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DESIGN OF A NEW PROGRAM OF EXTERNAL FINANCING FOR THE DEVELOPMENT OF SMALL HYDROELECTRIC POWER PLANTS

(Translation of Original Report in Spanish)

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and the

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Development of Small Hydroelectric Power Plants

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DEFINITIONS

AID	Agency for International Development
BANVIP	Peruvian Housing Bank (Banco de la Vivienda del Perú)
COMMSA	Consultores Mineros Metalúrgicos S.A.
CORDES	Departamental Development Corporations
EFET	ELECTROLIMA Electrotechnical Training School (Escuela de Formación Electrotécnica de ELECTROLIMA)
ELECTROPERU	Public Electricity Company of Peru (Empresa Pública de Electricidad del Perú S.A.)
EPS	Electricity Promotion Service of the Rural Electrification Department of ELECTROPERU
EPU	Electrification Project Unit (or Units)
ETEMHI	ELECTROLIMA Mechanics and Hydraulics Technical School (Escuela Técnica de Mecánica e Hidráulica de ELECTROLIMA)
GOP	Government of Peru
HIDRANDINA	Regional Electric Company Electro Norte Medio HIDRANDINA S.A.
IDB	Interamerican Development Bank
MEM	Ministry of Energy and Mines
OPAT	Office of the Program for Applied Technology
REC	Regional Electric Company (or Companies)
RULCOP	Unified Regulations for Bidding and Contracting of Public Works
SHPP	Small Hydroelectric Power Plants

"Gerencias" of ELECTROPERU are referred to as Divisions and "Sub-Gerencias" are referred to as Departments.

In all numbers, a period is used to separate decimals and a comma to separate thousands and millions

I/.	= inti
US$	= United States dollars (US$1 = I/. 17.50)
L	= pounds sterling (L 1.00 = I/. 20.15)
kW	= 1,000 watts
MW	= 1,000 kW
kV	= 1,000 volts
kWh	= kilowatt-hour

micro-hydro power plants - capacity up to 100 kW
mini-hydro power plants - capacity between 100 kW and 1000 kW
small hydroelectric power plants - capacity less than 10,000 kW

1. INTRODUCTION

1.1 Objective of the Report

This report has been prepared as an extension of the evaluation of the ELECTROPERU/AID Project for the Development of Small Hydroelectric Plants.

The overall objective of the report is to submit to ELECTROPERU, via its Rural Electrification Department, a document that can serve as the basis for the preparation of the information required to justify external financing for the development of another group of small hydroelectric power plants (SHPP), making use of the capabilities of the personnel and the institution which were developed during the implementation of the AID Project.

Specifically, the objectives stated in the terms of reference of the AID Project Evaluation are:

a) Develop a plan and preliminary design for a program to continue the development of small hydroelectric power plants that ELECTROPERU can present to an international development agency (such as the IDB or the World Bank).

b) Analyze the role of SHPP in the Peruvian Government's overall development plans and in its plans to expand rural electrification.

c) Determine how many small hydroelectric power plants ELECTROPERU can construct in the next five years.

d) Prepare preliminary cost estimates and an analysis of benefits and costs of the proposed program.

e) Recommend how ELECTROPERU can avoid the procurement and contracting delays encountered in the implementation of the AID Project and how the number of SHPP constructed in Peru can be substantially increased. Recommend the most appropriate mechanism for implementing the proposed program.

f) Identify additional studies that need to be carried out to prepare a project for consideration by international development agencies.

1.2 Scope of the Report

The report has been focused on the fulfillment of the above objectives, in accordance with the constraints imposed by the availability of information in ELECTROPERU and with the institution's present needs. It recommends measures that ELECTROPERU should take to prepare and justify a loan application and to submit an attractive program to the development agencies, as well as to ensure the successful implementation of the proposed program.

It should be noted that the construction cost estimates and the tentative scheduling of the works encompassed by existing and proposed agreements are preliminary approximations, based on the best information available at the time the work was done. Nevertheless, the results are considered to be reliable and to demonstrate adequately ELECTROPERU's present financial perspectives for the development of SHPP.

The information needed to prepare this report was obtained through interviews with the persons listed in Appendix 1-1 and review of the documents listed in Appendix 1-2.

1.3 Use of This Report by ELECTROPERU

ELECTROPERU can use the contents of this report in three different ways:

- some of the material can be included directly in the documents to be submitted to the development agencies, with little or no change;

- the material contained in the report can be used as an example or guide for the preparation of the required analyses and plans by ELECTROPERU staff; and

- the recommended measures can be implemented, not only for the preparation of the proposed financing program and its required documentation, but also to increase the effectiveness of ELECTROPERU in developing SHPP.

It is recommended that the medium term cost and resource projections be refined on the basis of better and more detailed data on the cost and physical progress of works being implemented, as these data become available, following the approach set forth herein and focusing on the costs and progress of individual projects. This analysis should include transmission line and distribution network projects and works.

It will be important to demonstrate to the development agencies how the proposed program will fit in with other rural electrification projects and agreements and how all potentially available resources will be used in the medium term.

It should be noted that ELECTROPERU's Rural Electrification Department has already begun discussions with the Interamerican Development Bank about a possible application for a loan to finance the construction of SHPP and distribution systems. The authors of this report have also made contact with IDB representatives in Lima and have confirmed the Bank's interest in receiving such an application. The proposed financing has already been included in a tentative list of potential projects to be considered by the Bank.

2. SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

2.1 The Role of Small Hydroelectric Power Plants (SHPP)

In order to achieve its overall development objectives, as well as the specific goals of the electricity sub-sector, the GOP has assigned a high priority to rural electrification. The Government's support of rural electrification is expressed concretely through the continuing allocation to it of revenues from the tax on electric power consumption. This tax and the use of the revenues it generates are established by Legislative Decree (D.L.) No. 163.

Small hydroelectric power plants (SHPP) play an important role in rural electrification, particularly in communities located at some distance from the interconnected systems or from existing power plants. They offer several advantages over other sources of electric power. The advantages of the SHPP include the following:

- they are relatively easy to operate and mantain;
- they use renewable water resources and reduce dependency on petroleum;
- if engineered and built satisfactorily, they can offer electric power at a reasonably low cost, especially in comparison to thermal options or the extension of transmission lines over long distances and/or difficult terrain;
- they provide opportunities for the development and support of a national industry o manufacture hydroelectrical and electrical equipment;
- the small magnitude of the works facilitates the involvement of regional entities (the Electrification Project Units and the Regional Electric Companies) in their construction, contributing to decentralization and regional development; and
- they offer greater security, as compared to large installations, through the geographic dispersal of energy sources.

From 1980 to the present, 36 SHPP, each with an installed capacity of up to 1,000 kW, have been placed in operation. These include 12 micro-hydro plants (with an installed capacity of less than 100 kW). Four of the 36 are presently out of service. During this period, the installed capacity in rural areas has increased by approximately 30 MW, to a total of 242 MW.

The 1985-1990 National Plan for Expansion of the Electric Frontier calls for an increase in the degree of electrification of small and medium-sized population centers from 17% of the rural population in 1984 to 25% in 1990. During this five-year period, the Plan seeks to increase the

total installed capacity in rural areas to 335 MW through the construction of 100 SHPP, supplemented by 9,400 km of new transmission lines and primary networks. The Plan estimates the total cost of achieving these goals at US$255 million, of which US$66 million is expected to be obtained from foreign sources.

From the foregoing considerations, it can be concluded that the small hydroelectric power plant development program in Peru should be continued. It is a very important component of rural electrification, to which the government has assigned a very high priority.

2.2 Ability of ELECTROPERU to Carry Out a New Program

In technical matters, ELECTROPERU possesses the necessary experience for carrying out studies, tendering works, and supervising construction, as well as for executing works by force account. ELECTROPERU and its dependencies would be fully prepared to implement a new SHPP external financing program. To ensure that ELECTROPERU's technical efforts are highly useful and facilitate implementation of the facilities, the following measures are recommended:

a) Review and consolidate the "AID Methodology" (the economic evaluation methodology developed by the AID Project Office), or a modification thereof, as the sole technique for evaluating SHPP projects in the Rural Electrification Department.

b) Modify the procedure for assigning priorities to projects, giving a greater weight to the benefit/cost ratio.

c) Ensure that only one unit in the Rural Electrification Department assigns priorities to the studies to be carried out, that the priorities are based on the resources available for implementation of the works, and that the assigned priorities are respected by all units and persons within ELECTROPERU.

d) Develop simple, economical and standardized designs for the various components of the small hydroelectric power plants and small electrical systems, specifying the conditions which govern their selection and use. Try to develop in the consulting firms the concept of design simplicity and flexibility, using uniform and standardized designs, in keeping with the quality of the basic information available.

e) Establish a strict supervision of studies, including those awarded to COMMSA, to ensure that adequate results are obtained, particularly with reference to obtaining and using topographical and geological data, design concepts, and the identification of potential construction problems.

f) Compile and consolidate, in a centralized and integrated data base, all information on hydrology, meteorology, topography, geology, power

demand, electric power consumption, other key socio-economic indices important for pre-feasibility and final studies, and an inventory of SHPP already in service and under construction.

Although a theoretically adequate organizational and administrative structure for the development of SHPP projects currently exists, several practical problems could interfere with the success of a new external financing program. The problems have contributed to delays of the projects funded by the AID and United Kingdom Agreements, resulting in an under-utilization of the funds available for rural electrification in the past few years.

In order to implement efficiently a future external financing agreement, several measures must be taken to facilitate management and improve the coordination and control of the work of the different units of the Rural Electrification Department. The recommended measures include:

a) Retain the technical personnel trained in the last few years in the Project Agreement Offices and integrate these employees into a unit that would enable ELECTROPERU to undertake successfully future rural electrification programs. Increase the salaries of contract employees and, where possible, provide them stable positions within the institution.

b) Fill personnel vacancies in the Rural Electrification Department, especially at the unit head level, or replace the vacant positions with another with the responsibility of assisting the Manager of Rural Electrification.

c) Devote attention to paying pending invoices and accounting for completed works more expeditiously, avoiding the accumulation of idle funds and/or delays in accounting for the funds.

d) Take steps to ensure that the Electrification Project Units are transferred to the Regional Electric Companies as integral units, without loss of their present effectiveness, and making full use of the experience and capabilities which have already been developed.

e) Facilitate the tendering, awarding and contracting process.

f) Prepare annually a medium-term program of projects to be implemented, in accordance with estimated costs and resources likely to be available each year.

g) Implement a single information system for SHPP and small electrical system projects, in order to maintain and make available, from a single source, reliable and up-to-date data on the status of each project and completed power plant.

ELECTROPERU's ability to finance rural electrification works depends on two main sources of funds: the electric power consumption tax imposed by D.L. 163 and external financing agreements.

The analysis of ELECTROPERU's financial capacity indicates that all the funds normally allocated to hydroelectric works (approximately US$12 million per year) would be needed just to finish the works of that type which are currently underway. No local funds will be available to supplement the resources that could be obtained from a new external financing agreement until 1989, unless funds usually allocated to transmission lines and networks are diverted to civil works and equipment. The ability to make use of external financing is limited by the availability of local funds, especially if the external financing is earmarked for the procurement of equipment, with no further provision for the associated civil (and electrical) works.

Based on the local funds expected to be available in 1987 and 1988, it is estimated that 26 SHPP projects could be completed in these years, including seven funded by AID, seven funded by the United Kingdom Agreement, and three funded by the Agreement with the Federal Republic of Germany, providing a total installed capacity of 33,000 kW. The completion during the next two years of the projects already underway would place in service an annual average of twice the annual average number of plants completed in the past four years, requiring a corresponding extention of the technical and administrative capabilities of the Rural Electrification Department.

2.3 Program Formulation

The formulation of the new external financing agreement is based on the availability of local counterpart funds for hydroelectric works. Because of a lack of complementary local funds, any new external financing program for SHPP, including the proposed Italian Agreement, which would consist of a US$5.3 million loan and a US$2.7 million grant for hydroelectric equipment, as well as a commercial credit of US$2.6 million for the procurement of thermal generating equipment, should not begin until 1989.

It is assumed that the loan and grant of the proposed Italian Agreement would finance the procurement of hydroelectric equipment for ten plants, with a total installed capacity of almost 20,000 kW. This program would require the equivalent of US$20.9 million during three years to carry out the associated civil works.

Assuming the United Kingdom Agreement is suspended and that the proposed Italian Agreement is implemented in 1989, a new external financing agreement for SHPP could consist of US$10 million for civil works and equipment, an equal amount for electrical works, US$1.4 million for studies and US$0.6 million for technical assistance and training. The works to be financed would be completed within a three-year period.

The new agreement would provide 12,000 kW of installed capacity, divided among an estimated 14 SHPP, with an average installed capacity of 850 kW. Including only civil works and hydroelectric equipment, the average

cost per installed kW is estimated at about US$1,670. The total cost of the hydroelectric works would amount to US$10 million.

In addition to covering half the costs of the 14 SHPP (including electrical works), the proposed level of financing would also cover a similar portion of the costs of extending new transmission lines and distribution networks in other service areas.

During the 1987-1991 period, the proposed program would put into service an annual average of 12 SHPP and would increase the installed capacity in rural areas by almost 70 MW to a total of approximately 310 MW. Sufficient resources to reach the goal of 335 MW installed by 1990 will probably not be available.

In addition to maintaining an adequate balance with local resources, the recommended level of external financing would also fall within the implementation capabilities of ELECTROPERU and the Regional Electric Companies. It is assumed that the resulting foreign indebtedness would not conflict with national economic policies. However, this is an aspect of the proposed agreement that would require further investigation.

To assist ELECTROPERU in strengthening its rural electrification program, it is recommended that the new external financing agreement include provisions for supplying technical assistance and training in the following areas:

- promoting productive uses of electric power;
- developing standardized designs;
- organization and management systems;
- strengthening technical schools, including procurement of equipment for workshops; and
- developing national industrial capabilities.

If requirements are met in a timely manner, the approval of a loan application can take an average of 18 months, such that funds could be available by mid-1988. To be able to begin construction work early in 1989, technical studies would have to be initiated no later than the beginning of 1988, enabling the tendering and contracting process for the first SHPP to be begun as soon as the loan request is approved (mid-1988). The preliminary studies, including prefeasibility analyses, should be carried out earlier, during 1987, in order to prepare a suitable package of potentially feasible and viable projects.

2.4 Comparison of Benefits and Costs

Without having available prefeasibility studies for a group of projects that could be carried out under the proposed new agreement, the specific

benefits of the agreement cannot be measured. However, bearing in mind the large number of potential projects that are known to exist, and assuming that within this universe there are several projects with benefit/cost ratios similar to those of the projects implemented under the AID Agreement, it can be concluded that a new external financing agreement would be economically justified.

Three of the above-mentioned AID projects, when evaluated, were shown to have benefit/cost ratios of 1.4, at a 12% discount rate, including the costs of transmission lines and distribution networks. Such a benefit/cost ratio indicates that it would not be difficult to find other projects with similar profitability, since the AID projects can be considered to be representative of the universe of potential projects.

3. PROSPECTS FOR THE DEVELOPMENT OF SMALL HYDROELECTRIC PLANTS

3.1 Brief History of Rural Electrification

Peruvian rural electrification policy was initiated in 1963 when a Technical Assistance Agreement was signed with AID to select an area in the Mantaro Valley where a Rural Electrification Pilot Plan would be implemented. After the Pilot Plan was concluded, rural electrification moved rather slowly. Until 1973, when ELECTROPERU was created, public power was supplied mostly by private enterprise, which tended to serve only the more profitable large urban centers.

For several years after ELECTROPERU's creation, its activities were limited to improving the provision of electricity to large and medium size population centers. Only after 1978 did it begin to direct its efforts towards increasing rural electrification. That year the Ministry of Energy and Mines (MEM) implemented a new program:

- In November 1978 top priority was assigned to the Small Hydroelectric Power Plants (SHPP) Program, and a special steering commission was created.

- In December 1978, ELECTROPERU created the Office of the Program for Applied Technology, charged with monitoring and coordinating the SHPP Program. The SHPP Electrification Fund was also established, using ELECTROPERU's internal resources.

- In 1981, the Provincial, District and Rural Electrification Division was created. At the end of 1985, it became a Department within the Construction Division of ELECTROPERU.

- In June 1981, Legislative Decree No. 163 levied a tax on electric power consumption to finance rural electrification construction costs.

- In 1982, the General Electricity Law No. 23406 was passed. The law called for the creation of the Regional Electric Companies and specified the preparation of the National Plan for Expansion of the Electric Frontier. In 1983, the Provincial, District and Rural Electrification Division prepared the first version of the Plan, which is updated annually.

A rural electrification program was thus established with the following objectives:

- to meet the energy needs of the country's microregions and isolated communities;

- to make use of the large number of potential small hydroelectric sites in the interior, mainly in the Sierra;

- to substitute hydroelectric power for petroleum-based generation of electric power; and

- to develop a domestic capability and technology for manufacturing hydroelectric equipment and for constructing the power plants.

Peru's large territory (1,285,000 km^2) and broken topography can be grouped into the following three areas: the coast (Costa); the mountains (Sierra), where elevations exceed 5,000 meters (16,000 feet); and the jungle (Selva). The Peruvian government has concentrated its studies of small river basin exploitation in the upper elevations of the Sierra, i.e. at the headwaters. It can be assumed that there are more than 1,000 sub-basins with hydroelectric potential that together could produce a total of one million kW.

There are in Peru over 1,100 population centers with hydroelectric development potential; these centers have a total population of about 2 million people of which 53% presently have no electric power at all. The remaining 47% are supplied with energy primarily from thermoelectric power plants, many of which are in poor condition due to their age and poor maintenance history. These power plants are very costly to operate because of their high fuel costs. Moreover, they supply power only for public lighting and residential use and often for only a few hours per day.

At the end of 1984, there were in Peru some 1,000 population centers with electric power, including 350,000 subscribers, 58% of which were supplied by ELECTROPERU via the Regional Electric Companies. An additional 25% of the electric power services were managed by municipal councils and 17% by autoproducers (mining centers, agricultural cooperatives, petroleum companies, etc.) The degree of electrification of this population sector is 17%.

From 1980 to the present, 36 SHPP have been placed in operation, each with an installed capacity of up to 1,000 kW. These include twelve micro-hydro plants (with an installed capacity of less than 100 kW). Four of the 36 are presently out of service as a result of terrorist attacks or other causes. During this period, the installed capacity in rural areas increased by approximately 30 MW, to a total of 242 MW.

If all the SHPP built since 1907, most of which are in rural areas, are taken into account, there are presently 105 operational and 42 paralyzed power plants (see Appendix 3-1):

Capacity (kW)	Number of SHPP		
	In Service	Paralyzed	Total
0-100	53	34	87
101-1000	45	8	53
More than 1000	7		7
Total	105	42	147

Because of the vastness of the country's water resources, no major efforts have been devoted to electrifying rural areas with other energy sources such as solar, wind, geothermal, biogas and biomass. However, in 1985 ELECTROPERU did create the Non-Conventional Energy Office for this purpose.

3.2 Development Priorities and Goals of the Government of Peru

The new Government has had to face serious economic and social problems that impede the country's development. These include an extremely high foreign debt, the centralization of economic and government activities in Lima, a deteriorated industrial sector, a high rate of unemployment, the stagnation of income and economic growth, and a terrorist movement that promotes social dissatisfaction. The problems are especially acute in the rural areas.

To overcome those problems, the Government has sought to encourage rural development, especially in the areas with the greatest poverty, to decentralize the country's activities, to reduce the bureaucracy, to increase production in the agricultural sector, to encourage national industry and to restructure the distribution of income. Special emphasis is placed on the development and improvement of the quality of life in the Andean region.

In the electricity subsector, the objectives and goals expressed in the 1986 Electricity Master Plan include (among others) the following:

- intensify the systematic evaluation of the hydroelectric potential, with the objective of increasing and optimizing the hydro-generation of electricity, raising it from 78 percent of total production in 1985 to 92 percent in the year 2000;

- consolidate the endeavors of the Regional Electric Companies in order to secure decentralization and improve regional development;

- supply electric power to 61 percent of the country's population by the year 2000 (presently 40 percent have electric service); and

- increase the use of electricity in productive activities.

In order to achieve the general development objectives, as well as the specific goals of the electricity subsector, the GOP has assigned a high priority to rural electrification. The Government's support of rural electrification is expressed tangibly through the continuing appropriation to it of revenues from taxes on electric power consumption. The tax and the use of its proceeds are established by Legislative Decree No. 163.

The 1985-1990 National Plan for Expansion of the Electric Frontier, which complements the General Electricity Law and was updated in May 1986, calls for an increase in the degree of electrification in small- and

medium-sized population centers from 17 percent in 1984 to 25 percent in 1990, thereby benefitting an additional population of approximately 1.3 million inhabitants. (The Government considers that the rural population includes all the country's population except for the inhabitants of the ten large cities, namely: Lima, Arequipa, Trujillo, Ica, Cusco, Chiclayo, Iquitos, Huancayo, Piura and Chimbote.)

During the previously-cited five-year period, the total installed capacity in rural areas would be increased to 335 MW (up from a total of 239 MW in July 1985), through the construction of 100 SHPP, complemented by 9,400 km of new transmission lines and primary networks. The Plan for Expansion of the Electric Frontier estimates the total cost of achieving these goals at US$255 million, of which US$66 million is expected to be obtained from foreign sources.

The current definition of rural population is rather vague, and it should be defined more precisely to assure that the available resources are invested in the areas with the greatest needs, outside the medium-sized urban centers, and with the potential for productive uses.

3.3 Benefits of Small Hydroelectric Plants

The importance of rural electrification within the country's development priorities is easily appreciated. It facilitates social development, education, the delivery of health services, communications and the encouragement of productive activities in rural areas. It helps to create a better community environment and an expectation of future benefits that make rural life more attractive and tend to curb the migratory wave toward the large urban centers, thus aiding the decentralized growth of the country and the promotion of the agricultural sector.

The SHPP play an important role in rural electrification, especially in the communities located at some distance from the interconnected systems or from existing power plants. They offer several advantages over other sources of electric power. The advantages of the SHPP include the following:

- they are relatively easy to operate and mantain;
- they use renewable water resources and reduce dependency on petroleum;
- if engineered and built satisfactorily, they can offer electric power at a reasonably low cost, especially in comparison to thermal options or the extension of transmission lines over long distances and/or difficult terrain;
- they provide opportunities for the development and support of a national industry to manufacture hydroelectric and electrical equipment;

- the small magnitude of the works facilitates the involvement of regional entities (the Electrification Project Units and the Regional Electric Companies) in their construction, contributing to decentralization and regional development; and

- they offer greater security, as compared to large installations, through the geographic dispersal of energy sources.

3.4 The Role of Small Hydroelectric Plants in Electric Power Development

From the points previously raised, it can be concluded that the program for developing SHPP in Peru should be continued. The program is a very important component of rural electrification, to which the GOP has assigned a very high priority. When compared with the other possible sources of electric power, SHPP can supply electricity to isolated rural areas at reasonable costs. The SHPP projects are relatively easy to carry out, facilitating their implementation by the Regional Electric Companies and contributing in this way to the goal of national decentralization. Their reduced size allows for rapid implementation and delivery of their benefits, in accordance with the country's ability to finance them, without requiring users to await the lengthy erection of a major facility. The SHPP also take advantage of renewable natural resources and reduce the country's dependence on petroleum, which are also important goals of the Government.

4. ABILITY OF ELECTROPERU TO IMPLEMENT A NEW PROGRAM

4.1 Present Rural Electrification Programs

To achieve the goals set forth in the Plan for Expansion of the Electric Frontier (see Section 3.2), ELECTROPERU can make use of local currency resources, provided primarily by the tax on electric power consumption authorized by Legislative Decree No. 163, and foreign currency resources obtained via several agreements that have been signed with friendly countries. Three such agreements are currently in effect:

a) Agency for International Development (AID)

The AID Agreement was signed in November 1980 with a projected life of five-years. It was subsequently extended until May 1987. A Loan of US$9.0 million, a Grant of up to US$1.0 million, and counterpart funds equivalent to US$6.36 million are financing the construction of 10 SHPP with a total installed capacity of 6,200 kW, including studies, civil works, hydroelectrical equipment, transmission lines and distribution networks. As of the date of this report, three of the 10 plants have been completed, and the others are expected to be completed during the first semester of 1987.

b) United Kingdom

On March 15, 1982 a services and supplies contract was signed for small- and medium-sized hydroelectric plants and the associated transmission systems for the 1982-1990 period. Financing consists of a 4.8 million pound sterling grant, plus a 20.8 million pound sterling loan earmarked primarily to pay for British technical services and equipment for 21 power plants, with a total capacity of 42,000 kW.

As of the date of this report, contracts for the procurement of equipment for nine SHPP have been signed; two of these nine sets of equipment will be used in AID projects as part of the local contribution. Procurement of the rest of the equipment has been suspended, and there would appear to be a low probability that it will be reinitiated in the future.

c) Federal Republic of Germany

On July 9, 1981 an agreement was signed for the development of non-exhaustible energy sources and small hydroelectric energy resources for rural electrification, with the following objectives:

- to prepare an overall program for the development of regional and local electrification plans and the implementation of hydroelectric projects;

- to formulate electrification projects at the feasibility study level in the model regions; and

- to prepare definitive studies for four pilot projects with a total capacity of 2,110 kW, and to supply the machinery for two of those projects.

The agreement includes a grant of two million German marks for equipment and materials for the hydroelectric plants to be built as pilot projects and for technical assistance (198 person-months). Three of the SHPP are still under construction.

d) Other Agreements

In addition to these three agreements, ELECTROPERU requested bids between May 1980 and January 1981 for the provision of hydroelectric equipment for 21 power plants with a total capacity of eight MW. Contracts were awarded to Somerin (Brazil) for US$205,000, Sercenco (USA) for US$1.3 million, and the National Chinese Corporation for US$1.4 million. The projects were not properly implemented because of a shortage of resources and a lack of final designs for the civil and electrical works, and the projects were suspended for several years. Subsequently, ELECTROPERU decided to complete the studies and build the facilities, primarily via force account. At present, 14 projects that will use the equipment which was previously purchased are under construction.

Table 4-1 presents a summary of the SHPP projects which are due to be completed in and after 1987. The table includes only those projects whose civil works are being or have been tendered, or whose equipment has already been purchased, and for which financing is presently available. The table does not include projects under the United Kingdom Agreement for which the procurement of the hydroelectrical equipment has not yet been initiated.

4.2 Existence of Potentially Feasible Projects

The National Plan for Expansion of the Electric Frontier for the 1985-1990 period, which was updated in May 1986, includes 92 projects for electric power generation in rural areas. The Plan encompasses primarily hydroelectric plants of up to 5 MW capacity, with a total capacity of 93 MW. Eleven of the projects would have capacities between 1,000 and 4,500 kW, and the capacities of the other 81 would range from 64 to 1,000 kW. Several of these are already under construction. The plan also includes 43 projects for the extension of distribution networks.

Apart from the projects which have already been included in the Plan for Expansion of the Electric Frontier, the Electrification Project Units and Regional Electric Companies have submitted new packages containing a preliminary total of 90 proposed projects. While financing is sought,

these are being analyzed and assigned priorities in a quarterly review process.

With the purpose of gathering information for the evaluation of projects which have already been defined, as well as to identify other new potentially feasible projects, ELECTROPERU has approved, at the suggestion of the Ministry of Energy and Mines, the employment of COMMSA, a state-owned consulting firm attached to CENTROMIN, to evaluate and compile an inventory of Peruvian river basins. COMMSA will seek the support of several domestic consulting firms, over a one-year period, to investigate the hydrology of the basins and collect other pertinent data needed for prefeasibility studies, as well as to carry out most of the final studies.

There are several projects with final feasibility and design studies either well advanced or already completed that cannot be implemented because of a lack of financing. For example, discontinuing the implementation of projects under the United Kingdom Agreement will leave some 12 projects whose studies are complete or almost complete and which could be financed with funds from another source.

Although specific projects are not identified in this report, there are many existing and potential projects that would be technically feasible and economically viable and from which 15 or 20 could easily be selected for implementation under a new loan agreement with a development agency. Studies have already been completed for some of those projects. A loan application submitted to one of the development agencies should include a list of the projects potentially qualified for financing under the proposed agreement, together with all the available information on their technical and economic feasibility.

4.3 ELECTROPERU's Technical Capabilities

ELECTROPERU'S experience in rural electrification based on small hydroelectric power plants can be summarized as follows. Since 1980, a total of 36 plants have been built; the construction of more than 30 additional plants with capacities of up to 5 MW is projected for the next three years; and packages of proposed projects which are presented to the Rural Electrification Department for analysis and scheduling are continually being evaluated.

More than 200 small- and medium-sized hydroelectric plant projects, in various stages of study and construction, have passed through ELECTROPERU's technical offices during a period of approximately seven years. This effort places Peru among the front runners in Latin America in the promotion of rural electrification based on small hydroelectric power plants.

Although some mistakes have been made during this period, and some of the installed units are presently not in service (for many reasons, not all technical), the success of the technical work that has been completed

should be pointed out. A team of professional and technical personnel, which constitutes ELECTROPERU's greatest asset for facing the future of rural electrification, has been trained.

Consequently, once the problems encountered in the past have been corrected (see recommendations ahead), ELECTROPERU and its dependencies would be fully qualified to carry out projects similar to those currently being implemented. There is within the company the necessary experience to carry out studies, tender works and supervise construction, as well as implement works via force account.

It is understood that ELECTROPERU will employ COMMSA, a state-owned consulting firm, to prepare most of the SHPP final studies, some of which will be passed on by COMMSA to private firms. To ensure that both the COMMSA studies and the future technical work of ELECTROPERU have a high degree of usefulness and facilitate the implementation of the projects, the following measures are recommended:

a) Compare actual SHPP results with the results forecast in the feasibility studies, with emphasis on demand and cost behavior.

b) Based on the above review, adjust the methodology for forecasting demand and costs and for the economic evaluation of projects, with the objective of simplifying the performance of the studies and improving the quality of the results.

c) Seek to consolidate the "AID Methodology" (the methodology for economic evaluation developed by the AID Project Office), or a modification thereof, as the sole technique for evaluating SHPP projects in the Rural Electrification Department.

d) Revise the procedure for assigning priorities to the projects, giving a greater weight to the benefit/cost ratio. Once priorities have been assigned based on this ratio, appropriate and necessary adjustments can be made to take into account Government policies with respect to other factors such as regional priorities.

e) Assign priorities to the studies to be carried out, whether of power plants or of transmission lines and networks, within only one unit of the Rural Electrification Department. That unit should plan and budget the projects to be implemented during a four to five year period, based on a technical and economic optimization of resource use, according to the availability of local and foreign financial resources.

f) Based on ELECTROPERU's experience to date, and taking advantage of similar work carried out in other countries, develop simple, economical and standardized designs for the various small electrical system and SHPP components, specifying the conditions which govern their selection and use.

g) Seek to develop in the consulting firms the concept of design simplicity and flexibility, using uniform and standardized designs, in keeping with the quality of the basic information available, in order to facilitate construction and reduce the costs of the works.

h) Extend the studies for evaluating diferent SHPP design capacities, considering possibilities for future expansion or interconnection with other plants or systems, especially in cases of interconnection with thermal plants. An analysis of several typical situations could be carried out to establish standards and guidelines.

i) Establish a strict supervision of studies, including those awarded to COMMSA, to ensure that adequate results are obtained, especially with regard to collecting and using topographical and geological information, design concepts, and the identification of potential construction problems.

j) To facilitate future project implementation, carry out a comprehensive inventory of existing SHPP, evaluating their present condition and the services being rendered, and draw conclusions to be used as guidelines for future projects.

k) Compile and consolidate, in a centralized, integrated data base, all the information available in ELECTROPERU and outside the organization regarding hydrology, metereology, topography, geology, power demand, electric power consumption, other socio-economic indices important for the prefeasibility and final studies, and an inventory of existing SHPP. In addition to maintaining and centralizing this information, teams of technical personnel should be organized to ensure the permanent gathering and recording of the data as well as to coordinate with other institutions.

4.4 ELECTROPERU's Administrative Capabilities

Although a theoretically adequate organizational and administrative structure for the development of SHPP projects currently exists, as a practical matter it would appear that the coordination of the functions of the Rural Electrification Department could be improved. Several problems which could affect the success of a new program of external financing have been identified. These are detailed as follows:

a) Project implementation proceeds very slowly because of a complicated bureaucratic process that requires decision-making at all levels from the Rural Electrification Department to the Board of Directors. These activities take too much time, which increases costs and delays project implementation.

b) There are significant delays in the payment of consultants and in the approval and signing of contracts for procurement of machinery.

c) Within the Rural Electrification Department, the offices of the various Project Agreements report directly to the Head of the Special Projects and Agreements Unit, a position that has been vacant for several months. The lack of a unit head has complicated the implementation and coordination of activities which must be carried out by the offices of the unit. The position of Head of the Planning and Scheduling Unit of the Rural Electrification Department is also unfilled. These vacancies make the job of the Manager of the Rural Electrification Department more difficult, as he must dedicate a large part of his time to relationships with other ELECTROPERU entities and with outside organizations, as well as coordinate the internal functions of his Department. (See organizational charts in Appendices 4-1 and 4-2.)

d) The information required for the efficient management of the rural electrification program is poorly distributed and organized. The organization and distribution of inventory data for projects which are already completed, still under construction, ready for tendering or under study is especially deficient. This information should be available from one central source.

e) In the AID Project Office, for example, there is significant delay in the preparation of accounting reports and in the final accounting for outstanding advances. Current information on the total invested to date from AID and D.L. 163 sources is not available.

f) Because of the many extraordinary demands on the time of Rural Electrification Department personnel, the detailed budget for the implementation of SHPP and small electrical system projects for 1987 had not been completed as of the end of November 1986. Neither had a resource and cost forecast for the implementation of projects in subsequent years been prepared.

These problems are but a sampling of the administrative deficiencies which limit ELECTROPERU's ability to develop hydroelectric power plants. These and other similar problems have contributed to the delays which have been experienced in the projects carried out under the AID and United Kingdom Agreements and which have led to an under-utilization in the last few years of the funds available for rural electrification (see Appendices 4-3 and 4-4).

In the last four years, an average of seven SHPP has been built annually, providing a total new capacity of 5,400 kW. As indicated in Table 4-1, the tentative program for project implementation in 1987 and 1988 calls for doubling the number of power plants completed each year and for increasing by sixfold (to 33,000 kW) the total installed capacity provided during the previous four years.

The Rural Electrification Department staff is dedicated to its work and is capable of carrying out this program. However, if these goals are to be met, and if a future external financing agreement is to be implemented

efficiently, a series of measures will need to be taken to facilitate management and improve the coordination and control of the work of the various Department units. The recommended measures are (see also Chapter 6):

a) Retain the technical personnel trained during the last few years in the Project Agreement offices and integrate these employees into an ELECTROPERU unit that would enable the institution to undertake successfully future rural electrification programs based on small hydroelectric power plants.

b) Raise the salaries of contract employees and, where possible, provide them a stable position and eliminate the annual renewal of their contracts. The annual contract renewal process creates a continuous concern in the employee regarding his permanency in the institution.

c) Make an effort to improve the coordination of work and to achieve a wide availability of reliable and unified information within the Rural Electrification Department. Assigning personnel to vacant positions, especially at the unit head level, or replacing those positions with another with the responsibility of assisting the Manager of Rural Electrification, would contribute to achieving this goal.

d) Take care to pay pending invoices and account for completed work more expeditiously, thus avoiding the accumulation of idle funds and/or delays in using and accounting for the funds.

e) Take steps to ensure that the Electrification Project Units are transferred to the Regional Electric Companies as integral units, without losing their present effectiveness and making full use of the experience and capabilities which have already been developed.

f) Facilitate the tendering, awarding and contracting process through measures such as the approval of awards and contracts at decision levels lower than the present ones. All the procedures of the process should be reviewed and modified, especially those that relate to the selection of the winning bidder, which should be based on the lowest reasonable offer from prequalified firms.

g) Prepare annually, support and adhere to a program of works to be carried out in the medium term, in accordance with the estimated costs and available annual resources.

h) Implement a single information system for the small electrical system and SHPP projects in order to maintain and make available, from a single source, reliable and up-to-date data on the status of each project, encompassing potential projects still being defined through completed power plants and small electrical systems which are already in service. Each project should be identified by only one name.

4.5 ELECTROPERU's Financial Capabilities

ELECTROPERU's ability to finance rural electrification works depends on two main sources of funds: the electric power consumption tax imposed by D.L. 163 and contributions from external financing agreements.

D.L. 163 is expected to generate a total of approximately I/. 450 million for rural electrification in 1987. At the present exchange rate (I/. 14/ US$), this amount is likely to be distributed approximately as follows:

Hydraulic generation	US$ 12.0 million/year	(37%)
Thermal generation	0.5	(2%)
Substations, lines and networks	13.0	(41%)
Studies	1.0	(3%)
Indirect costs	5.5	(17%)
Total D.L. 163	US$ 32.0 million/year	

Another source of local funds is the reimbursement (or, actually, the exemption) by the government of the applicable customs duties on imported equipment. In the present analysis, these duties have not been taken into account in the calculation of project costs, nor has the exemption from these duties been considered as a source of funds.

External financing is provided primarily through loans, with terms that vary from commercial to soft. In some instances, the agreements also provide grants. With the exception of the AID Project, which has financed studies, civil works, electrical works and equipment procurement, the external financing provided by the agreements currently in effect has been devoted primarily to studies and equipment, which means that local resources are required to complete the civil and electrical works for the projects which are financed.

ELECTROPERU's financial capacity for undertaking new external financing programs for the development of SHPP is shown in Tables 4-2 and 4-3. The first table projects the costs of completing the hydro-generating works (including civil works and hydroelectric equipment) presently being implemented (see Table 4-1).

Since in most cases reliable figures for costs accumulated to date were not available, future costs have been estimated based on the average cost per installed kW and expected progress in implementing the works according to probable year of completion. (In some cases, reliable individual project information was available.)

The project implementation disbursement schedule shown in Table 4-2 would require the provision of the local and external financing estimated in Table 4-3. This latter table indicates that the local fund requirements in 1987 and 1988 (the equivalent of US$12.5 million and US$12.2 million, respectively) would be slightly higher than the revenues anticipated from D.L. 163 in those years (the equivalent of US$12 million each year).

However, for the purposes of the present analysis, it is assumed that the distribution of these funds would be adjusted to cover the indicated requirements.

The analysis shows that all of the funds normally allocated to hydro-generating works would be required just to finish the works of that type that are currently underway. Unless funds usually allocated to transmission lines and networks are diverted to civil works and equipment, no local funds will be available until 1989 to supplement the resources that could be provided by a new external financing agreement. It should be noted that the Rural Electrification Department has recently undertaken an ambitious program for constructing substations, transmission lines and primary networks, such that it is highly unlikely that the portion of the D.L. 163 funds anticipated for the latter works could be reduced.

Although the analysis is based on approximate costs, the results are clear. The ability to make use of external financing is limited by the availability of local funds, especially if this financing is earmarked for the procurement of equipment, with no further provision for financing the corresponding civil (and electrical) works.

In summary, for the next five years, ELECTROPERU's financial capabilities are based on an annual availability of local funds equivalent to US$12 million. Considering an average cost for civil works and equipment of US$1600 per installed kW, a total of 7,500 kW could be put in service each year (five 1,500 kW power plants, ten 750 kW power plants, or fifteen 500 kW power plants).

It is recommended that prior to including this analysis as part of a request for new external financing, ELECTROPERU refine the calculations using reliable costs for individual projects.

TABLE 4-1

TENTATIVE PROGRAM FOR IMPLEMENTATION
OF HYDROELECTRIC WORKS:
WITHOUT NEW PROJECT AGREEMENTS (1987-1989)

			Implementation to be Completed in					
	No. of	Total kW	1987		1988		1989	
Agreement	Projects	Installed	Proj.	kW	Proj.	kW	Proj.	kW
AID	7	4,360	7	4,360	-	-	-	-
U.K.*	7	21,700	2	3,500	5	18,200	-	-
F.R.Germany	3	1,400	1	330	2	1,070	-	-
Other Projects	14	7,480	7	4,920	2	880	5	1,680
Total**	31	34,940	17	13,110	9	20,150	5	1,680

* Only projects for which equipment has already been contracted are included. In addition to the seven projects shown, equipment for two AID Agreement projects were purchased with funds provided by the United Kingdom Agreement.

** The present analysis includes SHPP projects that are considered to be in implementation, i.e., projects for which the tendering process for the civil works has already been started, or which are already under construction. Based on information from several sources in ELECTRO-PERU's Rural Electrification Department, these projects (with the installed capacity indicated in parentheses) are:

AID

Cutervo	(800)
Niepos	(1,000)
San Marcos	(330)
Namora	(580)
Pachiza	(420)
Celendin	(1,000)
Sorochuco	(230)

F.R.G.

Incuyo	(330)
Pozuzo	(870)
Laramate	(200)

United Kingdom

Quiroz	(1,600)
Chumbao	(1,900)
Sandia	(2,200)
Jaén	(3,000)
Chalhuamayo	(3,200)
Caclic	(4,400)
Muyo	(5,400)

Other Projects

Canta	(970)
Hongos	(240)
Huancasancos	(110)
Camaná	(600)
Huari	(1,440)
Pichanaki	(1,340)
Aucará-Cabana	(220)
Querocoto	(720)
Caraveli	(160)
Bambamarca	(1,000)
Pomacocha	(220)
Pomahuanca	(85)
Chuquibambilla	(200)
Sto. Domingo	(175)

TABLE 4-2

FORECAST OF COSTS OF HYDROELECTRIC WORKS:
WITHOUT NEW AGREEMENTS (1987-1989)
(Millions of US$)

Agreement	Year of Project Completion	Completion Costs* Civil Works	Completion Costs* Hydro. Equip.	Completion Costs* Total	1987 Civil Works	1987 Hydro. Equip.	1987 Total	1988 Civil Works	1988 Hydro. Equip.	1988 Total	1989 Civil Works	1989 Hydro. Equip.	1989 Total
AID	1987	1.8	0.4	2.2	1.8	0.4	2.2	-	-	-	-	-	-
United Kingdom	1987	1.3	0.5	1.8	1.3	0.5	1.8	-	-	-	-	-	-
	1988	17.1	6.3	23.4	7.0	2.6	9.6	10.1	3.7	13.8	-	-	-
	Total	18.4	6.8	25.2	8.3	3.1	11.4	10.1	3.7	13.8			
Federal Republic of Germany	1987	0.1	0.1	0.2	0.1	0.1	0.2	-	-	-	-	-	-
	1988	1.0	0.6	1.6	0.4	0.1	0.5	0.6	0.5	1.1	-	-	-
	Total	1.1	0.7	1.8	0.5	0.2	0.7	0.6	0.5	1.1			
Other Projects	1987	2.0	0.3	2.3	2.0	0.3	2.3	-	-	-	-	-	-
	1988	0.9	0.1	1.0	0.4	-	0.4	0.5	0.1	0.6	-	-	-
	1989	2.0	0.4	5.3	0.1	0.1	0.2	0.8	0.1	0.9	1.1	0.2	1.3
	Total	4.9	0.8	5.7	2.5	0.4	2.9	1.3	0.2	1.5	1.1	0.2	1.3
Total		26.2	8.7	34.9	13.1	4.1	17.2	12.0	4.4	16.4	1.1	0.2	1.3

* Forecast derived from an estimate of the percentage of total costs still to be incurred and the following average costs per installed kW:

	Civil Works	Hydroelectric Equipment	Total
0-1,000 kW	US$ 1,200/kW	US$ 500/kW	US$ 1,700/kW
Over 1,000 kW	US$ 1,100/kW	US$ 400/kW	US$ 1,500/kW

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TABLE 4-3

FINANCING OF HYDROELECTRIC WORKS:
WITHOUT NEW AGREEMENTS (1987-1989)

(Millions of US$)

Agreement	1987			1988			1989			Total		
	D.L. 163	External Financing	Total	D.L. 163	External Financing	Total	D.L. 163	External Financing	Total	D.L. 163	External Financing	Total
AID	0.8	1.4	2.2	-	-	-	-	-	-	0.8	1.4	2.2
United Kingdom	8.3	3.1	11.4	10.1	3.7	13.8	-	-	-	18.4	6.8	25.2
F.R.Germany	0.5	0.2	0.7	0.6	0.5	1.1	-	-	-	1.1	0.7	1.8
Other Projects	2.9	-	2.9	1.5	-	1.5	1.3	-	1.3	5.7	-	5.7
Total	12.5*	4.7	17.2	12.2*	4.2	16.4	1.3	-	1.3	26.0	8.9	34.9

* Local fund requirements for 1987 and 1988 exceed slightly the assumed annual availability of US$12.0 million.

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5. FORMULATION OF THE PROGRAM

5.1 Recommended General Scope

The analysis of ELECTROPERU's ability to implement a new program of external financing of SHPP led to the conclusion that there will be no local counterpart funds available until 1989 to devote to projects other than those which are already programmed. (If the United Kingdom Agreement were not discontinued, the absorption of local resources by current projects would continue beyond 1989.) It was also observed that the completion during the next two years of the projects already underway would annually place in service twice the annual average number of power plants completed in the last four years, requiring a corresponding extension of the technical and administrative capabilities of the Rural Electrification Department.

Consequently, any new external financing program for SHPP, including the proposed Italian Agreement, which would consist of a loan of US$5.3 million and a grant of US$2.7 million for hydroelectric equipment, as well as a commercial loan of US$2.6 million for the purchase of thermal generating equipment, should not begin until 1989. The tentative program described below was prepared on the basis of this conclusion.

A new agreement with an international development agency should encompass the following elements:

- studies and designs;
- civil works and hydroelectric equipment;
- substations, transmission lines and primary distribution networks; and
- technical assistance for the promotion of the productive use of electric power, the development of standardized designs, the improvement of the organization and administration of the Rural Electrification Department, and the strengthening of the technical training schools.

Secondary networks and residential connections have not been included among the elements that require financing since, by law, these must be financed by the users.

Although the implementation of the works would not begin until 1989, the studies, designs and technical assistance should begin as soon as possible, even before the proposed financing is granted.

Assuming that the United Kingdom Agreement is suspended and that the proposed Italian Agreement becomes effective in 1989, a new external financing agreement for SHPP could consist of US$10 million for civil

works and equipment, an equal amount for electrical works, and some US$2 million for studies and technical assistance. The works to be financed would be carried out during a three-year period. The resulting implementation program, which is described in detail below, is summarized in Table 5-1. According to the proposed program, an average of 12 SHPP would become operational each year during the 1987-1991 period, increasing the installed capacity in rural areas by almost 70 MW, to a total of approximately 310 MW. The goal of an installed capacity of 335 MW by 1990 will probably not be attainable because of a lack of sufficient resources.

5.2 Civil Works and Generating Equipment

The formulation of the new external financing agreement is based on the availability of counterpart funds for the hydroelectric works.

According to the proposed terms, the Italian Agreement would provide a loan of US$5.3 million for four sets of hydroelectric equipment with an average capacity of approximately 3,300 kW, and a grant of US$2.7 million for two sets of equipment of the same type and approximate capacity. However, it is assumed that, in accordance with ELECTROPERU's wishes, the number of sets of equipment to be financed, at least by the grant, can be changed, without increasing its total value, to allow for the purchase of six sets of equipment with an average capacity of 1,100 kW. It is estimated that the equivalent of US$20.9 million would be required over a three-year period to carry out the civil works needed to accommodate the equipment purchased with loan and grant funds.

The tentative amount of the possible new agreement has been determined on the basis of the local resources that would remain for use as counterpart funding for external financing after providing the funds required for the Italian Agreement and other projects which are already in progress. A 50% participation in the payment of the costs of civil works and equipment is assumed for each source of funds, along with a maximum annual availability of the equivalent of US$12 million in local funds for hydroelectric works. Table 5-2 shows the anticipated annual contributions of local funds and external financing in 1989, 1990 and 1991.

The total annual costs of the projects that would be implemented under the different agreements, in accordance with available financing, are summarized in Table 5-3. These were calculated using the same average costs per installed kW that were used in Chapter 4 to estimate the costs of projects which are still underway. Costs are based on the tentative implementation program shown in Table 5-4. The new agreement would finance an installed capacity of 12,000 kW, divided among an estimated 14 SHPP, with an average capacity of 850 kW. The cost per installed kW is estimated at approximately US$1,670, including only civil works and hydroelectric equipment. The total cost of the works and equipment would amount to US$10 million.

5.3 Recommended Level of Financing

Table 5-5 presents a possible financial plan for 1987-1991 that includes all the components of the rural electrification program.

The new external financing agreement would contribute a total of US$22 million, distributed as follows:

Hydroelectric plants	US$10.0 million
Electrical works	US$10.0 million
Studies	US$1.4 million
Technical assistance and training	US$0.6 million

In addition to covering half of the costs of the 14 SHPP (including the associated electrical works), the proposed level of financing would cover a similar portion of the costs of extending new transmission lines and distribution networks in other service areas. The length of the lines and networks to be constructed would depend on the requirements of the projects selected from the universe of feasible projects suitable for funding (see Section 4.2). Projects would be selected after the completion of the appropriate feasibility studies.

In addition to maintaining an adequate balance with local resources, the recommended level of external financing would also fall within the capabilities of ELECTROPERU and the Regional Electric Companies to carry out the selected projects. It is assumed that the resulting foreign indebtedness would not conflict with national economic policies. However, this is an aspect of the proposed agreement that would require further investigation.

5.4 Technical Assistance and Training

To help ELECTROPERU strengthen its rural electrification program, the new external financing agreement should contain provisions for technical assistance and training in the following areas:

a) Productives Uses of Electric Power

An advisor in the promotion of the productive use of electric power would have the overall mission of strengthening and training ELECTROPERU's Electricity Promotion Service (EPS), enabling it to act as a catalyst of rural development based on a better use of electricity. The technical assistance would be provided by contracting an expert in rural development with experience in Latin America to train and work together with EPS personnel for eight months in promotional tasks and studies such as the following:

- preparation of pilot feasibility studies of the most common potential uses of electricity, in order to determine indicators of viability that are easy to understand and apply, such as the number of cows necessary to justify a milking machine, or the amount of cultivated area that would justify an irrigation pump;

- determination of the requirements for obtaining loans from the Departmental Development Corporations, banks or other institutions, and the design and implementation of a program to assist users in the preparation of the required documentation;

- preparation of pamphlets and audio-visual tapes that demonstrate to farmers, carpenters, bakers, mechanics, etc. how they can increase their production and income and/or reduce the number of hours they work by purchasing electrical equipment and using electric power; and

- promotion, with the cooperation of the more capable and resourceful users, of the creation of model dairies, shearers and workshops which would demonstrate to other residents the advantages of using electricity.

b) Development of Standardized Designs

A civil engineer would be required for three months, and an electrical engineer for one month, to work with the engineers of the Planning Unit of the Rural Electrification Department, who have already begun research on the subject, to develop standardized designs that could be used to reduce the costs of studies and construction.

c) Organization and Management Systems

The services of an expert in organization and management, for a four-month period, would help the Rural Electrification Department to restructure its organizational scheme and improve its systems and procedures, including those that govern the tendering, awarding and contracting process. The expert would also aid in specifying links between the administrative and accounting systems of the Department and the Regional Electric Companies, with the objective of achieving a better coordination of functions and a better utilization of staff skills.

d) Strengthening of Technical Schools

ELECTROLIMA's two technical schools, which train the operations and maintenance personnel of the Regional Electric Companies charged with operating the SHPP, would benefit from the acquisition of new electrical equipment for their workshops. An electrical engineer with expertise in equipment for small electrical systems should be contracted for a one-month period, to examine existing equipment in the workshops and recommend an inventory of metering equipment and

other new teaching tools that should be purchased, and to train the school's instructors. The new agreement should also finance the procurement of the suggested equipment as well as the costs of one-month visits to the technical schools by experts from vendors to update the knowledge of the teaching personnel.

e) Development of the National Industrial Capability

An expert in the manufacturing of hydroelectric equipment could be employed for two months to assist local industries that have the capability to manufacture such equipment to improve their products and reduce their manufacturing costs.

f) Visits to Other Countries

An amount could be allocated to cover the costs of visits by personnel of ELECTROPERU and the technical schools to institutions or seminars in other countries, to exchange ideas and to make use of the knowledge and progress achieved in other countries.

Following is an estimate of the costs of the suggested technical assistance and training activities:

Advisors: 20 Months	US$300,000
Electrical Equipment:	250,000
International Travel:	50,000
Total	US$600,000

5.5 Studies and Designs

One of the primary objectives of the new external financing agreement would be the development and testing of the standardized designs recommended previously, as well as the review and refinement of the economic evaluation methodology formulated by the AID Project Office.

Experience already gained in Peru in the design and construction of SHPP indicates the path that should be followed in the development of future power plants. Based on a review of the progress achieved in the design and construction of the SHPP financed by the AID Project, several observations that should be considered in an adjustment of the design process have been formulated.

Most of the basic data available on hydrology, topography and geology are not very reliable, and the small size of the works does not justify lengthy and costly investigation to improve the reliability. The SHPP designs should reflect this situation. They should be as simple as possible and sufficiently flexible to allow for modification in the field, in accordance with the actual conditions encountered during construction. (The tendering and contracting process should also reflect this situation, with contracts based on unit prices rather than on lump sums.)

On the other hand, the studies and designs must identify the requirements, the principal factors that affect costs, and possible problems that could arise because of inadequate basic information, as well as the appropriate location of the major structures.

In SHPP projects, as has already been suggested, standardized designs can help to reduce costs and facilitate efficient development and implementation. Emphasis should be placed on simplicity and uniformity.

In general, design flows and capacities for power plants constructed recently have been based on an excedence value of 90% (i.e., the actual flow is expected to exceed the design flow 90 percent of the time, allowing the power plant to operate almost always at full capacity). Although a design based on a 90% excedence value can be justified in an isolated system that uses only hydroelectric power, such a standard may not always be the most appropriate for hydrothermal systems where a diesel plant must be combined with a SHPP to cover all the demand. In such a case, a SHPP with a greater capacity and a lower excedence value could be considered as an option that would displace thermal generation during periods of greater water availability. The viability of such an option would naturally depend on the sufficient duration of the higher flows.

Another factor to be considered in designing the plants is the possibility of future expansion, particularly where there is great uncertainty with respect to available flows or where there is a possibility of interconnection with other plants or systems. In such cases, the capacity of the canal can be a limiting factor, although sometimes a canal with greater capacity can be designed without significantly increasing construction costs. Then, if the flow of water in the river should exceed the design flow, the capacity of the plant could be increased in the future at a reasonable additional cost if the canal already had sufficient capacity and if the other structures had been designed to accommodate an expansion. Otherwise, increasing the capacity of the canal at a later stage would be very costly.

Section 4.3 presents several recommendations related to studies and designs, as well as recommendations regarding the economic evaluation and selection of projects.

The new external financing agreement should include approximately US$1.4 million for the final studies and designs, most of which would be awarded to domestic consulting firms through the state-owned COMMSA, which the MEM and ELECTROPERU have designated as coordinator of the studies.

5.6 Tentative Implementation Schedule

The approval of a loan application can require an average of 18 months. Based on ELECTROPERU's experience to date in SHPP projects, it is likely that the necessary procedures can be completed in this case during a

similar period of time, as long as all requirements are met in a timely manner (see Chapter 8). Based on this assumption, funds from the agreement could be available in mid-1988. In certain cases, preliminary activities reimbursable by an agreement can begin several months prior to the formal loan approval, subject to advance authorization by the development agency.

In order to begin construction in early 1989, the technical studies would have to be begun no later than the beginning of 1988, so that the tendering and contracting process for the first SHPP could be initiated as soon as the loan application is approved (mid 1988). The preliminary studies, including the pre-feasibility analyses, should be carried out earlier, during 1987, in order to create a suitable package of potentially feasible and viable projects.

Given the importance of the studies, it is suggested that the technical assistance in the standardization of designs be initiated at the beginning of 1988, in anticipation of the approval of the loan and the retroactive reimbursement of the corresponding costs. Other technical assistance activities would be carried out once the requested financing has been authorized.

The suggested tentative implementation program is illustrated in the diagram of Figure 5-1.

TABLE 5-1

SUMMARY OF THE TENTATIVE IMPLEMENTATION PROGRAM
FOR HYDROELECTRIC WORKS (1987-1991)

Year	No. of Completed Projects	Total kW Installed	Investment (in US$ millions) D.L. 163	External Financing	Total
1987	17	13,110	12.5	4.7	17.2
1988	9	20,150	12.2	4.2	16.4
1989	7	3,880	12.0	5.1	17.1
1990	10	13,800	12.0	7.6	19.6
1991	15	18,040	12.0	5.3	17.3
Total 1987-1990	43	50,940	48.7	21.6	70.3
Total 1987-1991	58	68,980	60.7	26.9	87.6
Annual Average 1987-1991	12	13,800	12.1	5.4	17.5

TABLE 5-2

FINANCING OF HYDROELECTRIC WORKS:
WITH NEW AGREEMENTS (1989-1991)*
(Millions of US$)

Agreement	1989			1990			1991			Total		
	D.L. 163	External Financing	Total	D.L. 163	External Financing	Total	D.L. 163	External Financing	Total	D.L. 163	External Financing	Total
Italian loan	4.9	1.3	6.2	5.4	2.7	8.1	4.2	1.3	5.5	14.5	5.3	19.8
Italian grant	3.2	1.2	4.4	1.6	0.9	2.5	1.6	0.6	2.2	6.4	2.7	9.1
New agreement	2.6	2.6	5.2	4.0	4.0	8.0	3.4	3.4	6.8	10.0	10.0	20.0
Other projects (Works begun previously)	1.3	-	1.3	-	-	-	-	-	-	1.3	-	1.3
Other projects (Works begun in or after 1989)	-	-	-	1.0	-	1.0	2.8	-	2.8	3.8	-	3.8
Total	12.0	5.1	17.1	12.0	7.6	19.6	12.0	5.3	17.3	36.0	18.0	54.0

* Includes financial requirements for civil works and hydroelectric equipment only.

Arthur D. Little, Inc.

TABLE 5-3

COST FORECAST FOR HYDROELECTRIC WORKS:
WITH NEW AGREEMENTS (1989-1991)*
(Millions of US$)

Agreement under Which Projects are Implemented	Project Completion Year	1989			1990			1991			Total		
		Civil Works	Hydro. Equip.	Total	Civil Works	Hydro. Equip.	Total	Civil Works	Hydro. Equip.	Total	Civil Works	Hydro. Equip.	Total
Italian loan	1990	4.9	1.3	6.2	2.4	1.3	3.7	-	-	-	7.3	2.6	9.9
	1991	-	-	-	3.0	1.4	4.4	4.2	1.3	5.5	7.2	2.7	9.9
	Total	4.9	1.3	6.2	5.4	2.7	8.1	4.2	1.3	5.5	14.5	5.3	19.8
Italian grant	1989	1.6	0.9	2.5	-	-	-	-	-	-	1.6	0.9	2.5
	1990	1.6	0.3	1.9	0.8	0.6	1.4	-	-	-	2.4	0.9	3.3
	1991	-	-	-	0.8	0.3	1.1	1.6	0.6	2.2	2.4	0.9	3.3
	Total	3.2	1.2	4.4	1.6	0.9	2.5	1.6	0.6	2.2	6.4	2.7	9.1
New agreement	1990	4.0	1.2	5.2	1.9	1.2	3.1	-	-	-	5.9	2.4	8.3
	1991	-	-	-	3.2	1.7	4.9	5.1	1.7	6.8	8.3	3.4	11.7
	Total	4.0	1.2	5.2	5.1	2.9	8.0	5.1	1.7	6.8	14.2	5.8	20.0**
Other projects (Works begun previously)	1989	1.1	0.2	1.3	-	-	-	-	-	-	1.1	0.2	1.3
Other projects (Works begun in or after 1989)	1990	-	-	-	-	-	-	-	-	-	-	-	-
	1991	-	-	-	0.9	0.1	1.0	1.8	1.0	2.8	2.7	1.1	3.8
	Total	-	-	-	0.9	0.1	1.0	1.8	1.0	2.8	2.7	1.1	3.8
	Total	13.2	3.9	17.1	13.0	6.6	19.6	12.7	4.6	17.3	38.9	15.1	54.0

* Costs are estimated in accordance with the tentative implementation program presented in Table 5-1 and the unit costs of Table 4-2. Costs are included only for civil works and hydroelectric equipment, excluding any expenditures for customs duties. Costs for electrical works are not included. The included costs would be funded by internal and external resources, according to the terms of each agreement.

** It is assumed that US$10 million would be contributed by new external financing and that the remainder would be covered by local resources.

TABLE 5-4

TENTATIVE IMPLEMENTATION PROGRAM
FOR HYDROELECTRIC WORKS:
WITH NEW AGREEMENTS (1989-1991)

Agreement	No. of Projects	Total kW Installed	Implementation to be Completed in 1989		1990		1991	
			Proj.	kW	Proj.	kW	Proj.	kW
Italian loan	4	13,200	-	-	2	6,600	2	6,600
Italian grant	6	6,600	2*	2,200	2	2,200	2	2,200
New agreement	14	12,000	-	-	6	5,000	8	7,000
Other projects (Works begun previously)	5	1,680	5	1,680	-	-	-	-
Other projects (Works begun in or after 1989)	3	2,240	-	-	-	-	3	2,240
Total	32	35,720	7	3,880	10	13,800	15	18,040

* It is assumed that there are projects currently paralyzed with 33% of their civil works completed.

TABLE 5-5

POSSIBLE FINANCING FOR RURAL ELECTRIFICATION WORKS (1987-1991)

(Millions of US$)

Source of Funds	1987	1988	1989	1990	1991
Hydroelectric Generation	17.2	16.4	17.1	19.6	17.3
D.L. 163	12.5	12.2	12.0	12.0	12.0
AID	1.4	-	-		-
United Kingdom	3.1	3.7	-	-	-
Federal Republic of Germany	0.2	0.5	-	-	-
Italian loan	-	-	1.3	2.7	1.3
Italian grant	-	-	1.2	0.9	0.6
New agreement	-	-	2.6	4.0	3.4
Thermal Generation	3.0	0.3	-	-	-
D.L. 163	0.4	0.3	-	-	-
I. Fraschini loan	2.6	-	-	-	-
Substations, Lines & Networks	13.6	13.2	17.4	17.3	16.8
D.L. 163	12.6	13.2	13.9	13.8	13.8
AID	1.0	-	-	-	-
New agreement*	-	-	3.5	3.5	3.0
Studies and Technical Assistance	1.0	1.2	1.2	1.2	1.2
D.L. 163	1.0	0.8	0.6	0.7	0.7
New agreement	-	0.4	0.6	0.5	0.5
Total	34.8	31.1	35.7	38.1	35.3
D.L. 163**	26.5	26.5	26.5	26.5	26.5
AID	2.4	-	-		-
United Kingdom	3.1	3.7	-	-	-
Federal Republic of Germany	0.2	0.5	-	-	-
Italian loan	-	-	1.3	2.7	1.3
Italian grant	-	-	1.2	0.9	0.6
I. Fraschini loan	2.6	-	-	-	-
New agreement	-	0.4	6.7	8.0	6.9

* Includes electrical works for the power plants financed with funds from the loan, in addition to the extension of lines in other service areas.

** Does not include indirect costs (administrative, imputed and financial expenditures) that are estimated at approximately 17% of the total available from D.L. 163 for 1987.

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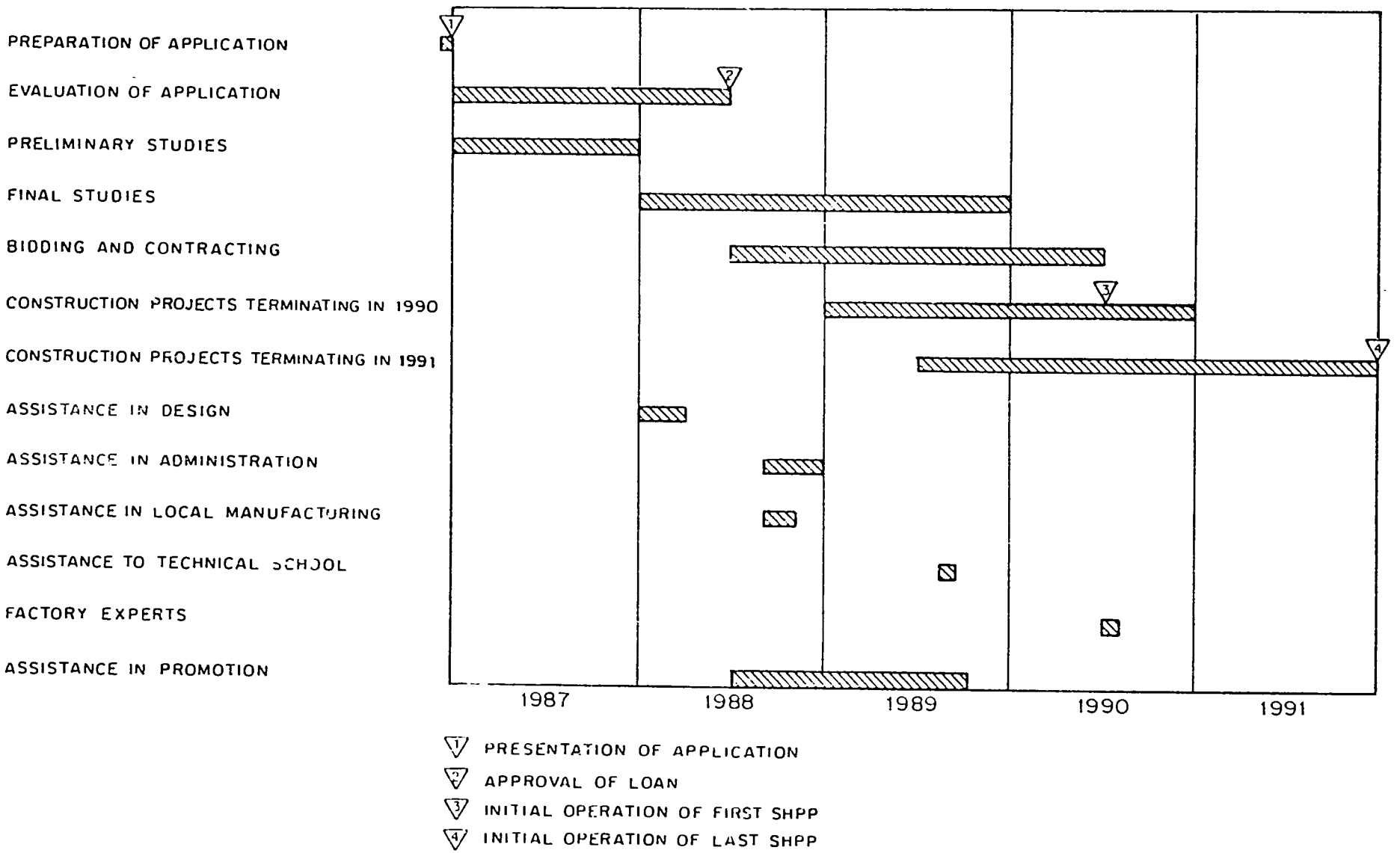
FIGURE 5-1

SCHEDULE OF THE PRINCIPAL ACTIVITIES OF THE PROPOSED EXTERNAL FINANCING PROGRAM



6. ORGANIZATION AND ADMINISTRATION OF THE PROGRAM

6.1 Coordinating Entity in ELECTROPERU

Although the decentralization policy of the GOP seeks eventually to give the Regional Electric Companies full responsibility for implementing projects such as the SHPP, this process will take some years to carry out. Thus, the coordination of the proposed external financing program should still be centered in ELECTROPERU's Rural Electrification Department.

However, the recent transfer of the Electrification Project Units to the Regional Electric Companies has resulted in the assumption of responsibility for project implementation and construction by the latter, which will require a change in the related responsibilities and duties of the Rural Electrification Department.

To coordinate the implementation of activities related to the new agreement, a Project Office should be established in the Special Projects and Agreements Unit of the Rural Electrification Department. However, to avoid duplicating efforts within the Department, the planning and scheduling of project works, as well as the control of their implementation, should be effected by the Planning and Scheduling Unit and the Management Control Unit, respectively.

The Project Office would be responsible for coordination with the development agency and for monitoring project implementation to ensure that the requirements of the loan agreement are met. The Project Office would help the other two units to adjust their work to meet those requirements. It would also ensure that adequate communication takes place between the Rural Electrification Department and the Regional Electric Companies, especially in matters relating to supervision and control of construction and cost accounting.

It is recommended that all relations with other entities of ELECTROPERU be conducted through normal channels, using existing capabilities and without creating new dependencies that would duplicate the functions of others.

In order to simplify the required coordination, consideration should be given to concentrating the projects of the new agreement in the geographic areas of only one or two of the Regional Electric Companies.

6.2 Regional Electric Company Responsibilities

The Regional Electric Companies covering the areas where the projects are located will be responsible for implementating them in accordance with the designs and using the resources provided by the Rural Electrification Department. To facilitate these tasks, an employee should be designated to coordinate relations with the Project Office and to provide all

information required by that office, thereby enabling the Project Office to conduct its business with the development agency in a satisfactory manner.

The designated employee should keep the Project Office and the Management Control Unit informed of construction progress and of any problems that might arise during implementation, permitting opportune measures to be taken to resolve them.

7. ESTIMATION OF BENEFITS

7.1 Project Evaluation Methodology

One of the major goals of the AID Project was the development of a methodology for the national economic evaluation of SHPP projects. This methodology, which incorporates the concept of consumer surplus, makes possible a uniform comparison of project benefits and economic costs and facilitates the assignment of implementation priorities to the projects based on their economic viability. Consequently, it is suggested that this methodology be used to evaluate the projects to be funded by the new agreement. Appendix 7-1 contains a brief description of the methodology (which is known internally at ELECTROPERU as the "AID Methodology").

The methodology was formulated without having available much information on the demand for electricity or SHPP costs. Much more information is now available as a result of the experience gained in constructing and operating the power plants built through the AID and other agreements. It would be reasonable now, prior to applying the methodology to projects of the proposed new agreement, and as a first step in the development of an evolving and ongoing methodology, to review the initial assumptions and to update them on the basis of the new information that is presently available. Aspects of the methodology that would be susceptible to modification and enhancement include the following:

a) The curves which are used to forecast the electrification coefficient (homes with electricity over total number of homes). The curves currently used appear to project a coefficient which is too low.

b) The curves for unit household and public lighting consumption as a function of the number of subscribers. The current curves are estimates based on limited data. An analysis of the actual power consumption patterns in the areas served by the recently-built SHPP could verify the validity of the curves or could lead to the estimation of unit consumption as a function of another independent variable (such as time) with different upper and lower limits. Distinguishing among urban, suburban and rural users might also be useful.

c) The assumptions regarding the number of residential subscribers per commercial subscriber and the unit consumption of commercial subscribers.

d) The set of data obtained from the survey of the consumption of energy from other sources "without the project". Gathering this information has turned out to be rather expensive, such that ways to reduce data collection costs should be sought, perhaps by identifying common consumption patterns in communities with similar characteristics. Such an approach would allow the development of unit consumption figures and the forecasting of total consumption based on preestablished standards, according to the classification of the community or

town. (Generally, this data is compiled for the prefeasibility study but is not updated in the final study.)

e) The expression for estimating operating and maintenance costs as a function of installed capacity. Actual costs of plants already in operation could verify the validity and update the form and coefficients of the equation, particularly those related to the labor required to operate the small hydroelectric plants.

f) Comparison with other sources of electric power. The petroleum costs used in the comparison with the thermal alternative have changed and should be updated. Explicit consideration should also be given to the alternative of extending transmission lines from another plant or from the interconnected grid.

7.2 Comparison With Other Sources of Electric Power

In addition to calculating the benefit/cost ratio for each project, the cost of obtaining electric power from a SHPP should be compared with the costs of obtaining it from other sources, including the extension of transmission lines and thermal generation. (No additional benefit analysis is required, since it is assumed that the benefits of providing electricity to a community would be the same for all sources.)

In addition to the analyses of this type that would be included in the feasibility studies of the individual projects, a comparison of the costs of obtaining electricity from different sources, based on discounted costs of typical projects, should be included in the documentation that supports the evaluation of the proposed new agreement. To illustrate and explain the type of analysis required, there follows here and in Appendix 7-2 a comparison of costs based on the information available when this report was prepared:

	US$/kW Installed	US$/Kwh Generated
100 MW hydroelectric plants	1,000-1,500	0.02-0.04
Small hydroelectric plants	1,700-3,000	0.05-0.08
50 MW thermal plants	400-1,350	0.06-0.09
Small thermal plants	--	0.08-0.10

The comparative costs per installed kW include the costs of civil works, hydroelectrical equipment and transmission lines (although transmission lines usually weigh much more heavily in the costs of SHPP than they do in the costs of large power plants). In the comparison of costs per kWh generated, both capital costs and yearly operating costs are taken into account.

In order to compare the cost indicators of SHPP with those of projects involving the extension of lines from an interconnected network, informa-

tion is required not only on the cost of the transmission lines, but also on the cost of generating the energy that would be consumed. This last cost depends on the level of utilization of the available capacity. In the short term, only the marginal cost of generating the additional energy required, which is generally lower than the marginal cost of increasing the capacity of the system, should be taken into account. In the medium and long term, however, not only the cost of generation, but also the cost of additional capacity must be considered, since eventually the installed capacity will have to be increased. For the interconnected system in 1987, the Electricity Master Plan forecasts an excess capacity of only 18 percent over the peak demand, without considering a reserve margin, and an average annual growth of demand of approximately five percent.

The cost of a 10 to 20 kV transmission line is estimated at US$15,000 per kilometer. If the alternative to constructing an 800 kW SHPP were the extension of a transmission line over a distance of 40 km, for example, the transmission cost incurred would be approximately US$0.02 per kWh. The total cost of the alternative (in the long run) would be calculated by adding the cost of transmission to the cost of generating the power (including capital costs and operating costs.)

7.3 Comparison of Benefits and Costs

Without having available prefeasibility studies for a group of projects that could be carried out under the proposed new agreement, the specific benefits of the proposed agreement cannot be measured. However, bearing in mind the large number of potential projects that are known to exist, and assuming that within this universe there are several projects with benefit/cost ratios similar to those of the projects implemented under the AID Agreement, it can be concluded that a new external financing agreement would be economically justified.

In Appendix 7-2 it can be seen that three of the AID projects were shown to have benefit/cost ratios of about 1.4, at a 12% discount rate, and including costs of transmission lines and distribution networks. Such a benefit/cost ratio indicates that it would not be difficult to find other projects with similar economic returns, since the above mentioned projects can be considered to be representative of the universe of potential projects.

7.4 Criteria for the Selection of Projects

The projects implemented under the AID Agreement were selected primarily because of their economic viability, with consideration having been given also to their technical feasibility and their location in regions which had already benefitted from other AID-funded projects and to which the GOP had assigned a high development priority. However, the economic rate of return criteria, usually measured by the benefit/cost ratio, is still

not generally used by ELECTROPERU as a basis for the selection of projects or the establishment of implementation priorities.

To assign priorities to the projects encompassed by the National Plan for Expansion of the Electric Frontier, which, with a few exceptions, tend to be isolated systems of less than 2.5 kW capacity, the Planning Office of the Rural Electrification Department has devised a ranking system based on the assignment of points in each of several different categories. Fifteen categories or evaluation factors have been defined, with each category having arbitrarily been given a maximum value, as follows:

Evaluation Factor	Maximum Scores
Present status of the study	5
Electrical infrastructure	11
Demand for electricity	6
Utilization of sources of energy	10
Physical progress	10
Financing	10
Committed investment	10
Investment per subscriber	15
Substitution of hydropower for thermal power	5
Population to be served	9
Geographic location	6
Existing infrastructure for access	9
Population growth rate	5
Priority of the microregion	18
Level of community organizations	3
Total	132

Each factor has an associated scale from which points are assigned to each sub-project according to its relevant characteristics. Project implementation priorities are determined on the basis of the total number of points assigned.

The weighted factor method suffers several defects. For example, the relative weights of the factors are arbitrary and very subjective; the factors give very little weight to the economic viability of projects; the effects of the distribution of costs and benefits over time are not considered; and the results do not necessarily lead to an increase in national wealth and welfare.

A much more rational approach would be to assign priorities initially according to the benefit/cost ratios. If necessary, these priorities could be adjusted to take into account government policies with respect to factors such as the geographic distribution of investments or the type of financing available. The benefit/cost ratio of a project implicitly includes an evaluation of several of the factors which are assessed individually in the weighted factor method.

Consequently, the present scheme for assigning priorities should be modified to take into account the benefit/cost ratio, and a relatively heavy weight should be given to the latter indicator. This change should be effected before the new agreement becomes effective, so that all SHPP projects, whether or not they fall under the new agreement, can be evaluated using the same criteria.

8. PREPARATION OF A LOAN APPLICATION

8.1 General Requirements

To support a formal application for external financing, a series of documents that describe the project and provide a justification for its implementation must be prepared. The timely preparation of these documents will facilitate the process and enable the application to be approved within a reasonable period of time. Such a reasonable period between the formal presentation of the application and the signing of a loan agreement by the GOP and a development agency could be from 15 to 20 months. The required procedures and documentation will depend on the agency to which the request for external financing is submitted. A guide or checklist of the procedures that must be followed and the documents that must be prepared can be obtained by ELECTROPERU directly from the international development agencies.

Nevertheless, to assist in initiating the process and preparing the documentation, the following is a preliminary guide for the preparation of the application that ELECTROPERU expects to submit to the international development agencies. This preliminary guide should be adjusted and completed once a specific institution has been selected by the GOP and ELECTROPERU.

The most important steps are:

1. Ascertain the priority that the GOP has assigned to the project and the selection of the development agencies that should be approached. Also, determine which local institution will be responsible for preparing and submitting the application.

2. Submit the formal application to the specified development agency, together with proof of the priority which has been assigned to the project and any descriptive information that may have been prepared.

3. Prepare the support documentation and, as it is completed, submit it to the financing agency. This documentation should include:

   - Frame of reference for the project, with a general overview of the energy sector and the electric power subsector, both on a national and a local level, with data on inputs, energy sources, type of fuels and capacities.

   - Basic data on the electric company responsible for implementing the project. This data should include: existing generating plants (location, type, age and capacity) and transmission, subtransmission and distribution systems. Works in progress, their financing and probable completion dates. Maintenance programs.

- Analysis of demand and of the productive uses of electric power.

- Project summary, including organizational charts, goals and objectives of the borrowing and the implementing entities, indicating hierarchies, dependencies and degrees of autonomy.

- Justification of the geographic location of the project, maps, general and detailed drawings.

- Complete project description and basic calculations.

- Total project cost broken down by local and foreign currency, total amount of the requested loan, and amount and origin of local counterpart funds. Suggested financial terms and conditions. Comparison of the selected solution with other alternatives, and its technical-economic justification.

- Role of the project in the country's overall development plans and in the energy sector, as well as in the global financial program of the implementing institution.

- Financial analysis of the sector and the institution, including a description and justification of its pricing policy.

8.2 Necessary Additional Studies

As a result of having prepared the National Plan for Expansion of the Electric Frontier and having collected the information necessary for a preliminary evaluation of the projects included in the Plan, ELECTROPERU already possesses a large part of the information required for the preparation of the loan application and the supporting documents. To be able to submit to the development agency a package of potentially feasible projects that will demonstrate the viability of the proposed agreement, ELECTROPERU has requested the state-owned consulting firm, COMMSA, in a joint effort with domestic consulting firms, to prepare prefeasibility studies for 11 small hydroelectric power plant projects, as well as 14 final studies for additional transmission line and network projects.

To ensure that the final package contains an appropriate number of feasible projects, approximately 20 prefeasibility studies should be carried out, since some of the proposed projects may ultimately be rejected for technical or economic reasons.

With the possible exception of special information that could be requested by the development agency once the loan application and the available documentation have been reviewed, the aforementioned prefeasibility studies should provide the necessary technical and economic information.

In preceding sections of this report, the need to prepare a projection of the use of the funds available to the rural electrification program has been mentioned. This financial planning is essential for the coordinated management of the projects and agreements and for the timely implementation of the construction work. It is recommended that the analysis in Chapter 5 be updated, refined and prepared in greater detail using specific data from projects currently underway as it becomes available.

To complete the required basic information, ELECTROPERU should prepare an analysis of the revenues and expenditures of the electrical sector, in order to indicate the degree to which the sector's expenditures are covered by the subscriber payments generated by present rate level and structure. The analysis should include an explanation of the GOP pricing policy and plans (if any) to achieve self-sufficiency in the sector.

Apart from the additional studies mentioned here, Chapter 4 recommends a series of measures that could be taken to improve ELECTROPERU's performance in the developoment of rural electrification.

APPENDICES

APPENDIX 1-1

LIST OF PERSONS INTERVIEWED

Agency for International Development (AID)

Mr. Mark Silverman	Chief, Office of Development Resources
Mr. Alfredo Larrabure	Project Coordinator

Empresa Pública de Electricidad del Perú (ELECTROPERU), Lima

Mr. Emilio Chaparro Chaparro	Construction Manager
Mr. Oswaldo Morán Márquez	Manager, Rural Electrification Department
Mr. Benjamín Ibarra	Head, AID Project Office
Mr. Juan Rojas Ramos	Head, Management Control Unit, Rural Electrification Department
Mr. Hernán Bustamante	Head, Rural Electrification Unit, Technical Division
Mr. Antonio Fernández Cáceres	Economist, AID Project Office
Mr. Hugo Meza	Accountant, AID Project Office
Mr. Pedro José Belleza	Cartographer, AID Project Office
Mr. Rafael Hospina	Head, United Kingdom Project Office
Mr. Six o Zegarra	Head, Planning Office, Rural Electrification Department
Mr. Jorge Suárez	Engineer, Planning Office
Mr. Luis Prieto	Head, Standardization and Design Office
Mr. Francisco Vilela	Head, Programming Office
Mr. Armando Guevara	Engineer, Programming Office
Ms. Rosario Torres	Sociologist, Planning Office
Mr. Homero Fuertes	Head, Accounting Control Office
Mr. Amador Hurtado	Head, Technical Evaluation Office
Mr. Isidoro Hernández	Head, IDB Project Office
Mr. Carlos Gonzáles	Economist, IDB Project Office
Ms. Emperatriz Ocola	Engineer, IDB Project Office
Mr. Luis Asmad García	Chief of Statistics, Operations Division

Regional Electric Company ELECTROLIMA S.A.

Mr. José Antonio Villena	Director, Technical Schools
Mr. Miguel Stucchi	Director, EFET
Mr. Agustín Farje	Director, ETEMHI

Others

Mr. Guzmán Aguilar de Ancos	IDB Assistant Representative
Mr. Rolando Yon Siu	IDB Energy Specialist

APPENDIX 1-2

PRINCIPAL DOCUMENTS REVIEWED

AID, "Convenio de Proyecto entre la República del Perú y los Estados Unidos de América para Desarrollo de Pequeñas Plantas Eléctricas", 24 de noviembre de 1980.

Arthur D. Little, Inc., "Evaluación del Proyecto AID No. 527-0226 para el Desarrollo de Pequeñas Plantas Hidroeléctricas", noviembre 1986.

ELECTROPERU, Oficina del Convenio AID, "Informe Trimestral USAID-15, Abr. May. y Jun. de 1986".

ELECTROPERU, "Metodología de Prefactibilidad o de Factibilidad".

ELECTROPERU, Oficina del Convenio AID, "Metodología AID para Pequeñas Hidroeléctricas--Formulación de Estudios de Factibilidad".

ELECTROPERU, Organigrama de la Sub-Gerencia de Electrificación.

ELECTROPERU, Convenio con el Reino Unido, III-Reunión-1986.

ELECTROPERU, Convenio Reino Unido, "Programa Priorizado de los Proyectos del Convenio Reino Unido".

ELECTROPERU, Proyecto Chongos Alto, "Estudio de Factibilidad", Vol. I, II, III y IV, 1982.

ELECTROPERU, "Plan Maestro de Electricidad 1986, Primera Versión", agosto 1986.

ELECTROPERU, "Plan Maestro de Electricidad, Generación Eléctrica", Vol. II, anexo del capítulo IV, 1985.

ELECTROPERU, "Plan Nacional de Expansión de la Frontera Eléctrica, Período 1985-1990", Vols. I y 2.

ELECTROPERU, Gerencia de Obras, Sub-Gerencia de Electrificación, Unidad de Control de Gestión, "Informe de Evaluación de la Ejecución Presupuestal de la Sub-Gerencia de Electrificación al 30.09.86", octubre de 1986.

ELECTROPERU, Exposición del Presidente del Directorio de ELECTROPERU ante la Comisión de Energía, Programa de Electrificación Rural, octubre de 1985.

ELECTROPERU, "Presupuesto por Programa D L. 163", 1986.

ELECTROPERU, Ing. A. Hurtado, "Centrales Hidroeléctricas en Ejecución", noviembre 1986.

ELECTROPERU, Ing. L. Prieto, "Relación General de Estudios y Obras", noviembre 1986.

ELECTROPERU, "Cronogramas de Desembolsos de Préstamos AID, RU, Gobierno Italiano, RFA, etc.", años 1986 y 1987.

ELECTROPERU, "Presupuesto de Proyectos de Inversión 1987; analítico, costo directo para distintas fuentes".

ELECTROPERU, "Programa de Grupos Hidráulicos Italianos para instalarse en minicentales hidráulicas" - Cuadro.

COPAL, Brasil, "Participacao Financeira em Programas de Electrificacao Rural", 1981

Instituto Nacional de Planificación, "Sistema de Planes de Desarrollo 1986-90--Proyecto: Plan del Trapecio Andino, Caracterización de la Problemática", febrero 1986.

Instituto Nacional de Planificación, "Proyecto Plan Nacional de Desarrollo a Mediano Plazo 1986-1990", enero 1986.

APPENDIX 3-1

SMALL HYDROELECTRIC POWER PLANTS IN PERU

First Year of Service	Installed Capacity (kW) 0-100 In Oper.	0-100 Out of Oper.	0-100 Total	101-1,000 In Oper.	101-1,000 Out of Oper.	101-1,000 Total	Over 1,000 Total
Not Specified	1	1	2		1	1	
1907-1939	1	1	2	1	2	3	2
1940-1959	12	12	24	4	3	7	1
1960-1969	28	17	45	11	1	12	2
1970-1979	2		2	6		6	2
1980-1986	9*	3	12	23**	1	24	
Total	53	34	87	45	8	53	7

Total, 0-10,000 kW:	Operational	105
	Out of Service	42
	Total Built	147

* Includes six completed projects not yet officially transferred to the Regional Electric Companies.

** Includes ten completed projects not yet officially transferred to the Regional Electric Companies.

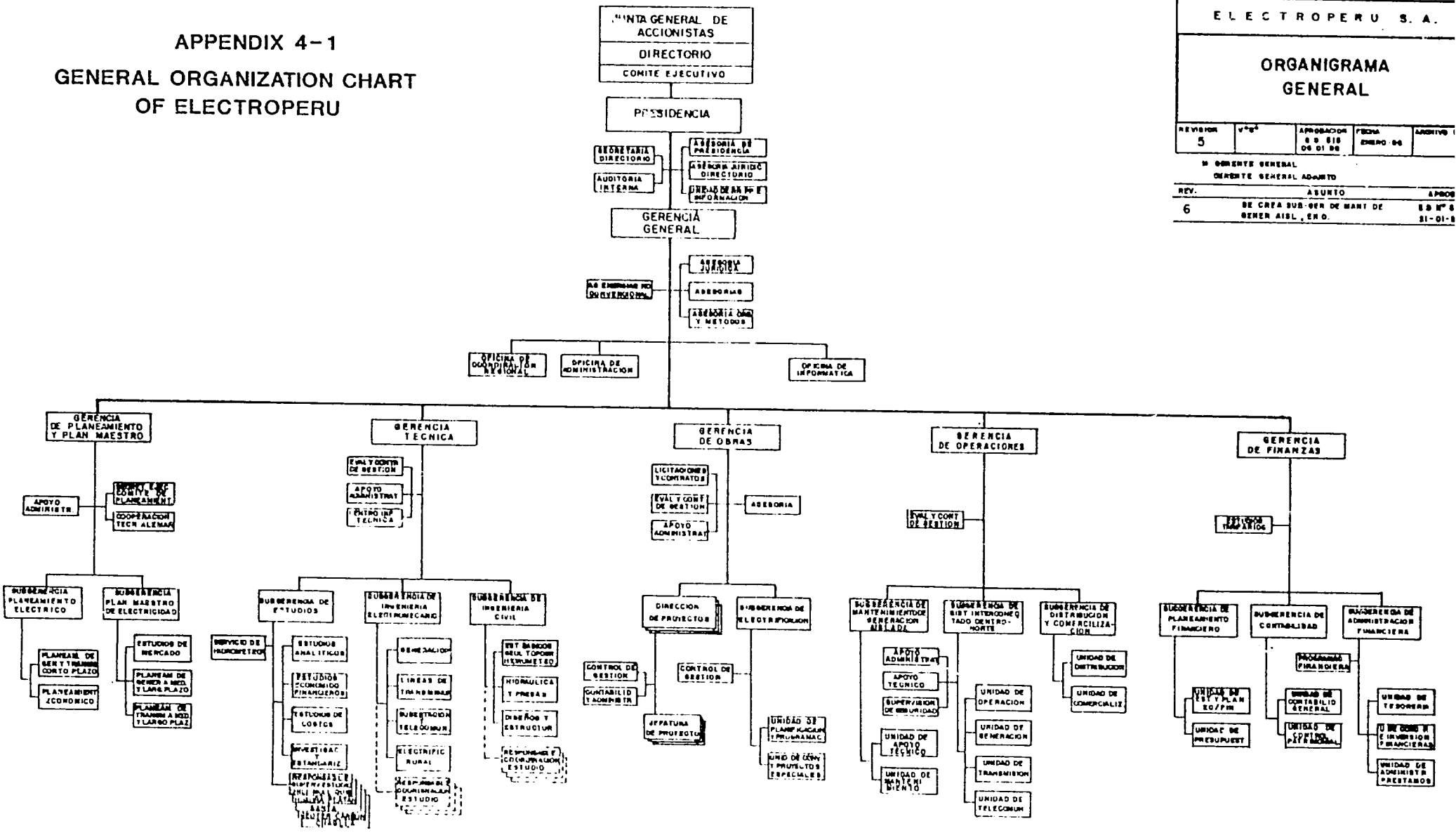
Sources:

- ELECTROPERU, Operations Division, Evaluation and Management Control, Statistics Unit, "Padrón y Estado de las Unidades de Generación, Centrales Hidroeléctricas Hasta 10 MW", October 31, 1986

- ELECTROPERU, Construction Division, Rural Electrification Department, Management Control Unit, "Informe de Evaluación de la Ejecución Presupuestal de la Sub-Gerencia de Electrificación al 30.09.86", October 1986.

APPENDIX 4-1

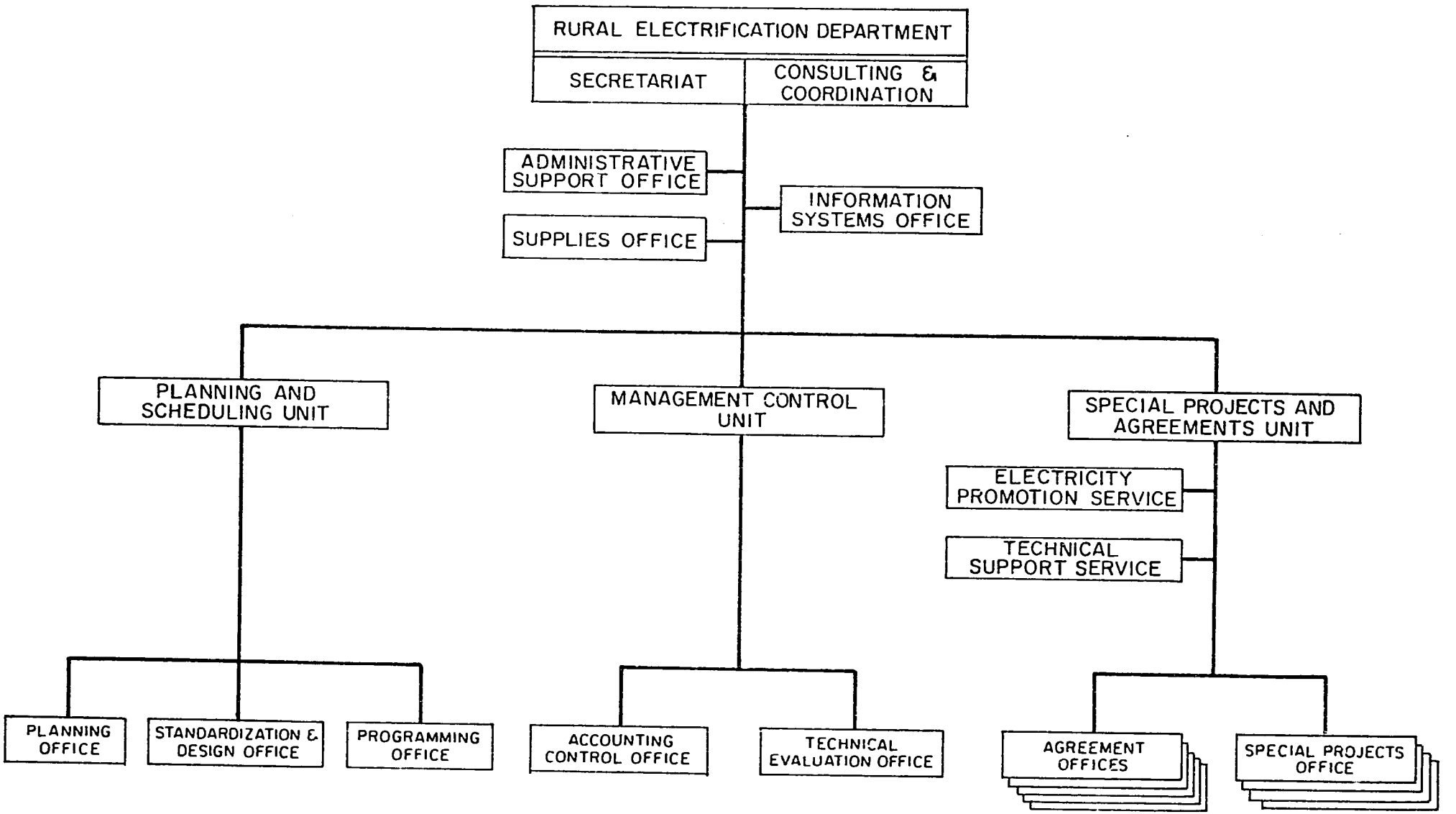
GENERAL ORGANIZATION CHART OF ELECTROPERU



Best Available Document

APPENDIX 4-2

ORGANIZATION CHART OF THE RURAL ELECTRIFICATION DEPARTMENT



APPENDIX 4-3

BUDGETED AND ACTUAL EXPENDITURES OF RURAL ELECTRIFICATION PROGRAM
(Millions of US$)

	1983			1984			1985			1986**		
	163	Other	Total	163	Other	Total	163	Other	Total	163	Other	Total
Budgeted	12.5	44.0	56.5	12.5	19.0	31.5	14.3	20.6	34.9	33.0	32.4	65.4
Hydro-generation	3.7	4.8	8.5	2.5	5.7	8.2	5.3	10.3	15.6	14.0	14.2	28.2
Thermal generation	-	5.3	5.3	-	0.5	0.[illegible]	-	-	-	0.5	7.0	7.5
Distribution networks	5.8	27.6	33.4	5.0	12.8	17.8	5.3	10.3	15.6	13.4	11.2	24.6
Other	3.0	6.3	9.3	5.0	-	5.0	3.7	-	3.7	5.1	-	5.1
Actual	10.8	24.0	34.8	11.7	12.7	24.4	11.8	15.4	27.2	13.6	9.6	23.2
Hydro-generation	4.0	3.0	7.0	3.1	2.4	5.5	5.6	9.1	14.7	7.5	7.3	14.8
Thermal generation	-	5.9	5.9	-	0.3	0.3	-	-	-	-	-	-
Distribution networks	4.2	14.8	19.0	6.1	9.7	15.8	4.1	6.1	10.2	4.4	2.3	6.7
Other	2.6	0.3	2.9	2.5	0.3	2.8	2.1	0.2	2.3	1.7	-	1.7
% of Budget Utilized	86	55	62	94	67	78	83	75	78	41	30	36
Hydro-generation	108	63	82	124	42	67	106	88	94	54	51	52
Thermal generation	-	111	111	-	60	60	-	-	-	-	-	-
Distribution networks	72	54	57	122	76	89	77	59	65	33	21	27
Other	87	5	31	50	-	56	57	-	62	33	-	33

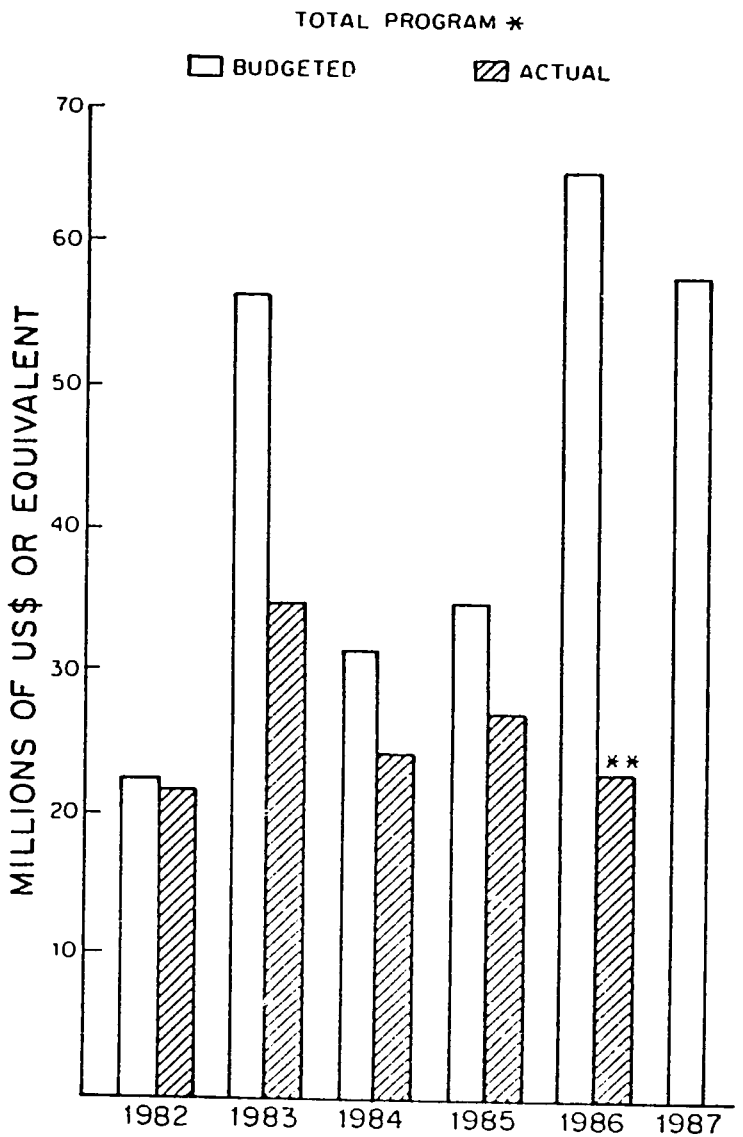
* Average exchange rate: 1983 I/. 1.68/US$
1984 I/. 3.61/US$
1985 I/. 11.22/US$
1986 I/. 13.98/US$

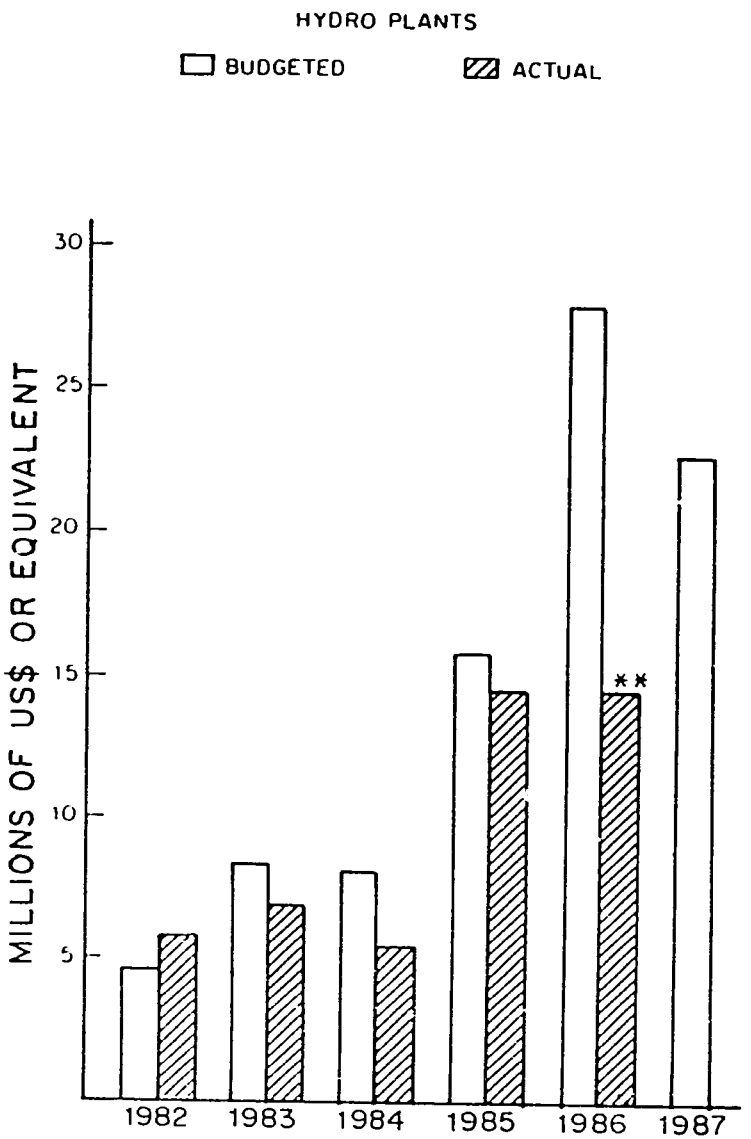
** Through September 30, 1986.

Source: Department of Rural Electrification, Management Control Unit.

APPENDIX 4-4

BUDGETED AND ACTUAL EXPENDITURES OF RURAL ELECTRIFICATION PROGRAM





* INCLUDES HYDRO PLANTS, THERMAL PLANTS, DISTRIBUTION SYSTEMS AND OTHERS

** THROUGH SEPTEMBER 30, 1986

APPENDIX 7-1

DESCRIPTION OF THE "AID METHODOLOGY"
FOR THE ECONOMIC EVALUATION OF
SMALL HYDROELECTRIC POWER PLANT PROJECTS

The "AID Methodology" is the name given in ELECTROPERU to the methodology for the economic evaluation of the SHPP projects. The methodology was developed and used in ELECTROPERU by the Office of the AID Project for the Development of Small Hydroelectric Power Plants. The evaluation is performed from a national point of view.

For a given project, the methodology seeks to forecast, for each year of the planning horizon, the gross benefits that would be obtained, as well as the total costs to the nation of producing those benefits. Gross benefits include the benefits derived from the resources assigned to the project (i.e., the value of the electric power to be produced, including consumer surplus), as well as the benefits obtained from alternate uses of the resources freed or displaced by the project (such as the income that would be received from the export of diesel fuel which would otherwise be used to generate electricity in an existing thermal plant).

The costs include the costs of constructing the power plants, their annual operating costs, and the costs of the displaced resources. The costs and the benefits are expressed at their real economic values (i.e., at their shadow prices), which sometimes differ from market prices, such that adjustment factors must be applied to convert market prices to shadow prices.

To determine the benefits, which are based on the value of the energy consumed, the existing use of energy must first be analyzed in order to forecast the consumption that would exist were the project not to be implemented. This analysis is carried out by surveying residents of the proposed service area. As a result of the analysis, forecasts of consumption are obtained, and based on the shadow prices of the different forms of energy, the cost per equivalent kWh is calculated.

The forecast of electric power consumption with the project is based on several equations (expressed graphically) that have been formulated from an analysis of the demand for electric power in a few communities which are already served with electricity. The equations yield an electrification coefficient (percentage of homes served with electricity) as a function of time, as well as the unit consumption as a function of the number of subscribers. These estimates, together with a forecast of the number of housing units in the service area, lead to projections of demand for residential use and public lighting. To arrive at total consumption, the following must be taken into account: commercial demand, obtained from the number of commercial subscribers per residential subscriber; unit commercial demand, previously specified according to type of locality; and industrial demand, based on information obtained from the survey.

The gross benefits for each year consist of the total value that the displaced sources of energy would contribute in other sectors of the economy, the revenues from the sale of electricity, at undistorted prices (estimated by the AID Project Office at US$0.06/kWh), and the value of the consumer surplus, which reflects the total value that subscribers would have been willing to pay for the consumption of the same amount of power at prices higher than the above-mentioned undistorted price.

The consumer surplus measures the value that subscribers would receive in excess of what they would be required to pay. It assumes that some subscribers would be willing to pay higher prices for at least a portion of the electricity which they would consume. The value of the consumer surplus is estimated on the basis of four values: the quantity of energy substituted (energy consumption without the project), consumption of power with the project, the price per equivalent kWh of the quantity of energy consumed without the project, and the undistorted price per kWh o the quantity of energy consumed with the project.

The concept of consumer surplus is illustrated in Figure 1. The curve SC is the energy demand curve, where the point S indicates the price and quantity <u>without</u> the project (p1 and q1, respectively), and the point C indicates the price and quantity <u>with</u> the project (p2 and q2). The area A1 is the consumer surplus. The area A2 is the total revenue from energy sales with the project.

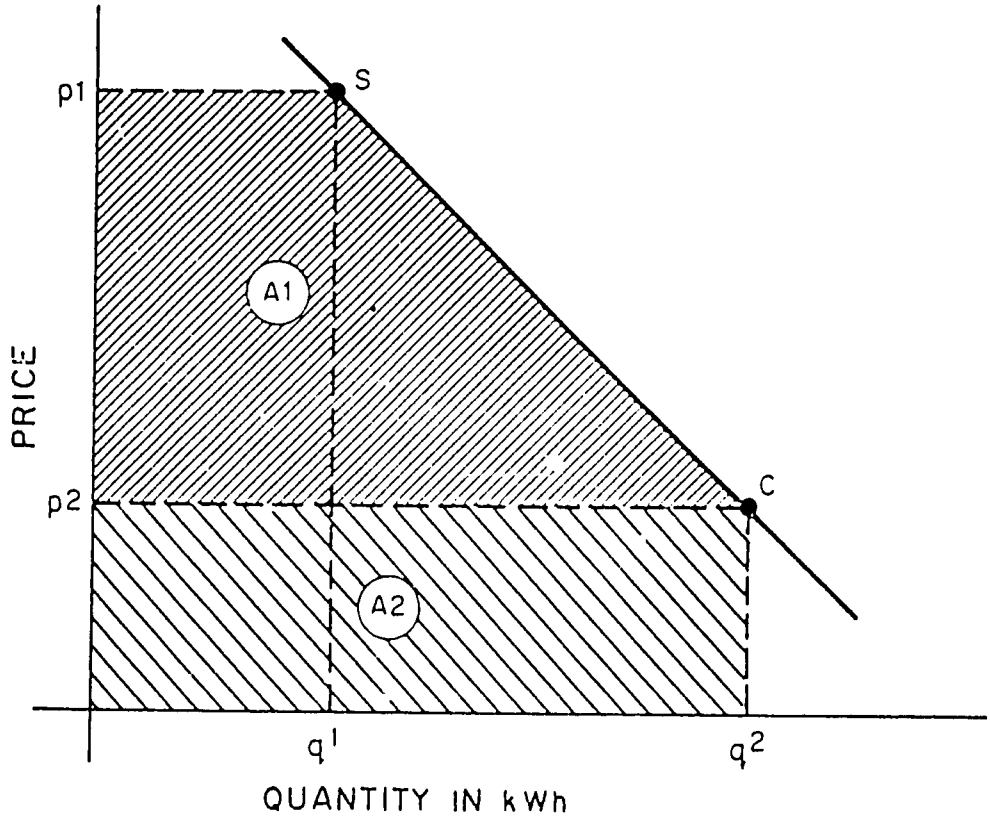
The market costs of the resources assigned to the project are determined in the technical study. Annual operating and maintenance costs are estimated via an equation that expresses costs as a function of installed capacity (in kW). The costs of the displaced resources are also included. All market costs are converted to opportunity costs (at the appropriate shadow prices).

After forecasting benefits and costs, three indicators of economic viability are calculated: the internal rate of return, the net present value, and the benefit/cost ratio. The latter two indicators are calculated at discount rates of 8%, 12% and 15%, considering the lowest to be the closest to the social discount rate. The assignment of implementation priorities to the projects is based on the three economic indicators, in addition to the cost per installed kW and the cost per kWh consumed.

The methodology also calls for a comparison of the costs of the SHPP with the costs of a thermal power plant, assuming that both alternatives would produce the same benefits.

FIGURE 1
(APPENDIX 7-1)

CONSUMER SURPLUS



A1 = Consumer Surplus

$= q1\,(p1 - p2) + \frac{1}{2}\,(q2 - q1)\,(p1 - p2)$

A2 = Revenues from Electricity Sales (with the project)

$= q2 \times p2$

APPENDIX 7-2

COMPARISON OF COSTS OF DIFFERENT SOURCES OF ELECTRIC POWER

Project	Installed Capacity (MW)	Cost in US$/kW Installed	Cost of Power (US$/kWh)	Benefit/ Cost Ratio
Large Hydroelectric Power Plants				
Expansion of Cañón del Pato	65	945	.018	
Jicamarca I (with reservoir)	104	951	.042	
Mayush I	100	1,485	.035	
Platanal	99	1,583	.030	
Large Thermal Power Plants				
Turbovapor - residual 6	50	1,352	.062	
Turbogas - diesel 2	50	368	.092	
Small Hydroelectric Power Plants**				
Chongos Alto	1.0	1,732	.050	5.0****
Cajabamba	0.52	2,019	.059	1.5
Namora	0.60	1,827	.059	1.5
San Marcos	0.33	2,840	.081	1.4

* Source: Electricity Master Plan, 1986, Table 5.3.

The costs per installed kW include costs of transmission lines between the power plant and the interconnected grid. In general, these lines are relatively short and represent a small part of the total cost.

** The cost indicators are calculated on the basis of the following costs and assumptions:

	Estimated Costs (US$000)			
	Civil Works	Equipment	Transmission Lines	Annual Operation
Chongos Alto	953	209	570	50
Cajabamba	712	206	132	32
Namora	610	353	133	46
San Marcos	615	212	110	27

Useful life: civil works, 50 years; equipment and lines, 30 years.

Discount rate: 12 percent.

An average load of 60% of installed capacity is assumed.

Source of costs: AID Project Office, ELECTROPERU. Chongos Alto and Cajabamba, actual costs according to the final accounting. Namora and San Marcos, estimated costs in the latest revision of the Project Implementation Plan.

The cost of civil works in Chongos Alto includes a contribution of communal labor valued at US$81,000. Costs of equipment do not include customs duties.

*** Benefit/Cost ratios, from the point of view of the national economy, including costs of distribution networks, were taken from the final feasibility studies for the SHPP. In the case of Chongos Alto, the ratio does not take into account the costs of transmission lines or distribution networks.