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THE VIABILITY OF AN AID FINANCED SMALL HYDRO PROGRAM IN THE DOMINICAN REPUBLIC

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1.0 INTRODUCTION

This report was prepared by a group of NRECA consultants who visited the Dominican Republic during approximately 5 weeks in June/July 1981. The objective of the NRECA Mission was to assist USAID/Santo Domingo in the preparation of the Small Hydro component of the forthcoming Project Paper entitled Energy Conservation and Resource Development that is scheduled for submittal to the DAEC of USAID/W in early FY 1982.

The overall objective of the Small Hydro component of the project is to consolidate and build upon existing institutional capabilities towards the design, construction and operation of Small Hydroelectric Power Plants (SHPP's). A country specific methodology, that was developed by the NRECA Team during intensive review, will be used to prioritize and select suitable candidate SHPP construction sites.

A two step approach is proposed for implementing the Small Hydro sub-project:

(i) Phase one consists of all necessary desk and field studies that are needed to develop definitive bid and design documents and includes site selection and feasibility studies. AID assistance for this project phase will be exclusively in technical assistance in the areas of project management advice, small hydroelectric resources development planning, project environmental assessment and optimal collection and processing of hydrometereological data.

(ii) Phase two consists of executing the sub-project and includes all activities from equipment procurement and installation through civil works construction, training of the plant operators to plant start-up and operation. AID assistance for this phase of the project will include i) financing for the procurement, primarily, of electro-mechanical equipment ii) technical assistance in the areas of a) promotion of productive uses of electricity, b) SHPP operation and maintenance, c) SHPP management (including tariffs, billing and collection

issues) and d) community organization for watershed conservation and improvement. The technical assistance will be directed towards developing a managerial capability at the local level for the management of SHPP's - an important goal of the Small Hydro sub-project.

The report consists of 8 chapters and 3 appendices. It includes technical, economic, financial, social, environmental and institutional analyses of the sub-project, that have been prepared for inclusion in the Project Paper, plus the above-mentioned site-selection methodology. In addition, the report includes 2 site selection studies that were conducted by DR professionals, under the direction of the USAID team of consultants, during the period of intensive review. The report also includes a Project Description that deals with activities sequencing and timing throughout the duration of the sub-project.

The principal conclusion of the report are:

i) Economically the installation of small hydroelectric power plants (SHPP's) is an extremely attractive option right now in the Dominican Republic for the following situations:

a) Replacement by a hydroelectric source of part of an existing isolated electric system currently supplied by fossil fuel sources.

b) Rural electrification of a community or region that does not have electricity and has the possibility ity of being connected to the national system grid and thereby selling surplus electricity generated back to the grid.

c) Electrification of a community which does not have electricity where the energy demand approximates the available hydroelectric energy supply.

(ii) Technically, electrification by SHPP in the DR is feasible because of the abundance of possible sites (a preliminary study has identified up to 40) and of more than 30 years of in-country experience in dealing with SHPP's. The successful conclusion of two site selection studies during the period of intensive review by two teams of DR professionals using a customized site selection methodology that had been developed by the USAID team of consultants, lends further creedance to this view (See Appendices I, II and III).

(iii) Socially, the project calls for participation of the primary communities that will be served by the SHPP's in many aspects of project execution from facilities construction through the permanent operation, maintenance and administration of the SHPP's. Extensive field investigations support this view (See Chapter 3).

iv) Environmentally; ongoing prudent management of the watershed that provides the 'fuel' for driving the SHPP turbine(s) is a sine qua non for the success of the project especially in light of the abysmal past record of soil conservation in major watersheds of the DR (See Chapter 5).

v) Institutionally, the situation is very promising and complex at the same time; promising since three distinct institutions with different mandates and experiences (the National Energy Policy Commission (CNPE), the Dominican Electricity Corporation (CDE) and the National Hydraulics Development Institute (INDRHI)) coordinated their efforts for the first time in the elaboration of two site selection studies under the guidance of the USAID team of consultants; complex because of the continued future project need to coordinate the contributions of the three institutions.

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The proposed project management plan has been discussed separately and jointly with high ranking employees of the three institutions. The management plan and project orientation incorporates many valuable suggestions made by DR personnel and has the broad agreement of the three institutions. (See Section 6.2). It is the judgement of the NRECA team that continued open and free exchange of information and cooperation between professionals of CNPE, CDE and INDRHI is a necessary condition for the optimum development of the nation's small hydroelectric resources.

TABLE 1-1 BUDGET FOR AID/GODR SMALL HYDRO PROGRAM

	AID Grant	AID Loan	Total	GODR Contribution	Grand Total
Technical Assistance	520,000		520,000		520,000
Salaries and other Employee Benefits				200,000	200,000
SHPP Construction		1,314,300*	1,314,300	729,500	2,043,800
	520,000	1,314,300	1,834,300	929,500	2,763,800
%	66.4			33.6	

Breakdown of AID Contribution by Phase

	Grant	Loan	Total	%
PHASE 1 (24 months)	290,000**	--	290,000	15.8
PHASE 2 (22 months)	230,000	1,314,300	1,544,300	84.2
	520,000	1,314,300	1,834,300	

* Assuming AID financing of Penstock, Power Plant and Electrical Equipment, Transmission Line and Projection Equipment and Contingencies. Information is based on 2 illustrative studies carried out during the period of intensive review.

** Phase 1 T.A. will include the visits of the Project Advisor (15 months), the planner in small hydroelectric resources (4 months), the expert in environmental assessment (4 months), the expert in hydrometeorological data gathering and processing (4 months) and the expert in AID procurement document preparation (2 months). Phase 2 T.A. will include the other remaining categories.

2.0 Technical Analysis

Introduction

The development of small hydroelectric resources in the Dominican Republic must begin with a comprehensive survey of the resources available, immediately followed by a systematic evaluation and prioritization based on a general methodology that accounts for technical, economic, social, environmental and institutional factors. A portion of this consulting effort has been devoted to the development of such a methodology which, in turn, has been field-tested by members of the Corporación Dominicana de Electricidad (CDE), the Instituto Nacional de Desarrollo de Recursos Hidráulicos (INDRHI) and the Comisión Nacional de Política Energética (CNPE) along with the USAID project team.

This chapter will deal with the criteria involved in the development of the site selection methodology, its goals, application and results. Two illustrative examples of the application of the methodology will follow, and demonstrate the generation of appropriate cost data. Further, the ensuing discussion will analyze the technical aspects of small hydroelectric installations — as they relate to isolated rural settings— as well as interconnection with the national electric grid. A typical scenario, tracking a potential project from the application of the site selection methodology to the point when the installation goes "on-line", will indicate the time-frame expected for pilot project delivery.

Finally, the two site selection studies performed as part of the intensive review demonstrate the capability of the implementing agencies to use the methodology developed.

2.1 Site Selection Methodology

The site selection methodology is designed for professionals in the field with a two-fold purpose. Its application will yield a set of objective criteria for the prioritization of the 40-odd sites presently identified and, in addition, will result in an analysis of each site that touches on all the topics and considerations covered in a full feasibility study. The following is a summary of the methodology.

1. Basic Site Selection Criteria

The basic criteria involved in site selection include:

- Technical Viability

- Economic and Financial Feasibility

- Social Desirability

- Institutional Compatibility

- Environmental Impact

2. Compilation of Existing Information

A first step in the conduct of a site selection study is the compilation of pertinent existing technical, social, institutional and environmental data. With this information at hand, the subsequent field visit to the site of a proposed small hydro development will be dedicated exclusively to fill identified data gaps. This data collection is broken down into 4 general categories:

- Technical information - Topographic maps, pertinent hydrographic data, as well as geologic and geographic material will be assembled from various sources specified in the text.

- Social information - It is necessary to characterize the community that will be served by the proposed hydro project in terms of community response, energy demand and economic resources. Agencies to contact and surveys to consult are specified.

- Institutional information - The existence of a possibility of upstream competing water uses must be determined. The appropriate agencies to contact are listed.

- Environmental information - It is emphasized that the condition of the watersheds should be researched fully. This is designed to evaluate the impact of the environment on the project rather than vice-versa.

3. The Site Visit and Field Survey

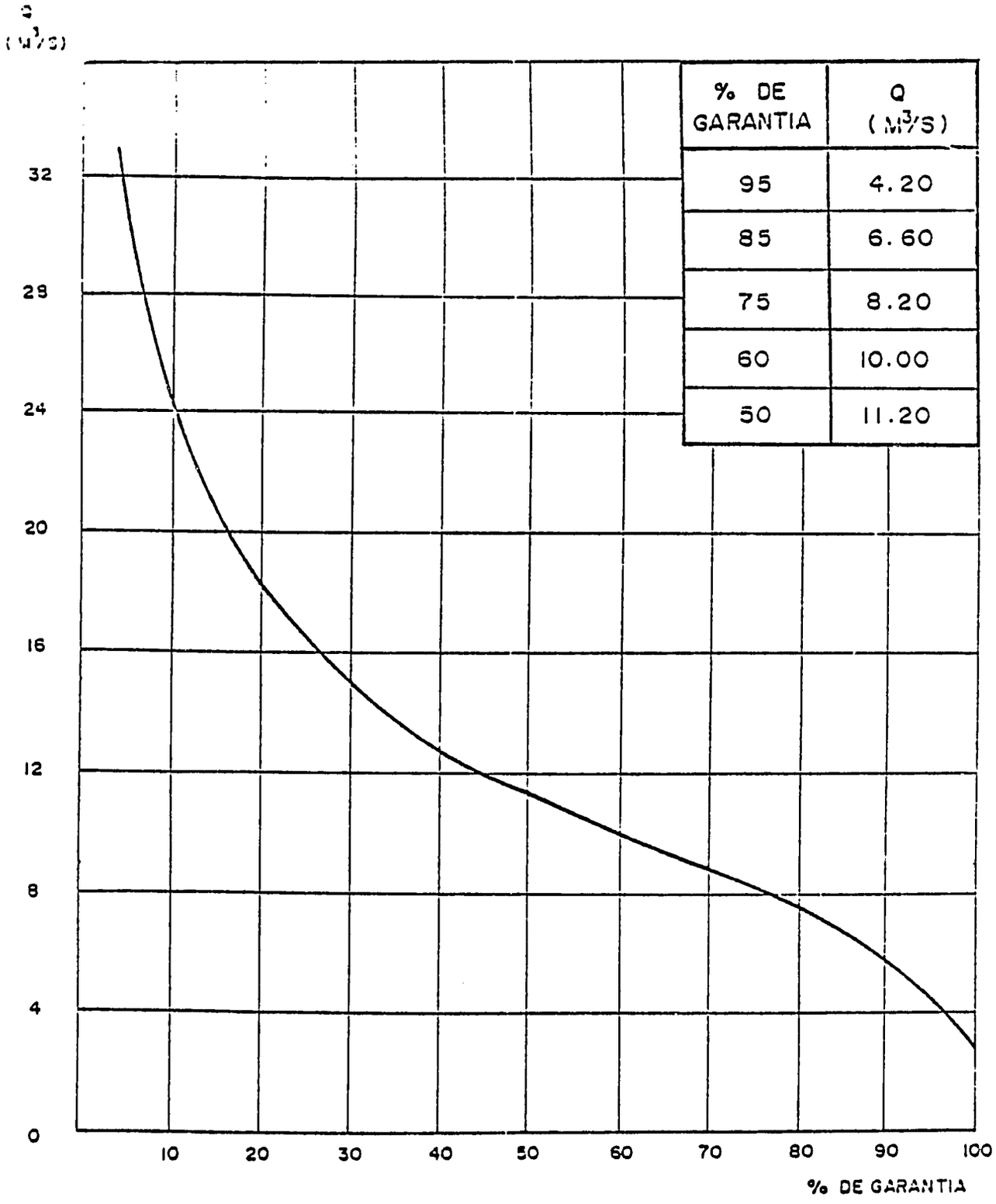
A field Questionnaire has been prepared by CNPE with additional input from the USAID consulting team. It has been designed to assist the field team in determining and quantifying physical site characteristics as well as social, institutional and environmental factors.

4. Processing of Hydrological Information

A discussion is presented emphasizing the importance of dependable hydrologic data and suggesting methods for the reasonable extension of available stream flow information. Conditions specific to the Dominican situation are addressed. A flow-duration curve is described and generated for use in subsequent sections. (See Figure 2-1).

LAMINA 3-3-1

FIGURE 2-1 CURVA DE DURACION DE LOS CAUDALES MEDIOS MENSUALES DEL RIO BOBA EN LA ESTACION DE LOS JENGIBRES



% DE GARANTIA	Q (M³/S)
95	4.20
85	6.60
75	8.20
60	10.00
50	11.20

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5. Social, Institutional and Environmental Guidelines

These guidelines are useful in evaluating the "human" and "natural" context of the SHPP development. They aim at a clear evaluation of the management capabilities which are required to put in place (including the appropriate timing of local construction) and administrating the SHPP.

For example, consumptive uses of water originating in the watersheds may be such that there is insufficient water available for operating the SHPP satisfactorily. Alternatively, the watershed may be in such a poor condition as to preclude the installation of an SHPP until restoration measures are in place and seen to be working.

6. Demand Calculation and Forecast

In the case of rural electrification it is essential that a potential electric demand be estimated. A method for forecasting this demand is presented along with tables to assist in the estimate. In the absence of actual demand growth rates, a conservative growth rate of 3% per year is assumed. This figure is the accepted population growth rate in the Dominican Republic and the assumption is made that the electric energy consumption will grow at the same rate.

7. Alternative Layout Schemes

The first level analysis that is presented in this methodology is intended to address all possible development alternatives of a potential hydro-electric site. Criteria are presented for the determination of gross static head to establish a degree of accuracy that will remain constant for varying installations.

In order to optimize the resource, it is proposed that all possibilities be sketched on a first-pass basis. The alternatives are very site-specific and a list of possible considerations are presented. Among others, these considerations include accessibility, competitive water use, availability of local labor, etc. Resulting schemes may range from run-of-river high head installations to multiple unit low-head storage installations with all encompassed possibilities examined. The layout sketches are to include gross dimensioning of appropriate features to assist in preliminary evaluation. Preliminary turbine selection is accomplished graphically, selecting the most efficient turbine for the particular layout as a function of head and design flow.

8. Estimation of Power and Energy

The installed capacity of the turbine must be selected with two major factors in mind:

a) Optimization of the resources and b) projected demand of the community to be served. The first consideration is dealt with on the direct path through the methodology (see flow chart, Figure 2-2) while the second is a review and possible redesign of the preferred scheme.

The flow duration curve derived in the hydrology section is employed to determine the design flow of the turbine. A methodology dependent on preliminary turbine selection, is presented that employs the practical limits of flow for calculation of average annual energy. (See Figure 2-3). A 15% exceedance level is suggested for determination of maximum turbine flow from which the design flow and minimum flow can be calculated. The area-contained within the turbine flow limits is the average annual energy the plant is capable of producing (when this area is converted to the proper units). The 15% exceedance level is a starting point for this calculation and may be changed to another exceedance level depending on the shape of the curve and/or the required loading factor. The installed capacity will be dependent upon the storage capacity (if any) but, usually in rural or isolated installations it will be sized according to effective head and 85% of maximum turbine flow.

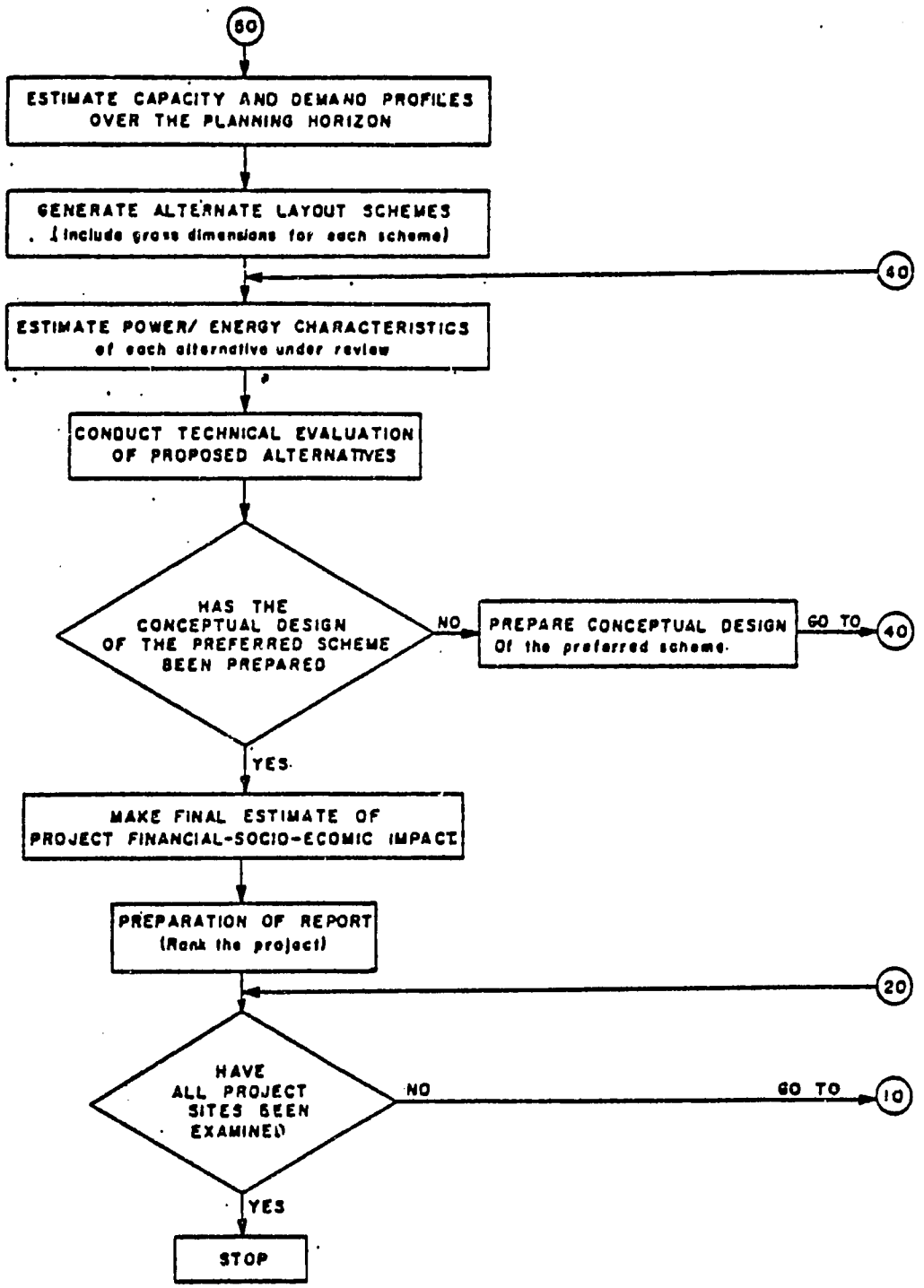
The layout task in the methodology is revisited following the selection of the preferred scheme (refer to flow diagram, figure 2-2). Refinements are made in the arrangement of the headworks, optimal powerhouse location, penstock configuration, etc. A more detailed analysis of head loss and turbine type is carried out. At this point the methodology calls for a re-evaluation of the preferred design considering the utilization of the project output, capacity and energy. For instance, in an isolated setting with limited demand requirements, present and future, the design may be modified to include two turbines with only one being installed at the time of construction. This would allow the project to operate at optimal efficiency while the load requirements are low yet permit full exploitation of the resource in the event that a grid connection becomes possible. Other considerations and possible modifications are suggested.

9. Technical Evaluation of Alternative Schemes

The possible development alternatives generated in the layout task are evaluated using sound engineering judgement based on the preliminary dimensioning of the layout sketches and the calculations previously developed. Experience in local civil construction costs, the availability of local labor and observed environmental conditions will play a large role in the evaluation process. The input from this task results in the selection of the preferred development scheme.

2-2

FIGURE/ . (CONTD.)



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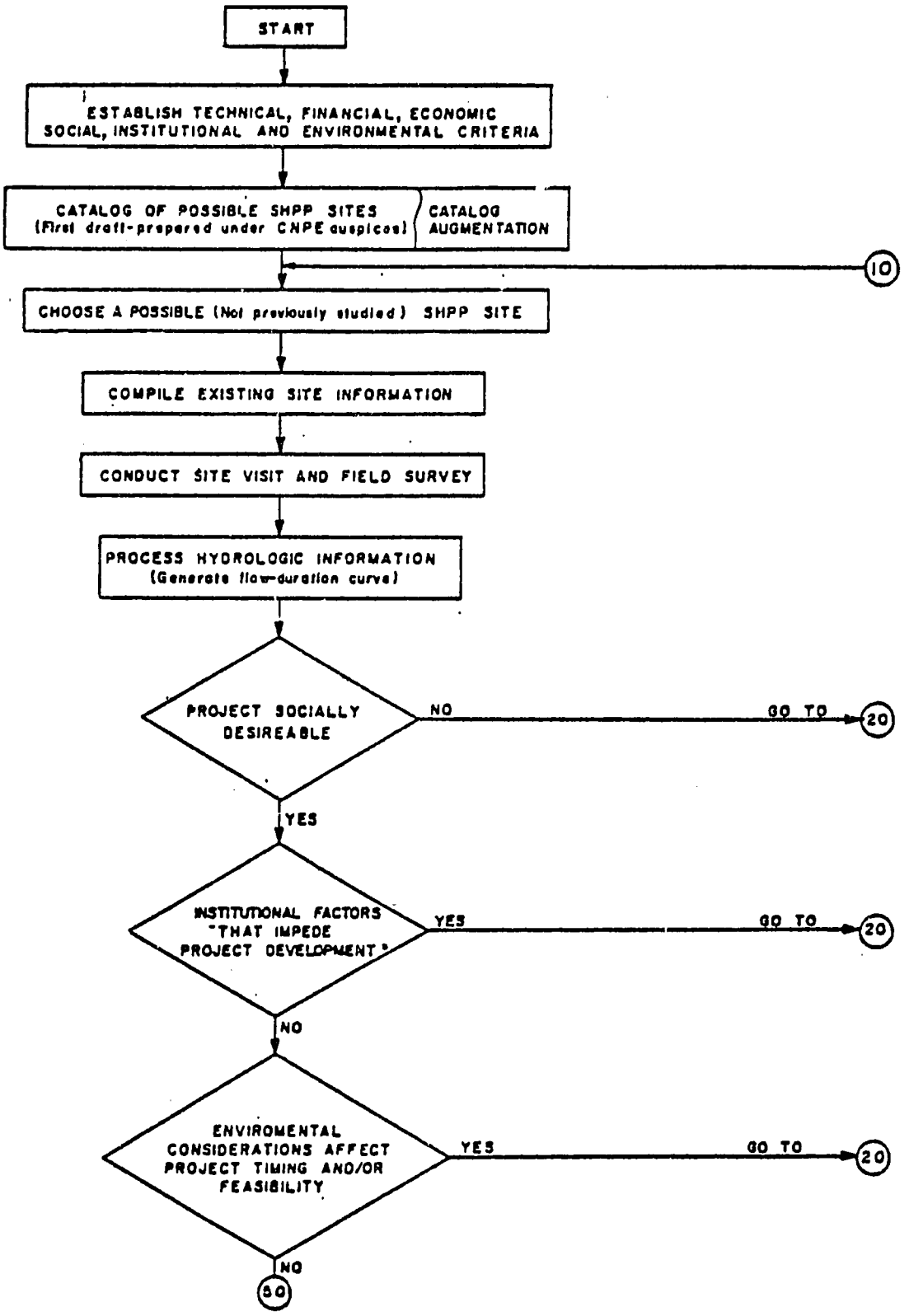
FIGURE' FLOW CHART OF THE SITE SELECTION METHODOLOGY



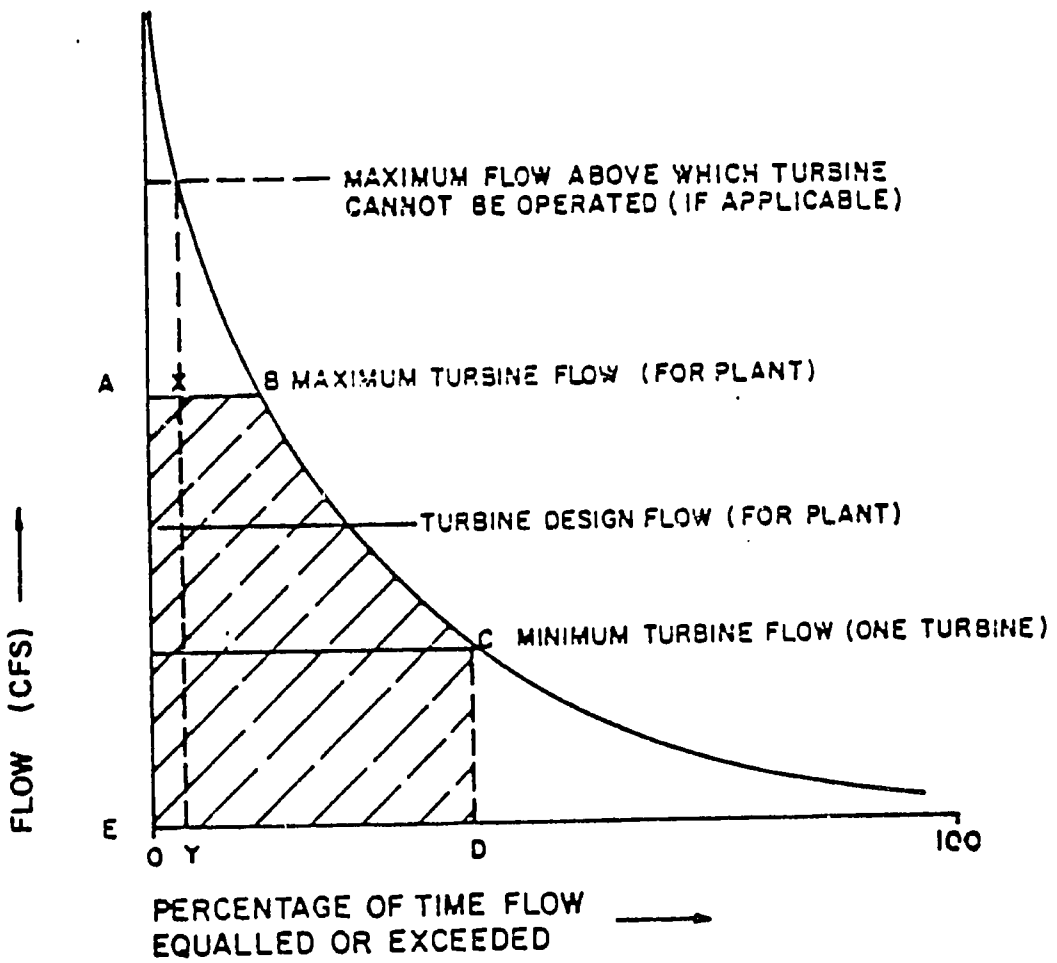


Figure 2-3 Procedure for Use of Flow-Duration Curve

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10. Conceptual Design of Preferred Scheme

The final layout will be prepared at this stage that will specify the following:

- Turbine type
- Estimated dimensions of civil works based on experience & available curves
- Generator (induction or synchronous)
- Transmission Requirements (length, voltage)
- Highlighting of any extraordinary feature or equipment that may be necessary for development.

Guidelines and suggestions for accomplishing the above are given in the text. These are complemented by tables and charts presented in the Appendices.

11. Project Cost Estimation

An important aspect of determining the preliminary feasibility of a potential hydroelectric development is an estimate of the costs involved in the construction, and an analysis of annual operating expenses. Cost curves, compiled for construction and equipment expense for low-head hydroelectric projects in the U.S. are presented in an Appendix to the methodology. It is noted that some of these curves are not particularly appropriate to small hydroelectric development in the Dominican Republic for various reasons. Rather, they serve illustrative purposes and give general cost relationships. It is strongly recommended that similar cost curves, locally valid, be prepared for use in the application of the methodology. The advantage of a graphical approach to costing is that quantities in civil works and per unit costs do not have to be derived for each project arrangement, thus accelerating the pre-feasibility process and standardizing costing procedures. The project costs thus derived are deemed to be accurate within ± 25%. An index is developed to relate costs in a base year to costs in subsequent years.

12. Economic and Financial Analyses

The cost effectiveness of a hydroelectric project is dependent upon the alternatives available to supply the same capacity and energy. In the Dominican Republic three general categories have been identified that will serve for the majority of situations.

a) Rural electrification of a community or region that previously has not had central electric service and has a low probability of being connected to the system grid. This type of hydroelectric installation will be costed against a diesel unit of the same installed capacity and supplying the amount of energy sufficient to meet the demand. The energy cost for the diesel will be the current price of fuel combined with unit efficiency to yield a cost in ¢/Kwh produced. This fuel expense is escalated (at 3% per year) which is then multiplied by the annual energy requirement (also escalated at 3% per year) to yield a total energy cost in RD$.

b) Rural electrification of a community or region that has a definite possibility of being connected to the system grid. The cost of service from the grid is broken into the following components.

1. An average capacity charge (in RD$/Kw) based on the CDE resources most likely to supply power to the community. The capacity expense is compiled using the constant capacity charge time the estimated peak demand. This will be escalated at the projected rate of demand growth (3%)

2. An average energy charge (in RD$/Kwh) based on the system bulk tariff structure. This total energy expense will be the product of the predicted annual energy growth rate and the average tariff (escalated according to CDE policy, which includes a rate increase of 2%/month or 27%/yr for the 16 month period starting December 1980).

3. A connection charge to the grid. This includes the cost of construction of the transmission line, the cost of protection equipment and the cost of voltage transformation from hydro generator voltage to line voltage.

Inherent in the grid connection option is the possibility of capacity and energy sales to the system at a negotiated long term rate. Here a hydroelectric plant would be constructed to fully optimize the resource, producing capacity and energy in excess of community requirements. The increased capital expense will be partially offset by the benefit derived from energy sales to the system. The cost of connection to the grid would be borne by the hydro development.

c. Replacement by a hydroelectric source of part of an existing isolated electric system currently supplied by fossil fuel sources or a historical energy mix. Here it is assumed that the energy produced by the hydro will replace an existing diesel resource. The same method of comparison outlined in option a will be used, with the exception that the energy produced by the diesel

will remain constant and equal to the median-year hydro production, with only the fuel cost escalated at 3%/year.

The financial and economic analysis draws the cost of mini hydro development from the Project Cost Estimate task and the alternative cost from one of the three cases described above. Assumptions for the analyses are enumerated and worksheets and examples provided. These analyses will yield standard measures of project worth: benefit/cost ratio, net present worth and internal rate of return.

13. Report Writing

Once the technical, social, economic, institutional and environmental analysis have been conducted, the evaluating team will write the final report on the site with recommendations for or against the selection of the site for SHPP development. An outline format for the report is suggested.

2.2 Illustrative Fxamples

The site selection methodology designed and prepared by the USAID consultants was field tested by teams composed of members from the following organizations: Corporación Dominicana de Electricidad (CDE), Instituto Nacional de Recursos Hidráulicos (INDRHI), Comisión Nacional de Política Energética (CNPE). The cooperative effort of these organizations during the course of the studies has proven to be an encouraging note for the continuing free exchange of information between them. The studies conducted were selected from a field of 40 contained in the Inventario Nacional de Recursos Hidráulicos prepared by the CNPE. Initially, four potential developments were selected for site visitation. This group was narrowed to the two study sites following field investigation. The following potential developments selected for application of the methodology were decided on in conjunction with the USAID consultants: Río Constanza in Constanza, la Vega Province, and Río Banilejo near El Pinar, Peravia Province. The following is a technical review of the studies conducted (the studies are presented in their entirety in Appendices II and III).

Technical Review #1 (Constanza)

Constanza, a small city in the country's central mountain chain, lies in a rich agricultural valley isolated from the nation's electric grid system. The population of some 8,184 persons is mainly employed in commercial agriculture including the cultivation of flowers. Although there is an extensive irrigation system through aqueducts and canals, a large portion of irrigation is accomplished through the use of electric pumps.

The electric supply of Constanza consists of three generating units: a 250 KW hydroelectric unit, a diesel driver generator rated at 1150 Kw and a small diesel unit of 150 Kw. The economic dispatch of these units theoretically supplies the energy requirements of the city and satisfies their present peak demand of 1000 Kw. The reality of the situation falls somewhat short of theory. The large diesel, rated at 1150 Kw, is only capable of supplying a maximum of 700 Kw due to disrepair of the diesel engine. The hydro unit, now out of service due to blockage of the power canal, has been operated erratically since 1975. (see Figure 2-4). The small diesel (according to CDE sources) is said to have a maximum output of 30 Kw. As a result of this situation the population of Constanza suffers frequent blackouts and voltage and frequency fluctuations.

The canal intake for the proposed hydro-electric installation would be located at the end of the Constanza Valley at the confluence of the Río Constanza and the Río Pantuflas (see Figure 2-5). The project would take advantage of the natural waterfall site called "El Salto", to produce an estimated 500 Kw of power.

(Continue to Page 2-15)

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STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

2-13

Computation Sheet

Project _____ Sheet _____

Feature _____ Designed _____ Date _____

Item _____ Checked _____ Date _____

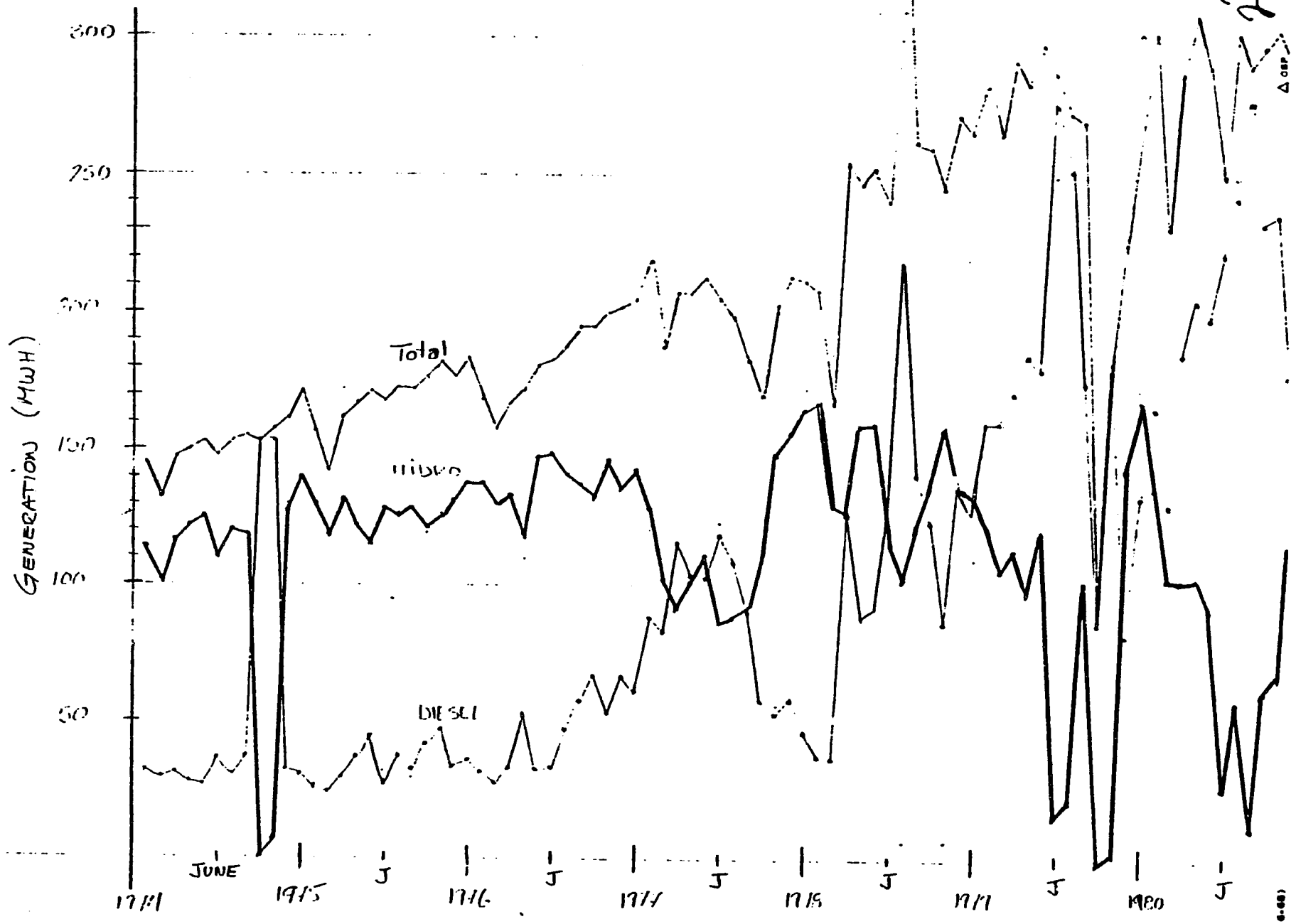

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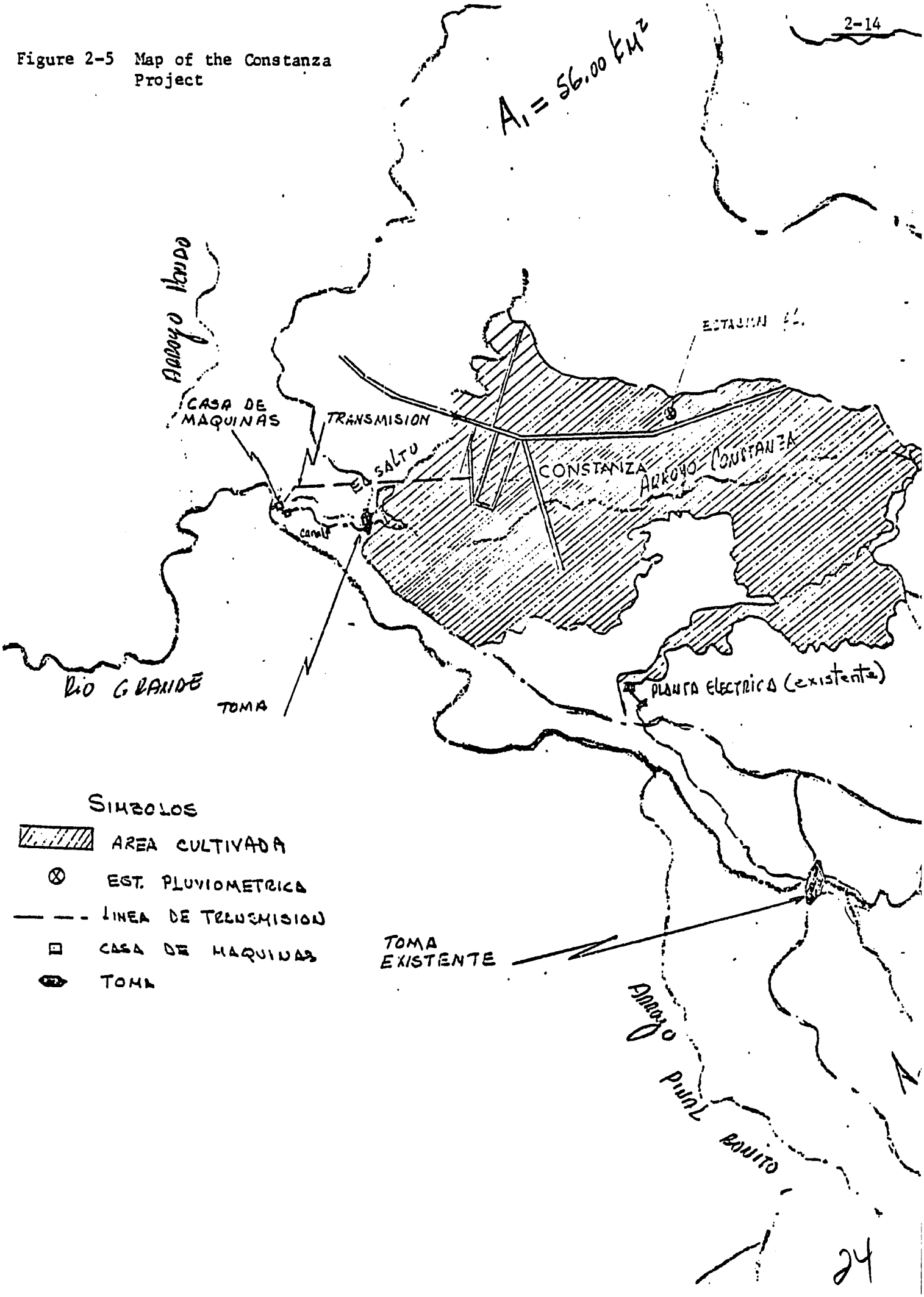
Figure 2-5 Map of the Constanza Project



Hydrology

There are no existing flow data for the drainage areas of the Río Constanza nor the Río Pantuflas. The study team collected existing rainfall information in three areas nearest the site all of which had at least 7 years of comprehensive data. Further, a flow duration curve was generated on the basis of daily flows available in drainage areas of similar size and characteristics. These inputs combined with instantaneous measurements at the time of the site visit, enabled the study team to make a preliminary estimate of the median flow available at the intake of the power canal.

This preliminary estimate of flow was then corroborated through the use of mass balance calculations based on runoff characteristics of the adjacent drainage area, hydraulic experience with the existing small hydro installation and irrigation data. The calculations appear in their entirety in Appendix II. The median flow arrived at through calculations was .84 m^3/s while the observed flow corelated with rainfall records was .7 m^3/s. The latter flow was considered a conservative estimate and adopted as the available median flow.

Alternative Project Layouts

During the identification process of possible sites for hydroelectric development three alternative schemes for development were proposed. The subsequent site visit eliminated two of the alternatives due to geologic and topographic discontinuities and it was agreed that only the following development would be studied further.

The proposed development would consist of a small dam 5 meters in height with a storage volume of some 8000 m^3 located at the confluence of the Ríos Constanza and Pantuflas. The geologic and topographic conditions at this point appear to be well suited to the construction of a concrete overflow dam. The impoundment would extend upstream some 500 meters. The conduction canal will be constructed from the left abutment of the dam and the flow regulated with a vertical slide gate. The canal is approximately 1.0 Km in length with a gradient of .5% and a capacity of .98 m^3/s. The canal ends at the headworks where a slide gate will regulate flow to the penstock 22" in diameter and 100 m in length. The gross head developed in this scheme is 70 meters as measured with an altimeter accurate to $\pm$ 3 meters.

Social, Institutional and Environmental Considerations

The existing electrical demand of Constanza is estimated at 1000 KW. The distribution system extends throughout the valley but does not reach the community of Tireo, about

7 Km southeast of Constanza. The estimated demand in this area is 200 Kw representing an increase of 70% of the present electric load. The inclusion of this community is not incorporated in this study, but it is noted that future expansion plans should address the electrification of Tireo.

Constanza has a history of community involvement and the population has participated in various public projects on a voluntary basis. The civil works construction involved in this project would draw on the labor force of the community.

The watershed area associated with the project appears to be in good condition. The community, being agricultural in nature, has used adequate farming and conservation techniques to avoid massive erosion. A reforestation program is in progress with the assistance of the community.

Capacity and Energy Estimates

The firm capacity of the hydro unit is based on the storage capacity of the impoundment and the regulation possible during a critical day, i.e. during a low flow period. Using the present demand curve of the system, it is found that energy from the hydro source must be available 11 hours daily (see Figure 2-6). This energy duration requirement combined with the storage capacity available yields a calculated firm capacity of 170 Kw. The flow required to produce this capacity is .3 m^3/sec., resulting in a power volume drawdown per day of 6500 m^3. The 95% duration flow is .14 m^3/sec. Thus allowing a daily cycling of the system (i.e., in flow - .14 m^3/sec. x (24-11) hours x 3600 sec/hour = 6552 m^3.

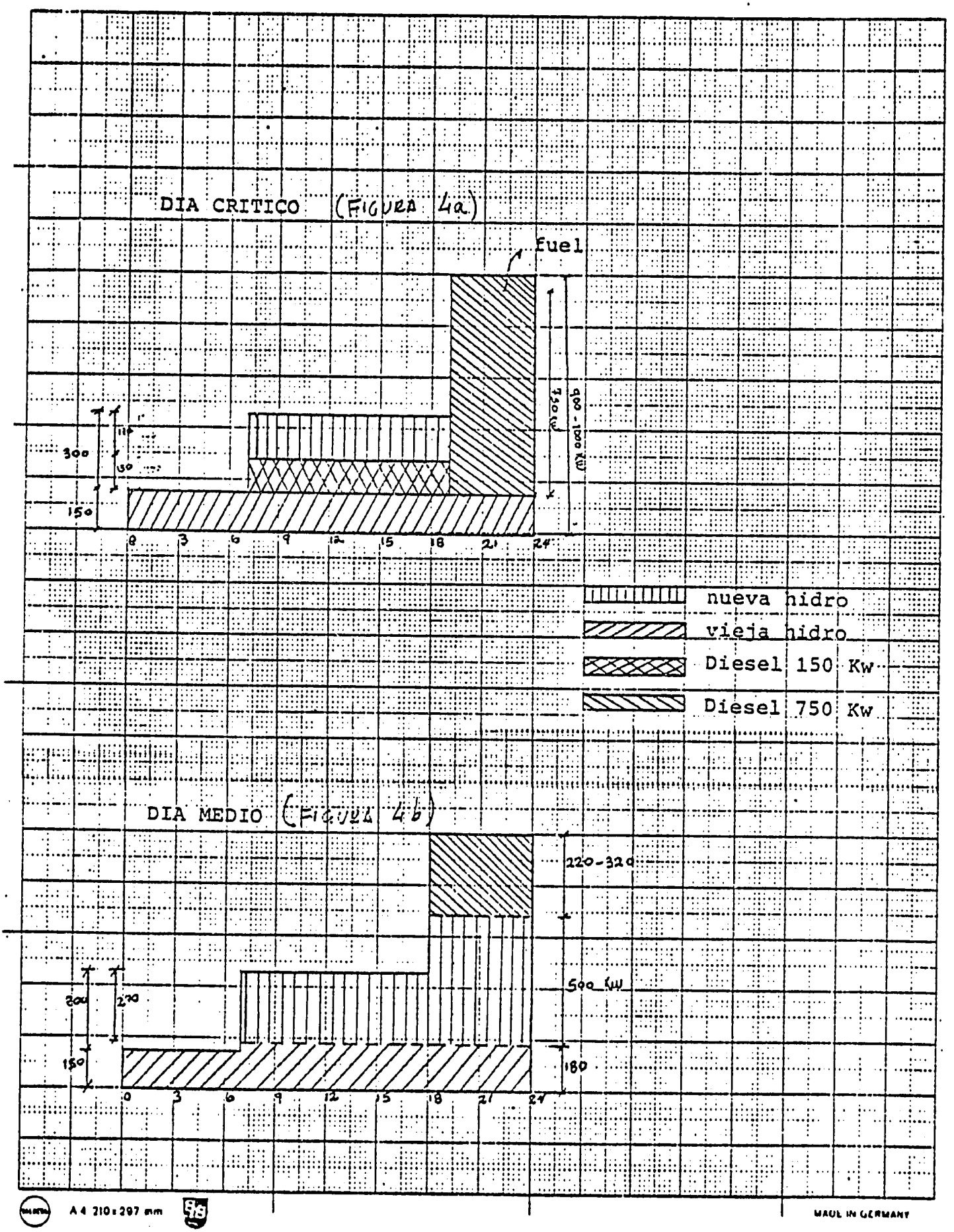
The average annual energy available from the hydro installation during a median year is 2.41 Gwh. This is calculated using the average annual flow of .55 m^3/sec. that occurs during the median water year.

The use of the generation of the project is shown graphically in Figure 2-6. The block diagram depicts the electrical demand and energy usage of Constanza during a critical day and a median day. In both cases the total hydro output will be fully utilized displacing expensive diesel energy.

Estimate of Project Cost

The civil works costs for the project were estimated using unit cost data compiled by CDE and INDRHI. These costs vary significantly from U.S. costs mainly due to the decreased cost of labor. The equipment costs are mainly U.S. costs based on curves compiled by Tudor Engineering Co. for low head sites. Where head or flow parameters fell outside the range

Figure 2-6 Use of Generated Energy on an Average Day and a Critical Day in Constanza



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of these curves previous experience with similar equipment was called upon. The institutions involved in these studies are currently compiling cost data that reflect Dominican prices and labor utilization to be used in a graphical format.

The costs presented below include the following assumptions:

1. The equipment costs are considered valid for delivery to the port in Santo Domingo. A separate item of 4.5% of direct costs is applied by CDE to account for transportation of equipment and materials to the site.

2. The cost of labor in construction and installation is assigned a value that is a weighted average of local labor costs and semi-skilled labor costs.

3. All costs are expressed in terms of 1981 RD$.

The following is a summary of the costs:

ITEM		COSTS (RD$)
1. New Dam and Spillway		54,700
2. Power Canal		125,200
3. Intake		7,000
4. Penstock		39,800
5. Power Plant and Electrical Fquipt.		372,000
6. Transmission line and Protection Equipment		52,000
7. Land clearing and Access		10,000
		660,700
Admin. and General Exp.	10%	66,100
Contingencies	15%	99,100
Equipment Transport	4.5%	29,700
		855,600

Economic and Financial Analysis

The benefits attributed to the installation of a hydroelectric plant are calculated on the basis of the cost that would be avoided by supplying hydro generation. In

TABLF 2-1 GENERAL PROJECT CHARACTERISTICS FOR CONSTANZA

New dam and spillway	Type: concrete overflow Length: 26 Mts. Height: 5 Mts. Upstream slope: vertical Downstream slope: 1:.9 Construction: rock and concrete
Conduction Canal	Section: Trapezoidal Length: 1 Km. Lining: rock & mortar Gradiant: .5% Flow capacity: .98 m^3/s Median velocity: 1.28 m/sec. Intake: slide gate, manual
Penstock	Type: steel Intake: slide gate Capacity: 1.0 m^3/sec Diameter: 22 inches Length: 100 m Thickness: 8 mm.
Turbine	Design head: 63 meters Design flow: 1.0 m^3/sec Type: horizontal Francis Rated output: 675 hp
Generator	Type: synchronous Rated output: 500 KW Voltage: 4160 volts at 60 hz. Speed: 1200 rpm
Transmission	Voltage: 4160 volts Length: 2 Km.

the case of Constanza, this may be calculated as the cost of production per kilowatt/hour of the existing diesel plant. In the median water year the SHPP would produce 2.41 GWH all of which would displace energy presently provided by Diesel Unit #1.

The costs associated with Diesel Unit #1 were supplied by the CDF and are based on historic fuel costs. The costs and calculations of the cost per KWH are presented in Appendix II; thus, for the economic analysis, the proposed hydro unit is compared to the diesel unit generating the same amount of energy at 17¢/KWH.

A summary of the financial and economic analysis appears below. The assumptions made for these calculations are:

1. The discount rate which represents the opportunity cost of capital is 12%
2. The life of a diesel plant is 20 yrs; hydro - 30 yrs.
3. The cost of production of hydroelectric energy is 1.3¢/KWH 1/
4. The fuel cost of production of diesel energy is 17¢/KWH (as per CDF figures for Constanza)
5. The cost of diesel fuel will escalate at 3%/year.
6. The shadow price of foreign exchange is 1.36.

	Financial Analysis	Economic Analysis
Total Benefits	970,998	4,225,442
Total Costs	938,225	1,086,743
Benefit-Cost Ratio	1.04	3.1
Net Present Value	32,773	3,138,699
Internal Rate of Return	14%	48%

The high benefit-cost ratio is due to the excessively high cost of production of energy in Constanza at the present time. As this equipment is not presently scheduled for replacement it was deemed appropriate to use this cost for the hydro comparison.

1/ For the calculation of this cost, see Section 4.2.1 "Social Tariff Calculation"

The economic analysis includes the shadow price of foreign exchange for the equipment to be procured overseas. The annual cost of hydroelectric energy includes discounted capital cost (12% - 30 years) and annual expenses. This has been calculated to be 1.3¢/KWH and results in a savings of about 15¢/KWH in the first year when compared to diesel fuel costs. The results of this calculation (See Appendix II) yields a discounted savings over the life of the plant (30 years) of RD$ 2,951,664.

Technical Review #2 (Río Banilejo)

A potential site for the installation of an SHPP on the Río Banilejo lies about 3 kilometers distant from a possible service village, El Pinar, which in turn is about six kilometers distant from the municipality of San José de Ocoa. The principal economic activity of El Pinar is directly related to agriculture in both the production and marketing aspects. The village consists of about 125 houses with an estimated 600 people. The village has no existing source of electricity. There are several other villages in the area, Los Corosos being one of them, that have similar characteristics and economic activity.

Hydrology

The headwaters of the proposed installation lie approximately 3.4 Km upstream from the confluence of the Río Banilejo and the Río Ocoa. A gaging station, installed and maintained by INDRHI is located on the Rio Ocoa just above the confluence with the Rio Limón. Five years of streamflow data are available. The drainage area associated with the gage is 410 Km^2 while that associated with the intake to the proposed power canal is 200 Km^2. An analysis of rainfall records reveals a relatively even distribution of precipitation throughout the total drainage area of the gage, thus permitting a transposition of gaged flow records to the canal intake through the use of the ratio of drainage areas 200/410. The available data has been computerized by INDRHI and a flow duration curve generated with the use of their software package. (See Figure 2-7).

As per the methodology, the curve is entered at the 15% exceedance level and the maximum turbine flow, Q_{max}, of 1.75 m^3/sec. is obtained. From this design flow Q_d (Q_{max}/1.15) and the minimum flow Q_{min} (Q_d x .30) are calculated. In order to maximize the energy available from the resource, INDRHI performed an optimization analysis plotting design flow versus energy. (See Figure 2-8). The flow which yielded the maximum energy production was found to be 1.5 m^3/sec using the maximum and minimum turbine flow limits suggested.

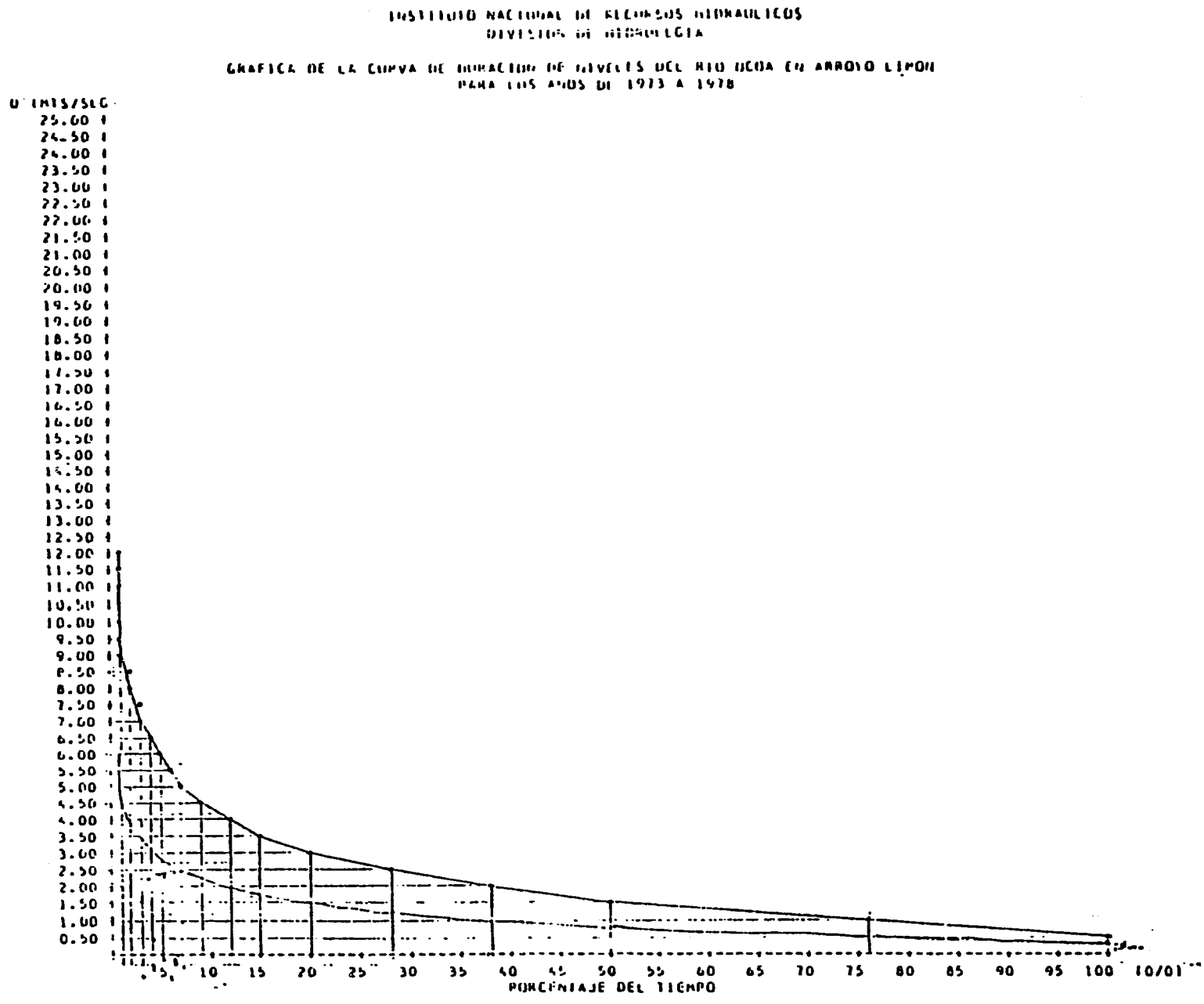
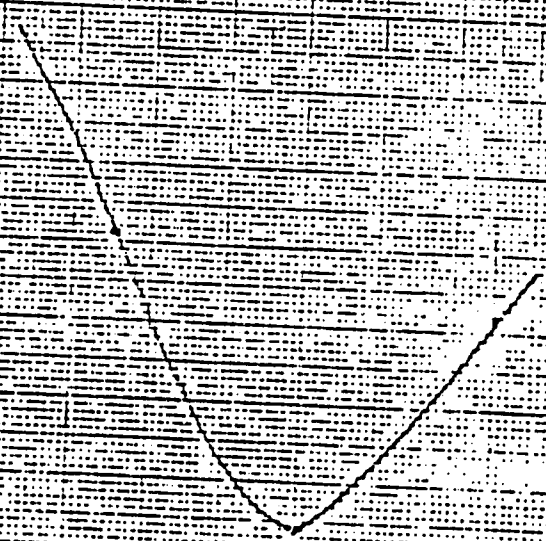


Figure 2.7: Flow Duration Curve for the Banilejo Study.

Figure 2.8 Graph of Design Flow vs. Energy (Banilejo)



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Alternative Project Layouts

Two alternative layout schemes were identified for project development. The topography of the river dictated the location of the power canal intake but the powerhouse location could be varied. Scheme A places the powerhouse at point A (see Figure 2-9) requiring a canal 2.3 km in length. This configuration provided a gross head of 66 m and an installed capacity of approximately 770 KW. Scheme B required a canal length of 5.0 Km., provided a gross head of 95 m, and an installed capacity of 1130 KW. In both cases the estimation of gross head was achieved through use of an altimeter accurated to ± 3 m and the location of the powerhouse identified by on-site investigation.

Each of the alternative schemes was examined for the inclusion of a single turbine and for a multiple turbine arrangement. It was determined that a single unit was the more effective alternative in both cases as the incremental amount of energy gained by the second turbine did not justify its inclusion.

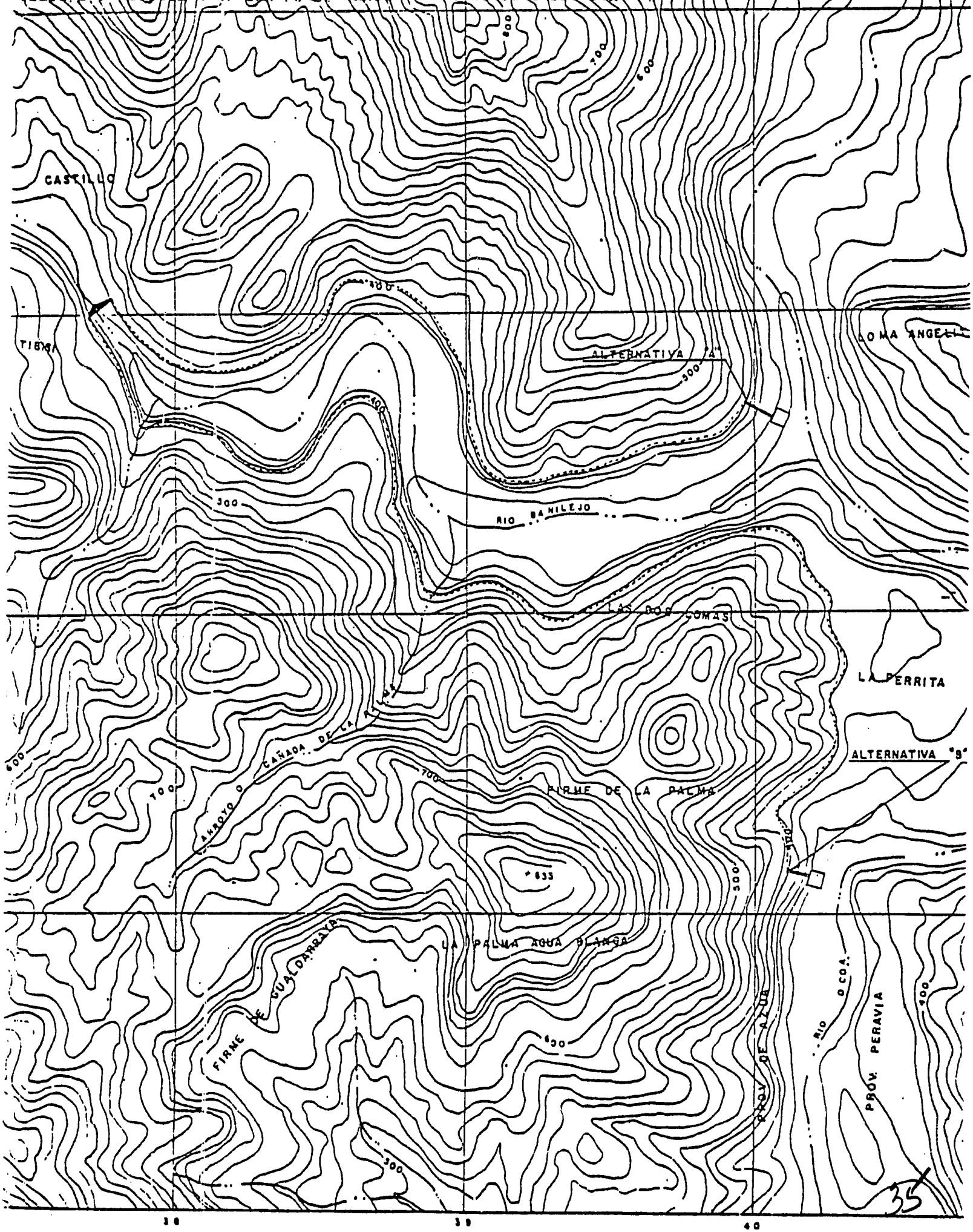
Social, Institutional and Environmental Considerations

El Pinar and its neighboring communities exhibit very modest energy consumption habits. The average family consumes approximately RD$4 per month in fuel, mostly for lighting requirements, while small stores utilize between RD$6 and RD$10 of fuel for illumination and refrigeration.

The watershed area that would directly affect the project was observed to be in moderate condition. According to conversations with town officials the area is maintained on a regular basis by the village although subsequent conversations with local citizens cast serious doubt on that statement. Sediment transport, if excessive, would necessitate a regular program of canal maintenance on the part of the village to prevent loss of power through decreased canal capacity and to prevent turbine damage.

El Pinar has a history of community organization to work on projects for the general good. Voluntary labor has helped construct the road to the nearest municipality, San José de Ocoa, (about six kilometers away) and has installed a public aqueduct for potable water. There are various active community organizations that assist the community in areas of health and education. The desire for rural electrification in this region is great. Community participation in the construction of an SHPP and subsequent administration and maintenance seems to be indicated.

Figure 2-9 Location of the Power Canal and Powerhouse for Banilejo



Capacity and Energy Estimates

The local estimated demand for the community of El Pinar in 1982 is 44 KW. If surrounding communities are included an incremental demand of 30 KW would be realized. The estimated annual energy consumption of the region is 298 MWH which is expected to grow at an annual rate of 3%.

Initial estimates of capacity and potential generation for the SHPP proposed for Río Banilejo are 770 KW and 2.85 GWH annually. In effect, the community or region could only utilize 8% of the project generation as proposed. At this point in the study, the investigating team examined the possibility of connection to the grid as a possible market for excess generation as well as a source of energy during periods of low flow and maintenance down time.

A 12.5 KW distribution line passes within 1 Km. of the proposed powerhouse location and the connecting line routing would be over moderate terrain. It was decided to include this possibility of interconnection as an alternative layout scheme to be used in conjunction with SHPP development.

Evaluation and Selection of Preferred Scheme

The evaluation process was begun with two basic development alternatives; Scheme A, a 770 KW installation and Scheme 8, a 1130 KW installation. As previously discussed, the multiple unit configuration in both cases was discarded as not being cost effective as a result of an incremental energy analysis. At this level of evaluation the factors entering into the selection process were:

- Length of power canal and associated cost
- Difficulty of canal construction (i.e. terrain, soil type)
- Length of penstock
- Length of discharge canal or tailworks
- Economic evaluation of incremental capacity and energy.

The selection process at this stage involves sound engineering judgement and experience in civil construction costs rather than exacting economic comparisons.

During this phase of the evaluation, INDRHI chose to perform rough cost estimates of the various schemes (See Appendix III). The result of this preliminary analysis indicated the shorter conduction canal would be the most

economically feasible (Scheme A). At this point a further refinement was introduced in the type of turbine to be employed. A crossflow turbine was examined for incorporation into the scheme with its associated decrease in efficiency and increase in flow utilization.

The preferred scheme has the following characteristics:

New Dam and Spillway

Type	:	diversion
Length	:	36 meters
Height	:	3 meters
Construction	:	Rock and Concrete

Conduction Canal

Section	:	Trapezoidal
Length	:	2.3 Km
Lining	:	Rock and Mortar
Gradient	:	.001
Flow Capacity	:	1.7 m^3/sec.
Median Velocity	:	1.2 m/sec.
Intake	:	Slide Gate

Penstock

Type	:	Steel
Intake	:	Slide Gate
Capacity	:	1.5 m^3/sec.
Diameter	:	36"
Length	:	100 m
Thickness	:	8 mm

Turbine

Design Head	:	61.75 m
Design Flow	:	1.5 m
Type	:	Cross Flow
Rated Output	:	980 hp

Generator

Type	:	Synchronous
Rated Output	:	726 KW
Voltage	:	4160 volts a 60 Hz
Speed	:	1200 RPM (through spped increaser)

Transmission

Voltage	:	12.5 KV
Length	:	7 Km

Further, the selected scheme incorporated interconnection with the national grid at a voltage of 12.5 KV. This is because the annual median generation far exceeds the comminity's energy requirements. The implications of energy sales to the grid will be discussed further in the following section.

Estimated Project Costs

The following table presents a summary of project costs for the Rio Banilejo study as prepared by the INDRHI study team. A complete breakdown of quantities and per unit prices are presented in Appendix III.

		RDS
1.	New Dam & Spillway	105,000
2.	Power Canal	198,700
3.	Power Intake	24,000
4.	Penstock	56,000
5.	Power Plant and Electrical Equipment	450,800
6.	Transmission line, Transformer and Protection Equipment	102,000
7.	Land Clearing & Access	14,000
		950,500
Admin. & General Expenses	(10%)	95,100
Contingencies	(15%)	142,600
		1,188;200

The INDRHI group has included equipment transportation in their costs of individual items and consequently that category does not appear in their estimate. This inconsistency in the costing methods and others to be discussed in the following section, emphasize the need for standardized costing procedures in a graphical format.

The costs as presented have been made with the following assumptions and conditions.

1. The equipment and material costs reflect the price as delivered to the site.

2. All costs are expressed in terms of 1981 RD$.

3. The cost of labor in construction and installation is assigned a value that is a weighted average of local labor costs and semi-skilled labor cost.

Economic and Financial Analyses

The analyses for the Rio Banilejo project were conducted in the following manner.

a. Analysis of cost effectiveness. This analysis compares the costs of an alternate means of generation (i.e. diesel) to the cost of hydro generation. The costs are discounted over a 20 year period (the assumed life of a diesel) at a rate of 12%. The fuel expense of the diesel unit is calculated on the basis of CDE's average diesel fuel cost for production (7¢/KWH) times the estimated annual generation of the hydro unit. The total present worths are 1,169,360 RD$ and 2,671,355 RD$ for the hydro and diesel, respectively.

b. Calculation of Financial Viability. The financial analysis considers the foreign cost of equipment at the official exchange rate of 1 RD$ = 1 US$. The benefits are calculated as the revenues from the sale of the annual generation at the assumed grid purchase rate of 5¢/KWH.[1/] Costs and benefits are discounted over the assumed life of the hydro plant (30 years) at 12% per year.

1/ Refer to Section 4.1.2 for calculation of this rate.

c, Economic Analysis - The costs of construction are broken down into foreign and local costs. Foreign costs are adjusted by the social rate of exchange of 1.36 RD$/US$. The economic benefits of the hydro are calculated as the product of the generation and the assumed tariff (equal to the hydro cost of production per KWH) plus the resource savings realized by generation by hydro generation when compared to the most likely alternative, i.e. CDE grid supply.

The table below summarizes the measures of project worth in terms of financial and economic analyses:

	Financial	Economic
Total Benefits	1,544,100	4,023,200
Total Costs	1,177,400	1,357,800
Benefit/Cost Ratio	1.31	2.96
Net Percent Worth	366,700	2,665,800
Internal Rate of Return	17.4%	33.5%

The derivation of the above is presented in detail in Appendix III.

2.3 Study Review

The two illustrative studies carried out by members of INDRHI and CDE effectively demonstrate the viability of a program that encourages a coordination of manpower resources. Expertise in one area of study was shared with the other group lacking in that area. The result of this cooperation was the successful completion of two site selection studies. Discussions subsequent to the application of the methodology were held at the request and under the direction of the USAID consulting team. It was deemed appropriate to receive constructive input from the groups participating in the study. Those discussions provided valuable feedback to the methodology, notably in the following areas:

- The need for standard costing procedures to the Dominican Republic's requirements was expressed. As stated in the methodology, costs that reflect the decreased cost of labor must be developed. INDRHI has extensive experience in civil works construction pertaining to the inpoundment and construction of water resources. CDE has available unit costs on installation and construction of electrical facilities.

Table 2.2 Summary of Studies

	Constanza	Río Banilejo
Drainage Area (Km^2)	36	200
Head Data:		
Gross Head	70 mt.	66. mt.
Head Loss	7 mt.	4.2 mt.
Design Head	63.0 mt	61.8 mt.
Turbine:		
Type	Horiz. Francis	Cross Flow
Design Discharge	1.0 m^3/sec	1.5 m^3/sec
Unit Capacity	500 KW	726 KW
Waterways:		
Canal: Length	1.0 Km	2.3 Km
Capacity	0.98 m^3/sec	1.5 m^3/sec.
Penstock Length	100 m	100 m
Diameter	22 in	36 in
Transmission Line:		
Voltage	4,160 KV	12.5 KV
Capacity	1 MW	1 MW
Length	2.0 Km	7.0 Km.
Site Developments		
Dam Type	Concrete Overflow	Diversion
Length	26 m	36 m
Height	5 m	3 m
General		
Condition of watershed	good	Moderate
Availability of Local Labor	Yes	Yes
Multiple Use of Water	None	None

Table 2-3 Cost Summary and Economic Evaluation

	Constanza	Río Banilejo
Installed Capacity	500	726
Total Financial Construction Cost	903,319	1,188,200
Average Annual Generation	2.14 GWH	3.85 GWH
Energy Market	Local	GRID
Energy Alternative	Diesel	GRID
Benefit Cost Ratio (economic)	3.1	1.96
Net Present Worth (economic)	3,138,699	2,665,300
Internal Rate of return (economic)	48%	33.5%

The format of this information is, at present, such that time consuming estimates of quantities must be calculated to apply the unitary cost data. A graphical costing format that breaks project development into general construction tasks, and incorporates civil and equipment costs has been recommended by the USAID consulting team to facilitate costing procedures. The need for such a format was demonstrated during the course of the studies and work has begun in the compilation of data and generation of curves.

- The economic viability of a project depends, of course, on the revenues or benefits derived from energy sales. The methodology suggests several alternatives by which to minimize costs and maximize benefits. The case of the Río Banilejo Project bears further discussion in this area. The projected demand and energy requirements of the local communities amounted to only 10% of the project generation thus making the project economically unattractive. The two possibilities to correct this situation are: 1) increase the energy market or 2) decrease the project generation (thus capital costs).

The latter would inciate underdeveloping a natural resource in the presence of an energy deficit in the country as a whole. Rather, increasing the energy market by connecting to the national grid was deemed more appropriate. Inherent in the adoption of this alternative, is the necessity of establishing an appropriate rate for the purchase of capacity and energy from small generating sources by the utility, CDE. The Río Banilejo Project effectively demonstrated to the participating agencies the lack of a current policy in this area. Preliminary discussions were conducted between CDE, INDRHI and the CNPE to arrive at a justifiable buy-back rate. The USAID consulting team has stressed this point and has suggested that in depth studies be conducted to determine the "avoidable cost" of the utility and that a policy decision be made on a high level. Such a policy will serve the dual purpose of extending the rural electrification program through stimulating small hydro development as well as augmenting the national generating capacity with renewable energy sources.

2.4 Demonstration Effects of the Project

The construction of at least two small hydroelectric pilot projects followed by a year of monitoring will provide valuable practical information for the future expansion of small hydro development. Areas that will be tested will consist of but not be limited to:

a) Institutional cooperation in the accumulation and processing of feasibility data.

b) Institutional cooperation during the design and construction phase.

c) The accuracy of the costing procedures previously discussed.

d) Rural electric demand projections and the productive impacts of rural electrification.

e) The management and maintenance of watershed areas under local administration.

f) The ability and efficiency of local administration of small hydroelectric generating units.

g) The sensitivity to local technical assistance requirements on the part of CDF.

2.5 Construction Schedule

The implementation plan presented in the Project Description incorporates all phases of project timing. The construction schedule begins with the decision to construct following the feasibility study. Detailed design drawing and comprehensive bid documents will be accomplished during the first 2 months following financial approval. Bid evaluation and the awarding of equipment contracts will occur as soon as practicable. Concurrently, preliminary land clearing efforts and access road construction or improvement employing local labor will take place. The project construction itself will include but not be limited to:

1. Civil works.

   - Construction of diversion canal, conduit or coffer dam
   - Dam excavation and construction
   - Canal excavation and lining (where necessary)
   - Canal intake and headworks construction
   - Land clearing and grading for penstock installation
   - Powerhouse and switchboard construction
   - Tailrace excavation and lower canal construction (where necessary).
   - Penstock

2. Transmission and Distribution.

   - Placement of distribution and transmission poles
   - Installation of conductors
   - Installation of distribution system i.e. metering, distribution transformers, protection equipment, etc.
   - Installation of power transformer, associated protection equipment and metering.

3. Procurement.

   - Scheduling and procurement of all equipment (valves, gates, trashrack, etc.) to be installed. A Program Evaluation and Review Technique (PERT) can be used to track the delivery of all construction items.
   - Delivery and transportation to the site of electro-mechanical equipment.

4. Installation.

   - Final installation of turbine, generator speed increaser, governor and related electrical equipment.
   - Testing of all systems
   - Energization

The time frame for the construction tasks enumerated is estimated to be 9 months. PERT techniques, as maintained above, will be used to coordinate and track the critical path.

Supervisory personnel will be required in a form dependent upon the contractual arrangement delineated by the lead Agency.

3.0 Social Analysis

This section defines the social framework for electrification by SHPP. At present, the Dominican Republic is highly dependent on imported fossil fuels for the generation of electricity. The social effect of this situation is that the price of electric energy continues to rise putting electrification out of the reach of many rural communities. Furthermore, the continuing price increases forces an increasing number of urban dwellers to "pirate" electricity thus contributing to the upward price spiral. Rural areas that are not electrified cannot justify nor afford the tariff associated with energy supplied by the national electric grid.

It is often believed that the introduction of electricity in a village brings along ipso facto social and economic prosperity. Some of the social benefits credited to electrification include; longer working and learning hours, increased productivity and employment opportunities, reduced migration to urban areas and more leisure time. An analysis of the rural situation in the Dominican Republic corroborated by field experience refutes these claims. The rising price of electricity has negated the possible benefits to the point where electrification has become a liability when supplied by the national grid at a current tariff of 11.7¢ per Kwh.

The SHPP program proposed in this Project Paper would differ from the preceeding description of rural electrification in the following ways:

a) An energy supply with a large non-escalating component (SHPP with grid connection)

b) A sense of community participation and accountability (management of the SHPP physical plant and tariff structure)

c) An effort to inform the community as to productive uses of electricity.

The social analysis continues by discussing the following issues in greater detail:

i) Community participation in SHPP Development

ii) CDE-community linkage

iii) Lessons from previous experience in community participation

vi) The role of women

3.1 Community Participation in SHPP Development

In order to enhance the possibilities of success of the project, community participation should extend from input at early stages of the project, through the construction of the facilities to the permanent operation, maintenance and administration of the SHPP. Therefore, the methodology incorporates as one of the criteria for site selection, the willingness of the community to participate in the SHPP development. The community adjacent to a site judged technically feasible by the site selection studies must be approached with a request for collaboration. Other nearby communities might also desire to be involved in the process.

Worldwide experience in community participation in sanitation projects demonstrates that, if an interested majority does not develop within a month of proposal to the community, it may be better to shift the project and resources to another community.1/ It is suggested that this criterion might be also a valid consideration for SHPP development. In cases where the wealthier strata of the population is interested in electrification by SHPP, they might be encouraged to stimulate community participation with cash or kind contributions.

The community organization process must include the following steps:

a) Evaluation of the community via surveys:

   i) Identification of formal and informal channels of community leadership and information via site visits.

   ii) Determination of the community energy uses and needs, and evaluation of the impact of supplying part of these requirements by electrification.

b) Assessment of the potential energy sectoral demands of the community:

   i) The calculation of present and projected demand will be a necessary input to the technical design of the SHPP, as well as the financial and economic analysis of the plant.

   ii) The potential for economic growth of the community will be enhanced by the procurement of cheap and reliable energy and viceversa, a community with good growth potential will improve the economic reliability of the SHPP.

c) Community participation in SHPP development

Community participation will be reflected through a Board of Supervisors whose membership will consist of:

1/ Kalbermatten et.al., Appropriate Technology for Water Supply and Sanitation, World Bank, December 1980, p. 100

1. The Mayor (Alcalde) of the Ayuntamiento or other pertinent administrative unit

2. A person who has the respect and confidence of all members of the community (such as a local school teacher, a social worker, a religious person (priest or nun).

3. A representative of the CDE (initially the SHPP Program Manager)

3.2 CDE - Community Linkage

Linkage between CDE and the SHPP Board of Supervisors and the community will be maintained for undertaking the following activities:

1. Technical assistance in SHPP operation and maintenance.

2. Technical assistance in SHPP administration (billing, tariffs, etc.)

3. Promotion of the productive uses of electricity

4. Watershed conservation

5. Monitoring of SHPP operation.

The details on how these activities will be carried out are given in Sections 7.9 and 7.10.

3.3 Lessons from Previous Experiences in Community Participation

Interviews with experienced personnel in community development plus a review of the pertinent literature[1/] lead to the following observations:

a) Programming of community activity in the development of an SHPP Program must take account of the daily work load of the community members, many of whom are living at subsistence levels. Particular care must be paid to participation in SHPP projects where the income levels are skewed, i.e. it will not be credible to a community if those with the most "free" time (and least economic resources) are requested to donate their labor when those who will benefit the most from the introduction of electricity are the richer segments of society large-scale farmers, shopkeepers, etc.) with less free time.

1/ e.g. Pineo, Charles, 1973. "Informe de los Resultados del Programa Nacional de Abastecimiento de Agua en la República Dominicana", p. 13

b) Community outreach in the area of watershed management should draw on the knowlege, experience and sensitivities that campesinos have built up over the generationsin water resources management and soil conservation.

3.4 The Role of Women

The 1970 Census gives a ratio of 1.069 men per women in rural areas which suggests that women migrate more to the cities given their relative facility to find work as domestic help.

Rural women participate fully in agriculture, yet in a traditional manner women are seen mainly in a reproductive role[2/], they spend many hours a day fetching water and firewood, cooking, washing, and raising the children.

Electricity in the household will improve women's working conditions. Acquirement of electric appliances will make women's tasks less burdensome and time consuming. Women could then use the resultant free time to undertake and explore new activities in training, education, child development and income generation.

Through the provision of credit and technical assistance, women will contribute to the community's productive use of electricity.

2/ The 1970 average fertility index was 68 children per woman.

4.0 Financial and Economic Analyses

Introduction

The Dominican Republic has been seriously affected by the increase in oil prices. Cash outlays for imported oil were RD$42.3 millions in 1973 and jumped to RD$199 million in 1978. In contrast, oil imports were 14.1 and 14.8 millions barrels of oil respectively. This has caused a substancial negative impact in the balance of payments.

The Corporación Dominicana de Electricidad (CDE) has an installed capacity of 683 MW, 65% of the total capacity of the country.1/ In 1980, CDE produced 2630 GWH, 92% of which were generated in fossil-fueled plants and 8% in hydropower plants.2/

Even though only 33% of the population have access to electricity (of which 82% is urban and 18% is rural), the system production capabilities frequently fall below the demand. Thus, due to excess in demand for electricity over available supply, CDE is frequently obliged to interrupt service in some sections of the grid to try to keep the load below the available system capacity.2/

The increased cost of energy, as well as the electric system's capacity deficit, have been a concern for almost every aspect of investment in the future development of the country. CDE has responded with an expansion plan, prepared by the French Society for Research and Development of Electrical Equipment,4/ which contemplates augmenting generation by coal-fired and hydroelectric plants. SOFRELEC also recommended a 2% monthly increase in tariff rates for 16 months, wich aims at covering CDE's deficit by 1984. These increases started in December 1980.

In the countryside, for those villages connected to the grid, new national tariff rate increases have discouraged the use of electricity. In the few cases where CDE provides electricity to villages isolated from the grid, electricity is generated with diesel motors. The cost of production of those systems is higher than the present average national tariff of RD$11.7/KWH.

Currently, for rural areas, small hydroelectric power plant (SHPP) electrification is an attractive inexpensive in situ renewable source of energy. It has a built-in check against inflation not only because of its low operation and maintenance costs, but principally because of its zero energy cost. It need not

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1/ CNPE, Energy Strategies-Sept. 1980, p. 28

2/ World Bank Data in Power Sector Memorandum, 1981, p.i

3/ CNPE Energy Strategies - Spet. 1980, p. 32

4/ Societé Francaise d"Etudes et de Realisations d'Equipments Electriques, Plan de Expansión del Sistema Eléctrico de la CDE, Dec. 1980.

depend on fuel transportation which, given present road conditions, are subject to the vagaries of rainfall. In addition, mini-hydro technology has a century long track-record: a fully developed yet simple technology.

In order to calculate the potential financial and economic costs and benefits of the mini-hydro component of the Energy Conservation and Resource Development project, this section draws upon cost data obtained in the analysis of two illustrative site selection studies. These site selection studies illustrate two situations: a) electrification of a community not connected to the grid but with the possibility of connection to the grid energy to compensate for periods of low flow and to sell excess capacity to the grid; b) replacement of a diesel-fired generating unit by an SHPP in an isolated community.

The studies were carried out by two teams of INDRHI and CDE engineers. The teams followed the methodology developed by the AID consulting team. The findings of these studies are summarized in sections 1.5 and 1.6 of the Technical Analysis. The methodology for the financial and economic analyses measures financial cost and benefits at market prices and economic cost and benefits at efficiency prices.

The economic justification for the project is based on: a) the cost effectiveness of SHPP versus diesel, the major alternative source of electricity for isolated rural communities; b) the cost and benefits used to calculate standard measures of project worth for the SHPP.

4.1 Analysis of Cost-Effectiveness

A cost comparison between a small hydro plant and an equivalent 500 KW diesel plant is based on actual cost data obtained for Constanza, La Vega province, for the hydro and estimated cost data for the diesel. This case is appropriate for the cost comparison because the hydro would substitute the existing diesel system at times of base load, i.e. they satisfy the same demand at the same times of the day. However, this analysis does not use the Constanza diesel's real energy cost because it operates very inefficiently and therefore the figures would not be representative.

The assumptions for the analysis are those used in the Site Selection Methodology, except that the energy demand will not be escalated at its projected growth rate because the diesel is part of an existing system (isolated from the grid) with deficit effective capacity.

Summary of Assumptions:

1. All costs will be in constant 1981 prices.

2. Capital cost:

a) include cost of plant, equipment, construction, contingencies and construction supervision.

b) all capital costs will be incurred in the first year of operation.

c) capital cost for the mini-hydro plant will be RD$855,605 and for the diesel plant it will be RD$220 per per KW capacity. The capacity of both plants will be 500 KW.

3. Recurrent cost:

a) includes the cost of operations and maintenance (O&M), (1.28% for hydro and 4.5% for diesel), administration and general expenses (A&G), (0.01% for both) as percentages of capital cost of a new installation.

b) energy cost for hydro will be zero.

c) include energy cost for a diesel alternative, assumed to be 6¢/KWH. This will be escalated for fuel price increases (over and above constant prices) by 3% per year.

The fuel cost of producing 1 KWH was calculated on the basis of average efficiency rates for diesel generators and present oil prices. The following procedure was followed:

barrel of oil	:	42 gallons at RD$32 (at the official exchange rate)
average efficiency	:	13.2 KWH/gal
total production per barrel	:	554.4 KWH
cost per KWH	:	5.77 ¢ or 6 ¢

4. Generation.

The estimated generation for the hydro in the median year, as dictated by the estimated flow regime, is 2.41 GWH/year. In other words, given the capacity of 500 KW, hydrological information indicates that the plant will generate on the average 55% of the time. i.e. 4860 hrs per year. For the diesel, the same generation of 2.41 GWH was used to calculate the energy cost.

5. Time span of the analysis

The time span over which values will be discounted will be the shortest-lived alternative, i.e. 20 yrs. for a diesel plant.

6. Discount Factor.

This discount factor represents the opportunity cost of capital, officially 12%.

Table 4-1 shows the calculations for cost-effectiveness of the SHPP vs. diesel option, based on the procedures outlined in worksheet 4-1 of the Site Selection Methodology.

4.2 Costs and Benefits of Electrification by SHPP

Electrification in rural areas is aimed at fulfilling social and economic objectives. The costs associated with electrification by SHPP are quantified in terms of the cash outlays necessary for the initial investment and the recurring costs. For the economic analysis, foreign and local cost will be evaluated at their efficiency prices using a shadow price of foreign exchange of 1.36 RD$/US$. 5/

For this analysis the benefits attributed to electrification by SHPP can be categorized as follows:

1. Revenues from the sale of electricity which is the product of the Kwh sold and the tariff that represents the true cost of production, i.e., cleared of taxes and subsidies.

2. Cost-savings in comparison to the cost of the most likely alternative energy source, i.e., the system grid. In this analysis, the published CDE's average production cost per Kwh for 1980, 6/ escalated at 15% for annual inflation to obtain the constant 1981 price, will be used.

3. Consumer surplus, i.e., the excess amount a consumer is prepared to pay for a product or service (rather than go without it) over the amount he/she actually pays for it. This benefit accrues in communities not previously connected to the grid. This assumption presupposes that electricity is superior to the alternative source of energy because of: a) the higher quality of illumination; b) capability to power machines, and c) convenience of service. In this analysis these beneftis will not be quantified given the subjective nature of some of the criteria. 7/

4.2.1 Social Tariff Determination

Electrification by SHPP will provide the enticement both to the community and to CDE to arrive at an agreement of close collaboration to the advantage of all parties.

5/ Current unofficial Central Bank's estimate

6/ CDE, Balance General y Estados Suplementarios, Nov. 1980, p 12

	Cost per Kwh	
Operation	9.15	
Maintenance	.42	
Total	9.67	At 15% annual inflation rate for 1981: 11.12¢/Kwh

7/ (See next page)

TABLE 4-1

ANALYSIS OF COST- EFFECTIVENESS

	HYDRO			DIESEL					COMPARISON	
YEAR	CAPITAL COST	OPERATION AND MAINTENANCE	TOTAL	CAPITAL COST	OPERATION AND MAINTENANCE	ENERGY COST	TOTAL	FACTOR	HYDRO	DIESEL
0	855,605		855,605	110,000				1	855,605	110,000
1		11,037	11,037		4,950	144,600	149,550	.893	9,854	133,548
2						148,938	153,888	.797	8,799	122,678
3						153,406	158,356	.712	7,856	112,715
4						158,008	162,958	.636	7,014	103,563
5						162,749	167,699	.567	6,263	95,157
6						167,631	172,581	.507	5,592	87,435
7						172,660	177,610	.452	4,993	80,342
8						177,840	182,790	.404	4,458	73,826
9						183,175	188,125	.361	3,980	67,840
10						188,670	193,620	.322	3,554	62,341
11						194,330	199,280	.287	3,173	57,288
12						200,160	205,110	.257	2,833	52,647
13						206,165	211,115	.229	2,529	48,382
14						212,350	217,300	.205	2,258	44,464
15						218,720	223,670	.183	2,016	40,864
16						225,282	230,232	.163	1,800	37,556
17						232,041	236,991	.146	1,607	34,516
18						239,002	243,952	.130	1,435	31,723
19						246,172	251,122	.116	1,281	29,157
20						253,557	258,507	.104	1,144	26,799
									938,045	1,452,839

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On the one hand, electrification by SHPP will stimulate and draw from active community participation in plant construction, O&M and A&G. This contribution will alleviate CDE's burden in terms of cost and administrative load. On the other hand, CDE will be able to: a) buy excess production from the SHPP at a cost below its average production cost, which in turn augments its production capacity; b) free resources now tied up in subsidizing inefficient isolated systems; c) further its objective of providing electricity to the nation.

The added attractiveness of electrification by SHPP will need to be taken into account in the tariffs to be implemented in collaborating communities. CDE should attempt to resolve tariff policy issues in these specific cases.

CDE's social tariffs for pricing energy produced by renewable resources could draw from the experience of the United States Public Utilities Regulatory Policies Act (PURPA), promulgated by the U.S. Congress in 1978, to stimulate the development of renewable energy resources (e.g., hydro, solar, biomass). The Act requires that Public Utility purchase energy from small producers that employ alternative means of generation.

Purchase rates are established by a State Public Utility Commission. Price guidelines are based on the concepts of "avoidable cost" (e.g., where oil-fired generation is predominant the price would reflect what the utility would have to pay to generate the same energy). The rate also takes into account the availability of dependable capacity.

The analysis in this chapter assumes a financial market rate of 5 ¢/Kwh, the rate presently paid by CDE to Falconbridge, an industrial co-producer of energy.

The tariff for the economic analysis was calculated as the present value of the aggregate financial cost of construction and O&M of the two illustrative sites, divided by the product of the aggregate annual median generation and the expected life of the plant (in years). Table 4-2 illustrates these calculations.

4.3 Financial Analysis

For the financial analysis, all costs foreign and domestic were calculated at 1 RD$ = 1 US$.

Capital cost includes civil works equipment and transmission lines. Salvage value of the plant after 30 years is assumed to be nil.

7/ Marshall's Consumer surplus analysis assumes that utility is a measurable quantity in the same way as profit, or income and output. Further development by Hicks redefined the concept of consumer surplus but using ordinal utility and indifference.

TABLE 4-2:
CALCULATION OF THE (WEIGHTED) AVERAGE COST OF PRODUCTION FOR SHPP GENERATION (¢/KWH)

	COST				GENERATION			
	Capacity (KW)	Capital RD$	Discounted O&M (12%, 30 yrs)	Total RD$	Annual (Gwh)	% of Total	Total 30 yrs. (GWH)	Tariff (¢/KWH)
El Pinar	726	1,067,723	110,114	1,177,837	3,855	60	115.65	1.
Constanza	500	855,605	88,905	944,510	2,410	40	72.30	1.3
		1,923,328	199,019	2,122,347	6,265	100	187.95	

weighted average 1.12

Annual costs include O&M and A&G expenses as a percentage of capital cost (1.28% and 0.01% respectively). Cost figures aggregate the cost obtained for the two illustrative sites at Constanza and El Pinar. In these particular studies, annual costs were calculated in the following manner:

In Constanza, the 0.01% of capital cost for A&G expenses was added due to the spill-over cost of administering a large existing capacity installation. However, in El Pinar, it is assumed that the facilities will be community-run at a lower cost, and therefore, A&G expenses were integrated in the 1.28% of capital cost allocated for O&M expenses. (Table 4-3)

Benefits are calculated as the revenue from the sale of the electricity generated at 5 ¢ per Kwh. Connection charges are not included in this analysis.

The discount rate of 12% utilized is the official opportunity cost of capital in the Dominican Republic.

All costs and benefits have been discounted over the life of the SHPP. The 30 year estimate is a conservative one (Table 4-4). The cash flow of costs does not include transactions that are merely financial such as depreciation, amortization and interest.[8/]

4.4 Economic Analysis

The economic analysis calculates costs and benefits at economic prices.

The social rate for foreign exchange has been provided by current (unofficial) Central Bank estimates of 1.36 RD$/1 US$. It is assumed that all annual costs are local costs. The cost of the program in economic terms is based on the cost breakdown made by CDE and INDRHI during the course of the two site selection studies (see Appendices 2 and 3). In each case, it was assumed that the civil works would be financed through local currency: precise assignations of foreign and local currency were made for the purchase of generating and transmission equipment. Annual costs are calculated as a percentage of the financial capital cost. Economic benefits are calculated as the economic value of the small hydro output (i.e. generation times production cost cleared of taxes and subsidies) plus the resource savings of servicing by hydro rather than the most likely alternative source (i.e. connecting to the grid).

Since the alternative source of electricity is generated by an energy mix which is predominantly fossil-fuel, its cost is escalated by 3% per year to account for its increasing economic value.

8/ A Van der Tak, Herman G., 1966. The Economic Choice Between Hydroelectric and Thermal Power Developments. World Bank Staff Occasional Papers #1.

TABLE 4-3

DERIVATION OF ANNUAL COST

LOCATION	CAPITAL COST RD$	O&M	A&G	ANNUAL COST RD$
El Pinar	1,067,723		1.28%	13,670
Constanza	855,605	1.28%	0.01%	11,037

Total annual cost for the two plants:..RD$ 24,707

TABLE 4-4

FINANCIAL ANALYSIS

YEAR	TOTAL CAPITAL AND ANNUAL COST	ANNUAL BENEFIT (GENERATION x 5¢ per Kwh)	DISC. FACTOR 12%	DISC. COST	DISC. BENEFIT
0	1,923,328		1	1,923,328	
1	24,707	313,250	.893	22,060	279,687
2			.797	19,696	249,721
3			.712	17,586	222,965
4			.636	15,702	199,076
5			.567	14,019	177,746
6			.507	2,517	158,702
7			.452	11,176	141,698
8			.404	9,979	126,516
9			.361	8,910	112,961
10			.322	7,955	100,858
11			.297	7,103	90,052
12			.257	6,342	80,403
13			.229	5,662	71,789
14			.205	5,056	64,097
15			.193	4,514	57,230
16			.163	4,030	51,098
17			.146	3,598	45,623
18			.130	3,213	40,735
19			.116	2,869	36,370
20			.104	2,561	32,474
21			.093	2,287	28,994
22			.083	2,042	25,888
23			.074	1,823	23,114
24			.066	1,628	20,638
25			.059	1,453	18,426
26			.053	1,298	16,452
27			.047	1,159	14,689
28			.042	1,034	13,116
29			.037	924	11,710
30			.033	825	10,456
				2,122,347	2,523,287

B/C = 1.19

NPW = 400,940 IRR: 15 %

All cost and benefits are discounted at 12% over 30 years (Table 4-5).

Resource savings calculations are shown in Table 4-6. Program costs in economic terms are shown in Table 4-7.

Salvage value is assumed to be nil.

4.5 Sensitivity Analysis

Two possible scenarios will be tested on the economic analysis:

1. Increase of the discount rate to 18% (Table 4-8).

   B/C = 1.98

   NPW = 2,322,242

2. Hurricane after 5th year.

If the economic analysis cash flow is interrupted after 5 years of operations, there would be a net discounted benefit of 404,271 RD$. If the hurricane came after only 4 years, there would be a net economic loss of 27,278 RD$.

4.6 Section 611(b) Compliance

Section 101 of the Foreign Assistance and Related Appropriations Act, 1979 requires that AID apply to certain water and related land resource construction projects that it supports the standards and criteria used in determining the feasibility of similar federally funded projects in the United States. Section 611(b) of the FAA, as amended, requires the application, insofar as practicable of the Principles and Standards (1973) of the Water Resources Council.

The Mission will ensure that these requirements are met in substance. The economic cost-benefit analyses to be prepared for all sub-projects which involve construction will show discounted total benefits greater than discounted total costs. The form and result of these analyses will constitute accomplishment of the substantive economic analysis requirements of section 611(b). In addition, the two site selection studies performed as part of the intensive review, demonstrate the capability of both CDE and INDRHI to use the site selection methodology incorporated in this PP. Environmental considerations in project concept and general design have been addressed in the Initial Environmental Examination and will be fully integrated in the detailed planning and implementation of project activities. This will constitute fulfillment of the substance of the environmental concerns portion of Principles and Standards.

The Mission concludes that adherence to the sub-project analysis methodology will ensure that the principles embodied in the applicable legislation will be met for each sub-project.

TABLE 4-5

ECONOMIC ANALYSIS

	COST STREAM			BENEFIT STREAM					
YEAR	CAPITAL	ANNUAL	TOTAL	SALES	RESOURCE SAVING	TOTAL	DISC. FACTOR AT 12%	DISCOUNTED COST	DISCOUNTED BENEFITS
0	2,234,993		2,234,993				1	2,234,993	
1		24,707	24,707	70,168	647,400	717,568	.893	22,060	640,686
2					668,927	739,095	.797	19,696	589,202
3					691,100	761,268	.712	17,586	541,855
4					713,938	784.106	.636	15,702	498,314
5					737,461	807,629	.567	14,019	458,270
6					761,690	831,858	.507	12,517	421,445
7					786,646	856,814	.452	11,176	387,579
8					812,350	882,518	.404	9,979	356,434
9					838,826	908,994	.361	8,910	327,792
10					866,096	936,264	.322	7,955	301,452
11					894,183	964,351	.297	7,103	277,228
12					923,114	993,282	.257	6,342	254,951
13					952,912	1,023,080	.229	5,662	234,464
14					983,605	1,053,773	.205	5,056	215,623
15					1,015,218	1,085,386	.193	4,514	198,296
16					1,047,790	1,117,948	.163	4,030	182,361
17					1,081,318	1,151,486	.146	3,598	167,707
18					1,115,863	1,186,031	.130	3,213	154,231
19					1,151,444	1,221,612	.116	2,869	141,837
20					1,188,092	1,258,260	.104	2,561	130,440

TABLE 4-5

ECONOMIC ANALYSIS (Contd.)

	COST STREAM				BENEFIT STREAM				
YEAR	CAPITAL	ANNUAL	TOTAL	SALES	RESOURCE SAVING	TOTAL	DISC. FACTOR AT 12%	DISCOUNTED COST	DISCOUNTED BENEFITS
21					1,225,840	1,296,008	.093	2,287	119,958
22					1,264,720	1,334,888	.083	2,042	110,318
23					1,304,767	1,374,935	.073	1,823	101,454
24					1,346,015	1,416,183	.066	1,628	93,301
25					1,388,500	1,458,668	.059	1,453	85,804
26					1,432,260	1,502,428	.053	1,298	78,909
27					1,477,333	1,547,501	.047	1,159	72,909
28					1,523,758	1,593,926	.042	1,034	66,737
29					1,571,576	1,641,741	.037	924	61,374
30					1,620,828	1,690,996	.033	825	56,442
					32,033,558	34,138,598		2,434,012	7,270,590

B/C = 2.99

NPV = 4,836,578

IRR = 34%

or 15,143 barrels of oil at $32/barrel (1981 price)

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TABLE 4-6

CALCULATION OF RESOURCE SAVINGS

YEAR	COST OF GENERATION 6.265 GWH a 11.12 ¢/KWH	ESCALATION FACTOR AT 3%	TOTAL COST	COST OF GENERATION a 1.12¢	RESOURCE SAVINGS
0	696,668	1	696,668		
1		1.03	717,568	70,168	647,400
2		1.061	739,095		668,927
3		1.093	761,268		691,100
4		1.126	784,106		713,938
5		1.159	807,629		737,461
6		1.194	831,858		761,690
7		1.220	856,814		786,646
8		1.267	882,518		812,350
9		1.305	908,994		838,826
10		1.344	936,264		866,096
11		1.384	964,351		894,183
12		1.426	993,282		923,114
13		1.469	1,023,080		952,912
14		1.513	1,053,773		983,605
15		1.558	1,085,386		1,015,218
16		1.605	1,117,948		1,047,780
17		1.652	1,151,486		1,081,318
18		1.702	1,186,031		1,115,863
19		1.754	1,221,612		1,151,444
20		1.806	1,258,260		1,188,092
21		1.860	1,296,008		1,225,840
22		1.916	1,334,888		1,264,720
23		1.976	1,374,935		1,304,767
24		2.033	1,416,183		1,346,015
25		2.094	1,458,668		1,388,500
26		2.157	1,502,428		1,432,260
27		2.221	1,547,501		1,477,333
28		2.288	1,593,926		1,523,758
29		2.357	1,641,741		1,571,576
30		2.427	1,690,996		1,620,828
			34,138,598		32,033,558

TABLE 4-7

PROGRAM COSTS IN ECONOMIC TERMS*

	CONSTANZA **			BANILEJO ***		
	FOREIGN CURRENCY	LOCAL CURRENCY	TOTAL	FOREIGN CURRENCY	LOCAL CURRENCY	TOTAL
Civil Engineering		301,723	301,723		416,093	416,093
Equipment	455,468	31,000	650,517	457,422	59,353	516,775
Transmission	29,008	12,432	51,883	37,728	14,750	51,828
Total	482,476	345,235	1,004,123	494,550	490,146	984,696
Contingencies						246,174
						1,230,870

* Data extracted from the Site Selection Studies at Constanza and Banilejo respectively.

** Foreign Currency (US$) must be multiplied by 1.36 the sahdow price of foreign exchange for the analysis of the Conatanza SHPP. Contingencies were taken into account in every step of the analysis at Banilejo.

*** In the case of the SHPP the foreign currency has already been taken into account. Note that contingencies were allowed for at the end of the analysis.

TABLE 4-8 SENSITIVITY ANALYSIS 1

(ECONOMIC COSTS

Yr	TOTAL COST	TOTAL BENEFITS	DISCOUNT FACTOR AT 18%	DISCOUNTED COST	DISCOUNTED BENEFITS
0	2 234 993			2 234 993	
1	24 707	717,568	.847	20 927	607 789
2		739,095	.718	17 740	530 670
3		761 268	.609	15 046	463 612
4		784 406	.516	12 749	404 754
5		807 629	.437	10 797	352 933
6		831 858	.370	9 142	307 787
7		856 814	.314	7 758	269 040
8		882 518	.266	6 572	234 750
9		908 994	.225	5 559	204 523
10		936 264	.191	4 719	178 826
11		964 351	.162	4 003	156 225
12		993 282	.137	3 385	136 080
13		1 023 080	.116	2 860	118 677
14		1 053 773	.099	2 446	164 324
15		1 085 386	.034	2 075	91 172
16		1 117 948	.071	1 754	79 374
17		1 151 486	.060	1 482	69 089
18		1 186 031	.051	1 260	60 488
19		1 221 612	.043	1 062	52 529
20		1 258 260	.037	914	46 556
21		1 296 008	.031	766	40 176
22		1 334 888	.026	642	34 707
23		1 374 935	.022	544	30 249
24		1 416 183	.019	469	26 907
25		1 458 668	.016	395	23 339
26		1 502 428	.014	346	21 034
27		1 547 501	.011	272	17 023
28		1 593 926	.010	242	15 939
29		1 641 744	.008	198	13 134
30		1 690 996	.007	173	11 837
	1 961 203	34 138 598		2 371 301	4 703 543

B/C = 1.98

NPW = 2,332,242

5.0 Environmental Analysis

The interaction between SHPP's and the environment is a two-way process

a) On the one hand, SHPP's (in both construction and operation modes) may affect the flow regime of the water source (river, canal) that drives the turbines and thereby have a limited impact on aquatic ecosystems and on the transmission of waterborne diseases.

b) On the other hand, the environment may affect the efficacy of SHPP operation especially if poor soil conservation and water resources management practices are in place upstream from the SHPP water diversion point.

The Peru Small Hydro Development Project Paper (1981) analyzes these issues in detail. A major conclusion of the analysis is that the interrelationship between watershed projection and SHPP is a vital one and that effective SHPP management must encompass reliable soil conservation and water resources management practices in the SHPP watershed.

The watershed conservation issue is of even more concern in the Dominican Republic where soil erosion has reached alarming proportions. For example, erosion of the Ocoa watershed (in which the Banilejo project site is located) has been calculated at 507 MT/Ha/Yr which is more than 50 times the rate of actual soil buildup due to biophysical processes. (USAID Project Paper, Santo Domingo 1981). The major hydroelectrical reservoir in the country (Tavera), which was completed in 1973, already has 18 m of sediments behind the dam causing 40% reduction in dead storage capacity and 10-14 m loss of active storage (Environmental Profile of the Dominican Republic, 1981).

5.1 Introducing Environmental Concepts into the Project Design

The project has been designed to integrate fully environmental concepts (and especially watershed management precepts) in every pertinent stage of the project development. In the project planning phase, environmental considerations will play a very important role in SHPP site selection and in the conduct of feasibility studies. In the project execution phase, all civil works will be executed to minimize i) impacts on the aquatic ecosystem and ii) soil erosion. A very important component of the project will be the training of the community served by the SHPP in the measures needed for protecting their watershed.

Institutionally, the project has been designed to upgrade the capabilities of CNPE, CDE and INDRHI in incorporating environmental concerns in SHPP project planning, construction and management. Environmental scientists will be hired as part of the site selection and feasibility study teams. Another environmental benefit of the project will be the organization and advancement of INDRHI's hydrometeorological collection services, which are in need of upgrading.

Technical assistance will be provided under the aegis of AID to upgrade the capabilities of the three institutions in environmental management. As a result it is expected that institutional linkages between CNPE, INDRHI and CDE and those institutions with a mandate for natural resources management at the national level (such as the Natural Resources Subsecretariat (SURENA), the General Forestry Directorate (FORESTA), the Environmental and Natural Resources Department (Medio-Ambiente) of the Technical Secretariat of the Presidency (STP), and at the international level (such as the Inter-American Institute of Agricultural Cooperation (IICA) will be strengthened.

Where pertinent, close linkages will be established between the Small Hydro Project and the National Resources Management Project, that is also projected for funding through USAID/Santo Domingo, especially in the areas of cartographic studies and watershed management.

Spinoff effects will occur producing more general environmental sensitivities throughout the three organizations (CNPE, INDRHI and CDE) perhaps even to the Directorate of Hydroelectric Development of CDE and the Project's Departments of INDRHI where currently environmental considerations are not being adequately incorporated into the planning and development of large water resources (including hydroelectric) projects.

Finally each SHPP Board of Directors, its staff and the population it serves will receive training in watershed management and other environmental concerns that will build on the availability of local knowledge and expertise in these areas.

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6.0 Institutional Analysis

Introduction

Three institutions are involved in different phases of the planning, development, installation and management of small hydroelectric power plants (SHPP's) in the Dominican Republic, namely, the National Energy Policy Commission (CNPE), the National Hydraulics Development Institute (INDHRI) and the Dominican Electricity Corporation (CDE). The institutional analysis will first discuss the role of each of the above institutions in the development of SHPP's taking into account their legal mandate, their technical capabilities and their experience as reflected in past, ongoing and planned projects. (Section 6.1).

The SHPP program component of the Energy Conservation and Resource Development Project will be designed to maximize the utilization of available institutional expertise in the minhydro area in the Dominican Republic. (Section 6.2). The primary emphasis of the program is on strengthening the capabilities of each institution, in those areas where its legal mandate and demonstrated experience so merit, through the provision of appropriate technical assistance. Funding will also be provided for a limited number of SHPP's with the primary objectives of developing a base for demand forecasting, providing experience in project design and management, as well as developing the capabilities of the local community served by the SHPP in construction, operation, maintenance and management (where appropriate).

6.1 Diagnosis of the Present Institutional Situation

6.1.1 The National Energy Planning Commission (CNPE)

6.1.1.1 Legal Mandate

The CNPE was established by Presidential Decree No. 584 of January 22,1979 as an advisory body to the President in charge of preparing short, medium and long-term policies for electricity generation, national use of energy resources and development of energy technologies compatible with the country's development objectives.

The CNPE has rightly considered that its mandate includes the preparation of short, medium and long-term plans and policies for hydroelectric generation, and to this end has set up a Hydroelectric Unit within the Research and Development Department.

6.1.1.2 Technical Capabilities

The Hydroelectric Unit, as of now, consists of three professionals: i) a civil engineer, ii) an electro-mechanical engineer and iii) a water resources engineer. In the near future, it is intended to extend the staff to five professionals by hiring another civil engineer and a sociologist.

6.1.1.3 Experience in Small Hydro Projects

Past Experience

The major accomplishment of the Hydroelectric Unit, to date, has been the publication of the report entitled "Inventario Nacional de Recursos Hidroeléctricos, Fase 1: Proyectos Hidroeléctricos Conocidos". This was the first effort in the Dominican Republic to compile in one report a construction and operation list of all known hydroelectric projects that are in different stages of development, ranging from identification of possible sites (through inspection of 1:50,000 maps) through reconnaissance studies, evaluation, design, construction and operation.

Ongoing Projects

Currently, the Hydroelectric Unit is undertaking the following projects that include a small hydroelectric powerplant component:

- In collaboration with the Universidad Madre y Maestra in Santiago, the Hydroelectric Unit is providing technical assistance on the fabrication, installation and operation of a Michel-Bank Turbine plus its associated governor of 15-30 KW capacity at Janey in the Province of Santiago.

- Phase II of the National Inventory of Hydroelectric Resources. The objective of this phase of the project is to develop an optimal plan on a watershed-by-watershed basis for the integral development of the nation's water resources. The project will include as distinct stages: i) reconnaissance studies, ii) preliminary designs, iii) prefeasibility studies, and iv) feasibility studies.

- Agreement with the Southwestern Development Institute (INDESUR). CNPE and INDESUR will jointly conduct a reconnaissance study of the possibilities for SHPP installation in the southwestern region of the country. More detailed studies will then be carried out to prioritize the sites, and a feasibility study will be conducted for a promising site of less than 100 KW capacity. The main criterion for site prioritization will be the potential economic impact of SHPP installation at each site. The final step of the agreement is the installation of the microhydro plant with possible INDESUR financing and the techniadvice of CNPE.

- National Plan for the Development of Small Hydroelectric Power Plants.

The CNPE is developing a plan for the development of suitable sites for the installation of small hydroelectric plants. Even though the title of the project envisages an effort national in scope, the terms of reference indicate that the study will be confined to an area of special importance for the National Development Plan. It is envisaged that a methodology similar in scope to the site selection methodology that was developed by the NRECA team will be employed, with the expectation that five sites will be evaluated at the appraisal or pre-feasibility stage. The next stage of the project will be the submission of the pre-feasibility studies to the Preinvestment fund of the Technical Secretariat of the Presidency with the view to obtain a grant for carrying out the corresponding feasibility studies. It is anticipated that this project would cost approximately RD$30,000 and take one year to complete.

- The Canadian International Development Agency (CIDA) Program.

In collaboration with a local engineering consulting company (SERCITEC, C. por A.), the CNPE is providing Dominican counterpart technical assistance for the following programs:

i) The design, construction and installation of a 70 KW capacity SHPP, at El Puerto on the Casui River, in the province of El Seybo. This is a RD$200,000 program, with 75% CIDA and 25% Dominican Government financing.

ii) Conduct detailed feasibility studies at 2 sites: a) Salto Cocuyo on the El Seybo River, in the province of El Seybo (2500 KW), b) Other Banda on the Río Limón, in the province of Samaná. This is an RD$100,000 program.

6.1.2 The National Hydraulics Development Institute (INDHRI)

6.1.2.1 Legal Mandate

INDHRI was created as an autonomous institution, by law No.6 of September 1965 with broad responsibilities as the supreme authority for the integral development of the nation's water resources, in accordance with national development plans. In the energy area, INDHRI's responsibilities include the development of the nation's hydroelectric resources through the distinct stages of planning, design and construction, either on its own or in conjunction with other competent institutions in the public and private sectors. (Preamble, Articles 4 and 5). As of today,

INDHRI still sees its role as ensuring that the maximum economic benefits result from every water development project, even in those cases where it does not take the lead agency role (Herrera Pellerano, 1981).

Some of INDHRI's mandate in the energy sector has been weakened because of the overlapping mandate of CDE, and because of the lack of funding and political support (USAID, Santo Domingo 1981). For example, according to law No. 264 of March 1968, the responsibility of INDHRI in the case of the major multi-purpose water resources project that has been developed, to date, (The Tavera/Bao complex) was limited to the construction, rehabilitation, operation and administration of the irrigation works in the lower Yaque del Norte Valley —while CDE was assigned the responsibility of constructing the Tavera/Bao complex.

6.1.2.2 Technical Capabilities

At the present time, the Projects Department of INDRHI (through the Dams and Hydroelectric Project Sections of the Design Division) is responsible for the development of hydroelectric projects within INDRHI. The staffing of these sections in July 1981 was as follows:

SPECIALTY	NUMBER OF PROFESSIONALS
Civil Engineering	6
Civil Engineering-Hydraulics	1
Electro-Mechanical	1
Electrical	1

When considered necessary, the Design Division can call upon professional support in other entities of INDRHI such as the Hydrology Division and the Geology Section.

In the development of the nation's (large-scale) hydroelectric resources, INDRHI's contribution has been the following:

- Of the 165 MW of hydroelectric generating capacity currently in operation, all but one of the facilities were developed by or under the supervision of INDRHI. The remaining facility (Tavera) was designed under the aegis of INDRHI and put in place by CDE.

- Of the hydroelectric facilities currently under construction (of 15 MW capacity) all were designed under the aegis of INDRHI.

- As far as projects in the evaluation and design stages are concerned, INDRHI has under review projects whose total capacity comes to 572 MW, i.e. 49% of the present system's capacity (INDRHI, July 1981).

6.1.2.3 Experience in Small Hydro Projects

Projects Under Construction

Currently, INDHRI has brought 1 SHPP to the construction stage - a 680 KW project at Los Ranchitos in the Ocoa Valley, in the province of Peravia. The project will utilize water that is being transferred by an irrigation canal. The canal is largely built and major work has been completed on the pressure case and the powerhouse. The turbine and generator have been purchased. However, the project has been on hold since the hurricanes of 1979 caused severe destruction throughout the Ocoa Valley, including major damage to the canal intake structure and to a small part of the canal itself. Further work on the project awaits a definitive decision by the Interamerican Development Bank on the funding of rehabilitation work on the canal.

Projects Ready for Construction

INDRHI has prepared detailed designs for 7 hydroelectric projects to be located in the southwestern region of the country in the provinces of Independencia, Bahoruco, Barahona and Azua. These projects, that range in capacity from 300 to 4100 KW for a total capacity of 12.5 MW, are planned for direct connection to the national grid. INDRHI has received a financing commitment from the Kreditanstalt fur Wiederafbau (KfW) - the development bank financed by the Government of the Federal Republic of Germany - to construct two of the SHPP's and is looking for financing from the same source for the remaining 5 projects.

Future Projects

As a result of a (fothcoming) technical agreement between the Government of the Republic of China (GOROC) and the Dominican Republic (GODR), the company Sinotech Engineering Consultants Inc., in conjunction with the INDRHI, will conduct site selection and feasibility studies for small hydroelectric projects in the following areas:

a) The eastern zone of the country limited to the west by the rivers Casuí and Chavón.

b) The upper basin of the Yaque del Sur River, upstream from the Sabaneta and Sabana Yegua Dams.

c) The middle part of the Yaque del Sur River that extends from the Sabaneta and Sabana Yegua Dams to the Llanura de Barahona.

d) The upper reaches of the Caña River, upstream

d) The upper reaches of the Caña River, upstream from the Los Mesas Dam.

The agreement envisages a level of effort of approximately 5 person-years on the part of Sinotech to be dedicated not only to the INDRHI projects, but also to a series of projects that have been identified by CDE (see below).

A corresponding level of effort is to be supplied by INDRHI and CDE.

6.1.3 The Dominican Electricity Corporation

6.1.3.1 Legal Mandate

The CDE, a public owned corporation that monopolizes the public electric sector, was established by law No. 4115 of April 21, 1955 as an autonomous institution to take over facilities purchased from the formerly U.S. investor owned "Compañía Eléctrica de Santo Domingo, Compañía por Acciones". CDE has the responsibility for the production, transmission and distribution of electrical energy. It establishes its own operating and development program and approves changes in its tariff with the President's agreement.

6.1.3.2 Technical Capabilities

Currently, the Directorate of Hydroelectric Development (DHR) of CDE has the responsibility for bringing hydroelectrical projects through all stages from concept to construction. Once a hydroelectric project comes on line, it is turned over to the Hydroelectric Plants Department of the Directorate of Production (DP), for operation and maintenance.

Altogether the DHR has 40 professionals that include civil engineers (specializing in hydrology, hydraulics, roads, structures, costs, project management and supervision) electromechanical engineers, geologists, and architects.

In the past and proximate future development of the nation's large-scale hydroelectric resources, CDE's contribution includes the following projects financed by international sources (such as the IBD and IBRD)

- Bringing to fruition the $46 millions Tavera Multipurpose Project for hydroelectric power generation (80 MW capacity), irrigation, flood control and water supply in the zone of the influence of the Yaque del Norte and Bao Rivers. (IDB Loan #173/SFDR).

- Managing the $49.0 million Bao Dam and related work multipurpose project that is interconnected with the above-mentioned Tavera Project. The average annual generating capacity of the Tavera-Bao complex will be increased from 100 to 286 GWH. The Bao Dam is scheduled for completion in 1981 (IDB Loan #408/SF).

- The Lopez-Angostura Project - a third project (of $64 million size) in the Tavera-Bao complex will have the capability of increasing the effective load factor of the Tavera generating station, especially in dry years and incorporate the Angostura power plant of 18 MW capacity that will have an average estimated annual production of electricity of 124 GWH. This project will be partially funded by the IDB and due to come into full operation in 1984.

- The CDE is in the final stages of negotiating a loan with the IBRD as part of a 91.5 million project that will include as an important component the construction of a hydroelectric plant on the Río Blanco of 25 MW capacity and an estimated 108 GWH annual production. This project is expected to come into full operation in 1985.

Essentially these projects have been brought to fruition by the Directorate of Hydroelectric Resources (DHR) or its predecessor organization.

6.1.3.3 Experience in Small Hydro Projects

Operating Projects

CDE has the responsibility for operating the only efficiently functioning SHPP in the Dominican Republic at the present time - a 270 KW capacity unit that is located in the town of Constanza in the province of La Vega. The unit was installed in 1949 and was managed up to 1980 by the Ayuntamiento de Constanza, when this responsibility was turned over to the CDE. The system has been so designed that even when there are high sediment loads in the stream at the site of the diversion barrage, the water sediment loads are relatively low by the time it reaches the turbine intake.

Projects Under Study

In 1980, the Spanish Engineering Consulting Company, INTECSA, conducted a three-week reconaissance study on the hydroelectric generating capacity of 14 sites in the upper reaches of the Yaque del Norte and Bao River Basins. The site generating capacity ranged from 500 KW to 5 MW with ten sites demonstrating a capacity of less than 1 MW.

Preliminary site identification was based on information available in 1:50,000 topographic maps of the area including estimation of available head. Design flows at each site were based on regional correlations of hydrological information from a limited number of runoff and rainfall gauges. Rough sketches were used to layout each system indicating critical points, such as the diversion barrage, the pressure intake and the powerhouse.

Cost data for each site was calculated using gross formulae, which were not customized to conditions in the Dominican Republic. Unitary capacity costs ranged from RD$2005/KW to RD$6,420/KW - a very high range. No explicit effort was made to evaluate any of the projects in terms of the community that would benefit from it or to address the possibility of the local community taking full responsibility for its operation, maintenance and management.

Future Projects

As part of the (forthcoming) agreement between the Governments of the Republic of China (GOROC) and the Dominican Republic (GODR) the company Sinotech Engineering Consultants Inc., in conjunction with a CDE team, will conduct pre-feasibility studies for the 14 SHPP sites identified in the INTECSA report (see also Section 5.1.2.3.). Engineering and cost data will be determined to a similar degree of precision as outlined in the site selection methodology developed by the NRECA team of consultants. It is expected that some of the sites will be adjudged attractive enough to obtain financing for feasibility studies in their (later) construction and operation.

It is interesting to note that additional site-specific data will be available for conducting the site-selection studies. They include: i) records from 6 rainfall gauges and 5 streamflow gauges in the Bao River Basin, ii) aerial photographs of the region to the scale of 1:20,000, iii) field geotechnical and geophysical data.

6.1.4 Summary

At this stage, it is appropriate to summarize the foregoing discussion, especially in the context of defining the roles that each institution will play in the SHPP program component of the Energy Conservation and Resource Development Project. Mention will be made of the efforts that the different institutions have made in the areas of project planning, construction and operation. It bears noting that the three institutions coordinated their efforts in providing input to the SHPP Site Selection Methodology and in conducting two illustrative site selection studies.

CNPE sees its role as the instigator and coordinator of a coherent strategy for developing the nation's small hydro resources. The CNPE had a very valuable part to play in the development of the site selection methodology that is an important component of this project paper. First, CNPE acted a a logistics coordinator for the AID-CDE-CNPE-INDRHI working group not only by providing a common working space but also in coordinating the field visits that were a necessary component for carrying out the two illustrative site selection studies. Second, CNPE personnel provided invaluable technical input and country specific data to the site selection methodology.

INDRHI, by law, has the responsibility to be the supreme arbiter in the integral development of the nation's water resources. It is the only Dominican Republic institution with proven experience in the design and execution of multipurpose (including electricity generation) water resources development projects. INDRHI also is at the point of signing an agreement with the KfW for the financing of two of its small hydroelectric projects.

CDE, by law, has the responsibility for the production, transmission and distribution of electrical energy. It is the only institution that has experience in the management, operation and maintenance of hydroelectric facilities (including SHPP's). CDE also maintains a training program for unskilled technical personnel in areas such as generating plants, electricity sales, transmission and distribution systems and maintenance. Finally, CDE has a credible record in rural electrification, having managed a 5 year RD$14.5 million program (entitled Programa de Electrificación Rural (PER) I, that included approximately 50% Interamerican Bank financing) that surpassed the original physical targets (such as the kilometers of transmission and distribution lines installed, the number of towns that benefited from the program).

Coordination between CDE and INDRHI

As has been previously indicated CDE and INDRHI have overlapping mandates in developing the nation's hydroelectric resources, which has led at times to interinstitutional turf fights and to the lack of needed coordination between professionals in the hydroelectric resources development. These conflicts have frequently been exacerbated by differences in the styles of operation of the two institutions.

The problematique of the lack of needed cooperation between the two institutions, especially in the area of hydroelectric resources development, has been recognized by the Executive Directors of both institutions on their signing an agreement on August 19, 1980 to appoint a Joint Working Commission with the mandate: i) to prepare a plan for the operation and maintenance program for all hydroelectric complexes, ii) to coordinate closely in the programming and study preparation on multi-purpose projects and iii) to plan the coordination of small dam projects.

Up to July 1981, the CDE/INDRHI Joint Working Commission has concentrated on developing sound operating rules for operating the two multipurpose reservoirs of Tavera (nominal capacity - 80 MW) and Valdesia (nominal capacity - 54 MW).

6.2 The SHPP Institutional Framework

The execution of the SHPP program will be in two phases. The first phase will consist of carrying out the site selection and feasibility studies. The second phase will consist of construction and operation of the two SHPP's.

The discussion that follows delineates a framework for the optimal execution of the SHPP program.

6.2.1 The Site Selection/Feasibility Studies

The institutional framework that has already been put in place and demonstrated during the period of intensive review will be used during Phase 1 of the Small Hydro Program, i.e. the site selection/feasibility studies will be carried under the direction of a designated member of the Hydroelectrical Unit of the National Energy Planning Commission (CNPE) using as a team selected professionals from the Dominican Electricity Corporation (CDE) and the National Hydraulics Development Institute (INDRHI).

The Study Manager will be answerable to an SHPP Advisory Committee which will consist of high level representatives at the directorate director level of CNPE (who will act as Committee Chairman), INDRHI and CDE plus the AID Project Manager. The Study Manager will be the Secretary of the SHPP Advisory Committee and will prepare a monthly report for the Committee on the progress of the SHPP program. This report will subsequently be forwarded to the Office of the Executive Secretary and will be discussed at the Commission level, when deemed appropriate. Figure 7-2 shows the management set-up for carrying out Phase I of the Project.

This arrangement ensures a maximization of institutional inputs in getting a small hydro program under way. A special advantage will be the combination of INDRHI's expertise in the design, construction and maintenance of civil works (including power canals) with CDE's preponderant expertise in the design, installation, and operation of the electro-mechanical equipment for hydroelectric systems. It is further proposed that the SHPP site selection/feasibility studies team be located physically in one place (for example, CNPE headquarters) so that cross-fertilization of ideas can take place on a continuing basis.

Furthermore, the designation of a CNPE employee as the SHPP study manager, combined with the functioning of the SHPP Advisory Committee will ensure an optimal distribution of the work load according to the special expertise of each institution (e.g. CDE would have major responsibility for generating the electro-mechanical equipment costs) and the coordination and avoidance of duplication of (potentially overlapping) efforts, such as site visits for example.

It bears noting that INDRHI will take the lead role in all matters relating to civil engineering works and design at this phase of the project including specifications in the bid documents. Matters relating to the electro-mechanical components of the project would be undertaken with CDE in the lead role.

6.2.2 SHPP Construction and Operation

The SHPP Construction and Operation phase of the Small Hydro Program will be managed by CDE. The SHPP Program Manager will be an employee of the Directorate of Hydroelectric Development of CDE. Through the Directorate of Hydroelectric Development, the SHPP Program Manager will have direct access to the Administrator of CDE and thus be able to guarantee the collaboration of other Directorates and Departments of CDE (such as the Production and Planning Directorate and the Personnel Department). When pertinent the SHPP Program Manager will also be the point of contact between the CDE and the communities that will be served by the SHPP's. Each community will organize a Board of Supervisors to manage the SHPP system. Its membership will be:

i) The Mayor (Alcalde) of the Ayuntamiento or other pertinent administrative element.

ii) A person who has the respect and confidence of all members of the community (such as a local school-teacher, a social worker, a religious (priest or nun).

iii) A representative of the CDE (initially the SHPP Program Manager)

The SHPP Program Manager's responsibilities will include:

(a) Supervision of the Civil Engineering Works subcontracted to INDRHI

(b) Procurement and installation of the electro-mechanical equipment.

(c) Putting in place of the transmission and distribution lines.

(d) Organizing a training program for pertinent staff of employees in O&M and A&G of the SHPP system.

(e) Monitoring of the operation of the SHPP system for 1 year.

However, INDRHI will have a continuing role in the SHPP program first through its membership of the SHPP Advisory Committee and second through being the sub-contractor responsible for the construction and maintenance of the civil works. The canal maintenance arrangement is already in place in Constanza. The management setup is shown in Figure 7.3..

In this phase, the SHPP program manager will be the Secretary of the SHPP Advisory Committee. In all other respects the membership of the SHPP Advisory Committee will not change. The same reporting arrangements that were in place for Phase I of the program will also hold for Phase II.

Concluding Remarks

It is emphasized that the proposed institutional arrangement has been proposed in the light of developing the institutional capacity to exploit small scale hydro in an optimal manner and to involve local communities in the development and management of SHPP's. Phase I of the program has been designed to maximize existing institutional expertise in civil engineering works (INDRHI) and electro-mechanical works (CDE), in the conduct of site selection feasibility studies and in the preparation of the bid documents under the chairmanship and guidance of CNPE in its rightful role of inter-institutional coordinator in the energy policy/planning field.

It is proposed that Phase II of the program be managed by CDE for the following reasons:

i) Of the six major activities that make up this stage of the program (civil works construction, putting in place of transmission and distribution lines, procurement and installation of electromechanical equipment, SHPP operation) five are the special competence of CDE. Thus the SHPP program manager must be able to count on having the full support and cooperation of CDE top management.

ii) The success of the program will eventually depend on a successful working relationship between CDE and the SHPP Board of Supervisors and a successful resolution of the case of selling excess electricity to CDE.

iii) Using another management arrangement (such as that proposed in Phase I of the Program) would dilute the effectiveness of the program.

The proposed institutional arrangement was been discussed at length with representatives of the CNPE, CDE and INDRHI (including the Executive Secretary of the CNPE, the Director of Directorate of Hydroelectric Development and Ing. Diógenes Lamarche of INDRHI) and incorporates valuable suggestions that have been made by them. The interest of the three institutions in the Small Hydro Program is commendable and there is every reason to think that the program will succeed. Because of the multi-institutional aspects of the program and the incorporation of local communities in important aspects of the program development it is vitally important that the SHPP Study Manager and especially the SHPP Program Manager be high-calibre technical people with a flair for management. It is obvious that the AID Project Manager will need to have a talent for diplomacy and a good sense of timing of when to involve himself actively in the program as well as possessing the other attributes mentioned under the Technical Assistance chapter.

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7.0 Project Description

Introduction

The project can conveniently be thought of as 10 separate activities as delineated in Figure 7.1. The lead responsibility for the management of each activity has been assigned to that institution whose mandate and capabilities (as reflected in past, present and future activities that relate to SHPP development) most closely corresponds to the activity.

The expected results for this program are as follows:

i) strengthening overall institutional capabilities in the development of SHPP's with a special emphasis on maximization of cooperation and interaction between the three institutions involved in mini-hydro development, i.e. CNPE, CDE and INDRHI.

ii) 20 site selection studies.

iii) 2 feasibility studies

iv) 2 procurement documents including detailed site specific SHPP designs.

v) 2 small hydro systems that have been designed, installed and monitored for 1 year after installation.

vi) 2 teams of local trained personnel who will act as representatives of the local ayuntamiento in the management of the SHPP (including watershed management, O&M and A&G).

7.1 Selection of Program Personnel

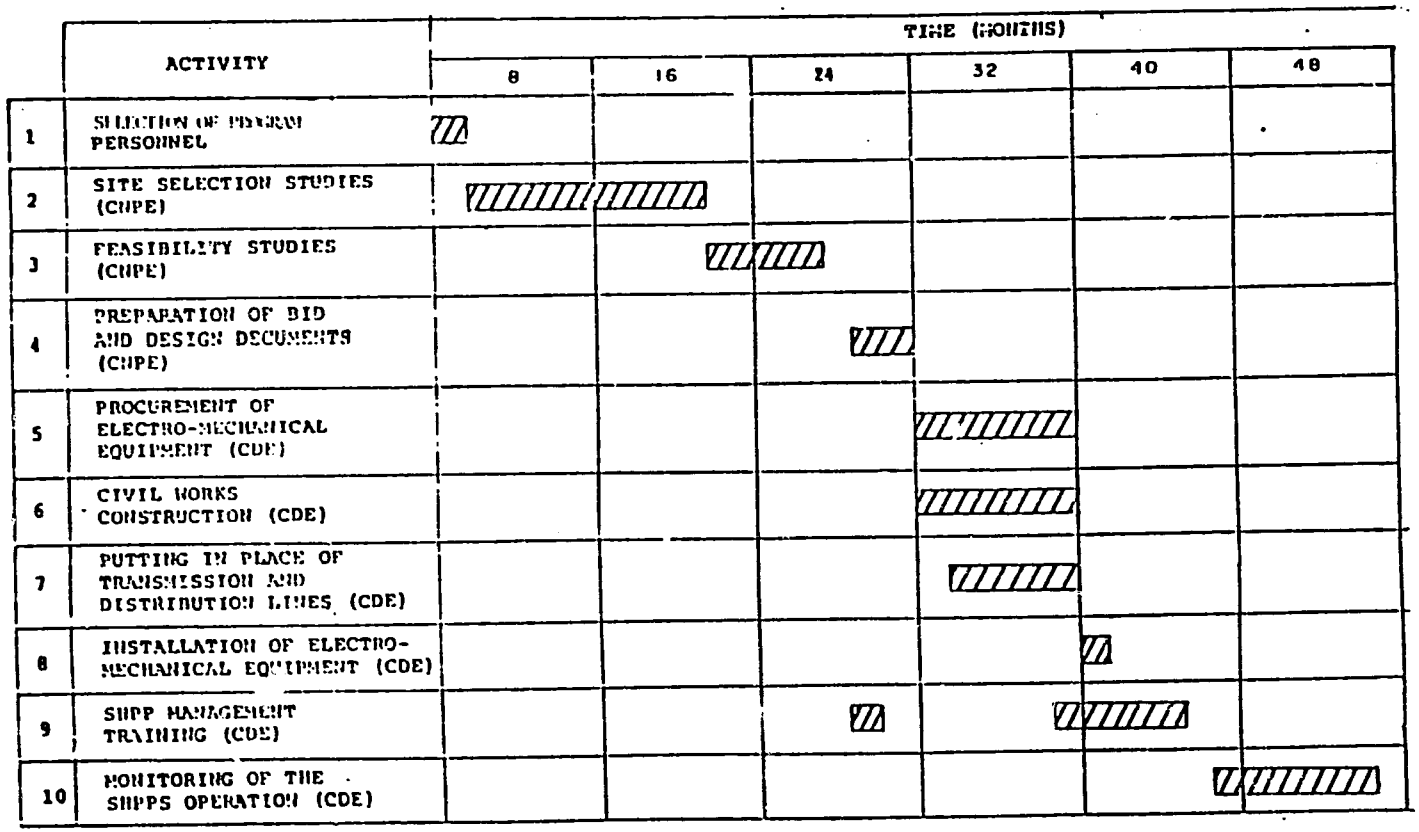
The first activity of the small hydro project will be the selection of appropriate personnel. The manager of Phase 1 of the Project (The SHPP Study Manager) will be an employee of the Hydroelectric Unit of the Research and Development Department of the National Energy Policy Commission (CNPE). The other professionals that will participate in the SHPP study will be selected from both CDE and INDRHI, as appropriate.

The SHPP advisory board will consist of representatives of CNPE (who will be the Chairman), CDE and INDRHI, the AID Project Manager and as Secretary the SHPP Program Manager (see Figure 7-2).

For Phase 2 of the project, the SHPP Program Manager will be an employee of the Directorate of Hydroelectric Development of the CDE. The SHPP Program Manager will also be able to draw upon the resources of the community, that will be served by the SHPP, either in the provision of unskilled voluntary labor or through a contribution in kind. Consult Figure 7-3.

Consult Table 7-1 for a breakdown of the manpower loading (in months) for each of the 10 activities.

FIGURE 7.1 ACTIVITY CHART FOR THE AID-CHPE-INDHRI SMALL HYDRO PROGRAM*



*THE LEAD AGENCY FOR EACH ACTIVITY IS INDICATED IN PARENTHESES UNDER THAT ACTIVITY

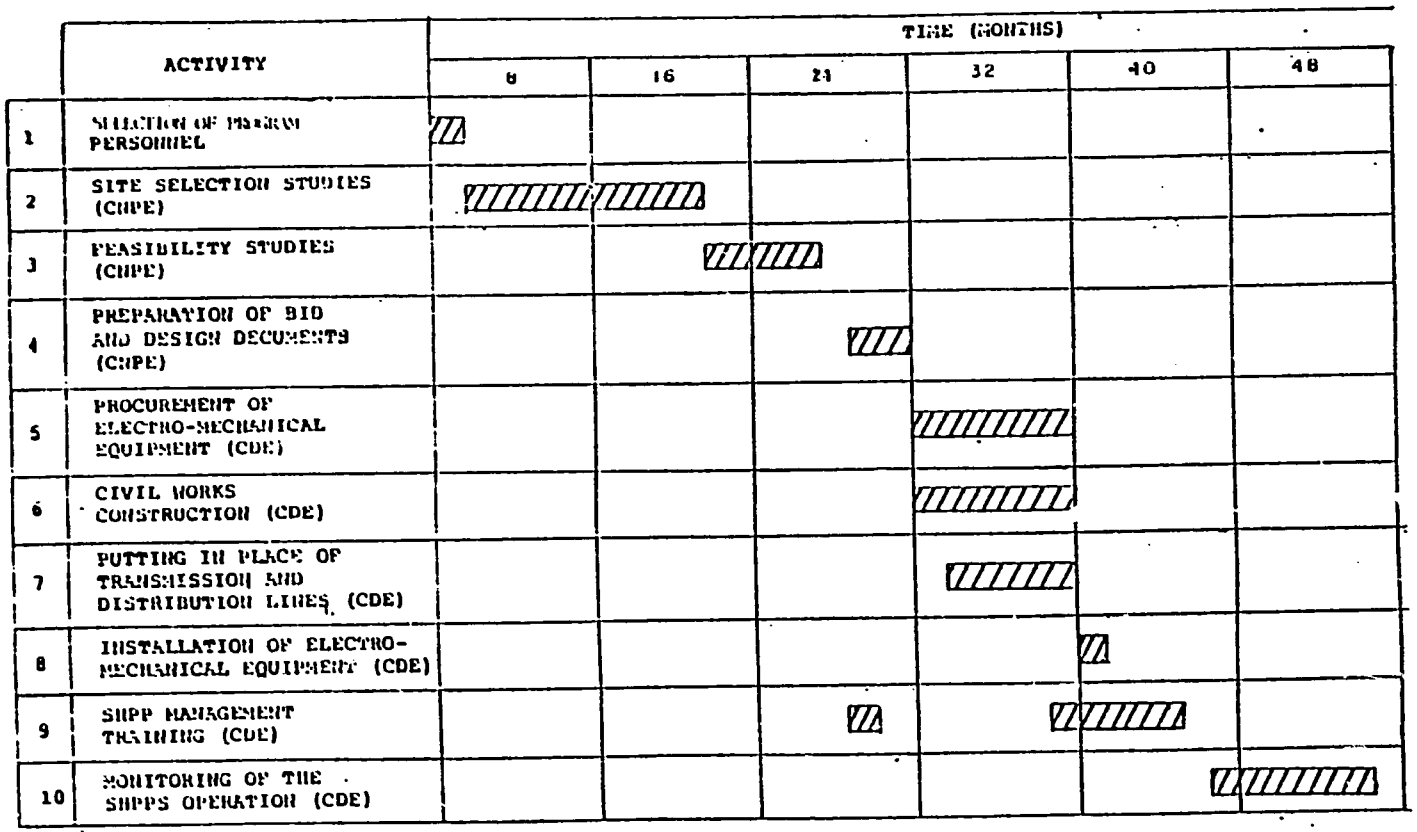
TABLE 7-1 MANPOWER LOADING (MONTHS) AND BUDGET - DR BASED PERSONNEL*

TECHNICAL SPECIALTY \ ACTIVITY NO.	1	2	3	4	5	6	7	8	9	10	Total	Monthly Salary (RD$)	Total Salaries RD$
SHPP Study Manager	1	4	3								8	1,200	9,600
SHPP Program Manager				0.5	0.5	2	2		1.5	1.5	8	1,500	12,000
Electro-Mechanical Engineers		6.7	10								16.7	1,200	20,040
Design Eng. (Civil)		6.7	4								10.7	1,200	12,840
Design Eng. (Elect.)			2	1.5				0.5			4	1,300	5,200
Environmental Scientist		2.2	1								3.2	800	2,560
Geologist		2.2	0.5								2.7	900	2,430
Sociologist		2.2	1			1					4.2	800	3,360
Surveyor			1								1	800	800
Site Inspectors						14					14	600	8,400
Transmission/Distribution Lines Installation Supervisors							14				14	600	8,400
O&M Instructor									3		3	1,000	3,000
Instructor in Tariffs and Accounting									3		3	800	2,400
Electricity Promotores									6		6	500	3,000
Draftsperson			10	8	2						20	350	7,000
Secretary	1	7.5	4.5	0.25	0.25				0.5		14	400	5,600
Chauffeur		7	1						2		10	250	2,500
Attorney			4								4	750	750.
										GRAND TOTAL			RD$ 109,880.

Sources: Based on information provided by CNPF, CDE and INDRHI Personnel

* An equitable salary structure will be used for all employees of this project. Currently there are striking differences in the salary scales of CDE and INDRHI

FIGURE 7.1 ACTIVITY CHART FOR THE AID-CHPE-INDHRI SMALL HYDRO PROGRAM*



*THE LEAD AGENCY FOR EACH ACTIVITY IS INDICATED IN PARENTHESES UNDER THAT ACTIVITY

FIGURE 7.2 AID/CNPE/CDE/INDRHI SMALL HYDRO PROGRAM - PHASE 1

SITE SELECTION/FEASIBILITY STUDY ORGANIZATION CHART

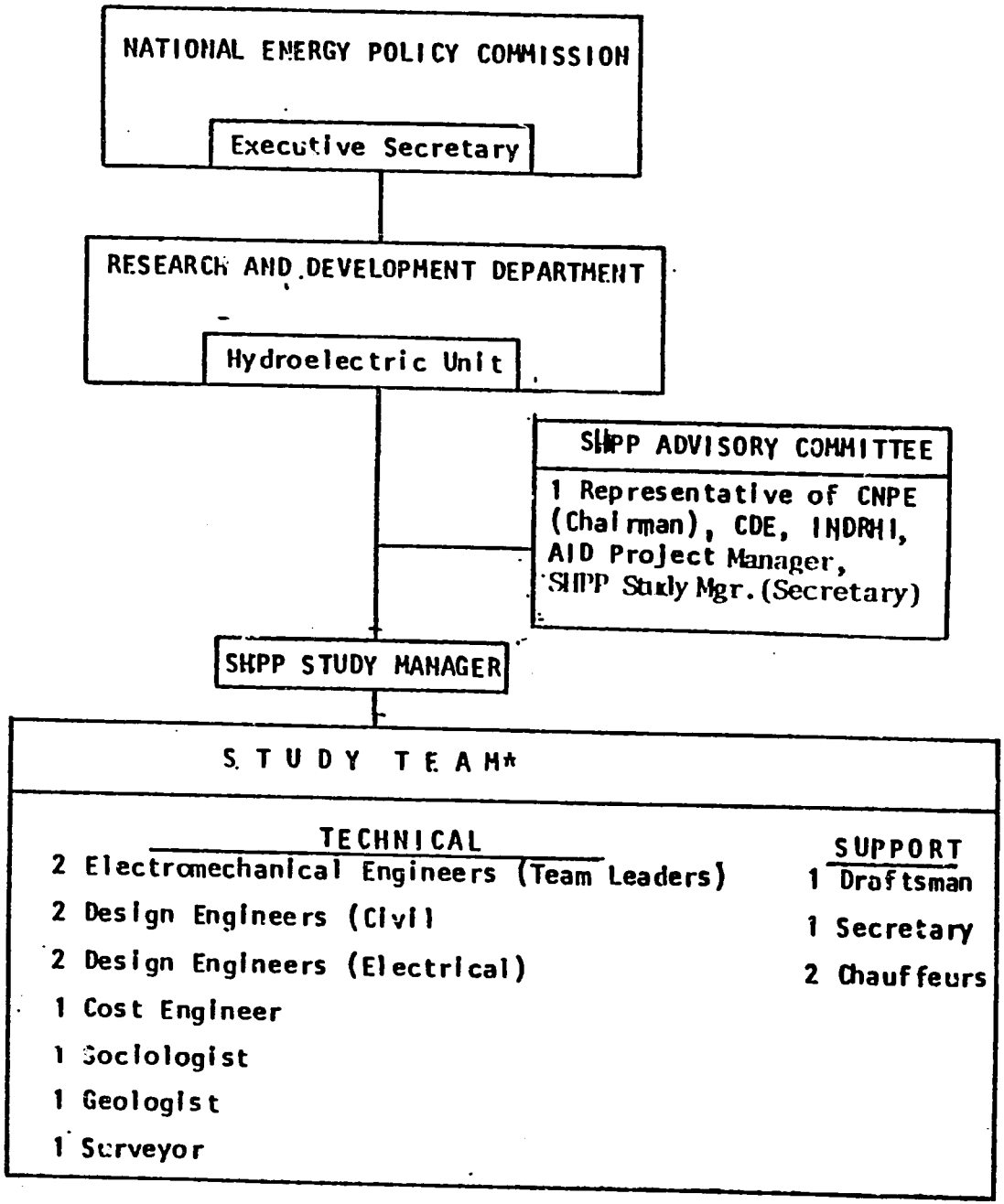
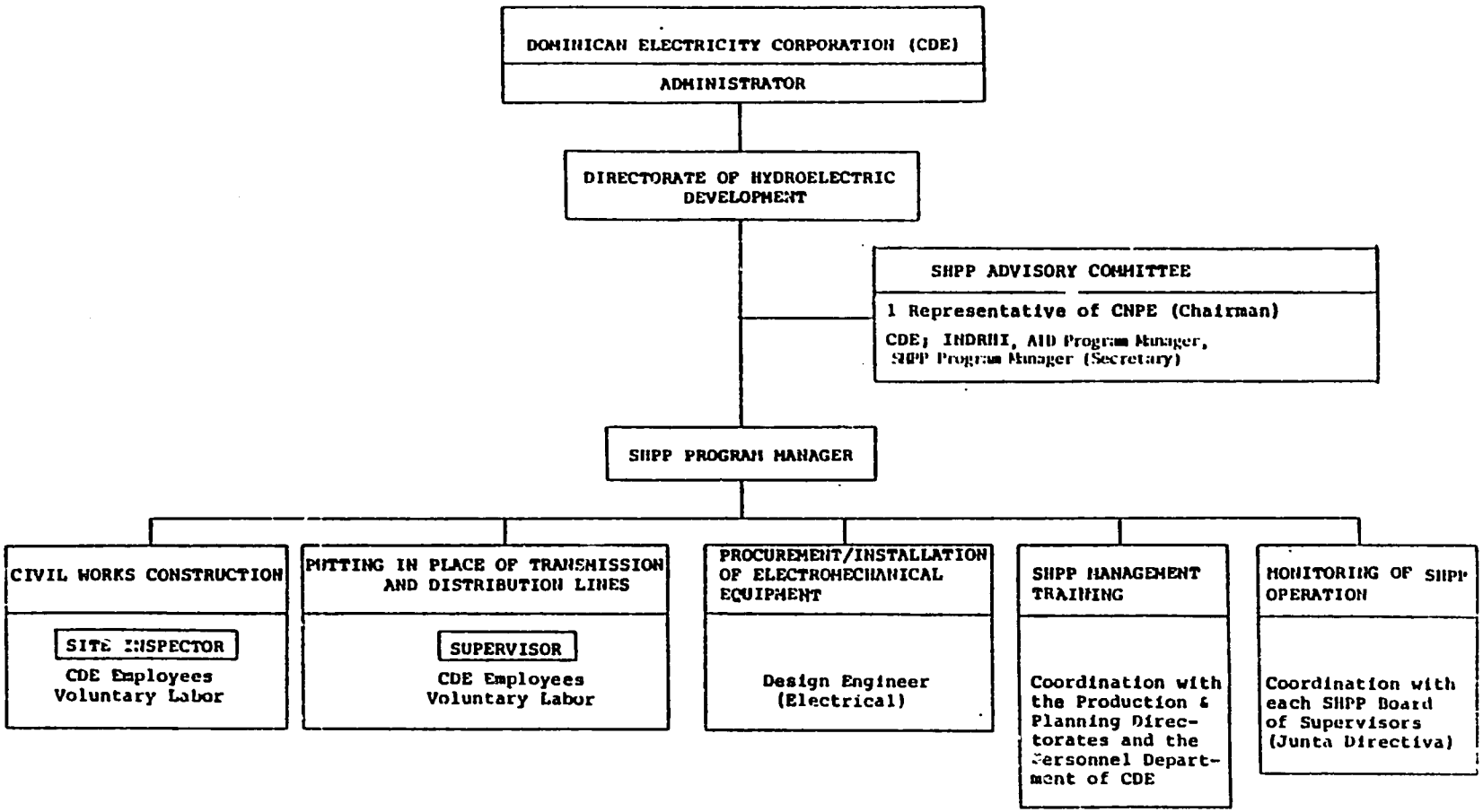


FIGURE 7.3 AID/CNPE/CDE/INDRHI SMALL HYDRO PROGRAM - PHASE 2

SHPP CONSTRUCTION AND OPERATION



7.2 Site Selection Studies

Approximately 20 site selection studies will be conducted by two teams. The project manager for the site selection studies will be an employee of CNPE, preferably from the Hydroelectric Unit. Each site selection study will last three weeks.

The composition of each of the two teams will be as follows:

- 1 Electro-Mechanical Engineer
- 1 Design Engineer (Civil)

Professional support personnel will include:

- 1 Sociologist
- 1 Geologist
- 1 Environmental Scientist (Expert in soil conservation and water resources management)

Approximately 1 person month of effort will be dedicated to each site selection study. The site selection studies will be completed within 7 1/2 months of their initiation.

An expert on the optimal location of hydrometeorological and runoff gauging stations and in the processing of generated information will be provided at this juncture, under the technical assistance component of the small hydro program.

7.3 Feasibility Studies

Two feasibility studies will be carried out. The procedure for conducting the feasibility studies will be similar to that employed in conducting the site selection studies, but providing a greater level of detail for arriving at more precise cost estimates. For example, major equipment pricing is developed on a more formal basis than used for appraisal studies. Additional study areas that are looked at in greater detail than the site selection studies include:

- Layouts and designs
- Availability of access
- Environmental issues and resolution of problem areas
- Detailed schedules for construction and funds allocation.

Whereas site selection studies will generate costs with ± 25% confidence limits, the feasibility studies costs should be dependable, using appropriate contingency costs. Each feasibility study should take approximately 4 1/2 months and involve approximately 1 person-year of professional effort. The composition of each feasibility study and the appropriate level of effort for each team member is as follows:

	LEVEL OF EFFORT (MONTHS)
1 Electro-Mechanical Engineer (team leader)	5
1 Design Engineer (Civil)	2
1 Design Engineer (Electro-Mechanical)	1
1 Cost Engineer	0.25
1 Environmental Scientist	0.50
1 Geologist	0.25
1 Sociologist	0.50
1 Surveyor	0.50
1 Draftsperson	4

7.4 Preparation of Bid and Design Documents

The bid and design documents for each site will be prepared under the supervision of the electro-mechanical design engineer. They will include all electro-mechanical specifications and tolerances. Terms of delivery (including but not limited to method of shipment, place of delivery, penalty clauses, etc.) will also be specified plus an appropriate level of technical assistance.

7.5 Procurement of Electro-Mechanical Equipment

Standard USAID procurement procedures (including bid evaluation guidelines) will be followed including but not limited to advertising in appropriate media (such as the Commerce Business Daily) and accepting and evaluating bids from contractors who meet USAID guidelines.

7.6 Civil Works Construction

The civil works construction will be supervised by a site engineer appointed by INDRHI. Where feasible, there will be local participation in carrying out the civil works either in labor or in kind. All materials and necessary equipment will be supplied by INDRHI.

7.7 Putting in Place of Transmission and Distribution Lines

Transmission and Distribution lines will be put in place under the supervision of CDE, the institution with considerable experience in this area. Local labor will be utilized in this task, where appropriate.

7.8 Installation of Electro mechanical Equipment

Installation of electro-mechanical equipment will be supervised by CDE, drawing on this institution's extensive experience in the installation of similar equipment in larger powerhouses and in the operation of SHPP's.

7.9 SHPP Management Training

Training will be provided by CDE for training employees of each SHPP board of supervisors in the following areas:

- SHPP operation and maintenance
- Organization of cooperatives (including billing, tariffs, etc.)

In addition, CDE will arrange that experts be provided in the following areas for training the population to be served by the SHPP's:

- Promotion of the productive uses of electricity
- Conservation of watersheds

Training Offered by CDE to the SHPP System Employees

Training in SHPP O&M will be arranged through the Directorate of Production of CDE, which has the responsibility for operating and maintaining all the CDE (hydroelectric, gas turbine. steam turbine) generating plants and which will have a support role in the operation and maintenance of the new SHPP's. CDE's experience in training all the operators of large, medium - and small scale hydroelectric plants has shown that a six month course (including 3 months of theoretical training and 3 months of on-the-job experience) would be adequate for preparing an SHPP operator. Technical assistance will be provided in the area of O&M with particular emphasis on preventive maintenance.

CDE will also arrange that technical assistance (to be provided under the AID grant) will be provided to key personnel of the SHPP Board of Supervisors and its employees in the organization of electric utility cooperatives with special emphasis on appropriate accounting, billing and collection procedures.

Training Offered by CDE to the SHPP System Members

CDE will arrange that training will be given to the SHPP system members in the productive uses of electricity. Local technical assistance will be provided to develop a detailed curriculum to equip promotores with the necessary technical and pedagogic skills to accomplish this activity.

Dominican specialist in small industry, farm development, crop storage and marketing, home economics, nutrition, anthropology/rural sociology and a consultant with previous experience in the implementation of such promotion campaigns will be engaged on a short-term basis for the design of the program curriculum. This consultant will subsequently conduct the promoter training seminar.

The promotores' tasks will consist of 3 parts: promotion of the productive uses of electricity for pumping for irrigation and potable water supply, agro industry, small industries and crafts developments, promotion of social uses in the form of health centers, schools, etc. and promotion of household uses of electricity for food processing, cottage industries, cooking hygiene and storage. At all times emphasis will be put, where feasible, on those activities that will improve the income generating productive uses of electricity.

CDE will also arrange that training be given to the community on watershed conservation and that the SHPP Board of Supervisors draw up and execute a plan for conservation of the watershed that is the source of "fuel" for the SHPP.

7.10 Monitoring of the SHPP's Operation

The management of the SHPP's by the local community in all their facets from watershed protection, through energy generation, transmission, distribution, tariff setting, consumer billing, administration, promotion of the productive uses of electricity and the relationship developed between the SHPP Board of Supervisors and CDE will be monitored very closely for the first year after startup.

CDE will appoint a liaison person who will be responsible for the coordination of all CDE-SHPP management board activities. He will act as a resource person for the SHPP management and will visit the SHPP site and service area, every two weeks. He will also be available to assist the SHPP management in dealing with any emergencies that may arise. Finally, the CDE contact person will arrange, when deemed necessary, for specialized assistance from professionals such as land use management specialists, civil and electrical engineers, economists and behavioural scientists.

The liaison person will be a member of the SHPP Board of Supervisors.

A team of professionals including a land use management specialist, an engineer (civil or electro-mechanical), an economist and a sociologist will visit each SHPP site and service area at the time of SHPP start up, and again a year later. A report will be prepared detailing how the SHPP system has been managed for the first year with special emphasis on innovative approaches that have been used and deficiencies that need corrective action.

Figure 7-1 is an activity chart for the small hydro program indicating

i) The activities that must be carried out under the program.

ii) The lead agency for each activity and

iii) The appropriate timing of each activity within the entire program.

Other institutional arrangement details are given in Section 6.2.

Technical Assistance

The Small Hydro component of the Energy Conservation and Resources Development Project includes 52 person-months of technical assistance. AID funding will be provided to finance:

a) 30 person/months for a project advisor. The project advisor will have an M.S. in E.E. (specializing in power systems) and membership of the American Institute of Electrical and Electronic Engineers. He/she will have 10 years experience in the design and management of power systems (including small hydroelectric power plants), be fully fluent in Spanish (equivalent to the Foreign Service Language Training Institute, Level 3) and have 3 years professional experience in hispanophone America.

b) 4 person/months of the beginning of the project for a planning expert in the development of small hydroelectric resources. He/she will be assigned principally to CNPE.

c) 4 person/months for an expert in the environmental assessment of small hydro projects, including a demonstrated expertise in soil conservation and water resources management. He/she will be assigned principally to INDRHI.

d) 4 person/months for a specialist in the following areas (within the context of a nationwide-scale small hydro program):

i) optimal location of hydrometeorological and runoff gauging stations

ii) development of appropriate computer software for efficient storage and access to all existing and future pertinent hydrometeorological and hydrological records. He/she will be assigned principally to INDRHI.

e) 6 person/months in Community Training to be assigned as follows:

i) 2 person/months for a curriculum development specialist to assist CDE in the design of a training program for the promotion of the productive uses of electricity.

ii) 2 person/months for a specialist in the state-of-the-art O&M for SHPP's who will advise CDE on developing an appropriate training course for SHPP operators.

iii) 2 person/months to assist CDE in determining appropriate policy for tariffs, billing and collection methods for areas served by SHPP's.

iv) 1 person/month for an expert in community organization for watershed conservation and improvement. He/she will be assigned to CDE.

f) 2 person/months to assist in the preparation of procurement documents to meet AID specifications.

g) 2 person/months for project monitoring and evaluation.