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Honduras

Recommendations for a small hydropower project

NRECA Small Decentralized Hydropower (SDH) Program

Honduras: recommendations for a small hydropower project

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Small decentralized hydropower program

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Summary

Physical and economic conditions in Honduras are very favorable for the development of small decentralized hydropower. Numerous rivers with year-round flows and the mountainous terrain offer excellent sites for small hydro projects. Many isolated towns and villages in the rich agricultural valleys are too remote to be served from the national electric grid. These towns could replace their existing diesel electric systems, which are expensive and unreliable, with hydroelectric generation. The country's dependence on imported fuel would be reduced and the quality of life would be improved through the availability of inexpensive hydroelectric power.

The proposed 5-year, $10.5 million program would supply about 3,000 kW in mini- and micro-hydro installations ranging from about 40 to 300 kW capacity. AID would fund $8 million and the balance would be GOH contributions. Training and technical assistance are part of the project. Local manufacture of some equipment is also foreseen. The private sector of the economy would benefit from the project.

The national utility, ENEE, is competent and has considerable hydroelectric experience. It presently owns and operates isolated electrical systems and would be the principal implementing agent. Feasibility studies carried out by the Taiwan Technical Assistance Mission would be used to the fullest extent. The studies indicate unit cost of $1,900 to $3,150 per kilowatt installed capacity. Turbines such as Pelton and cross-flow, that are suitable for the existing large stream flow variations and potential high heads, are recommended. Partial stream flow diversion with low weirs is foreseen instead of costly dams. Environmental impacts would be mostly beneficial.

To develop the Project Paper (PP), the mission should seek assistance from an experienced hydropower engineer, civil engineer, an institutional advisor, and a power economist.

Introduction

The AID mission in Honduras requested assistance from the Energy Office (ST/EY) in developing of a small hydropower project. In response, the National Rural Electric Cooperative Association (NRECA), through its cooperative agreement with ST/EY, provided the services of two engineers for a period of two weeks. The purpose of the assistance was to make recommendations on the scope, cost, and technical soundness of a small hydro project in Honduras.

Most of the electrical load in Honduras is served from a national grid. However, the grid does not extend into the western and eastern parts of the country. There, small cities, towns, and villages generally utilize small diesel engines to generate their electricity needs. These areas, especially in the western portion, are rich agricultural areas with numerous small farms and commerical enterprises.

The Empresa Nacional de Energia Elèctrica (ENEE) is a semi-autonomous government agency responsible for meeting the electric needs of the country. In addition to the national grid, ENEE owns and operates several small isolated systems in the rural areas of Honduras. Since 1979, the Taiwan Power Company has been providing technical assistance in evaluating small hydro sites to supply power to the isolated systems. They have studied about 22 sites and produced reports of high quality with detailed information. To date, ENEE has not found financing for these projects.

Purpose

The purpose of the proposed small hydopower project is to provide hydroelectric energy at a reasonable price to (1) displace the consumption of diesel-fired electic energy and (2) provide capacity for future load growth. Since electricity supplied from the national grid in Honduras is basically supplied from large hydroelectric installations, this project will focus on rural cities, towns, and villages that either have existing diesel generators or are considering purchasing diesel generators for new or increased electric service. Some villages have no electricity.

Assuming, that the hydroelectric installations can be operated properly for several years in the rural areas of Honduras, installing of hydroelectric power plants will lead to program goals of (1) reducing the country's dependency upon imported fuels and (2) increasing the quality of life in the rural areas of Honduras by creating employment in small industries and providing improved household amenities and public facilities.

Project description

This project proposes to install about 3,500 kW of small hydropower capacity in rural areas of Honduras by 1988. In addition, the project will train 20 power plant operators and develop standardized civil and electrical designs. The project will have two major components: (1) mini-hydro units with capacities of 100 kW or more, to be owned and operated by ENEE and (2) micro-hydro units of less than 100 kW to be owned by parties other than ENEE. Each component will include rehabilitation of abandoned projects, construction of new projects, installations on water supply systems, and possibly local manufacture of turbines.

The estimated cost for the 5-year program is $10.5 million to consist of $8 million AID funds and $2.5 million GOH contribution. Approximately $7 million will be for equipment and construction and $2 million for studies, specifications, designs and construction supervision.

Mini-hydropower component

Target communities for the installation of mini-hydroelectric units are towns and cities not served by the national electric grid, which have existing electric service powered by small diesel-electric generators. The electrical load generally consists of a few restaurants, hotels, service stations, residential service, street lighting, and some small commercial enterprises. The present cost of service in these communities is high ($ .15 - .30 per kWh) and development is often restricted due to either the high cost of energy or insufficient capacity. ENEE will perform the feasibility studies, purchase the equipment, manage the construction, own and operate these units. Approximately 3,000 kW can be developed with an average unit capacity of 200 kW at an approximate cost of $7.5 million.

Alternatives to the installation of small hydro units are:

- o continue using diesel fuel (to do nothing)
- o extend the national grid at a cost of $20,000 per Km (34.5 kV)
- o install other renewable energy power supplies such as wood gasifiers.

Micro-hydropower component

Target areas for the micro-hydro installations are towns and villages in the rural areas not served by the national grid that either have power from a small diesel generator, or are considering purchasing small diesel generators to provide electric service to their community. ENEE will assist in the studies, designs, and specifications for these sites, but construction management and operation will be provided by other institutions such as the Peace Corps, municipalities, or other government agencies. ENEE is willing, if paid, to provide operating assistance to these installations in the form of special maintenance and repair services.

Training

At its existing sites, ENEE has well trained and experienced personnel operating the equipment and will only require training for operators of the new equipment. At sites where electricity is being introduced, managers and operators will have to be fully trained. The obvious places to train the new operators is at ENEE's training center followed by on-the-job training at one of ENEE's small hydro

installations. The proposed project will select the best isolated system with a small hydroelectric generator and place a senior manager with the capability to train new personnel at that location.

About $25,000 will be allocated for sending ENEE engineers to special courses relevant to small hydropower development. This amount would allow each of ENEE's engineers to attend one course or conference a year during the life of the project.

Institutional background and issues

ENEE will serve as the primary government institution for implementing the project. ENEE is a semi-autonomous agency of the Honduran Government with its own budget, purchasing office, and administrative procedures. It is comprised of three large operating units: Central Division, Northern Division, and the Interconnected Generating System Division. These units are backed up by an Engineering and Planning Division and Administrative Services Division.

In addition to the interconnected system, ENEE owns and operates 12 isolated systems in rural areas. A typical isolated system consists of 4 or 5 diesel generators serving a peak load of 75 to 200 kW and several hundred consumers (meters). One or two of the diesels are usually inoperable and the towns frequently have rotating blackouts. Diesel fuel now costs about $1.20 per gallon, and the consumers pay from 15 to 30 cents per kWh for electricity. Transportation of fuel to the isolated sites is a problem.

The number of employees on the isolated systems varies with the size. Smaller systems have a manager, 5 operators, and an administrative assistant. Larger systems also have an electrician and additional administrative help. The administrative assistants read the consumer meters. Billing is from the headquarters office and payments are made through the local bank.

Plant operators perform routine maintenance. Special maintenance is performed by mechanics from the Division headquarters, and when major problems occur the unit is transported to the regional repair shops. These shops maintain a spare parts inventory and order special parts as required. Daily records are kept on kWh production, peak loads and operating problems. Maintenance such as oil and filter changes are also recorded and reported.

Five isolated systems were visited during a four-day field trip. From this brief observation, it appeared that the quality of electric service depended primarily on the competency of the plant manager. When systems had managers with less than 10 years' experience and no technical training (political appointees) the consumers suffered. Presently, ENEE requires that all managers be Technical School graduates and have at least 3 years' experience with ENEE.

In addition to ENEE-owned and operated systems, there are numerous isolated municipally owned and operated diesel-electric systems in rural areas of Honduras. ENEE provides these systems with technical assistance and will perform special maintenance and repair services for a fee.

For the proposed project, ENEE will set up a special small hydro unit within the Engineering and Planning Division. This unit will consist of a Chief, several engineers, draftspersons, and a secretary. Their salaries, plus the cost of support services such as surveying, and transportation, will act as the major GOH contribution to the project. Their duties will include preparing the feasibility studies, bid specifications, and detailed designs. Additional assistance will come from the Taiwanese Technical Assistance Team that has performed most of the existing small hydro studies. The small hydro unit will also have responsibility for construction management for the mini-hydro units, but the construction work will be let to local contractors. For the micro-hydro installations, the small hydro unit will assist in developing standardized designs and bid specifications.

Institutional issues for the proposed project are:

- o assurance that good managers are selected to supervise the small hydro installations
- o training program for the project engineers and hydropower plant operators
- o training and maintenance agreements for non-ENEE owned systems.

Technical background and issues

The Taiwan Power Company has provided technical assistance to ENEE since 1977. Since 1979, one of its major activities has been the study of potential small hydro sites. It has performed several feasibility level studies and has prepared and issued machinery specifications. This activity has slowed down recently due to ENEE's concern for additional energy sources by 1990 (they will have sufficient installed capacity).

ENEE and the Taiwan Technical Assistance Team have had considerable experience on large hydropower projects. Hence, much of the work done in small hydro reflects a "scaling down" of large hydro designs and procedures. In most cases this is appropriate, but in some cases it is not. Although the reports are of very high quality, there are opportunities to reduce costs and select more appropriate equipment. Hence, for at least the first year of the project, a technical advisor will be assigned to the project to advise ENEE on appropriate civil structures, specifications, and bidding procedures.

Hydrology. The rainfall patterns in Honduras are complex. The Caribbean coast, particularly in the east, receives more than 2400 mm of rain annually. The interior highlands receive less, with less than 1000 mm per year falling the driest areas near Tegucigalpa. The Pacific coast, while wetter than the interior, is drier than the Caribbean coast. These patterns are only generalities, since local topographic conditions cause considerable variations, particularly between windward and leeward sides of mountains. The Honduran dry season runs from November to April, with a minor "dry" season during July-August in the midst of the rainy season.

Streamflow data exist for 48 guaging stations in Honduras although the data is often unreliable.

On small drainage basins, with which this project will be concerned, the minimum flows will depend upon the base flow from springs. Base flow is site specific and generally cannot be extrapolated from nearby drainage basins or larger basins. Since the turbine's dependable capacity is a function of the minimum flow, they should be confirmed by on-site measurements before machinery specifications are prepared.

Turbine selection. Some of the existing studies recommend the use of horizontally mounted Francis turbines. This type of turbine is quite limited in its ability to operate under flow conditions of less than 60% of rated flows. Hence, it is not the most suitable unit for schemes operating under wide stream flow variations as found in Honduras.

Cross-flow turbines are more appropriate under those conditions since they operate at good efficiencies over a broad range of flows. Pelton units reach and retain peak efficiencies of 85-90% when operating above 40% of capacity.

Equipment and specifications. In the existing studies, specifications have been developed for each of the unit components - the turbine, generator, governor, and oil supply system. This detail of specification hinders manufacturers of pre-engineered units in bidding their packaged units. Hence, specifications should be written requesting packaged turbo-generating units and the bids evaluated on the basis of their cost, guaranteed efficiencies, and operating range.

Local manufacture. Facilities to cast and machine centrifugal pumps exist in Honduras. This capability can be utilized to manufacture Pelton, cross-flow, and Francis turbines. A Francis turbine is nearly identical to a centrifugal pump, but operated in reverse. The team recommends that a program for in-country manufacture of turbines begin with very small units, up to 66 horsepower (50 kW), because the requirements for material strength and machining tolerances become much more stringent for larger units.

Valves and gates used in the projects can be manufactured locally. Other technical issues that need to be addressed are:

- o selection criteria for potential sites
- o the need for an inventory of sites before selecting sites for construction
- o selection of design flows from the flow duration
- o adequacy of flow data and load forecast
- o designs to allow for the multi-use of the water
- o criteria for installing multiple units.

Economic background and issues

In its studies, the Taiwan Technical Assistance team evaluated sites using the annual benefit and annual cost comparison method. The annual gross benefit was represented by the annual cost of the most probable alternative - a small diesel engine. The amount of capacity and energy benefits are based on load projections. In the Quimistan Hydro Power Study, they used a 19% average growth rate over the next 15 years, which appears quite high.

Economic issues to be addressed are:

- o Is the method described above acceptable?
- o Are the load forecasts reasonable?
- o Should an inventory of sites be conducted and preliminary B/C be established before a site is chosen for construction?
- o Are the O and M cost figures used in the existing studies reasonable?

No financial or cash flow analyses have been performed for the potential sites.

Environmental issues

Small hydroelectric plants generally have benign environmental impacts, such as partial control of floods, prevention of erosion and improving fish and wildlife habitat. The installations can be aesthetically pleasing. Adverse impacts that can result occasionally with large hydro projects, such as hindering fish migration or flooding large wilderness areas, do not occur with small hydro plants.

One area requiring special environmental attention is near the Copan Ruinas where extensive Mayan ruins remain unexcavated. Other areas may require archaeological attention as well.

Private sector aspects

This proposed project will involve and affect private sector enterprises in the United States and Honduras. The equipment to be used in the project will be purchased from the United States which will give those manufacturers an opportunity to introduce their equipment to the Honduran market. A U.S. consultant will be used for the technical assistance.

Construction contracts will go to local contractors, giving them experience in constructing small hydro projects. Power plants will provide elecricity needed in the rural areas of Honduras for small enterprises to develop, particularly agro-industries such as mills for grinding grain and husking coffee, oil extractors, and corn dryers.

Local manufacture of equipment would also promote private sector enterprises.

Cost information

Cost estimates developed by the [illegible] capital investment in the range of [illegible] 1982 figures include indirect costs such as contingencies and [illegible] construction. Engineering and administrative costs are not included [illegible] civil works are relatively inexpensive in Bangladesh, [illegible] of the total cost. The [illegible] and electrical equipment, including distribution.

Unit costs for civil works were [illegible] mechanical and electrical components were [illegible] responses from equipment manufacturers. [illegible] electro-mechanical equipment could [illegible] package instead of individual parts. [illegible] generators are prepared to supply a complete package [illegible] governor, control board, motors, and [illegible] achieved through local manufacture of [illegible]

Installations with a relatively high [illegible] reduce the project cost because the [illegible] and the Pelton and [illegible] reaction turbines.

Costs could be reduced in the civil works [illegible] boulders and rocks, or with [illegible] concrete as foreseen in the [illegible] structures need not be watertight. [illegible] some sites.

General factors affecting the project cost are [illegible] geology. Also, [illegible] but time consuming and difficult to construct. [illegible] maintenance problems, [illegible] downstream and they will [illegible] flow is usually sufficient [illegible] should not exceed 1 metres.

Finally, the project cost [illegible] project serves other purposes such as [illegible] fish propagation. The cost of the civil [illegible] part by these features.

The cost of micro-hydro projects, [illegible] $600 to $2,000 or more per kW. [illegible] been constructed in Pakistan and Nepal, [illegible] civil works were built by the [illegible] turbines were manufactured in [illegible] from oil drums and scrap pipe. [illegible] code and the entire project was managed [illegible] advantage of long experience with [illegible] installations.

Apart from these special conditions, the cost per kW [illegible] micro-hydro installations than for single [illegible]

Project preparation strategy

The team recommends that the Mission seek 4 specialists to assist them in preparing the Project Paper: an engineer with small hydro experience; a civil engineer, an economist with experience in power projects; and an institutional advisor with experience in electric utility operations and planning. Such assistance could be supplied through the Latin America Bureau, ST/EY, or by contracting with private consultants. The Mission should supply a Team Leader, sociologist, economist, and general team support. ENEE should assist with the PP by providing background information and site specific data.

The PP should not attempt to be site specific. Since no inventory of potential sites has been developed, the best sites are not known. Also, the exact number of sites and total installed capacity will not be known until after the feasibility studies have been completed.

The PP Team should look at 3 sites in detail: (1) mini-hydro site near an ENEE system; (2) mini-hydro site near a municipal system; and (3) a micro-hydro site near another, non-ENEE system. This will allow the team to establish institutional arrangements for each type of installation and address the unit cost figures for mini- and micro-hydro installations. If time permits, the team should also visit an abandoned site.

The scope of work for each of the 4 specialists is outlined below:

- Institutional advisor. The institutional advisor will prepare the institutional analysis, administrative arrangement, implementation plan, and evaluation plan portions of the PP. In addition, he/she will assess the load projections, tariff structure, and operating procedures of the implementing agents. Duration: 4 weeks.

- Economist. The economist will assist the Mission economist in establishing a procedure for conducting the economic and financial analyses of the PP. Duration: 1-2 weeks.

- Small hydro engineer. The small hydro engineer will produce the technical analysis portion of the PP and provide cost estimates to the Mission economist. This will require field visits to at least 3 sites. Duration: 4-5 weeks.

- Civil engineer. The civil engineer will work with the small hydro engineer to assess the hydrology, structures, and unit cost figures used in the PP. Duration: 4-5 weeks.