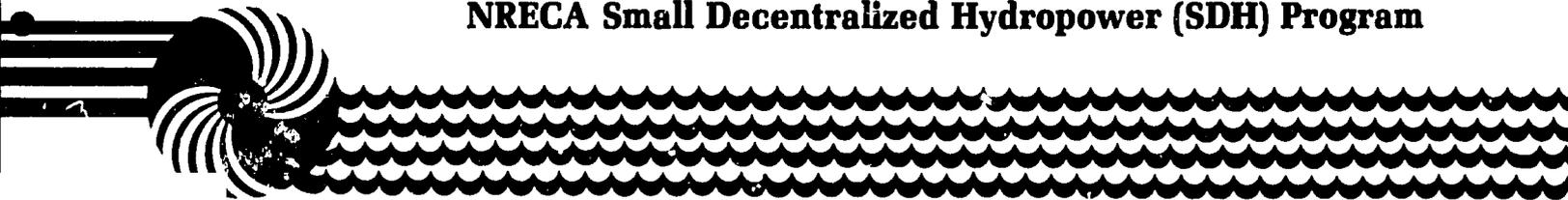


PN-AAP-543  
ISN 33912

# **Sierra Leone**

**Report to USAID/Freetown  
on mini-hydropower**

**NRECA Small Decentralized Hydropower (SDH) Program**



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Report to USAID/Freetown on Mini-Hydropower in Sierra Leone

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by Daniel J. Boyle

March 1982

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

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Small Decentralized Hydropower (SDH) Program  
International Programs Division

National Rural Electric Cooperative Association  
1800 Massachusetts Avenue NW, Washington, DC 20036

## Small decentralized hydropower program

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This publication is one of a series that fosters the effective use of small decentralized hydroelectric power systems. The series is published by the Small Decentralized Hydropower (SDH) Program, International Programs Division, National Rural Electric Cooperative Association (NRECA). NRECA operates 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. NRECA provides such technical assistance by--

- Designing and implementing regional workshops in Africa, Asia, and Latin America
- Scoping and managing in-country resource surveys and site assessments
- Providing engineering, design, supervision, and specialized assistance
- Developing specialized publications, such as state-of-the-art reports, inventories of manufacturers, and assessment methodologies
- Conducting special studies into subjects of finance, management, and evaluation
- Providing training services in such topics as operation and maintenance, resource assessment, management, and fabrication
- Carrying out specialized services, such as tours of U.S. manufacturing plants
- Creating specialized products, such as productive-use plans for energy from small decentralized hydropower.

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## Summary

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### Purpose of visit

In correspondence with the AID Office of Energy, USAID/Freetown had expressed interest in examining the potential for mini-hydropower in Sierra Leone. NRECA is the Office of Energy's principal contractor for Small Scale Hydropower. As part of its agreement with ST/EY, NRECA co-sponsored a regional workshop on Small Scale Hydro in Abidjan, Ivory Coast from March 1-5. Given the Freetown mission's interest in the technology, it was felt that a visit to Sierra Leone by NRECA staff member, Daniel Boyle, following his participation at the regional workshop in Abidjan, would be a convenient means of clarifying NRECA's capabilities and of assisting the mission in assessing Sierra Leone's technical assistance requirements. USAID/Freetown concurred with Mr. Boyle's visit.

Mr. Charles Uphaus explained that the mission hoped to gain answers to three basic questions:

1. Where does Sierra Leone stand with respect to development of its mini-hydro potential?
2. What information is available and what are the remaining information needs in the country?
3. What are the design and technical assistance needs and how might NRECA fulfill those needs under its contract with AID's Bureau of Science and Technology, Office of Energy.

### Findings and conclusions

Through interviews with knowledgeable individuals from the University of Sierra Leone, the Ministry of Energy and Power, the United Nations Development Program and the World Bank, answers to the above questions became apparent. (A list of the individuals contacted is provided at the end of the report.) The following is a brief synopsis of the information gathered during two days of interviews.

1. Government. The Ministry of Energy and Power is very interested in small hydropower. Their emphasis would be on diesel replacement and consequently they would like to look at plants at around 2 MW in capacity. In addition, the government has recently formed a National Energy Commission which will be looking into all possible sources of energy including hydropower.
2. United Nations Development Program. For the past three years, a UNDP consultant, Mr. Thomas Watt, has been investigating the hydropower potential in Sierra Leone. He has identified some 20

sites (most above 10 MW in capacity) and has performed preliminary calculations for most of these. Mr. Watt's work is based on a study done in 1971 by Motor-Columbus Consulting Engineers entitled, The Strengthening of the Sierra Leone Electricity Corporation. Mr. Watt is extremely pessimistic about the potential for hydropower in Sierra Leone. The reasons for his pessimism will be described later, however, it should be pointed out that of all the individuals visited he was by far the most knowledgeable of the hydropower potential in the country, having done field work in all of the major river basins. Neither the UN's final report nor the Motor-Columbus report have been officially released by the government of Sierra Leone for public use.

3. Miscellaneous groups. The Fourah Bay College (The Engineering School) of the University of Sierra Leone has an interdisciplinary group working on energy problems. Mr. David Kamara of this group has done the most work in the field of small scale hydropower, however, the group as a whole has not made significant headway due to funding constraints. The group did feel there is a need for the development of a comprehensive inventory of potential micro-hydro sites (0-100 kW). Although they felt capable of performing such a study, lack of funds has prohibited them from doing so. In addition to the University, several other groups have expressed interest in small scale hydro. The Chinese have reportedly begun work on a 4 MW (500 kW firm) scheme near Kenema. The Canadians (Canadian Energy Development Systems International) have funded two feasibility studies, one of which is completed for a 300 kW site near Kabala (reportedly costing \$9000/kW). Furthermore, based on Mr. Watt's findings, both the UN and the French Embassy have decided against sending teams to Sierra Leone for further studies.

#### Options for NRECA assistance

Given the state of affairs and emphasis of mini-hydro developments in Sierra Leone to date, there are several options for NRECA to provide technical assistance. All of these options would require local support in terms of ground transportation, collection of maps and data and assignment of counterparts. For summary purposes, these options will just be mentioned here. Draft cables for future mission use which provide scope of work, manpower requirements, timing, e't.c., are suggested at the end of this report.

1. Country assessment. Although the Motor-Columbus and UN studies have essentially done this, their emphasis appears to have overlooked the potential for micro-hydropower for remote villages currently without power. Perhaps NRECA's inputs here would be desirable. Furthermore, Government may wish a third opinion. In deference to the United Nations, however, it would appear that government reaction to the UNDP report should be assessed before the arrival of an NRECA team.

2. Prefeasibility studies of Canadian sites. At Mr. Watt's suggestion, the Canadians are performing studies of two out of the 20 sites. These two sites were felt to be the most promising according to Mr. Watt. Unfortunately, their results are not so encouraging. Nonetheless, a second opinion on these same sites or a look at some of the remaining sites might be warranted. Again in deference to the Canadians, they should be given a chance to complete their work and government reaction to their studies should be known before NRECA's arrival.

3. Specific micro-hydro assistance. In conjunction with villager oriented, local initiative energy projects, NRECA could provide technical assistance in project formulation and design. This assistance could be useful in the early stages of a demonstration project. Normally, however, these projects are initiated at the local level and sites are identified before NRECA's involvement. Furthermore, local resources and University manpower would perhaps be a more effective means of providing this service.

4. No assistance at this time. Until clarification of government reaction to the UN study is obtained, perhaps the most prudent option is to wait until the National Energy Commission requests further assistance from USAID.

This report merely tries to explain NRECA's capabilities in providing technical assistance under our contract with the Office of Energy. USAID/Freetown can then determine how those capabilities might be utilized given the status of hydropower developments in Sierra Leone and their priorities for the years ahead.

## NRECA's small hydro program

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In May, 1980, the Office of Energy of the United States Agency for International Development signed a cooperative agreement with the National Rural Electric Cooperative Association (NRECA) to promote the development of small scale hydropower in the developing countries. The program was designed to help USAID missions within host countries in the field of small hydro. Within the broad range of activities undertaken by NRECA's small hydro program, assistance to missions has included the performance of country assessments of small scale hydro potential, prefeasibility studies of selected sites, preliminary design and specification of equipment and assistance in preparation of project identification documents and project papers for small hydro programs. (A Program Status as of January, 1982 is provided as Annex 2.)

During the course of NRECA's contract with the Office of Energy, there have been several indications that the USAID mission in Freetown was interested in taking advantage of the services provided under the agreement. Recently USAID/Freetown expressed interest in a country assessment of mini-hydro potential. Since several members of NRECA staff were travelling to West Africa in conjunction with the Regional Workshop on Small Hydro, it was felt that a visit to Freetown would be an effective way of clarifying NRECA's capabilities and also to discuss a scope of work for an assessment as well as timing, manpower requirements, collection of background information, etc. Mr. Daniel Boyle of NRECA travelled to Freetown from March 7-12, 1982 to discuss these matters with USAID.

## Brief description of hydropower in Sierra Leone

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At present there are two small hydroelectric plants in operation in Sierra Leone. A 2.6 MW plant in the Guma Valley is owned and operated by the Sierra Leone Electricity Corporation. A 100 kW isolated scheme which provides power to a water treatment plant is also in operation in the same valley. Plans for the construction of a major hydroelectric facility at Bumbuna are well underway. The total installed capacity at the plant will reach 304 MW. Initially, however, the installed capacity will be 73 MW, with a firm capacity of only 23 MW. The commissioning of this station is planned for 1988. The only other planned power station is a 4 MW (installed capacity) plant at Kenema. This project is being carried out by the Chinese and due to seasonal flow variations is expected to have a firm capacity of only 500 kW.

There is no national grid in Sierra Leone. All major towns receive electricity from diesel plants. The commissioning of Bumbuna will be the start of a national grid. In the meantime, the Ministry of Energy and Power is very interested in mini-hydropower and its potential for replacing the diesel sets. Two studies have been performed to look into the matter--the Motor-Columbus study, The Strengthening of the Sierra Leone Electricity Corporation and the UNDP study of 20 sites which has recently been completed. Although Ministry officials are aware of these studies, they would still welcome the development of a comprehensive inventory of hydro sites. Presumably, the two studies already performed provide that inventory; however, one suspects (this is based on conversations with Dr. Basse of the University) that the engineers in the Ministry do not agree fully with the underlying assumptions of those studies. Since neither report has been made public and since official reaction is unknown, it is impossible to ascertain exactly where officials disagree and for what reasons.

A glance at a map of Sierra Leone reveals numerous rivers. With an annual precipitation exceeding 4000mm in some areas, this is to be expected. However, rainfall is very seasonal with the majority of precipitation occurring between the months of June and November. Stream flows are thus highly variable. In terms of hydropower, this means that in order to take advantage of rainy season flows and increase the firm capacity of the plant, storage is required. Storage requires dams and large investment in civil works. On the other hand, one can design hydro schemes on the basis of minimum flows. This reduces the installed capacity and consequently the total investment. In addition, one could base his installed capacity on rainy season flows and not expect to produce full power year round. However, the impression was gained from all sources that dry season flows in most cases would not allow year round power production without storage facilities. Whether or not year round power production is necessary depends on

power requirements and the availability of alternative means of generation (i.e., diesel). In the final analysis, economic considerations are paramount.

Topographically, it appears that most river slopes are very gentle in Sierra Leone. In fact, the UNDP consultant who has been studying the river beds for the past three years, stated that for the 20 possible sites he located, dams would be required to create head. Furthermore, the shallow nature of the river basins in practically all cases would require wide dams which naturally raise the cost of civil works.

It should be pointed out that the UNDP consultant based his entire investigation on the premise that hydropower should be considered only where it can replace existing diesel plants. Furthermore, he found that the only feasible sites were fairly remote from the diesel plants. To compensate for line losses and maximize investment benefits, he based all his calculations on the maximum potential of the site. Consequently, most of his sites are of the order of 10 MW and above.

When asked about the potential for smaller capacity sites, Mr. Watt stated that no sites were close enough to existing diesel plants and population centers. In his opinion, line losses for lower capacity sites would nullify investment benefits. As far as the potential for micro hydro plants (below 100 kW) to provide energy to small villages currently without power, Mr. Watt did not think that many sites for that purpose are available. Thus, he felt that a micro-hydro demonstration plant would be misleading since it would have limited prospects for replicability. He further felt that such plants would be a luxury item for the country.

It is immediately recognized that the above statements are based on the professional judgment of one individual. Although another opinion may be warranted and although there may be gaps in his study, until the government actively solicits another opinion, the fielding of a team appears to be premature. In other words, the ball is still in their court.

The idea of tying hydropower production into existing or planned irrigation or flood control projects was also broached with Mr. Watt. He stated that no such projects or plans exist. Mr. Uphaus concurred. In the future, however, as major water resource projects for the country are planned, the feasibility of producing hydropower as an adjunct activity should be examined.

## Draft cables requesting NRECA assistance under various options

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In the event that the mission and/or the Ministry of Energy and Power wish to have an NRECA team travel to Sierra Leone to perform any one of the previously mentioned options, the following draft cables are provided. These cables describe the scope of work, the expertise required, the time frame and the counterparts involved. If one of these options are elected, local support, as stated must be guaranteed. If the time frame becomes skewed, the mission should make the necessary adjustments, allowing NRECA 30-45 days notice.

Of the three options mentioned previously, Option 2 (Prefeasibility (Prefeasibility studies) would have to be considered hypothetical at this time. Someone from the Ministry of Energy and Power or the National Energy Commission would have to select which sites were to be examined. Presumably they could use the UN report as a starting point. Field visits would have to be planned in advance, allowing a half to a full day at each site. (The mention of six sites for prefeasibility studies is merely a point of reference for the draft cable.)

## Country assessment

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USAID/Freetown requests ST/EY to provide a technical assistance team to perform a country-wide assessment of mini-hydropower in Sierra Leone. The purpose of the assessment would be to develop an inventory of potential hydro sites below 5 MW in capacity according to the following priorities--

1. Replacement of existing diesel sets
2. Supplementary power for diesel sets in order to conserve fuel
3. Remote electrification of villages currently without electrical power
4. Potential for hydropower in conjunction with planned or existing irrigation and/or flood control projects.

The team should include a hydrologist, a hydro engineer and an energy economist, all familiar with both mini and micro hydro. The team should expect to spend three full weeks in the country. They will work closely with officials from the Ministry of Energy and Power and the National Energy Planning Commission. Field visits will be planned by the above agencies who will also provide ground transportation.

The team should be prepared to assess the effect of potential mini-hydro development on future hydro projects of a larger scale.

It is suggested that NRECA attempt to contact UNDP officials in New York to discuss contents of their recent evaluation of 20 sites throughout the country. This report was performed by Mr. Thomas Watt and has not yet been made public (pending government review).

Team should plan arrival no later than early May since heavy rains will begin in June. Please telex detailed bio-datas and travel particulars as soon as possible.

## Prefeasibility studies

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USAID/Freetown requests the services of a NRECA technical assistance team to perform prefeasibility studies for 6 small hydro sites throughout Sierra Leone. The team will be responsible for assessing the technical, economic, financial, social and environmental characteristics of each site. Special attention should be given to potential productive uses of the power in rural areas. Benefit/cost ratios and economic rates to return are to be calculated for those sites found feasible. All sites are to be ranked according to technical and economic feasibility.

The team should consist of four individuals: a hydrologist, a civil engineer, a mechanical/electrical engineer and a socioeconomist. All team members should have appropriate small hydro and developing country experience.

It is expected that three weeks in country will be required, including three to four days for data collection and analysis, seven to ten days in the field and the final week to perform calculations, analyze field data, prepare draft conclusions and hold de-briefing meetings. A final report will be expected within 45 days of team departure.

Team will work closely with counterparts from the National Energy Commission.

Please cable bio-data and travel particulars as soon as possible. Suggest team plan arrival before mid-May.

## Micro-hydro assistance

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USAID/Freetown requests the services of a micro-hydro engineer under ST/EY contract with NRECA. The engineer should be familiar with site reconnaissance, design layout, civil structures, equipment and costs associated with village level micro hydro projects (below 100 kW) in developing countries. The person selected will work closely with engineering professors from the Fourah Bay College of the University of Sierra Leone who have formed an interdisciplinary group to evaluate energy problems and solutions. The specific assistance required will be to aid in the selection of appropriate sites for micro hydro installations, establish preliminary designs including equipment and material selection and assess the costs for site development. Availability of power (that is, output and duration) as well as appropriate end uses should be an integral part of the study. Of all the sites reviewed, at least one should be selected for demonstration purposes.

The engineer should plan on remaining in country for two to three weeks.

Please cable bio-data and travel particulars when available.

Annex 1--List of contacts

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Name and title

Ms. Theresa Healy, Ambassador	U.S. Embassy, Freetown
Mr. Charles Uphaus, Agricultural Economist	USAID, Freetown
Dr. Michael Bassey, Professor (ME)	University of Sierra Leone
Mr. B.B. Ibrahim, Dean of Faculty	University of Sierra Leone
Dr. D.L.B. Kamara, Professor (EE)	University of Sierra Leone
Dr. A.E.O. Gilpin, Professor (CE)	University of Sierra Leone
Mr. Kabia, Chief Engineer	Ministry of Energy and Power
Mr. Harleston, Deputy Chief Engineer	Ministry of Energy and Power
Mr. Thomas Watt, Consultant	United Nations Development Program
Mr. Campbell, Consultant	World Bank
Mr. Alex Dickie, AID Affairs Officer	USAID, Freetown
Mr. Louis A. McCall, Commercial Officer	U.S. Embassy, Freetown