construction of their plants, stress is placed on maximizing use of locally available materials. This results in low costs, ranging from 1-3 cents/kW, and a return of investment for a small hydropower station of 3-4 years (Jing and Li, 1979).

In the Asian region, a number of other nations have initiated small hydropower programs.

The State Electric Power Company (P.L.N.) in Indonesia began the installation of small hydropower projects with their Five Year Plan of 1969. Over the first ten years, 26 plants with capacities up to 500 kW were installed and contributed a total of 4 MW. Another 8 plants with a total capacity of another 3.5 MW were still under construction. Initially the aim was electrification of isolated rural areas with units whose capacities ranged up to about 100 kW. However, with the growing global energy crisis, present efforts are focused on larger units, on interconnection with the grid, and on optimizing and maximizing plant capacity. Many of the turbines are manufactured locally in one or two large workshops. Small workshops are entrusted with fabrication of turbine

components (Elliott, ed., 1981). Several groups are involved in addressing needs of remote isolated communities through the development of small micro hydro systems.

In 1979, the National Electrification Administration, which had developed a nationwide system of locally owned and operated electric distribution cooperatives in the Philippines was assigned the task of executing a mini-hydro development program. Less than three years later, it has placed five power plants in operation, initiated construction on five more sites, placed equipment orders for about 20 plants and have completed 45 feasibility studies. Initially overseas firms are supplying most of the electro-mechanical equipment but within the next several years, a majority of the equipment should be manufactured locally. By the end of 1987, at least 250 plants with a total installed capacity of 300 MW are expected to be operational. (Elliott, ed., 1981).

Urged by the looming firewood crisis and the need to assist rural development, the government of Nepal has initiated a small hydropower program and 20 schemes, from 60-1000 kW, are under various stages of design or construction. (Elliott, ed., 1981). Several private companies have developed designs for small cross flow turbines with the assistance of expatriate expertise and these are being installed at an increasing pace, primarily to directly drive agricultural processing equipment in the remote parts of the country. More than 50 plants, with capacities averaging 10 kW, have been installed to date. Only the processing equipment and bearings are imported from India.

Pakistan's Appropriate Technology Development Organization has also been involved with installation in the remote northern areas of the country. These involve rudimentary, locally fabricated, cross-flow turbines used to drive both generators and a wide variety of agricultural processing and workshop equipment. All aspects of installation, operation, maintenance, and management is undertaken by the local villagers. This

coupled with the use of locally available materials wherever possible contribute to the unusually low total installed cost of US$250-400/kW. (ATDO)

Several agencies of the government of Thailand have recently embarked on small hydropower programs to tap the resources in the rural, mountainous portions of the country. Whereas most of the equipment used to date has been imported, the National Energy Administration is developing and testing turbines in the micro range. Several have already been installed to date.

Whereas there are scores of private micro-hydro installations through the rugged mountains of Papua New Guinea, it is only recently that the national government has become involved. It is presently involved in the installation of four plants with outputs ranging from 200-500 kW. In order to reduce the costs of small units, the Appropriate Technology Development Institute and the University of Technology are involved in the design, testing, and fabrication of turbines and related equipment and in their installation in village settings. (Elliott, ed., 1981).

Other developing countries is Asia, including Sri Lanka, Malaysia, Fiji, and Turkey have also been involved in some aspects of research or implementation of small hydropower schemes.

Some work has also be undertaken in Latin America.

History in the use of small hydro plants in Colombia extends back to the end of the last century. To this date there are numerous small foundries which can cast turbines and fabricate and install hydro units. At the national level, the Instituto Colombiane de Energia Electrica (ICEL) has been charged in 1973 with the development of small

hydropower schemes up to 10 MW to cover some of the many areas which will remain with no possibility of grid electricity. After making a preliminary survey, further studies were justified at twenty sites and a dozen schemes in the 40-1,000 kW range are presently in the feasibility and design stage, with the work being undertaken by five national consulting firms. (C.CH.LG. Ltda, 1980).

Before launching the national grid, fifty small hydropower plants were installed throughout Ecuador. Many of these have been superceded by the grid. At present efforts by the Ecuadorian Electrical Institute (INECEL) are underway to initiate a small hydropower program which would include refurbishing some of these old sites. (USAID,1980).

In 1978, a program was initiated by the Ministry of Energy and Mines in Peru to undertake all aspects of new and ongoing small hydropower work. The following year, activities from feasibility studies through to actual site construction of both new and reactivitated projects at 38 sites were undertaken, with capacities of from 80 to 2,000 kW, averaging 400 kW. (Ministerio de Energia y Minas, 1980).

To date there seems to have generally been little work done to date in Africa in the area of small hydropower. A number of mission stations in remote areas in the central and eastern portions of the continent have installed small schemes.

SYSTEM VARIETY

There are several ways of classifying or categorizing small hydropower plants. One of the most common is based on system capacity. Plants generating under about 100 kW are

classified as "micro". These are generally found in remote areas far from the main grid. They may serve rural communities, hospitals, mission stations and government outposts. These installations might be very capital-intensive but they often need not be. Local materials may be used for a large part of the scheme, and these units can often be designed simply and fabricated in-country. These schemes are often managed and operated by local personnel. Plants above the micro range, up through about 1000 kW are generally considered "mini". These are often installed to serve small towns and it becomes economically advisable to consider connecting these units on to the national grid if it is readily accessible. Proper management of these plants becomes more complex but increasingly essential. Larger civil works are generally required and the turbo-generating and control hardware become more sophisticated, often with less of an opportunity for local manufacture.

In each of these two categories, hydroplants can be classified according to their requirement for water. They can either be run-of-the-river schemes or else require impoundment. Where the river flow is more than sufficient to meet the power requirements year-round, a run-of-the-river scheme can be constructed. This simply involves the diversion of a portion of the flow in the river through the intake to the hydro scheme. No dam is usually necessary though a permanent weir can be built across the river bed to prevent the gradual lowering of the river bed in the vicinity of the intake through erosion over the years. In areas where no noticeable lowering of the bed is apparent, a weir may be built simply to ensure that the water is diverted toward the intake during periods of low flow.

A scheme requiring impoundment may be required either in regions of pronounced dry periods during which time the flow of the river is not adequate to supply the power requirements or on streams where the flow is more than adequate during one portion of

the day but insufficient during another portion due to increased power requirements during that time. Schemes requiring impoundment require the construction of a dam and these require careful design and site location.

These schemes can be further classified according to head requirements. A low-head installation requires a larger flow of water than high-head sites for the same power generation. This implies larger and therefore more costly turbines and the necessity of tapping a large river. With the large and intense rainfall in many parts of the tropics, tapping large rivers can lead to major problems with the intake structure. The intake must be able to handle a river whose depth may vary widely and which often transports large quantities of debris, of tree trunks, boulders, gravel, and sediment. Also because of the requirement for higher flow, if an impoundment is required, it must be of a much larger size than an impoundment for an equivalent power, high-head site. More thought need then be placed on the technical and environmental implications of such a large inmpoundment.

A high-head site, on the other hand, would require lower flows to produce the same desired power and possess a number of advantages. The lower flow implies the need for a turbine smaller in physical size and cost. It also means that a smaller source of water need be tapped, simplifying the design of the civil works at the intake.

INTEGRATED SYSTEMS

The cost of the civil works for small hydropower schemes often accounts for a large portion of their overall costs. This is especially true when more conventional approaches are adopted as, for example, in the heavy use of concrete for headrace canal and the use

of relatively large dams or weirs. It is however possible to integrate small hydropower schemes into broader water-related projects — flood control, irrigation systems and water supplies — and thereby share costs of the common components among several projects.

Indonesia has, for example, a large irrigation network on its most populous island of Java. Integration into that system has been a part of its small hydropower program. This integration has taken two forms:

1. Circumventing the water around existing irrigation drops. A plant at Wonodadi, for example, which uses a drop of 3-4 meters to generate 200 kW required the construction of only a power house and a short length of intake canal. Canal flow remains unaffected.
2. Using canal flows in excess of those required for the immediate irrigation needs. At these sites, irrigation water is diverted to an appropriate point where energy can be extracted from the water before it is returned to the river.

Alternatively, as part of a flood control scheme, a series of dams might be constructed. Turbo-generating units might be included as part of these structure to make use of the variable flows which are probably available year-round.

Or, on occasion, the source of water for a community or town water supply might be at such an elevation as to require pressure reducers. Turbines could be installed to serve that purpose and generate electrical power in addition.

ISSUES

A. Paucity of hydrologic data for adequate planning

After locating sites for SDH schemes which seem to possess sufficient head, are near end-users or a grid connection, etc., there is a need to determine whether sufficient flow is available year around. This is required for several reasons:

1. Funding is generally conditional to the site being economically viable and adequate flow is an essential condition for this to be possible
2. Cost-effective choice of turbine equipment and design of the civil works requires that the flow characteristics are known with some degree of accuracy.

Specifically there is a need for a knowledge of the peak stream flow at a site for the design of the civil works at intake as well as for a flow duration curve at the site. The latter is a curve relating the flow frequency to time throughout an average year. Its use is for equipment selection and forecast of project capacity and economic viability. The gauging of rivers is usually used to obtain the required information. However, in most developing countries, this is not performed except possibly on larger rivers and tributaries. The chance is better that meteorological data has been obtained more widely and methods must be designed so that this data coupled with topological and geographical information can be used to predict peak flows and flow duration curves. Even then, high accuracies cannot be expected.

B. Equipment and Design

Is there a net advantage to importing and installing sophisticated, well-engineered units bought from the West by developing countries? What effects does this have on system cost, on the ability of these countries to repair and maintain them, and on the ability to reproduce similar schemes elsewhere in the country.

Western equipment is designed specifically to cater to Western needs (such as precise frequency control and maximization of efficiency) and realities (such as availability of sophisticated or costly materials or the need for automation because of the high labor cost). But the realities in developing countries may not always coincide with these needs and realities. Local manufacture may be more attractive: lack of capital, need for wide-scale reproducibility, desire to maximize use of local workshops and available indigenous skills. Towards this end, China has,for example, fabricated turbines of wood and concrete and Pakistan completely avoids the use of governors and can make up lower efficiencies by slightly increasing the size of the runner.

What are the possibilities of local manufacture? China, India, and Indonesia have been manufacturing a range of turbine sizes for years. The Philippines also is entering the field. With smaller schemes, local fabrications becomes more widespread. Several companies in Nepal have been manufacturing well-engineered turbines and now a growing number of small workshops are also beginning to manufacture these. Similar examples can also be found in Colombia, Pakistan, Thailand, and Papua New Guinea.

At what point should a nation consider the advisability of fabricating the other components essential to a hydropower program? Some countries have the necessary resources and expertise and are fabricating their own generators. On the other hand,

very few are involved in the manufacture of governors, primarily because this is a component for which quality control is essential and for which little demand exists to date.

What designs for the civil works should be adopted? Reinforced concrete structures are commonly used but are costly and often over-designed. Designs and materials should address the specific conditions prevalent in many tropical countries, e.g. immense variations of flow, poor quality control in manufacture, and large bed and silt load due to deforestation. Local materials, including stone, brick, timber and soil, might be more appropriate, and designs to make best use of these should be considered. Pakistan uses wooden penstocks where appropriate, Nepal avoids permanent structures in its streams and uses temporary stone weirs to deflect water into the intake, and in Colombia, a soil-cement mixture has been used in the contruction of headraces.

C. Economics

(Opportunity Costs)

When considering limited national budgets, sinking funds into rural development projects that offer little if any hope for a worthwhile economic return, and continuing to commit valuable funds to foreign energy suppliers is surely not desirable. The opportunity costs associated with a nation's energy plan need careful thought. How are the country's own natural resources being utilized? Endangered woodlands can provide internal and external markets with valuable raw and/or processed materials, rather than the wood being used solely as a direct fuel source. Colombian officials report, "Wood has represented a participation between 41% and 23% in the consumption of energy during the period 1965-1977 and it is hoped that its contribution will have been reduced to 10%

by 1990....In this way the serious effects of wood burning upon the ecosystem may be avoided." (C.CH.LG. Ltda, 1980).

In the same way, questions can be asked conerning the present activities of the rural poor. How are particular tasks such as cooking and the transport of water performed. In Nepal and northern India, pumping drinking water reduces time and effort spent by women fetching and carrying water from nearby streams which can in some countries entail round trips of many kilometers. In what other activities that would be more productive could so many participate?

Some activities from which the rural population benefit require an outlay of cash on their part. In these cases, the introduction of a mini-hydro system will bring a cash savings or consumers' surplus benefit to the community. This extra capital, whether from an existing or contemplated cost, is then free to be spent elsewhere.

(Substitution)

Reserves of fossil fuels (oil, natural gas, coal) are decreasing day by day and their prices are increasingly high, unstable and unpredictable. For use in rural areas, these problems are compounded by difficulty in transportation and handling, and complicated maintenance requirements of the systems. The development of small hydroelectric plants can play a very important role in a nation's energy plan, by decreasing energy costs and reducing dependence on imports. Kenya's energy consumption, for example, is mainly dependent on imported petroleum based sources and exceeds 30% of total national imports. (Industrial Survey and Promotion Center, 1979). Similar situations exists in a number of other nations. To the extent that mini-hydro units can replace fuels used in diesel generators, kerosene lamps and stoves, and other petroleum-consuming devices, they can serve to marginally reduce foreign exchange costs.

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Mechanical and electrical power from a mini-hydro plant can also serve as needed substitute for traditional energy sources. For example, either form of power can be harnessed for use in domestic cooking which accounts for most of all rural energy use. This can replace charcoal or wood burning which has caused the rapid depletion of valuable forest resources, leaving the land exposed to soil erosion and further reducing its fertility.

(Infrastructure)

A major source of domestic instability in developing countries is the migration of poor people from the countryside to the major cities and the costly burdens that this places on the national governments. The development of an adequate and affordable rural energy supply can facilitate the improvement and development of infrastructure, of medical and educational facilities, of communications and transportation systems. It can assist in the provision of basic necessities, of adequate food, clothing, shelter, and employment. All these factors should tend toward offsetting the attraction of the urban areas and serve as the foundation for any successful rural development program.

The case of Colombia, for example, shows that the principle necessity is for electrical power for lighting for health centers and schools. The possibility then exists of using energy for local industry. (C.CH.LG. Ltda, 1980). Overcoming the disequilibrium between rural and urban production and consumption and resulting socio-economic problems is of great concern to developing country leaders.

(Income Generation, Employment)

Even if rural infrastructure is developed, the lack of a secure energy supply restrains

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further economic development. Potentials in both income generation and employment opportunities depend on an energy which small hydropower might provide. Most people in rural areas rely heavily on agriculture for their livelihood. Even the landless, who comprise the lowest-income group, have much to gain from the introduction of an energy system that will increase employment potential. (World Bank, 1975).

Hydropower has great potential for increasing the productivity of local agriculture. When used in conjunction with irrigation schemes, raising yields can be accomplished by expanding the amount of arable land, lengthening the growing season and increasing the number of plantings. Grinding and milling of grain, extracting oil, and other agricultural processes are greatly enhanced by mini-hydropower's mechanical and electrical capabilities. Both time and finished product are conserved. The Chinese have simultaneously developed forestry, livestock and fishery activites around their small hydro stations. (Jing and Li, 1979).

Described as the key to the economic advancement of the poor, rural employment opportunities utilize the labor productivity of the millions otherwise unemployed or underemployed. Industrial production techniques at even the smallest scale, require energy as an essential input in one form or another. (Industrial Survey and Promotion Center, 1979) Craft industries, commercial activities and other side-occupation industrial are able to expand operation. Refrigeration in shops and services, motive power in workshops (carpentry, welding and repair shops), water pumping, mills, etc. raise the community level of output and subsequently, the level of rural income also rises. Increased production can be used to more adequately meet local needs, and any surplus can be exported for increased local income generation.

(Convenience/Indirect Benefits)

The category of indirect or "convenience" benefits is much more difficult to quantify but is of great value to rural people. Household and community lighting are popular initial uses of electrification. Within the financial and technical constraints of the system, household convenience appliances are then added. In addition, income-generating activities such as ironing and sewing can be conducted from within the home.

D. Environmental Impact

Especially in subsistenance agricultural communities where life is tied so closely to the natural environment, the environmental impacts of any proposed energy system need careful consideration. If the system has been properly designed and constructed, small-scale hydropower schemes cause only negligible adverse impacts to water quality and land use. In the water system, increased siltation may occur, but is easily controlled by choosing the proper design for the geologic conditions of the site. Aquatic life may be adversely affected, especially when impoundments are involved. If desired, smaller versions of common fish ladders can be added to larger structures. If no impoundment is needed and only part of the flow of the stream is diverted to the intake, then no special structures are needed.

Except for plants in the micro range, the construction of hydroelectric schemes may produce some impacts with regard to land use. A reservoir may result in flooding of arable land. Other project components such as canals, penstock, power house, and transmission and distribution lines will also impose some land demands. Canal design and construction is a factor of particular importance due to the risks of erosion and therefore potential loss of productive soils and also the possibility of increased incidences of

bilharzia (schistosomiasis). If planned properly, with special regard given to variability of weather patterns, this should pose little problem.

Consideration must also be given to area land use and subsequent impact on water rights and dependable flow, i.e. irrigation withdrawals, water supply, etc. Another important factor in land use is the degree of existing development. If the environment is already severely stressed by various forms of development, then an additional incremental project, no matter how small, may have a disproportionate impact.

As previously stated, the greatest potential environmental impact of small hydropower is a positive one — that of reducing the need for traditional energy sources and the subsequent overuse of local forest and woodland areas.

E. Development Approach

With little interest in small hydropower until recently, most hydropower undertakings were limited to large schemes. Now, with growing interest in smaller schemes, the capital intensive approach used in large schemes continues to be used. This approach is often reinforced by a reliance on Western consultants whose training and experience has to datea primarily been restricted to capital-intensive projects. The use of sophisticated western technology results in increased costs and potentially continuing reliance on external expertise for maintenance and repair.

Of all energy sources, the development of hydropower can make maximum use of local materials. Local materials such as stone, gravel, sand and wood are easily obtained in

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rural areas. To minimize costs, imported materials such as concrete and reinforcing steel bars should be used only where essential and designs must cater to this option.

Realities in a number of the less developed countries is such that capital is at a premium, but that a large labor pool exists. Both India and PRC are examples of countries placing a heavy reliance on locally available labor, supplemented with heavy equipment only when and where appropriate, for construction of even massive civil works. Use of rural labor might be maximized especially on smaller schemes and designs might be adopted which make this possible. Maximum involvement of local villagers of course also has numerous spin-off benefits which can give further impetus to rural development.

F. Management

In many nations, the generation of electric power is an undertaking of the state and these efforts have been largely restricted to the larger hydro and thermal generating stations. These are relatively few in number, are located in population centers, and are therefore relatively easily managed centrally during construction as well as during operation.

With the advent of small decentralized hydropower generation of electricity, it seemed natural that these be managed by the same state agency. But shifting the focus of management to smaller plants is difficult because of the very nature of the small decentralized system. The plants are small in size, potentially large in number, and generally are found in more remote areas — far from both population centers and developed infrastructure. These factors combine to make small hydropower's potential role in a nation's energy plan highly dependent on a radically different management scheme.

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G. Financial Aspect

Probably the most important single economic characteristic of hydropower projects is the relative absense of escalation in the total cost of power generation. Hydropower facilities have a long life. Dams and civil works will generally perform for decades with little maintenance required. As no fossil fuels are required, operating costs are low. Because of this and the long life of the facilities, a hydropower installation is essentially inflation-proof. This is a unique financial advantage to hydropower schemes.

In most developing countries, power generation is overseen by the national government or one of its appointed agencies. Funding is usually handled through the national authorities, with help from international funding institutes, regional development banks, and national funds. But funding from large funding organizations presents a problem. Because of relatively fixed administrative and overhead costs geared to single, large scale, capital-intensive projects, these organizations find small hydropower projects very expensive on a cost/kilowatt basis. According to an official of one such organization, requests for funding assistance for such projects is simply viewed by them as having a "nuisance value". One alternative for funding small hydropower projects which is being considered is the designing of one project which itself includes the installation of a series of small hydropower plants. This permits a larger financial sum to be committed toward a single umbrella project and integrating a number of similar schemes facilitates overall management and execution.

On occasion, small hydropower schemes can be implemented by local communities who are to use and directly benefit from these schemes. Local funds, possibly augmented by outside organizations, can be used. With properly designed low-cost schemes, this

approach permits the implementation of small hydropower projects on virtually a self-reliance basis with most effective use of available resources, financial and otherwise.

CONCLUSION

It may be seen then that small hydropower has a substantial potential world-wide. The most extensive development has occurred in Asia, followed by Latin America and Africa and a substantial potential still remains on these continents.

System configurations may include both run-of-river and impoundment schemes, depending on system capacity and available flow.

There is a strong potential for developing large numbers of sites in an integrated program, for multiple use schemes and for hybrid systems.

Issues are focused around a lack of hydrologic data, proper equipment and design, economic considerations, and environmental impact.

Development approaches vary between centrally planned, capital intensive and decentralized, labor intensive programs. Management entities must recognize the risks and benefits of each.

Financial considerations include advantages of life-cycle costing, care and maintenance, biases of large funding organizations and local funding abilities.

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3. C.CH.LG. Ltda, Micro Hydro Prospects and Developments in Colombia, 1980

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Appendix C

Resumes

One provision of the cooperative agreement between the National Rural Electric Cooperative Association and the AID Office of Energy requires the development of a resource file of SDH experts capable of assisting us in the work we undertake for the AID missions. In fulfilling this requirement, we have contacted specialists throughout the U.S. and abroad, most of whom have been anxious to work with us, enabling us to be very selective.

Enclosed are sample resumes of some of the individuals we have used on various assignments to illustrate the wide range and depth of experience from which we can draw.

Also enclosed are the resumes of the SDH staff members.

Specialist

Walter Lawrence	Engineer	Independent Consultant
John Topik	Engineer	Independent Consultant
Keith Oberg	Economist	Independent Consultant
Jack Hicks	Engineer/Manager	Member Cooperative
Fred Keys	Manager	Member Cooperative
Tobie Lanou	Economist	Consulting Firm
A.G. Mercer	Engineer	Consulting Firm

Staff

David Zoellner	Program Manager
Bard Jackson	Principal Engineer
Allen Inversin	Micro-Hydro Engineer
Paul Clark	Information and Training Specialist
ELizabeth Graham	Assistant Information and Training Specialist

Whenever possible, members of the SDH staff, where consistent with the cooperative agreement, assist the AID missions directly in such areas as: project identification; site selection and project design; training; and development of SDH data base to assist in carrying out these activities.

Resumes on file in SDH Talent Bank

Last Name	First Name	Discipline
Abidi	M. Mike	Electrical Engineer
Allison	Richard C.	Environment
Amorin	Cesar A.	Economics
Asin	Jorge R.	Economics
Armstrong	Ellis L.	Civil Engineer
rde	Adalbert R.	Electrical Engineer
t	John M. Jr.	Electrical Engineer
r	Jeffrey D.	Anthropology
n	Richard H.	Sociology
Brownrigg	Leslie A.	Anthropology
Burris	Harry D.	Physics
Cada	Glenn F.	Zoology
Cafky	James W.	Physics
Capestany	Cecilia D.	Translating
Carter	Lee	Economics
Cassidy	John J.	Civil Engineer
Coates	Vary T.	
Cooley	Lawrence S.	Economics
Chacon	Jose A.	Management
Chase	Sherret E.	Mechanical Engineer
Chin	Hubert	
Cecelski	Elizabeth	Economics
Cunningham	Alfred B.	Hydrology
Dailey	Nancy	Administration
Dalton	William R.	Management
Dawsey	Charles L.	Electrical Engineer
Dawson	Marilyn J.	
Defay	Jacques	
Dehavenon	Anna Lou	Anthropology
Dellello	Joseph-John	Management
deSilva	Lalith	Economics
Donnelly	Thomas F.	Civil Engineer
Dumbach	Otto K.	Sociology
Eberhard	John P.	Architect
Evans	Rupert A.	
Erskine	George S.	Electrical Engineer
Farell	Cesar	
Frederickson	Robert A.	
Fritz	Erica W.	Translating
Garriott	Gary L.	Small Hydro
Gladwell	John S.	Civil Engineer
Goldberg	Michael J.	Administration
Groff	David H.	Anthropology
Harder	John D.	Civil Engineer
Harold	Andrea L.	Translating
Hayes	Peter J.	Economics
Henwood	Mark I.	Electrical Engineer
Hicks	Jack K.	Electrical Engineer
Hinton	James D.	Management
Ho	Donald T. K.	Electrical Engineer
Hynilicza	Esteban	Electrical Engineer

Last Name	First Name	Discipline
Holland	Raymond E.	Electrical Engineer
Holt	Allen F.	Administration
Howe	Joseph G.	Civil Engineer
Huebner	Frederick C.	Accounting
Jadaun	Yogendra Singh	Electrical Engineer
Kannan	Narasimhan P.	Economics
Karl	Edward	Electrical Engineer
Keeys	Lynn A.	Sociology
Key	Fred G.	Management
Kirshen	Paul H.	Civil Engineer
Klock	Thomas E.	Civil Engineer
Kornreich	Theodore R.	
Kraljevic	Ivo Josip	Anthropology
Kum	Veronica	Economics
Lamb	G.	Economics
Lawrence	Walter D.	Electrical Engineer
Maine	Kenneth	Administration
Manley	Frank P.	Administration
Margitan	Peter	Accounting
Mashaw	John M.	Economics
Matthews	Jeffrey	Administration
Maurer	Frederick R.	Management
McBay	Gilbert C.	Management
McLemore	Ralph S.	Accounting
Menage	Nicole	Economics
Modi	Hari	Chemical Engineer
Moodie	Patricia	Physics
Morgan	Kent A.	
Nelson	Vaughn	Physics
Oberg	Keith L.	Economics
Periasamy	Palani G.	Economics
Schwartz	Marion W.	Electrical Engineer
Stevenson	Thomas W.	Accounting
Verdery	Richard N.	Economics

DAVID RICHARD ZOELLNER

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Education

Civil Engineering, Ph.D., Texas A&M University, 1972
Biology, M.S., University of Alabama, 1967
Biology, B.S., University of Alabama, 1963
Academic Societies, Beta Beta Beta (Biology Honorary)

Experience

Assistant Administrator, Small Decentralized Hydropower Program, International Programs Division, National Rural Electric Cooperative Association (1980-present). Responsibilities include: administration of a $2.2 million program funded by USAID Office of Energy to facilitate the application of small hydropower technology in developing countries; directing SDH professional and clerical staff; overseeing teams of specialists assembled to provide in-country consulting services to AID Missions in plant siting, project design, economic and technical feasibility studies, environmental/social impact analyses, and institutional development. Other program activities include sponsoring two international small hydropower workshops (Quito, Ecuador, August 1980; Bangkok, Thailand, June 1981; another workshop will be held in Africa in 1982); identifying reliable small hydro equipment manufacturers; development of methodologies for conducting country assessments of mini-hydro potential and for prefeasibility studies of candidate mini-hydro sites.

Environmental Planner, Institute for Water Resources, U.S. Army Corps of Engineers (COE) (1978-1979). As a management team member of the National Hydropower Study, a 3-year, $7 million feasibility assessment for Congress, identified and analyzed energy, water, and environmental policies and issues attendant to hydropower planning, development, and operation. Determined budget allocations, developed detailed government estimates for key studies, and managed and participated in select policy study. As Chairman, Technical Program Committee, for Waterpower '79, first international conference on small-scale hydropower, developed the conference plans, assembled and briefed conference committee, selected and monitored contract support service, developed technical program concept, assembled same, and designed and monitored the publishing of the proceedings.

Resource Scientist, Center for Resource and Environmental Systems Studies, SRI International, formerly Stanford Research Institute (1976-1978). Project activities and responsibilities included proposal development, project management (staff and budget), report preparation, and client liaison. Studies emphasized natural resources - current and future problems, issues, policies and options for management decision making. Principal work conducted in areas of: legislative assessment in water quality (analysis of impact of Federal law on water quality and molluscan shellfish industry); environmental indicators for Council on Environmental Quality; interagency coordination; impact assessment of decontrolling prices and regulations on crude oil and petroleum distillates; geologic isolation of radioactive wastes; and geothermal energy development.

Staff Officer, Environmental Studies Board, National Research Council/National Academy of Sciences (1974-1975). Provided professional staff support to the Study Committee on Water Quality Policy. Committee activities included establishment of subcommittees or panels in the areas of technology and costs, modeling, waste water reuse, secondary treatment, institutional arrangements, and ecosystem analysis. Professional staff activities included planning conferences

and other meetings of the advisory committee; coordinating documents for review and information exchange; drafting panel and progress reports; and supervising support staff in providing necessary services.

Research Scientist, Environmental Systems and Management Program, Center for the Environment of Man, Inc., formerly Traveler's Research Center (1971-1974). Participated in water and land resources studies with emphasis on marine biology, water quality, and institutional aspects of planning and implementation. Work included the areas of: coastal management; coastal wetlands; environmental monitoring; environmental reconnaissance; and, dredging.

Teaching

Physical Sciences Department, Prince George's Community College, suburban Washington, D.C. area (Spring Semester, 1978). Taught a three-credit course in Oceanography to non-science students covering physical, chemical, and biological principles and characteristics; duties included delivering lectures, administering quizzes, presenting audio-visual material, assigning and reviewing out-of-class projects, field trips, and administering final examination.

Trinity University, Hartford, Connecticut (Fall Semester, 1973). Participated as a team member in teaching an upper-level course in environmental principles and practices; delivered lectures and administered quizzes.

University of Alabama, Tuscaloosa, Alabama (Academic years 1964-65, 1965-1966). Taught six labs per week, 24 students per lab, in courses of General Zoology, General Botany, and Invertebrate Zoology; duties included preparing laboratory demonstrations and laboratory lectures; assisted with proctoring and grading lecture section examinations.

Graduate Experience

A&M University, Texas (1967-1971). Graduate program included a broad background in the area of environmental engineering with emphasis on waste

treatment, water quality, and water resources, and additional training in oceanography, mathematics, hydraulics, and biology. Ph.D. Dissertation: "The Development of a Hyperbaric Reactor for the Biological Oxidation of a Colloid."

A&M University, Texas (September 1967-December 1971). FWQA Training Grant, Environmental Engineering. Grant for support while obtaining degree in area of pollution control.

A&M University, Texas (1969-1970). Elected by students from a five-state region to serve on Student Committee on Pollution and the Environment (SCOPE), an advisory body to the Secretary of the Interior.

University of Alabama (1963-1967). Graduate studies emphasized marine science and included training in commercial fisheries, oceanographic techniques and ecology. M.S. Thesis: "The Relation of Substrate to the Accumulation of Marine Fouling Organisms."

University of Texas (June 1967-September 1967). NSF Research Grant, Marine Science Institute. Coursework and research in marine sciences.

U.S. Department of Interior, Aquatic Biologist (June 1966-September 1966) Comprehensive survey of stream quality in North Central Alabama.

Stanford University, NSF Fellowship (R/V te Vega) (June 1965-September 1965). Cruise from American Samoa to Monterey, California, learning applications of oceanography and receiving lectures in biological oceanography.

University of Alabama, Research Assistant, Alabama Marine Resources Lab. (September 1963-September 1964). Involved in comprehensive study of ecology, hydrography, and commercial fisheries of Mobile Bay; construction and maintenance of offshore artificial fish reefs; and determining toxic effect of pesticides on oysters.

Consulting

Inter-American Development Bank, Washington, D.C. (Winter 1980). Developed information criteria manual for environmentally-related loan applications.

Decision Science Consortium, Inc., Reston, Virginia (Spring 1979). Developed impact assessment methodology for water resource decision process.

Nero and Associates, Inc., Portland, Oregon (Fall 1979). Developed research team and coordinated briefing to U.S. Department of the Interior on Outer Continental Shelf oil and gas development impact assessments.

Organization of American States, Washington, D.C. (Spring 1978). Reviewed water resource assessment methodology for river basin planning in South America.

Office of Technology Assessment, Oceans Program, U.S. Congress, Washington, D.C. (Spring 1978). Assisted in the development of a study plan to examine the question of high and low-level radioactive waste disposal in the seabed.

Selected Publications

Papers

Mini-/Micro-Hydro Development (in development), RERIC Journal, Asian Institute of Technology, Bangkok, Thailand, 1981.

Small Hydro Equipment Opportunities (in development), Agricultural Engineering, Journal of American Society of Agricultural Engineers, 1981.

Small Hydropotential in Developing Countries, Proceedings, UNITAR Conference on Small Energy Resources, September 10-18, 1981, Los Angeles, California, 1981.

Small Hydro for Rural Energy, Proceedings, OAS Energy Conference, September, 1980, Sao Paulo, Brazil, 1980.

Water Resource Impacts of Hydropower Development and Operation, Proceedings, ASCE Conference on Water Resources and Hydroelectric Energy Development, 1979.

Issues in Ocean Policy Related to Land Use Planning and Regulation, National Ocean Study, U.S. Senate Subcommittee on Oceans and Atmosphere, 1975.

Reports - Principal Responsibility

Water Quality and Molluscan Shellfish. An Overview of the Problems and the Nature of Appropriate Federal Laws, Stanford Research Institute, GPO 003-02-00135-1 (U.S. Government Printing Office), for U.S. Congress (via National Marine Fisheries Services), 1977.

Interagency/Intergovernmental Coordination for Environmental Planning. Handbook for Federal Agency Coordination, Vols. I and II, Stanford Research Institute, Project No. 4744, for U.S. Air Force, 1977.

Environmental Reconnaissance Techniques for Connecticut River Basin Watersheds, Report No. 4155-498 for New England River Basins Commission, 1974.

Reports - Editing, Drafting, and Technical Assistance

Environmental Quality Indicators: A Sourcebook of Graphics for President's Council on Environmental Quality, 1977.

Technology Transfer in the Marine Environment of Long Island, CEM, Inc., Report No. 4133-475 for Nassau-Suffolk Regional Planning Board, Marine Resources Council, 1973.

A Methodology for Applying Research to Environmental Planning and Management: A Case Study of Issues Important to the Chesapeake Bay Region, CEM, Inc., Report No. 4138-491 for National Oceanic and Atmospheric Administration, 1973.

Wetlands on Long Island, CEM, Inc., Report No. 4103-460 for National Oceanic and Atmospheric Administration, 1972.

Reports - Contributory Analysis and Coordination

Environmental Analysis for Geothermal Energy Development in the Geyers Region, Vol. II, Master Environmental Assessment, Stanford Research Institute, CRESS Report No. 3 for State of California, 1977.

Proposed Outline of Safety Analysis Report for Facilities for Geologic Isolation of Radioactive Wastes, Stanford Research Institute, CRESS Report No. 24 for Oak Ridge National Laboratory, 1977.

Environmental Impact Assessment of the Exemption of Middle Distillates from Mandatory Allocation and Price Controls for U.S. Federal Energy Administration, 1976.

Guidelines for Dredged Material Placement in Marsh Creation, CEM, Inc., Report No. 4165-511 for U.S. Army Engineers, 1975.

Report to the Advisory Panel on Water Reuse, Study Committee on Water Quality Policy, National Academy of Sciences for National Commission on Water Quality, 1975.

Report of the Advisory Panel on Secondary Treatment, Study Committee on Water Quality Policy, National Academy of Sciences for National Commission on Water Quality, 1975.

Advisory Report of the Joint Panel on Ecosystem Analysis, National Academy of Sciences/The Institute of Ecology for National Commission on Water Quality, 1974.

Applicability of Limited Capability Buoys to Potential Operational Data Uses, CEM, Inc., Report No. 4128-466 for National Oceanic and Atmospheric Administration, 1972.

Professional Societies

Society for International Development
International Water Resources Association
American Fisheries Society
Water Pollution Control Federation
Marine Technology Society
American Association for the Advancement of Science

Foreign Language Capability

French, Spanish

BARD C. JACKSON

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Education

Electrical Engineering (Power Systems), M.S.
Georgia Institute of Technology
Navy Nuclear Prototype Training Unit, 1973
Navy Nuclear Power School, 1972
Electrical Engineering (Power Systems), B.S.
'cum laude,' California State
University at Long Beach

Experience

Principal Engineer, Small Decentralized Hydropower (SDH) Program, International Programs Division, National Rural Electric Cooperative Association, Washington, D.C. (1980-present). Responsible for the technical content of the SDH Program. Respond to requests from developing countries for assistance with planning and designing small-scale hydropower projects. Have managed over a dozen teams of specialists who conducted small hydro assessments and provided assistance to developing countries including Peru, Dominican Republic, Togo, Dominica, Zaire, Thailand, Rwanda, Morocco, Panama, Ghana, Tunisia, and Bangladesh; and personally helped provide assistance to Rwanda, Dominica, and Panama. Participate in conferences and seminars as necessary to monitor the "state-of-the-art" in small hydropower technology.

Electrical Engineer, Department of Energy, Division of Power Supply and Reliability (1978-1980). Analyzed performance of bulk power systems to make engineering determinations on network performance when subjected to contigencies. Monitored transfers of electric power and use of natural gas by electric utilities which displaced use of oil.

Analyzed regional impacts on fuel consumption for proposed regulatory actions. Studied economic and regulatory factors affecting reliable bulk power performance using production cost and loss-of-load probability techniques. Received reports of bulk power system emergencies and assisted in investigation of their causes and effects.

Electrical Engineer, Rural Electrification Administration, SEAE (1975-1978). Performed engineering assignments related to the design, construction, and operation of rural electric systems. Assisted REA cooperatives with environmental documents, reliability criteria, and transmission line planning criteria as required to support REA financing. Reviewed substation and transmission designs for proper coordination and conformance to REA and NESC standards.

Electrical Officer, USS Sanctuary (AH-17), U.S. Navy (1972-1974). Responsible for the entire electrical operations of the ship. Supervised technical personnel in the Electrical and Intra-Communications shops. Collateral duties included Engineering Department Administration Officer, Formal Survey Officer, and Motion Picture Officer. Qualified Power Plant supervisor, OOD Underway, and Command Duty Officer.

Volunteer, Peace Corps (1970). Assisted with Rural Electrification Program in Northeast Brazil.

Publications

Methodology for Prefeasibility Studies of Candidate Mini-Hydro Sites, 1981

Methodology for Country Assessments of Mini-Hydropower Potential, 1981

Foreign Language Capability

None

ELIZABETH HALE GRAHAM

Education

Madison College, Harrisonburg, Virginia, Psychology major; Sigma Phi Lambda Honor Fraternity; Psi Chi (Psychology) Honor Fraternity, 1971-1973

Longwood College, Farmville, Virginia, 1970-1971

Experience

Assistant Training and Information Specialist, Small Decentralized Hydropower (SDH) Program, International Programs Division, National Rural Electric Cooperative Association (July 1981-present). Assist in collecting and dissiminating information on small hydropower technology and development in U.S. and developing countries; developed training proposal to train engineers, planners, and managers of hydro projects from developing countries at U.S.-based university in all aspects of small hydro; managed major undertaking to revise and upgrade over one dozen publications developed by SDH Program; assisted in planning and management and coordinated logistical arrangements for African regional international workshop on small hydropower; recruit student assistants and support staff.

Researcher (March 1981-July 1981). Researched, compiled, and cross-referenced data on political contributions by Political Action Committees (PACs) for last three national election years; Wrote abstracts of PACs for PAC guide to be published by political scientist; interviewed executive directors of PACs about history of PAC, method and criteria for selecting candidates for political contributions, membership composition, key legislative issues of interest, other types of candidate support (media, polling, precinct targeting).

Consultant, Teleprompter, Inc. (April 1981). Wrote political analysis of city in Arizona as guidance and background for franchise bid for cable television company; interviewed community activists to determine kinds of programming for visual and performing arts community sought; interviewed school administrators to learn requirements for and potential uses of cable television for educational purposes.

Executive Assistant to Deputy Assistant to the President for Political Liaison and White House Personnel, The White House (May 1979-January 1981). Researched and drafted memoranda to the President recommending candidates for appointment; established system to track available slots and statutory requirements for candidates for approximately 700 Presidential and Secretarial advisory boards and commissions throughout Federal government; liaison with several Federal departments to locate candidates for appointment and conducted ongoing talent outreach to identify prospective candidates for advisory boards through contacts with various special interest groups (Hispanics, state government officials, Democratic party officials, business and community leaders); wrote and edited report, The Carter Administration and Hispanics: A Partnership to Progress, outlining the Carter Administration's efforts to delineate and alleviate problems unique to the Hispanic community in dealing with the Federal government; disbursed, tracked, and reviewed assignments of professional staff of 6; supervised work of 2 interns and clerical staff.

Assistant to Deputy Campaign Manager, Carter/Mondale Re-Election Committee (August 1980-November 1980). From national headquarters, acted as conduit and ombudsman for state campaign managers for 19 western states and national campaign in all aspects of campaign (budgets, information, campaign materials, political intelligence, polls); coordinated trips to western states of President, Vice President, and Cabinet officers for campaign purposes and wrote political overviews of states for President for campaign trips; wrote daily reports on each state's activities; advised state campaign managers on expenditures for political purposes; helped design special interest media (Hispanic brochures and television ads).

Research Assistant, Democratic National Committee (February 1979-May 1979). Assisted in coordinating national Democratic Party's delegate selection plan for national convention through contacts with State Party Chairs and DNC Executive Committee members; researched and compiled candidate filing requirements based on state statutes and state Democratic Party plans; reviewed 1976 delegate selection plans and state statutes to determine possible conflicts with new delegate selection rules; compiled legal file on state election laws.

Office Supervisor, Graduate Program in Science, Technology, and Public Policy, The George Washington University (May 1978-December 1978). Handled financial management of budgets totalling $250,000 for research grants and contracts; researched and helped write proposals to obtain Federal funds for research grants and contracts; coordinated series of science and energy policy seminars for members of the science and technology policy community; counseled students on graduate program coursework requirements; assigned, supervised, and reviewed work of secretarial staff and student assistants; interviewed applicants for staff positions.

Caseworker for Rep. Joseph L. Fisher, 10th District of Virginia (January 1975-May 1978). Established and operated district office for U.S. Congressman; acted as ombudsman handling constituents' problems with Federal government (upgrading military discharges; obtaining Federal workers' compensation, or Social Security disability benefits); developed briefing papers for Congressman for meetings with constituents; helped communities obtain Federal funds for sewer and water treatment facilities through EPA, FmHA, and HUD; acted as liaison for and monitored meetings of local government officials to determine when congressional intervention would be helpful; monitored legislation of particular interest to farming community (arranged series of meetings with farmers culminating in Congressman's interest in sponsoring legislation to raise exemption for estate tax purpose to help keep small family farms and businesses intact); arranged two-year series of town meetings to discuss issues of interest with constituents; spoke to groups on behalf of Congressman; supervised support staff of 5-9.

Vice Chairman, Loudoun County Democratic Committee (June 1976-November 1976). Coordinated county-wide campaigns for Carter, Zumwalt, and Fisher; coordinated literature distribution and telephone canvassing; arranged fund raising events; arranged production and placement of radio and newspaper advertisements; coordinated election day coverage of polling places.

Campaign staff, Fisher for Congress. (June 1974-December 1974). Helped coordinate activities of volunteers; helped plan, promote, and operate series of coffees and neighborhood meetings with candidate; compiled, district-wide list of campaign volunteers for future campaigns; helped coordinate distribution of literature throughout district.

Foreign Language Capability

Some Spanish, some French.

PAUL JESSON CLARK

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Education

Economics/Middle East Studies, M.A., The School of International Service, The American University, Washington, D.C., 1979
Political Science/International Affairs, B.A., The Colorado College, Colorado Springs, Colorado, 1972

Experience

Information and Training Specialist, Small Decentralized Hydropower (SDH) Program, International Programs Division, National Rural Electric Cooperative Association, Washington, D.C. (February, 1981-present). Duties include coordinating collection and dissemination of information pertaining to program; organizing and conducting international workshops on mini-hydropower including development of program, logistical planning, and management of publication of proceedings; developing training programs; and developing economic analysis of mini-hydro development.

Committee Advisor to U.S. Senator Jim Sasser, Budget Committee (June, 1977-January, 1981). Advised Senator on fiscal (spending, tax), monetary, international economic policies, energy policies, and all legislative matters coming before the Committee. Organized hearings and drafted legislation, speeches, and correspondence relating to economic issues.

Legislative Assistant to U.S. Senator Gary Hart (January, 1975-April, 1977). Developed positions relating to tax, energy, and foreign policy matters, including drafting legislation and providing recommendations on Senator's votes and actions in these fields.

Foreign Language Capability

French, some Arabic

ALLEN R. INVERSIN

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Education

S.B. (Aeronautical and Astronautical Engineering), Massachusetts Institute of Technology (MIT), Cambridge, 1966
S.M. (Honors), MIT, January, 1968
Engineer in Aeronautics and Astronautics Degree, MIT, June, 1968
Secondary Science Teaching Certification, College of Education, University of Maryland, 1976

Experience

Micro-Hydro Engineer, Small Decentralized Hydropower (SDH) Program, International Programs Division, National Rural Electric Cooperative Association, Washington, D.C. (1980-present). Responsible for gathering and evaluating technical and field information relating to small decentralized hydropower (SDH) developments. Involves review of available reports and documentation and supplementing this information by overseas visits, preparation of appropriate documentation to provide guidance to organizations and developing country government departments in implementing SDH schemes, and provision of technical information and advice on small hydropower developments to NRECA staff.

Staff Engineer, Appropriate Technology Development Unit, The PNG University of Technology, Papua New Guinea, serving with International Voluntary Services, Inc. (1976-1980). Researched, designed, fabricated, and tested several devices including major efforts with micro-hydroelectricity generating sets and hydraulic ram pumps, with work directed toward designs more appropriate in the

local context; documented efforts and final designs in fully illustrated manuals which included detailed descriptions of construction, performance data, and relevant notes. Co-ordinated self-help installation of a water supply and micro-hydro scheme in a remote mountain village (Baindoang). Inputs included design, supervision of fabrication of hardware, logistical planning, maintaining liaison with villagers, and training.

Volunteers in Technical Assistance/Papua New Guinea Field Representative (1976-1978). Provided VITA's first detailed view of development realities in PNG. Assisted with and evaluated its by-mail technical assistance. Prepared recommendations for the appropriate technology component of a Southern Highlands Province proposal for the World Bank.

Science Educator, Royal Lao Government (RLG), Ministry of Education, Vientiane, Laos, serving with International Voluntary Services, Inc. (1969-1975). Taught primarily physics and mathematics at the National Teacher Training College, including the preparation of teaching materials stressing active student participation in the learning process. Contributed to science teaching workshops. Co-edited a 300-page science teaching and improvisation handbook in the Lao language, a task which included preparation of materials and guiding contributions of several Lao science teachers. Coordinated a joint RLG-USAID student summer work program to provide work opportunities nationwide, primarily in the rural areas, to secondary school students.

Engineer, Helio Aircraft Corp., Bedford, Massachusetts (1968). Involved in problem solving for design modifications of STOL aircraft.

Publications

Directory of Sources of Small Hydroelectric Turbines and Packages, 1981.

"Rural Power Schemes in Pakistan," International Water Power and Dam Construction, November, 1981.

"Pakistan: Low Cost Villager-Implemented, Micro-Hydro Projects," a case study written for Micro-Hydro Sourcebook under development.

A Pelton Micro-Hydro Prototype Design, Appropriate Technology Development Unit, Papua New Guinea, June, 1980.

Technical Notes on the Baindoang Micro-Hydro and Water Supply Scheme, Appropriate Technology Development Unit, Papua New Guinea, February, 1980.

Foreign Language Capability

French, Lao, Pidgin English (PNG); some Spanish, German, Marathi.

JACK KEITH HICKS

Education

Electrical Engineer, B.S., University of Iowa, 1949

Experience

General Manager, Linn County Rural Electric Cooperative, Marion, Iowa (October, 1949-present). Responsible for total operations of rural electric system. System has nearly 1,400 miles distribution lines serving nearly 7,000 consumers with an investment exceeding $6 million. Supervises 30 employees in total system operation. Responsible to Board of Directors, but reports regularly to membership and public on system operations. Serves as system engineer for some engineering problems and employs consulting engineers as needed. Has planned and carried out, with staff assistance, a computerized billing and accounting system on-site. Plans budgets, both long- and short-term, and maintains regular analysis of operating results.

Rural Electrification Specialist for International Programs Division, National Rural Electric Cooperative Association and UNDP, Western Samoa (August, 1981). Duties included providing advice on appropriate technologies for transmission line installation and cost estimates for each alternative; determining equipment and materials requirements; and undertaking overall assessment of progress on rural electrification project.

Institutional Advisor for Small Decentralized Hydropower (SDH) Program, National Rural Electric Cooperative Association, Thailand (March-April, 1981). Provided technical expertise as part of two-man team sent to Thailand to conduct prefeasibility studies on six sites at request of AID Mission. Duties included providing team with technical advice on rural organization, management of cooperatives, rural electric tariffs and rates, and rural institutional development.

Professional Societies

Institute of Electrical and Electronic Engineers

Foreign Language Capability

None

FRED G. KEY

Education

Smith County High School, Tennessee
International Correspondence School
(Distribution of Electricity)
Also have taken numerous NRECA
Management Training Courses

Experience

Team Leader and Rural Electrification Specialist, Small Decentralized Hydropower (SDH) Program, National Rural Electric Cooperative Association, Ghana (August-September, 1981). As member of three-man team, worked with officials of the Consultative Committee on Rural Electrification, at request of AID Mission, in reviewing Ghana's Western Region rural electrification scheme. Team effort included determining potential for development of isolated and/or grid-connected mini-hydropower and developing recommendations for the rehabilitation and possible extension of the existing grid.

Secretary, Rutherford County Industrial Development Board (presently). Currently engaged in $450 million bond issue to build a plant for Nisson Motor Company in Rutherford County. This represents the largest private investment expenditure ever made in Tennessee

Middle Tennessee Electric Membership Corporation (1939-1980). Retired March, 1980 as General Manager of the cooperative, the

fourth largest in the U.S. with an annual budget of over $40 million and an annual construction budget of over $5 million. Cooperative had grown in last nine years from 29,000 to 54,000 members and 160 employees. Cooperative received National Safety Accreditation in eight of the last nine years. Chairman, Tennessee State Safety and Job Training Committee (1974-1980); NRECA Region III Representative on Insurance and Employee Committee (1971-1980); I&EW Committee Representative on the Safety Accreditation Committee.

Consultant, International Programs Division, National Rural Electric Cooperative Association, Venezuela (July-October, 1965). At request of AID, spent three months organizing two rural electric cooperatives.

Service Representative, Tennessee Electric Power Company (1934-1939).

Professional Societies

Middle Tennessee Electric Managers Association, Past President

Foreign Language Capability

None

JOHN HANS TOPIK

Education

Mechanical Engineering, B.S., University of Colorado, 1948. Extensive post-graduate work in civil, hydraulic, and water resources engineering, mathematics, and economics.

Registration

Civil and Mechanical Engineering: Washington, Oregon, Colorado, Arizona, California

Experience

Consultant, Small Decentralized Hydropower (SDH) Program, National Rural Electric Cooperative Association, Rwanda (November-December, 1981). Provided technical assistance through AID Mission to Rwanda Energy Research Center. Provided detailed analysis of one proposed site and preliminary analysis of three additional sites.

Team Leader and Small Hydro Engineer, Small Decentralized Hydropower (SDH) Program, National Rural Electric Cooperative Association, Bangladesh (September - October, 1981). Advised AID Mission on hydropower potential in Bangladesh; evaluated appropriate SDH site equipment for sites and provided approximate costs for development.

Consultant (January, 1978-present). Assignments: U.S./AID-sponsored Irrigation Project in Senegal, Africa; United Nations-funded water and electric utility projects in Burundi, Africa; water supply and irrigation projects in Oregon and Nevada; inventory of ground-water resources of Douglas County, Oregon.

Stevens, Thompson & Runyan, Portland, Oregon (1973-1977). Activities included water quality management study for King County, Washington; river basin development project in Senegal, Mali, Mauritania; abatement plan for combined sewage overflows in Milwaukee, Wisconsin; irrigation project with sewage effluents, Tualatin River Basin, Oregon.

R.W. Beck & Associates, Seattle, Washington (1970-1973). Principal Engineer on conventional and pumped storage hydroelectric projects, water supply, and irrigation.

Daniel, Mann, Johnson & Mendenhall, Los Angeles, California (1968-1970). Project Engineer in Instanbul, Turkey, on water supply and sewerage plan for World Health Organization.

Metcalf & Eddy, New York, New York (1966-1968). Project Engineer on water supply and sewerage plan for Allegany County, New York.

Hydrotechnic Corporation, New York, New York (1963-1966). Principal Engineer in Peru, Spain, and Morocco on feasibility reports and preliminary design for hydroelectric, irrigation, and water supply projects.

Economic Planning Board, Government of Korea (1963). Senior Advisor on water supply projects including preparation of loan applications for international financing.

Litchfield, Whiting, Bowne Associates, New York New York, (1957-1962). Deputy Chief Engineer in Iran on development projects for all southern provinces: field reconnaissance, scheduling, supervision of design, and construction for water supply, sewerage, flood control, electrification projects. Project Manager in Pakistan on water supply and drainage project for City of Karachi.

Development & Resources Corporation, New York, New York (1957). Resident Engineer on Dez Dam, Iran, hydroelectric and irrigation project.

Justin and Courtney, Philadelphia, Pennsylvania (1955-1957). Project Engineer on field exploration, feasibility reports, and design of two multi-purpose dams in Iran. Resident Engineer on construction of hydroelectric plant in Pakistan.

Harstad Associates, Inc., Seattle, Washington (1952-1955). Project Engineer on planning, feasibility studies, and design of small hydroelectric projects in Alaska, water supply, and other municipal utilities.

U.S. Bureau of Reclamation (1948-1952). Design Engineer of Colorado-Big Thompson multi-purpose project. Special studies on underground hydroelectric construction. Liaison to foreign engineers.

Foreign Language Capability

French, Spanish, German

KEITH L. OBERG

Education

International Economics, Latin American Studies, and International Law and Organization, M.A., School of Advanced International Studies (SAIS), The John Hopkins University, Washington, D.C., 1977.

Rotary Foundation Graduate Fellowship, Economics/Rural Sociology, University of the Andes, Bogota, Colombia; field work in El Cocuy, Boyaca, on the role of middlemen in the consumer good market, January-December 1974.

Political Science and History,B.A. cum laude, Middlebury College, Vermont, 1973; received Departmental High Honors in History

Experience

Five years varied economic development experience in U.S. and Third World at project and program levels. Sector specialties include cooperative/small enterprise development, rural development/agriculture, urban development/housing, and energy. Skills include economic/financial analysis, social analysis, field evaluation/research, interviewing, technical writing/editing, and proposal writing. Extensive independent work experience (three years as free-lance consultant).

Consultant, Small Decentralized Hydropower (SDH) Program, National Rural Electric Cooperative Association, Dominica (November, 1981). As part of three-man team, provided assistance to AID Mission in performing prefeasibility studies on candidate small hydro sites and assessment of feasibility of providing grid interconnection or mechanical power production from mini-hydro installations.

sector individuals. Made recommendations to AID as to institutions, programs, and strategies which it might support, particularly on a regional basis and at the rural level. Team effort resulted in two-volume study entitled Energy and Development in Central America (March 27, 1980).

Consultant, Conference on Alternative State and Local Policies (June 1980 - January 1981). Wrote/edited a resource guide for organizing and financing energy cooperatives in the United States, including chapters on the energy crisis, co-op structure and process, existing and potential energy cooperatives, steps in organizing a co-op, developing a business plan (including rates, marketing, technical and operational, and financial plans), potential sources of financing, and how to apply to the National Consumer Cooperative Bank (to be published, 1981, by the National Center for Appropriate Technology).

Program Analyst, Inter-American Foundation (October 1976 - October 1978). (Among other assignments) participated in site visit and project analysis of proposal from urban neighborhood coalition in Bogota, Colombia, to combat retail price speculation in local fuel through a community-owned bulk purchasing and retail distribution system.

Associate, Devres, Inc. (July 1979 - June 1981, on intermittent basis). (Among other assignments), researched trends in domestic and world coarse grains production for fuel alcohol production feasibility study for private client.

Foreign Language Capability

Fluency in Spanish, working knowledge of Portuguese, and introductory-level ability in French.

A.G. MERCER

Northwest Hydraulic Consultants, Ltd.
222 Brooksbank Avenue
North Vancouver, British Columbia VJ7 2C1
604-980-6011

Education

Civil Engineering, Ph.D., University of Minnesota, 1963, specialized in fluid mechanics, sedimentation, and computer analysis
Civil Engineering, M.S., University of Minnesota, 1957, specialized in hydraulics
Civil Engineering, B.S., University of British Columbia, 1954

Experience

Hydrologist, Small Decentralized Hydropower (SDH) Program, National Rural Electric Cooperative Association, Bangladesh (September-October, 1981). As part of two-man team, assessed potential for small decentralized hydropower development in Bangladesh for AID Mission. Responsibilities included collecting flow and head data, assessing its reliability, and identifying problems of integrating SDH with other water resource projects in Bangladesh.

Director, Hydraulic Modelling Division, Northwest Hydraulic Consultants, Ltd., North Vancouver, British Columbia (June, 1974-present). Senior consultant in international operations specializing in hydraulic model studies, irrigation and water supply, hydraulic structures, sedimentation, and coastal engineering.

Associate Professor of Civil Engineering, Colorado State University (1967-1974). Taught graduate courses in hydraulics, hydraulic structures, coastal engineering, and hydroelectric engineering. Shared the leadership in a weekly seminar on international inter-disciplinary water management research for three years. Conducted various research studies.

Head, Hydraulics and Hydrology Section, International Power and Engineering Consultants, now B.C. Hydro, Engineering Division (1966-1967). Supervised design work, hydrology studies, and energy generation studies for the Portage Mountain Hydroelectric Project. Supervised hydraulic structure design, hydrology, and energy investigations for feasibility studies and preliminary design studies for several related projects.

Civil Engineer, Tipton and Kalmbach Consulting Engineers, Lahore, Pakistan (1964-1965). Supervised staff working on contract supervision for Link Canal phase of the Indus Basin Project.

Teaching Assistant, Instructor, and Project Leader, University of Minnesota (1954-1963). Classroom instruction in civil engineering, fluid mechanics, hydrology, and research on hydraulic problems. Project leader for many models of major dams.

Selected Project Experience

Civil Engineer, Link Canals, Pakistan. Contract administration on major canal project involving eight canals each about 25 km long and carrying 250 to 500 m^3 of water.

Civil Engineer Coordinator, Agricultural Water Management, Pakistan. Inter-disciplinary study of water management of agricultural water supply.

Civil Engineering Coordinator, On Farm Water Management Study, Indus Basin, Pakistan. Inter-disciplinary study conducted at Colorado State University.

Project Originator/Cooperation Scientist, Alluvial Channel Observation Program, Pakistan. Coordinated collection of data on sediment transport for link canals in Pakistan.

Section Head, Hydraulics and Hydrology, W.A.C. Bennett Dam, British Columbia. Hydraulic design and hydrology for 2300 MW hydroelectric project.

Section Head, Hydraulics and Hydrology, Site One Dam, British Columbia. Feasibility study for low-head hydroelectric development of W.A.C. Bennett Dam.

Section Head, Hydraulics and Hydrology, Jordan River, British Columbia. Feasibility study for high-head peaking hydroelectric development on Vancouver Island.

Project Leader, McGregor Diversion Dam, British Columbia. Feasibility study for major inter-river diversion project involving a 150 m high earth-filled dam.

Project Leader, Mangla Dam, Pakistan. Hydraulic model study of 35,000 m^3 spillway having two-stage energy dissipators.

Project Leader, Tarbela Dam, Pakistan. Hydraulic model study of high-head (125 m) release gates for 12 m diameter tunnels.

Jebba Hydroelectric Development, Hydraulic Model Studies. Overall responsibility for hydraulic model and analytical studies required for design of hydroelectric project on Niger River in Nigeria.

Principal in charge of Lower Ruvu Diversion, Tanzania. Hydraulic model study of diversion works to provide sediment-free water for Dar-es-Salaam.

Publications

Riverbed Scour Related to the Growth of a Major Ice Jam. Proceedings, Third National Hydrotechnology Conference, Canadian Society for Civil Engineers, Quebec, May 29-31, 1977, written with R.H. Cooper.

Mechanics of Alluvial Bed Forms: Chapter 10, Proceedings of Institute of River Mechanics, C.S.U., Fort Collins, June 15-26, 1970, published in 1971, given again orally at C.S.U. in August, 1972.

Diversion Structures: Chapter 22, Proceedings of the Institute of River Mechanics, C.S.U., Fort Collins, June 15-26, 1970, published in 1971.

Bibliography, with Annotations, on Water Diversion, Conveyance, and Application for Irrigation and Drainage: U.S. Agency for International Development, Contract No. IAD/cds-2162, September, 1969, CER69-70KM3, written with Khalid Mahmood and E.V. Richardson.

Study of Factors Affecting Feasibility of Low-Head Hydroelectric Generation: Final Report, U.S. Bureau of Reclamation, CER68-69AGM26, March, 1969.

Characteristics of Sand Ripples in Low Froude Number Flow: Ph.D. Thesis, University of Minnesota, June, 1964.

Study of Seepage from Earth Canals by Hydraulic and Electric Analog: M.S. Thesis, University of Minnesota, October, 1957.

Professional Societies

Canadian Society of Civil Engineers
Association of Professional Engineers of British Columbia
American Society of Civil Engineers
Association of Professional Engineers of Colorado

Foreign Language Capability

None

TOBIE E. LANOU

Education

Master of Regional Planning, University of North Carolina, 1967
Special field: economics in planning
Government, A.B., Harvard College, 1958

Experience

Fifteen years experience in economic consulting and internationally focused program activities, both as principal of other consulting firms and as an independent consultant.

Economist, CH2M Hill. (1979-present) As project economist for the Milwaukee Water Pollution Abatement Program, a $ 1.6 billion undertaking, consults in the areas of economic and financial impacts, and financial programming for the project, including use of specially-designed computer models. Other projects include project feasibility analyses, including forecasting of internal rate of return, for a small hydro project in Oakland, Pennsylvania and energy cost analyses and forecasting studies for alternative wastewater treatment plant systems at Jones Island, Milwaukee, Wisconsin.

Consultant, Small Decentralized Hydropower (SDH) Program, National Rural Electric Cooperative Association, Togo (March-April, 1981). Part of two-man team sent to Togo at request of AID Mission to assess small hydropower potential. Work included identifying appropriate drainage basins for small hydro development; visited selected sites and recommended technical standards for mechanical and electrical facilities.

Vice President, Gladstone Associates, Washington, D.C. (1965-1975). Conducted studies on urban and real estate economics and finance.

Independent Consultant (1975-1979). Work included economic consulting on various projects and publishing work including publishing small magazine.

Interpreter, U.S. Department of State (1963-1965). French interpreter.

Foreign Language Capability

Fluent French.

WALTER D. LAWRENCE

Education

Electrical Engineering, B.S., Colorado University, 1940
Advanced Power Course, Department of Agriculture, 1967

Registration

State of Wyoming Professional Engineer Certificate No. 200, 1953

Experience

Team Leader and Electro-Mechanical Engineer, Small Decentralized Hydropower (SDH) Program, National Rural Electric Cooperative Association, Dominica (November, 1981). As part of three-man team, provided assistance to AID Mission in performing prefeasibility studies on candidate small hydro sites and assessment of feasibility of providing grid interconnection or mechanical power production from mini-hydro installations.

Consultant Small Decentralized Hydropower (SDH) Program, National Rural Electric Cooperative Association, Togo (March-April, 1981). Part of two-man team sent to Togo at request of AID Mission to assess small hydropower potential. Work included identifying appropriate drainage basins for small hydro development; visited selected sites and recommended technical standards for mechanical and electrical facilities.

Consultant (June 1977-present). Perform short-term contract work for AID including a small hydro powerplant feasibility study in Zaire and further work on the Indonesian rural electrification project assisting the Government in reconstruction of their power generation and transmission systems destroyed by hurricanes David and Frederick in August-September, 1979.

USAID/Indonesia (July 1973-June 1977). Worked with Government of Indonesia and their consultants in preparation of major power plant equipment procurement documents for a thermal powerplant and the implementation of two distribution rehabilitation projects in Central Java. Performed preliminary feasibility analyses on a rural electrification project.

USAID/Turkey (January 1968-July 1973). Worked with Government of Turkey in justifying loans on two major hydro powerplants, one thermal powerplant and a trans-Turkey 380 kv transmission line and major substations. Set test criteria for AID-financed Central Railway Control system between Ankara and Istanbul and the same for a micro-wave repeater telecommunications system in Iran financed by AID.

AID/Washington (June 1966-January 1968). Worked on a comprehensive electric power study for India to develop a schedule of major generation capacity requirements as a basis for evaluating Indian power loan requests. Prepared loan paper for a Korean power loan.

USAID/India, New Delhi (August 1962-June 1966). Developed loan papers for Government of India for six major steam power plants and two large hydro plants. Review and approval of specifications and procurement of documents for AID financing were followed by monitoring construction progress.

Electrical Engineer, Sri Lanka (October 1958-August 1962). Member of a seven-man team which developed a multi-purpose scheme for major river in Ceylon. Electrical market surveys and optimum

water utilization criteria for hydroelectric power, irrigation, and flood control were integrated into a large-scale plan for transport of water from southern Ceylon to the comparitively dry north. Provided cost estimates and financial analyses, as well as final design criteria, to Government of Ceylon. Parts of this system have been implemented.

U.S. Operations Mission (USOM), Lebanon (October 1957-September 1958). Acted as advisor on rural electrification to Government of Lebanon.

Internation Cooperation Administration (now A.I.D.) in India (April 1954-October 1957). As advisor to the Dasendar Valley Corporation (an Indian TVA) in West Begal, developed operation and maintenance plans. Later assigned to I.C.A. in New Delhi implementing AID assistance in the electric power sector. Established a successful hot line training center and training course in south India which continued to function after American advisors left.

U.S. Bureau of Reclamation District Office, Casper, Wyoming (October 1948-April 1954). As head of Resources and Development Division, formulated a multi-purpose development plan for the Colorado-Wyoming-Nebraska interconnected system which involved several utilities, many municipal sub-systems and rural electric cooperatives. Generation, transmission, telemetering, load-frequency control, and an extensive patrol radio system were parts of this plan.

U.S. Bureau of Reclamation Regional Office, Denver (August 1945-October 1948). Developed general plan for hydroelectric power projects in Colorado starting with hydrological and topographic data and electric power market studies. Made determinations on power plant characteristics and transmission requirements for serving the Colorado system.

General Electric, West Lynn Works (September, 1943-August, 1945). Product development and factory production engineer on mercury vapor and vacuum tube devices and development of electrical instrument hearings made of glass.

Office Contract Service Division, General Electric Company, Boston (September, 1941-September, 1943). Work included installation of wide variety of industrial control and municipal water pumping plants; field representative on GE-ALCO road diesel-electric locomotives; installation of fire control and drive control on U.S. Navy ships under construction.

General Electric Company Test Course, Schenectady (September, 1940-September, 1941). Technical, business, and factory floor work on industrial control, steam turbines, searchlights, and vacuum tube production.

Electrical Draftsman, Giffels & Vallet, A&E firm, Detroit (June-September 1940). Worked on factory electrical layouts for Ford Motor Company plants.

Foreign Language Capability

some French

NRECA NATIONAL RURAL ELECTRIC COOPERATIVE ASSOCIATION
1800 Massachusetts Avenue, N.W.
Washington, D.C. 20036/202-857-9500

April, 1982

PROGRAM STATUS

The following is a summary of activities undertaken by the Small Decentralized Hydropower (SDH) Program since June, 1980 under a cooperative agreement between the National Rural Electric Cooperative Association (NRECA) and the U.S. Agency for International Development (USAID).

I. RESOURCE IDENTIFICATION

A. Country Assessments Completed

Peru

In July, 1980, NRECA sent a team of Spanish-speaking specialists to Lima, Peru to assist the AID Mission in formulating their project paper for a program in small-scale hydropower development. The program was designed to promote rural and regional social and economic development through reasonably-priced hydro-generated electrical energy and to provide technical assistance to the mini-hydro program within the Ministry of Energy and Mines.

The NRECA team consisted of an economist, a social scientist, an engineer, and two environmental specialists. Their task was to develop the following sections of the project paper: a. project activities; b. prefeasibility methodology; c. feasibility methodology; d. economic analysis; e. institutional analysis; f. social analysis; and, g. environmental analysis. In addition, the team helped supervise preparation of feasibility studies for two mini-hydro sites that ELECTROPERU, the Peruvian national electric authority, proposed to develop.

The team worked for more than five weeks in Peru. Based on the information provided by the team, the project was approved for FY80 funding. The project proposed to lend the Government of Peru US$9 million to finance feasibility studies, civil works, equipment, and local distribution systems for approximately 28 small-scale hydroelectric installations in the 100 to 1,000 kW range. In addition, a grant of US$1 million was included for institutional assistance, prefeasibility studies, and a program for productive uses of electricity.

Panama

NRECA sent a micro-hydropower specialist to Panama in June, 1980 to assist the AID Mission and the Panamanian Institute of Hydraulic Resources and Electrification (IRHE) in planning a country-wide, micro-hydropower program.

In November, 1980, the SDH Program's principal engineer traveled to Panama to review the status of two micro-hydro demonstration sites. He provided technical advice on the electrical distribution design, project schedule, and program management.

Togo

In April, 1981, NRECA sent a three-man team to conduct a major, country-wide feasibility survey of small hydropower potential of Togo. The team, including a hydrologist, a small-hydro electrical engineer, and a socio-economist, selected a number of potential sites and evaluated them based on technical and economic criteria. The SDH Program's principal engineer assisted in on-site team coordination and field evaluation.

Tasks accomplished by the team during the survey included: a. hydrological study of drainage basins; b. identification of sites with appropriate hydrological and topographical features; and, c. comparison of sites based on potential capacity, annual energy production, proximity to grid and/or advantageous loads, social considerations, and problems in site development.

Based on the above, the team concluded in its report that mini-hydropower will not play a role in Togo's energy profile. Nonetheless, out of ten potential sites, two with favorable conditions were chosen for detailed prefeasibility studies including preliminary cost estimates and calculation of their internal economic rate of return. In addition to these sites, others not visible from the documents used might be worthy of further consideration and development.

Dominican Republic

NRECA sent a team to the Dominican Republic for five weeks during June and July, 1981 to assist the USAID Mission in preparing the small hydro component of its Energy Conservation and Resources Development Project. The team consisted of a small hydro engineer, an institutional advisor, and a socio-economic analyst.

The small hydro component focused on consolidating and building existing institutional capabilities in designing, constructing, and operating small hydroelectric plants in the Dominican Republic. The team developed a country-specific methodology to set priorities and select suitable candidate sites for AID funding as demonstration projects.

The team provided the information necessary for AID funding for a small hydro project. The report included technical, economic, financial, social, environmental, and institutional analyses of the sub-project. In addition, it contained two site-selection studies conducted by professionals from the Dominican Republic using the methodology developed by the team.

The team found that small hydro is an extremely attractive option for the Dominican Republic now for both oil displacement and new capacity additions. There are approximately 40 potential sites identified in the Dominican Republic with the possibility of many more as the Government begins to seriously consider the future role of small hydro in its overall energy picture.

Ghana

In August, 1981, at the request of the Government of Ghana, NRECA sent a three-man team, including a mini-hydro specialist, an economist, and a rural electrification specialist, to assess the rural electrification options and priorities in the Western Region of Ghana. The team submitted a report evaluating the role mini-hydropower could play in decentralized generation schemes in Ghana.

Bangladesh

At the request of the AID Mission in Dacca, NRECA sent a two-man team, including a hydrologist and a small hydro engineer, to Bangladesh in October, 1981. The team assessed the potential for small hydro in Bangladesh and looked at particular applications of low-head installations during a three week stay. The team visited four areas where small, low-head hydroelectric projects are feasible and should be pursued, recommended six sites for prefeasibility studies, and conducted a prefeasibility study on one barrage. Follow-up work with NRECA assistance on project development is anticipated in the near future.

Tunisia

In December, 1981, the SDH program manager led a fact-finding mission to Tunisia at the request of the AID Mission. The three-man team, including a small hydropower expert, a solar specialist, and a wind expert, prepared a report which evaluated the renewable energy potential in Tunisia. Based on the team's findings a decision will be made whether to send a survey team to Tunisia to conduct a resource assessment.

Sierra Leone

In March, 1982, the SDH mini-hydro development specialist visited Freetown, Sierra Leone at the request of AID to make a preliminary assessment of the interest and potential for small hydro development in that country, and submitted a report of his

findings and recommendations. AID/Freetown has requested ST/EY to perform a follow-up country-wide assessment later during the year.

B. Country Assessments Anticipated

Burundi	Pakistan
Egypt	Portugal
Guinea	Sri Lanka
Honduras	Sudan
Indonesia	Vanuatu
Lesotho	

II. SITE SELECTION AND PROJECT DESIGN

Morocco

In August, 1980, AID/RABAT requested the immediate services of a small-scale hydro specialist to assist the Mission in reviewing the Moroccan country assessment performed by a large U.S. engineering firm. The Mission felt that the firm was oriented toward large-scale civil works and needed to be guided toward smaller-scale projects. Within a week, NRECA contracted the services of a mini-hydro specialist and flew him to Morocco.

After two meetings with the engineering firm, AID engineers, and representatives of the Government of Morocco, the large civil works approach was deleted from the project. Since the smaller structure improved the economic feasibility of the hydroelectric program, AID/RABAT continued with the program. Three potential sites were identified for development and site data was collected. In November, 1980, NRECA sent an engineer to Morocco to supervise a survey team which developed the site profiles and preliminary layouts.

In October, 1981, NRECA sent its Micro-Hydro Engineer and a mini-hydro specialist to work with local consulting firms and representatives of the Office National de l'Electricite and the Centre de Developpement des Energies Renouvelables in prospecting for sites in Ouarzazath Province and to review any potential interference of a proposed small hydro scheme at Argbalou-N-Kerdous with the existing irrigation system.

Thailand

The AID Mission in Bangkok requested NRECA technical assistance for prefeasibility investigations of potential small hydro sites throughout Thailand. There were 25 sites identified for consideration.

The 25 sites were characterized according to physical characteristics and potential demand structure. From this ranking, six sites were chosen for prefeasibility studies

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according to the following criteria: a. priority of area development; b. potential for productive uses; c. replacement of existing diesel-generating sets; d. lack of potential for grid connection; e. favorable benefit to cost ratios; and, f. potential for co-financing.

The NRECA members of the team included a small hydro engineer and an institutional advisor who manages one of NRECA's member rural electric systems. The team conducted prefeasibility studies on the six sites selected. The studies were conducted and written in such a manner that they could be incorporated in the Mission's project paper and be proposed for financing through AID.

NRECA also provided the services of an electro-mechanical engineer whose duties included working with engineers from the National Energy Administration and helping them select appropriate equipment. A report was prepared recommending the selection of appropriate governors (mechanical or electronic) and determining the potential for their manufacture in Thailand.

Zaire

NRECA provided technical assistance to a group of individuals from the northwestern United States that raised money to install a small hydro unit in Nundu, Zaire for a church hospital. In addition, the staff located possible sources of additional funding for the project.

In March, 1981, NRECA sent two engineers to Zaire to assist the AID mission in evaluating several proposed small hydro projects. Their assessment was aided by the SDH principal engineer who assisted in coordination and field evaluation. The engineers visited sites throughout the country, which were generally found to be feasible, and assessed the possibilities for a national small hydro program. At the end of the assignment, the team left a report with the mission outlining options available to AID for a small hydroelectric project. The options ranged from financial assistance at selected sites to a massive, multi-donor program involving institution building, training, and introducing productive uses of electricity. Further SDH assistance in developing a $10 million small hydro project is under request.

Rwanda

In November, 1981, a two-man team, including the SDH Program's principal engineer, travelled to Rwanda to conduct a detailed study on one micro-hydro site at Kaviri Falls and initial assessment of nine undeveloped sites, and to prepare a report of its findings and recommendations. This work was performed through the AID mission for Rwanda's Center for Energy Research.

Dominica

In September, 1981, at the request of the AID mission in Barbados, the SDH Program's principal engineer travelled to Dominica to develop a scope of work for a small hydro team. Subsequently, a three-man team, including a small hydro engineer, a civil engineer, and an economist, was sent by NRECA in November, 1981 to evaluate the potential for small hydro development in Dominica during their three-week stay in November. The team identified several possible sites and conducted on-site prefeasibility studies to assess potential for providing decentralized rural electrification, and submitted a report of its findings and recommendations.

Liberia

At the request of AID's Africa Bureau, a two-man NRECA team in February, 1982 visited an on-going AID/Peace Corps-sponsored project for a 35 kW micro-hydro scheme in Yandohun, Northern Liberia, to evaluate progress on construction of the site and to advise the resident Peace Corps volunteer and the AID Mission on means of bringing the project to successful completion. The team will soon submit its final report of findings and recommendations.

III. DEVELOPMENT OF SDH DATA AND INFORMATION BASE

A. Equipment Manufacturers

NRECA has developed an inventory of U.S. manufacturers of small hydroelectric equipment, and has contacted and, in some cases, visited the manufacturers. NRECA has classified the manufacturer's products for appropriate applications and continually revises the file of U.S. manufacturers and products, reflecting market changes. When requests for U.S. equipment are received, NRECA notifies the manufacturers.

The second edition of the Directory of Sources of Small Hydroelectric Turbines and Packages in now available. It contains descriptions of U.S. and developing country firms which satisfy U.S. source requirements and their equipment lines as well as an introductory chapter on packaged units.

B. State-of-the-Art Technology

NRECA engineers have visited numerous small-scale hydro projects in developing countries to study various approaches that have been undertaken using conventional as well as unconventional technologies. NRECA has gathered photographic documentation of small hydropower sites in five Asian countries (Indonesia, Nepal, Pakistan, Papua New Guinea, and Thailand) in the form of nearly 1,000 slides to document their social, economic, and technical characteristics. This documentation has helped to provide the basis for recommending appropriate, decentralized hydropower

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technology for developing areas, and has been used in the SDH workshop series to expose other developing countries to methods that have proven successful in typical rural settings in the developing world.

The first case study, "A Case Study: Micro-Hydropower Schemes in Pakistan," is complete and discusses the unusually low-cost ($350-500/installed kW) approach being used to install hydropower plants (up to 50 kW) in remote mountainous regions of northern Pakistan. A similar study for Nepal is underway.

C. Methodologies

NRECA has developed the following methodologies:

1. Country Assessment of Mini-Hydropower Potential--for assessing a country's physical characteristics, in determining the need and feasibility of a national mini-hydro program;

2. Prefeasibility Studies of Candidate Mini-Hydro Sites--for analyzing specific sites to assure that there is sufficient hydraulic and economic potential to justify more detailed investigations; the methodology can be used to rank a group of sites under consideration;

3. Hydrological Estimates for Small Hydroelectric Projects--for estimating stream-flow duration and peak flows in regions where very little data is available; and,

4. Environmental Methodologies for Small Hydropower Project--for assessing environmental impacts of a prospective mini-hydro project.

D. Special Studies

NRECA has undertaken three special studies designed to focus on key problem areas in the implementation of SDH programs and projects in developing countries on--

1. management (analyses of issues of centralized versus decentralized control, including successes and shortfalls);

2. site evaluation (development of criteria from which to build a methodology for evaluating small-scale energy systems).

3. economic planning (comprehensive planning guide consisting of economic feasibility methodology, end-use planning guide, costing methodologies, and

financial analysis approaches and a directory of private and public financial sources and their lending criteria.

E. Audio-Visual Aids

NRECA working with Energy Independence Research Corporation, has prepared slides with written narrative describing the testing, installation, and start-up of mini-hydroelectric units in Panama.

In addition, the NRECA has prepared a slide presentation which outlines the SDH Program rationale and activities, reviews basic small hydro technology, and identifies specific problem areas in small hydro development.

Also completed is a slide presentation outlining appropriate end uses of mini-hydro in developing countries. NRECA is in the process of developing a catalogue of information on appropriate productive uses of SDH in agriculture, cottage and rural-based industries, and households in remote rural areas of developing countries.

IV. TRAINING PROGRAM

Responding to the urgent need for training in developing countries, the NRECA has developed a proposal for a small hydropower training program to train mid-level engineers, planners, and project managers from developing countries. The proposal outines a six-week, intensive, multi-disciplinary training program to be conducted at a U.S.-based university to help developing countries more effectively plan, build, operate, and manage small hydro schemes. The training covers all aspects of small hydropower including site assessment, civil engineering, electrical and mechanical equipment, economic feasibility, financing, and management. Hands-on training, where trainees are actually engaged in the mechanics of the subjects, and field trips to small hydro sites under development and operating plants are an integral part of the training.

NRECA's role will be to not only coordinate the program, but to assist in the actual classroom training, select and prepare training materials, recruit candidates from its member systems, in-house training specialists, university faculties, and the private sector, and monitor and evaluate the overall effectiveness of the training program.

V. WORKSHOPS

A. Latin America and the Caribbean

NRECA conducted its first international workshop on small hydro development August 19-21, 1980. Held at the Hotel Inter-Continental Quito in Quito, Ecuador, the workshop attracted 118 attendees from 13 Latin American countries and the U.S.

NRECA, in cooperation with USAID, jointly sponsored the workshop with the Instituto Nacional de Energia (INE) and the Instituto Ecuatoriano de Electrificacion (INECEL). NRECA developed the technical program, which included recruiting, coordinating, reimbursing AID-sponsored attendees, and preparing printed materials for the workshop.

Nineteen technical papers were presented dealing with various aspects of small hydroelectric development including site selection, environmental effects, design, operation, and economic feasibility. Speakers from Ecuador, the U.S., Peru, England, and France participated in the program.

Complete proceedings of the workshop, prepared by the SDH Program staff, are available in Spanish and English on a limited basis.

B. Asia and the South Pacific

NRECA held its second workshop on small hydro development in Bangkok, Thailand, June 8-12, 1981. NRECA, in cooperation with USAID, cosponsored the workshop with the Asian Institute of Technology (AIT) and the National Social and Economic Development Board of Thailand (NESDB). More than 100 attendees from 15 Asian and South Pacific nations heard technical presentations and panel discussions, and participated in small workshop groups on subjects ranging from hydrological methodologies to economic and financial issues pertaining to the development of small-scale, rural hydroelectric projects.

NRECA, in collaboration with AIT, is in the process of editing the workshop proceedings for publication, which will be available for distribution by spring, 1982.

C. Africa

The third regional workshop was held March 1-5, 1982 in Abidjan, Ivory Coast attended by representatives from 22 nations of the Central and West African regions. Cosponsored by NRECA, AID, the Union of Producers, Conveyors, and Distributors of Electrical Energy in Africa (UPDEA), and the African Development Bank (ADB), the workshop featured 15 major paper presentations by several SDH staff members and other speakers from Pakistan, Colombia, Ecuador, New Zealand, Germany, Malaysia, Great Britain, the United States and a number of African countries, on a wide range of technical

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and non-technical subjects pertaining to small hydro development. A field case study of a site in nearby Aboisso that is under consideration by the Government of Ivory Coast for development was conducted. The participants were given four design options ranging from 700 to 14,000 kW and divided into four working groups to study the relative technical and economic merits of each approach. At the workshop conclusion, representatives from each group presented their findings in a plenary session to review the issues that had been raised during the week's presentations in the practical context of a simulated project design. A proceedings of the workshop is planned.

D. Financial issues

NRECA conducted a one-day workshop on financing SDH development. Speakers from private and multilateral banks, NRECA, and AID regional Bureaus presented their views on key problems facing developing countries in locating financing for SDH projects and programs.

A transcript of the proceedings is available upon request.

VI. OTHER ACTIVITIES

A. Conferences

In September, 1980, the SDH program manager was invited by the Organization of American States (OAS) to participate on a rural energy panel at the Inter-American Symposium on the Development of Alternative Energy Sources. The symposium was held in Sao Paulo, Brazil September 2-5, 1980.

Two members of the SDH staff presented papers at the UNITAR Conference on Small Energy Resources in Los Angeles, California September 10-18, 1981. The papers outlined small hydropower potential in developing countries and the SDH Program's efforts to assist these countries in tapping this resource. Both papers generated wide discussions with the audience. The conference attracted more than 200 participants, mostly from developing countries.

In December, the SDH Program's micro-hydro engineer traveled to Nairobi, Kenya at the request of USAID to present an overview on small hydropower with slides at a USAID-sponsored workshop. The workshop was designed for those USAID individuals in African AID Mission countries involved with energy programs.

B. Miscellaneous

At the request of the Institute of Hydraulic Resources and Electrification (IRHE) in Panama, NRECA's International Programs Division sent the SDH Program's mini-hydro development specialist and a senior power use specialist to develop a promotional program

in conjunction with Panama's Five Year Rural Electrification Plan. The two-man team developed guidelines for a complete promotional program based on NRECA experiences in the U.S., Bangladesh, Bolivia, and other developing countries.

The SDH staff also acts as a resource for NRECA's member rural electric systems in the field of small hydropower development. The staff has provided technical advice to member systems on the installation of mini-hydroelectric plants.

VII. PUBLICATIONS

A. Publications Completed

- Small Decentralized Hydropower (SDH) Program--brochure describing the SDH Program history and activities; also available in Spanish and French;

- Small Hydroelectric Powerplants: An Information Exchange on Problems, Methodologies, and Development--proceedings of the small hydropower workshop held in Quito, Ecuador, August 19-21, 1980, sponsored by the SDH Program (in cooperation with USAID), the Instituto Nacional de Energia and the Instituto de Electrificacion; available in English and Spanish;

- Methodology for Country Assessments of Mini-Hydropower Potential--from a country's physical characteristics, conclusions can be drawn on the need and feasibility of a national mini-hydro program; also available in Spanish and French;

- Methodology for Prefeasibility Studies of Candidate Mini-Hydro Sites--for analyzing specific sites to assure that there is sufficient hydraulic and economic potential to justify more detailed investigations; the methodology can be used to rank a group of sites under consideration; also available in Spanish and French;

- Hydrologic Estimates for Small Hydroelectric Projects--for estimating stream-flow duration and peak flows in regions where very little data is available;

- Environmental Methodologies for Small Hydropower Projects--for assessing environmental impacts of a prospective mini-hydro project.

- Directory of Sources of Small Hydroelectric Turbines and Packages--descriptions of U.S. and developing country manufacturers and their equipment lines as well as information on packaged units; second edition now available; also to be available shortly in French;

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- "Thinking Small: When the Oil Crunch Hit, Pakistan Turned To Small Hydropower," Agenda, January-February, 1982 issue;

- "Rural Power Schemes in Pakistan," International Water Power and Dam Construction, November, 1981 issue--article summarizing the work of the Appropriate Technology Development Organization in implementing micro-hydropower schemes in Pakistan;

- "A Case Study: Micro-Hydropower Schemes in Pakistan"--discusses the unusually low-cost approach used to install hydropower plants in remote regions in northern Pakistan;

- Requirements to Finance Small-Scale Hydroelectric Projects--transcription of proceedings from the March 10, 1981 NRECA Workshop on financing small hydropower projects;

- "Use of Alternative Energy Technologies by U.S. Rural Electric Systems," ELETRORURAL, November, 1981 issue; article outlines efforts of U.S. rural electric systems in renewable energy technologies (wind, solar, hydroelectric, biomass, peat, and geothermal);

- Small Hydro Potential in Developing Countries--paper presented at the UNITAR Conference on Small Energy Resources, September 10-18, 1981 in Los Angeles, California; outlines potential for small hydropower development in developing countries;

- NRECA's Small Hydro Activities in Developing Countries--paper presented at the UNITAR Conference on Small Energy Resources, September 10-18, 1981 in Los Angeles, California; outines efforts by SDH Program staff in developing small hydro potential in developing countries;

- Developing Small Hydro Sites: Process for REA Borrowers--paper describing the sequence of events for processing the front-end activities of a small hydroelectric project;

- Small Hydro for Rural Energy--paper presented at OAS Energy Conference, September, 1980, Sao Paulo Brazil;

- Environmental Issues and Site Selection Criteria for Small Hydropower Projects in Developing Countries--an evaluation of environmental issues in selecting small hydropower sites.

- Institutional Models for Implementing and Managing Small Hydropower Projects--field studies of analyses of issues of centralized versus decentralized control, including successes and shortfalls;

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- Evaluating Electrification Experience: A Guide to Social Evaluation of Small Hydroelectric Units in Lesser Developed Countries, and the Results of the AMARU Study of Social Factors in Local Electrification Lessons from the Literature--development of criteria from which to build a methodology for evaluating small-scale energy systems.

B. Publications Underway

- Micro-Hydro Sourcebook--to provide a wide range of information useful in implementing micro-hydropower schemes;

- Report on the NRECA Private Sector Participation Project--analyzes potentially viable approaches to encourage the U.S. private sector to participate in the development of hydropower sites in developing countries;

- The Contribution of Legislative Initiatives such as PURPA Towards Involving the Private Sector in the Development of Small Hydroelectric Powerplants in Developing Countries--analyzes effects of PURPA on the private sector's involvement in developing small hydropower plants in developing countries;

- Considerations, Sources, and Requirements to Finance Small-Scale Hydroelectric Systems--examination of plans and policies of international lending institutions and their effectiveness in small-scale, isolated energy development;

- Small Decentralized Hydropower for Asian Rural Development--proceedings of a regional workshop held in Bangkok, Thailand June 8-12, 1981 on small hydropower sponsored by NRECA, in cooperation with USAID, the Asian Institute of Technology (AIT), and the National Social and Economic Development Board of Thailand (NESDB).

- Small-scale Hydropower in Africa--proceedings of a regional workshop held in Abidjan, Ivory Coast, March 1-5, 1982 under the joint sponsorship of NRECA, USAID, the African Development Bank (ADB) and the Union of Producers, Conveyors, and Distributors of Electrical Energy in Africa.

- "A Case Study: Butwal's Experiences with Micro-Hydropower Schemes in Nepal"--discusses unique approach using local resources to implement small hydro systems.

WORKSHOP EVALUATIONS-QUITO (Sample)

YOUR COMMENTS ARE APPRECIATED
APRECIAREMOS SUS COMENTARIOS

Has this workshop been helpful to you professionally?
Le ha resultado profesionalmente provechosa esta conferencia?

yes

2. Would you recommend any changes in the content or organization of this workshop?
Recomendaría usted cambios en el contenido u organización de la conferencia?

one free morning or afternoon for sightseeing and/or shopping would have been very convenient for the benefit of foreign participants.

3. Which presentation(s) was(were) most helpful to you? Least helpful?
Presentaciones que le fueron más beneficiosas - o menos beneficiosas?

In order of preference - Grover, Gladwell, Arndt, Mata and Cassidy.
Although not technical, the presentation of Mr. Armstrong has been very interesting and it is a pity there is no corresponding paper.

4. How do you rate the physical facilities (hotel, meeting rooms, food service, etc.)
Evaluación de las facilidades físicas (Hotel, salas de conferencia, servicio de alimentos, etc.)

good

5. Do you feel there is much potential for small hydroelectric generation in your area? (Please specify area)
Cree usted que hay potencial para centrales pequeñas de generación hidroeléctrica en su área? (Favor de especificar el area) - ECUADOR

yes. In the upper reaches of all mountain rivers, specifically of the Mira, Esmeraldas, Guayas, Pastaza, Jubones and Santiago basins. INECEL will establish the priorities as part of the studies of Plan Maestro de Electrificacion

6. General comments -- Comentarios generales:

It would be beneficial if NRECA acting as a base, could maintain postal contact between participants for interchanging information.

7. NAME (Optional) -- NOMBRE (Opcional)

Ing. SVIAT KROCHIN S.

Extracted from Quito Conference Evaluations

Specific recommendations:

More dialogue involving participants

Small group to exchange information and develop relationships

Each participant should introduce himself

A checklist covering factors involved in planning and implementation of a micro hydro project should have been presented

Step by step slide presentation on a mini hydro project development

Papers prepared should be oriented to stated themes of the workshop

A trip to mini-hydro in operation and some time for shopping should have been included in the program (Perhaps Monday p.m. before formal meetings)

Field trip to a potential site (a good one and a bad one) and a plant already constructed

There should perhaps be some consideration on geotechnical aspects, more on hydrologic assessment when data doesn't exist, and on differences in planning for public and private projects

Should be more technical

Armstrong's slide presentation excellent - need more of this type of perspective

Handout or brief introduction of speakers background to better evaluate presentation

Division of participants into working groups according to area of interest or technical area (planning, institutional organization, technology, etc.) These groups could prepare the recommendations of the workshop.

Financing representatives could present their policies towards financing small hydro, method for evaluating project proposals, etc.

Relationship between regional or rural development and hydro schemes; importance of energy development in the diversification of economic activities in rural areas.

There needs to be a clear definition between the different technological levels and requirements according to the scale: mini, micro, small.

Comparison and analysis of case studies done in small working groups.

Distribute copies of papers just before each presentation

Should be kept within the subject of the workshop

Recommendations cont.

Should be kept within the subject of the workshop

Less emphasis on informative subjects

More details on implementation process

Some means to control long winded speakers

Most important has been the opportunity for small hydro persons to meet, exchange ideas and develop foundation for future contacts

Want to be kept informed about similar meetings coming in Central and South America

More round table discussions

Greater discussion of extension, productive uses of electricity and repayment or amortization

Social economic creiterion for selection of sites for small hydro facilities

Advanced translation of papers

Mini/micro hydropower needs greater flexibility to incorporate 1 to 5 MW

Institutional Management and the possibility of connection to the National Grid

Economic analyses need to develop new set of priorities for the approval of projects, i.e., social benefits, the availability of resource,

More importance on financial analysis rather than B/C ratio

Want better explanation on quantification of qualitative aspects

Request bibliography, specific for small plants in industry

Some consideration of the possibility of utilization of small hydropower plants in industry

One free morning or afternoon should have been set aside for sightseeing and/or shopping

NRECA maintain postal contact between participants for interchanging information

Some practical application topics should be dealt with in more detail

Organize another workshop to evaluate progress

Eliminate theoretical aspects -- concentrate on technological practical aspects

More participation at a national level by people already involved in this area

More exchange of practical experience

More information re government enterprises for electric public services in Latin America and consumer coops

Recommendations - cont.

Use more modern methods of translation

Enclosed quarters for translators should have no public accessibility

Best received papers

Ken Grover -- 22

Juan Mata La Cruz -- 15

Dr. Armstrong -- 9

Dr. Cassidy -- 7

Dr. Arndt -- 7

Gladwell---4

Zoellner -- 3

Henwood -- 3

Ayora -- 2

Egoavil -- 1

Evans -- 1

Smith -- 1

Least useful presentations:

Community Load Determination -- 2

Environmental Impact -- 2

Generation & Distribution -- 3

Feasibility Studies Methodologies -- 1

Site Selection & Turbine Setting -- 1

Total Number of evaluations: 43 (39.81 %)

Total Number of Registration Cards: 108

WORKSHOP EVALUATIONS-BANGKOK (Sample)

Your profession:

Other areas of interest:

To enable us to plan and conduct future workshops such as this in a better fashion, we ask that you answer the questions below. (Use other side if needed)

1. What were the general strengths and weaknesses of the workshop?

2. What format best served the purpose of presenting useful information?

paper presentations ___ panels ___ workshops ____ other_____

3. Which of the topic areas covered in the paper presentations offered the most useful technical information?

4. Was the detail generally sufficient?

5. Which topics deserved more attention?

6. Which topics deserved less attention?

7. Are slides a useful medium, or should they be emphasized less in the future?

8. Give examples of session topics that were most useful to what you are interested in learning about:

9. What do you feel was most lacking in this workshop?

10. What improvements in the organization of the workshop (transportation, financial arrangements, audio-visual arrangements, meals) could you suggest?

Participants Evaluation of the Bangkok Workshop.

This summarizes the responses to the ten-question survey which was filled out and returned to NRECA by 38 of the participants of the Bangkok Small Hydro Workshop, June 1981. The questionnaire is attached.

The responses were analyzed in the same numerical order used in the questionnaire. An exception was called for to deal properly with questions number one: "What are the general strenghts and weaknesses of the workshop?", and question number ten: "What improvements in the organization could you expect?". Many of the respondents concentrated their reponses on these two questions; therefore, they range from the very general to the very specific. For the purpose of tabulating them, only the general comments were summarized under question one and ten below, specifics were incorporated with the answers that address thst particular issue.

Most of the responses fall within three general areas, which correspond closely to the format of the workshop sessions. The areas are: I. Technology: Issues, Design, Manufacturing; II. Management; and III. Social and Economic Implications.

There are limitations in the utility of responses, due to the terminology used by participants. In some cases terms are too general and can be applied to a number of different subjects, i.e. "planning", "data gathering", "energy conservation". Another limitation is the low percentage which responded consistently to all the questions; therefore, there are extremely few questionnaires which represent a composite view of the workshop by any particular participant. More importantly, it seems that the breadth of question one tended to invite a wide range of comments and acted as a disincentive to answer more specific subsequent questions. In the end, neither the broad nor specific questions were properly addressed.

---Responses to Question One, "What are the general strenghs and weaknesses of the workshop?":

The following positive factors were mentioned: contacts, information exchange and stimulation of cooperation (10); extensive coverage of workshop subject (2); contact with NRECA staff (1).
The following referred to coverage of technical aspects: considered covereage not sufficient (4); considered it adequate (1); too much (1).
The following comments were addresed to the workshops: mentioned deficient moderator (9); considered workshops too short (3); saw presentations too long and discussions too short (3); felt panels did not include a good cross section of countries (3); discussions were seen as redundant or off-subject (3); saw too much emphasis on U.S. (1); rated workshops as good (1); rated workshops as poor (1); rated panels as poor (1); felt not sufficient chance for participants to take part (1); praised role of U.S. consultants (1).
In addition, there were the following comments with regards to general organization, six participants called it "excellent", thirteen mentioned "good".

---Responses to Question Two: "What format best served the purpose of presenting useful information? paper presentations------.

panels------, workshops--------,other-------."
Thirty two participants responded,most checked more than one format. 20 responses mentioned paper presentations, 11 mentioned panels, 24 mentioned workshops, 5 checked "other".

---Responses to Question Three: "Which topic areas covered in the paper presentations offered the most useful technical information?"
I. Technology:Issues, Design, Manufacturing and Operation. The following subjects are listed in this general area: turbine design (14); hydrologic methodology (8), site location and civil works (6); electrical design (2); operation and maintenance of minihydro equipment (1); design (1); technical (1).
II. Management. The following subjects are listed: financial issues and economic feasibility (6); planning for productive end uses (3); planning for minihydro development (2); evaluation criteria (2); project organization (1).
III. Economic and Social Implications. The following opinions were recorded: community participation (1); institutional issues (1).
In addition, question three received the following general comments: everything (1), many (1), none (1).

---Responses to Question Four: "Was the detail generally sufficient?". Twenty two responded positively, two added that greater detail should be furnished as follow-up to conference. Twelve responded it was not sufficient, and one said there was too much detail.

---Responses to Question Five: "Which topics deserved more attention?"
I. Technology: Issues, Design, Manufacturing and Operation. The following was recorded in this area: site location and civil works (10); design (3); operations and maintenance (3), turbine design (2); analysis of construction and istallation (1); hydrological methodology (1); local manufacturing (1).
II. Management. The following responses were recorded: planning for product end-uses (5); financial issues and economic feasibility.(4); integrated planning (1); project organization (1); energy conservation (1).
III. Social and Economic Implications. This area received the following mentions: social aspects (5); institutional issues (4); social and economic analysis (1); community development and technology transfer (1).

---Responses to Question Six: "Which topics deserved less attention?".
I. Technology:Issues, Design, Manufacturing and Operation. The following was recorded under this general area: hydrological methodology (3);equipment design (1); turbine design (1); electrical design (1); civil works design (1); operations and maintenance (1); physical aspects (1); purely theoretical presentations (1).
II. Management. The following responses were recorded for this area:financial issues and economic feasibility(4); planning (2); commercialization (1); evaluation criteria (1); general feasibility (1); general topics (1).
III. Social and Economic Implications.
The following responses were recorded: social and institutional (5); community development and technology transfer (1); textbook

introductions (1).

---Responses to Question Seven: "Are slides a useful medium , or should they be emphasized less in the future?"
Thirty three participants responded slides were a useful medium, one responded negatively. Six respondants said, "use more", of these two added "but improve". Four respondants said "use less", of these two added "but improve".

---Responses to Question Eight: "Give examples of session topics that were most useful to what you are interested in learning about".
I. Technology:Issues, Design Manufacturing and Operation and Maintenace. The following responses referred to this general area: manufacturing (9); operations and maintenance (6); design (5); turbine desing (5); site selection (3); hidrological methodology (3); general technology(2); local technology (1); implications of size (1); general "how to" (1).
II. Management. The following responses were recorded in this area: financial issues and economic feasibility (13); planning for productive end-uses (5); none (2); general feasibility (2); evaluation criteria (1); local management (1).
III. Social and Economic Implications. The following responses mentioned topics in this area: social impact (3); community participation (3); institutional issues (2), specific examples of experiences in other countries; none (2).

---Responses to Question Nine: "What do you feel was most lacking in this workshop?"
The respondents mentioned the following: role and effectiveness of moderator (8); availability and timely distribution of papers (5); more practical experience (2); sessions of equal interest to participants overlapped (1).

---Responses to Question Ten: "What improvements in the organization of the workshop (transportation, financial arrangements, audio-visual arrangements, meals) could you suggest?"
These responses included the following: better food (and consideration for dietary and religious limitations) (5); meetings should take place at the hotel or place of lodging (3); more field trips (2); schedule too tight (2); accomodations at site should be provided for all participants (1); more advanced notice of conference (1); better information package (1); better slide screen (1); better finnacial arrangements (1); too much money (1); better transportation; more experts in the area of design and operations (1).

Recommendations for Future Questionnaire Designs.

Open ended questions. such as "general strenghs" should be included at the end of the questions. When placed at the beginning. as is the case in the present design. it disorients repondents about the length and breadth of response, tending to discourage attention to subsequent questions.
Greater use of multiple choice and quick check-mark question may be useful in a number of ways: help participants recall the issues, specifics. etc. and give more accurate responses. assure a higher

percentage of responses and simplify the tabulation and analysis of the answers. Space can be given at the end of each question, or at the end of the questionnaire, to encourage personnal and general comments.

Summary Tabulation Of Responses to Bangkok Workshop

I. General strenghs and weaknesses:

The most frequently cited strenghs (in order of mention) were:
a- Information exchange and contact (26 %).
b- Extensive coverage of topic (0.05%).

The most frequently cited weaknesses (in order of mention) were:
a- Deficient workshop moderator (23%).
b- Lack of good representation of all countries in panels (0.07 %).

II. The most frequently mentioned areas which offered useful techn. :al information were:
a- Turbine design (36%).
b- Hydrological methodology (8%).
c- Site location and civil works design (15%).

III. The most frequently mentioned areas which deserved more attention were:
a- Site location and civil works (26%).b- Planning for product end-uses (13%).
c- Financial issues and eco. feasibility (10%).

IV. The most frequently mentiones areas which deserved less attention were:
a- Social and institutional issues (13%).
b- Financial issues (10%).
c- Hydrological methodology (0.07%).

V. The most mentioned areas regarding useful topics were:
a- Financial issues and eco. feasibility(34%).
b- Manufacturers (23%).
c- Operations and maintenance (13%).

VI. The areas most mentioned as "lacking" were:
a- Role of the moderator (21%).
b- Availability and timely distribution of paters (13%).

VII. The most mentioned impprovements meeded in the organization of the conference were:
a- Better food (13%).
b- Meetings should take place in hotel or lodging (0.07%).

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Bangkok Workshop Evaluations

2. What format best served the purpose of presenting useful information?

   32 participants responded, most with multiple responses. The breakdown of responses is listed below.

paper presentations	panels	workshops	other
20 of 32	11 of 32	24 of 32	5 of 32

WORKSHOP EVALUATIONS-AFRICA

(Sample)

SMALL HYDROPOWER IN AFRICA

Daily Evaluation Form

Monday, March 1

Please rate the overall quality of each presentation, using a scale of 1 (poor) to 5 (excellent). Please circle only one number of each line that corresponds to the quality of the presentation in terms of: (1) the applicability of subject matter, (2) the presentation of the subject matter, and (3) technical substance.

1. Paper: Introduction to Small Hydro Technology and Development

	POOR				EXCELLENT
applicability of subject matter	1	2	3	(4)	5
presentation of subject matter	1	2	3	(4)	5
technical substance	1	2	3	(4)	5

2. Slide Presentation: End-Uses

applicability of subject matter	1	2	3	(4)	5
presentation of subject matter	1	2	3	(4)	5
technical substance	1	2	(3)	4	5

3. Case Study: Ivory Coast

applicability of subject matter	1	2	3	(4)	5
presentation of subject matter	1	2	3	(4)	5
technical substance	1	2	3	(4)	5

4. Case Study: Ecuador

applicability of subject matter	1	2	3	(4)	5
presentation of subject matter	1	2	3	(4)	5
technical substance	1	2	(3)	4	5

5. Case Study: Pakistan

applicability of subject matter	1	2	3	(4)	5
presentation of subject matter	1	2	(3)	4	5
technical substance	1	2	3	(4)	5

6. Case Study: Zaire

applicability of subject matter	1	2	(3)	4	5
presentation of subject matter	1	2	3	(4)	5
technical substance	1	2	(3)	4	5

7. Panel: Rural Small Hydro Systems

applicability of subject matter	1	2	3	(4)	5
presentation of subject matter	1	2	3	(4)	5
technical substance	1	2	3	(4)	5

SMALL HYDROPOWER IN AFRICA

Daily Evaluation Form

Tuesday, March 2

Please rate the overall quality of each presentation, using a scale of 1 (poor) to 5 (excellent). Please circle only one number on each line that corresponds to the quality of the presentation in terms of (1) applicability of subject matter (2) the presentation of the subject matter, and (3) technical substance.

1. Slide Presentation: Small Hydropower Schemes

	POOR----------				EXCELLENT
applicability of subject matter	1	2	3	4	(5)
presentation of subject matter	1	2	3	4	(5)
technical substance	1	2	3	(4)	5

2. Paper: Hydrologic Assessment Methodologies

applicability of subject matter	1	2	3	(4)	5
presentation of subject matter	1	2	3	4	(5)
technical substance	1	2	3	4	(5)

3. Paper: Site Development and Turbine Setting

applicability of subject matter	1	2	3	4	(5)
presentation of subject matter	1	2	3	4	(5)
technical substance	1	2	3	4	(5)

4. Paper: Equipment Design and Local Manufacturing Opportunities

applicability of subject matter	1	2	3	4	(5)
presentation of subject matter	1	2	3	(4)	5
technical substance	1	2	3	(4)	5

SMALL HYDROPOWER IN AFRICA

Daily Evaluation Form

Thursday, March 4

Please rate the overall quality of each presentation, using a scale of 1(poor) to 5 (excellent). Please circle only one number on each line that corresponds to the quality of the presentation in terms of (1) applicability of subject matter, (2) the presentation of the subject matter, and (3) technical substance.

1. Paper: Economic Feasibility and Economic Returns

	POOR				EXCELLENT
applicability of subject matter	1	2	3	4	5
presentation of subject matter	1	2	3	4	5
technical substance	1	2	3	4	5

2. Paper: End-Use Planning

applicability of subject matter	1	2	3	4	5
presentation of subject matter	1	2	3	4	5
technical substance	1	2	3	4	5

3. Paper: Cost Implications of Small Hydro-power Systems

applicability of subject matter	1	2	3	4	5
presentation of subject matter	1	2	3	4	5
technical substance	1	2	3	4	5

4. Paper: Financial Strategies and Planning

applicability of subject matter	1	2	3	4	5
presentation of subject matter	1	2	3	4	5
technical substance	1	2	3	4	5

SMALL HYDROPOWER IN AFRICA

Daily Evaluation Form

Friday, March 5

Please rate the overall quality of each presentation, using a scale of 1 (poor) to 5 (excellent). Please circle only one number on each line that corresponds to the quality of the presentation in terms of: (1) the applicability of subject matter, (2) the presentation of the subject matter, and (3) technical substance.

1. Paper: Institutional Development for Managing Small Decentralized Hydropower Systems

	POOR				EXCELLENT
applicability of subject matter	1	2	3	4	(5)
presentation of subject matter	1	2	3	4	(5)
technical substance	1	2	3	4	(5)

2. Paper: Training, Operation, and Maintenance in the Management of Small Hydropower Systems

applicability of subject matter	1	2	3	4	5
presentation of subject matter	1	2	3	4	5
technical substance	1	2	3	4	5

3. Panel: Local vs. Centralized Management Approaches

applicability of subject matter	1	2	3	(4)	5
presentation of subject matter	1	2	3	(4)	5
technical substance	1	2	3	(4)	5

4. Paper: The Process of Introducing Hydropower to Rural People

applicability of subject matter	1	2	3	4	5
presentation of subject matter	1	2	3	4	5
technical substance	1	2	3	4	5

SMALL HYDROPOWER IN AFRICA

Overall Evaluation

1. Nationality: GHANAIAN

2. Your professional activities: CIVIL ENGINEERING (WATER RESOURCES)

3. Please check the subject areas covered in the conference which relate to the technical needs of your work activities:

Technology:

- Equipment design and local manufacturing opportunities ..... ✓
- Resource assessment and site selection ..... ✓
- Hydrologic assessment ..... ✓
- Site development ..... ✓
- Sources of equipment ..... ✓
- General feasibility ..... ✓

Project Planning and Management:

- Financial strategies and planning ..... ___
- Economic feasibility ..... ✓
- End-use strategies ..... ✓
- Management approaches ..... ✓
- Training, operation and maintenance ..... ✓

Socio-Economic Aspects:

- Socio-economic evaluation criteria ..... ✓
- Institutional issues ..... ✓
- Rural energy and rural development objectives and impacts .. ✓

Please assess the overall quality of the conference by answering the following questions.

4. Which methods of delivery were most effective in helping you understand and gain knowledge of the subject matter? Please check the two best methods.

- panel presentations ..... ✓
- panel discussions ..... ___
- participatory workshops ..... ___
- field exercises ..... ___
- country case studies ..... ✓
- between-session exchanges ..... ___
- other (please specify) ..... ___

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E. What organizational or content changes do you think would result in a better workshop?

Please check those areas in need of improvement and provide as much elaboration as you can on how we might achieve better results.

Content: different subject matter ..... ____
additional subject matter .... ____
pre-workshop reading material. ____
presentation format ..... ____
presentors ..... ____
field trip ..... ____

Suggestions for improvements: NIL

Organization: transportation ..... ____
room ..... ____
meals ..... ____
financial arrangements .... ____
length of total workshop .. ____
length of sessions x
translation x

Suggestions for improvements: (i) Some of the translations from French to English were difficult to follow.
∴ Translations need some organizing.
(ii) There should be time for discussions or questions after the presentation of papers. This I believe could easily have been accomodated if (c) we had started on time!
∴ Need for enforcement of punctuality.
i.e. Sessions should start on the stipulated times on the distributed programs.

(Please return on Friday morning before the first session.)

NAME: BASEERU M. SONII

Based on the site visit to Aboisso and a page of hypothetical data, four alternatives for developing the site will be presented to the plenary session Thursday afternoon.

1. BASED ON THESE PRESENTATIONS, WHICH ALTERNATIVE WOULD YOU RECOMMEND? ALT. #4.

2. WHY WOULD YOU RECOMMEND THIS ALTERNATIVE?

I recommend alternative #4 because of: least excavation and concrete works, more power output, less flood hazzard and room for additional units; three sites were identified (A, B, + C) however site "B" was chosen for high output and financially feasible. Alt. #1 is extremely high excavation costs, concrete cost and very high flood hazard and erosion problem will occurred for the homes upstream and up the hill. Alt. #2 is even dangerous for the aging bridge and high cost incurred for excavation and concrete works. The output is small and less mechanical + electrical costs. Alt. #3 like Alt. #1 with high excavation and concrete costs for entry channel, very high risk for under the bridge Dam, more concrete works to improve the banks before and after turbine; and risk of flood and erosion for the island down stream.

Thumbnail analysis of Abidjan evaluation statistical summary

Time has not yet permitted a thorough analysis of the evaluations the Abidjan participants returned, particularly the portions that were written, much of which is in French.

However, we have done the tabulations for the parts that required only numerical responses, which reveal some interesting trends:

1) the response, indicating the participation rate in the workshop, was high--about 85% among the official African country delegations. This corroborates comments by officials at the Bank and REDSO people that the attendance was by African standards very good.

2) the overall numerical rating for the plenary sessions--3.95 on a scale of 1-5--was a bit disappointing, but most of the major technical papers were well received. The problem areas were the panels, and a couple of the African speakers, Mulamba and Semanou.

3) the applicability of the subject matter for the plenary presentations was quite high--4.17--meaning we were pretty much on target with what they wanted to hear about.

4) the majority of the participants, in terms of absolute numbers, said they were most involved in "resource assessment and site selection," "economic feasibility," and "rural energy and rural development objectives and impacts," in the three general areas of participant activities, which is not surprising since Africa is relatively new to the SDH field.

5) the field exercise, followed closely by the paper presentations and the workshop discussion groups was viewed as the most effective presentation method . This would indicate that the field trip was very worthwhile as a means of hands-on type training and should be emphasized in the future.

6) In terms of organizational improvements, a majority said they thought the papers and reading materials should have been sent to participants prior to the workshop.

7) Again, in terms of absolute numbers, the biggest problem with the workshop from a purely organizational point of view was the length of the workshop; in reading the written comments, it was clear that they meant by this that it was too short.

Statistical Summary for Workshop Evaluations

No. of participants receiving evaluation forms.....47

No. of forms at least partially completed and returned.....40

No. of field trip exercise evaluations forms returned.....27

Section I. Daily evaluations

Name	App. of Subj. Matter	Present.	Tech. Subst.	Overall
Albertson	4.20	4.06	4.24	4.17
End-Use Slide Presentation	3.97	3.79	3.97	3.91
Kroko	3.79	3.81	4.05	3.88
Moran	3.51	3.34	3.50	3.45
Abdullah	4.51	4.37	4.32	4.40
Mulamba	3.08	2.83	2.92	2.95
Panel-Kooi	3.82	3.75	3.73	3.77
Inversin	4.09	4.18	4.03	4.10
Kirshen	4.27	4.18	4.46	4.30
Armstrong-Evans	4.12	3.94	4.00	4.02
Metzler	3.91	3.79	3.75	3.82
Lanou	4.16	3.91	4.00	4.04
Boyle	3.90	3.87	3.71	3.83
Clark	3.97	3.81	3.84	3.92
Gardner	4.32	4.32	3.65	4.10
Brown	3.75	3.58	3.63	3.65
Semanou	3.87	3.70	3.57	3.71
Panel-Albtson	3.68	3.73	3.55	3.65
Soedjarwo	4.00	4.00	3.72	3.92
Conference Totals	4.16	3.84	3.84	3.95

Section II. General Evaluations

A. Workshop Subjects that relate to participants' activities

Technology:

Equipment design and local manufacturing opportunities....16
Resource assessment and site selection.....25
Hydrologic assessment.....21
Site development.....21
Sources of equipment.....19
General feasibility.....22

Project Planning and Management:

Financial strategies and planning.....15
Economic feasibility.....20
End-use strategies.....18
Management approaches.....15
Training.....19

Socio-Economic Aspects:

Socio-economic evaluation criteria.....20
Institutional issues.....15
Rural energy and rural development objectives and impcts..21

B. Presentation methods most effective (best two checked)

Paper presentations.....13
Panel discussions..... 6
Participatory workshops.....13
Field exercises.....15
Country case studies..... 6
Between-session exchnages..... 5
Other..... 1

C. Content or Organizational Improvements Needed

Content:

Different subject matter..... 2
Additional subject matter..... 3
Pre-workshop reading material..... 9
Presentation format..... 4
Presentors..... 2
Field trip..... 7

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Organization:

Transportation..... 1
Lodging..... 5
Meals..... 3
Financial arrangements..... 7
Length of total workshop.....13
Length of sessions.....11
Translations..... 6

Section III. Field Trip Exercise Evaluations

Design Options Recommended Based on Group Presentations

Design option 1..... 6

Design option 2..... 3

Design option 3..... 7

Design option 4.....10

No option recommended..... 1

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PROPOSAL FOR TRAINING

DEVELOPING COUNTRIES

IN SMALL HYDROPOWER

Submitted to the Energy Office, U.S. Agency for International Development, November, 1981

Small Decentralized Hydropower Program
International Programs Division
National Rural Electric Cooperative Association

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Small Decentralized Hydropower (SDH) Program Training in Perspective

The challenge to help developing countries work toward energy self-sufficiency involves the integration of project development with training and institution-building to allow effective development and management of practical rural energy systems over the long-haul. This integration process of the basic engineering, construction, management, operation, and maintenance elements of these systems, in tandem with the provision of timely and appropriate technical assistance, must be well-planned and carefully nurtured. The training program outlined in this proposal must be an integral part of this overall, coordinated approach to small hydropower project development and not isolated, separate and distinct, from the larger picture.

The litmus test of short-term training programs is their effectiveness at the project and program levels. Too often the objectives of training efforts are not clearly defined in relation to the specific need; as a result, the training is frequently ineffectual. The training program, therefore, must be closely identified with the desired result to be achieved in each case, if not for each trainee. In turn, this result must be based on the specific project or program requirements. The timing and substance of the training offered must be appropriate. Preparatory assistance and follow-up training must be considered in each context to ensure that the training is ultimately useful. Above all, hands-on experience should form an important ingredient of the training that is offered, directly related to the kinds of project or program activities that the trainee is likely to encounter.

To provide an adequate response to these needs, the training component of a given project or program effort must be managed by a resource base that is intimately familiar with the project or program context in which the training is offered. The National Rural Electric Cooperative Association's (NRECA) role in this process is to fill this function.

NRECA

NRECA, in its capacity as ST/EY's contractor for the SDH Program, is uniquely qualified to act as ombudsman for this training program and to provide the vital link between the necessary training and overall project development. As a leader in bringing electricity to remote rural areas, NRECA has accumulated a wealth of knowledge, experience, and trained personnel to assist developing countries in the technical, economic, financial, and management aspects of rural energy system development. In many cases, this assistance has included the establishment of viable, professionally-managed local institutions responsible for providing reliable electric energy in rural areas. Training has been an integral part of that effort.

For more than 25 years, NRECA's Management Services Department has provided effective, appropriate training for its member systems' managers, directors, and supervisors. Today, the MS training consists of over 60 courses in problem solving, decision making, crisis prevention, accounting, planning, and organized, effective management structure of one day to several weeks duration. The MS Training Division employs ten full-time professional trainers, several of whom worked with NRECA member systems previously, as well as consultants for developing course content, evaluating course effectiveness, and in-class training. The SDH Program will make full use of this in-house expertise in developing an effective training program.

Since its inception in 1961, NRECA's International Programs Division has carried out more than 300 assignments in assisting developing countries in planning and implementing rural electrification and renewable energy development programs. As an integral part of this rural energy development assistance, IPD has developed a dynamic training program designed to expose key developing country personnel to problems associated with rural electric system operation, organization, and management. Through its work, IPD has accumulated vast international experience and expertise in assessing and responding to developing countries' needs, including training requirements. IPD is also sensitive to basic human needs of trainees from far off developing countries arriving in the U.S. for the first time. The initial phase of IPD's training is geared toward helping these visitors from developing countries adjust to the resultant culture shock. Many of NRECA's member systems have graciously served as hosts over the years for visitors from developing countries who are interested in taking a closer look at U.S. rural electric systems and who want some extended hands-on training.

NRECA's 1046 member rural electric systems are indeed a rich resource from which the SDH Program can draw skilled engineers, managers, and planners, many with experience in developing countries. The SDH Program can tap this valuable resource to assist in developing course content and for in-class teaching as well. In addition, eighteen of NRECA's member systems currently have operating small hydropower plants and an additional approximately 100 small hydro plants are proposed. Most of the operating plants owned by NRECA's member systems, which are listed in Attachment A, are located in the western part of the U.S. The SDH Program intends to take full advantage of this proximity of these operating plants to the University of Minnesota wherever possible for hands-on training. The SDH Program recognizes that there may be instances where trainees from developing countries require more extensive hands-on training than is proposed for this training program and will call upon NRECA's member systems to assist in this effort.

In addition to the institutional strength and experience NRECA and its member systems bring to the Office of Energy's small hydro training effort, the SDH Program staff includes engineers with both developing country and training experience. The SDH Program staff, having worked in numerous developing countries, is uniquely familiar with small hydropower project developments worldwide, and therefore can offer an eclectic perspective on site development and design details and the social, economic, and managerial implications of alternative approaches.

Summary of SDH Program Training Program

To meet the urgent need for training of those in developing countries responsible for planning and carrying out small hydropower programs, the National Rural Electric Cooperative Association's Small Decentralized Hydropower Program proposes the intensive, multi-disciplinary training program outlined below to be conducted at a U.S.-based university. A more detailed description of this training program follows.

Goals:	short-term goal of helping developing countries more effectively plan, build, operate, and manage small hydropower schemes; long-term goal of achieving self-sufficiency by training those ultimately responsible for training others in developing countries and by assisting them in developing appropriate training programs within their countries
Audience:	mid-level engineers, planners, and project managers from developing countries
Curriculum:	six-week, intensive, multi-disciplinary program including overview of all aspects of SDH development, choice of electives in specific topic areas, and hands-on training
Faculty:	SDH Program staff, faculty of university selected to conduct training, as well as faculty from other academic institutions, specialists in the field of hydropower including those associated with NRECA's member systems, and equipment manufacturers
Materials:	original materials prepared for training program, SDH publications, and other published materials
Costs:	$900-$1,400 per student, per week
Timing:	six-weeks in late May-early June at close of academic year
Location:	University of Minnesota

Introduction

In recent years, shortages of energy worldwide and the concomitant hardships they wreak on national economies have focused international attention on alternative, particularly renewable, energy technologies. Nowhere are the hardships more apparent than in developing countries.

To keep pace with the demand to expand domestic production of energy, particularly renewable energies, training will become an ever more integral feature in the development of these new technologies especially in developing countries which depend so heavily on imported technical expertise.

The National Rural Electric Cooperative Association's Small Decentralized Hydropower Program proposes to help meet this growing training need by formulating and cosponsoring a training program for developing country nationals in small hydropower.

Short-Term Goals and Objectives

NRECA/SDH believes that the most appropriate short-term means of addressing this urgent need is through a multi-disciplinary, intensive training program at a U.S.-based university. Building on previously acquired technical expertise, developing country nationals will gain practical experience through NRECA/SDH's training program to more effectively plan, design, build, manage, and operate and maintain small hydropower schemes. This training is designed to expose them to the latest developments in the field and to help ensure that there is no gap between project planning and project performance because of poor implementation.

SDH Program's Role

The SDH Program staff will be responsible for the overall implementation of this training program. Its duties will include:

--coordinating with AID Mission, developing countries, AID/Washington, and University in development and implementation of program;

--designing and developing courses targeted to needs of trainees;

--promoting training program and recruiting appropriate candidates;

--assisting in locating and providing final approval for selection of faculty;

--authority for developing and final selection of course materials;

--monitoring program to assure that it runs smoothly;

--follow-up evaluation of training effectiveness.

Audience

The SDH Program expects that the bulk of the trainees will be middle-level engineers, government policy planners, and project managers from national utilities, energy ministries, and universities who will assume responsibility for energy management programs in developing countries. To participate in the training program trainees must have at least a passing familiarity with hydropower technology; must have a good written and oral working command of English; and must have good problem-solving and analytical skills.

NRECA/SDH anticipates contacting AID Missions in developing countries by circular cable for assistance in locating and, ultimately, screening appropriate potential candidates for this program. The SDH Program will also notify other interested agencies, groups, and institutions active in the development process, such as the Peace Corps and the World Bank, that may be eager to have nationals with which they work participate in this program. To assist in this effort, NRECA/SDH will develop a well-designed brochure describing the training program, its objectives, curriculum, etc.

Criteria for Training Location

In selecting an appropriate university to help conduct this training program, NRECA/SDH considered the following requirements:

--existence of appropriate, well-trained faculty including engineers, economists, planners, and hydrologists;

--access to nearby SDH demonstration sites and on-campus SDH equipment for hands-on training;

--existence of a well-established international program and experience in dealing with foreign students;

--adequate classroom facilities;

--ease of transportation and proximity to airport;

--access to support facilities including dormitories, motels, restaurants, and translators.

Curriculum

We propose a six-week training program consisting of an introduction and overview of all facets pertinent to small hydro development and a series of very intensive electives from which the trainees may choose to better tailor the training to their needs. The SDH Program has designed three courses of partic-

ular interest to engineers and technicians and three courses geared toward planners, managers, and economists. Attachment B outlines the structure of the six-week course. The overview is essential to familiarize engineers and planners alike with the factors crucial to successful implementation of a small hydro scheme. The training program will include lectures with notes provided, discussion and problem-solving sessions for each topic, and hands-on training using the university's facilities and nearby small hydro sites.

Efforts will be made continually throughout the program by the trainers to relate the training to problems indigenous to developing countries and to address each of the topics, described in detail in Attachment C, in small hydro terms.

Field Trips and Hands-on Training

Hands-on training is an essential component of this program. In addition to field trips to nearby small-scale hydro sites and to working with equipment available at the university, NRECA/SDH proposes to place each trainee, interested in more on-site, hands-on training, in a small hydro scheme operated by one of NRECA's member rural electric systems or at a small hydro site under development.

Faculty

The SDH Program will rely not only on the resident faculty at the university selected, but will draw on the talents of:

--members of the SDH Program staff;

--academicians known to the Program who are intimately familiar with particular aspects of SDH development;

--selected talented managers and engineers from NRECA's over 1,000 member rural electric systems;

--specialists including civil, mechanical, electrical, and chemical engineers, hydrologists, economists, institutional advisors, anthropologists, and sociologists available through the talent bank of specialists which the SDH Program has developed and can access, according to speciality, language capability, and developing country experience through its word processor;

--equipment manufacturers such as GE, Allis-Chalmers, and Leffel.

In addition to considerable experience in small hydro technology, trainers ideally will have language capabilities, experience in training or teaching, or have a proven facility for communicating technical information, and have experience in developing countries.

Materials

Appropriate course materials will be selected jointly by the SDH staff, the coordinating staff of the university chosen, and trainers. The SDH Program anticipates that course materials will include selected SDH Program publications:

--Quito, and other SDH Program workshop proceedings, which are currently being used as source materials for two training programs in small hydro;methodologies;

--methodologies for country assessments and prefeasibility studies as well as the hydrologic methodology;

--special studies on management and evaluation criteria;

--sourcebook;

--and audio-visual materials.

Because of the dearth of appropriate SDH material for training purposes, NRECA/SDH proposes that selected lecture notes, original material prepared for the training program, and other course materials be edited and published in book form by the SDH Program and the university to serve as a formal training manual.

Costs

The SDH Program anticipates that the per student, per week cost will be between $900 and $1,400 excluding air travel. These are only preliminary cost figures. More targeted costs will be available shortly.

Timing

NRECA/SDH believes that the period immediately following the academic year, in late May or June, is the most appropriate time to conduct this training permitting trainers more flexibility because of their summer vacations. However, this training program can be arranged at other times of the year if deemed necessary.

Follow-up Evaluations

To better tailor future training programs to developing countries' needs, NRECA/SDH proposes to conduct follow-up evaluations of its training methods, course content, and materials. Trainees, at the end of the program, will complete a questionnaire designed to draw

out its strengths and weaknesses. A similar questionnaire will be sent, after an appropriate period of perhaps 2-3 months to the supervisor of each trainee to canvass their reactions to and impressions of the quality and effectiveness of the training. In addition, AID Mission personnel familiar with participants will be surveyed for their impressions of the training.

Training Location

To locate an appropriate site for this training program, the SDH staff visited several universities including the University of Minnesota, Colorado State University, University of Missouri-Rolla, and Appalachian State University. Based on the requirements for a satisfactory training location mentioned previously, NRECA/SDH believes that the University of Minnesota is the best location available. All four universities visited are described below.

University of Minnesota

The St. Anthony Falls Laboratory at the University has excellent classroom facilities which include a 90-seat capacity auditorium located within the Lab. In addition, the University has classrooms equipped with individual video TV screens. The Lab. is in the process of acquiring state-of-the-art SDH equipment and has numerous models of channels, spillways, etc. that can be used in SDH training. Allis-Chalmers has donated a model test stand, a closed-loop operation to run a 150 kW turbine generator for the Lab.'s use. This offers several advantages: the operating conditions can be varied to simulate various operating conditions; since it is not controlled by a utility, training will not affect the local power system; and students can observe operating conditions such as cavitation. Although students are not exposed to all operations of an actual site such as cleaning trash racks or serving fluctuating loads, there are several small hydro sites near the Lab. where these features can be demonstrated. The Lab. is adjacent to the St. Anthony's Lab. Hydropower Plant which has four 800 kW Francis turbines.

The Lab. and faculty have designed turbines and have been involved in hydraulic testing for 30 years. They conducted a small hydro site identification study for the State of Minnesota in the past year and are conducting feasibility studies on six sites. The Lab. conducted a week-long training course last summer using chiefly its own staff, which attracted over 80 participants from the U.S.

The Lab. can draw upon the 5,000 members of the University of Minnesota faculty for support in related topics such as electrical engineering and ecnomics. The University has a very active International Programs Division, experience in developing countries and with foreign students, and has translation capabilities.

Located in downtown Minneapolis, the Lab. is convenient to hotels and the airport. University dormitories can be used during

the summer months.

We have discussed the possibility of the University of Minnesota working with us in cosponsoring this training program and they are quite interested. They will have more specific cost figures by January 1, 1982.

Colorado State University

The second most attractive choice in location for this program is Colorado State University. Although the University is not currently involved in small hydro work, it has the facilities and faculty to develop a fine program.

The Engineering Research Center has a Hydraulics Lab., with perhaps the best program in the country, and a Hydromachinery Lab. which can be useful in SDH training. The Labs. are situated downstream of a Bureau of Reclamation reservoir and are equipped with some hydro equipment, a solar-city, and a wind turbine. There are good classroom facilities throughout the University and at the Labs.

Although there are no hydro calsses taught, faculty members have done much work in such areas as hydromachinery, cavitation, canal design, etc., all of great interest to trainees. The Engineering School can tap its faculty to assist with the electrical, civil, and hydrology aspects of a hydro training program. In addition, the University has a very active International Programs Division.

Transportation to the Denver airport, 60 miles from the University, is easy to arrange. The University has a dormitory, available year round, especially designed to house students enrolled in short courses at the rate of $14/night.

University of Missouri-Rolla

Perhaps the most attractive feature of the University is its Center for International Programs (CIPAS) which organizes a variety of international on-campus and overseas education and training programs. In addition, the University has a unique Engineering Management Department with courses in all aspects of personal, institutional, and economic management. The Electrical Engineering Department is perhaps the strongest department on campus and, although they are not greatly experienced in small hydro schemes, they have the necessary faculty and experience to cover the full range of engineering issues and problems in small hydro. The University can also draw on its civil engineering, sociology, and economics departments.

CIPAS handles all logistical arrangements for foreign students and visitors. During the academic year, foreign students are housed in nearby motels; during the summer on-campus housing, at less than $10/day, is available. In addition, CIPAS provides transportation to and from St. Louis and provides other courtesy services such as information on social and tourist activities.

Appalachian State University

Appalachian State University currently has short courses on micro-hydro which include discussions of head and flow measurements, penstock and turbine selection, and economic feasibility. The Universtiy hopes to initiate a mini-hydro turbine testing program. However, the faculty, although quite enthusiastic, does not have the experience or technical background necessary to conduct a quality program.

The University has installed a 15 kW Pelton turbine for training purposes. In addition, the University hopes to install a cross-flow turbine for comparison studies.

Although there are sufficient restaurants and motels available, the University is about 2 1/2 hours' drive from Charlotte, N.C. and transportation is difficult to arrange.

Long-Term Training Goals and Objectives

Although the short-term, intensive training outlined above helps meet the immediate training needs of developing countries, NRECA/SDH, recognizing that self-sufficiency is a long-range objective of AID and that AID has a declared interest in technology transfer and institution building, proposes a longer-term goal of self-sufficiency through training trainers. SDH will train those who will ultimately be charged with the responsibility of training others within their own countries.

NRECA/SDH proposes to train engineers, planners, and policy makers with appropriate training abilities here in the U.S. and envisions assisting them in developing training courses of their own. These training courses can be conducted at existing regional training centers or may use sites under development for on-the-job and hands-on training. It may take four or five years to make the change from U.S.-based training to developing a workable training program at regional centers or within individual developing countries, but NRECA/SDH believes that reducing developing countries' dependency on developed countries is in the best interest of all parties.

Other Training

There will be a continuing need to share experiences and information on state-of-the-art developments and new technological innovations with developing countries. To respond to this need for on-going training and for follow-up training, NRECA/SDH proposes to draw on the inventory of training specialists it uses in the main training program outlined above. NRECA/SDH envisions sending individuals or teams of specialists to perform site and country specific training, as needed, after the basic training program. There may be certain specialized training requirements best accomplished by having an instructor spend a short time at a specific site. SDH currently performs training in this second sense when it dispatches a team to a country to perform site surveys. In every case, where possible,

host country counterparts accompany SDH specialists in the course of their work to learn techniques for resource assessments, economic feasibility studies, social impact analyses, preliminary design, ordering equipment, etc.

NRECA/SDH envisions expanding its current program of workshops to exchange information among host-country personnel and recognized experts on specific topics. The present series of workshops, of one-week duration, are very general in nature, covering the entire range of technical, economic, institutional, social, and financial aspects of mini-hydro development. There is much interest in using the small discussion group format popular in the regional workshops the SDH Program has organized for specific topics such as turbine design or alternative financing sources. NRECA/SDH has a proven track record having developed two successful regional workshops, with two more currently under development, and can easily respond to this kind of request.

ATTACHMENT A--NRECA Member Systems with Operating Small Hydropower Plants

Cooperative	Location	Plant Capacity (MW)
Alabama Electric Co-op.	Andalusia, Ala.	5.2
Alabama Electric Co-op.	Gantt, Ala.	2.44
Chugach Electric Assn.	Cooper Landing, Alaska	15.0
Metlakatla Power & Light	Metlakatla, Alaska	3.0
Northern Michigan Electric Co-op.	Tower, Mich.	.56
Northern Michigan Electric Co-op	Tower, Mich.	1.2
Sho-Me Power Corporation	Camdenton, Mo.	3.0
Copper Valley Electric Assn.	Valdez, Alaska	12.0
Garkane Power Assn.	Boulder, Utah	4.2
Moon Lake Electric Assn.	Neola, Utah	.90
Moon Lake Electric Assn.	Altamont, Utah	1.2
Craig-Botetourt Electric Co-op	New Castle, Va.	.30
Oconto Electric Co-op	Stiles, Wis.	1.0
Dairyland Power Co-op	Ladysmith, Wis.	15.0
Lower Valley Power & Light	Bedford, Wyo.	1.5
Fall River REC	Felt, Idaho	1.2
Colorado-Ute	Ames, Colo.	3
Colorado-Ute	Tacomo, Colo.	8

ATTACHMENT B--Training Program Schedule

Outlined below is the schedule NRECA/SDH envisions for this training program. Each "block" consists of one and one-half weeks. During the first block, everyone will participate. For the next three blocks, each trainee has the option of choosing which courses he wants to take of the two taught simultaneously, although each series of three courses is designed primarily to respond to either engineers and technicians' needs or to those of planners, managers, and economists. The topics listed below each course are described in Attachment B.

Block 1--Introduction and Overview

Block 2--Data Collections	or	Economics and Financing
-site assessments. -problem solving and decision making		-ecnomic feasibility -alternate and conventional sources of financing -demand assessments -resource assessments -problem solving and decision making
Block 3--Civil Engineering	or	Management
-civil works -development and construction planning -problem solving and decision making		-institutional development -problem solving and decision making -load management
Block 4--Hydraulic, Electrical Equipment	or	End-Uses, Hybrid Development, and Applications
-mechanical equipment -electrical equipemtn -development and construction planning -manufacture, local fabrication -problem solving and decision making		-site assessments -civil works -economic feasibility -alternate and conventional sources of financing -development and construction planning -demand assessment -institutional development -load management -problem solving and decision making

ATTACHMENT C--Course Topic Descriptions

Listed below are the topics that will be covered during the overview and which the six electives will focus on in more detail.

--site assessments--how to measure head, flow, and power; how to assess geologic formations and soils; how to assess environmental aspects; hydrology

--resource assessments--hydropower, wind, solar, and petroleum assessments for planning hybrid systems and comparative analysis;

--civil works--impoundments; conduits and canals; refuse controls and trash racks; flow controls; maintenance; intake structures; forebays; foundations; powerhouse; penstocks; economies of scale; materials; design options

--mechanical equipment--turbine selection and design; mechanical governors; maintenance; turbine-generator coupling; mechanical end-uses; state-of-the-art technology

--electrical equipment--generators; electronic governors; switch gears, controls, and protection; distribution and interconnection; maintenance; transformers; voltage drops

--economic feasibility--end-uses and demand; cost/benefit analysis; proximity considerations; other infrastructure; social impacts; developmental considerations and opportunity costs; comparative energy assessments including oil substitute calculations; rates and revenues

--alternate and conventional sources of financing--procedures for securing loans; accounting; depreciation; imports and foreign exchange; cash-flow analysis; repayment of loans; financial planning

--development and construction planning--construction methods; capital; labor; materials; technical assistance; quality control; start-up; bidding and contracting; scheduling and budget preparation

--demand assessments--original load and bringing customers on line; pricing; subsidies; accounting; forecasting load; potential uses; daily, weekly, and seasonl load factors; residential and industrial uses

--institutional development--matrices; cooperatives; operation and maintenance; leadership; personnel; training; centralized and decentralized management approaches

--problem solving and decision making--political, social, technical, institutional pitfalls; employee and public relations; unexptected outages; how to resolve lack of load and developing load growth; problems of reliability; record keeping; problem causes and analysis and anticipation and avoidance tactics

--load management--peak load control; balancing phases; starting surges; minimum loads; load sharing; radial feeders

--manufacture, local fabrication--mechanical equipment; electrical equipment; civil works components; distribution equipment