

SMALL DECENTRALIZED HYDROPOWER (SDH)

Program Status, April 1984

The following is a cumulative summary, updated each month, 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).

L COUNTRY FIELD ASSISTANCE

To date, the SDH Program has provided field assistance to 21 AID host countries. This assistance has consisted of short-term field assignments by teams of up to several specialists to conduct country surveys of SDH potential, to develop country-specific site selection methodologies, identify and rank sites based on these methodologies, and to prepare preliminary designs and cost estimates for representative projects. In some instances, this assistance was specifically tailored to address problems with on-going projects and programs; in others, it involved assistance in developing AID project papers. In most cases, the teams studied not only technical aspects, but also institutional and energy planning concerns in support of efforts to organize AID host countries to carry out systematic programs of SDH development.

In addition to the countries listed below, the SDH Program staff have visited several other countries to conduct preliminary discussions and/or field assessments leading to possible future SDH developmental activities: Guinea, Costa

Rica, Sierra Leone, Madagascar, Papua New Guinea, Sri Lanka, Ecuador, Zimbabwe, and the Niger River Basin (headquartered in Niger).

BANGLADESH

Initial activity

At the request of AID/Dhaka, a hydrologist and a small-hydro engineer visited Bangladesh for four weeks in September 1981. The team was to suggest criteria for assessing the suitability of proposed sites, make recommendations concerning equipment, estimate costs and net economic benefits, visit a number of sites and rank them for further consideration, and make institutional recommendations. A sample prefeasibility study would be made of one site.

The team's report, Bangladesh: An assessment of small hydropower potential (November 1981), concluded that small, low-head hydroelectric projects are technically feasible and economically viable if linked to irrigation and flood control schemes. Of the twenty-four sites considered (thirteen of



them actually visited by the team), six of the most promising were selected for prefeasibility studies. A sample prefeasibility study was made of two possible schemes on the Teesta Barrage irrigation project, for which the available data indicated that a project of 2,000-5,000 kW could be viable, although completion of the canals was several years away. The team's recommendations also included the establishment of a permanent hydroelectric directorate, reconnaissance of other potential sites, and a study of the potential for manufacturing turbines and other components locally.

Follow-up

The possibility of hydropower development at the Teesta Barrage was nullified by subsequent changes in the irrigation scheme. In March 1982, as a result of the NRECA report, AID/Washington recommended that a team visit Bangladesh to conduct more detailed studies of six sites. By October, however, AID/Dhaka had reassessed the available data and, while agreeing that small hydropower could be potentially viable as an element of other water control projects, concluded that under present circumstances Bangladesh should concentrate on the development of its gas resources for electricity generation.

Status

AID/Dhaka presently has no plans to assist in the development of small hydropower in Bangladesh, although the GOB continues to be interested in pursuing small hydro.

BURUNDI

Initial activity

In October 1982, at the request of AID/Bujumbura, NRECA sent a small-hydro engineer and an institutional

advisor to conduct a preliminary assessment of the country's small hydropower program and to review the institutional, staffing, and training needs for small hydropower development.

The team's report, Burundi: Institutional requirements and technical alternatives for a small hydropower program (February 1983), detailed training requirements over eight years and assessed manpower needs to improve technical planning. The team visited a number of sites and found small hydro potential to be substantial. However, the projects being contemplated would require low-cost investments, owing to the very modest energy demand and disposable income of the communities which would be served. As requested, the team drew on experience in other developing countries having similar demographic and energy demand characteristics to assess the viability of a community-based approach to small hydro development. Institutional changes were proposed, at national and sub-national levels, stressing formal definition of the mandates of relevant authorities.

Follow-up

During 1983, AID/Bujumbura expressed an interest in further assistance in training personnel for the operation and maintenance of a small hydropower plant under construction which is to provide power to an experimental farm funded under a bilateral project.

Status

The GOB has plans for a number of small hydro schemes to reduce dependence on thermal generation wherever possible, but staff resources remain limited. AID/Bujumbura has decided not to pursue the development of small hydropower although the possibility of specific assistance at Buhiga is still under consideration.

CAPE VERDE

Initial activity

In January 1981, the Cape Verde Institute for Technological Research expressed interest in an assessment by NRECA of the potential for small hydropower in Cape Verde. As preliminary hydrologic data indicated that stream flows are quite intermittent, it was decided that NRECA would first conduct a "desk" assessment of small hydropower potential. The report, Assessment of small hydroelectric potential in Cape Verde (November 1981), concluded that there is insufficient surface water in Cape Verde to economically develop small hydropower. This conclusion was based on an economic analysis of a hypothetical site on San Tiago Island, using information available from several study sources.

The evidence thus did not justify sending a team to conduct an in-country survey, but the report recommended that requests for assistance on any site-specific projects be submitted through AID.

Follow-up

None.

Status

No further request for assistance has been received. AID's Renewable Energy Project, which terminated in 1983, has emphasized wind and solar power.

DOMINICA

Initial activity

In September 1981, at the request of AID/Barbados, the SDH Program's Principal Engineer traveled to Dominica to develop a scope of work for a small-hydro team requested by the GOD to assess the feasibility of energizing remote communities in the sparsely populated East Coast region. In

November 1981, NRECA sent a three-man team to conduct prefeasibility studies of candidate sites in the prescribed region and to assess the feasibility of installing a grid-connected plant at the Antrim waterworks near the capital city of Rosseau.

The team carried out preliminary technical surveys of 12 sites and chose six for further analysis. Four of these—at Petite Savane, Bagatelle, Rosalie, and Penville—were found to have potential for SDH development, and preliminary costs and economic benefits were calculated. One site, Layou River at Bells, was found to be appropriate for grid-connection. At the Antrim waterworks, however, it was found that retrofitting the existing water supply system to accommodate hydroelectric generation was not economically viable. The team also selected six sites for the placement of stream-gauging equipment and made proposals for institutional reform. The team's report, Dominica: An assessment of small hydropower potential (January 1982), generally found that small hydro was technically feasible and would be economically practical if integrated into a rural development program, particularly if combined with the reconstruction of village water-supply systems in Bagatelle and Petite Savane.

Follow-up

In January 1983, the SDH Program's Principal Engineer returned to Dominica at the request of AID/Barbados. At his recommendation, plans for the Antrim project were rejected on economic and technical grounds. In his report, Dominica: A proposal for technical assistance in micro-hydro development (January 1983), it was recommended that further study of an abandoned water-wheel site be conducted as a substitute for the Antrim project to demonstrate the viability of small, grid-connected projects. In a separate report, Dominica: Prefeasibility study of the Belfast River site (January 1983), it was recommended

that another site, having a capacity of 900 kW, is quite promising and merits further study.

Status

The Caribbean Development Bank has offered to finance the development of decentralized hydropower projects in Dominica, but no further action has been taken to date. The GOD has contacted the U.S. Department of Energy for assistance in initiating some projects. Mini-hydro is said to be a high priority for Dominica in a Caribbean energy project that is being prepared by AID/Barbados. The proposal will be submitted in October and is expected to take effect in FY 1985.

The Canadian International Development Agency is considering participation in a Caribbean Development Bank loan for a 4 MW plant on the island.

DOMINICAN REPUBLIC

Initial activity

NRECA sent a team to the Dominican Republic for five weeks during June and July 1981 to assist AID/Santo Domingo in preparing the small hydro component of its Energy Conservation and Resource Development Project. The team, which consisted of a small-hydro engineer, an institutional advisor, and a socio-economic analyst, began by developing an extensive methodology for the selection, assessment, and ranking of sites. Two sites studies were conducted by Dominican professionals using this methodology, entitled Site selection methodology for small hydroelectric power plants.

In a separate report, The viability of an AID-financed small hydro program in the Dominican Republic (July 1981), the team found that because of the excellent physical conditions in the Dominican Republic and the presence of reasonably good technical expertise within the

GODR to carry out such a program, small hydro is an extremely attractive option in economic terms. However, the team observed that a successful program would depend on a high level of community participation, improved awareness of the environmental implications, and an effective institutional framework for implementing such a program. The report examines each of these issues in depth and considers all aspects of the project, from the selection of potential sites to the monitoring of final operations.

Follow-up

NRECA was invited by AID/Santo Domingo to bid on an ensuing RFP, issued in November 1982, for 52 man-months of technical assistance in support of a \$4 million small hydro component of AID's Energy Conservation and Resource Development Project.

Status

In September 1983, a contract for these services was awarded to Harza Engineering Inc. The AID project, which is scheduled for completion by 1985, will include the construction of three or four demonstration projects. It is now at the stage of reconnaissance and site evaluation, although, according to recently received information, progress appears to be hampered by a general lack of institutional coordination among the three primary GODR implementing agencies involved. Discussions are currently underway to determine whether further NRECA assistance will be provided.

GHANA

Initial activity

In August 1981, at the request of the GOG, NRECA sent a three-man team, including a mini-hydro specialist, an economist, and a rural electrification specialist to assess the potential for

mini-hydro in the Western Region of Ghana. They studied technical, organizational, and socio-economic aspects of developing projects and considered other options for rural electrification in the area.

In its report, Analysis of rural electrification options in Ghana with special emphasis on Western Region and small hydro generation (November 1981), the team concluded that small hydro is not a viable technology for a program of decentralized electrification of rural towns in the Western Region.

Follow-up

None.

Status

The GOG has set up a National Planning Committee on Mini-hydro and, during 1982 and 1983, expressed interest in receiving further assistance by NRECA to study the Brong Ahafo and Eastern Regions for small hydro potential. Power supplies are at present severely restricted due to drought, which has drastically reduced water levels at the main Akosombo dam. No formal request for additional assistance has been made to date.

HONDURAS

Initial activity

At the request of AID/Tegucigalpa, NRECA sent two engineers in September 1982 to advise on the scope, cost, and technical soundness of a proposed AID-financed program to provide small decentralized hydropower for towns isolated from the national grid. Honduras has ideal physical characteristics for such a development.

In its report, Honduras: Recommendations for a small hydropower project (October 1982), the team considers institutional, technical, economic, and

environmental issues, as well as implications for private sector involvement, of a national small hydro program in Honduras. The team recommended that a second team be provided to prepare a project paper.

Follow-up

None.

Status

AID/Tegucigalpa has been forced to postpone its small hydro project indefinitely due to other priorities. A 292 MW project at El Cajon, financed by the Inter-American Development Bank (IDB) is due to be completed in 1985. The project is reportedly experiencing large cost overruns.

INDONESIA

Initial activity

In June 1982, at the request of the AID Mission, the SDH Program Manager travelled to Indonesia to make a preliminary assessment of Indonesia's small hydro resources and development needs and to initiate plans for further field assistance in support of the government's expressed interest in expanding their national small hydropower program. His trip report noted various scattered activities underway by a number of Indonesian and foreign groups and found that these activities could be strengthened by an institution-building effort to improve the general structure of Indonesia's overall small hydro program plan. Several specific areas of assistance were recommended, including resource assessment, research and technical design assistance, and training.

Follow-up

The SDH Program Manager returned to Indonesia in July 1983 to arrive at a general agreement with the government and AID Mission for continued SDH

Program assistance. As a result of this trip, a rural energy/institutional specialist visited Indonesia for five weeks in November 1983 to prepare a more detailed review of existing small hydro policies and programs. In his report, Indonesia: Recommendations for promoting small hydropower development (March 1984), recommendations were given for policy and program actions with respect and responsibilities to domestic energy pricing, implementing institutions, and program financing.

Status

The report is being reviewed by the GOL. The report recommends, as the next step, a resource assessment of several potential sites in southern Sumatra.

LESOTHO

Initial activity

In November 1982, NRECA sent a small-hydro engineer and a hydrologist to Lesotho, at the request of AID/Maseru, to conduct a four-week assessment of the potential for small-hydro development. After reviewing existing data, policy and plans, they were to visit potential sites in order to confirm basic data, assess potential loads, analyze costs, and advise on appropriate equipment.

In its report, Lesotho: Recommended activities in small hydropower development (December 1982), the team found that extensive small hydropower development would be difficult because of extreme seasonal variations in flows and specific discharge. While the physical features are appropriate for large hydropower, small installations—without investing in costly water storage structures—would be appropriate only for applications not requiring year-round energy supply or otherwise would have to be backed up with diesel generators. There are 20 to 40 potential sites in the

micro-hydro range, with installed costs between \$3,000 and \$6,000 per kW. For such small projects, it was recommended that the appropriate lead agency should be the Ministry of Rural Development (MORD) with assistance from technical departments of the Ministry of Water, Energy and Mines. Careful attention would need to be paid to the potential uses of electric power in isolated communities which could be served by such plants.

Follow-up

None.

Status

Canada is financing a \$7 million rural development project in Thaba Tseka district, which includes the installation of a small hydro plant. AID's Renewable Energy Technology project will use this as a test site.

LIBERIA

Initial activity

At the request of AID's Africa Bureau, NRECA sent a micro-hydro engineer and an electrical engineer to Liberia, in February 1982, to assist with a 35 kW micro-hydro project at Yandohun, sponsored by USAID and the Peace Corps. The team assessed the technical adequacy of the designs adopted and made recommendations to speed its completion.

The team held discussions with the Peace Corps volunteer involved in charge of the project and with AID and GOL officials before visiting the site. In its report, Liberia: Evaluation of the Yandohun micro-hydro project (March 1982), the team indicated that the project suffered from needlessly elaborate civil structure design and a lack of proper planning and coordination among the parties involved. Given both the current commitment of all involved and the importance of suc-

cessfully concluding a pilot project, they recommended that it be completed. To this end, the team made a detailed evaluation of civil, electrical, and mechanical designs. A series of design modifications were recommended to reduce the cost and speed progress, including a reduction in the height of the dam proposed. They recommended that local personnel be appointed and trained and that a management structure be carefully designed. Successful completion will require continued commitment from the Peace Corps and AID, further technical assistance, and involvement of the Liberian Electricity Corporation.

Follow-up

None.

Status

The project, entering its fourth year of construction, is continuing under the direction of the present Peace Corps volunteer, Mr. John Macorkindale, who is the fourth Peace Corps volunteer to join the project since its inception. Despite the problems encountered with this project, the GOL is planning to undertake additional projects. Site studies have been carried out with funding support of the German government.

MOROCCO

Initial activity

In September 1980, at the request of AID/Rabat, NRECA provided a small-hydro specialist to review plans to develop 23 projects, including four having detailed design plans. On his advice, changes were made to reduce the scale of the large civil works for these projects and render them more economically viable. The specialist supervised a survey team which developed site profiles and preliminary layouts.

Follow-up

In November 1981, at the request of AID/Rabat, NRECA sent a micro-hydro engineer and a small hydro specialist to work with officials of the Office National de l'Electricite (ONE), two local engineering firms, and representatives from Centre de Developpement des Energies Renouvelables in reviewing the data and plans. Five sites were visited in Ouarzazate Province, one of which presented two alternatives where low-head installations appeared feasible, subject to the collection of more accurate data. At the site of Er Rachidia province, the technical aspects had already been studied. As regards the perceived conflict with irrigation, detailed topographical and water-use surveys were necessary to determine whether power generation can be integrated with the existing irrigation need.

The team found that potential for small hydropower exists in remote areas that have sufficient water resources, provided that technical and socio-economic pitfalls are avoided. It also recommended that AID/Rabat continue the current policy of working with local contractors, providing technical assistance where necessary.

Status

Subsequent to this assistance, a French company has been contracted by ONE and is finalizing site surveys and designs for three sites, with capacities estimated at 600, 200, and 60 kW.

NEPAL

Initial activity

In February 1984, the SDH Program sent a four-man team to Nepal at the request of the AID Mission and the GON to make a general appraisal of a national small hydro program being undertaken by the Small Hydel Development Board (SHDB).

The team was to assess the progress of the program and to identify institutional and technical needs which exist. The team found that, in general, existing data and institutional capacities are inadequate to successfully undertake such a program. SHDB staff capacities were found to be weak in certain areas and are presently being underutilized due to poor organizational and planning. Consequently, little positive action has been taken, despite a considerable national commitment to small hydro by the GON and despite excellent physical and economic conditions for small hydro in Nepal.

In its report, Nepal: Status of the national small hydropower program and recommendations for assistance (March 1984), the team proposed several options to assist in addressing the SHDB program needs, including strengthening of data collection and analysis necessary for proper planning, developing less costly and more appropriate project designs, increasing productive uses of energy generated by small hydro plants, and improving the institutional organization and coordination of activities of the SHDB. The team also found that, while funding appears to be adequate to support implementation, a need exists for funding to support institution-building and training activities.

Follow-up

The SDH Program is preparing to provide additional field assistance to Nepal in several possible forms, depending on the outcome of on-going discussions with AID Washington staff, Mission staff, and SHDB staff, per recommendations of the team's report.

Status

The Government of Nepal is fully committed to the continuation of its small hydropower program. Designs have been prepared for three sites with AID funding; roughly 30 other sites are being funded by various other sources, includ-

ing the United Nations Capital Development Fund (5), OPEC Fund for International Development (3), and the Asian Development Bank (6).

PAKISTAN

Initial activity

In August 1982, NRECA sent a three-man team, consisting of the SDH micro-hydro engineer, a socio-economic advisor, and an energy planner, to assist AID/Islamabad with the mini-hydro component of its Energy Planning and Development Project. Pakistan's Water and Power Development Authority (WAPDA) is responsible for electricity generation and distribution and is expanding large hydro generation in the Indus River system. But most of the North West Frontier Province (NWFP), which has favorable characteristics for small decentralized hydropower, is likely to remain beyond the grid for many years. The NRECA team obtained data on actual and potential energy needs and load patterns with a view to encouraging productive end uses. It developed site-selection criteria for small hydropower schemes, reviewed existing activities of the Irrigation Department and the Appropriate Technology Development Organization (ATDO), evaluated existing projects and their impact on the communities involved, and suggested training programs.

The report, Pakistan: Proposed small hydropower project (September 1982), recommended integrating AID assistance with a program to construct 20 prototype small hydro projects. The Power Wing of the Irrigation Department of the NWFP would be trained and reorganized to implement the program while the ATDO, with technical assistance, would concentrate on research and development. In addition to advice on the local manufacture of turbines, the report recommended training visits to small manufacturers in Nepal and, perhaps, the United States. Economic analysis

showed that decentralized hydro schemes would be cheaper than extending the national grid to these areas and confirmed extremely high internal economic rates of return for projects that use the "participatory" approach to small hydro development. With industrial loads, the potential benefits are even greater. The report found that there is room for increasing tariffs and encouraging local entrepreneurial participation.

Follow-up

None.

Status

AID's Energy Planning and Development Project, of which the NRECA report was a component, was completed in May 1983. The project is currently being implemented and is at the stage of recruiting personnel.

PANAMA

Initial activity

NRECA sent a micro-hydro specialist to Panama in March 1980 to assist AID/Panama and the Panamanian Institute of Hydraulic Resources and Electrification (IRHE) in planning a country-wide micro-hydro program as part of a three-year AID alternative energy project. He assisted in the establishment of a work schedule and the preparation of an instruction program.

Follow-up

In November 1982, the SDH Program's Principal Engineer traveled to Panama to review plans for two demonstration projects. He advised on the electrical distribution design, project schedule, and program management. AID subsequently contracted with Small Hydroelectric Systems and Equipment of Acme, Washington, for delivery of turbine-generator equipment for the two

systems, one of 50 kW and one of 10 kW, by January 1981.

Status

Two installations, at Buenos Aires and Pueblo Nuevo, are supplying power to two rural technical schools. Bid specifications have been re-issued for four additional AID-assisted projects. The GOP has indicated an interest in exploring means of reducing future project costs, including the possibility of fabricating small hydro equipment locally, and establishing cooperatives to assist in the implementation and management of future projects.

PERU

Initial activity

In July 1980, NRECA sent a team of Spanish-speaking specialists to Peru to assist AID/Lima in formulating their project paper for a program of small hydropower development. The team, which consisted of an economist, a sociologist, an engineer, and two environmental specialists, spent more than five weeks in Peru. Their task was to develop the following sections of the Project Paper: project activities; pre-feasibility and feasibility methodologies; and economic, institutional, social, and environmental analyses. In addition, the team supervised the preparation of feasibility studies for two mini-hydro sites that ELECTROPERU, the national electricity authority, proposed to develop.

The project was approved for FY80 funding. It proposed to lend the government of Peru \$9 million to finance feasibility studies, civil works, equipment, and local distribution systems for small hydroelectric installations in the 100—1,000 kW range. An additional grant of \$1 million covered technical assistance and training to strengthen Peruvian institutional capability in the planning, implementation, and manage-

ment of such programs. A long-term advisor accordingly began work in 1983 and short-term specialists are to be recruited at various stages in the project.

Follow-up

At the request of AID/Lima, NRECA submitted names of candidates for five short-term positions in September 1983 to support the Mission's small hydro project. Candidates for these vacancies are currently under consideration by ELECTROPERU.

Status

Environmental and equipment advisors have been contracted, while candidates for the other positions are currently under consideration by ELECTROPERU. Bids have been issued for two 450 kW plants at Chongos Alto, and the system is expected to be energized by December 1984. Work has also begun on three other projects in Cajamarca province.

RWANDA

Initial activity

At the request of AID/Kigali, NRECA sent a two-man team to Rwanda for three weeks in November 1981. The team assisted the Energy Research Center (CEAER) of the National University in the development of a small hydroelectric program, as part of AID's Renewable and Improved Traditional Energy Project. The team was to analyze a proposed pilot project at Kaviri, producing a preliminary design, cost estimates, and equipment specifications. In addition, a reconnaissance level evaluation of three other sites was to be made.

The team's report, Small decentralized hydropower in Rwanda (January 1982), found that Rwanda has exceptional potential for small-scale hydroelectric generation and rural electrification.

However, the team recommended that the Kaviri site not be developed because of high cost, difficult construction, and uncertain energy use. Instead they proposed that CEAER begin its program by reactivating an abandoned small power plant.

Follow-up

In June 1983, the SDH Program's Principal Engineer returned to Rwanda, at the request of AID/Kigali, to advise on the rehabilitation of an abandoned 100kW plant that had supplied power to a coffee co-operative until about 1975. In his report, Rwanda: renovation of the Nkora site (July 1983), it was noted that the project could involve very little cost, had good potential end-uses, and could serve as a useful pilot project. Existing equipment was examined and found to be in good condition, with the exception of the electrical equipment. The report made recommendations for the procurement of a new generator and suggested productive end uses and appropriate institutional arrangements.

Status

In December 1983, the World Bank undertook to re-establish the Nkora Coffee Cooperative, thus assuring productive end uses. NRECA is working with the Volunteers in Technical Assistance (VITA) to purchase the electrical equipment.

SUDAN

Initial activity

In May 1982, at the request of AID, the administrator of NRECA's International Programs Division and the Program Manager, along with two staff members of the Tennessee Valley Authority, visited the Sudan to conduct a three-week assessment of the potential for decentralized hydropower. In reviewing possible sites throughout the Sudan, the team conducted an aerial reconnaissance

of several rivers and irrigation systems and made ground visits to a number of sites in the reports to assess the potential for hydropower at existing and planned dams and within irrigation systems.

The team's report, Sudan: An assessment of decentralized hydropower potential (July 1982), concluded that much of the decentralized hydropower potential lies in the southern Sudan along the mainstream Nile and certain secondary rivers and that further site-specific evaluations should be made on selected irrigation barrages. Furthermore, there is some potential for hydropower development on at least one of the existing mainstream dams and at least one of the existing cataracts. The report recommended further study of all the potential sites, a major review of management requirements, and the initiation of a training program.

Follow-up

In October 1983, an engineer from the Energy Research Institute of Khartoum visited Washington to discuss a possible small hydro demonstration project with SDH staff. It was agreed that the GOS would prepare more detailed site data prior to requesting additional NRECA assistance.

Status

No further assistance has been requested.

THAILAND

Initial activity

In February 1981, at the request of AID/Bangkok, NRECA sent a small hydro engineer, a mechanical engineer, and an institutional advisor to conduct prefeasibility studies of six sites previously identified by the government and to recommend appropriate institutions for their management. The mechanical

engineer was also asked to assist the GOT in selecting appropriate governing systems for the proposed small hydro plants.

Follow-up

In June 1981, the SDH Program's principal engineer remained in Bangkok after the NRECA regional workshop to assist the AID Mission and NEA officials in the preparation of a Project Paper for small hydropower in Thailand. The project to include the construction of up to 12 small hydropower installations was approved; and in August 1982, a senior engineer was selected to coordinate its implementation.

Status

Implementation of the AID project remains delayed while contracts are negotiated due to administrative difficulties.

TOGO

Initial activity

In April 1981, NRECA sent a team to Togo at the request of AID/Lome to conduct a country-wide assessment of small hydropower potential focusing on small isolated communities requiring under 50 kW of capacity. The team consisted of a hydrologist, a small-hydro engineer, and a socio-economist. The SDH Program's Principal Engineer also assisted with on-site team coordination and field evaluation.

Over a period of three weeks, the team evaluated ten sites previously identified by the government and international agencies. In its report, Togo: An assessment of decentralized hydropower potential (July 1981), the team reviewed the hydrologic characteristics of Togo's three major drainage basins and made reconnaissance evaluations of selected sites within each basin based on potential power and energy production, proximity

to grid and/or local loads, social considerations, and design options. Although the team was asked to focus on small micro-hydro sites, it was evident that there was limited potential for development of small isolated projects due to the extreme variation on flows between wet and dry seasons. However, the team did identify several larger sites (up to 8 MW) that could supply very low-cost energy to Togo's national power network.

Follow-up

At the request of AID, NRECA prepared a more detailed economic analysis of two of the small hydropower sites visited by the team to assess whether these and other sites warrant further study. The SDH Program's Project Planning Specialist traveled to Togo in June 1983 to brief the AID Mission and key GOT officials on the findings of this report. The report indicated that excellent economic rates of return could result from the investment in certain small hydro projects which would displace costly thermal-driven energy currently supplying Togo's grid system.

Status

Based on the team's findings, the GOT has determined to pursue a policy of diversifying Togo's electrical energy supply system and has requested additional NRECA assistance to assess in greater detail the role decentralized hydropower can play in such a policy. Plans are presently underway to field a second NRECA team later this year.

TUNISIA

Initial activity

In December 1981, at the request of AID/Tunis, the SDH Program Manager visited Tunisia to prepare a preliminary assessment of small hydropower potential and discuss a possible scope of work for more detailed study. His work was part of an AID evaluation of

renewable energy that also considered wind and solar power.

The report, Tunisia: Small scale hydro potential: a fact finding visit (December 1981), indicated limited small hydro potential in Tunisia. Visits to two irrigation schemes, at Djoumine (under construction) and Nbhana, suggested the possibility of retrofitting barrages to generate an estimated 500 kW each. The sites could serve a variety of small rural loads; some are suitable for grid-connection. The report included a scope of work for further study of these sites.

Follow-up

In August 1983, the SDH Program Manager stopped in Tunis to discuss possible follow-up assistance with staff of AID and the Societe Tunisien du Electricite et du Gas (STEG).

Status

Although interested in developing small hydropower, the GOT lacks the financial resources to carry out such a program. Negotiations began in March on a proposed \$38 million World Bank loan (Power IV) to finance the expansion of power distribution in rural areas and its rehabilitation in urban areas, together with training.

ZAIRE

Initial activity

In January 1981, 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. The staff also located possible sources of additional funding for the project.

In March 1981, NRECA sent an engineer and an engineer/economist to assist AID/Kinshasha in outlining a strategy for assistance to small hydropower in Zaire. They would suggest site-selection

criteria, institutional mechanisms, appropriate equipment, guidelines for cost-benefit analysis and training requirements.

In its report, Small Hydropower and Rural Electrification Project for Zaire (July 1981), the team outlined options for AID, ranging from financial support at selected sites to a massive, multi-donor program involving institution-building, training and the promotion of productive end-uses. They analyzed 13 proposed sites and found them to be feasible.

Follow-up

In May 1982, NRECA sent a three-man team to assist AID/Kinshasha in the preparation of a Project Identification Document for a Small Hydro-Rural Electrification Project. The team, which consisted of a French-speaking engineer, an economist, and an institutional advisor, found Zairean technical and managerial capabilities to be inadequate. They recommended that, over five years, two groups be trained as counterparts by expatriate specialists. The first group (to be attached to SOFIDE, the national development bank) would give financial, administrative and managerial support to rural electrification projects; the second group (to be attached to SOFIDE or SPE, Service Presidenciel d'Etudes) would deal with technical/economic feasibility, design, procurement, construction, and operation. Two or three demonstration projects, in the 50-1,000 kW range, would be carried out during the training period.

Status

Both AID and GOZ remain interested in rural electrification, but the AID budget in Zaire is concentrated on agriculture, health, and population projects. They will, however, be funding a small hydro project for a missionary group through a grant to NGOs, approved in September 1983.

Country assistance anticipated

Preparations for new assistance or follow-up assistance are presently underway for the following countries:

Costa Rica	Nepal
Indonesia	Panama
Madagascar	Ponape/FSM
	Togo

Discussions which may lead to SDH Program assistance in the near future are in process with the following other countries:

Bolivia	Peru
Dominican Republic	Sierra Leone
Guatemala	Zimbabwe
Guinea	

II. DEVELOPMENT OF DATA AND INFORMATION BASE

Whereas a wealth of experience exists worldwide with small hydropower technology, at the time of the initiation of the SDH Program little had been done to document it. The SDH Program has, therefore, devoted considerable resources to the publication of case studies, methodologies, directories and sourcebooks, and special studies to supplement a large and growing data base which has been collected.

A. SDH Library

The SDH Library currently consists of some 2,000 reports, studies, articles, papers, and other documents related to the field of SDH. Country files have been compiled for over 80 countries. In addition, SDH Program staff have visited numerous small hydro projects in developing countries to study various approaches that have been undertaken using conventional as well as unconventional technologies. The SDH Program has gathered written and photographic documentation of small hydropower sites in numerous countries, in terms of their social, economic, and technical characteristics. This documentation has helped

to provide the basis for recommending appropriate, decentralized hydropower technology for developing areas, and has been used in SDH Program training efforts to expose other developing countries to methods that have proven successful in typical rural settings in the developing world.

B. Case Studies

Two complete case studies have been published, Pakistan: village-implemented micro-hydropower schemes, and Nepal: private sector approach to implementing micro-hydropower schemes. These discuss the unique, low-cost (\$350-1,000 per installed kW) approaches being used to implement hydropower plants up to 20 kW to serve the energy needs of remote rural villages in these two countries.

In addition to these studies, data have been compiled on the technical, economic and management approaches used in micro- and small hydropower development in a number of other countries.

C. Equipment Directory

The SDH Program has developed an inventory of U.S. manufacturers of small hydroelectric equipment, and, in most cases, has visited the manufacturers. Manufacturers' products have been classified for appropriate applications and are updated on a regular basis.

A recently revised edition of the Directory of manufacturers of small hydropower equipment 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.

D. Methodologies

The SDH Program has developed assessment guidelines and methodologies in the following areas:

- o Country assessment of mini-hydro-power potential—for assessing a country's physical characteristics, in determining the need and feasibility of a national mini-hydro program
- o 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
- o Hydrological estimates for small hydroelectric projects—for estimating stream-flow duration and peak flows in regions where very little data is available
- o Environmental assessments of small hydropower projects—for assessing environmental impacts of a prospective mini-hydro project.

In addition to these methodologies, the SDH Program is in the process of preparing two major publications offering guidelines for the appraisal, planning and design of SDH projects: the Micro-hydro sourcebook, and the SDH economics handbook.

E. Special studies

The SDH Program has undertaken a number of special studies to focus on key problem areas in the implementation of SDH programs and projects in developing countries on:

- o management—analyses of issues of centralized versus decentralized control, including successes and shortfalls
- o site evaluation—development of criteria from which to build a methodology for evaluating small-scale energy systems
- o private sector development—guidelines for private development

and ownership of decentralized hydropower systems based on recent U.S. experience.

III. TRAINING PROGRAM AND WORKSHOPS

In support of its country field activities, and to provide effective means by which the SDH Program data base can be applied to specific country or regional needs, the SDH Program has carried out a multi-faceted training effort encompassing workshops and seminars, study tours and intensive topic-specific training courses.

A. Regional Workshops

The SDH Program has organized four regional workshops to provide an overview of SDH technology, design, implementation techniques, and assessment methodologies for some 400 participants from over 70 developing countries in Latin America, Asia, and Africa. Originally designed to provide a forum for the exchange of information and experiences among SDH practitioners, this workshop series evolved into a highly practical, experience-gaining exercise in the planning, design, and evaluation of SDH projects.

All four workshops were principally sponsored by AID and NRECA, with co-sponsorship by various local organizations. The SDH Program staff were primarily responsible for all logistical arrangements, and for the technical substance of each workshop. Proceedings of each workshop have been published, and are available to the public.

Latin America and the Caribbean. The first SDH regional workshop was held August 19-21, 1980 in Quito, Ecuador. There were 118 attendees, including participants from Bolivia, Costa Rica, Dominican Republic, Ecuador, Guyana, Guatemala, Haiti, Honduras, Jamaica, Nicaragua, Panama, Peru, and Uruguay. Resource people attending came from

the U.S., England, France, Peru, and Ecuador. Nineteen technical papers were presented on topics including site selection, plant design, and operation, economic feasibility, environmental effects, end-uses and case studies. The workshop was cosponsored by two Ecuadorian agencies: the Instituto Nacional de Energia (INE), and the Instituto Ecuatoriano de Electrificacion (INECEL).

Asia and the South Pacific. The second workshop was held June 8-12, 1981 in Bangkok, Thailand. Participants, 108 in all, came from Bangladesh, Fiji, India, Indonesia, Malaysia, Nepal, Pakistan, Papua New Guinea, Philippines, Sri Lanka, Thailand, and Western Samoa. Resource people were drawn from the U.S. and Australia, with the special attendance of a representative from the People's Republic of China. In addition to technical presentations on hydrologic assessment, civil design, turbine design and selection, electrical aspects, plant operation and maintenance, economic feasibility and project evaluation, this workshop featured panel discussions and working groups to compare and discuss different nations' approaches to project assessment, development and management. The workshop was cosponsored by the National Economic and Social Development Board of Thailand (NESDB) and the Asian Institute of Technology (AIT), which served as host.

West/Central Africa. The third workshop was held March 1-5, 1982 in Abidjan, Ivory Coast. Attended by 93 participants from 22 countries in West and Central Africa, this workshop marked the transition of the series from primarily an informational event to one incorporating practical aspects of hands-on training. Technical papers were presented on the basic engineering, economic, and institutional aspects of SDH development, followed by a field working group exercise to evaluate four design options for a prospective low-head site at nearby Aboisso. The participants divided into four working groups and

were asked to study the relative technical and economic events of the schemes, having capacities ranging from several hundred kW to 14 MW. Each group then made a presentation in a final plenary session to review the issues raised during the week's presentations in the practical context of the design selection exercise. The participants not only gained practical knowledge in assessing and costing out SDH projects, but also learned that a single site offers a wide range of design options to appropriately meet potentially differing energy demand, economic, and technological criterion.

Countries participating in the workshop were Algeria, Benin, Burundi, Cameroon, Central African Republic, Chad, Congo, Gabon, Ghana, Guinea-Bissau, Ivory Coast, Liberia, Mali, Morocco, Niger, Rwanda, Sao Tome and Principe, Senegal, Togo, and Tunisia, Upper Volta, and Zaire. Resource people attended from the U.S., England, Germany, New Zealand, Indonesia, Malaysia, Pakistan, Ecuador, and Colombia. The workshop was cosponsored by the Union of Producers, Conveyors, and Distributors of Electrical Energy in Africa (UPDEA), and the African Development Bank (BAD), which served as host.

East Africa. The fourth and final workshop was held June 20-24, 1983 in Mbabane, Swaziland. Participating countries were Burundi, Kenya, Lesotho, Madagascar, Malawi, Mauritius, Rwanda, Seychelles, Swaziland, Tanzania, Zambia, and Zimbabwe. Resource people attending came from the U.S., England, Nepal, and Pakistan, for a total attendance of 75 participants.

This workshop, as in previous workshops, included a series of topical lectures to provide an introduction to the fundamental concepts of small hydro assessment and development. Participants were then given an opportunity to apply these principles in a working group exercise to prepare preliminary feasibility assessments of a micro-hydro-

power scheme to serve a small isolated rural load, and a larger, grid-connected scheme. Each of four working groups were provided with detailed maps and supporting hydraulic and cost data of an actual site in Swaziland, and were asked to recommend designs for each hypothetical demand circumstance. The groups were then required to present and defend their respective design proposals on the final day of the workshop. Field visits were also scheduled to a potential hydro site where participants received instruction on methods used in making head and flow calculations, and to several operating small hydro plants. Cosponsoring the workshop were the Swaziland Electricity Board (SEB) and the Ministry of Works, Power, and Communications.

B. Seminars

In March 1981, the SDH Program sponsored a one-day seminar 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.

In July 1982, NRECA hosted a two-day seminar on private sector participation in small hydropower development overseas. The seminar brought together representatives from the U.S. small hydro manufacturing sector with U.S. government and multilateral development agency officials to discuss means of expanding the role of the private sector in furthering small hydro programs in the developing countries. The private sector representatives were briefed on overseas activities in the field of small hydropower, followed by extensive discussions during which ideas to coordinate private and public sector approaches to small hydro development in the developing countries were explored. The SDH Program has since worked closely with AID/PRE in identifying opportunities to establish private joint-ventures between U.S. firms and host-country partners for

fabrication, assembly, engineering, and implementation of small hydro equipment and systems.

C. Study Tours

With the recent enactment of legislative and regulatory measures to encourage small hydro development in the U.S., there has been a major rejuvenation of small hydro activity throughout the country. Long established as a leader in small hydro, the U.S. provides an excellent source of state-of-the-art technology, equipment, and design information to other regions of the world seeking to exploit small hydro resources. To allow exposure to developing countries to the technical resources U.S. firms, universities, and developers can offer, the SDH Program has developed a study tour of U.S. sites and suppliers for visiting engineers from developing countries interested in learning from the U.S. experience.

In May 1982, the first SDH study tour was conducted for two Panamanian engineers interested in looking at U.S. small hydro equipment in the shop, testing laboratory, and in operation. Panama is undertaking a substantial small hydro program with AID support, and the study tour offered a timely and valuable means of gaining first-hand information on potential suppliers of equipment. In addition to visiting a number of small hydro firms, the team visited some operating plants from 10 kW to several thousand kW, as well as two hydraulic laboratories where turbine testing was being carried out.

A similar study tour was conducted in May 1983 for a team of small hydro engineers from Ecuador.

D. Training Courses

The May 1980 cooperative agreement called for the preparation of a comprehensive training proposal for SDH. The proposal was completed in August 1982, and provided a range of options to carry

out training activities, basically consisting of a series of 15 short-courses in various aspects of SDH technology and development. These short-courses could be offered individually or as a comprehensive, six-week program, either in-country or at a U.S. university. Each short-course involves a mix of training formats, including classroom lectures, working group exercises, and is geared to hands-on training. The SDH Program is presently making preparations to conduct one of these courses, on hydrology, for countries of the Association of South East Asian Nations (ASEAN).

In addition to formal training courses organized by the SDH Program, staff members regularly participate as guest lecturers in other AID and non-AID formal training programs. These programs have included the AID-funded Training in Alternative Energy Technologies (TAET) Program, conducted by the University of Florida, and the Small Hydropower Management course conducted by the Denver Research Institute at the University of Denver.

IV. OTHER ACTIVITIES

A. Invited conference participation

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 held in Sao Paulo, Brazil.

Two members of the SDH staff were invited by the UN to present papers at the UNITAR Conference on Small Energy Resources in Los Angeles, California, September, 1981. The papers outlined small hydropower potential in developing countries and the SDH Program's efforts to assist these countries in tapping this resource.

In December 1981, the SDH Program's micro-hydro engineer traveled to Nairobi, Kenya at the request of USAID

to present an overview on small hydro-power with slides at a USAID-sponsored workshop. The workshop was designed for those USAID individuals in African AID Mission countries involved with energy programs.

In June 1982, the SDH Program's micro-hydro engineer was invited by the Organization of American States (OAS) to participate in the Regional Mini-Hydro Workshop, making an oral presentation on appropriate designs and approaches to small hydropower development and participating in a panel discussion on low-cost approaches to equipment design. This workshop, held in Jamaica, is the first of four workshops to be held in the Caribbean area in the OAS biennium 1982-83. The objective of these workshops is to increase capabilities of the participating countries in all stages of mini-hydro development.

In November 1982, a member of the SDH staff presented a paper on "End Use of Small Scale Energy Systems in Rural Areas" at the First U.S.-China Conference on Energy, Resources, and Environment held in Beijing, the People's Republic of China. This paper was also presented at a workshop on the Productive Uses of Rural Electricity of Bangladesh in Dhaka, November 1982.

In December 1983 the SDH Program Manager attended an international conference on Alternative Sources for the Generation of Electricity in Caracas, Venezuela, at the request of the U.S. Embassy, where he presented a paper on small hydropower development in the U.S. and considerations for rural energy based on NRECA experience in the small hydro on developing countries.

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.

In March 1983, the SDH Program's Principal Engineer traveled to Malaysia at the request of the World Bank and the Government of Malaysia to review progress on a major small hydropower program being undertaken with World Bank financing and to recommend measures which could reduce construction costs of projects. A report was provided by NRECA to the Malaysian government outlining a number of recommendations on the areas of civil works design and equipment selection.

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.

V. PUBLICATIONS

Copies of the following SDH Program publications can be obtained by contacting the SDH Program. To receive a publication for which there is a charge, please send a check, payable to NRECA, to the Training and Information Coordinator, NRECA/IPD, 1800 Massachusetts Avenue N.W., Washington, D.C. 20036. Add 35% to the listed price for mailing costs in the U.S. and Canada, 80% for Latin America and Europe, or 100% for Africa and Asia. These publications are available at no charge to AID Missions and developing country governments.

Small Decentralized Hydropower (SDH) Program—brochure describing the SDH Program history and activities; also

available in Spanish and French (no charge).

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 Electrificación; available in English and Spanish. Printed editions no longer available; photocopies available for \$12.50/copy.

Country Assessments of Mini-Hydropower Potential: A Methodology—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 (\$1.50/copy).

Prefeasibility Studies of Candidate Mini-Hydro Sites: A Methodology—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 (\$2.75/copy).

Hydrologic Estimates for Small Hydroelectric Projects—for estimating stream-flow duration and peak flows in regions where very little data is available (\$2.75/copy).

Environmental Methodologies for Small Hydropower Projects—for assessing environmental impacts of a prospective mini-hydro project (\$3.50/copy).

Directory of Manufacturers of Small Hydropower Equipment—descriptions of U.S. and developing country manufacturers and their equipment lines as well as information on packaged units; third edition now available (\$6.00/copy).

"Thinking Small: When the Oil Crunch Hit, Pakistan Turned to Small Hydropower," Agenda, January-February, 1982 issue (no charge).

"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 (no charge).

"Pakistan: Villager-Implemented Micro-Hydropower Schemes, A Case Study"—discusses the unusually low-cost approach used to install hydropower plants in remote regions in northern Pakistan (\$3.00/copy).

"Use of Alternative Energy Technologies by U.S. Rural Electric Systems," ELECTRORURAL, November, 1981 issue; article outlines efforts of U.S. rural electric systems in renewable energy technologies (wind, solar, hydroelectric, biomass, peat, and geothermal) (no charge).

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 (no charge).

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; outlines efforts by SDH Program staff in developing small hydro potential in developing countries (no charge).

Centralized vs. Decentralized Management of Small Hydropower—analysis of issues of centralized versus decentralized management approaches (\$2.00/copy).

Evaluating Electrification Experience: A Guide to the Social Evaluation of Small Hydroelectric Units in Lesser Developed Countries—development of criteria from which to build a methodology for evaluating small-scale energy systems (\$6.50/copy).

"Private Sector Participation in Decentralized Hydropower Programs in Developing Countries"—report of a seminar held July 1982 in Washington, D.C. (\$2.00/copy).

"End-Use of Small-Scale Energy Systems in Rural Areas"—paper to be presented at First U.S.-China Conference on Energy, Resources, and Environment, November 1982, Beijing, PRC; discusses options for baseload and load-leveling uses of small isolated hydropower plants (no charge).

"Nepal: Private Sector Approach to Implementing Micro-Hydropower Schemes, A Case Study"—discusses unique approach using local resources to implement small hydro systems (\$3.00/copy).

Catalogue of Rural Electric Utility and Small Hydropower Training Programs—lists 78 training courses offered by NRECA in the U.S. and abroad in the areas of rural electric utility management, accounting, engineering, construction, operations and maintenance, and small hydropower assessment, design, construction and management (no charge).

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) (\$12.50/copy).

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 (\$12.50/copy).

Les mini-centrales hydrauliques en Afrique - proceedings of a workshop held in Abidjan, Ivory Coast March 1-5, 1982 (French Edition) (\$12.50/copy).

"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 (\$3.00/copy).

Publications underway

Small Hydropower in Africa - proceedings of a workshop held June 20-24, 1983 in Mbabane, Swaziland.

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

SDH Economics Handbook—presents guidelines for conducting cost analysis, end-use planning, financial planning, and socio-economic analysis of small hydro projects in developing countries.