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Zaire

Small Hydroelectric - Rural Electrification Project

NRECA Small Decentralized Hydropower (SDH) Program

Zaire: Small hydroelectric-rural electrification project

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SUMMARY

A three-man team was requested by the AID Mission in Kinshasa to assist in the preparation of a Project Identification Document (PID) for a Small Hydro-Rural Electrification Project. The objective of the project is the creation of an organizational framework for construction and operation of small hydroelectric generating plants in isolated rural localities in Zaire.

The team found the physical potential for hydroelectrical installations and the need for rural electrification evident but the implementation of such projects beyond the technical and managerial capabilities of existing Zairian organizations. Training of Zairian counterparts by expatriate specialists will be needed for at least 5 years. Two groups should be set up and trained during this period: one that will be able to give financial, administrative and managerial support to rural electrification projects, and a second group to assist in the determination of technical/economic feasibility, design, procurement, construction and operation. On-the-job training should be given by means of two or three demonstration projects, taking the trainees through all phases of a project from first appraisal through construction and operation. After the training period it is expected that the two groups be able to continue on their own as a permanent assistance organization.

The most promising organization for the financial/managerial assistance group appears to be SOFIDE, the national development bank, which combines financial expertise and experience with other lending institutions and expatriate management. SOFIDE's technical staff would also be a suitable nucleus for the small hydro technical assistance group. In the event that SOFIDE does not wish to expand its present technical functions, the Service Presidentiel d'Etudes (SPE) should be selected for the technical assistance group.

Sponsors, or owners/operators of the first demonstration projects should be Private Voluntary Organizations (religious missions) or rural industrial-commercial enterprises where a basis of technical and managerial skills exists. Project sponsorship by community councils or rural electric cooperatives should be encouraged at a later date. Businesslike practices and financial viability, i.e. ability to pay the cost of operation, maintenance and amortization of the investment, should be stressed for all projects, regardless of sponsorship.

The projects should be in the 50 to 1000 kW range and the electric systems should serve all customers that can be economically reached. Technically the projects should be as simple as possible, taking advantage of the sites where high-head and run-of-the-river installations are possible without elaborate dams. Minimum heads should be 7 meters and the height of dams or weirs should not exceed 3 meters. The experience of some religious missions and rural industrial plants where small hydro systems have been built should be used to the extent possible.

USAID should contract the services of an expatriate specialist team with an organization that has ample international experience in the appraisal, design, construction and operation of small electric utility

systems. Strong home office back-up and the availability of experienced specialists in quite a number of diverse fields would be essential. The ability of the specialists to communicate in French would be highly desirable.

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I. Objective of project

The project intends to create a permanent institutional framework for the construction and operation of rural electric systems based on small hydroelectric generating plants. Availability of low cost energy is expected to improve the life in rural communities, assist isolated medical and educational institutions, and create new small industries, particularly in agricultural processing and forest products.

The objectives are to be accomplished through training of Zairian counterparts in technical and economic assessment of proposed installations, detailed design, equipment selection, procurement, construction supervision, and operation and management of completed electric systems. Practical training will be obtained through construction of pilot projects in the 50 to 1000 kW range, encompassing physical and social-economic conditions typical for Zaire. Simpler hydro-mechanical installations, omitting electric generation, will also be considered.

The Zairian counterparts are to be the nucleus of a permanent technical and financial assistance organization capable of engineering, economic, and managerial assistance to future rural electrification systems. These systems are expected to be economically viable, i.e. capable of amortizing the original capital investment and paying for their operating, maintenance, and replacement costs.

II. Existing economic and energy situation in Zaire

A. Economics. Situated in Central Africa, Zaire is the third largest country of the continent with an area of more than 2.3 million square kilometers. It is the fifth largest in terms of population with an estimated 28 million. Population and urbanization growth are about 2.8% and 7% per year respectively. Although Zaire is rich in natural resources, its per capita income is among the lowest in all Africa.

Agriculture (commercial and subsistence) accounts for about 2.5% of the GNP while it provides employment for more than 75% of the population. Mining and mineral processing normally accounts for about 24% of the GNP and is the largest source of public revenue. It provides more than two-thirds of the country's export earnings.

B. Energy supply and consumption. In addition to coal, oil, and an almost unlimited supply of wood, Zaire has an enormous hydroelectric energy potential that is estimated to be 530 tetrawatt hours (530 million Megawatt Hours) per year. Current hydroelectric production is about 4.0 million MWH/year. In spite of this substantial production, only about 2% of the population has access to electrical power. Most of these customers are in large cities and the rural areas are practically without electricity. About 97% of the domestic energy consumption depends on wood, charcoal and vegetable wastes. The main reasons for the small domestic consumption of electrical energy are the lack of suitable transmission - distribution lines and the high cost where electrical power is available.

Undeveloped hydroelectric sites have a theoretical capacity of about 45,400 megawatts (MW). About 42,000 MW of this potential is at Inga, near the mouth of the Zaire River. However, there are also many small sites, in the 0.1 MW to 1.5 MW capacity range, which are within the scope of this small hydro-rural electrification project. The Société Nationale d'Electricité (SNEL), USAID and the World Bank (Report on Rehabilitation of Shaba Power System) have lists of about 1000 small hydroelectric possibilities.

Actually installed hydro capacity consists of 2732 MW operated by SNEL and 87 MW produced by private owners. The partially developed Inga site accounts for 1750 MW of SNEL's total installed capacity. SNEL also has 59 MW of diesel generation and there are many more small diesel installations at religious missions and privately owned industries.

C. Energy distribution. The total length of installed transmission lines is 2712 kilometers at voltages of 50 to 220 KV. In addition, there is the 1700 kilometer Inga-Shaba direct current, extra high voltage (1000 V) transmission line from Inga to the mining centers in the Shaba province. This line has a capacity of 510 MW. It is completed and undergoing tests at the present time, for operation within a year.

The power requirements of the Shaba region are projected to be less than 20% of the Inga-Shaba line capacity. In spite of this surplus, and in spite of the fact that the line passes major cities like Kananga and Kikwit which depend on inadequate, poorly operating, and costly diesel-electric

plants, there are no intermediate taps into the Inga-Shaba line planned at this time.

A 1978 estimate for a 25 MW tap at Kananga, population 500,000, arrived at a cost of $38 million. This cost estimate includes dc/ac converters, transformers, 2 substations as well as transmission and distribution lines for Kananga and an existing important railroad which could be converted to electrical operation. This 1978 cost translates into $1520/kW. This information is mentioned in the context of the Small Hydro-Rural Electrification Project because a possible power tap at Kananga could also supply a number of small towns and rural areas, possibly at a lower cost than a small hydro power plant.

III. Project implementation

A. Required steps for implementation. Implementation of the project will include the following components:

a. Selection of the institution in which a group for the financial management of project funds will be organized.
b. Selection of the institution wherein the Technical Assistance Group (TAG) will be organized.
c. Evaluation of potential pilot project sites for technical and financial feasibility (training of the technical assistance group by expatriate specialists).
d. Selection of the pilot project(s). Approval by SNEL, Department of Rural Development and AID or other funding agency.
e. Contract with pilot project applicant after discussion of financial terms and responsibilities of all parties involved.
f. Detailed surveys, designs, construction drawings, equipment selection, list of materials, procurement and shipping (training of TAG).
g. Project construction with TAG assistance and supervision.
h. Selection and training of pilot project managers and operators. Commissioning and testing of installations.
i. Continuing support and supervision of operating personnel during initial period.
j. Continuing efforts by financial management group to secure funds for additional projects.
k. Phasing out of expatriate specialists. TAG and Financial Management Group continue as a permanent organization.

The flow chart presented in Figure 1 indicates the sequence of steps foreseen to implement a pilot project.

B. Institutional selection for technical and managerial training. The government of Zaire (GOZ) has given a high priority to rural electrification and small hydroelectric plants. Various government departments are involved in one way or another but rural electrification is generally interpreted to be concerned with the larger provincial towns which depend on costly, inadequate diesel-electric power plants or have no electricity at all. "Small Hydro" in this connection is interpreted to mean plants in the 1000 to 10,000 kW range.

Meetings were held with all concerned government organizations in order to determine the most suitable place for the training of the Technical Assistance and Financial Management Groups. A number of private sector organizations were also interviewed for the same purpose. The following summarizes the impressions gained from these meetings and the advantage and disadvantages of the various organizations.

1. Government organizations. The Departement de l'Energié has overall responsibility for energy policy and implementation, from hydroelectric as well as from other energy sources. Discussions with this department gave the impression that its scope of responsibilities is very broad, with an organization chart that is mostly unfilled in the technical positions, and that a small hydro assistance group would play a subordinate role within this department. Above all, the comprehensive planning of the department

does not include small, isolated hydroelectric systems and it does not want responsibility for the training for such installations.

The Societé Nationale d'Electricité (SNEL) is part of the Departement de l'Energié and is responsible for generation, transmission, and distribution throughout Zaire. SNEL does not design nor construct power plants and power lines but hires consulting engineers and construction firms for that purpose. SNEL, like its parent department, has a shortage of qualified, trained staff. Some 40% of its senior positions are either vacant or held by persons with multiple responsibilities. Its small hydro department is staffed by one man and its concept of 'small hydro' consists of plants considerably larger than the 50 - 1000 kW range foreseen for the pilot projects. The shortage has resulted in poor technical operation and financial control. The organization is also burdened by the huge Inga/Inga-Shaba complex and the financial debt for this construction. Putting the technical-economic-managerial training for small hydro projects and the operation of completed pilot projects into SNEL does not appear promising. In view of SNEL's mandate for all generation and sale of electrical power, it is nevertheless imperative to obtain SNEL's agreement to the actions taken under the AID project.

The Department for Rural Development also has a small Hydro Section on its organization chart. The position is not filled and no staff is available. The department appears to be unsuitable in the intended framework for the small hydro projects. However, its support of rural electrification projects is essential.

The Service Presidentiel d'Etudes (SPE) is a small but prestigious organization which works directly under the President on technical and economic studies in many fields. It is a consulting organization which has completed a small hydro feasibility study, among other things. SPE appears to have a dynamic chief and is looking for more work. Until now, SPE has concentrated on studies and has no practical experience in detailed design, construction, operation, and management of projects. Professor Malu, the Head of SPE, indicated some reservations about setting up a permanent small hydro assistance group, especially with responsibilities that go beyond their usual studies, such as responsibility for construction supervision and training in system operations and management. However, he is definitely interested, largely to find a paying assignment for his engineers. Since SPE evidently has capability, it is a definite possibility that they supply the counterparts for the technical-operational-managerial training, with the trainees eventually becoming a permanent technical assistance group.

The Departement du Plan (PLAN) is a high level organization dealing with development planning for all sectors of the Zairian economy. It is also in charge of counterpart funds of the GOZ and controls the use of local currency. PLAN's support of the Small Hydro-Rural Electrification Project is therefore essential. PLAN's Secretary of State expressed such support and suggested government departments where the technical-economic assistance groups could be located. The PLAN organization itself would not be the appropriate place.

The Société Financiére pour le Développement (SOFIDE) is the national development bank, owned jointly by the Zairian Government and Belgian

interests. It makes loans to private enterprises, including industrial developments which include small hydroelectric plants for the development's own use. It is also connected with the World Bank and frequently arranges loans from international finance organizations such as the African Development Bank (ADB).

SOFIDE has an engineering staff which reviews the plans and technical details of projects for which loan applications have been made. The engineers only review and check the projects; they do not make feasibility studies of their own nor do they have experience in design, construction supervision, and operational training.

It is possible that SOFIDE could serve two functions that are necessary for the AID project: (a) it could do the detailed management of the fund which AID makes available for specific pilot projects and continue later (after the AID funds are exhausted) with the procurement and management of funds from other sources for additional small hydro projects; (b) its engineers could be trained as the technical assistance group for feasibility studies, detail design, construction supervision, and operational-managerial training.

2. Private sector organizations. The private sector, represented by church organizations and manufacturing-construction companies has the best technical resources and experience in design and construction of small hydroelectric projects. It would also be the most efficient and cost-effective avenue to accomplish these objectives, mainly because of expatriate management and businesslike orientation.

The AID project, however, not only proposes to design and construct pilot projects, but intends to build the institutional framework for continuing rural electrification. The church organizations quite normally are interested only in the religious missions which they represent. They are not likely to be interested in assistance to a project which other religious groups, a private industry, or a community council apply for. Construction companies have a good technical staff but as a rule lack the permanent roots in Zaire which are necessary for a continuing assistance group.

The following organizations were interviewed to explore their interest and suitability for the training of a small hydro assistance group:

"Church of Christ in Zaire" (ECZ) is "an umbrella" organization of most of the main-line Protestant church missions in Zaire. It has a small fleet of fixed-wing aircraft and aircraft mechanics for mission transport and communications activities. ECZ also provides short term volunteers and specialists for other technical projects to the missions. While the ECZ representative believed his organization might be interested in supplying the institutional support required for the project, it seems doubtful that it could be relied on to provide the technical staff to handle the project needs on a permanent basis. In this connection it must be mentioned, however, that some religious missions have outstanding technical people, often born in Zaire, who have constructed small hydroelectric systems and are excellent sources of information on such items as locally available materials, construction methods, costs, procurement and transportation problems, useful construction machinery, and time requirements. Any

technical assistance group created by the AID project would be well advised to take advantage of this available expertise.

Constructeurs Inga Shaba (CIS) is the largest construction company in charge of the Inga-Shaba 1000 kV DC transmission line. CIS is essentially the Morrison-Knudsen Company of Boise, Idaho, together with its engineering affiliate, International Engineering Company (IECO). CIS and IECO are technically capable of training the desired local technical assistance group. That, however, is the function of the expatriate specialists foreseen under the AID project. Since CIS and IECO have no permanency in Zaire, the local technical assistance group must be based on a different organization.

Chainmetal is a large firm in the ship building, steel products (such as pipe), and heavy construction business. It is owned by the GOZ and Belgian interests. Chainmetal has constructed small hydroelectric projects for private industrial firms. Its engineers have done the surveys and preliminary layouts for such projects, procured equipment and materials, and also supervised the construction. The detail design was done in Belgium. Economic feasibility studies with market analyses and benefit/cost ratios were not a part of these projects since no energy was sold and the industry itself was the only market.

Chainmetal expressed interest to do the AID small hydro project on a "turnkey" basis, from the first site reconnaissance and prefeasibility study through to construction. While this might be the most efficient and cost-effective way to complete the pilot projects, it does not appear to meet the training and institution building objectives of the AID project.

3. New government organization. A new independent institution could be established within the government with the specific mandate and authority to develop economically viable small electric generation and distribution installations in isolated areas of Zaire. It would be similar to the Rural Electrification Administration (REA) in the United States.

The disadvantage of such an institution is that it would first have to be set up by a government decree and then compete with SNEL and other established institutions for scarce technically capable people for its staff. However, any existing institution will also have to organize a small hydroelectric unit within its organizational framework and staff it with capable people.

C. Preferred institution for financial and technical assistance. The institution in which the financial and technical assistance group will be trained, must have the following ingredients:

- A clear mandate from the government to develop financially viable small hydroelectric installations for rural electrification. The mandate must include an obligation that electric service will be provided to the largest possible number of customers, at rates that will meet operating and maintenance expenses, as well as the amortization cost of the project investment. Such a mandate is the strongest motivation for action and success.

- o A strong belief and commitment by the institution head and staff in the importance of their mandate.
- o A strong technical and innovative staff commited to the goals of the project.

For the detailed financial management of the AID-funded pilot projects, there appears to be no alternative to SOFIDE. It is a permanent Zairian institution, committed to the development of small and medium sized enterprises, with expertise in financial management and ability to attract a capable staff. Above all, it has established connections with the World Bank, the African Development Bank, and other international sources of development funds which will be necessary for future construction of small hydro-rural electrification systems. SOFIDE could also provide accounting and management advice for the owner-operators of the installations.

For the financial management, SOFIDE would have to be paid a fee. Also, AID would still be involved with checking disbursements as long as its funds are being used. Future funding organizations would be similarly involved. But SOFIDE would do the details of comparing bids for equipment, transportation and customs arrangements, and payments to subcontractors and the project applicant himself.

Provided that SOFIDE is willing to expand its technical functions, it would also be the best institution for setting up and training the Technical Assistance Group. SOFIDE would have to be willing to set up a separate small hydro group which would continue indefinitely after training under the AID program. A decision about this possibility will have to be made by SOFIDE and AID at an early date.

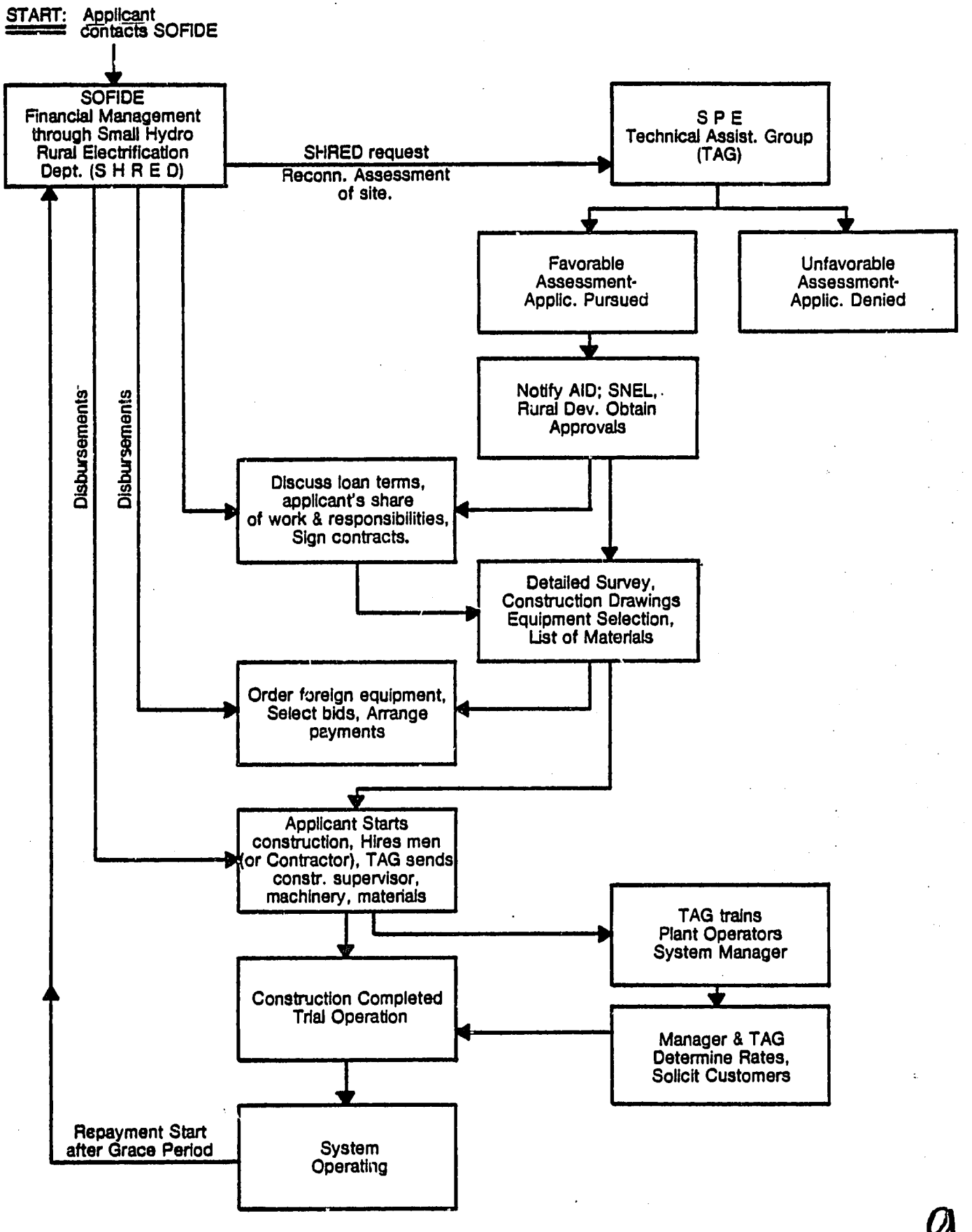
The inducement for SOFIDE would be the fee for the financial management and the training of its technical staff. Also, in the event that SOFIDE eventually makes small hydro loans of its own, it would keep its eyes on the project investment. For the AID project, the advantage would be (a) to have two major functions under one roof, (b) the experience of SOFIDE with other potential loan organizations, and (c), the expatriate top management of SOFIDE which gives a better chance for success.

M. Delforge, Directeur Adjoint of SOFIDE, was undecided about expanding the bank's functions into technical assistance which is normally not within the scope of activities of a financial institution. He was, however, very interested in the management of project funds and this arrangement should be pursued further.

In the event that SOFIDE does not wish to assume the responsibility for technical advisory services, SPE appears to be best qualified to harbor the Technical Assistance Group. SPE would then operate in conjunction with the financial management group to be set up in SOFIDE. The enclosed flow chart shows the division of responsibilities between the two groups, from the time an application for an electrical system is received to the completion and operation of the project.

Sequence of Steps for a Small Hydro Rural Electrification Project

FIGURE 1



IV. Staffing of the technical assistance group

Training of the counterpart Technical Assistance Group will be accomplished by expatriate specialists under contract with US AID. Provisionally, the counterpart group will include the following personnel:

1 Chief Engineer (civil-electrical)
2 Engineers (civil)
2 Engineers (electrical)
1 Construction Supervisor (civil-mechanical)
1 Construction Supervisor (electrical)

The Chief Engineer should preferably be a man of considerable experience in one or more of these specialties: public utility administration, rate determination, technical and financial feasibility analysis, contracting, and construction.

Between the two civil engineers, there should be some experience in hydrology, geology, design, surveying, feasibility studies, cost estimating, specifications and procurement, hydropower equipment, and construction.

Between the two electrical engineers, there should be capability in powerline design and construction, generators, transformers, switch gear and instrumentation, meters, and residential wiring.

The civil-mechanical construction supervisor should have familiarity with construction machinery, construction of small dams, canals, pipelines, foundations and buildings, installation of gates and hydraulic control equipment.

The electrical construction supervisor should have familiarity with commercial and residential installations, powerline construction including transformers, protective gear, meters, and powerhouse instrumentation.

In addition, the counterpart group will require one or two clerk-secretaries.

Zairian personnel with the above qualifications will be very difficult to find and the expatriate specialists may have to start with basic training in most of the above listed specialties. This applies in particular to the start-up, operation, and management of the entire electric system. Practical training through all steps of the pilot projects should result in a competent Technical Assistance Group which can eventually continue on its own.

V. Selection of pilot project sites

A. Owner-operators. Loan applications to construct, own and operate a small hydro-rural electric system will come in the beginning from religious missions and private commercial enterprises. The main motivation will be to obtain additional electric power, to replace costly, unreliable diesel-electric generation and to do away with the ever-present problem of obtaining fuel for the diesel plants. The religious missions generally require additional, dependable power for the medical apparatus and air conditioning of their hospitals, for their schools, water pumps, workshops, staff houses and public lighting. Rural commercial enteprises are mostly engaged in agricultural processing, such as coffee hulling, tea drying, corn and cassava grinding, oil extraction, and lumber mills.

To assure success, it is essential that the first pilot projects be built by such organizations where a basis of technical and business know-how through expatriate management is available. Villages and isolated rural towns which have no experience with electricity nor technical-managerial skills cannot be expected to build and operate an electrical system successfully.

After the mission or commercially owned demonstration projects have set an example, loan applications can be expected from local "commercants" and village councils which would operate like consumer-owned electric cooperatives, selling electricity at cost to the members. Such applications should be actively encouraged.

To make sure that the missions and commercial enterprises serve not only their own needs, they should be obligated through a condition in their loan agreement to operate the electric system in a businesslike fashion and provide electric service to nearby communities to the extent feasible.

B. Technical criteria. First, the small hydro site must be located in a place where the energy can be used, i.e. where an existing or potential load center can be reached without prohibitive transmission cost. For the planned projects in the 50 kW to 1000 kW range, the distance could be anywhere from 10 kilometers for the small plants to 75 km or more for the larger ones. Buried transmission cables, have been used at some missions' small hydro installations where the soil was suitable.

The proposed capacity range of 50 to 1000 kW is intended as a general guideline. The lower limit of 50 kW would be adequate for a very small load center and anything less would appear to be inadequate for an economically viable electric system. Each of the two religious missions that were visited had about 30 kW of diesel-electric generation at this time. This was inadequate for their own needs and did not permit expansion to nearby villages. The Karawa mission, which is constructing a 375 kW hydroelectric plant, has calculated that it could use about 500 kW. The calculation includes a service extension to a coffee processing plant which is 15 km from the hydro site and would like to replace its 125 kW diesel electric plant. The Karawa mission also has fairly extensive welding, wood working and machine shops in addition to a medium-sized hospital and a small corn and cassava grinding mill for the convenience of the villagers.

The upper limit of 1000 kW is about the maximum for self-help construction. Larger plants require sophisticated controls and instrumentation which is probably beyond the capability of the owner-operators.

The potential capacity of a hydro plant is directly proportional to the product of the available head and flow. The greater the head, the less the required flow for a given kW output. High head sites are therefore more attractive as a rule because they need less water and smaller, less expensive turbines. High head sites also require less civil works, such as a dam to increase the head. A minimum head of 7 m to 10 m would be a preferred criterion.

Zaire has innumerable rivers with waterfalls or cataracts to provide a substantial, natural head without the necessity of a major dam. In addition, most rivers have a good, sustained flow throughout the year which is essential for dependable power generation. The variation between high flow and dry season flow is generally no more than 10:1, a very favorable ratio which removes the necessity of a dam and storage reservoir for dry season flow.

With a substantial natural head and adequate dry season flow, a run-of-the-river plant can be built which requires only a simple diversion weir to direct the river flow into the plant intake and penstock. The diversion structure can be of simple rock and boulder construction which can be easily replaced after a flood.

When the natural head or the dry season flow is insufficient, a dam must be built. Dams are not only costly and difficult to construct, but above all time consuming. In addition, the dam may cause environmental problems, may silt up, require more maintenance, and, frequently, requires relocation of houses. Finally, a dam is a hazard to the powerplant and other properties downstream in the event that it fails. Dams more than 3 m in height should be avoided for the small hydro projects.

Other factors that influence the technical suitability are the accessability of the site (road construction), the site geology (power plant and dam foundations) the topography (opportunity for storage, if required), and finally, the potential of the planned hydro project to serve other purposes such as water supply, irrigation, flood control and fish propagation. The last factor affects both the technical and the socio-economic suitability of the site.

C. Economic and social criteria and issues. All of the technical criteria discussed above effect, of course, the cost and therefore the economic viability of a project. But the main factor for economic and social soundness of the project is the potential market for the generated power.

For the pilot projects it is essential that a guaranteed market exists in the form of a local factory which may want to substitute existing diesel power for cheaper hydro power and/or a religious mission which needs additional, reliable power for its hospital, work shops, mills, and residential use. Such a nucleus of energy demand as well as basic technical and business know-how must exist in any case. An active farming community,

an income producing market center, and the presence of small local entrepreneurs or "commercants" would be a favorable criterion. For the residential electric use, it is important that a concentrated potential load center such as a large village or small town exist in reasonable proximity to the generating plant. Service to isolated farms will not be economically feasible and should not be counted on when a market survey for the feasibility study is made.

A dynamic village chief can be very important. With such a chief and some local entrepreneurs, a community council may be formed, similar to a rural electric cooperative, which would expand the service area and eventually operate and manage the electric system. However, in the early stage of rural electrification, a native village that has no experience with electricity, no technical/managerial skills, and no expatriate help, would be a poor risk for a pilot project.

Governmental and regional development priorities must be taken into consideration when an electrification project is selected. The government has stated a priority for "income-producing, employment-enhancing, productive uses of electricity." Such uses may be in the agricultural sector, the mining sector, or in the forest product sector, depending on the region. An electrification project which supports, at least in part, the local priority would receive preferential consideration.

The issue of subsidies must be clearly decided. Basically, it is expected that the projects be funded through repayable loans, not grants. The repayment condition is a strong inducement to operate the electric system in a businesslike manner, with a realistic but equitable rate structure that encourages the expansion of electric services while producing adequate revenue to pay for operation, maintenance, replacements, and amortization of the loan. Some form of subsidy will be necessary, of course, in the early stages of the electric system. These subsidies will consist of free technical and managerial assistance, a grace period on the repayments, a low interest rate on the loan, and possibly a staggered repayment schedule which allows for easier payments during the early years of the projects, with increasing payments as the service area and revenue builds up. Low subsidized residential rates may also be necessary to encourage the spread of electric usage.

Finally, the intangible social benefits of having electricity in isolated areas must also be considered. Such social benefits can not be quantified but may be decisive when the economic feasibility analysis indicates a marginal repayment potential.

VI. Recommendations

A. The organizational framework for the small hydro-rural electrification projects should consist of two groups:

1. A financial assistance group to relieve USAID of the detail management of pilot projects, such as disbursements to owner/operators and subcontractors, invitations for and analyses of bids, transportation and customs arrangements. The financial group would also attempt to secure funds for additional small projects and assist the owner/operators in the financial management of the electric system, accounting, rate structures and business practices. All projects would start with an application to the financial assistance group.
2. A technical assistance group to appraise the technical and economic feasibility of proposed projects, investigate the potential power market, prepare detail surveys, construction drawings and bid documents, select equipment, supervise construction and train the system operators.

B. The financial assistance group should be attached to SOFIDE, the national development bank. As soon as the project funding is approved by USAID/Washington, and before the arrival of the foreign training specialists, AID should negotiate with SOFIDE the terms of the financial management, including the staffing of the group to be trained.

C. The technical assistance group should be attached to SOFIDE or SPE. The decision will depend on SOFIDE's willingness to assume the additional function and expand its technical staff. The arrangement including staffing requirements should also be completed before the arrival of the training specialists.

D. Agreement should be reached with PLAN to pay the local currency salaries of the counterpart trainees. PLAN, the Department of Energy, SNEL and the Department of Rural Development should be kept informed of all steps taken in the implementation of the project and concurrence obtained.

E. USAID should contract the services of the foreign specialist team with an organization that has ample international experience in design, construction, operation, and management of electric utility systems. Solid home office back-up and availability of diverse skills is essential. Most of the specialists will be needed for the full length of the project. Others, such as the specialists for the training in power plant operation, plant and powerline maintenance, business management, and accounting, will be needed for shorter periods. Short term assignments of a geologist, hydrologist, or dam specialist may also be required if an unusual problem arises. All training specialists should be reasonably conversant in French in order to function with their Zairian counterparts.

The USAID project should be scheduled and funded for a minimum period of 5 years since it will take about 3 years to bring a pilot project on line. Much of this time will be spent in initial arrangements, approvals, staffing, training, procurement and transportation. At least two pilot

projects should be completed in order to take the counterpart trainees through all steps of project development. After two or three projects with the foreign specialists, the counterparts should be able to continue on their own.

F. Pilot projects should be in the 50 to 1000 kW range in order to meet minimum requirements and to avoid the sophistication of large installations. The initial projects should be for religious missions or rural industrial enterprises, preferably under expatriate management, where a basis of technical and managerial skills is available. Contracts with the owner/operator should, however, contain the condition of extending electric service to nearby communities.

G. The formation of community councils or rural cooperatives for construction and operation of their own projects should be encouraged as soon as this becomes practical and feasible. However, all projects, whether by PVO's or rural industries or cooperatives, must have the potential for economic viability.

H. Technically, the selected small hydro projects should have a minimum head of about 7 meters. Projects with higher heads and run-of-the-river installations with partial flow diversion from a waterfall should be selected wherever possible. Dams or weirs higher than 3 meters should be avoided. A power canal with a short penstock should be constructed in place of an expensive, long penstock when the topography offers the opportunity. Project sites should be reasonably accessible and projects with multi-purpose features (water supply, irrigation, fish propagation) should be favored. Simple hydro mechanical installations without electric generation should also be considered. In the selection of the generating equipment, two small turbine-generators should always be preferred over a single large unit, even if the cost of the two smaller units is somewhat higher.