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ANALYSIS OF RURAL ELECTRIFICATION IN GHANA WITH SPECIAL EMPHASIS ON WESTERN REGION AND MINI HYDRO

FINAL REPORT

ANALYSIS OF RURAL ELECTRIFICATION IN GHANA, WITH SPECIAL EMPHASIS ON WESTERN REGION AND MINI HYDRO

Submitted to:

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PREFACE

This report is the final product of a brief study of rural electrification in Ghana conducted in August of 1981 by the National Rural Electric Cooperative Association. The study was sponsored by the United States Agency for International Development.

For clarity of presentation, the report is divided into three parts. Part I includes the Findings, Conclusions and Recommendations, Terms of Reference, Background on Electrification in Ghana and the Analytical Approach used in the study. Part II assesses the Potential for Mini Hydro Generation for electrification of five rural towns in Western Region and provides a Site Analysis of those same five towns. Part III deals with several broader issues of Rural Electrification in Ghana.

For purposes of this report, the following classifications are assumed:

Micro Hydro:	0-100kW
Mini and Small Hydro:	100-5,000kW
Medium Hydro:	5,000-50,000kW
Large Hydro:	above 50,000kW

The technical analysis of the mini hydro generation potential of particular towns under consideration in Western Region included: review of topographical maps of all areas surrounding those towns; discussions with numerous surveyors, geologists and others familiar with the landscape; a visit to several of the towns; site visits to two potential hydro sites.

The conclusion was reached that mini-hydro does not represent a viable technology for those towns since the costs for low head sites with new dams are prohibitive. Maps were of a scale 1:62,500. The large scale of the maps and the brief nature of the study introduce a margin of error. Therefore, the conclusion must be viewed as preliminary and specific to areas surrounding those towns in Western Region. A detailed assessment would be required before a definitive conclusion for the entire country could be reached.

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NRECA's International Programs Division is pleased to have had the opportunity to work in collaboration with the Government of Ghana in carrying out this study.

The work of the NRECA study team would have been impossible without the support and cooperation of many individuls and organizations in Ghana. The team wishes to express its gratitude to the many people in the Ministry of Fuel and Power, The Volta River Authority, the Electricity Corporation of Ghana, the Architectural and Engineering Services Corporation, and the Western Region who gave so freely of their time and ideas. Our special personal thanks are due to Mrs. Lydia Barnor, Mr. Robert Ankrah, Mr. Larry Appiah, and Dr. Kaku Kyiamah whose active day-to-day support throughout the study were indispensible.

While this study incorporates the ideas and information of many people, the conclusions and recommendations are soley the responsibility of NRECA.

LIST OF ACRONYMS AND ORGANIZATIONS

NRECA..... National Rural Electric Cooperative Association

TCC..... Technical Consultative Committee on Rural Electrification (comprised of officials from the Ministry of Fuel and Power, the Electricity Corporation of Ghana, the Volta River Authroity and the Architectural and Engineering Services Corporation)

VRA..... Volta River Authroity (semi-autonomous agency responsible for power generation, transmission and supply to ECG, VALCO, the mines, Togo and Benin)

ECG..... Electricity Corporation of Ghana (public corporation responsible for sub-transmission and distribution of power throughout Ghana, except to those consumers served by VRA)

AESC..... Architectural and Engineering Services Corporation (public corporation with diverse technical responsibilities including collection and analysis of hydrological data)

VALCO..... Volta Aluminum Company (private company and largest consumer of electric power in Ghana)

GWH..... Gigawatt hours of (Units of energy, 1GWH = 1,000,000 kWH)

AT & P.....African Timber & Plywood Company

point.....A lighting or appliance receptacle

CHAPTER I.

SUMMARY OF MAJOR FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

TECHNICAL

FINDINGS	CONCLUSIONS	RECOMMENDATIONS
1a. No fully suitable sites for economic development of small hydropower for purposes of electrification of any one of five major towns (Enchi, Samreboi, Asankrangwa, Dadiaso and Akropong) in Western Region were found by the team. 1b. Although low head (less than 20 meters) hydro plants are technically feasible, the equipment costs for these plants are substantially greater than those for higher head plants. When extensive civil works construction costs are added to these equipment costs, site development must be examined carefully from an economic perspective.	1. Small scale hydropower by itself does not appear to represent a viable technology for a program of decentralized electrification of rural towns in Western Region.	1a. There is reason to believe that potential exists for higher head sites in Brong-Ahafo, Eastern and Volta Regions of Ghana. An assessment of the mini hydro potential vis-a-vis generation alternatives should be undertaken in those regions if and when energy supply investments are expected. 1b. Future assessments of mini-hydro potential should pay special attention to opportunities for combined water resource projects (such as irrigation schemes) where power generation would be a secondary benefit.
2a. Existing diesel sites in Ghana are plagued with operational problems such as lack of fuel and spare parts. However, whereas small hydro is limited to certain sites, diesel generation can be accomplished anywhere at relatively competitive rates. 2b. Decentralized thermal plants are in operation in Ghana in connection with industries which produce the raw materials for fuel such as sugar and timber processing. Two plants visited supplied electricity to the local villages as an adjunct activity.	2a. Unfortunately, diesel generation for decentralized electrification of rural towns in Western Region appears to be the only short run alternative for many areas. 2b. When tied to a productive consumer and/or an industry which produces the combustible material (e.g. bagasse, sawdust), decentralized thermal plants represent a viable technology for electrifying rural towns.	2. In terms of short and medium run requirements, isolated communities with a potential for high productive demand should be served by decentralized diesel generation except where industries provide ample supplies of raw materials for steam generation or where hydrologic and topographic features favor small hydro applications. Additional effort should be made to ensure that these diesel plants have access to the needed spare parts and fuel.

TECHNICAL

FINDINGS	CONCLUSIONS	RECOMMENDATIONS
3. The existing grid comes close to, but does not serve, a large portion of Ghana's population. Also, certain distribution practices lead to operational problems.	3. Expansion of the existing grid offers the optimum long run solution for rural electrification.	3. In the long run, available resources for electrification should be concentrated primarily on rehabilitation and secondly on the eventual extension of the national grid. Such extension should be preceded by carefully performed feasibility studies.
4. Sites for development of medium scale hydro potential have been identified on major rivers in Western Region. Feasibility studies for these sites were completed years ago.	4. As far as hydropower goes, medium scale hydro appears to offer the optimum option for river basin development in Western Region.	4. Additional investigation should be made of the potential for supplementing regional electricity generation in Western Region through already identified medium scale hydro potential. Such generation could energize a regional distribution system and/or supplement the national grid. The investigation should include a comparison to the feasibility of generation from the recently discovered natural gas deposits in the region.

ORGANIZATIONAL

FINDINGS	CONCLUSIONS	RECOMMENDATIONS
1a. Electricity is supplied in rural areas by several different groups including the Electricity Corporation of Ghana (ECG), private individuals or groups, district and local administrations. 1b. There is a proliferation of public sector organizations at all administrative levels in Ghana.	1. There are many underutilized and partially overlapping organizations in Ghana, particularly in the public sector.	1. Concentrate available technical assistance on strengthening of existing organizations, rather than the creation of new ones.
2. For electrification purposes, localities are designated "rural" if they are served by decentralized generation and distribution systems and receive explicit central government subsidy. Thus, by definition rural electrification programs are not solvent.	2. There are important potential advantages to increasing the commercial orientation of the electricity sector.	2. Explore private sector alternatives for providing rural electrification.
3a. No one outside the central ECG organization in Accra currently has responsibility for ensuring financial viability of individual supply areas, for promoting productive uses of electricity, or for encouraging new connections. 3b. Although ECG has representatives at the regional level, all key management decisions, financial as well as technical, are taken in Accra. 3c. Demands for extension of rural electrification originate at the district and regional levels, but are evaluated in Accra. 3d. Local administration in rural areas is not established as body corporate, but district and regional administrations are. 3e. Several countries, including the U.S., Great Britain, the Philippines and others, have had impressive success with rural electrification through the decentralization of management and operation of the sub-transmission and distribution facilities.	3. There is some reason to believe that the provision and extension of electrication would be improved by decentralizing management and control of sub-transmission and distribution to regional and district administrations, respectively.	3. Further consideration should be given to the decentralization of sub-transmission and distribution to the regional and/or district levels, and a decentralized program should perhaps be tried in one region.

ECONOMIC

FINDINGS	CONCLUSIONS	RECOMMENDATIONS
1a. Electricity in rural areas is currently regarded and priced as a social service, thus unit costs of service are not a major consideration in selecting areas for rural electrification. 1b. ECG's rural electrification schemes are operating under heavy subsidy (ratio of operating revenues to costs = 1:4). 1c. In some areas, rural consumers are expected to pay a substantial connection fee covering the costs of bringing electricity to their homes or businesses. There is some evidence that these fees act as a substantial deterrent to requests by consumers for service. The study team learned of no examples where this connection fee was amortized over monthly billings.	1a. The current pattern of tariffs for rural electrification distorts utilization patterns and puts additional pressures on government budgets. 1b. The ability to charge economic tariffs in rural areas in dependent on the selection of sites offering low unit costs of service.	1a. Rural electricity tariffs, expecially for decentralized schemes, should vary by locality and should be linked to the cost of service and/or other development objectives. 1b. Priority for electrification of new sites should be linked to the ability to charge economic tariffs to consumers. This favors sites with low service costs and/or significant productive uses.
2a. With the exception of large industrial users, electricity in rural areas of Ghana seems to be used primarily for street lighting and domestic lighting. 2b. To date, productive uses of electricity in rural areas have been confined to use by the few major processing industries located in these areas. Other productive uses are currently limited by: the unreliability of electricity supply, the level of "sunk cost" in non-electrified machinery, the unavailability of electric machines and ancillary devices and the lack of promotional efforts.	2a. The ability to charge economic tariffs in rural areas is dependent on the existence of productive uses. 2b. Specific actions can be taken to increase the productive uses of electricity in rural areas.	2. Where electric service is already supplied or is being installed, a concerted campaign should be launched to encourage productive uses of electricity.

CHAPTER TWO
BACKGROUND, TERMS OF REFERENCE AND PROGRAM OF ACTIVITIES

A. BACKGROUND

This study was initiated in October, 1980 at the invitation of Prof. George Benneh, then Minister of Lands, Natural Resources, Fuel and Power of the Republic of Ghana. A 4-day visit to Ghana to discuss terms of reference for the study was conducted in December 1980 by two officials of NRECA, Mr. George Doud (Regional Administrator for the Middle-East and Africa) and Dr. David Zoellner (Assistant Administrator for Small Hydropower Projects). Based on these preliminary discussions, it was decided to focus the study of rural electrification on one region of the country (Brong-Ahafo) and to give special attention to an investigation of the feasibility and applicability of small hydropower generation options.

Draft terms of reference were submitted by NRECA to H.E. Wulff-Tagoe, Minister of Fuel and Power, in March of 1981. In April of 1981, NRECA reveived a formal request from Minister Wulff-Tagoe to provide the services of a 3-person team for three weeks to conduct the study.

NRECA conducted the study in Ghana from August 16 through August 31, 1981. The composition of the team was: Mr. Lawrence S. Cooley, Team Leader and Economist of Management Systems International, Mr. Fred G. Key, Rural Electrification Specialist and retired General Manager of Middle Tennessee Electric Cooperative and Daniel J. Boyle, Mini Hydro Specialist of NRECA.

The team worked in close collaboration with the Ghana Government's Technical Consultative Committee on Rural Electrification (TCC), responsible for decentralized rural electrification. This committee, composed of representatives of the Ministry of Fuel and Power, the Volta River Authority (VRA), the Electricity Corporation of Ghana (ECG), the Architechtural and Engineering Services Corporation (AESC) and outside consultants, has responsibility for examining, inter alia, the possible role and scope for small hydro rural electrification. VRA has been designated as the coordinating agency for any small hydro implementation efforts.

B. TERMS OF REFERENCE

Initially, NRECA was to conduct a brief study of rual electrification in the Brong-Ahafo Region of Ghana. This study was to include but not be limited to, an assessment of the potential for isolated generation from mini-hydro plants. Based on NRECA's experience in rural electrification in the United States and abroad, it was felt that its advisors could provide a unique perspective and some useful insights for rural electrification planners in Ghana. Futhermore, through the expertise of its mini-hydro program, an alternative to grid extension could be explored.

Prior to the team's arrival, the Volta River Autority made the decision to extend the grid through Brong-Ahafo to the northern reaches of Ghana. The result was a change in emphasis for the NRECA study from Brong-Ahafo to Western Region. A second change concerned the issues to be addressed in the study. For reasons unclear but perhaps due to personnel changes, Ghanaian officials came to expect the study to focus entirely on decentralized hydroelectric plants. As a result of these changes in region and focus the Terms of Reference presented to the team upon its arrival differed from those

discussed previously in three respects: 1) the change in regions; 2) the strict emphasis on mini-hydro to the point of design and bid document preparation; and 3) the absence of any consideration of the broad issues of rural electrification. After discussion, agreement was reached on final Terms of Reference which are described in Chapter 2 and which form the basis of this report. These Terms of Reference reflect the geographical shift to Western Region and the increased emphasis on mini-hydro alternatives. They also include attention to some broader issues of rural electrification and exclude detailed design of particular mini-hydro schemes.

The final Terms of Reference adopted for the study were as follows:

"The Team, working in close cooperation with Ghana Counterparts, shall provide the following services and studies:

(1) The team shall make an inventory of mini-hydro potential sites on all the western rivers with initial reference to sites near the following load and population centres:

(a) Enchi

(b) Samreboi

(c) Asankrangwa

(d) Dadiaso

(e) Akropong

(2) The team shall make technical, organizational and socio-economic evaluation of the identified potential sites to compare viability of small hydro with that of other sources of energy supply such as:

(a) Extension from the existing transmission grid (in consultation with ERGS Engineering who have been commissioned by Western Regional

Administration to carry out feasibility studies for electrification of the region);

(b) Thermal sources.

The team shall rank all the sites on the basis of the above evaluation.

(3) All reports of the team shall be submitted in English to the client, first in draft and then finalized after Client has discussed the draft with the team. Fifteen copies of the reports shall be submitted to the Client."

In addition, it was agreed that the team should, to the extent feasible, review and make recommendations concerning more general technical, organizational, and economic considerations affecting rural electrification in Ghana.

C. PROGRAM OF ACTIVITIES

The team spent 2 1/2 weeks in Ghana in August of 1981. During this period, the team's time was divided roughly as follows:

DAYS: 1-5; LOCATION: ACCRA

ACTIVITIES:

Clarification of terms of reference; initial briefings; technical discussions with officials of the Ministry of Fuel and Power, VRA, ECG, AESC, Ministry of Youth and Rural Development, Technoserve, U.S. Peace Corps, ERGS Engineering, and others; review of technical data.

DAYS: 6-12; LOCATION: Western Region

ACTIVITIES:

Investigation of specified sites; assessment of alternative small hydro sites; investigations of existing decentralized generation schemes; review of existing and potential productive uses of electricity in rural areas; discussion with electricity consumers, prominent citizens, regional officials of ECG and VRA, and officials responsible for administration and development at the regional, district and town levels; de-briefing with regional officials.

DAYS: 12-16; LOCATION: ACCRA

ACTIVITIES:

Preliminary review of findings, conclusions and recommendations with officials of the Ministry of Fuel and Power, VRA, ECG and AESC; preparation and discussion of draft report; de-briefing with Minister of Fuel and Power and other key government officials.

While in Western Region, the team was accompanied by Dr. Kaku Kyiamah of ERGS Engineering and Mr. Larry Appiah of VRA who, in effect, served as advisors to the team.

The many people with whom the team held substantive discussions in Accra and Western Region are listed in Annex 10, along with their organizational affiliations and the localities at which they were contacted.

A draft report including a summary of major conclusions and recommendations was prepared in Ghana and presented to the Minister of Fuel and Power prior to the departure of the team. This final report reflects comments on the draft made in Accra and Washington. The major conclusions and recommendations do not differ substantially from those included in the draft report.

CHAPTER THREE
ELECTRIFICATION IN GHANA

A. COVERAGE AND GROWTH

Ghana has a long history of electrification dating back to the early part of the 20th century. The magnitude of electricity produced and consumed remained relatively small until independence in 1957, and was primarily confined to decentralized diesel and steam plants for major cities, towns and industries. The system was expanded after independence to provide power for the extensive industrial and infrastructural development which accompanied independence.

A quantum leap in electricity production and consumption occurred in 1965 with the completion of Ghana's first major hydroelectric scheme at Akosombo, the establishment of a commercial aluminum smelter, and the initiation of electricity sales to Togo and Benin.

A second major hydroelectric scheme is virtually completed at Kpong and other schemes have been studied at Bui and at other sites around the country. These additional sources of electricity are intended to supply the increasing demand from current consumers, facilitate increased industrial activity, and permit grid extension to other parts of the country, to Upper Volta and to the Ivory Coast. Potentially major natural gas deposits have been located offshore near Takoradi, and use of these resources to energize an integrated iron and steel industry is being considered.

Diesel and steam plants have been established over the years in several towns around the country. Some of these plants are operated by ECG as part of their program of rural electrification and others are operated by a variety of public and private

entities. The number of such plants has increased only slightly in recent years as some schemes have been added and others have fallen into disrepair.

A loan has recenty been approved by the German Bank for Reconstruction for 50m DM to extend rural electric supplies in the Volta Region from the existing power grid.

A map showing the existing and proposed grid, is presented in Annex 2 of this report, while a map of ECG diesel sets can be found in Annex 6.

In 1981, the total approximate power demand on the sytem was 670 MW, of which 60% went to the VALCO aluminum smelter, 6% went to major mines, 6% went to Togo and Benin, and most of the remaining power (27% or 43MW) was provided through ECG to industrial, commercial, domestic and municipal consumers. Expressed in energy units of GWH and using 1977 data, the following pattern emerges:

TABLE I

Electric Energy Production and Sales (1977)

SOURCE	GWH	% OF TOTAL
Consumption:		
ECG	968	22·9
VALCO Smelter	2,784	65·9
Mines	260	6·2
Togo and Benin	179	4·2
Other	35	0.8
	4,226	100%
Generation:		
VRA	4,390	98·9
ECG	50	1·1
	4,440	100%

In calender year 1978, the system had 178,727 consumers in a national population of approximately 13 million; of these consumers, 133,810 were domestic consumers. The system coverage thus included one domestic connection for each 100 members of the population.

Although domestic consumers accounted for approximately 75% of the electricity consumers, they consumed on average only about 2500 kWh per consumer per year. Industrial consumers (0.1% of consumers) on the other hand, purchased 46% of ECG's power. The remainder of ECG's supply was sold to commercial and other consumers. This data is summarized in table 2 below:

TABLE 2

ECG'S ENERGY SALES

Category	kWh sold	% of Total	Number of Consumers	% of Total	Average kWh/Consumer Per Year
Domestic	349,925,000	33.66	133,810	74.9	2,563
Commercial	192,064,000	18.85	43,135	24.1	4,453
Industrial	465,589,000	45.70	211	0.1	2,206,583
Other	18,287,000	1.79	1,571	0.9	11,635
TOTAL	1,018,865,000	100.00	178,727	100.00	5,701

These figures exclude VRA's direct sales to VALCO, the Mines, Togo and Benin and Akosombo.

Over the ten year period from 1969 to 1979, maximum demand by ECG's consumers increased by approximately 115% from 80,000 kW to 203,000 kW. During the same period ECG's consumers approximately doubled in number (from 92,000 to 179,000) but consumption per consumer remained approximately constant at 5,000 to 6,000 kWh per year. Over the same period, it has been estimated that electricity grew from 9.3% of total energy used in the country to 9.5%, with an annual growth of approxiamtely 4.7%. The vast bulk of energy consumption continues to be from wood which is plentiful, provides an estimated 67.5% of energy used, and has been increasing by 5.1% annually.

B. SERVICE TO RURAL AREAS

In 1978, ECG was responsible for operating rural electrification schemes in 22 towns. By definition, these sites are off the grid and are accounted for seperately in ECG's accounts. Rates charged are based on those for grid consumers, though unit costs are considerably higher. In 1978, there were a total of 7,586 consumers in these schemes (less than 1% of the total number of ECG consumers and less than 1% of rural households). These consumers used 17,616 kWh (approximately 1.5% of ECG sales). In addition, ECG operated diesel plants in 7 other sites producing 34,000 kWh (approximately 3% of ECG sales).

In addition to the service provided to rural areas by ECG, a number of rural towns have managed to acquire electrification through a variety of other means. In some cases, a large mill or factory has been established in an area and provides electricity to the town on a free or subsidized basis. In other cases, individuals have acquired generating plants and provide or sell electricity to their neighbors. In still others, town or district administrations have acquired generating plants and sell electricity to local people at low rates. There are no reliable estimates of the number of consumers and

quantity of electricity provided to rural areas in these ways. By all accounts, however, the magnitudes appear to be very small and probably are colletively less than the electricity provided to rural areas by ECG.

There is no indication of substantial commercialization of electricity provision in these rural areas and those providing and receiving the electricity appear to view it as a subsidized service to the community.

C. MAJOR PROBLEMS

The electrification system in general, and the rural electrification system in particular, suffer from several endemic problems. These problems can be summarized in terms of two categories: fiscal/financial problems and internal management/planning problems.

ECG has operated for the last several years with significant and growing operating losses. In 1977 this loss was 2.2 million Cedis*, in 1978 it was 3.8 million Cedis, and there is no apparent evidence of any improvement in the situtaion. While this is partially a reflection of management problems, it also reflects systemic problems in the tariff structure. For example, ECG's major supplier, VRA, can increase its prices with minimal diffuculty while ECG is forced to seek an act of Parliament in order to pass these costs on to consumers. In addition, the rural electrification program (discussed below) is subsidized by design. To compound these problems, the ECG has serious difficulties in collecting its accounts receivable, particularly from public sector clients. And finally, the ECG suffers, like other enterprises in Ghana, from limitations in its access to foreign exchange. Given its dependence on foreign commodities (it still uses concrete poles and

*($1US = 2.75 Cedis, (exchange rate as of August 1981)

copper conductors), the corporation's limited access to foreign exchange is particularly debilitating. As a result of these problems, the system is supply constrained and unable to meet existing demands for extension of the system to new localities and consumers.

Internal management and planning problems in the electrification sector are at least as serious as the sector's fiscal/financial difficulties. All significant management and operational decisions are taken in Accra, notwithstanding the existence of regional ECG representatives. Given the problems of communications within Ghana and the many demands on the ECG's central office personnel, simple difficulties often take several weeks to address or are not addressed at all. A second effect of the current system is the absence of any necessity for relating expenditures to revenues at any level other than top management. Tariffs are not rigorously related to costs of service for geographical areas or types of consumer.

Critical vacancies in ECG management further limit the management effectiveness and resiliency of the organization, as does the necessity of responding to numerous and intense political pressures. The net effect of these factors is an overburdened, over-extended and reactive management which is driven by crises rather than by objectives and plans. These problems adversely affect revenue collection, system extension and long-term planning. The reliability of the existing urban grid system, however, continues to meet or exceed minimum standards of performance.

Rural electrification has a unique set of difficulties. Within ECG, rural electrification is accounted for as a program, but not managed as one. There are few policies or plans for rational expansion of rural electrification, and very little attention to growth potential and stimulation, subsidy analysis, and supply alternatives. Rural diesel systems, where they have been installed, are notoriously unreliable. The costs of

service to rural areas are explicitly subsidized by the central government to permit a tariff structure comparable to that in effect in urban areas. The program is viewed as a subsidized social service to rural areas with few links to commercial considerations and/or overall rural development or electrification plans. Given the small size of the program relative to ECG's other responsibilities, ECG officials are understandably reluctant to devote extensive management attention to the program.

CHAPTER FOUR
ANALYTICAL APPROACH

A. OVERVIEW

The purpose of this study is to illuminate and assess electrification options for market towns of 2,000 to 15,000 persons and not currently served by the national power grid. The study was focused, for analytical and policy reasons, on Western Region. In addition, special attention was to be paid to the options for several key towns in the midwestern portion of the region and to the specific feasibility of small hydro generation there and elsewhere.

The study included discussion and data analysis at the national and regional levels, and on site investigation of designated sites. The investigation included interviews with policy makers, administrators, electricity generation and supply officials, consumers, factory managers, surveyors, planners, and private citizens; review of maps, hydrological data and previous studies; and inspection of existing generation facilities, factories and potential small hydro sites. Analytically, the study reveiws separately the technical options, organizational options and economic options for providing rural electricity to rural towns.

B. KEY STUDY QUESTIONS

The study team sought answers to a number of questions. The most critical of these questions were:

1. TECHNICAL

1.1 Is mini hydro generation a feasible option for providing electricity to rural towns in Western Region and elsewhere?

1.2 What is the most feasible technical option for providing electricity to selected rural towns in Western Region and elsewhere?

1.3 What are the most severe technical problems facing rural electricity systems in Western Region and elsewhere, and how can these problems be minimized?

2. ORGANIZATIONAL

2.1 Is the current ECG management and organizational framework a viable structure for managing the supply of electricity to rural towns in Western Region and elsewhere?

2.2 What is the most feasible organizational option for managing the supply of electricity (with centralized and/or decentralized generation technology) to rural towns in Western Region and elsewhere?

2.3 What are the most severe management and organizational problems facing the rural electrification system in Western Region and elsewhere, and how can these problems be minimized?

3. ECONOMIC

3.1 Is the provision of electricity to rural towns in Western Region and elsewhere economically and financially justified?

3.2 What pricing and other policies are most likely to contribute to the economic and financial viability of electrification for rural towns in Western Region and elsewhere?

3.3 What are the most severe problems limiting the productive uses of electricity in rural towns of Western Region and elsewhere, and how can these problems be minimized?

The following chapters address these questions in detail. Given the limitations of time and data, the answers to some of the questions are necessarily somewhat subjective or tentative. Nevertheless, the study team offers these observations in hopes that they will contribute to the ongoing planning process for rural electrification in Ghana.

CHAPTER FIVE
MINI HYDRO POTENTIAL IN WESTERN REGION

A. FINDINGS

1. Nature of Mini and Small Hydro

The use of water power to generate electricity on a small scale is a proven technology, in existence for over 100 years. The relatively recent worldwide interest in small scale hydroelectricity is mainly due to the increasing cost of generation alternatives (i.e. diesel) and low operating costs associated with hydro. Nonetheless, the captial cost associated with site development for small scale hydroelectric installations can be substantial, and, extreme care and careful planning are required in site selection, design, installation and management.

There are important differences between small and large hydroelectric installations, also between small hydro plants and equally small diesel fueled plants.

Compared with a large hydro installation, the small hydroplant has little influence on the overall power grid. The small hydroplant cannot be depended on in the event of a major power outage or blackout, nor does the small plant give much help to a power system that is chronically short on peaking capacity. Consequently the small plant does not need all the controls, safety equipment and auxiliaries which are necessary for large hydro to prevent failures and to facilitate plant re-starting. The machinery and instrumentation of a small plant is much simpler and less costly. A small hydroplant can also be engineered and built in a relatively short time. Frequently it is simply an addition to an existing structure.

Compared with a diesel generating unit of equal capacity, the initial captial investment for a small hydro unit is much greater, even though the diesel engine is a more complex mechanism. The reason is simply that diesel engines are mass produced while hydro turbines are custom made. However, the concept of small hydro turbines has gained importance only in recent times and manufacturers are now begining to standardize small units for lower cost.

What gives small hydro turbines an advantage over diesel in the long run is, of course, the fact that hydro "fuel" is free while diesel fuel becomes more and more expensive and requires foreign exchange.

The unit cost (per kW) of a hydro turbine increases as the capacity and the available head decrease. The smaller the capacity and the lower the head, the greater is the cost per kW. The reason is that the output of the turbine is a direct function of head and flow. To produce the same amount of power, a turbine with a 10ft. head requires twice as much flow as a turbine with a 20ft. head. Therefore the lower head turbine will be physically much larger, ergo more expensive, than the higher head unit.

The energy output as well as the dependable or "firm" value of a small hydro installation can be increased by a reservoir which stores the wet season flow. This storage is usually difficult and expensive to build. Ideally the water storage, and the head, come from an existing storage dam which requires only the addition of a generating unit. Such reservoirs do not exist in Western Region.

2. Features of Western Region Relative to Mini Hydro

The southern half of Western Region lies below 500 feet above sea-level. The northern half lies between 500 and 100 feet. All of the five towns under study lie below 500 feet. The landscape is hill, not mountainous. The rivers and streams which flow in the region, in general, have very gentle gradients. A physical map of Ghana is present in Anex 3.

Western Region, on average, receives more rainfall than any other region in the country during two rainy season. The principal rainy season reaches its peak in May and June and the secondary one in October. The driest month is August.* A map of average annual rainfall in Ghana is reproduced as Annex 4.

The region is drained by three major river basins: the Bia Basin, the Tano Basin and the Ankobra Basin. Annex 5 is a map of the major river basins in Ghana, and Table 3 provides some information on the basins in Western Region.

TABLE 3 WESTERN REGION BASIN CHARACTERISTICS

CATCHMENT AREA RIVER/GUAGING STATION	AREA (MI^2)	AVE. FLOW (cusecs)	MIN:MAX FLOW (cusecs)
Tano/Tanoso**	5742	4213	887:8519 1:10
Ankobra/Bonsa**	3267	1748	263:4177 1:16
Bia/Dadiaso***	2500	200	30:1100 1:37

*"Environmental Report on Ghana," Arid Land Information Center, University of Arizona, October 1980.
**Figures provided by AESC.
***Data not exact. Based on a review of four years of flow data provided by VRA.

The study team was provided topographical maps of Enchi, Sambreboi, Asankrangwa and Dadiaso, including surrounding areas. Hydrologic and topographic features were also discussed with surveyors and geologists from the Tarkwa School of Mines, the Gold Mines at Prestea and the African Timber and Plywood Company at Samreboi. Several residents of the region were also interviewed regarding the physical characteristics of the areas under study.

After a review of the maps and discussions with knowledgeable residents, no high head sites were identified by the study team.

Two lower head sites were inspected for potential power production. The first was Muminicamp some 20 miles south of Samreboi. The second site was within walking distance of Akropong. Unfortunately, the streams were minor and the available head was under 15 feet. The potential power production in both cases at the time of observation was on the order of 5kW. Since the purpose of the study was to investigate potential sites for electrifiction of major towns, these sites did not merit further analysis.

The only way small scale hydroelectric technology could accomplish the goal of electrification of the towns in question would be through the construction of dams on major streams and rivers to create head. This option would involve large investment in extensive civil works, flooding of large areas and considerable site investigation and design work. To illustrate the high costs associated with such an alternative,* an analysis of two alternative sites near Dadiaso is presented in Annex 7.

The analysis in annex 7 is not based of field visits; it is not a preliminary feasibility study. It is merely a rough estimate for purposes of cost comparison. The

*See "A Simplified Methodology for Economic Screening of Small-Scale - Low Head Hydroelectric Installations," Electric Power and Research Institute.

analysis demonstrates that small scale, low-head hydroelectric facilities which require construction of new dams and spillways can rarely be justified on the basis of power production alone. Of course, benefit-cost comparisons for multi-purpose projects such as irrigation, fish production and flood control will yield different results. In the absence of hard data, many assumptions were required in order to quantify this analysis. These assumptions are explained and discussed as they arise.

Although no low cost mini hydro generation sites seem to exist in Western Region, site conditions more favorable for low cost mini hydro generation may exist in other parts of the country. Often these conditions are found near waterfalls. Four waterfalls were mentioned which might be worthy of prefeasibility studies. (It is important to keep in mind that use of these sites for generating electricity during daylight hours would diminish their value as tourist attractions.)

The four locations are:

1) Boti Falls, Koforidua, Eastern Region
2) Wli Falls, Hohee, Volta Region
3) Amedzofe Falls, Amedzofe, Volta Region
4) Fullers Falls, Kintampo, Brong-Ahfo Region

CONCLUSIONS

1. Small Scale Hydropower By Itself Does Not Appear to Represent a Viable Technology for a Program of Decentralized Electrification of Rural Towns in Western Region.

The natural topography in Western Region does not allow for development of simple run-of-the-river schemes which avoid the necessity of major civil works. Thus, the minimum power requirements could only be met after considerable expense in site studies and dam construction, involving flooding, relocation and environmental problems. Low head sites which require extensive investment in new civil works can rarely be justified on the basis of power production alone. If other benefits such as irrigation and fish production on the order of 80-90% of project costs can be identified, projects worthy of investment might be located.

Localized use of micro-hydro power (under 100kW) at existing dams or reservoirs was not evaluated since it would not suffice for electrification of rural towns. Nonetheless, these installations might prove economically viable under certain conditions, especially when tied to a specific productive end use such as a mechnically driven mill.

It is possible that a more extensive evaluation of the Western Region would reveal small hydro sites. If these sites were near a load center and if they were economically viable, consideration should be given to them on a case-by-case basis.

RECOMMENDATIONS

1a. <u>There is Reason to Believe that Potential Exists for Higher Head Sites in Brong-Ahafo, Eastern and Volta Regions of Ghana. An Assessment of the Mini Hydro Potential vis-a-vis Generation Alternatives Should be Undertaken in those Regions if and when Energy Supply Investments are Expected.</u>

1b. <u>Future Assessments of Mini-Hydro Potential Should Pay Special Attention to</u>

Opportunities for Combined Water Resource Projects such as Irrigation Schemes Where Power Generation Would Be a Secondary Benefit.

CHAPTER SIX
SITE ANALYSIS

A. INTRODUCTION

Chapter four of this report reviews the analytical approach used in carrying out this study. To reiterate, the approach included discussions and data analysis at the national and regional levels, and interviews and investigations at the local level. Several technical, organizational and economic issues were germane to the approach and the process of executing the study. Many of these issues overlapped at most sites under investigation, and therefore it was not necessary to analyze each issue at each individual site. Furthermore, technical considerations at some sites preempted the need for detailed, on site analysis of the remaining issues. The following paragraphs provide a brief description of the application of the analytical approach to the sites under study. Much of the general information was acquired during discussions held at the national and regional levels.

Before describing each site, it will be useful to review some aspects common to the areas under study. With the exception of Akropong, which is semi deciduous forest, the towns in question fall in a transition zone between moist semi-deciduous forest and tropical rain forest. Dadiaso falls in a forest ochrosol soil group while the others are classified as forest ochrosol-oxysol intergrades. Rainfall is heavy, ranging from 60-70 inches per year. All of the five towns are below 500 feet above sea level. The area is very rich in timber and a variety of agricultural products are grown nearby (cocoa, rubber, coffee, cassava, plantain, rice and other food products).

B. ENCHI

Enchi is a town of approximately 5000 which lies on the Disue River, some 15 miles from the border with Ivory Coast. Major activities include food processing and rubber plantations. It is expected that Enchi will soon become a district center.

Mini hydro does not appear to be a viable technology for electrifying Enchi. The river gradients are gentle and no site with the necessary head was located. It might be technically feasible to dam up the Disue to create head but the dam would be wide and costly and the investment in site studies alone would be sizeable. The feasibility of a small thermal plant would depend on the proximity of an industry of the type that generates the raw material. To our knowledge, at the present time, no such industry is in operation in Enchi. The town does have a diesel plant which suffers from the typical problems of availability of fuel, oil, and spare parts and the high cost of operation. In the short run, efforts to improve the reliability of the existing system appear to be the best technical option for Enchi. In the long run, a medium scale hydro site at Tanoso and/or grid extension might be the optimal solutions. The grid at Prestea is roughly 65 miles from Enchi.

From an organizational perspective, it is noteworthy that: 1) ECG does not own or operate a diesel station in the area. 2) The town council does operate and sell electricity from a plant it owns; 3) The paramount chief is said to be very influential in Enchi; 4) Enchi will soon become a district center and, therefore, will be authorized as body corporate. In conclusion, the elements for successful decentralized management of electricity distribution are prominent in the public sector in Enchi.

The price of electricity supply in Enchi is not related to cost. Tariffs have been administratively established at rates below the true cost of supply.

Potential developments in the area include a rubber plantation and there is scope for palm oil processing and timber milling. The need for electricity supply for these activities needs to be analyzed, along with the possibility of using electricity generated by and for these facilities to meet the needs of the township.

C. SAMREBOI

Samreboi is one of the biggest rural towns in the Western Region with an estimated population of near 10,000 in 1980. The town is surrounded by forest and owes its importance to the timber industry, namely the African Timber and Plywood Company. As the name implies, Samreboi lies at the junction of the Tano and the Samrei Rivers.

Again, however, river slopes are gentle and mini hydropower is not an appropriate technology for electrification. The African Timber and Plywood Company generates large amounts of biomass which it then uses to produce steam. The steam is used to drive machines and to generate electricity both for the mill and for the town. Unfortunately, the ubiquitious problem of spare part shortages has reduced plant operations which in turn has affected the reliability of power since less sawdust is available for combustion. Technically, then, Samreboi is electrificied and the appropriate action in the short run is to improve reliabiity at the existing facility. As equipment depreciates beyond repair, however, grid extension will have to be weighed against new investment in a power plant.

The African Timber and Plywood Company requires electrical power for plant operations. Electrification of Samreboi is an adjunct activity of AT & P, thus managed by an established organization at the local level. This sytem works well under present conditions. If electrification requirements were to expand beyond the capabilities of AT & P, however, organizational alternatives would have to be sought.

As an electrified town, Samreboi provided an opportunity for insight into the economic issues surrounding decentralized electrification in Western Region. Company personnel receive the installation free of charge, while other villagers must purchase the equipment. Rates are 2.2 Cedis per point per month, with an extra charge for refrigeration. Electricity is almost exclusively used for domestic purposes (lighting, ironing, and a handful of stoves and refrigerators). Diesel mill owners have not converted to electrical power for several reasons (sunk investment, reliability problems, non-availability of electrical motors and appurtenant devices and the lack of promotional efforts). These reasons or constraints have also restricted the establishment of small scale industries. In particular, despite the availability of raw materials and cheap electricity, local carpentry and furniture shops do not use power tools (except at the AT & P plant). Overcoming these constraints to productive use will be a pre-requisite to financial viability of rural electrification.

D. ASANKRANGWA

Asankrangwa is a district center. Its population in 1970 was 6571 and has experienced an estimated annual 2.5% growth rate since then.

Due to the lack of appropriate topographical features for economic small scale hydroelectric development, the technical options available to Asankrangwa fall in line with the general recommendations made in Chapter One. That is, improving the reliability of existing diesels in the short run, and pressuring for responsible grid extension in the long run, are the best means of electrification (except where special industrial schemes make thermal generation a more viable alternative).

The team had the priveledge of attending a meeting of the District Council at Asankrangwa. There, several things were noticed. First, the Council was exceptionally dynamic, actively seeking good projects for income generation. Second, they were very concerned about the welfare of their community and the optimum allocation of scarce resources in the community's best interest.

The diesel plant in Asankrangwa was donated by a local mill. The electricity is distributed at subsidized rates, but the extent of the subsidy is unknown since costs are not closely accounted for. Rates are three cedis per point per month. One council member speculated that people might be willing to pay 10 cedis per point. Even the higher figure would not cover the true costs of supply.

Uses of electricity are almost entirely domestic. Provision of service is viewed as a social amenity, not as an input to production. The team feels that the relationship of electricity to developmental efforts in the area needs to be analyzed in greated depth and that efforts to promote the productive use of electricity need to be undertaken.

E. DADIASO

It is hoped that the development of Dadiaso will help stem emigration to the Ivory Coast. The town lies near the border between Ghana and the Ivory Coast.

Dadiaso is very close to the Bia River. Unfortunately, the river bed is virtually flat, thus, small scale hydropower is not a suitable technology (see technical and economic assessment in Annex 7 of hypothetical schemes). Grid extension for the small (population 1923 in 1970), fairly inaccessible town does not appear economically feasible nor is there an industry nearby which generates sufficient biomass to justify the establishment of a thermal plant. Thus, if electrification is a development priority for Dadiaso, diesel generation appears to be the only technical option, at least in the short run.

The chieftainship structure in Dadiaso is extremely strong, with the chief providing leadership in all community development efforts. This develops close community cohesion, lending optimism to the cause for decentralized management of electrification for the town since cohesion and participation will undoubtedly provide a basis for responsible decision making.

Other development projects near Dadiaso include a rubber plantation. Project documents for the plantation call for the installation of a diesel generator for both processing and electrification of workers' quarters. Electrification requirements for this project, for similar projects, and for the town, could perhaps be integrated into a broader, more effective scheme.

F. AKROPONG

Akropong lies to the northeast of Asankrangwa and the two are connected by a partially paved road. The team visited Akropong at the recommendation of several individuals. Although the town was not part of the original terms of reference, there was some speculation as to the suitiability of a nearby stream for generation of electricity.

Unfortunately, the stream was minor, practically dry during periods of low flow; and the available head at the site was not sufficient for economic site development. The general recommendations made above with respect to the other four sites are applicable to Akropong as well.

CHAPTER SEVEN
RURAL ELECTRIFICATION: THE NRECA PERSPECTIVE

In the early 1930s, about 2% of rural farms and homes in the U.S. had central station electric service. A national effort was mounted to extend the benefits of electricity to rural areas. This campaign ultimately resulted in the Rural Electrification Act of 1935. This Act established a Rural Electrification Administration which was to provide long-term, low-interest loans to any organization that would extend electricity to the farms. These loans would be for a 25 year period at a rate of interest equal to the cost of money to the government plus a small surcharge to support a staff to administer the loan program. The cost of money to the government at that time was slightly less than 2 percent.

Initially no existing organization would accept the loans. The investor owned power companies refused to participate in the program, saying the farmers did not want electricity, and that if these farmers had electricity they would be unable to pay for it.

The model which eventually evolved in the U.S. to meet this electricity distribution problem was a decentralized model based on electricity cooperatives owned by groups of rural consumers. Initial experience was gained in the Tennessee Valley, during 1934 and 1935 where electric service was being distributed by electric cooperatives with loans provided by the Tennessee Valley Authority, a generation agency formed in 1933 to harness the Tennessee River. The program slowly evolved during the period 1935-1941 as more and more electric cooperatives were organized. World War II brought the program to a halt.

In 1943 the War Production Board, seeing the need for increasing the production of food, authorized the resumption of the program to extend electric service to large food production farms. In 1945, facing a pent up demand for electric service and a desire to

expedite the program, Congress passed the Pace Act establishing a flat 2 percent interest rate and extending the loan term from 25 years to 35 years. This provided the desired impetus, and in a few years the job of electrifying rural America was, for all practical purposes, completed under the aegis of 912 rural electric cooperatives.

It has been the experience in the United States that organizations are able to provide electricity efficiently and profitably to rural areas only where these organizations are regionally based, decentralized, professionally managed and business orientated. In the United States, this structure was provided by rural electric cooperatives. These rural electric cooperatives were occasionally involved in generation and/or transmission, but most were (and are) involved solely in electricity distribution. They are conceived and operated as businesses and, in virutually all cases, operate profitably. It is noteworthy that of the several billion dollars lent to electricity cooperatives by REA over the last 45 years, there has been only a single default of $40,000. Where cooperatives do not appear to be fiscally, financially and organizationally viable, REA refuses to provide them with debt financing.

In the 1940s, rural electric cooperative leaders, seeing the need for concerted action and some centralized services, organized a national organization, the National Rural Electric Cooperative Association (NRECA). NRECA was established in Washington, D.C. where it continues to provide services to its member cooperatives and, through its International Programs Divisions, to foreign governments.

The situation in the Philippines is modelled very much on the United States experience, adpated to the special needs and circumstances of the Philippines. This model of rural electric cooperatives has also proven successful in such diverse countries as Bangladesh, Indonesia and Costa Rica. In Britain, the provision of electricity to rural

areas is provided in a somewhat different fashion. Once again, distribution is provided by independent business organizations with specific geographical responsibilities. Unlike the U.S. and the Philippines, however, these business organizations are established as public boards rather than cooperatives.

In all these countries, consumption in rural areas was initially limited to a small number of consumers using electricity largely for domestic purposes. But the number of consumers and the range of uses of electricity increased only with the passage of time and the active promotion of electricty use. This promotion was carried out, in each case, by the organization responsible for electricity distribution and sales (and by the electric equipment manufacturers). Electricity tariffs were established on commercial bases by the distributing organizations, who were also responsible for billing and collections. It is a commonly held view that one of the keys to the success of these organizations has been their desire and ability to manage electricity provision as a business.

In sum, there is considerable international experience in using decentralized businesslike organizations to distribute electricity to rural consumers. The precise organizational "model" differs from country to country, but certain key features including commercial oreintation, decentralized control, and active promotion are common to many of the most successful organizations.

CHAPTER EIGHT
RURAL ELECTRIFICATION IN GHANA: TECHNICAL ALTERNATIVES TO MINI HYDRO

A. FINDINGS

1a. Decentralized Generation Schemes: Diesel

Proliferation of diesel generation schemes in remote areas of the world began in the 1920's and 30's. For reasons of low capital costs, simple installation, ready availability in a large range of sizes, and versatility, diesel sets were (and continue to be in many cases) the least cost option for decentralized power generation. This cost situation over the years has led many developing countries into a "diesel dependency" and has placed a special burden on net oil importing countries. The stepped up search over the past few years for "energy options" and "renewable energy alternatives" is partly due to the worsening foreign exchange effects of this diesel dependency. The rekindled interest in small scale hydropower is a prime example of this search.

The use of diesel generation sets for decentralized rural electrification has not been without its problems, even during the days of cheap fuel. Except where one can afford the relative luxury of redundant capacity, reliability problems are characteristic of diesel plants. Lack of access to spare parts, skilled labor, fuel and lubricating oil often prolong outages and consequently severly reduce the effectiveness of rural electrification as an input to production. Absence of foreign exchange is thus a cause as well as an effect of various negative aspects of diesel generation.

Despite its numerous shortcomings, diesel generation is often the best or only alternative available. Ghana is dotted with diesel installations. Many of these are owned and operated by ECG, but there are some privately owned or owned by other public agencies. Annex 6 gives the precise location of the ECG owned and operated sets. In

most or all of these localities and in most other towns in Western Region there does not, unfortunately, appear to be a decentralized generation technology technically or financially superior to diesel generation.

1b. Decentralized Generation Schemes: Thermal

Use of various fuels for decentralized steam generation and electrical power production has been commonplace for some time in Ghana and in many other countries. Fossil fuels, wood, and bagasse are among the more typical fuels. The theoretical basis for this technology is the Rankine Power Cycle and more recently the Stirling Cycle. In practice, the minimum equipment requirements are a boiler (with combustion appropriate to the fuel), a turbine, a condenser and a pump. Commercial systems are seldom this simple since they seek to maximize efficiency by pre-heating the air, superheating and re-heating the steam and using feedwater heaters to pre-heat the water. An overall efficiency for a small scale (under 5MW), wood fueled power plant is of the order of 20-25%.

Remote industries such as sugar and timber processing plants are often especially suitable for this technology. Such schemes are often for cogeneration purposes which means the steam is used for process applications and for power production simultaneously. The use of wood and other fuels exclusively for power production, however, is also feasible under certain circumstances. In some parts of the world (e.g. The Philippines, and Panama), fuel "plantations" are being established purely to fire these decentralized plants. Fast growing trees with high calorific value serve as the fuel. With the proper conditions, wood plantations and power plants can be made technically and economically viable, but careful planning to avoid deforestation, high transportation expenses and environmental problems is crucial to success. Highly

equipped local organizations must be in place to manage these complex schemes and to avoid the major problems.

The team visited two decentralized thermal power plants in Ghana. The first, a bagasse fired plant, was located at the sugar refinery in Komenda. The second was located at the African Timber and Plywood Company in Samreboi. Both utilized waste raw materials as fuel, generated both process steam and electricity for plant operations and electrified the local village as a service (partially paid for) to their workers. Other villagers (i.e. non-employees) could receive service at a subsidized cost.

With respect to these installations, it is important to note that the motivation for investment was the need for power at the respective processing plants. Electrification of the adjacent village came as an afterthought or adjunct.

The National Academy of Science (Washington, D.C.) in their publication, Energy for Rural Development, 1981 Supplement, reported:

> "The overall conversion efficiency for conventional steam generation of electricity from wood is about 25 percent, including boiler efficiency, steam cycle efficiency, and auxiliary power requirements, all of which are variable (Banemann 1978). Thus if hardwood containing 42 percent moisture were used as a fuel (at a conversion efficiency of 25 percent), 1.8^{t}/day of biomass would be needed to support a 50kW electrical generating plant, 5.4 t/day for a 150kW plant, 18t/day for a 500kW plant and 36t/day for a 1MW plant (see Karchesy and Koch 1979)."

Although exact figures of raw material requirements were not available for the installations visited, it is expected that the overall conversion efficiencies were

somewhat lower than the figure reported above due to age. It is estimated that 60 tons of sawdust per day are required to fuel the thermal plant at AT and P in Samreboi.

2. Extension of National Grid.

The national grid in Ghana forms a complete loop around the southern, most populated areas of the country where population of the country is concentrated (see Annex 2). The transmission lines are fairly close to the large percentage of the population. Annex 6 gives detailed information on ECG supply areas, number of consumers, energy sales and population. The map also shows the 161kV transmission line.

The team made two observations with respect to the grid and distribution practices. The first was that the transmission lines along the coast often pass directly over entire towns without stepping down to serve them. The second point of special interest to the team was the long length of secondary circuits from the distribution transformers.

The experience of other countries in the field of rural electrification provides some contrast to the above mentioned practices. In retrospect, the most successful approach to rural electrification has been a conservatively and carefully planned extension from the backbone grid to serve those communities with a potential for the development of productive loads. The "potential for the development of productive loads" is often measured by a proxy criterion which is the existence of expensive decentralized diesel installations.

The limiting factor on the length of secondary circuits in most rural distribution schemes is voltage drop. As a result of thinly spread operations, secondary circuits in

Ghana (especially in rural areas) are unusually long, leading to problems with voltage regulation. But, the appearance of productive loads in rural areas is very much a function of the quality and reliability of service. Consumers are unwilling to link the success of their livelihood to electrical power when they do not have confidence in its benefits and, the safe and efficient operation of virtually all electrical devices (especially motors) is a function of proper voltage and frequency. Limiting the length of secondary circuits may help alleviate some of the problems with voltage regulation.

To summarize our findings with respect to grid extension, there is a need for consolidation of existing facilities in order to effect improvements in quality of service; and there are population centers close to the existing grid which might be appropriate targets for subsequent extension.

3. Medium Scale Hydro

The feasibility of several medium size hydro plants has been studied at various sites on the Tano, Ankobra and Pra Rivers. One power station each on the Pra, Tano and Ankobra show a potential of 72 MW of dependable power.* These studies were not reviewed by the study team, nor were they discussed in depth with the Technical Consultative Committee. Nonetheless, the power output for any one site should be more than enough to supply the requirements for the towns of Western Region. Consequently, if and when the economics of rural electrification become favorable in the Region, a regional grid powered by one of these sites could prove a viable alternative to central grid extension and/or an important component of that extension.

*Figures provided by AESC.

B. CONCLUSIONS

1a. Unfortunately, Diesel Generation for Decentralized Electrification of Rural Towns in Western Region Appears to be the Only Short Run Alternative for Many Areas.

The economic and organizational issues surrounding rural electrification in Ghana have a strong bearing on the operation of decentralized plants. In particular, foreign exchange shortages severely curtail the efficient operation of diesel sets. In addition to consideration of the organizational and economic conclusions and recommendations offered later, serious attention should be paid to resolution of present difficulties at many of the diesel installations before increasing the number. In other words, consolidation with an aim towards easing import license and foreign exchange restrictions for spare parts and facilitating diesel fuel and spare parts deliveries, should be given preference over system expansion or new investment.

With the above caveats in place, the team's reluctant conclusion is that diesel generation appears to offer the only short term solution for decentralized electrification of rural towns in Western Region.

1b. When Tied To A Productive Consumer and/or an Industry Which Produces the Combustible Material, (e.g. Bagasse, Sawdust) Decentralized Thermal Plants Represent a Viable Technology for Electrifying Rural Towns.

Small thermal power plants utilizing bagasse or wood wastes for combustion operate at low overall efficiencies (20-25%) and require large amounts of raw material. These plants are often located at sugar refineries or lumber mills where the waste materials would otherwise go unused. At these sites, power and process steam are required for plant operations. Excess power can often be generated for electrification of adjacent areas at cost-effective rates.

Growth of timber and other agricultural products soley for power production is beginning to receive attention worldwide but entails considerable planning and managerial expertise at the local level. Costs of transportation and afforestation programs have to be closely evaluated in any feasibility study for fuel plantations and associated power plants. In Western Region there does not appear to be scope for this technology at the present time due to the lack of a qualified local organization capable of handling the complex technical and managerial problems concomitant with these schemes.

2. Expansion of the Existing Grid Offers the Optimum Long Run Solution for Rural Electrification.

Distribution from the existing grid in Ghana is currently used primarily for electrifying urban centers, often passing directly over intermediate towns. Rural electrification in other countries often proceeds from this backbone grid, expanding through priority provision to more populated areas with productive potential. Before that expansion can take place, however, Ghana will find it necessary to consolidate the existing grid. Operations are spread thinly now and will require some rehabilitation before electrification of new areas can take place. Still, given the isolated context of generation alternatives, grid expansion offers the best long run option for rural electrification.

3. As Far as Hydropower goes, Medium Scale Hydro Appears to Offer the Optimum Alternative for River Basin Development in Western Region.

Feasibility studies show 72 continous megawatts potential from one powerstation each on the Tano, Ankobra and Pra Rivers.

C. RECOMMENDATIONS

1. In Terms of Short and Medium Run Requirements, Isolated Communities with a Potential for High Productive Demand Should be Served by Decentralized Diesel Generation Except Where Industries Provide Ample Supplies of Raw Material for Steam Generation or Where Hydrologic and Topographic Features Favor Small Hydro Applications. Additional Effort Should be Made to Ensure that these Diesel Plants have Access to the Needed Spare Parts and Fuel.

2. In the Long Run, Available Resources for Electrification Should be Concentrated Primarily on Rehabilitation and Secondly on the Eventual Extension of the National Grid. For Extension Purposes, Rural Communities Should Receive Priority Based on Their Proximity to the Grid and their Probable Level of Demand - Particularly Demand for Productive Applications. Priority Targets Should be Determined Only after Performing Detailed Feasibility Studies.

3. Additional Investigation Should be made of the Potential for Supplementing Regional Electricity Generation in Western Region through Already Identified Medium Scale Hydro Potential. Such Generation Could Energize a Regional Distribution System and/or Supplement the National Grid. The Investigation Should Include a Comparison to the Feasibility of Generation from the Recently Discovered Natural Gas Deposits in the Region.

CHAPTER NINE
RURAL ELECTRIFICATION IN GHANA: ORGANIZATIONAL ANALYSIS

A. FINDINGS

1. Current Organization and Management of Rural Electrification

The overall organizational framework of rural electrification was discussed briefly in Chapter Three. It was noted, among other things, that the program is a small component of ECG efforts; that it is accounted for, but not managed, as a separate program area; that there are substantial delays in solving system problems and extending service to new consumers; that there is no clear relationship between the cost of service and its price; and that the management of the system is highly centralized in Accra.

The rural electrification system is, for the most part, a spinoff of other developments in the country. Where grid electrification has been extended from one load center to another, rural communities en route have sometimes been energized. Where factories or wealthy individuals in rural areas have acquired decentralized generation schemes to satisfy their own needs, they have often extended these systems to adjacent towns or population groups. Occasionally, district (and/or local) administrations have acquired generating plants - usually as largesse from a local factory - and provide electricity to their constituencies. And certain administrative centers have been selected by ECG for energizing. In each case, the organization providing the service is also responsible for its operation and maintenance, and for the setting and collection of tariffs.

At present, the definition of "rural electrification" in Ghana is an administrative one. Localities are designated as "rural" for electrification purposes if they are served

by decentralized generation and distribution systems and receive explicit central government subsidy. There are approximately 20 such sites served by ECG. In the large rural electrification scheme currently being initiated for Volta Region, this arbitrary definition has been modified somewhat to include small towns to be served through distribution from the national grid. Since the definition of rural has been selected primarily for financial rather than operational or programming reasons, it is not surprising that the category is organizationally relevant primarily for budgetary purposes.

No reliable extimates were available to the team of the number of households or businesses in rural areas which consume electricity. In addition to the exclusion from official figures of consumers in rural areas who receive their service from the grid, the figures also exclude rural consumers served by systems not owned and operated by ECG. While there are various inter-agency committees concerned with rural electrification policy, the management of rural electrification is diffuse and fragmentary to date. The debate on rural electrification is more political than economic, and political considerations tend to dominate both financial and rural development considerations in the public dialogue.

No one outside the central ECG organization in Accra currently has responsibility for ensuring financial viability of elements of the system, for promoting productive uses of electricity, or for encouraging new connections. (See Chapter Seven below for a fuller explanation of the phenomenon.) This relative absense of a business orientation to the organization and management of rural electrification is also characteristic of those schemes-owned and operated by local factories or district/local administrations. In all of these schemes, rural electricity is viewed primarily as a subsidized consumption good. In

the ECG schemes, the effect of this perspective is magnified by the centralized and aggregate approach to managing the sector.

ECG has representatives at the regional level. These representatives typically have staffs of several engineers and various administrative and revenue collection personnel. However, all key management decisions -- financial as well as technical -- are taken in Accra, and many key services and materials are provided from Accra. Rural electrification receives very little attention from these regional ECG representatives.

Demands for extension of rural electrification orginate at the district and regional level, but are evaluated at the central level. Those responsible for initiating these demands (largely politicians and administrators) have no opportunity or responsibility for assessing these proposals relative to one another or relative to their technical or business implications.

2. Organizational Profile of Rural Areas

Ghana has no shortage of organizations. Casual observation revealed 39 national public sector organizations with permanent representations to the district level(see Annex 8 for a list of these organizations). One informed observer suggested that upwards of 75 such national organizations are represented at the regional level. A comparable proliferation exists in Accra.

There are few municipal, district or regional government agencies which are not headquartered in Accra. There is, however, an extensive public administration system at the regional, district and local level. There is also an unusually large number of religious, social and political organizations established in rural areas. In certain rural

towns, a major industry or other commercial concern provides an additional organizational focus in the community. Otherwise, there is relatively little commercial organization in rural areas.

By comparison to most other countries in Africa, the rural population of Ghana is quite clustered. The bulk of the rural population lives is small to medium sized towns and is exposed to a variety of public, communal and private organizations.

As noted above, the public administration system at the sub-national level is divided into three tiers - local (typically several hundred to several thousand people), district (typically 30,000 to 150,000 people) and regional (typically 500,000 to 2,000,000 people). Each of these levels of administration is discussed briefly below.

Local administration in rural areas is not currently established as body corporate. It is well integrated with the local chieftainship structure and normally operates with the sufferance of the local chief. It is responsible for organization and control of certain social services, and collects some taxes and revenues. Its members are very accessible to their constituency, and it typically gives substantial consideration to individual needs and problems in assessing and collecting taxes and fees. It rarely engages in commercial projects.

The district administration in rural areas is established as body coporate. It too is integrated with the chieftainship, though often not as fully as at the local level. It devotes considerable effort to coordinating the efforts of the many national organizations operating at the district level. It raises taxes and receives modest government subventions; and it oversees the provision of certain key services. It operates under the day-to-day supervision of a District Chief Executive who is a paid

civil servant. It too is quite accessible to the citizenry, but is much less subject than are local authorities to special pleadings. On occasion, district administrations operate commercial ventures. Cases exist where district administrations have acquired diesel generators and sell electricity to citizens, normally at subsidized rates. USAID has, for several years, been operating a project to enhance the management capability of district administrations.

Like the district administrations, the regional administrations are incoporated. Each region operates under the guidance of a regional minister and is directed, on a day-to-day basis, by a Regional Chief Executive. There are regional development corporations which operate semi-autonomously at the regional level, though these corporations are chronically short of funds and frequently engage more in commodity trading then in fixed investment. Among the responsibilities of the regional administration are the formulation of integrated development plans for the region, and the coordination, oversight and review of government activities in the region.

B. CONCLUSIONS

1. There are Many Underutilized and Partially Overlapping Organizations in Ghana, Particularly in the Public Sector.

Many of these organizations were formed to meet very particular needs and/or to compensate for other public organizations which were performing suboptimally.

It is a widely held conclusion, and one shared by the study team, that in the current circumstance, further proliferation of public organizations is more likely to

impede performance than to enhance it. Organizationally, preference should be given to solutions which build on and strengthen existing public organizations, many of which operate in the private sector.

2. There are Important Potential Advantages to Increasing the Commercial Orientation of the Electricity Sector.

Often this objective can best be served where electricity provision is owned and operated by a private sector commercial concern, though this pattern of ownership raises its own unique problems.

In rural parts of Ghana, the study team noted the relative efficiency with which electricity was provided by industry to adjacent communities. Where a large factory was not providing this service, however, we did not identify any obvious group of entrepreneurs, or any other organization, to provide electricity on a business like basis in rural areas. The emergence of such an organization will be related to the capability of charging rates commensurate with the cost of providing service. Given the deep subsidies in the current system (see Chapter Ten below), any inclination the private sector might have to enter the rural electricity sector is unlikely to emerge.

3. There is Reason to Believe that the Provision and Extension of Electrification Would be Improved by Decentralizing Management and Control of Sub-transmission and Distribution to Regional and District Administrations, Respectively.

Currently, there appear to be considerable operational pressures or stresses on the ECG system. These stresses result from various systemic weaknesses, and from a

relative lack of attention to emphasis on electrification of rural areas.

Local, district and regional administrations make significant demands for extension of the rural electrification system. They typically are not required, however, to assess the financial implications of their demands or to ensure that there is some relationship between the costs of service and revenues received. As a consequence, electricity has come to be regared in rural areas largely as a government financed social service rather than a costly commodity to be used productively.

Some form of decentralization of electricity appears to offer promise in addressing some of the problems noted above. Largely by default, we believe the public administration system is the most feasible organizational vehicle for managing this activity. In other words, the public administrative framework would perform a function analogous to that of the rural cooperatives in the U.S. in providing electricity to non-municipal consumers.

For a variety of reasons-technical, economic, and managerial-any decentralized management unit should concentrate on sub-transmission and distribution of electricity, not on generation. The exception to this general rule should be those cases in which decentralized generation is the preferred option.

For legal and managerial reasons, the most appropriate administrative units for implementing a decentralized sub-transmission and distribution network in rural areas may well be the regional and/or district administrations working with the assistance of local administrations. This conclusion is extremely tentative and would require considerable deliberation inside Ghana before any final decisions are reached. An alternative approach would be to giver greater financial and administrative autonomy to

regional ECG offices.

An interim or partial implementation of a decentralization program would be to decentralize and balance the accounts on a basis which analyses the costs and revenues of various geographical units separately. This financial disaggregation would assist in decisionmaking and facilitate any subsequent administrative decentralization.

Regional and district administrations and/or regional ECG offices would require substantial technical assistance if they were to assume administrative control for the rural electrification systems in their respective geographic areas.

If decentralized agencies are expected to manage and administer the rural electrification system, they must establish seperate, commercial, books for that purpose. Rural electrification costs and revenues must be kept clearly distinct from any other sources of income or expense. In addition, these agencies will need access to long-term, low interest financing, similar to that provided by REA in the United States. This finance could conveivably be channelled through some national institution, the regional development corporations, or some other entity. Should this prove successful, Ghana may wish at some later date to consider establishing a central financing organization responsible for providing such debt financing.

C. RECOMMENDATIONS

1. Concentrate Available Technical Assistance on Strengthening of Existing Organizations, Rather than the Creation of New Ones.

Even if a pattern of administrative decentralization is adopted, this pattern should be pursued in concert with a policy of institutional upgrading and consolidation.

2. Explore Private Sector Alternatives for Providing Rural Electrification.

The study team did not identify a plausible private sector mechanism for meeting rural electricity distribution needs, except where these needs are being met as a spin-off from a major industry in the area. Nevertheless, a private, commercially oriented, approach to rural electricity distribution would seem to have a number of potentially attractive features, and we therefore recommend that additional consideration be given to ways in which the private sector could be used to provide electricity to rural areas. The cooperative model applied successfully in the U.S., the Philippines, and elsewhere might also be considered.

3. Further Consideration Should Be Given to the Decentralization of Sub-Transmission and Distribution to the Regional and/or District Levels, and a Decentralized Program Should Perhaps Be Tried in One Region.

Further attention should be devoted to the advantages, costs, other implications and procedures of instituting a decentralized system of sub-transmission and distribution for regions and districts or for the rural areas of regions and districts. This study should also include an identification of the most appropriate instituions for managing this electricity provision. Special attention should be given to the possible roles of regional district and local administrations and to the possibility of expanding the functions of regional ECG offices. Regional development authorities and other institutions should be assessed as possible sources of debt financing. Ghana may wish to seek some source of technical assistance for assessing and elaborating these organizational options.

Should further consideration determine decentralized distribution to be an attractive and feasible option, the study team recommends that it be tried in one region on an experimental basis.

CHAPTER TEN
RURAL ELECTRIFICATION IN GHANA: ECONOMIC ANALYSIS

A. FINDINGS

1. Structure of Tariffs for Rural Electricity

Electricity in rural areas is currently regarded and priced as a social service. In the case of ECG, these tariffs are based on urban rates despite the substantially higher cost of service in rural areas. Where electricity is provided to rural consumers by local factories or district administrations, it is typically provided either free of charge or for a nominal flat rate (typically ₵2.50 or ₵3.00 per point per month). There is no effort to relate these prices to the cost of supplying the service or to willingness of consumers to pay. The study team obtained no reliable information on the rates at which local individuals with generators sell electricity to their neighbors.

There is no systematically-produced information on what rural consumers are willing to pay for electricity. Given the widespread perception of electricity as a social service, the predominant use of electricity for lighting, and the generally low level of income of rural residents, there is a reasonable presumption that these consumers would be unwilling to pay substantial amounts for electricity. It was suggested to the study team that rural residents might be willing to pay up to ₵10 per point per month.

In some areas, rural consumers are expected to pay a substantial connection fee covering the costs of bringing electricity to their homes or businesses. There is some evidence that these fees act as a substantial deterent to request by consumers for service. The study team learned of no examples where this connection fee was amortized over monthly billings.

2. Financing of Rural Electrification

Rural electrification schemes are accounted for separately in ECG's financial programming and analysis. By definition and design, these rural electrification sites are recipients of direct subsidy from ECG, which is reimbursed for all or part of this operating loss by the central government treasury. Figures showing operational costs, revenues, subsidies and reimbursement have been reproduced from ECG's 1978 Annual Report (the most recent available figures) and appear in Annex 9.

As indicated in these accounts, operating costs exceeded revenues accrued in a ratio of 4 to 1. In other words, ECG collects only ¢1 for every ¢4 it spends on those schemes. Moreover, the figures indicate that the level of subsidy differs significantly from station to station, from a low of 9.4p per unit sold to a high of 63.4p per unit sold.

It is thus fair to say that the common perception that rural electricity is a publicly financed social service has substantial basis in fact.

It is also noteworthy that rural electricity sales amounted to less than 2.5 % of ECG revenues in 1978.

3. Costs of Service

No detailed data exists on the costs of service to rural areas. There is considerable evidence, however, that these costs are very high and extremely variable. The level and characteristics of load, distances between consumers and from the grid, and source of generation are the key factors affecting these unit costs.

Unit cost of service does not appear to have been a major consideration in selecting rural sites for electrification.

4. Productive Use of Electricity

In general, electricity is not being used for productive activities in those rural parts of Ghana visited by the study team. A major exception to this generalization is the use of electricity (usually self-generated) by large rural industries such as timber mills and sugar refineries. In addition, a few commercial enterprises make use of electricity for such things as refrigeration and home lighting and in some cases electricity contributes indirectly to the productivity of rural households.

With the exception of large industrial uses, electricity in rural areas of Ghana seems to be used primarily for street lighting and domestic lighting. Cooking is almost universally done with firewood or charcoal, which are available in abundance. Occasionally, households use electricity to energize other appliances such as irons, radios or refrigerators, but these applications are relatively infrequent.

Even in areas which have both small industries and electricity, electricity is rarely used to power these industries. Irrigation pumps, woodworking tools, flour mills, bakery ovens, sewing machines, etc. continue to be powered in other ways, despite the availability and subsidized price of electricity.

The investigation of the NRECA study team indentified four reasons for the low level of productive use of electricity in rural Ghana. These are:

- "sunk cost" in non electric machinery,
- unreliability of electricity supplies,
- unavailability of electric machinery, and ancillary machines.
- absence of promotion of productive uses.

Experience suggests that whereas only time can overcome the first of these constraints, there are specific remedial actions which can be taken to addres the other three. The same constraints initially limited productive use of electricity in the United States and a number of developing countries, and considerable experience has been amassed on how to overcome these constraints.

B. CONCLUSIONS

1a. The Current Pattern of Tariffs for Rural Electrification Distorts Utilization Patterns and Puts Additional Pressures on Government Budgets.

The current tariff structure for electricity implicitly regards electricity as a subsidized social service. The extent of subsidy is directly proportional to the business inefficiency of particular schemes; in other words, the higher the unit costs of producing electricity at a particular site, the greater per unit subsidy allocated to that site.

The study team was given the distinct impression that the priority placed by rural households on domestic electrification is relatively low. Given the opportunity to choose between electricity and other sources of government subsidy such as roads, water supplies, and even signboards, it appeared that few would choose electricity.

Community preference notwithstanding, there might well be a case to be made for subsidies to rural electrification if these subsidies were associated with plans for rural production or other rural development schemes. An alternative rationale for subsidy might be the prospects in particular areas for generating productive loads in the medium-term future.

The current pattern of subsidy varies greatly from site to site and this variation bears no obvious relationship to development investment in the locality, productive uses of electricity or long-term electricity consumption prospects. Rather, the subsidy reflects an effort to maintain a uniform tariff structure.

1b. <u>The Ability to Charge Economic Tariffs in Rural Areas is Dependent on the Selection of Sites Offering Low Unit Costs of Electricity.</u>

For sites located near the national grid, grid extension will invariably result in substantially lower unit costs than are available through decentralized generation and distribution. Such grid extension also offers the benefits of reliability. Other things being equal, there would seem to be considerable financial advantage to focussing initial rural electrification efforts on areas near to the national grid. Ghana is relatively unique in the high proportion of its rural population which lives within several miles of the grid.

For those towns not located near the grid, the size and characteristics of the probable load and the distance from sources of fuel and maintenance are critical factors in assessing likely unit costs of service.

2a. <u>The Ability to Charge Economic Tariffs in Rural Areas is Dependent on the Existence of Productive Uses.</u>

Domestic users in rural Ghana seem unable and unwilling, for the most part, to pay the economic cost of electricity. If this is correct, the backbone of any economically justified program of rural electrification will necessarily be productive uses. Domestic consumers would, in this reasoning, be secondary beneficiaries of electrification schemes which have their main justification in their contribution to production.

2b. Specific Actions Can Be Take to Increase the Productive Uses of Electrificty in Rural Areas.

As noted above, the team found four major constraints to increased productive use of electricity, namely, sunk costs, unrealiability, unavailability of machinery, and absence of promotional activities.

The easiest way to expand productive uses of electricity is to give priority for electrification to those sites which have an obvious (and unmet) demand for energy to increase the scope or efficiency of an existing productive activity.

In a number of rural areas, electricity already exists or could be provided cheaply (due to proximity to the grid). In these cases, active interventions might, the study team believes, have significant effects on the level of productive use. In particular, actions to do any or all of the following could be expected to increase productive use of electricity:

- specific actions to increase the reliability of diesel generators
- import and marketing of efficient and simple electric machinery
- an active promotional campaign indicating and encouraging possible productive uses.

In the current situation, electricity is a potentially valuable, but underutilized, resource. Promotional efforts have proven to be essential to accelerating productive use of electricity in the United States and in most other countries. Considerable expertise now exists in how to elicit increased productive application of electricity from rural consumers.

Given the current situation and policies in Ghana, electricity producers are unlikely to undertake such promotional activities for two reasons. First, the shortage of imports and other key inputs results in an inability of the system to keep pace with current urban demands. System officials are hardly likely, in this situation, to promote any additional demands in rural areas. And secondly, rural consumers currently enjoy substantial subsidies. The more electricity the electricity suppliers (public or private) "sell" to rural consumers, the more these suppliers "lose". Once again, this situation is hardly likely to result in active promotional efforts.

Unless or until the supply and pricing situation changes, promotion of productive uses in rural areas is more likely to be fostered by the government agencies and private voluntary organizations committed to rural development. As noted above, however, there is reason to believe that the identification of such productive uses is central to the ability to demonstrate a positive return on investments in rural energy.

C. RECOMENDATIONS

1a. Rural Electricity Tariffs, Especially for Decentralized Schemes, Should Vary By Locality and Should be Liked to Cost of Service and/or Other Development Objectives.

The study team strongly recommends that the Ghana Government begin to look at rural electricity as a business. Costs per consumer vary widely among sites, particularly among decentralized schemes, and the probable contribution of electricity to the government's rural production and other rural development objectives differs from locality to locality.

It has been the experience in the United States and in a number of developed and developing countries that variable tariff structures for rural areas lead to more rational decisions by planners in extending the system and by consumers in requesting and using electricity. Any subsidies to rural electricity should be analyzed on a case by case basis and assessed relative to the social and economic benefits they produce and the alternative uses of these subsidy funds.

1b. Priority for Electrification of New Sites Should Be Linked to the Ability to Charge Economic Tariffs to Consumers. This favors Sites with Low Service Costs and/or Significant Productive Uses.

The study team strongly recommends an investment approach to determining the pattern of rural electrification expansion. In practice, this approach will favor larger and more economically active towns, towns closer to the grid, towns with relatively concentrated populations, towns with productive energy uses currently going unmet or being inefficiently met, towns where people are able and willing to pay higher tariffs, and towns which are slated for other rural development activities.

2. Where Electric Service is Already Supplied or is Soon to Be Installed, a Concerted Campaign Should Be Launched to Encourage Productive Uses of Electricity.

Without a concerted campaign to promote productive uses, rural electricity is likely to remain an underutilized resource for some time to come. To make the most out of past and future investments, specific promotional actions are required. The study team therefore recomends that a decision should be taken as to who should assume responsibility for this promotional effort. NRECA will be prepared to offer guidance to any agency(ies) or group(s) which undertake this activity.

CHAPTER ELEVEN
THE NEXT STEPS

Implementation of the recommendations made in this report would require a fundamental change in Ghana's philosophy towards rural electrification. That change can be summed up in two ways:

1) Consideration of rural electrification as a producer good, not a consumer good.

2) Consideration of rural electrification as a production input, not as a social amenity and government responsibility.

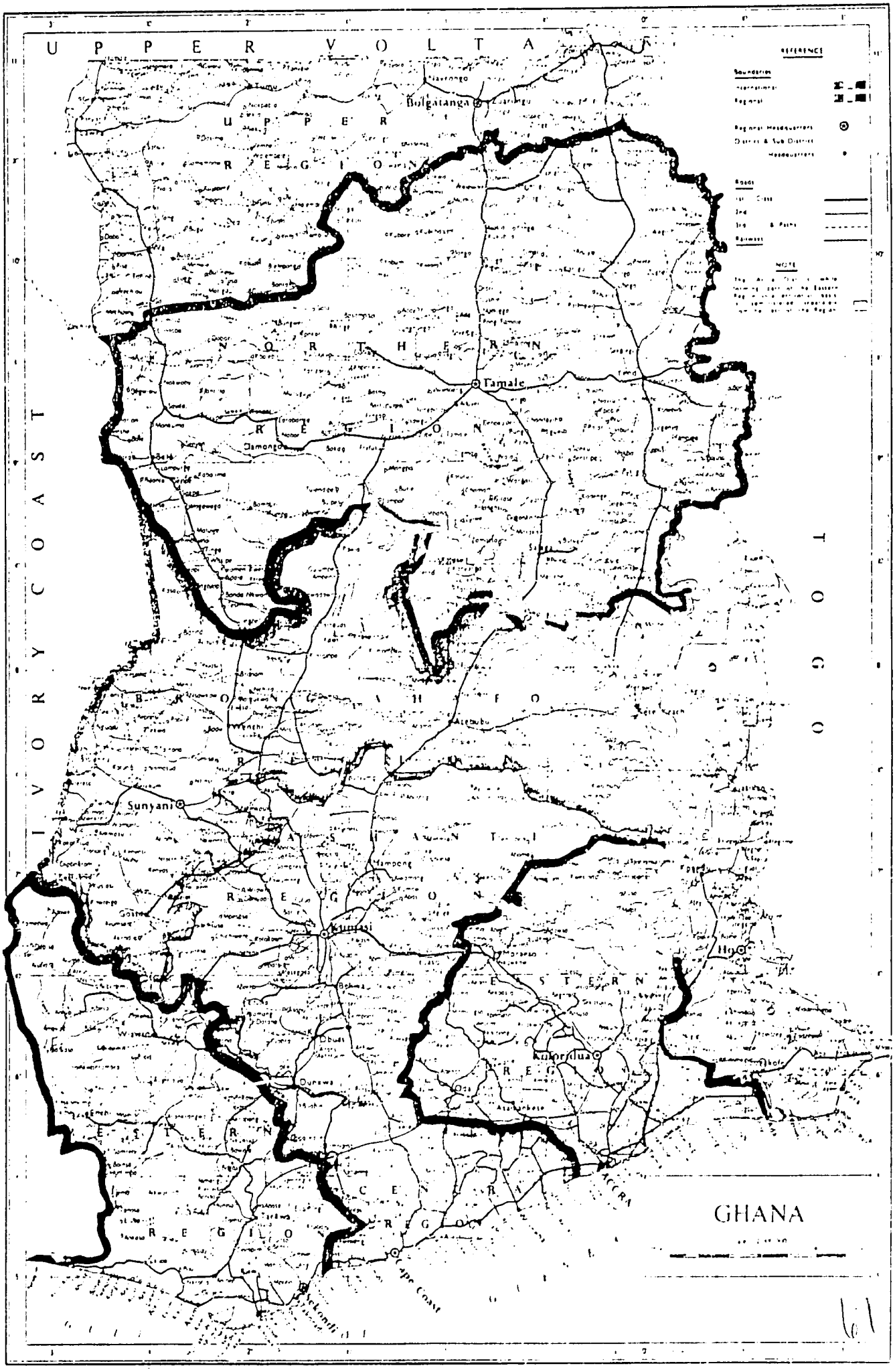
While NRECA recognizes that these changes may not be politically expedient, we feel that they are in the long run interests of the country and people of Ghana.

The elaboration and execution of the specific activities required for implementation of these recommendations would require the participation of several groups (especially members of the TCC). With respect to the eventual extension of the national grid, NRECA feels that the extension should be preceded by a carefully performed feasibility study. The purpose of the study would be to examine the technical, economic and social aspects of electrifying new areas from the grid. It would include among other things: surveys to predict levels of use in each economic sector, preliminary designs to estimate costs, and rate of return calculations for subsequent financial decisions. NRECA's experience has shown that these studies require a minimum of three to six man months depending on the number of target areas to be evaluated. They are an essential first step in any decision to electrify new areas.

Two other recommendations which deserve special consideration are the decentralization of the management of the distribution facilities and the establishment

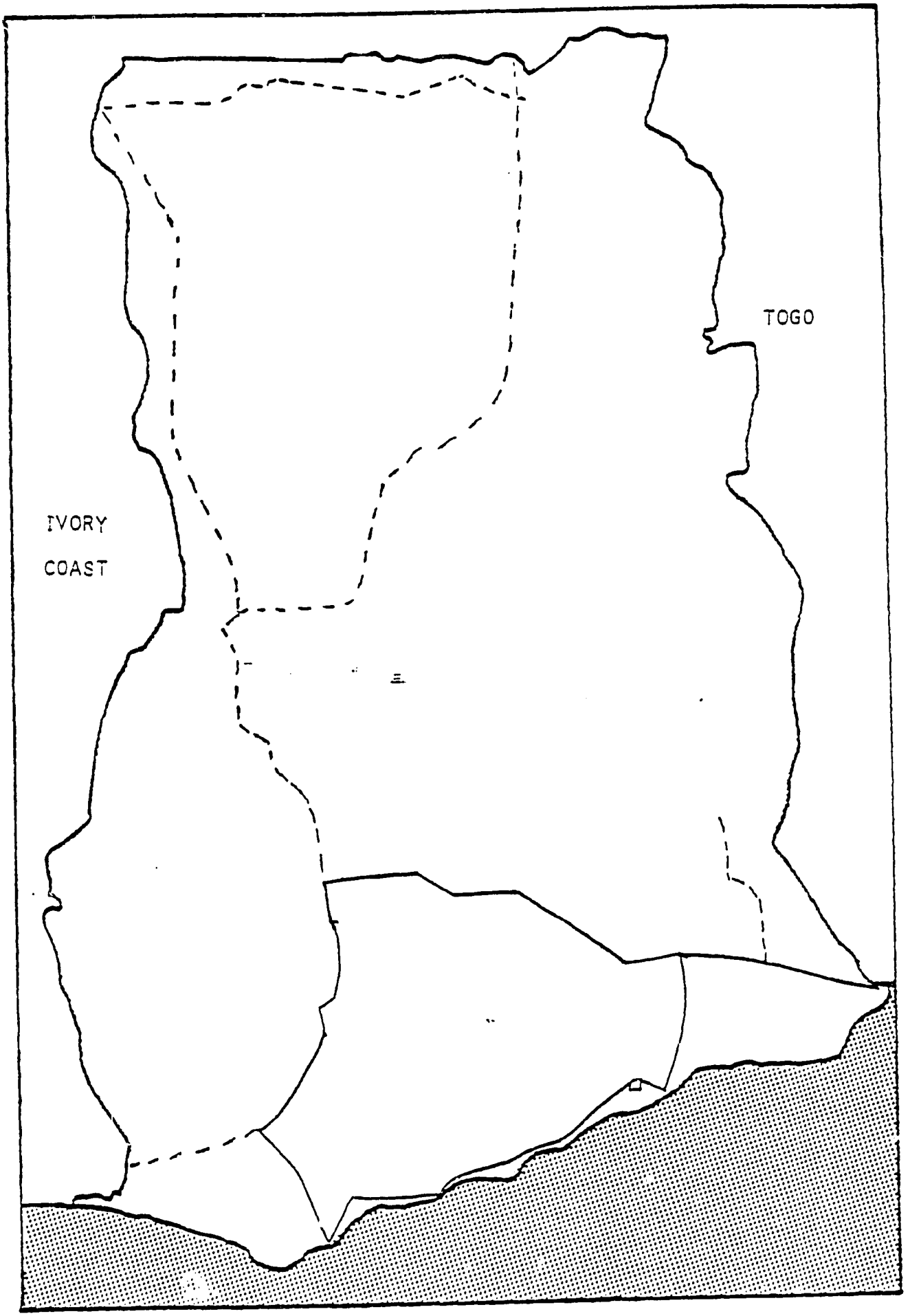
of programs for the promotion of productive uses of electricity in rural areas. These two concepts have been central to the success of rural electric schemes in the United States and several other countries where the local rural electric institutions are characterized by healthy management and a deep sense of pride of ownership. The development of programs to carry these recommendations forward would be a challenging yet extremely rewarding task, worthy of special attention.

ADMINISTRATIVE



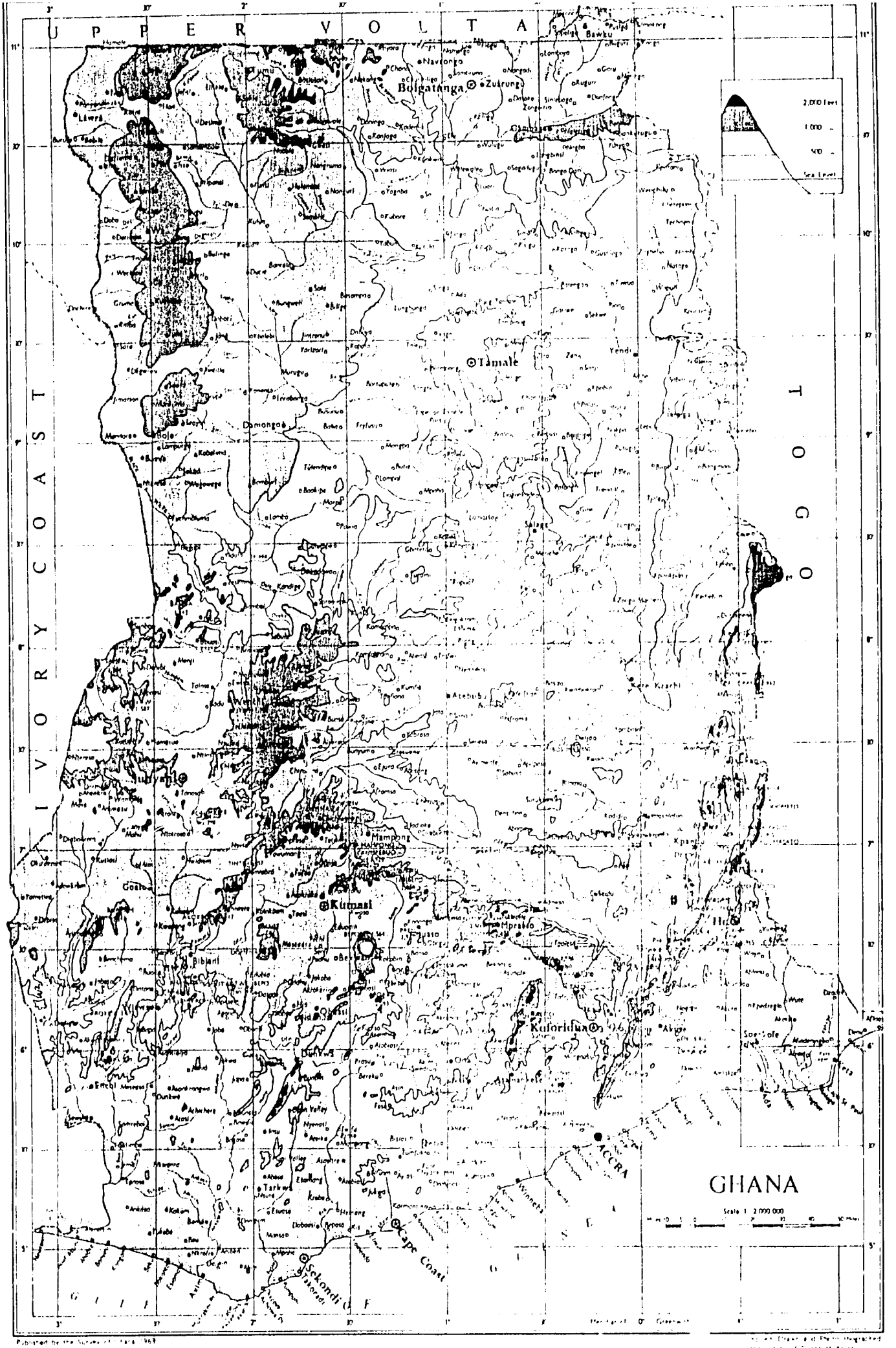
Ghana

ELECTRIC POWER TRANSMISSION



Existing

Proposed



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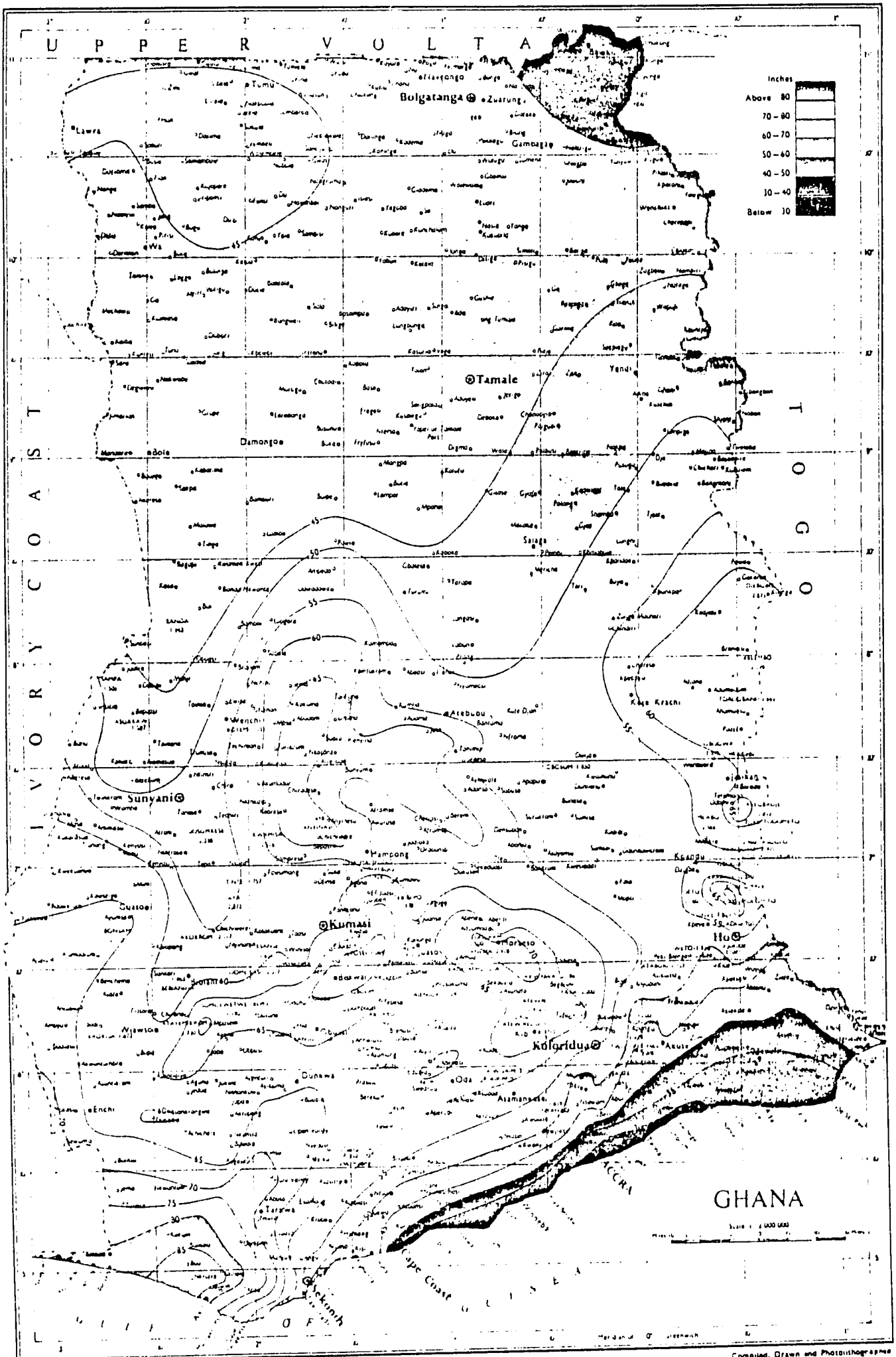
AVERAGE ANNUAL RAINFALL



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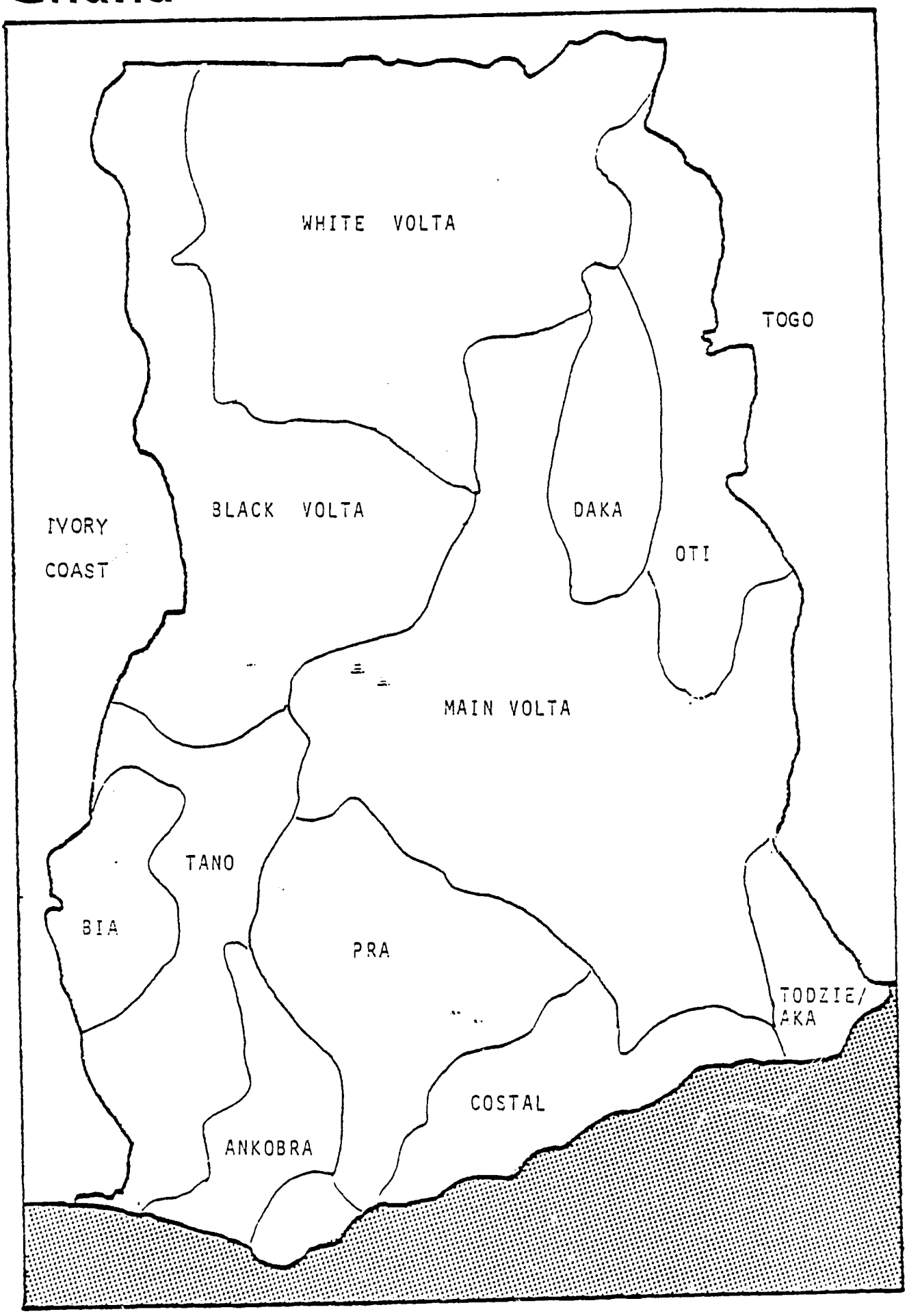
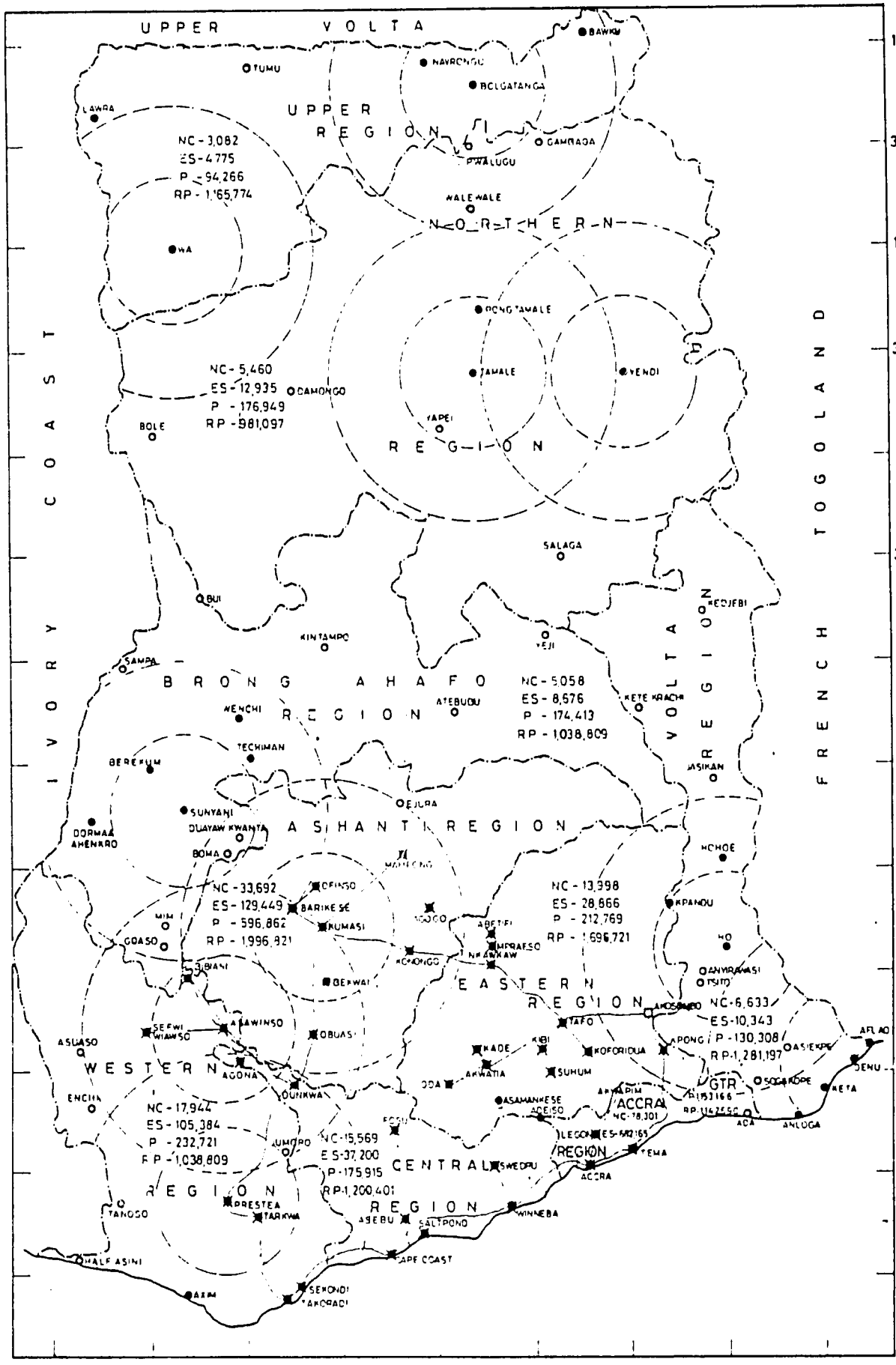
Ghana

MAIN RIVER BASINS





LEGEND

● – Generating Stations - Diesel
NC – Number Of Consumers (1978)
E S – Energy Sales 000KWHS (1978)
P – Population (1978)
R P – Regional Population (1930)
■ Grid Supply Points

—— 161KV Transmission Line
—— 33KV O/H Line
O – Other Major Towns

25 & 50 MILE RADIUS

Electricity Corporation Of Ghana
Accra

E.C.G SUPPLY AREAS - NUMBER OF CONSUMERS, ENERGY SALES AND POPULATION

Drawn By [illegible] Scale [illegible]
Date 5 - 6 - 80 Drg No ECG [illegible]

Annex 7 HYPOTHETICAL COMPARISON OF TWO ALTERNATIVE MINI HYDRO SCHEMES NEAR DADIASO WITH A LIFE CYCLE COMPARISON TO DIESEL GENERATION.

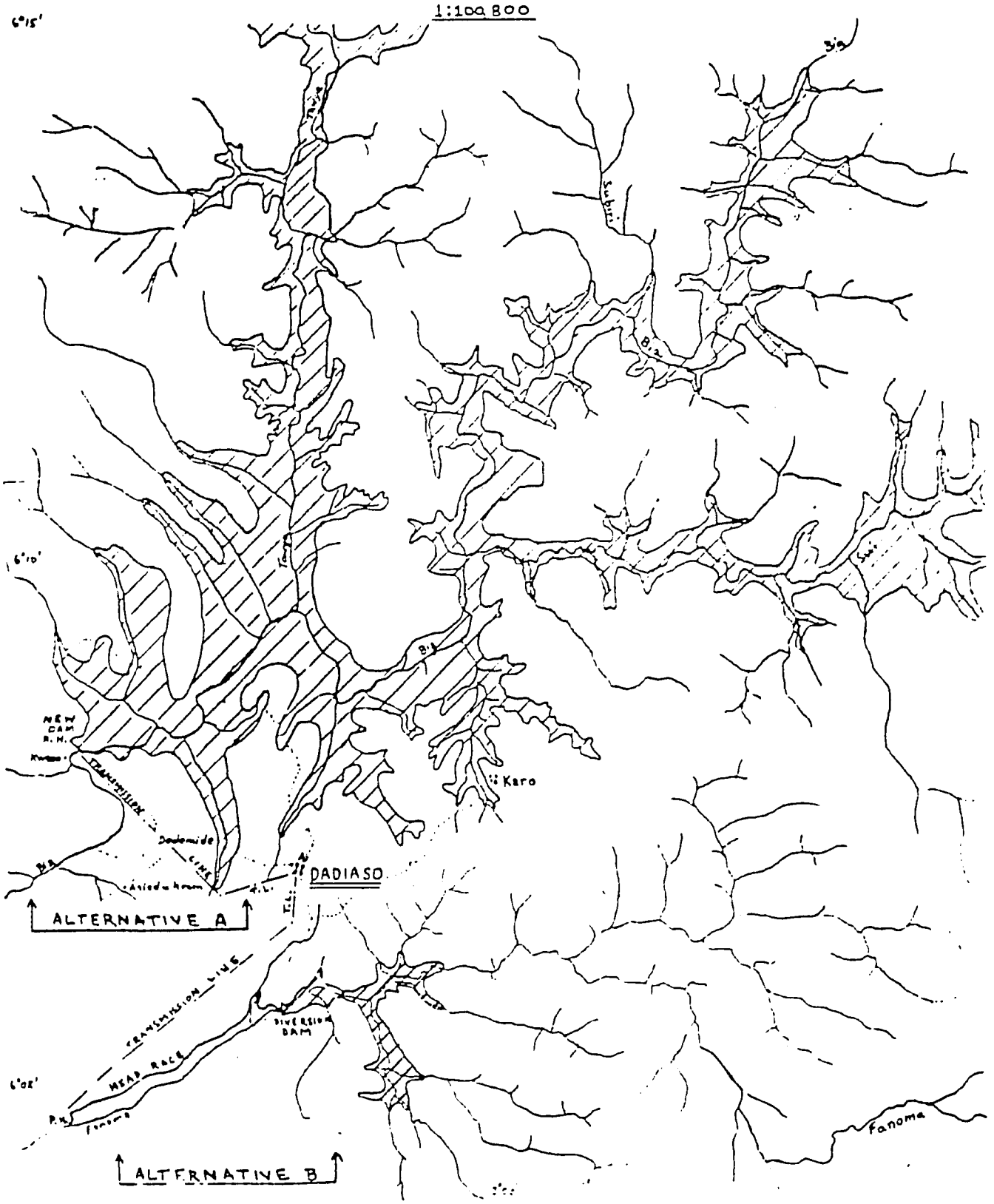
This annex provides a rough analysis and comparison of two conceivable mini hydro schemes near Dadiaso. Cost estimates for each approach are presented. A benefit/cost ratio is then developed for the most attractive alternative. Finally, this alternative is submitted to a life cycle cost comparison with a comparable diesel installation under the assumption of a 5% increase per annum in fuel cost. This analysis clearly shows that diesel is the preferred option under the given conditions.

Since the analysis is not based on field visits, several assumptions were required. These are explained as they arise.

We believe the estimates to be roughly correct and representative of the situation facing many towns in Western Region.

FIGURE 1. TWO ALTERNATIVE MINI HYDRO SCHEMES AT DADIASO FOR PURPOSES OF COST COMPARISONS. ALTERNATIVE A IS A NEW DAM AND POWER HOUSE AT KWASO (UPPER HALF). ALTERNATIVE B IS A DIVERSION DAM ON THE FANOMA WITH OPEN CANAL HEADRACE LEADING TO PENSTOCK AND POWERHOUSE 2 1/2 MILES DOWNSTREAM. (SHADED AREAS REPRESENT FLOOD PLANES)

1:100,800



ALTERNATIVE A: Dam at Kwaso

Description

Earthfill dam with concrete spillway; height=35 feet, total width=1000 ft. Powerhouse with open flume turbine (350 kw), synchronous generator, 5kv class transmission to Dadiaso.

*APPROXIMATE COST (U.S. Dollars)

Earthdam	$300,000
Concrete Uncontrolled Spillway	500,000
Powerhouse Civil Works	275,000
Open Flume Turbine & Generator	220,000
Power House Electrical	150,000
Transmission Line (3 miles)	70,000
Feasibility Study	25,000
Access Road	50,000
Interest During Construction	250,000
Engineering Design, Supervision, Admin. (15%)	275,000
Contingencies (20%)	423,000
Total Estimated Cost without Distribution Facilities, Relocation or Land Purchase	$2,538,000
Cost per kW	$ 7,250

*These approximate figures include all materials, transporataion, labor and land preparation

ALTERNATIVE B: Diversion Dam on Fanoma

Description

Earthfill diversion dam with uncontrolled concrete spillway; height = 20ft., total width = 500ft. Three mile long headrace to powerhouse with 120 kilowatt cross flow turbine, synchronous generator and 5kv class transmission to Dadiaso. Net head = 35ft. Flow required = 48 cusecs. Season flow problems anticipated.

APPROXIMATE COSTS (U.S. Dollars)

Earth Diversion Dam	120,000
Uncontrolled concrete spillway*	200,000
24ft.^{2}unlined head race:	
clearing	150,000
excavation	150,000
Powerhouse Civil Works	110,000
Crossflow Turbine and Generator (120 kW)	125,000
Penstock (400 ft. long, 30" dia., concrete)	40,000
Powerhouse Electrical	100,000
Transmission Line	80,000
Feasibility Study	25,000
Access Road	75,000
Interest During Construction	125,000
Engineering, Constr. Sup., Admin. (15%)	190,000
Contingencies (20%)	300,000
Total Estimated Cost	$1,790,000
Cost per kW	$14,900

*Less expensive alternative approaches might prove viable.

MAJOR PROBLEMS WITH DEVELOPMENT OF ALTERNATIVE A.

- Huge flood plane
  - environmental problems
  - land rights problems & relocation
- Access for construction
- High cost per kW
- Benefit - Cost ratio = 0.1

MAJOR PROBLEMS WITH DEVELOPMENT OF ALTERNATIVE B.

- Extremely high cost per kW
- Flow data not available
- Small catchment area suggests seasonal variations will disrupt power supply
- Access for construction
- Long headrace in difficult forest
- Long penstock for low head

MAJOR ASSUMPTIONS FOR ESTIMATE

The analysis here is for illustrative purposes. No investigation of the practicality and feasibility of dam construction at these points was undertaken.

2) Costs were obtained from the U.S. Department of Interior Manual "Reconnaissance Evaluation of Small, Low-Head Hydroelectric Installations," and subjective adjustments were made in light of relevant cost data obtained while in Ghana. Essentially, those adjustments reflect low labor costs and higher transporation costs in Ghana. Dam construction figures are considerably reduced from comparable U.S. figures.

3) Average flow in the Bia is used for the power estimate. A 350 kW installation should suffice well into the future. Little savings could be gained by reducing the installed capacity, however, additions should be possible.

4) To the team's knowledge, no flow data is available for the Fanoma. The power calculation for alternative B assumes 60 watts per inhabitant (population 2000) with a net head of 35 feet and an assumed efficiency of 85%. The flow required would be 48 cusecs. The availability of this flow would have to be verified by detailed hydrological investigations. Seasonal variations could disrupt power production. Load growth would be severely restricted.

5) For alternative B:

a) Head race of 24 ft.^{2} cross section; 16,400 feet long, requiring 14,500 yd.^{3} of escavation at 30 cedis per yd.^{3}

b) Penstock in concrete, 30 inch diameter, 410 feet long at $100/ft. installed.

6) Barring major site problems, estimates should be $\pm$ 30% accurate.

BENEFIT/COST RATIO FOR ALTERNATIVE A.

Annualized Costs

Capital Cost	$2,500,000
Annual Cost Factors:	
Interest	.12
Sinking Fund	.0013
Operation & Maintenance	.012
	0.1333

Annual Cost = $2,500,000 x .1333 = $333,000

Annual Benefits

The calculation of benefits in the Ghanaian rural context is not clear cut since rates are not based on KWh consumption. Existing rates are around 3 cedis per point per month. The District Council in Asankrangwa suggested that consumers might be willing to pay 10 cedis per point per month. Assuming an average of 2.5 people per point, one obtains:

$$\left(\frac{2000 \text{ persons}}{}\right) \cdot \left(\frac{1 \text{ points}}{2.5 \text{ persons}}\right) \cdot \left(\frac{10 \text{ cedis}}{\text{point-mo.}}\right) \cdot \left(\frac{12 \text{ months}}{\text{yr.}}\right)$$

$$= 96{,}000 \text{ cedis/yr.} = \$34{,}900 \text{ U.S.}$$

$$\text{Benefit/Cost Ratio} = \frac{\$34{,}900}{\$333{,}000} = 0.10$$

LIFE CYCLE COMPARISON: DIESEL VS. HYDRO

CONSTANT U.S. DOLLARS (000)

	HYDRO COSTS				DIESEL COSTS				
Year	Capital	Recurring	D.F.	P.V.	Capital	Rec.	Energy	Tot	P.V.
0	2,500			1	350				350
1		333	.893	297		62.6	59.7	122.3	109
2		333	.797	265		62.6	62.7	125.3	100
3		333	.712	237		62.6	65.8	128.4	91
4		333	.636	212		62.6	69.1	131.7	84
5		333	.567	189		62.6	72.5	135.1	77
6		333	.507	169		62.6	76.2	138.8	70
7		333	.452	151		62.6	80.0	142.6	64
8		333	.404	135		62.6	84.0	146.6	59
9		333	.361	120		62.6	88.2	150.8	54
10		333	.322	107		62.6	92.6	155.2	50
11		333	.287	96		62.6	97.2	159.8	46
12		333	.257	86		62.6	102.1	164.7	42
13		333	.229	76		62.5	107.2	169.8	39
14		333	.205	68		62.6	112.5	175.1	36
15		333	.183	61		62.6	118.2	180.8	33
16		333	.163	54		62.6	124.1	186.7	30
17		333	.146	49		62.6	130.3	192.9	28
18		333	.130	43		62.6	136.8	199.4	26
19		333	.166	39		62.6	143.6	206.2	24
20		333	.104	35		62.6	150.8	213.4	22
21		333	.093	31	350	62.6	158.3	570.9	53
22		333	.083	28		62.6	166.2	228.8	19
23		333	.074	25		62.6	174.5	237.1	18
24		333	.066	22		62.6	183.2	245.8	16
25		333	.059	29		62.6	192.4	255.0	15
26		333	.053	18		62.6	202.9	264.6	14
27		333	.047	16		62.6	212.1	274.7	13
28		333	.042	14		62.6	222.7	285.3	12
29		333	.038	13		62.6	233.8	296.4	11
30		333	.034	11		62.6	245.5	308.1	10
31		333	.030	10		62.6	257.8	320.4	10
32		333	.027	9		62.6	270.7	333.3	9
33		333	.024	8		62.6	284.2	346.8	8
34		333	.021	7		62.6	298.4	361.0	8
35		333	.019	6		62.6	313.3	375.9	7
36		333	.017	6		62.6	329.0	391.6	7
37		333	0.15	5		62.6	345.4	408.0	6
38		333	.014	5		62.6	362.7	425.3	6
39		333	.012	4		62.6	380.8	443.4	5
40		333	.011	4		62.6	399.8	462.4	5
				P.V. = $5252 Hydro					P.V. = $1686 Diesel

D.F. = Discount Factor
P.V. = Present Value

MAJOR ASSUMPTIONS FOR HYDRO/DIESEL COMPARISON

.Hydro costs are based on alternative A.

.Discount rate = 12%

.Hydro Life = 40 years

.Diesel life = 20 years

.Constant 1981 dollars

Cost of 350 kW diesel plant = $350,000*

.Btu/gal. for diesel = 145,000

.Plant capacity factors = 35%

.Diesel plant efficiency = 55%

.Fuel cost = $1.30 U.S./gallon, escalation at 5% per annum.

.Operation and maintenance costs for hydro = 1.2% of capital costs

.Operation and maintenance costs for diesel = 4.5% of capital costs

.Amortization of investment included in recurring costs

*High costs per kW assumption is based on a review of recent quotation from British diesel suppliers to ECG.

PARTIAL LIST OF CENTRAL GOVERNMENT ORGANIZATIONS

WITH PERSONNEL AT DISTRICT LEVEL

1. Office of the District Chief Executive
2. Forestry Department
3. Audit Service
4. Ghana Education Service
5. Agricultural Extension Service
6. Ghana Highway Authority
7. Government Hospital
8. Department of Community Development
9. P. & T. Corporation
10. Medical Field Unit
11. Town and Country Planning
12. Youth Council
13. Co-operative Bank
14. Ghana Police Force
15. Veterinary Services
16. Labour/Birth and Deaths
17. Ghana Book Suppliers
18. C.M.B. (Min. of Cocoa Affairs)
19. District Treasury
20. District Court Grade II
21. Information Services
22. Food Production Corp. (Moseaso)
23. Environmental Health Services
24. Immigration Department
25. Special Branch
26. Ghana News Agency
27. Ghana Water & Serverage Corps.
28. Produce Buying Division
29. P.W.D.
30. Produce Inspection Unit
31. Valuation Department
32. Rural Development
33. Agric. Economics
34. Agri. Economics
35. Information
36. Bank
37. Cocoa Plantation
38. Magistrate Court
39. Town Planning

RURAL ELECTRIFICATION

DEFICIT ACCOUNT FOR THE YEAR ENDED 31ST DECEMBER, 1978

1977 ¢		¢
4,461,145	Accumulated deficit brought forward	4,700,3(
2,239,219	Deficit for the Year	3,807,5(
6,700,364		8,507,9:
2,000,000	*Less:* Reimbursement by Government	2,300,0(
¢4,700,364		¢6,207,9:

The above Deficit Account should be read in conjunction with the attached notes on pages 30 *to* 3: *Report of the Auditors, page* 17.

RURAL ELECTRIFICATION

REVENUE ACCOUNT FOR THE YEAR ENDED 31ST DECEMBER, 1978

1977 ¢			¢
913,918	Revenue from Electricity Sales		1,291,75
	OPERATING AND GENERAL EXPENSES		
2,207,116	Generation		3,245,71:
622,637	Distribution		893,90'
123,067	Transport		167,90:
	Administration		
354,255	Districts	555,031	
129,294	Head Office	204,062	759,09:
3,436,369			5,066,62:
109,752	Depreciation of Fixed Assets in use (Note 1)		130,84:
3,546,121			5,197,47:
2,632,203	OPERATING DEFICIT		3,905,71:
(9,231)	Consumer Contributions to Assets (Note 7)		(11,342)
(29,008)	Other Income		(86,811)
(354,745)	Government Subsidy (Note 8)		—
¢2,239,219	Net Deficit		¢3,807,564

The above Account should be read in conjunction with the attached notes on pages 30 *to* 31. *Report of the Auditors, page* 17.

RURAL ELECTRIFICATION

BALANCE SHEET AS AT 31ST DECEMBER, 1978

1977 ₵		Note	₵	₵
	ASSETS EMPLOYED			
	FIXED ASSETS IN SERVICE			
3,187,593	Gross Value	1	4,039,991	
851,855	*Less:* Depreciation		982,704	
2,335,738				3,057,287
3,506,516	CAPITAL WORK IN PROGRESS	2		3,384,880
	CURRENT ASSETS			
453,858	Stocks	3	710,131	
064,593	Debtors	4	823,291	
381,273	Cash and Bank Balances		386,769	
1,499,724			1,920,191	
	Less: CURRENT LIABILITIES			
859,723	Accounts payable and Accrued Liabilities		345,095	
3,914,936	Electricity Corporation of Ghana	5	3,804,501	
4,774,659			4,149,596	
(3,274,935)	NET CURRENT ASSETS/(LIABILITIES)			(2,229,405)
₵2,567,319				₵4,212,762
	FINANCED BY: CAPITAL AND SURPLUS			
(6,602,610)	Government Contributions		9,502,610	
(4,700,364)	Accumulated deficit		(6,207,928)	
(28,237)	Capital Reserve		28,237	
(1,930,483)				3,322,919
(412,990)	Government joint Water and Electricity Scheme			412,990
(2,343,473)				3,735,909
	DEFERRED CREDIT			
223,846	Consumer Contributions to Assets			476,853
₵2,567,319				₵4,212,762

The above Balance Sheet should be read in conjunction with the attached notes on pages 30 *to* 31. *Report of the Auditors, page* 17.

Managing Director

J. Agyepong
Ag. Chief Accountant

Annex 9

PERSON AND TITLE	ORGANIZATION	PLACE
H.E. F. Wulff - Tagoe, Minister	Ministry of Fuel & Power	Accra
Mr. Akoto Sasu, Principal Secretary	Ministry of Fuel & Power	Accra
Ms. Lydia Barnor, Asst. Principal Secretary	Ministry of Fuel & Power	Accra
H.E. E.K. Andah, Minister	Ministry of Youth & Rural Dev.	Accra
Mr. Offei - Amoyaw	Department of Youth & Rural Dev.	Accra
H.E. Sam-Cudjoe, Regional Minister	Western Regional Adm.	Sekondi
Mr. Lee Ocran, Deputy Minister	Western Regional Adm.	Sekondi
Mr. Oduro, Regional Administrative Officer	Western Regional Adm.	Sekondi
Mr. A.A. Artuhur, Economic Planning Officer	Western Regional Adm.	Sekondi
Mr. Tenkrah, Regional Agricultural Officer	Western Regional Adm.	Sekondi
Mr. Dadza, Asst. Economic Planning Officer	Western Regional Adm.	Sekondi
Mr. Edufu, District Chief, Executive	Western Regional Adm.	Tarkwa
Mr. George S.C. Anaba, District Chief Executive	District Council	Asankrangwa
Mr. George Twum, Councillor	District Council	Asankrangwa
Mr. Matthew Armah, Councillor	District Council	Asankrangwa
Mr. A.A. Essuman, Councillor	District Council	Asankrangwa
Mr. Takyi Amoah, Councillor	District Council	Asankrangwa
Mr. S.K. Arloo, Councillor	District Council	Asankrangwa
Dr. Kwame Duffuor	--	Asankrangwa
Nana Anyani Boadum III, Chief	--	Asankrangwa
Nana Gyasihene, Chief Linguist	--	Asankrangwa
Mr. Tandoh, Chief of Young Men	--	Asankrangwa
Mr. Francis Taima, Councillor	--	Asankrangwa
Mr. P.A. Buah, Councillor	--	Asankrangwa
Mr. L. Casely Hatford, Chief Executive	Volta River Authority	Accra
Mr. K. Kalitsi, Deputy Chief Executive	Volta River Authority	Accra
Mr. E. Nanka Bruce, Deputy Chief Executive	Volta River Authority	Accra
Mr. B.G.A. Akoto, Director of Engineering	Volta River Authority	Accra
Mr. G.O. Dokyi, Deputy Director of Engineering	Volta River Authority	Accra
Mr. R.O. Ankrah, Principal Civil Engineer	Volta River Authority	Accra
Mr. Larry Appiah, Civil Engineer	Volta River Authority	Kpong
Mr. Botchway, Area Engineer	Volta River Authority	Takoradi
Mr. C.W. Adom, Principal Engineer	Electricity Corp of Ghana	Accra
Mr. C.A.M. Brown, Asst. Chief Engineer	Electricity Corp of Ghana	Accra
Mr. S.T. Accuh-Addo, Regional Manager	Electricity Corp of Ghana	Takoradi
Mr. James A. Tackie, Director of Public Relations	Electricity Corp of Ghana	Accra
Mr. Kwamina Longdon, Asst. Public Relations Officer	Electricity Corp of Ghana	Accra

PERSON AND TITLE	ORGANIZATION	PLACE
Dr. Nigh	A.E.S.C.	Accra
Mr. A.S. Chavalraj, Indian Consultant	A.E.S.C.	Accra
Mr. Albert Ottu, Civil Hydraulic Engineer	A.E.S.C.	Accra
Mr. Michael Dakwa, Chemical Eng.	GHASEL	Komenda
Mr. Kodo Kumi, Assistant Personnel Officer	African Timber and Plywood Co.	Samreboi
Mr. Quarmi, Personnel Manager	African Timber and Plywood Co.	Samreboi
Mr. Paul Amponsah, Manager for Forestry Operations	African Timber and Plywood Co.	Samreboi
Mr. M.M. Koomson, Electrical Engineer	African Timber and Plywood Co.	Samreboi
Mr. Edward Saiers, Deputy Director	U.S. Agency for International Dev.	Accra
Mr. Kjiarma, Consulting Engineer	ERG's Engineering	Accra
Mr. Bruce Shaw	U.S. Agency for International Dev.	Takoradi
Dr. Appiah, Geologist-Lecturer	School of Mines	Tarkwa
Mr. Koko, Surveyor	Gold Mines	Tarkwa
Mr. Steve McCarthy, APCD	U.S. Peace Corps	Accra
Mr. Ross Kreamer, APCD	U.S. Peace Corps	Accra
Ms. Mary Rush, Volunteer	U.S. Peace Corps	Takoradi
Mr. John Doko, Country Director	Technoserve, Inc.	Accra
Mr. Dwight Marburger, Vice President, Africa	Technoserve, Inc.	Accra
Dr. Richsteig, Legal Officer	Embassy of Federal Republic of Germany	Accra
Mr. S.K. Kukwaw, Surveyor	--	Akropong
Mr. Duku, Surveyor	Goldmines	Prestea

Annex 10. List of Contacts