PN-AAP-547
ISN 33916

Guinea

Proposal to renovate the Macenta mini-hydro site

NRECA Small Decentralized Hydropower (SDH) Program

Guinea: Proposal to renovate the Macenta mini-hydro site

Bard Jackson

December 1983

Sponsored by the United States Agency for International Development under Cooperative Agreement AID/DSAN-CA-0226

Small Decentralized Hydropower (SDH) Program
International Programs Division

National Rural Electric Cooperative Association
1800 Massachusette Avenue N.W.
Washington D.C. 20036

Small Decentralized Hydropower Program

This publication is one of a series that fosters the effective use of small decentralized hydropower systems. This series is published by the Small Decentralized Hydropower (SDH) Program, International Programs Division, National Rural Electric Cooperative Association (NRECA). NRECA manages the SDH Program under the terms of Cooperative Agreement AID/DSAN-CA-0226 with the Office of Energy, Science and Technology Bureau, U.S. Agency for International Development.

Under the agreement, begun in May 1980, NRECA provides a broad range of technical assistance to developing countries by:

- Designing and implementing regional workshops in Africa, Asia, and Latin America,
- Developing and conducting in-country resource surveys and site assessments,
- Providing engineering, supervision, and specialized assistance,
- Developing specialized publications such as state-of-the-art reports, inventories of manufacturers, and assessment methodologies,
- Conducting special studies on issues pertaining to finance, management, evaluation, and other subjects,
- Providing training services in such areas as operation and maintenance, resource assessment, equipment fabrication, and institution building,
- Carrying out specialized services such as tours of U.S. manufacturing plants and small hydro sites and seminars on private-sector involvement, and
- Creating specialized products such as productive-use plans for energy from small decentralized hydropower.

For more information on the SDH Program, contact:

Training and Information Coordinator
Small Decentralized Hydropower Program
International Programs Division
National Rural Electric Cooperative Association
1800 Massachusetts Avenue N.W.
Washington, D.C. 20036

Telephone: 202-857-9622
Telex: 64260
Cable: NATRECA

Contents

Summary

Background
Forest Region
Macenta

Mini-Hydropower Project
Project Framework
Planning Issues
Technical Issues
Economic Issues
Institutional Issues
Schedule of Activities
Cost Estimates

Recommendations

Appendix A Macenta Hydropower Report

Summary

In November 1983, NRECA's Principal Engineer for the Small Decentralized Hydropower Program visited Guinea for four days to explore the possibilities of mini-hydropower development and, if appropriate, recommend roles for AID/Conakry and AID S&T/EY.

During discussions with GOG officials, they expressed a strong desire to develop the country's hydropower potential and referred to recent Government proclamations declaring such a policy. However, its energy plannning is focused toward large, expensive hydropower schemes incorporating power production with irrigation and domestic water supply. Development of these schemes will be constrained by Guinea's ability to raise the necessary capital.

Smaller, run-of-river hydropower schemes could be an affordable alternative to the present development plans. The opportunity for run-of-river sites appears to be greatest in the forest region of the country which has well-developed agricultural and mining operations, but has no centralized electric grid service. Rainfall and streamflow are fairly level throughout the year, indicating that run-of-river schemes could probably supply the areas with over 20 MW of capacity at a lower unit cost than existing isolated small diesel units or planned larger hydropower schemes.

The recommended project would rehabilitate and upgrade the abandoned 120 kW Macenta hydropower plant to demonstrate the viability of using run-of-river mini-hydropower, with diesel back-up, to supply electrical loads in the forest region. Cost estimates for the project are under US$ 400,000, with major financing to be sought from equipment suppliers. If successful, the project will provide a basis for future regional energy planning, an institutional structure for developing decentralized powerplants, a procedure for accessing capital through private-sector suppliers, and appropriate designs for future installations.

Most of the information in this report was obtained through conversations with officials in Conakry with little supporting documentation. All figures and conditions must be confirmed during the initial phase of the proposed project.

Background

Guinea is a small French-speaking country in West Africa with a population of 5.5 million, 85% of which live in the rural areas. The socialist government controls development of the country's rich agricultural and mineral resources. About 93% of its exports stem from bauxite which does not balance its import needs, 33% of which are petroleum products. Its balance-of-trade problem is exacerbated by an overvalued exchange rate for its currency. The official exchange rate is about 23 Sylis per US$ 1 and the market rate is about 200 Sylis per US$ 1.

Guinea has four major geographical regions: the coastal plains; the upper plateau; middle Guinea; and the forest region (see Fig. 1). Rainfall is highest in the coastal region and decreases the farther it moves inland. The forest region has the most levelized annual rainfall distribution. This mountainous area of Guinea is the source of the Niger River and several other smaller rivers that flow toward Liberia and Sierra Leone. The United Nations Development Programme (UNDP) and the World Bank recently completed a major study proposing a master plan for water resource development in Guinea which identified over 200 possible sites to provide electric power, irrigation, and domestic water supplies in rural areas. It is estimated that potential exists for several hundred megawatts of developable hydropower. Schemes usually included storage dams and would cost between $3,000 to $5,000 per kilowatt for the power production.

Most of Guinea's present electric power supply comes from hydropower. Diesel units are used for peaking and emergency power on the national grid and for scattered isolated electric loads. The national grid is operated and maintained by the Societe' Nationale d'Electricite' (SNE), which suffers from a lack of spare parts and trained personnel. This results in high system losses and widespread daily power outages. Hydro Quebec is presently providing technical assistance to SNE to improve the maintenance and planning for the grid system.

Forest region

The forest region is located in southeastern Guinea and is characterized by mountainous terrain, trees, and year-round rainfall (see Fig. 2). The country's major agricultural production and potential is found in the forest region. Wood, rice, tea, quinine, and iron mining activities all presently exist here on a commercial basis.

About one-third of the country's population lives in the forest region. Since the area produces most of the country's agricultural goods and holds most of the potential development, the towns are prime candidates for basic infrastructure development, including electricity. Five towns have electric power service supplied by diesel units—Seredou, Macenta, Gweckedou, Kissidougou, and N'Zerekore. The units are owned and operated by SNE. Fuel is transported from Conakry over an all-weather road as far as Gweckedou, and then on "good weather only" roads, which makes fuel supplies unreliable in the rainy season.

Because of the rainfall pattern and the topography, this region has the best features for mini-hydropower development. Most of the towns in the forest region are situated near rivers that could supply the majority of their electric energy needs.

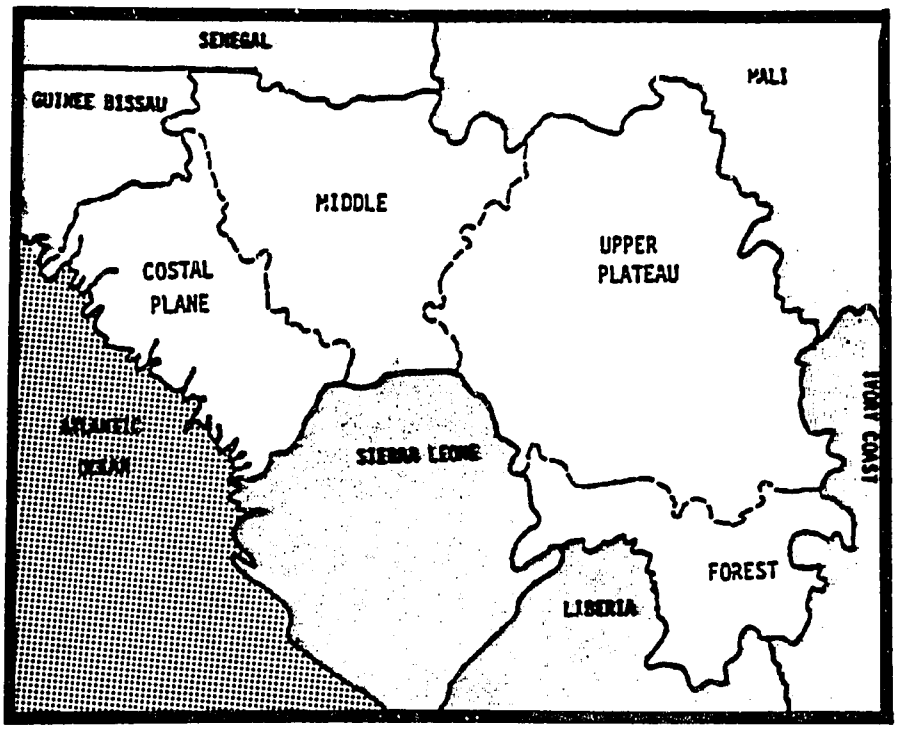

Figure 1 - GUINEA

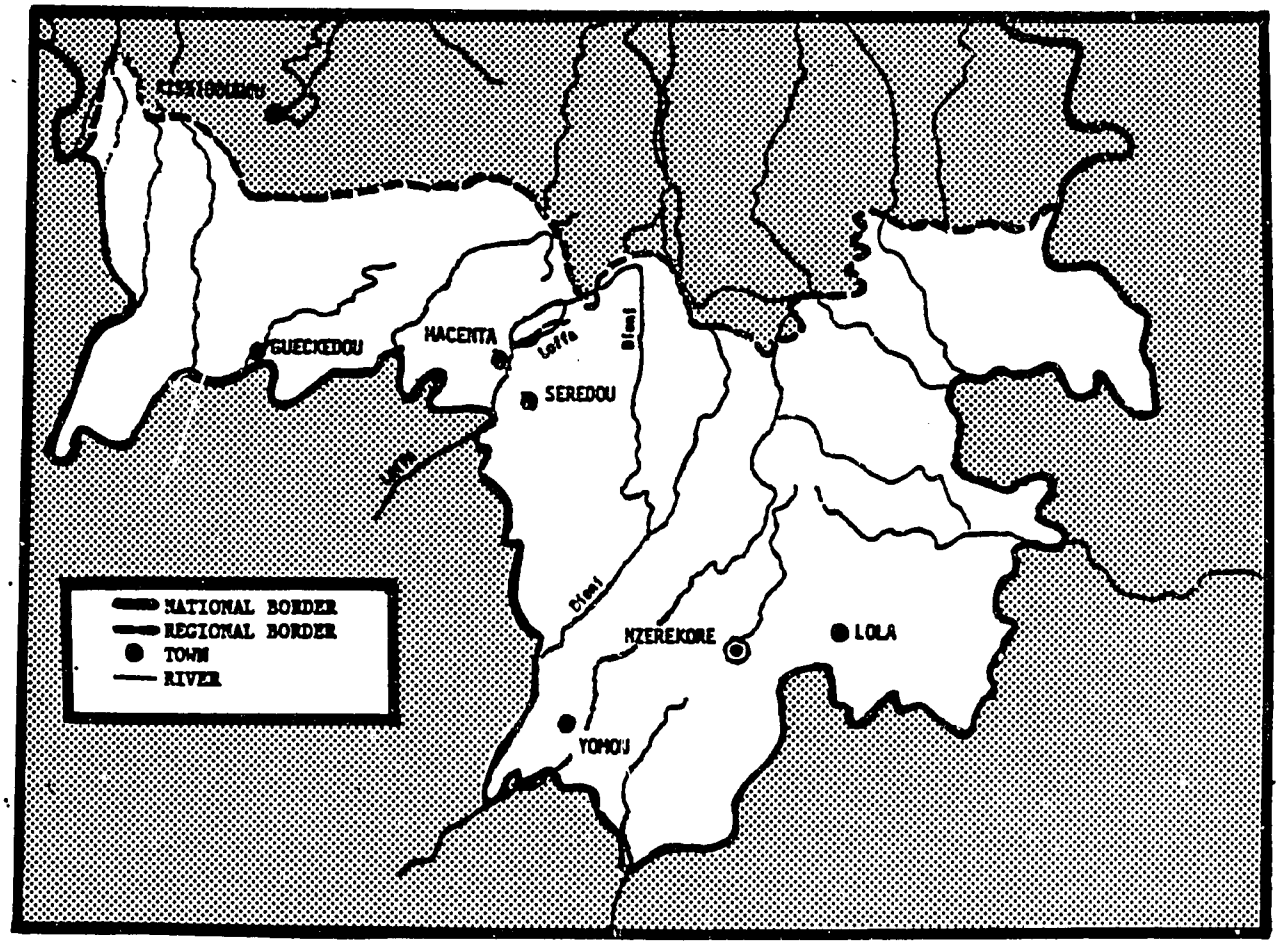

Figure 2 - FOREST REGION

For these reasons, most of the small hydropower study teams that have come to Guinea from all over the world have concentrated their efforts in the forest region. Most of these have assisted with developing an inventory of sites, and proposing implementation plans and programs, but it appears the proposals were not backed by financing. One inventory of potential sites is contained in the United Nations Department of Technical Cooperation for Development's (UNTCD) report titled Evaluation des Resources en Petits Amenagements Hydroelectriques, December 1981. This inventory lists 35 potential sites in the forest region with a total installed capacity of over 140 MW. The GOG has assigned priorities for the investigation and implementation of most of these sites. Since the GOG has projected large growth rates for this region, it is interested primarily in the larger sites. The more recent UNDP/World Bank report Plan General D'Amenagement Hydraulique de la Guinee Forestiere provides greater detail on about 20 of the larger sites. The French Government is also conducting another study of mini-hydro in the forest region, but no decision to finance them has been made.

Macenta

Macenta is a rural city near the center of the forest region with a population of over 26,000. It is served by a small airport and has schools, a hospital, restaurants, a small hotel, and government administrative offices. Macenta is the center for much of the business related to the nearby tea, coffee, banana, and rice plantations.

Macenta receives electricity from two SNE diesel generators with a combined capacity of 600 kW. They operate from 18:00 to 24:00 when fuel trucks can travel as far as Macenta. Fuel is purchased in Conakry and trucked to Macenta at a cost of $270 per ton (about 11 cents per kWh). Diesel capital costs are estimated at $700 per kW, which makes the energy cost to SNE from 15 to 19 cents per kWh depending upon capacity factors, interest rates, and the expected life of the facility. There are approximately 500 connections in Macenta and about nine people serviced for each connection. The peak demand is around 400 kW.

Located near Macenta is the abandoned 120 kW Ouin-Ouin hydropower plant which was installed in 1958 and shut down in 1970. A UNDP mission visited the site in April 1983; a copy of its report appears in Appendix A. Reportedly, the turbine is worn, the generator is burned out, and the reservoir is filled with silt.

In addition to this abandoned site, there are numerous other potential mini-hydropower sites in the Macenta area that were identified in the UNDP/World Bank report. These sites could provide additional capacity and energy to the Macenta area if the demand for electricity grows as projected by the GOG.

Mini-hydropower project

The proposed project would entail restoring and upgrading the existing facilities at the 120 kW hydroelectric plant near Macenta to supply energy to the city and nearby farms. The existing diesels would be called on to serve daily peak loads and base loads during dry periods or when the hydropower plant is shutdown. The existing facilities are located on the Loffa River about 6 km from Macenta. The plant was designed to operate at the river's minimum flow of 0.5 m^3/s under a head of 30 m. More details are given in the UNDP report (Appendix A). The riverflow characteristics in the forest region are fairly well known, and streamflow data exist for the Diani River (located in the drainage basin adjacent to Macenta) and for the Ouin-Ouin site. A review of the rainfall data supports this stream-guaging data.

Project framework

Purpose. The purpose of the proposed project is to demonstrate the viablity of run-of-river hydroelectric energy to serve the electrical energy needs in the forest region of Guinea. Properly implemented, small hydropower will decrease regional reliance on diesel fuel, provide lower-cost energy, and improve the electric supply availability. The project will demonstrate the technology, the institutional framework for decentralized power development, the potential for additional sites, and the economic benefits of small hydropower.

Goal. If the purpose is achieved, the project should lead the way to a larger regional program of mini-hydropower development thereby reducing agricultural production costs, increasing the economic output of the area, and decreasing the country's dependence on imported oil. Financing for additional schemes may be available from multilateral sources.

Outputs. At the end of the project, there would be an operational hydropower plant in the forest region of Guinea implemented through a governmental agency using capital secured through the private sector with designs adapted for local conditions. Local personnel would be trained to operate the plant and GOG officals would have experience in implementing a mini-hydropower installation.

Inputs. Several donor sources would supply components of the project which will require time and effort to coordinate. These components and sponsors are:

Planning (GOG and AID/Washington)	Develop regional energy plan, recommend institutional responsibilities, and identify financing for a regional program.
Technical assistance (AID/Washington)	Three man-months of technical assistance from S&T/EY to assess the site, develop equipment specifications, and recommend appropriate procurement procedures and designs.
In-country logistical support (AID/Conakry)	Two man-months of project management assistance and funding of local currency items with P.L. 480 funds.

Equipment financing (Supplier)	Turbine manufacturers and their corresponding donor financing agencies will be requested to propose financing for the electro-mechanical equipment.
Civil works (GOG)	The GOG, with assistance from S&T/EY, would be responsible for designing the civil works and managing the construction, installation, start-up, and operations of the site.
Training (Other)	Operator training could be funded through programs under the Energy Initiatives for Africa project or UNITAR-type programs. GOG staff would receive assessment and implementation training by participating in the technical assessment assignments.

Planning Issues

The World Bank funded a $2 million study of potential sites for development of multipurpose water resources—hydropower, irrigation, water supply, flood control, etc. Although the GOG is supportive of the study and wants to develop these sites, NRECA has the following concerns:

- the sites are scaled to provide power supplies far in excess of any realistic demand projection; and
- as with many debt-ridden developing countries, a large-scale project design and attendant benefits sound attractive, and the estimated unit costs of power are low, but the GOG cannot finance these large expensive schemes.

Development of the Macenta site, on the other hand:

- demonstrates the physical potential typical of the forest region for small hydropower at a more realistic scale (rehabilitating existing sites is particularly attractive, economically);
- provides an opportunity to save foreign exchange currently spent on fuel for diesel at the present forest region sites; and
- provides an opportunity to save foreign exchange currently spent on fuel for diesels at the present forest region sites; and
- provides an opportunity to add meaningfully to the national energy supply and also can economically enhance rural areas through increased production from agricultural processing, cottage industries, and small enterprises.

Since the Ministry of Energy and Konkoure appears to be at odds with the "Macenta model," an initial visit explaining this approach and attendant benefits in more detail may be in order, possibly as part of the planning assistance phase. Work on plan development and implementation, such as site-selection criteria, management responsibilities, etc., could then proceed.

Ideally, three major project components should be addressed before a demonstration site is undertaken: energy planning; assignment of institutional responsibilities; and identification of possible financing. The mini-hydro energy plan would contain an inventory of potential sites, a realistic load forecast, and a schedule of site development to meet anticipated loads. A GOG institution would assign the responsibility of training staff, obtaining the financing, and constructing the sites. A financial institution would be identified for funding viable sites and would be continually apprised of the progam's progress. The AID S&T/EY office is reluctant to provide field technical assistance until commitments, to address these components, are made through written national and regional energy policies, development of specific development goals, assignment of responsibility, training of staff, establishment of budgets, and identification of financing. Before field work begins, the GOG should begin addressing these issues or another source of funding for the initial technical assistance would be needed.

Technical issues

The project, as conceived, will demonstrate the benefits of run-of-river hydropower installations. By avoiding a large dam, costs are reduced significantly, construction is quicker, feasibility studies are simpler, and there is less reliance on foreign technical and construction contractors. Since run-of-river sites are generally smaller than larger schemes with dams, planning is based on short-term projected loads rather than projections some 10 years in the future which may never materialize. Although run-of-river installations allow little, if any, storage of water, they allow river silt loads to pass downstream rather than be trapped in reservoirs, which eliminates the storage benefits of dams.

The disadvantage of run-of-river schemes is that they can not supply dependable capacity during dry seasons, and therefore back-up capacity is usually required. However, this back-up capacity is generally less expensive than the cost of constructing a storage dam.

Equipment and materials. There are technical issues to be resolved during the study phase of the project in order to determine the equipment and material requirements. A major issue will be the amount of flow the existing 600 mm diameter penstock can permit without creating significant head losses. The present penstock diameter can probably handle two to three times the present design flow of 0.5 m^3/sec. Hence, the site could be upgraded for two or three times the present 120 kW nameplate capacity without requiring an additional expensive penstock. Other technical issues are:

- Size of installation;
- Number and type of turbines;
- Condition of existing facilities; and
- Civil works and electrical distribution requirements.

Economic issues

The size of the proposed installation will be a function of the hydrology, the cost per kilowatt, and the anticipated benefits of the energy produced. These parameters will be determined during the study stage. Since the existing diesel units will provide the firm capacity, the value of hydroelectric energy to be produced is equivalent to the present fuel cost of diesel energy. Using this assumption, the preliminary evaluation indicates that the site could and should be developed for several times its minimum flow potential of 120 kW. However, more information is needed concerning the daily electric load patterns, penstock condition, and distribution facilities before the exact size can be recommended.

Before agreements are made for technical assistance, it should be understood that the GOG set electric power tariffs sufficient to repay debt service and establish a sinking fund for repairs and maintenance of the units.

Institutional issues

Since the units would be operated by SNE, which has the most extensive expertise in electric power systems, it would be the best implementating agency. However, the existing electric grid system in Guinea, which serves Conakry, suffers from poor maintenance, frequent outages, excessive voltage drops, and high losses. Correcting these problems is SNE's most urgent task and requires the full commitment of its management and technical staff.

The Director of SNE indicated that a rural mini-hydro project would be implemented through the Ministry of Energy and Konkoure and that, after construction, it would be turned over to SNE for operation. Such an arrangement appears reasonable. The Ministry of Hydrology would prepare the flow-duration curves and other hydrologic studies as needed.

Financing issues

The major financing requirements will be for the equipment, which should run from $500 to $800 per kW. Frequently, a manufacturer can identify financing from its national bilateral financial institution. For example, U.S. firms could request Export-Import Bank financing guarantees for projects generally over $5 million. German, French, Japanese, Chinese, and British foreign assistance programs have funded projects similar to the Macenta project. It is presently unknown if these bilateral institutions would make similar loans to Guinea.

If a parallel penstock is needed, financing for it could be included with that for the turbo-generating package.

Schedule of activities

The following is an approximate schedule starting with the month all Ministries and donors agree to the proposed project:

Activity	Month
Project approved	0
Planning initiated	1
Flow-duration curves prepared	3
Study team visit	5
Study report written	7
Request for bids let	9
Detail designs prepared	9
Contracts awarded	12
Civil works constructed	17
Equipment delivered	17
Start-up tests conducted	18
Plant operational	18

Cost estimates

The site was not visited, so the following estimates are based on opinions developed from conversations while in Conakry.

Source/Component	US$	Sylis (US$ equivalent)
Financed		
Turbo-generating equipment, switchgear, transformer (300 kW @ $700/kW)	210,000	
USAID/Conakry		
Local labor, transport, and materials		60,000
Administration		10,000
USAID/S&T/EY		
Planning assistance	20,000	
Technical assistance	40,000	
GOG		
Planning		10,000
Detail design		7,000
Construction management		3,000
Hydrologic study		1,000
Training Program (EIA, UN, etc.)		
Operator training	5,000	
Sub-total	275,000	91,000
TOTAL	366,000	

Recommendations

The Division of Studies in the Ministry of Energy and Konkoure was not supportive of the proposed Macenta project. Instead, it wanted to follow the recommendations presented in the UNDP/World Bank report to develop a larger (10-20 MW) installation, a 110 kV electric grid system for the forest region, and a 20-40 m high dam to store water for power production, irrigation, and domestic water supply. It would serve the projected regional electric needs beyond the year 2000 and would require financing of over US$ 100 million.

It is NRECA's opinion that the technical and financial risks associated with the schemes described in the UNDP/World Bank report are extremely high and that the funding requirements are unrealistic for Guinea at this time. There is insufficent evidence that the area will develop to the agricultural or electric load levels forecasted by the GOG, that there is sufficient justification for irrigation in a region which receives rainfall 9-10 months a year, or that land management practices will be enforced to prevent the proposed dam from filling with silt within a few years of operation. For others reasons, large projects have not worked well in Guinea.

Instead, NRECA recommends the development of run-of-river mini-hydropower schemes for the forest region. These smaller projects have several advantages: they can be scheduled to follow the electric load growth for the area; the initial financing is within reason for the country; and the installation is technically simple. The Macenta site has very attractive conditions to demonstrate these technical and economic benefits. We further recommend that AID/Conakry present our conclusions to the Ministry of Energy and Konkoure and keep the Macenta proposal "on the shelf" in the event that the GOG changes its position.

A MR. BOUKARI DJOBO
REPRESENTANT RESIDENT
PNUD - CONAKRY
(GUINEE)

RAPPORT

de la mission sur le terrain
du 12/4/83 au 21/4/83 en Guinée Forestière

Objet : Microcentrale hydro-électrique Ouin-Ouin sur la Loffa près de Macenta.

A/ INTRODUCTION

1.1 Pendant la mission de reconnaissance sur le terrain que j'ai effectué dans le cadre du projet PNUD/GUI/79/004, Plan Directeur Sommaire des Ressources en Eau en Guinée Forestière, j'ai visité la ville de Macenta et la microcentrale hydro-électrique Ouin-Ouin sur la Loffa près de Macenta. La ville de Macenta dispose d'une installation thermique consistant en groupes diesels : 1 x 400 KW et 1 x 200 KW. Ces groupes doivent alimenter en électricité les industries qui y sont installées et satisfaire les besoins domestiques de la population. Lors de la visite, j'ai constaté que les deux groupes ne fonctionnent pas. Aussi l'acheminement du carburant présente une difficulte permanente pour le fonctionnement des groupes thermiques.

../..

Copie : Mr. C. Baldé
Directeur Général
de l'Hydraulique
Conakry
Mr. Joseph Mangué
Ministère de l'Energie et Konkouré
Conakry

Best Available Document

1.2 Pour la ville de Macenta on peut envisager une solution pour résoudre provisoirement le problème d'alimentation en électricité : rétablissement immédiat de la microcentrale hydroélectrique Ouin-Ouin sur la Loffa. Cette solution peut se réaliser dans un délai très court et ne peut pas entraîner des dépenses d'un ordre de grandeur important. La centrale a été construite en 1958 et exploitée jusqu'en 1970.

B/ CONSTATATIONS SUR LE TERRAIN

1.3 Chemin d'accès à la centrale

Au départ de Macenta, suivre la route nationale en direction de Kérouané et Kankan. A 5 km de Macenta à gauche se trouve un chemin carrossable montant sur 4,5km environ vers la centrale. Un sentier, long d'environ 1 km permet alors d'atteindre la centrale. On traverse à gué un petit ruisseau peu profond, et de la largeur de 4-5 mètres environ.

1.4 Ouvrage de retenue

L'ouvrage de retenue présente un seuil déversant de faible hauteur en bon état. La retenue à côté de la rive gauche du seuil déversant est légèrement envasée. Le curage de la retenue ne présente pas un grand problème.

1.5. Ouvrage de prise d'eau

La prise d'eau latérale sur la rive droite est constituée de parois massifs en béton - stables et en bon état. Pour le moment l'infiltration en eau qu'on peut constater par les parois en béton peuvent être facilement arrêtée. On peut colmater les fuites avec l'injection de ciments spéciaux (par exemple bentonnite). Ces travaux ne seront pas trop coûteux.

La vanne vidange de fond de la retenue (une vanne plate glissante) se trouve sur place. L'état mécanique de la vanne parait satisfaisant. L'engin de manutention de la vanne (pour le lavage manuel) est sur place en bon état.

La vanne de prise d'eau (vanne de garde) située au départ de la conduite forcée se trouve sur place et enferme bien la conduite forcée. C'est une vanne plate glissante à

../..

manoeuvre manuelle. L'engin de manutention de la vanne (le levage de la vanne) manque. Elle était sous l'eau et on n'a pas pu procéder à un examen plus détaillé.

Les grosses grilles inclinées de protection au départ de la conduite forcée se trouvent dans un état peu satisfaisant.

1.6 Ouvrage de dérivation - conduite forcée

La conduite forcée de diamètre 600 mm en tuyau de fonte est en très bon état. Juste au départ de la conduite, à côté de la prise d'eau, un tuyau de 1,0 m environ et un coude horizontale sont déformés et doivent être remplacés. Un stock de tuyaux neufs en fonte se trouve près du bâtimen de la centrale.

La vanne plate (pour le réglage du débit) située à l'extrémité aval de la conduite se trouve sur place.

1.7 Bâtiment de la centrale

Le bâtiment de la centrale est en bon état.

La partie électromécanique qui se trouve dans le bâtiment de la centrale (turbine, générateur, tableau de commande et transformateur) est en très mauvais état et ne peut pas être exploitée. La partie électromécanique de la centrale peut être renouvellée.

1.8 Ligne de transport

La ligne de transport au départ de la centrale existe en bon état. Les trois fils conducteurs sont sur place. Nous n'avons pas pu poursuivre la ligne de transport jusqu'à la ville de Macenta et un examen ~~leur~~ de leur état.

C/ TRAVAUX NECESSAIRES POUR LA MISE EN ETAT DE LA CENTRALE

1.9 Les travaux essentiels pour le rétablissement de la centrale sont les suivants :

a) Le renouvellement de la partie électromécanique de la centrale notamment :

- turbine
- générateur
- tableau de commande
- transformateur

../..

Best Available Document

b) Réparation de la conduite forcée : au départ de la conduite forcée, il est nécessaire de changer un tuyau Ø 600 mm, de longueur d'un mètre environ et un coude horizontal de diamètre Ø 600 mm.

c) Inspection et réparation éventuelle de trois vannes.

D/ CONCLUSIONS

1.10 Le rétablissement de la centrale Ouin-Ouin peut s'effectuer très rapidement à un prix relativement modéré. Etant donné que les structures de génie civil sont relativement en bon état, il est nécessaire seulement de renouveler la partie électro-mécanique de la centrale.

Le cours d'eau (Loffa) est perenne. La centrale fonctionnera toute l'année en pleine capacité.

Ivan Tomov

IVAN TOMOV
Projet GUI/79/004
Conakry