SUMMARY

The Republic of Ghana has two major hydroelectric power sources (total 1,060 MW) and has been exporting electric power to neighbor countries. While, on the other hand, only about 20% of its total population of 14 million can enjoy the benefit of electric power because of lack of the domestic transmission and distribution system.

Therefore, the Ghanaian Government has placed the promotion of domestic electrification as one of the important policies, and has prepared "National Electrification Plan" since 1989 with an objective to complete the electrification of villages nationwide by 2020. Especially with regard to district capitals, their complete electrification by 1995 is aimed for. Japan has extended a grant aid for a project of rural electrification in Ashanti and Great Accra Region in 1989 responding to a request from Ghanaian Government, and contributed greatly to the promotion of domestic electrification.

Valuing this very highly, the Government of the Republic of Ghana has requested the Government of Japan this time for Grant Aid Program with regard to "Ada Foah Electrification Project" which is a part of the National Electrification Plan and is a rural electrification project inclusive of three yet-to-be-electrified district capitals (Ada Foah, Adidome, Sogakope) in the south eastern part of the country.

The project site is located on the lowest reaches of the Volta River which is said to be the area sacrificed for the construction of Akosombo Dam because natural conditions changed drastically as regular flooding has ceased to occur creating problems on the life of humanity such as a problem of drinking water and hazards of bilharzia. However, because of its geographical features it still retains a high potential, and the residents of Ada Foah which is the sole district capital yet to be electrified in Great Accra Region as well as two other district capitals in Volta Region, have expressed a strong expectation on the improvement of the bases of their life and vitalization of local economy which will be realized by electrification.

Responding to this request, the Japanese Government decided to conduct an preliminary investigation for the project and Japan International

Cooperation Agency (JICA) dispatched a preliminary study team to the site in July 1992. As a result of this preliminary study, the Japanese Government concluded that it is adequate to consider the project as the one for grant aid program and decided the execution of a basic design study. In accordance with this governmental decision, JICA has dispatched the Basic Design Study Team to the Republic of Ghana for the duration of one month from November 12, 1992, to December 11.

The study team deliberated with the Ministry of Finance, Ministry of Energy, Electricity Corporation of Ghana, Volta River Authority, and Ghana Highway Authority and other organs concerned in Ghana, and conducted a series of on-site survey and collection of materials. After having returned to Japan, the study team examined and analyzed the project scheme to prepare a draft report, and visited the site again during the period between March 8, 1993 and March 18 to explain the contents of the basic design, and has compiled this report finally this time.

In this occasion, it was agreed through the discussion that the project title should be changed as "The project for Electrification in Lower Volta Area", instead of the original name "Ada Foah Electrification Project". Hereinafter, we use it for the project name.

As for responsible organs to execute this project on the part of Ghana, it has been decided that the main enforcement organ of the project is to be the Ministry of Energy while actual designing and construction works to be taken care of by Volta River Authority (VRA) as far as the upper-level system is concerned and by Electricity Corporation of Ghana (ECG) as far as lower-level system. Both public corporations are large-scale governmental enterprises which have no problem at all with the operation and maintenance of the facilities after completion of the project, as they have already possessed and have been operating wide-range existing electric facilities.

The following are the particulars confirmed by the investigation this time.

(1) The total population in the entire project site is 105,000 (estimated in 1992).

(2) The number of towns/villages to be electrified is 23 including the above three district capitals.

(3) It is accessible to all the sites for project facilities by wide roads.

(4) Composition of requested system is a scheme to pull out a 69 kV transmission line from the existing Asiekpe substation, and install a new substation of 69/33 kV in Sogakpe to pull out 4 systems of 33 kV distribution lines. Another plan to apply 33 kV wholly was also examined, but it has been revealed that the original plan is adequate in view of power loss and voltage drop.

(5) As there are existing facilities of VRA in the vicinity of the 69 kV transmission line and Sogakope Substation, facility design is to be done in conformity with these existing facilities.

(6) The capacity of the transformer of Sogakpe Substation has been decided to be 15 MVA as a result of a calculation of demand forecast.

(7) Laying of a power cable on the bridge of Sogakpe has been adopted as the method to install 33 kV distribution line across the Volta River as the most adequate option.

(8) As for the location of distributing substations, an optimum number of stations with appropriate capacities are to be installed based on the deliberation with ECG.

(9) The capacity of distribution transformer is to be two kinds, i.e. 50 kVA and 100 kVA.

(10) The low-voltage materials and equipment will be provided as per an appropriate quantity determined per transformer.
The construction/installation should be carried out of by the Ghanaian side.

(11) Vehicles and tools for the construction/electric works should be provided.

Outline of planned facilities are as follows.

(1) Outlet of 69 kv transmission line of Asiekpe substation

69 kV switching facilities (breaker, disconnecting switch, and attached facilities)	1 set
Indoor operation panel	1 set

(2) 69 kV transmission line

Between Asiekpe-Sogakpe, one circuit	40 km
Supporting structure: steel tower	approx. 150 units
Electric conductor : 185 mm2 AAAC	

(3) Sagakope Substation

Main transformer, voltage 69/33 kv, capacity 15 MVA	1 unit
69 kV switching facilities (breaker, disconnecting switch, arrestor, and attached facilities)	1 lot
Outlet of 33 kV distribution lines (breaker, disconnecting switch etc.)	4 systems
33 kV precision class watthourmeter device	1 set
Communication equipment	1 set
Indoor operation panel	1 set
Building	1

(4) 33 kV distribution line

33 kV 100 mm2 AAC, one circuit distribution line	approx. 120 km
Supporting structure: wooden pole (locally produced)	1 set

(5) Power cable laid on the bridge

Cable: 33 kV cross-linked polyethylene insulated steel wire armoured and PVC jaketed power cable approx. 1,000 m

Method of installation:
cleated to the outside of the handrails of the bridge surface, with a sunshade attached

Streight through joint 1

(6) Distributing substation

Transformer mounted on the pole: three-core 33 kV/415,210 V capacity 100 kVA, 50 kVA — 42 units

High tension side protection: 33 kV power fuse, arrestor to be installed

Low tension side protection: 400V cut-out switch to be installed

(7) Vehicles/tools for construction/electric works — 1 lot

Construction period has to be divided into two phases in view of the size of work and work capabilities in Ghana.

It is supposed that the construction period for 1st phase is needed 12 months from the contract for contractors, and for 2nd phase 10 months from the contract.

Division of the period is as shown below:

The 1st Phase

Expansion of Asiekpe substation
New construction of 69 kv transmission line
New construction of Sogakope substation
Linkage of Sogakope substation and Keta system
Supply of all vehicles and approximately 1/3 of tools for
construction/electric works

In the first phase, inter-linkage for Sogakope substation - Keta system are made. All load in Keta system will be supplied from the new facilities constructed in this Project and irrationality on power supply situation that is reimporting from Togo will be relieved.

The 2nd Phase

Laying of 33 kV power cable on the bridge
New construction of 33 kv distribution line between Sogakope and Adidome
" " between Sogakope and Ada Foah

" " between Vume and Battor

" " between Kase, Sege and Akplabanya

New installation of pole-mounted transformers in 42 locations

Supply of materials for low-voltage distribution lines

Supply of the remaining 2/3 of tools for construction/electric works

The project is to be completed with the electrification of three district capitals, and a requested area located in lower Volta River.

Division of work between Ghana and Japan was deliberated on the occasion of field survey and has been confirmed as follows.

a. Execution Survey (transmission line route, location of substations) — Ghana's Job

b. Site Acquisition, Tree trimming along the route (substations, distribution/transmission lines) — Ghana's Job

c. Ground Leveling, water supply and drainage work — Ghana's Job
Civil Work for the foundation of equipment in the substation sites

d. Construction of Low-voltage Distribution Lines — Ghana's Job

e. Construction of Transmission Lines — Japan's Job

f. Installation of Substation Equipment (including building) and their Testing — Japan's Job

g. Construction of 33 kV Transmission Lines — Japan's Job

h. Construction of Distributing Substations — Japan's Job

i. Supply of Low-voltage Materials & Equipment, Work Vehicles, and Tools — Japan's Job

This project will at a stroke electrify three yet-to-be-electrified district capitals of Great Accra Region and Volta Region which are included in the "National Electrification Plan", bringing about a big progress in the "District Capitals Electrification Plan" which is one of Ghanaian Government's urgent policies of importance. And it is accompanied with the introduction of transmission lines in the neighbor which will enable the local residents of more than 100,000 to enjoy the benefit of electric power.

It also provides superb infrastructure to a promising salt industry project which is now under preparation by the Ghanaian Government, and it is expected to give a big impact on the local economic activities.

Since a lot of effects can be expected from the execution of this project as has been described above and the project is also in line with the purpose of grant aid of the Government of Japan in the view point of enhancement of livelihood of residents by the electrification in the project area i.e. support to basic human need, it is concluded that the materialization of this project is extremely worthwhile.

Ghana

Basic Design Report on

"The Project for Electrification in Lower Volta Area"

Contents

CHAPTER 1
INTRODUCTION

Chapter 1 Introduction

The Republic of Ghana has two major hydroelectric power sources, that is, Akosombo Hydroelectric Power Station (912 MW) which was constructed in 1966 and has a large reservoir, and Kpong Hydroelectric Power Station (160 MW) which was constructed in 1981 located just downstream from Akosombo. These two stations supply the entire domestic demands of electric power and even export electric power to Togo, Benin, and Cote d'Ivoire. However, on the other hand, as preparation of domestic power distribution system has been delayed only about 20% of the total population of 14.42 million can enjoy the benefit of electric power.

Under such circumstances the Ghanaian Government has taken up the promotion of local electrification as an important policy, and prepared the "National Electrification Plan" in 1990 which set an objective to complete the electrification of the whole villages by 2020. It especially aims strongly to electrify all the district capitals within an immediate future years (by 1995). Various foreign supporting organs such as the World Bank have been rendering support to this plan, and our country also carried out a program of the electrification of villages in the Ashanti Region and the Great Accra Region responding to their request for Grant Aid Program, and contributed a lot to the electrification of the above areas.

The Ghanaian Government valued this highly and has requested our country this time for Grant Aid Program in "The Project for Electrification in Lower Volta Area" (original name: The Ada Foah Electrification Project" which is to electrify three yet-to-be-electrified district capitals (Ada Foah, Adidome, Sogakope) and neighboring villages in south-eastern part of the country.

The area taken up in this project is located on the lowest reaches of the Volta River where regular flooding of the river is said to have produced fertile farmland and have cleaned up the river. However, since the construction of the Akosombo Dam, natural conditions have changed drastically and it uttered extreme influences on the life of humanity in the area including a problem of drinking water and hazards of harmful bilharzia etc.

Therefore this area is said to have been sacrificed for the Akosombo Project while is was forced to decline commercially and economically. So, the Ghanaian Government has put a high priority on the execution of this plan in order to improve the bases of life of the residents in the said area.

But, it is certain that the introduction of electric power by this project will become the driving force for the rapid progress of the local industry as the area still possesses a high industrial potential (agriculture, stock raising, salt industry etc.) thanks to its geographic conditions.

Based on the above particulars, the Japanese Government carried out a preliminary study for this project in July 1992. Based on the deliberation with the Ghanaian counterpart and on the results of the on-site survey the Japanese Government came to judge that it is adequate to consider the said project as an objective of Grant Aid Program and has decided this time the execution of a basic design study of "The Project for Electrification in Lower Volta Area of the Republic of Ghana". In accordance with this governmental decision Japan International Cooperation Agency (JICA) dispatched a basic design investigation team to Ghana for a period of one month between November 12, 1992 and December 11. (Team Leader: Mr. Hisatoshi Okubo, 1st Basic Design/Study Division, Grant Aid Study/Design Department, JICA)

The study team held deliberations and hearings with the Ministry of Finance, Ministry of Energy of the Ghanaian Government, Electricity Corporation of Ghana, Volta River Authority, Ghana Highway Authority and other organizations related with this project, and it also conducted a series of on-site survey and collection of materials in cooperation with the parties concerned. Based on the results the team examined the necessity of the requested project and its adequacy as a grant project, and studied further the basic design, execution method, etc. in order to materialize the said project, and has prepared the "Basic Design Report (Draft)".

Prior to preparing the final report, JICA dispatched a team to Ghana from March 8 to 18, 1993 to explain the contents of the said draft-report. (Team Leader: Mr. Hidetoshi Ishioka, 1st Basic Study/Design Division, Grant Aid Study/Design Department).

The Team deliberated on the contents of the project with Ghanaian authorities mentioned above and acquired a consent to the contents of the report. Based on this, this report was finalized.

Attached at the end of the report are the list of the members of the study team, schedule of investigation, a list of the staff members of the Ghanaian counterparts, minutes of deliberation meetings etc.

CHAPTER 2
BACKGROUND OF THE PROJECT

Chapter 2 Background of the Project

2.1 Background of the Preoject

2.1.1 Current Status of Electric Utilities

2.1.1.1 Energy Policy

The first president of Ghana, Nkrumah, built a huge dam on the Volta River and constructed a large hydro power station to attract heavy industries which require inexpensive power aiming to make this the driving force for national development. The Akosombo Dam was constructed based on this policy and completed in 1963, and an aluminum refining firm began operation relying on the 1 million kW of hydro power.

This plan was later criticized as the cause of economic failure in Ghana because of the heavy burden of redemption caused by the long drought which followed and the drop of cocoa prices, the main farm product in Ghana. But energy wise, Akosombo and the later constructed Kpong Hydro Power Station downstream even now provides sufficient and stable energy for the nation and even has enough to export. In the long run, the development of a large scale hydro power station was an appropriate plan.

Ghana currently exports power to Togo, Benin and Cote d'Ivoire. Power export is an important source of acquiring foreign currencies.

But because of poor profitability, construction of the transmission system within the country is delayed. Some cities in the north still rely on diesel power and the expansion of the power system to the north is hastened. In the south, a special high voltage (161 kV) power system is constructed for the entire area but a secondary power system (33 kV) is not completed and many areas are left unelectrified. This is obstructing the development of industry. For this reason, the Government of Ghana has the "National Electrification Program (explained later)" currently under way. A long-range project to eliminate unelectrified areas in the nation.

2.1.1.2 Organization of Electric Utilities

There are two public corporations related to energy generation and transmission, the Volta River Authority (VRA) which is in charge of generating and supplying energy, and the Electricity Corporation of Ghana (ECG) which is in charge of distribution. The Ministry of Energy is the supervising government agency. The organization of the Ministry of Energy, VRA and ECG are shown in Fig. 2-2, 2-3, 2-4.

(1) VRA (Volta River Authority)

VRA is a state owned power production and wholesale supply firm which owns and operate two large hydro power stations, Akosombo and Kpong, and a 161 kV power transmission system interconnecting the entire nation. Beside this, VRA is also involved in fishing and shipping business using the Volta River.

Recently, it was decided to have VRA be in charge of the development and management of power distribution in the northern region as this region needs large facilities to be constructed and ECG lacks funds. Northern Electricity Department (NED), a separate organization under VRA will be in charge of this business.

The company outline of VRA is shown in Fig. 2-5.

(2) ECG (Electric Corporatic. of Ghana)

ECG is a state owned power distribution firm which distributes power to general customers nationwide.

ECG buys power at wholesale from VRA at VRA owned 161 kV or 69 kV substations located around the nation, or in areas where VRA transmission line is not available produces power at diesel power stations owned by ECG, and supplies and sells this power to customers using 33 kV or under 11 kV distribution system.

ECG is in charge of rural electrification. (NED is in charge in the northern region.)

The company outline of ECG is shown in Fig. 2-6.

2.1.1.3 Power Source

VRA

Akosombo Hydro Power Station

Maximum capacity: 900 MW (147 MW x 4, 162 MW x 2)

Rehabilitation works are now under way to up-grade the present capacity of each equipment to 180 MW.

Head : Max. 65 m, Reference 65 m
Discharge : 255m3/s/unit
Commissioned in: 1966 (4 units), 1972 (2 units)

Kpong Hydro Power Station

Reregulating reservoir of Akosombo
Maximum capacity: 160 MW (40 MW x 4)
Head : 11.75 m
Commissioned in : 1981

Tema Diesel Power Station

A reserve power station for the above two, and is normally not operated.

ECG

Small-scale diesel power stations are located in small cities which are not connected to the power system.

Total installed capacity: Is said to be 21.3 MW, but very few are in operation.

2.1.1.4 Power System

(1) VRA

There are six 161 kV transmission lines connecting Akosombo and Kpong hydro power stations to Tema the main industrial area of Ghana, of which 2 lines are extended to Accra, the capital city. A total of 770 km of 161 kV transmission line, including the above, interconnects the main cities of the southern half of the nation into the power system. Since 1989, this power system was extended to include the northern region, and major cities such as Tamale and Bolgatanga were interconnected to the national power system. There are 20 substations in the system which are operated by VRA. The voltage is dropped to 33 kV or 11 kV and wholesale supplied to ECG.

The Asiekpe Substation included in this project is one of them and is owned by VRA. This substation was build in 1982 to supply power to the Ho area located in the east of Volta Lake. A 69 kV transmission line is connected to the substation.

Also a 225 kV 220 km international interconnecting line lead-out from Prestea Substation in the Western Region where the voltage is raised for export to Cote d'Ivoire. Power is exported to Togo and Benin via the above mentioned Asiekpe Substation using a 161 kV 129 km transmission line.

(2) ECG

Receives 33 kV or 11 kV power from the 20 substations in the power system. Distributes power to customers directly at 33 kV or through 11 kV distribution line via 33 kV secondary transmission line and 33/11 kV secondary substation.

The distribution transformers are 33 kV/433 V and 11 kV/433 V, and the low voltage distribution methods are 3-phase 4-line 420 V, single phase 240 V.

Neutral earthing method is direct earthing.

(3) Transmission System Diagram

The transmission system for the southern part of Ghana is shown in Fig. 2-7.

The position in the system of the areas connected to this project is also shown in the same figure.

2.1.1.5 Current Status of Power/Energy Supply

Power for the 161 kV system which covers the most part of the country is supplied from the two large-scale power stations, Akosombo and Kpong, which are capable of supplying enough power for the time being.

But Ghana's neighboring nations, especially Burkina Faso, hope to import cheap electric energy and wish Ghana to newly develop the undeveloped points of the Volta River.

The following supply outlook is reported in the National Electrification Planning Study (NEPS). With the improvement and expansion of the domestic power system, power supplied to ECG will increase from 295 MW in 1990 to 420 MW in 2000. The power demanded by existing mines will increase from 48 MW in 1990 to 73 MW in 2005, and NED power demand is expected to increase from the present 24 MW to 69 MW in 2010.

Presuming that power export to CEB (Electricity firm in Togo and Benin) and CIE (Cort d'Ivoire electricity firm) will remain as now (185 MW), and that the demand by the largest concession firm in Ghana VALCO (Volta Aluminum Co., Ltd.) will remain the same as currently agreed (340 MW), the total power demand considering loss and demand factor is predicted to increase from 820 MW in 1990 to 963 MW in 2000.

When we add the forecasted load 70 MW (2000) of the National Electrification Program, the demand will almost equal the present maximum power generating capacity 1060 MW. Therefore, it is necessary to materialize a new power development project in the near future and add new power sources to the system.

The following projects are being studied for this purpose.

i) Gas turbine power station using heavy oil from the oil refinery in Tema as fuel. (100 MW)

ii) Oil thermal power station using oil imported in large volume. (to generate 600 MW in about 20 years from now)

iii) Middle-scale hydro power station. (total 135 MW, at 2 places, Oti)

2.1.2 Outline of Related Projects

2.1.2.1 National Development Plan for Rural Electrification

(1) National policy and progress of rural electrification plan

Although Ghana has a large power generating capacity, enough to export, because its domestic power transmission system is not complete the electrification rate of the country is only 20% and many areas are left without electricity. The Government of Ghana is extremely concerned about this and has advocated electrification of all areas for a long time. And finally the desire to materialize the plan has developed.

The National Electrification Program (NEP) planned in 1989-1990, aims to electrify every town/village in the nation by ???1920???. As the first stage of this plan, it was set forth, as a national policy, that electrification of all district capitals be completed by 1995. (District Capital Electrification Program: DCEP)

Out of 110 district capitals, there are 48 district capitals, as of 1990, that have no prospect of electrification. Further more, 10 district capitals are supplied electricity by unreliable diesel power stations. So, 58 district capitals should be electrified by means of connecting to the grid.

The Government of Ghana explained the aim of the District Capitals Electrification Program as follows.

The district capital is the center of government and economy of the area. By electrifying the capital, the development of every sector in the area becomes possible. Building hospitals, technical training schools, communication facilities and provide drinking water is especially important. Electrification will contribute greatly to the development of local industries and increase employment opportunities in the area.

(2) National Electrification Plan

Power consultant company, Acres International, in Canada, submitted a report on this plan in July, 1990. Following is an outline of it.

(a) The national population as of 1988 is 13.5 million, of which 3.1 million is receiving electricity. The electrification ratio is 23%.

(b) There are 4221 towns/villages in the nation, of which 478 are electrified and the remaining 3743, its population 5.4 million, have no electricity.

(c) There are 590 towns/villages which have a population of over 2000. These villages will be electrified using 69 distribution lines. The small villages along the line route will inevitably be electrified, which will make the total of villages receiving electricity 1630, a population of 3.3 million.

(d) Using this first project as the backbone, the distribution line will be extended radially electrifying about 2100 villages, a population of 2.1 million.

(e) Extending the existing 33 kV system is most economical. Generally, an intermediate substation for 33/11 kv is not needed.

(f) 3-phase will be used for all primary systems. But when extending radially to villages of 500 kW and under, it will be very advantageous to use single or 2-phase.

(g) Calculated using 1990 prices, the direct project cost is estimated to be US$726.7 million; $349.9 million for the primary system, $266.4 million for extending radially, and $110.4 million to reinforce the existing line.

(h) The district capitals will be electrified in the first five years. The others will be electrified in five phases.

(i) The work period and the cost are phased as follows.

Phase	Period	Cost
1	1991-1995	$114.1 million
2	1996-2000	$72.1 million
3	2001-2005	$112.3 million
4	2006-2010	$144.0 million
5	2011-2015	$148.1 million
6	2016-2020	$136.4 million

"The Project for Electrification in Lower Volta Area" which was requested by the government of Ghana is included in this National Electrification Plan as Phase 1.

2.1.2.2 The Previous Japanese Cooperation Project

(1) Project Outline

The following project was carried out as a Japanese grant aid project in 1989.

Areas electrified:

Ashanti Region; from Kumasi to district capital Bekwai and the surrounding towns.

Accra Region; from Tokuse to district capital Senyaberak and the surrounding towns.

Official papers exchanged: June, 1989
Completed : November, 1990
Facility and Equipment Outline: Outlet for 33 kV transmission line from Kumasi substation additionally constructed.
Bekwai Substation 33/11 kV, 2500 kVA newly constructed.
110 km of 33 kV transmission distribution line newly constructed.
Material and equipment for 20 km of 11 kV distribution line supplied.
43 distribution substation newly constructed.
Low-voltage material and equipment supplied.
Construction vehicles supplied Total Amount of Assistance:
8.6 hundred million yen

(2) Utilization of facilities after completion

In November, 1990, at three locations in each region, opening ceremonies were held with the Minister of Energy, governor of the region and the Japanese Ambassador present. A huge number of area residents gathered for the ceremony and were overjoyed.

The general area residents who were long awaiting for electricity, and small factories who were operating with small diesel generators were first in line to register as customers. The number of customers is increasing rapidly and the project is contributing greatly to the development of the area.

One year after commissioning, as of November 1991, the data of customers are as follows:

Six industrial consumers 650 kW have been already supplied and other eight consumers 380 kW follow until the end of 1992. Number of consumers reached 3,200, it means 37% of households in the area have been electrified.

2.2 Outline of the Request

2.2.1 Details of the Request for Assistance

(1) Initial Request

In 1990, the Government of Ghana, grounded on the national need for rural electrification, as explained in 2.1.2, requested the Japanese government to give gratis assistance for this project.

The request was to electrify three district capitals including Ada Foah and the areas around the transmission line route. The facilities to be constructed are as follows.

(a) Additionally construct facility to connect 69 kV transmission line to Asiekpe Substation.

(b) Newly install 69 kV transmission line between Asiekpe and Sogakope.

(c) Newly construct 69 kV/ 33 kV substation at Sogakope.

(d) Newly install 33 kV distribution line between Sogakope Substation and Ada Foah.

(e) Newly install 33 kV branch line to Mepe and Battor.

(f) Newly install 33 kV/420, 230 V distribution transformers for electrification of each town.

(g) To supply low voltage distribution line material and equipment.

The above are for the electrification of the following 10 areas.

District capitals: Ada Foah, Sogakope, Adidome
Towns: Battor, Mepe, Aveyme, Vume, Tefle, Kasseh, Big Ada.

(2) Additional Requests

In response to this request, the Japanese Government decided to conduct a preliminary study, and sent a preliminary study team to Ghana in July, 1992.

In the discussions held at that time, the Government of Ghana requested the followings, to electrify additional areas.

(a) To extend 33 kV distribution line to Lekpoguno by branching from Kasseh on the Ada Foah line.

This will electrify: Koledor, Mantse, Sege, Anyaman, Akplabanya, Lekpoguno.

(b) To extend the Ada Foah distribution line to Pute.

This will electrify: Pute, Tochimekope

(3) The Range of the Project Agreed On

As mentioned, at the preliminary study stage the Government of Ghana made additional requests to install a branch line between Kasseh-Sege-Akplabanya-Lekpoguno, and to extend the distribution line from Ada Foah to Pute. Therefore, the first item to be discussed in the basic design study was to decide the appropriate range of the project.

Based on the on-site survey, it was judged by both parties that it is inevitable to omit Lekpoguno and Pute from the project. Lekpoguno and Pute is currently depopulated and future development of industry and population growth in the area can not be expected judging from the topography and the surrounding environment. These areas were also a low priority area in the Ghana's list of requests.

The needs and the validity of the areas included in the project will be studied in the next chapter.

The basic design study team investigated the electrification needs of the area. After discussions, the final range of the project was confirmed and agreed on by both parties. The details are in the following section. (Refer to Annex-1 "Minutes")

2.2.2 Project Description

The final details of the project requested by Ghana is as follows.

(a) Additions to the existing Asiekpe Substation

To add one 69 kV transmission line outlet and newly construct auxiliary facilities.

(b) Newly construct 69 kV transmission line.

To construct one 69 kV transmission line between Asiekpe Substation and Sogakope Substation (approx. 40 km).

(c) Newly construct Sogakope Substation

To construct 15 MVA capacity substation to transform 69 kV down to 33 kV.

(d) To newly construct the following 33 kV distribution lines.

Between	Sogakope	- Ada Foah			
Between	Sogakope	- Adidome			
Between	Vume	- Battor			
Between	Kasseh	- Sege	-	Akplabanya	

(e) Construction of distribution substation.

The following 20 towns and villages will be electrified under this project.

Adidome, New Bakpa, Sogakope, Sokope, Tefle, Vume, Mepe, Battor, Kpotame, Kasseh, Tomatoku, Dogo, Big Ada, Ada Foah, Tochimekope, Mantse, Koluedor, Sege, Anyaman, Akplabanya

A distribution substation will be installed at an appropriate location in each town or village as the origin of low voltage power system.

(f) To supply low voltage material and equipment (including measuring equipment).

(g) To supply construction vehicles, tools

Trucks, cranes, administrative vehicles
Construction tools, gauges

Fig. 2-5 VRA Company Outline

Energy Generation (GWH)		1990	1991
Generation	Akosombo	4,827	5,149
	Kpong	893	958
	Total	5,721	6,108
Imported	CEB (Benin)		6
	CIE (Ivory Coast)	3	0.3
In-station consumption		2.8	3.1
In-substation consumption		1.3	1.7
Transmission loss		179(3.1%)	194(3.2%)
Power Generation (MW)			
Peak power generation		812.5	856
Average generation		653.5	689
Load factor(%)		78.4	80.5
Akosombo average discharge (m3/s)		992	1,001
Energy supplied to VALCO(GWh)		2,788	2,795
Energy Export/Import			
Export to CEB(GWh)		452	359
Maximum export to CEB(MW)		82	93
Export to CIE (GWh)		312	453
Import from CIE (GWh)		3.5	0.3

State of salable electric power

(per customer)	GWH	MW (1991)
ECG	1,752	312
Mine	407	60
NED	93	18.8
Valco	2,795	350
CED	359	93
CIE	449	110

VRA Company Outline (cont.)

Unit power price	¢/kWh	
Generating cost	5	
Average selling price	7.5	
Valco	7.5	
ECG	3.5	
Mine	7.7	
CEB	19	
CIE	17	
Financial State (1990)	(c 000)	
Fixed assets	249,959,840	
Current assets	368,457,113	
Long-term loans	76,576,149	
Income and Expenditure (1990)		
	(¢000)	(¢000)
Power sales income	37,233,372	
Other income	2,203,318	
Total income	39,436,690	
Operating expenses		8,174,106
Depreciation cost		8,684,650
Total expenditure		16,858,756
Operating profit	22,577,934	
Less allowance for currency exchange rate change loss, etc.		8,472.466
Less allowance for doubtful receivables, etc.		2,176,013
Total extraordinary expenditure		10,648,479
Net Income		11,929,455
Number of Employees		
End of 1991	2204	
Others NED	373	

ECG Company Outline

Fig. 2-6

	1991	1990
Purchased power(from VRA)	1,780 GWH	1,560 GWH
Salable energy(max.)	1,402 GWH	1,249 GWH
Power demand (max.)	330 MW	297 MW
Number of customers	323,889	304,819
Electricity charge unit price		
Big customer	3.60 ¢/kWh	3.60 ¢/kWh
General customer	10.75 ¢/kWh	10.75¢/kWh
Power sales income	(¢000)	(¢000)
Residential	5,289,844	4,258,962
Non-residential	4,096,405	3,181,595
Industry	4,857,009	3,439,457
Total	14,243,258	10,880,014
Financial State	(¢000)	(¢000)
Fixed assets		28,115,604
Current assets		3,889,596
Long-term loans		21,247,973

Annual income and expenditure	1991		1990	
	(¢000)	(¢000)	(¢000)	(¢000)
Power sales income	14,243,258		10,880,014	
Other income	222,479		200,836	
Total income	14,465,738		11,080,850	
Operation cost		9,626,831		8,339,697
Depreciation cost		7,574,888		2,264,692
Total expenditure		17,201,719		10,604,389
Operating profit	-2,735,982		476,461	
Less allowance for currency exchange rate change loss, etc.		1,329,093		1,598,044
Net income	-4,065,075		-1,121,583	

Number of employees	1991	1990
Total	3,190	3,106
of which engineers are	77	70

2.3 Outline of Project Area

2.3.1 Location, and Social and Economical Condition of Project Area

(1) Natural and Social Environment

The project area is located in the southeast part of Ghana and includes Ada Foah, the only unelectrified district capital in the Great Accra Region, and Adidome and Sogakope of Volta East Region.

Ada Foah, the district capital of Dangbe East and the main target of this project is located on the right bank at the mouth of the Volta River where it flows into the Atlantic Ocean. In the past, the capital prospered from shipping on the Volta River and agriculture products grown on fertile land bestowed by periodic flooding of the Volta River. But with the construction of the Akosombo Dam, its role as the center of trade for farm products ended and is no longer the prosperous bustling town that it was. But the government of Ghana is aiming to revitalize the area by promoting the development of marine products and salt industries, and as a tourist resort area, which it still is famous for.

Sogakope is the capital of the Sogakope District. It is located at the crossing of National Highway Route 1 running from Ghana to Togo and the Volta River. Sogakope is a distribution center of goods and is greatly expected to grow in the future.

Adidome is the capital of the Adidome District. It is located on the Volta River surrounded by fertile farmland. It is the center of trade for agricultural and dairy products in the area. In the past, there were large-scale state owned farms aided by the U.S.S.R. Today, it is still the center of government and economy, and is largely populated. By electrifying this district capital, it is expected to prosper from further development of agricultural and dairy products trade.

Mepe and Battor belong to the Adidome District. Mepe and Battor spread on the opposite side of Adidome on the Volta River and have existed from olden times with their economy centering on dairy farming. The largest hospital within this project area is located in Battor.

The electrification of each area is in great need. There are great expectations for the improvement of people's living standards and the activation of the area economy through electrification.

The added areas, Sege and Akplabanya are flat and vast areas surrounding the Ada Songor Lagoon facing the Gulf of Guinea. For the most part the land is cassava growing arable land and savanna dotted with pasturing land for cow and sheep. Akplabanya located along the Gulf of Guinea is a large fishing village.

Sege is located at the junction of second-class national highway to Battor and National Highway Route 1. It is the center of distribution and is largely populated. Koluedor and Mantse is near the lagoon and their economy is centered on dairy farming and small-scaled self owned saltworks.

Akplabanya and Anyaman face the Gulf of Guinea, and are largely populated. Most of their residents engage in the fishing business using many fishing ships to fish on the sea. Many are also employed at the large saltworks nearby.

(2) The Salt Industry

The salt industry is the largest industry in this area.

The former Vacuum Salt Products Ltd., (VSPL, currently state owned) is currently in operation. The factory operates a large-scale solar crystalling-pan method saltworks cleverly using the geographical and weather conditions of the area.

The lagoon is divided by banks to make several large evaporating ponds. Seawater is taken in at high tide using the natural flow. Next, the seawater is condensed while passing through the evaporation ponds and is pumped up from the final evaporation pond to the reservoir. Then it is flowed down to the crystalling pans to make saturated saltwater. In several days the salt crystal which accumulates at the bottom of the pan is collected. The salt is collected from the pan manually offering many jobs to the residents of the area.

In this region there is no rainfall in the dry season. The lagoon is shallow and it is easy to construct banks. On top of that, a thin sandbar divides the sea and the large lagoon. The range of tide is great making it easy to lead the seawater in to the ponds at high tide. This region has these favorable natural conditions for the above mentioned salt manufacturing method.

VSPL is currently the largest salt manufacturing factory in Ghana. Its annual production is 50,000 tons (150,000 tons for whole Ghana). At a selling price of $40/ton, the annual sales is said to be about 1 billion cedi (2.5 hundred million yen). The study team confirmed that this factory is the most active operating factory in the project area.

If electricity is secured, VSPL will increase pumps and by utilizing the unused pans, wants to increase production to 100,000 - 150,000 tons in a few years, regardless of the master plan which will be mentioned later.

2.3.2 Natural Conditions

The statistical data of temperature and rainfall in the project area is shown in Fig. 3-3.

2.3.3 Existing Power System of Nearby Areas

The project area is considerably behind in electrification becauseis the area is located far from the center of the country and has no big cities. No distribution line is extended to the area from the power system and the whole area is in general unelectrified. Hospitals, factories and farms have their own small diesel generators but the generated energy is not supplied to the general public.

Keta which is located further to the east is near the border with Togo, and was electrified a few years ago by re-importing power from Togo. (Recently, this power is lead into Sogakope and a part of Sogakope is electrified.)

A 161 kV transmission line which interconnects with Togo crosses the northern part of this area. Asiekpe Substation is located 40 km north of Sogakope. This is the nearest power system.

As mentioned before, Keta in the east is electrified by re-importing power from Togo, and has a 33 kV distribution system. But it is illogical to extend a line from this system to this area which is further to the west in Ghana. There are also technical problems such as power loss and voltage drop.

Fig. 2-7 shows existing power system in southern part of Ghana including proposed system for the project, Fig. 3-1 shows the location of power facilities to be installed and Fig. 3-2 is the connection diagram for them.

Fig. 2-1 ORGANIZATION OF PNDC(Provisional National Defense Council)

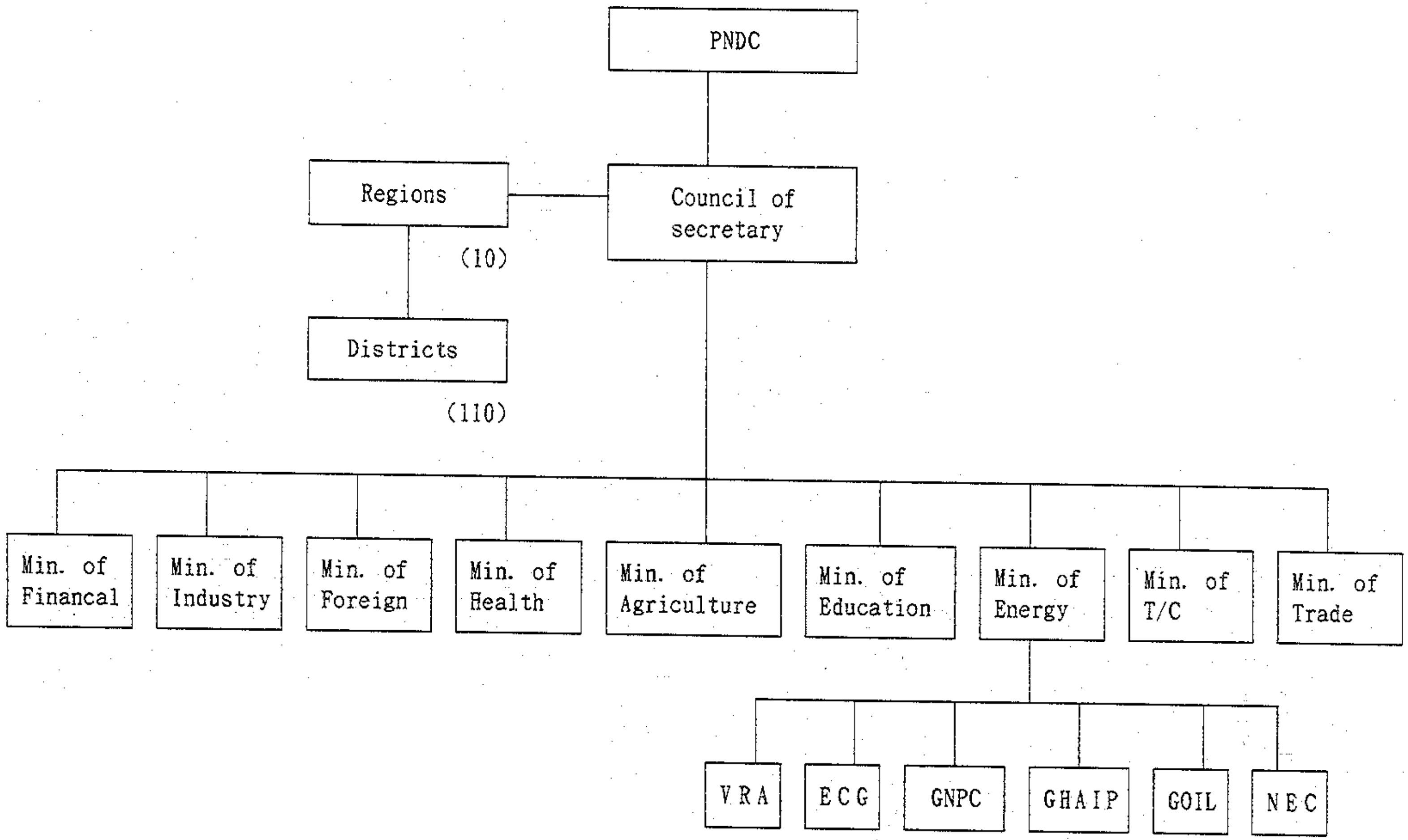

Fig. 2-2 ORGANIZATION OF MINISTRY OF ENERGY (MEn)

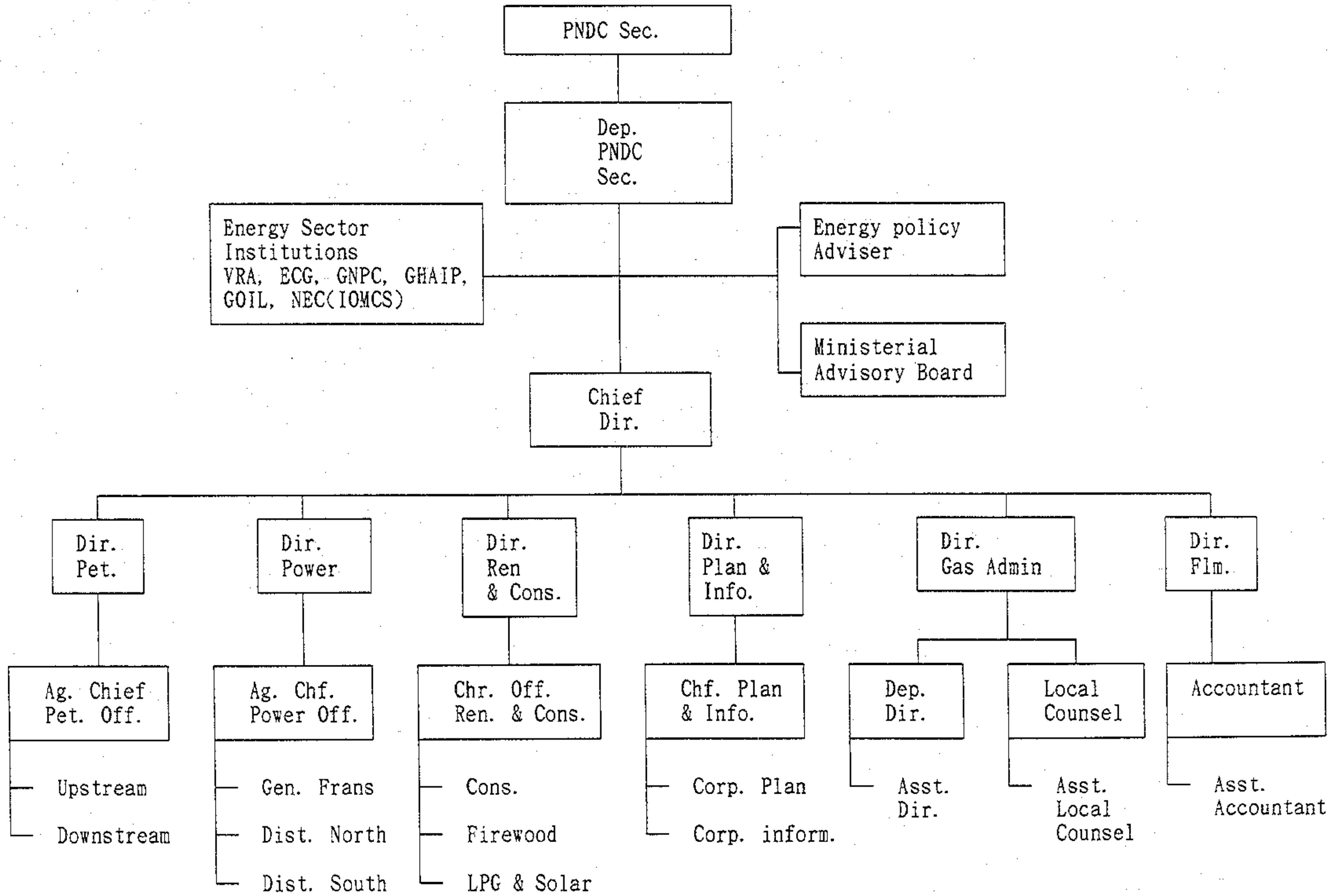

Fig. 2-3 ORGANIZATION OF VOLTA RIVER AUTHORITY(VRA)

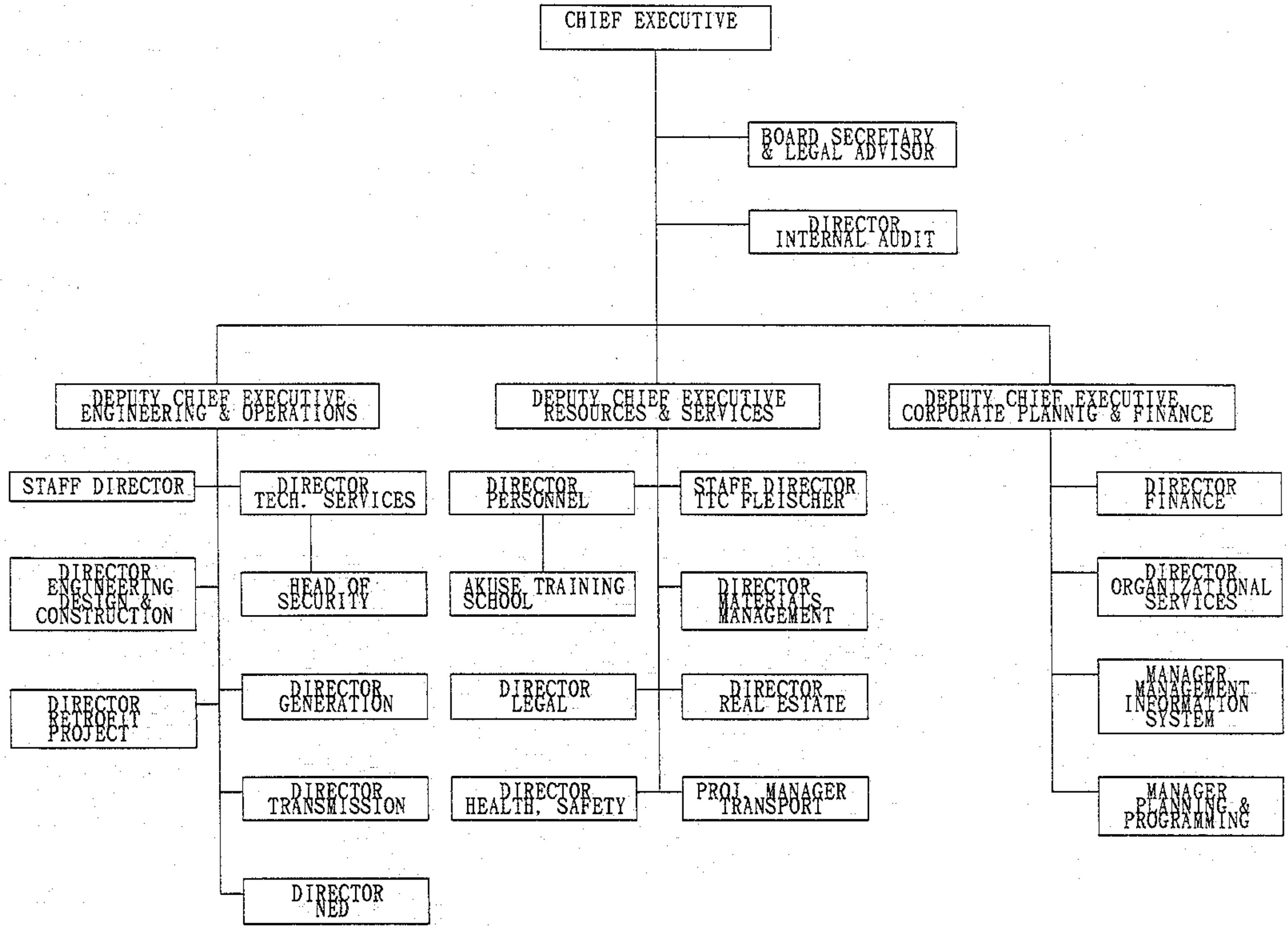

Fig. 2-4 ORGANIZATION OF ELECTRICTY CORPORATION OF GHANA(ECG)

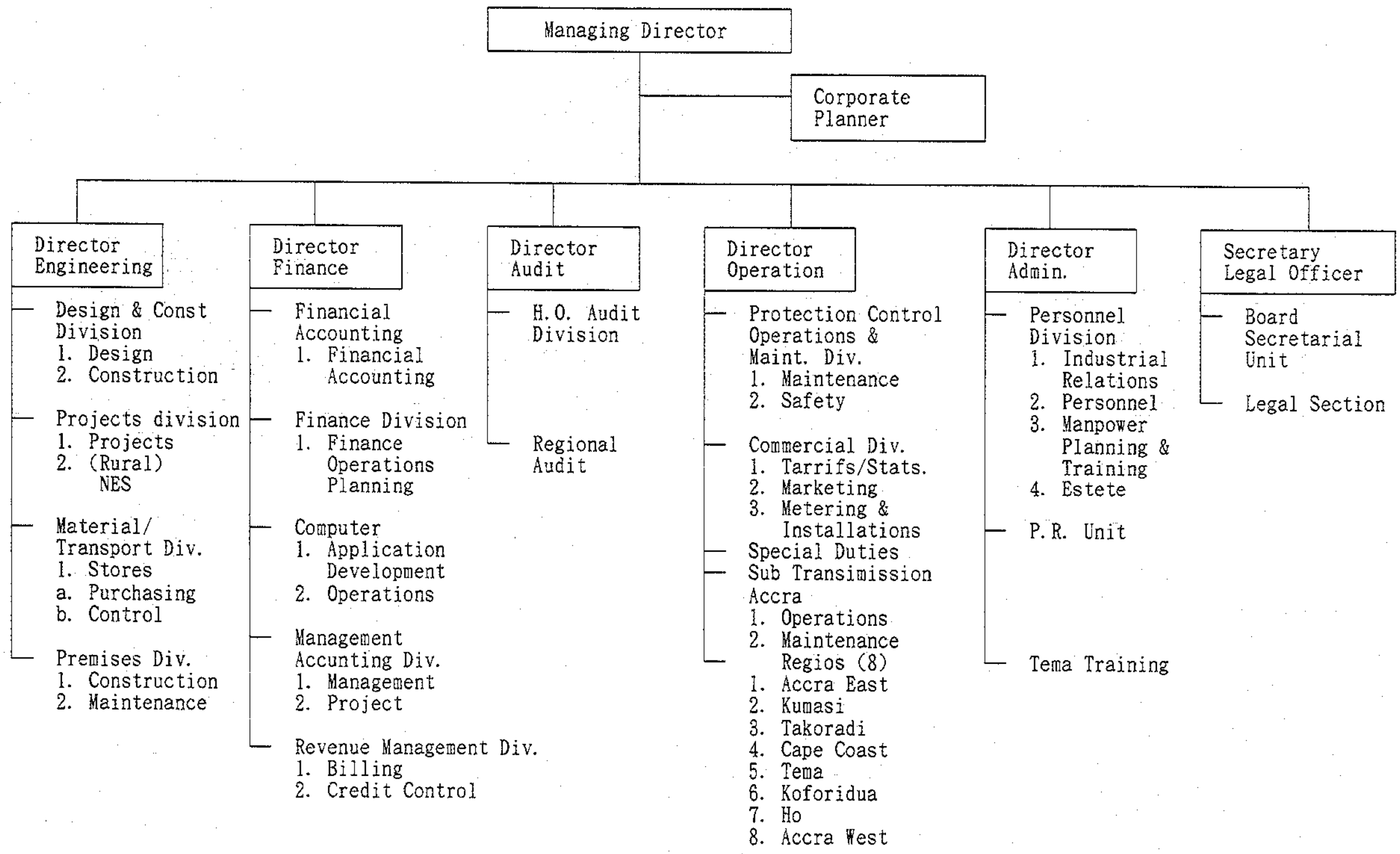

Fig. 2-5 VRA Company Outline

Energy Generation (GWH)		1990	1991
Generation	Akosombo	4,827	5,149
	Kpong	893	958
	Total	5,721	6,108
Imported	CEB (Benin)		6
	CIE (Ivory Coast)	3	0.3
In-station consumption		2.8	3.1
In-substation consumption		1.3	1.7
Transmission loss		179(3.1%)	194(3.2%)

Power Generation (MW)	1990	1991
Peak power generation	812.5	856
Average generation	653.5	689
Load factor(%)	78.4	80.5

	1990	1991
Akosombo average discharge (m3/s)	992	1,001
Energy supplied to VALCO(GWh)	2,788	2,795
Energy Export/Import		
Export to CEB(GWh)	452	359
Maximum export to CEB(MW)	82	93
Export to CIE (GWh)	312	453
Import from CIE (GWh)	3.5	0.3

State of salable electric power

(per customer)	GWH	MW (1991)
ECG	1,752	312
Mine	407	60
NED	93	18.8
Valco	2,795	350
CED	359	93
CIE	449	110

VRA Company Outline (cont.)

Unit power price	¢/kWh	
Generating cost	5	
Average selling price	7.5	
Valco	7.5	
ECG	3.5	
Mine	7.7	
CEB	19	
CIE	17	
Financial State (1990)	(¢ 000)	
Fixed assets	249,959,840	
Current assets	368,457,113	
Long-term loans	76,576,149	

Income and Expenditure (1990)

	(¢000)	(¢000)
Power sales income	37,233,372	
Other income	2,203,318	
Total income	39,436,690	
Operating expenses		8,174,106
Depreciation cost		8,684,650
Total expenditure		16,858,756
Operating profit	22,577,934	
Less allowance for currency exchange rate change loss, etc.		8,472.466
Less allowance for doubtful receivables, etc.		2,176,013
Total extraordinary expenditure		10,648,479

Number of Employees

End of 1991	2204
Others NED	373

ECG Company Outline

Fig. 2-6

	1991	1990
Purchased power(from VRA)	1,780 GWH	1,560 GWH
Salable energy(max.)	1,402 GWH	1,249 GWH
Power demand (max.)	330 MW	297 MW
Number of customers	323,889	304,819
Electricity charge unit price		
Big customer	3.60 ¢/kWh	3.60 ¢/kWh
General customer	10.75 ¢/kWh	10.75¢/kWh
Power sales income	(¢000)	(¢000)
Residential	5,289,844	4,258,962
Non-residential	4,096,405	3,181,595
Industry	4,857,009	3,439,457
Total	14,243,258	10,880,014
Financial State	(¢000)	(¢000)
Fixed assets		28,115,604
Current assets		3,889,596
Long-term loans		21,247,973

Annual income and expenditure	1991		1990	
	(¢000)	(¢000)	(¢000)	(¢000)
Power sales income	14,243,258		10,880,014	
Other income	222,479		200,836	
Total income	14,465,738		11,080,850	
Operation cost		9,626,831		8,339,697
Depreciation cost		7,574,888		2,264,692
Total expenditure		17,201,719		10,604,389
Operating profit	-2,735,982		476,461	
Less allowance for currency exchange rate change loss, etc.		1,329,093		1,598,044
Net income	-4,065,075		-1,121,583	

Number of employees	1991	1990
Total	3,190	3,106
of which engineers are	77	70

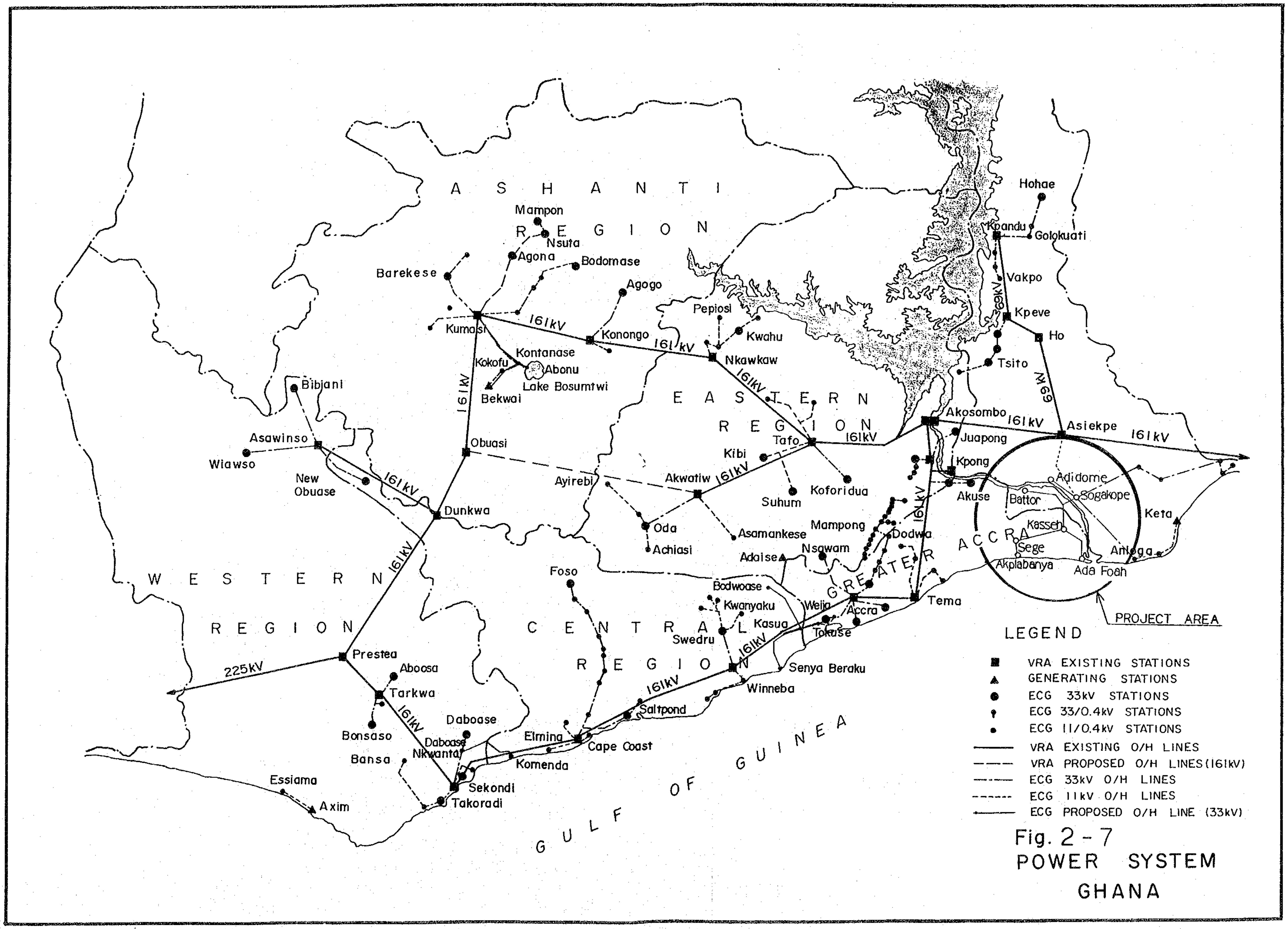

Fig. 2 - 7
POWER SYSTEM
GHANA

Fig.2-8 District Capitals without Electricity Supply in ECG Area (as of 1988)

	District Capitals without Electricity Supply	
Region	Funding in Place For Extension	Non Fund in Place For Extension
Ashanti (7 Towns)	Ejura * Tepa Kutenasi ** Bekwai **	New Eduabiase Manso Nkwanta Mankraso
Eastern (2 Towns)		New Abirem Dokorkrom
Volta (7 Towns)	Keta	Nkwanta Kadjebi Jasikan Akatsi Sogakope *** Adidome ***
Greate Accra (2 Towns)	Amasaman	Ada Foah ***
Central (3 Towns)	Asikuma	Twifo Praso Ajumako
Western (6 Towns)	Axim Asankragua Enchi Agona Nkwanta Half Assini Juabeso	
Total	13 Towns	14 Towns

NB:
* Covered by the ongoing Norhtern Electrification and system Reinforcement Project
** Electrified by the Former Jpanese Project
*** To be electrified by this Project

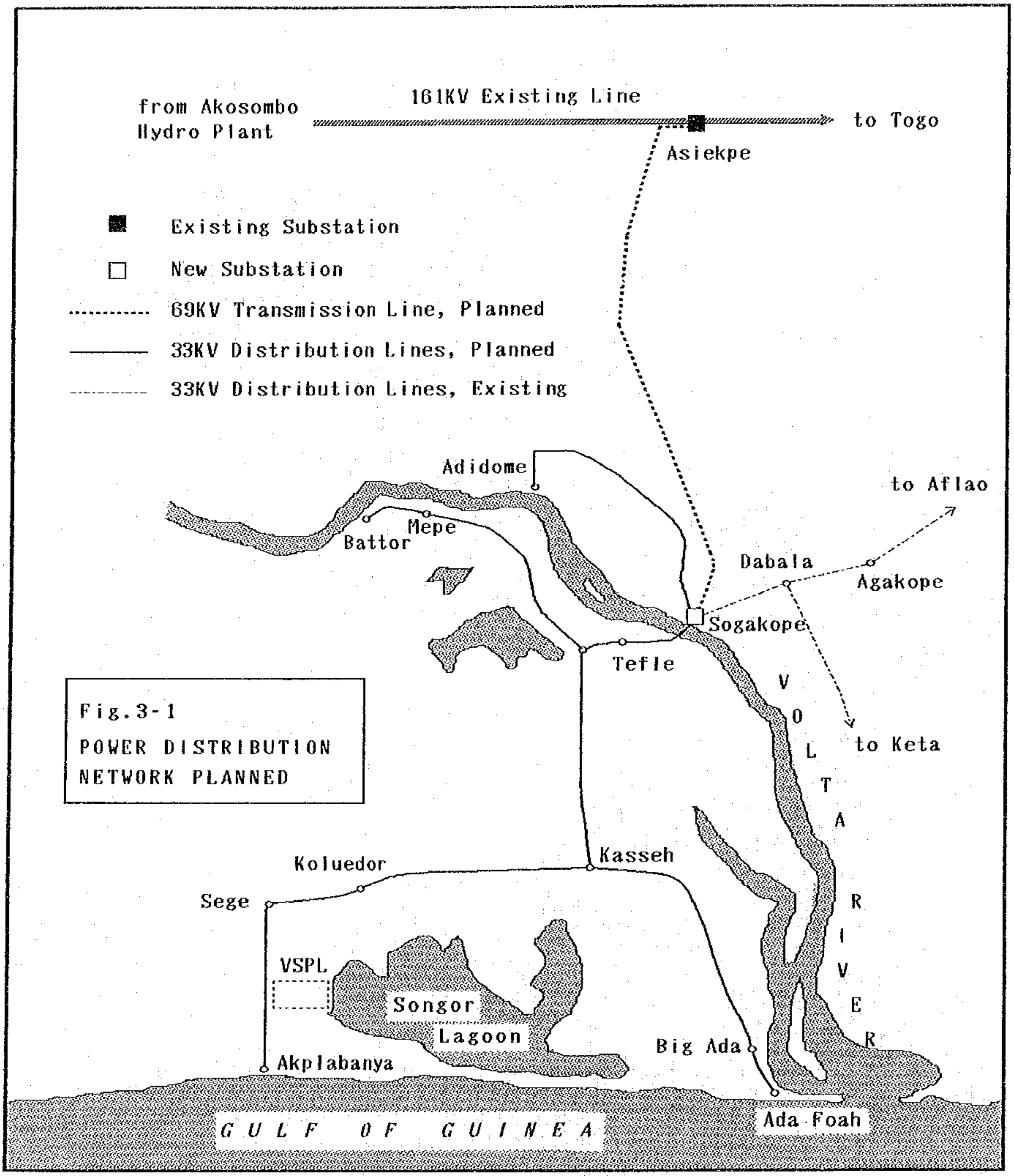

Fig.3-1
POWER DISTRIBUTION
NETWORK PLANNED

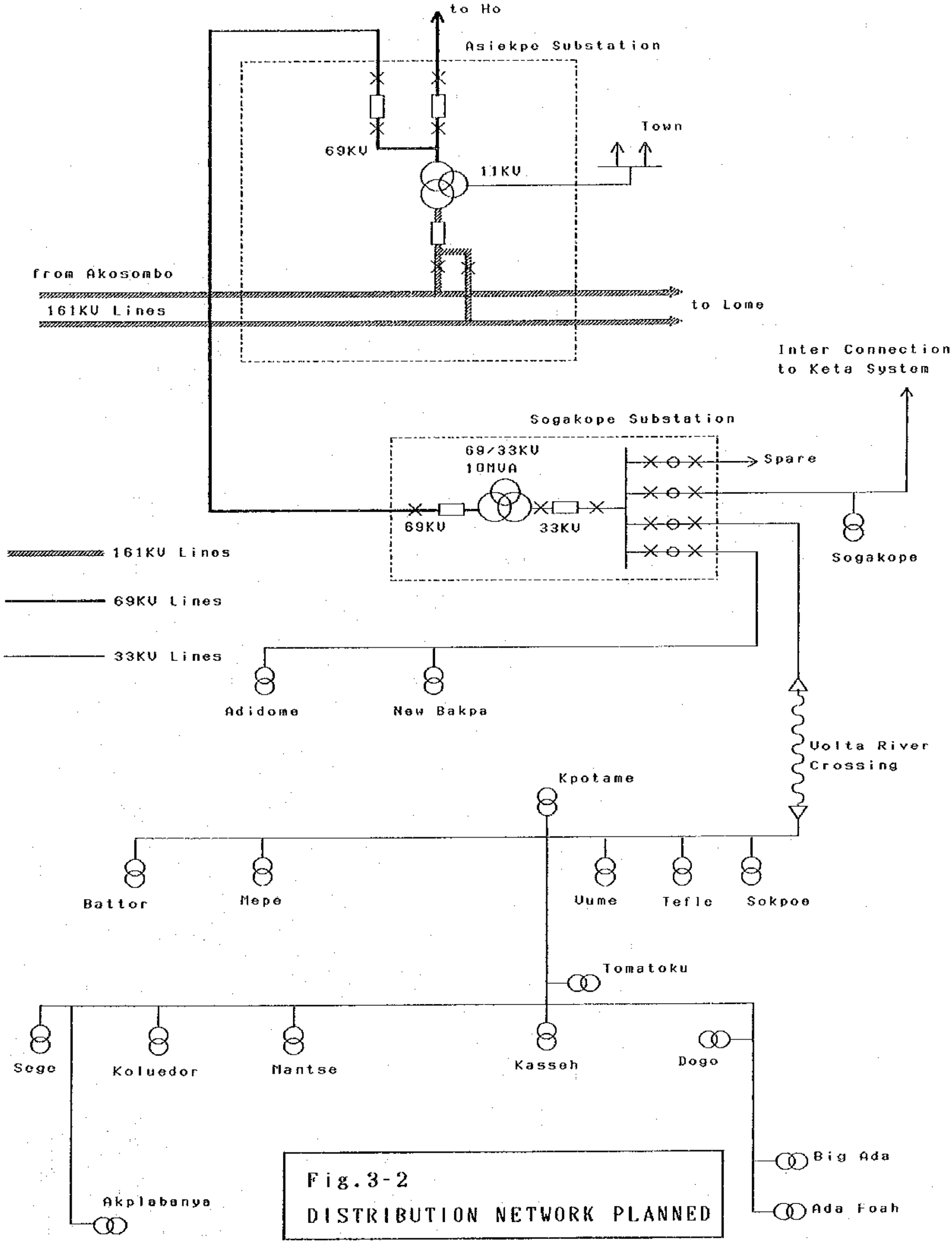

Fig.3-2
DISTRIBUTION NETWORK PLANNED

Fig. 3-3 Climatic Condition in the Area
Ada Foah, Adidome, Sogakope

Month	Monthly Rainfoall (mm)	Mean Monthly Temperature (° C)	Solar Radiation (Sunshine Duaration) (hours)	Wind Speed (km/hr)
JAN	6.73	28.01	6.6	2.960
FEB	17.08	19.03	6.7	3.860
MAR	65.23	29.02	7.0	3.840
APR	102.80	29.06	6.9	3.475
MAY	155.88	28.48	6.1	3.500
JUN	146.30	27.20	4.5	4.075
JUL	40.55	25.91	5.2	3.725
AUG	20.85	25.43	5.5	3.725
SEP	59.60	25.81	6.0	4.500
OCT	75.04	27.43	7.2	4.525
NOV	34.57	28.48	7.7	3.367
DEC	7.03	27.94	7.0	3.030
Total	731.66			
Mean		26.82	6.4	3.715

Population and number of households

'93,1,29
[File:ADA-Pop]

Town Name	Char-acter	Population '90	Population '92	No. of House Holds
1) Main System (Sogakope-Adafoah)		Pop.Growth:3.36 %/y		Pop./House:11.05 /H
Sokpoe		870	929	84
Tefle	*	1,893	2,022	183
Vume		999	1,067	97
Kpotame		800	855	77
kasse	*	3,160	3,376	306
Tamatoku		1,744	1,863	169
Adzomanikope		867	926	84
Bedeku		1,002	1,070	97
Dogo		670	716	65
Togbloku		1,332	1,423	129
BigAda	*	5,143	5,494	497
AdaFoah	D	6,748	7,209	652
Totimekope		1,549	1,655	150
Otorokper		650	694	63
Anyakpor		747	798	72
Pute		2,204	2,355	213
Totope		1,278	1,365	124
Ocansey		1,261	1,347	122
Elavanyo		851	909	82
Alorkpem		628	671	61
Total		34,396	36,746	3,325
2) Sege Branch (Kasseh-Akplabanya)		Pop.Growth:3.64 %/y		Pop./House:11.05 /H
Addo Korpe		955	1,026	93
Amlakpo		865	929	84
Koluedor		3,187	3,423	310
Mantse		1,022	1,098	99
Luhuor		689	740	67
Sege	*	2,422	5,000	452
Boni		874	939	85
Akplabanya		3,434	3,822	346
Anyaman		3,394	3,778	342
Goi		4,149	4,457	403
Lolonya		2,830	3,040	275
Wekmagbe		2,561	2,751	249
Total		26,382	31,002	2,806

3) Sogakope Area (Sogakope city)

Pop.Growth:3.36 %/y   Pop./House:8.19 /H

Sogakope	D	5,206	5,562	679
Agorkpo		648	692	85
Dabala Jct		652	697	85
Dabala		1,538	1,643	201
Adutor		2,744	2,931	358
Total		10,788	11,525	1,407

4) Adidome Branch (Sogakope-Adidome)

Pop.Growth:3.36 %/y   Pop./House:8.19 /H

Fieve		600	641	78
New Bakpa		919	982	120
Adidome	D	4,835	5,165	631
Mafi K,S		2,714	2,899	354
Avakpedome		613	655	80
Mebiawoe		679	725	89
Dofor Adidome		734	784	96
Vome		614	656	80
Total		11,708	12,508	1,527

5) Battor Branch (Kp (Kpotame-Battor間)

Pop.Growth:3.36 %/y   Pop./House:8.19 /H

Adidokpu		1,142	1,220	149
Drakope		959	1,025	125
Bakpakope		679	725	89
Mepe		2,210	2,361	288
Battor	*	1,836	1,961	239
Agbogbla		769	822	100
Volo		901	963	118
Kpompko		815	871	106
Atsiemfo		741	792	97
Kluma Agawu		714	763	93
Torgome		634	677	83
Ngorlikope		615	657	80
Juapong		?	0	0
Total		12,015	12,836	1,567
Grand Ttl.		95,289	104,617	10,633

Note:
D: District Capital
*: Big Commercial Center
 : Rural

CHAPTER 3
OUTLINE OF THE PROJECT

Chapter 3 Outline of the Project

3.1 Purpose of the Project

This project is a part of the District Capitals Electrification Program (DCEP), a high priority project in the National Electrification Program (NEP) of the Government of Ghana. Its purpose is to electrify Ada Foah, Sogakope and Adidome, three unelectrified district capitals in the Great Accra Region and the Volta East Region, and the area along the distribution line route.

By electrification of these capitals the Government of Ghana aims to improve the living standards of the people, activate the industry in the area to financially stabilize the residents and promote people to stay in the area. This will also help to stop the inflow of people to Accra, a big city.

3.2 Study of the Requested Items

3.2.1 Validity and Necessity of the Project

(1) Necessity of the Project

Although Ghana has developed the Volta River for hydro power generation at an early stage and has the ability to generate cheap energy in abundance, and even exports to the neighboring nations. However, only 20% of the country is electrified, because of the incompleteness of its power transmission/distribution network.

The Government of Ghana is recently very eager to solve this problem. The National Electrification Program described in Section 2.1.2 was planned to promote rural electrification. But because of financial reasons it is difficult to execute this program on their own budget, and therefore, is asking other nations and international organizations for assistance to materialize this plan.

High priority is given and efforts are made to electrify all district capitals by 1995, as the first stage of this project. The request from the Government of Ghana, as a part of this project, is to electrify

Ada Foah the only capital that is not electrified in the Great Accra Region and two other district capitals, and the area along the distribution line route.

This project aims to return the superior resource of Ghana to its people to improve the standard of living and to activate the staggering local industry and promote the economical development of the country. Therefore, we have judged that it is highly necessity to realize the project by grant aid.

Rural electrification projects are not very profitable, and if national need and advantages in the long range are not considered, generally, electric companies are negative about taking on such projects.

Considering the current ECG income and expenditure, it will be a great burden on them and it is inevitable that the Government of Ghana for hopes for grant aid to materialize the project.

(2) Study of the Project Range

The validity of the range of this project was studied as follows.

(a) Beneficial Population

Comparing the beneficial population per unit length of distribution line, we try to study an effectiveness or validity of the additional area requestged at the time of preliminary study vs. the original project area including the three district capitals.

The name of the city, town, village and the population of each section of the project area are shown in Fig. 3-4.

The original area and the additional area are compared in the following table.

Original area: Ada Foah, Sogakope, Adidome, Battor
Additional area: Kase-Sege-Akplabanya

Population/km Comparison Chart of Original Area and Additional Area

	Beneficial Population	Line Length	Population/ km	Ratio vs. Original
Original area	64.080	89.3	718	100
Additional area	18,991	30.0	633	88
All area	83,071	119.3	696	97

When we compare the beneficial effect of the additional area, with the population per unit length of distribution line as the criterion, to the original area, the additional area is only 12% lower. Therefore, we consider that it is valid to include the additional area to the project considering the promotion of industry in the area explained in the following section.

(b) Promotion of Industry

The state-operated saltworks (VSPL) currently in operation in Sege and Akplabanya annually produces 50,000 tons of salt and offers employment for over 1500 in the area. The lack of pumps to pump up the saltwater to the reservoirs is holding down the production. It is necessary to increase these pumps, but the power source for these pumps is an old diesel generator (Total capacity 150 kW) that breakdown from time to time. If stable power can be supplied from the distribution line it will be possible to increase the number of pumps. Production increase to 100,000 - 150,000 tons planned by VSPL will become closer to reality.

The promotion of the salt industry in this area as a national project will certainly considerably activate the economy of this area. Electrification is the basis, and from this point also we consider that the area should be included in this project.

Other existing industries which need electricity are, the leather factory in Battor, pottery near Tefle and hotels in Sogakope and Ada Foah. They are small-scale but desire stable power supply.

If the area is electrified many new industries will develop and the economical effect they will bring about on the area is immeasurable.

3.2.2 Implementation and Management

In this project power facilities which will be connected to the existing power system will be constructed. On completion, the special high-voltage (69 kV) facilities will be managed by VRA, and the 33 kV and under facilities will be managed by ECG. The implementation agency of the construction will be the Ministry of Energy, but VRA and ECG will be in charge of the actual works for the above mentioned sections.

The organization chart at the construction stage is shown in Fig. 5-13.

Both VRA and ECG are as described in Section 2.2 large organizations. The existing power facilities they operate are one of the largest in Africa. They both have a large number of employees and are sufficiently able to maintain and manage the facilities which will be built in this project.

(Refer to Fig. 2-5, 2-6 for details of VRA, ECG)

Both VRA and ECG currently have no business office in the area as this area is an unelectrified area. But after the completion of this project VRA will station maintenance engineers to operate and monitor the new Sogakope Substation as with the existing Asiekpe Substation. In the near future, remote monitoring and control will be done from Tema Load Dispatching Office.

It is necessary for ECG to newly set up business offices within the area for collecting electricity charges and such. Some operators and maintenane technicians are slso needed for the distribution feeders at the Sogakope Substation and ECG will study and make concrete plans on how to organize management and operation in the future.

The projected annual maintenance and operation cost for facilities of the project is small comparing their budget for existing facilities owned and is estimated as 4.8 m¢ and 16 m¢ respectively. Both VRA and ECG will be able to include this in their budget with no problem.

The implementation plan of the project will be described in Chapter 5.

3.2.3 Similar Projects and Relations with Assistance Plan by International Organization

This project is a part of the National Electrification Program (NEP). The details of which was described in Section 2.1.2.

This requested project is for the Grater Accra Region and the Volta Region. The Project Number in the NEP is GA01 and VR01. The Government of Ghana has made no duplicated request of assistance to other international organizations concerning this project.

3.2.4 Project Constituents

(1) Validity of System Structure

The requested plan is to connect a 69 kv transmission line to the existing Asiekpe Substation and construct a new substation at Sogakope to transform this down to 33 kv and connect a 33 kv distribution line to each area from here. Refer to Fig. 3-1, 3-2.

The validity of this system structure will be studied on the following three points.

(a) Origin of System

Of the existing system Asiekpe Substation shown in Fig. 3-1 is the closest to the project area. There are no other power reception point which can provide the demanded 15 MVA for this electrification project. Therefore, it is appropriate to start the system from Asiekpe Substation.

(b) Comparison with the plan to substitute 69 kV transmission line with two 33 kV distribution lines

The alternative plan is to substitute the 69 kV transmission line with 33 kV distribution lines by constructing a 69/33 kV substation at Asiekpe and connecting 33 kV distribution lines directly to Asiekpe. A 33 kV switchyard will be constructed at Sogakope. Voltage drop and power loss in this plan were studied as follows.

The calculations are shown in Fig. 4-2 (1) - (6).
Alternative Plan to be Studied:

New 69 kV/33 kV 15 MVA substation will be constructed at the existing Asiekpe Substation.

Two 33 kV secondary transmission lines will be newly installed between Asiekpe and Sogakope.

New 33 kV switchyard will be constructed at Sogakope.

33 kV distribution line beyond Sogakope will be the same as the original plan.

Loads were set to be 4,870 kW (soon after electrification), 6,680 kW (in 5 years), 9,300 kW (in 10 years).

12,200 kw (15 years after electrification. This is for reference only)

The results are as follows:

	Year	Voltage drop (%) Ada Foah	Power loss (%) (Main system only)
Directly after,	1995	6.0	4.2
in 5 years	2000	9.2	6.3
in 10 years	2005	14.2	9.8
in 15 years	2010	20.5	14.6

This plan poses no problem for the load directly after electrification. But in 10 years, the voltage drop at Ada Foah will be over 14% and the power loss reachs about 10% as against the forecasted load, it means some improvements are needed. Furthermore, we can see from the load forecast that in 15 years it will become impossible to supply power.

Compared to this, in the original plan (using 69 kV transmission line), the power loss is 3.7% and the voltage drop is 4.3% at Ada

Foah as against the load forecasted for 2010. The values are good. (Fig. 4-2 (7))

A 69 kV transmission line already exists from Asiekpe Substation to the Ho area in the north. It was built in 1982 and is currently used. Therefore, the construction of a 69 kV lines does not mean introducing a new standard voltage and will pose no problem for operation.

From these studies we have concluded that it is appropriate to use a 69 kV transmission line between Asiekpe - Sogakope in the system as in the original plan.

(c) Selection of distribution line voltage

33 kV distribution line is requested for the distribution system beyond Sogakope Substation.

Although high voltage is generally used in rural electrification where small load areas are distributed in a wide spread area, we have concluded that it is appropriate to use 33 kV for the following reasons.

i) The standard voltage for distribution lines in the National Electrification Program is 33 kV, and it is convenient for maintenance and operation.

ii) 11 kV is an alternative. But Ada Foah and Akplabanya are 40 km from Sogakope and may cause voltage drop and power loss problems even with the load forecast for the near future.

iii) The system must be interconnected with the existing Keta System which is 33 kV.

From the above studies we have judged that the requested system structure is appropriate.

Concluded power system diagram is shown in Fig. 4-1.

(2) Load Forecast for Project Area

(a) Load Forecast Term and Planned Capacity

Load forecast was made up to 2010.

As time of completion of the Project is prospected 1995, 2000 will be 5 years and 2005 will be 10 years after electrification. 2010 is 17 years future from now, so, because of various uncertain elements, the load forecast for 2010 will only be a reference value and will not be used as a basis for facility planning.

The following concept will be adopted in reflecting the load forecast for facility planning.

With upper class systems which are difficult to expand it is necessary to plan them based on a comparatively long- range load forecast. But with lower class systems which can easily be expanded, it is valid to plan the facilities based on a short-range load forecast.

The load forecast for which the facilities will be based on was set at 10 years after electrification (2005) for the key facilities such as transmission line, substation and main distribution line. It was set at 5 years after electrification (2000) for branch lines, distribution transformer and low voltage facilities.

(b) Method of Load Forecast

The load for the project area was forecasted following the method used in the National Electrification Planning Study (NEPS) by Acres International in 1990.

The following conditions were set.

i) District, village name and population:

Those reported in the Acres Report, pages 44, 45, 46 were used. The population was corrected in 1992 using the growth rate of each district.

ii) The various parameters for load forecasting are as in the chart below.

iii) The Market Penetration Parameter directly after electrification (1 year after), 5 years after and 10 years after are each set at 10%, 35% and 75% . NEPS parameters were used as reference.

iv) The load increase rate after electrification was set uniformly at 3.5%.

Basic Data for Load Forecast

Load Consumption and Market Penetration Parameters

	Consumption per household (kWh/yr)	Nonresidential consumption per household (%)
Rural	920	27
Commercial Center	1250	32
District Capital	1540	32

v) The followings were considered as point loads

District Capitals	50 kW
Hospital at Battor	36 kW
VSPL	300 kW

vi) On load for Keta system, as ECG wishes to cut receiving power from Aflao but continue it for only emergency use, all the power for Keta system will be supplied from new system planned in this project.
(Max. peak demand sent from Aflao: 3,228 MW, Oct. 1991)

vii) Pute, Lolonya and Legupoguno etc. which were not included in this project are included in the load forecast on the assumption that they will be electrified in 5-10 years.

Load forecast calculation data is shown in Fig. 4-13.

(c) Summary of Load Forecast Results

Load Forecast Results Summary (kw)

	1995	2000	2005	(2010)
Project area	1,210	2,340	4,140	6,070
Aflao system	3,660	4,340	5,160	6,130
Total	4,870	6,680	9,300	12,200

(3) Installed Capacity

(a) Main transformer capacity at Sogakope Substation

The main transformer capacity at Sogakope Substation is set at 15,000 kVA, based on the before described load forecast and the following reasons.

The total load forecast at 2005 is 9,300 kW. Assuming the power factor at 80% and diversity factor at 0.9, the needed transformer capacity is estimated to be 10,500 kVA.

Therefore, in 2005, the required transformer capacity will exceed 10,000 kVA. Furthermore, in 2010, it is supposed to need a capacity of 13,700 kVA if same assumption be adopted. It is nature to avoid such a plan as some expansion work at fundamental facility shall be needed in only 10 years after completion.

Accordingly, capacity of main transformer should be 15 MVA, taking into consideration the situation of load demand in 15 years.

(b) Capacity of various facilities in the project

The facilities will be built for the first time in the unelectrified area. Therefore, the lower class system (especially pole-mounted transformers) should be built to handle the load forecasted for 1995-2000. It is appropriate to plan the project to meet the needs for the first five years after electrification, and then study the load trends and add facilities as needed.

As for the 33 kV main system and the 69 kV upper class system, it is necessary to build them to meet the longer-range load forecast. Expanding these systems is difficult and expensive, and prior investment must be made. These should be built to meet the load forecast for 2005-2010.

3.2.5 Facility and Equipment

(1) Substation Plan

(a) Expansion of Asiekpe Substation

A 69 kV existing transmission line has been connected Asiekpe Substation to the existing Ho Substation (Capacity 7 MVA). This project resembles this, and considering operation convenience, it was decided to build a series of 69 kV switchgears with the same arrangement as the transmission outlet for Ho Substation.

A method for connection to new 69 kV transmission line by using 69 kV power cable was considered in order to avoid some difficulties on selection of transmission line route, but taking into consideration the fault of cable though very rare and the fact it may follow very long outage in Ghana, it is decided to adopt overhead line connection as same as Ho line. Therefore, transmission line route will be settled to make a detour around substation site and new lines will pass through under the 161 kV existing lines.

(b) Construction of new Sogakope Substation

One 69 kV transmission circuit line will be connected, one 69/33 kV 15 MVA transformer will be installed and 33 kV distribution line will be connected to the 33 kV bus.

Four 33 kV distribution circuit lines will be connected. One for Ada Foah, one for Adidome, one interconnection line for the Keta System including the line to supply Sogakope City and one reserve line.

This substation is similar to the existing Ho Substation managed by VRA and the specifications will basically resemble that of Ho Substation.

The substation is divided in to sections controlled by VRA and ECG.

A 33 kV disconnector will be installed at the border to clarify the maintenance and operation division. A precision watt-hour & demand meter will be installed for wholesale of power from VRA to ECG.

The 33 kV distribution line outlet breakers will be GCB with automatic reclosing devices.

Control and protection relay panels will be housed indoors.

The transformer capacity will be studied in former section.

(2) Transmission Line Plan

The new 69 kV transmission line will resemble the existing transmission line to Ho Substation and the engineering standards will follow its specifications, in principle.

The structures will be lattice type self-support towers, one circuit, 185 mm^2 AAAC wires will be used. The standard span will be 300 m with overhead earth wire.

Towers to be used in the place nearby Asiekpe substation are of special structure in order to pass through under the existing 161 kV line.

(3) Distribution Line Plan

The main distribution line will all be 33 kV, 3-phase, with neutral earthing, and will be installed to the end of the electrification area. But single phase circuit will be used for small villages such as New Bakpa and Dogo where there is no need for extension in the future.

For Mepe, Battor branch line and Sege branch line, a section switch will be installed at where they branch off from the main line for operational convenience.

Local wood poles will be used as supports following the wishes of the Government of Ghana.

(4) Crossing the Volta River

The power cable will be laid on the Lower Volta Bridge to cross the Volta River because the on-site survey showed that a satisfactory installation space can be secured on the bridge. Aerial crossing by constructing long span towers was considered, but the on-site survey showed that there was no satisfactory crossing point under 1000 m, and this plan was eliminated.

33 kV CV cable of 8 cm outer diameter will be installed in the 12 cm wide space outside along the outer rail of the bridge.

The cable transmission capacity will be about 8000 kVA considering the load forecast for 2010 4500 kW, the additional load demanded by the saltworks and capacity decrease caused by sunshine.

In the preliminary survey, interference with the bridge rehabilitation works was under concern. But in this plan the cable will be installed on the upper part of the bridge and the works will not in reality interfere with each other. Therefore, it is not necessary to adjust the work schedules.

(5) Distribution substation (pole-mounted transformer)

A provisional transformer layout plan that was discussed and planned with ECG at the on-site survey is shown in Fig. 4-4. But it is necessary to correct it to meet the load forecast of each town area described in the previous section.

The transformer capacity of the following 5 locations differ greatly compared to the load forecast.

Tefle (large), Kase (large), Sogakope (small), Sege (small), Akplabanya (small), Anyaman (small)

From the results of the on-site survey and the future development possibility as district capitals, the provisional layout plan was partially corrected. The corrected transformer layout plan is also shown in Fig. 4-4.

A big difference remains at Sege. This is because the forecasted load (300 kw, final) for VSPL (salt manufacturing factory) is included in the load forecast, but in the transformer plan VSPL is not included on the presumption that VSPL would provide their own transformer.

Summary of Distribution Transformer Plan

Load Forecast (at 2000)				Transformer Plan		
				Number of transformers		Total capacity
Total kW	for VSPL kW	Load kW	Needed capacity kVA	50 kVA unit	100 kVA unit	 kVA
2338	204	2134	2510	33	9	2550

(6) Material and equipment for low voltage distribution line

Material and equipment for low voltage main and branch distribution lines which must be bought with foreign currency will be supplied. Service lines to customers will not be supplied.

Quantity and items will be as follows based on the previous project (1989) record.

(a) The entire main distribution line will be 3-phase 4-line, and the length will be each 1 km in both directions per transformer with 50 kVA transformers, and 1.5 km with 100 kVA transformers.

(b) The branch distribution line will be single phase, and average 700 m per transformer. 5 systems with 50 kVA and 8 systems with 100 kVA.

(c) Low voltage insulated wire will be used.

(d) Insulator and hardware for the distance of the line (above mentioned) will be supplied.

(e) Wood poles will not be supplied.

(f) Watt-hour meter to meet the number of customers forecasted for three years after the commissioning of the main line will be provided.

Single-phase ... 3000, 3-phase ... 30

(7) Supply of Construction Vehicle, Tools

(a) Vehicles

Vehicle types and quantity needed for future maintenance will be supplied in principle. These will be used by the power companies for supervising construction during the construction period. They may also be used by the contractors if using them will not obstruct the construction under way by the power companies.

Stringing vehicles, construction machines and special transport vehicles which are needed for construction only are not included.

Types and quantities other than supplied needed to improve construction efficiency will be provided by the contractors.

The details of the type and quantity of vehicles to be supplied, set following the previous project report, will be described in Chapter 4.

(b) Tools

General tools and a set measuring instruments needed for this project will be supplied to assure future maintenance.

After the major construction is completed, distribution and service lines will be extended by ECG every time a new customer applies for service. Therefore, these tools and measuring instruments will be kept/maintenanced at the local ECG maintenance office or business office.

The details of the tools and measuring instruments are described in Chapter 4.

3.2.6 Necessity of Technical Cooperation

Both VRA and ECG are sufficiently able to maintain and operate the facilities in general.

However, as both VRA and ECG are not used to maintain Japan made equipment, training for maintenance technique of gas circuit breakers is supposed to be necessary that is of some difficult comparing general other equipment for successful operation and maintenance of them. Both VRA/ECG expect Japanese Government to accept some engineers to get such training in Japan. (refer to Minutes of discussion dated 15 March, 1993, Annex-2)

3.2.7 Basic Principle in Providing Cooperation

From the studies conducted, the effects and realization method of the project, and the implementation ability of Ghana side were confirmed.

The effects which the project will produce agrees with the principle of Japanese grant aid system and therefore, it is appropriate to implement this project through grant aid by Japan.

3.3 Project Outline

(1) Implementation Agency and Management System

The implementation system in Ghana is as follows:

Implementation agency: Ministry of Energy
69 kV facilities: Volta River Authority
33 kV and low voltage facilities: Electricity Corporation of Ghana

(2) Purpose

Electrification of three district capitals (Ada Foah, Sogakope, Adidome) and the nearby towns in the Greater Accra Region and Volta Region as part of the National Electrification Program which the Government of Ghana aims to materialize as soon as possible.

Project name: "The Project for Electrification of Lower Volta Area"

(3) Location and Condition of the Project Area

The area is a flat savanna delta area of the Volta River located in the southeast part of Ghana.

The area is along National Highway Route 1, which is paved for the most part. Wide branch roads are available for easy access to all parts of the project area.

Where the power cable crosses the Volta River, there is a 2-lane concrete bridge. The distribution line will be laid on the bridge to cross the river.

(4) Facility, Equipment and Material Outline

(a) New 69 kv switch facility at existing Asiekpe Substation

Switch and accessory equipment to connect 69 kV transmission line to Asiekpe Substation (owned by VRA) will be newly installed.

(b) New 69 kV transmission line

69 kV steel tower transmission line between Asiekpe and Sogakope Substations will be newly constructed.

Distance: about 40 km,
Number of circuit line: 1

(c) New Sogakope Substation

A substation to transform the voltage from 69 kV down to 33 kV will be built at Sogakope, the load center of the project area.

Transformer capacity 15 MVA, 1 unit, four outlet of 33 kV distribution lines.

(d) New 33 kV distribution lines

Each 1 distribution line for Adidome, Ada Foah (main line), Sogakope City and Keta interconnection line will be connected to Sogakope Substation.

Aerial Distribution Line

Support: Wood pole, Conductor: 100 mm 2 Aluminum line

Ada Foah main line	Sogakope - Ada Foah	43 km
Battor branch line	Kpotame - Battor	21 km
Sege branch line	Kassah - Sege - Akplabanya	40 km
Adidome line		25 km
Sogakope - Keta interconnection line		2 km

Power Cable laid on bridge

33 kV power cable will be laid on the Sogakope Bridge to cross the Volta River.

Conductor: 70 mm^2 3-core crosslinked polyethylene armored Cable, Length: about 1.0 km

(e) New distribution substation

50 kVA and 100 kVA pole mounted transformers and protective switchgear will be installed on 33 kV distribution lines as distribution substations. Low voltage lines will be connected to these.

Number of Transformers: 50 kVA - 33 units
100 kVA - 9 units
Voltage : 33 kV/415, 240 v

(f) Low voltage equipment and material supply

Low voltage insulation wire, insulators and line hardware for the total distance 174 km of low voltage main and branch lines, and total 3,030 watt-hour meters will be supplied.

Actual construction will be done by ECG and Japan will not participate.

(g) Vehicle, tool supply

Appropriate number of vehicles and tools needed to supervise the construction, for the actual construction done directly by the electric companies, and those necessary for maintenance after completion will be calculated and supplied.

These will be delivered before the main works starts and will be available for use by the contractors of the main works.

(5) Maintenance Plan

After completion, the 69 kV facilities will be maintained by VRA and the 33 kV and under facilities by ECG. Both firms already own and operate large-scale power facilities. They are fully experienced and there is no problem in their ability to maintaine the facilities built in this project.

After completion, maintenance, operation and sales are required to service the newly electrified area. Of these new duties, maintenance and operation can be dealt with the present organization. Therefore, what is newly needed is for VRA to station a few operater for the new transmission lines and substations, and ECG needs to increase some technicians for maintenance and operation of distribution system and to open business offices to collect electricity charges and as the reception office for receiving applications of new customers.

The projected annual expenses needed to station new personnel and opening business offices will be about 4.8 million ¢ (Approx. 1.2 million yen) for VRA and about 16 million ¢ (approx. 4 million yen) for ECG. Therefore, both VRA and ECG must fully study the work necessary after commissioning and include it in their budget.

3.4 Technical Cooperation

It is appropriate that the content of technical cooperation described in 3.2.6 would be as follows:

1) Kind of training : Receiving trainees in Japan
2) Kind of trainees : Electrical engineers
3) Number of trainees : 2
4) Period : 1.5 months
5) Timing : In the later half of 1994

6) Contents of training:

Learning the maintenance technique on gas-circuit breakers in suitable manufacturer's factories.

- Knowledges on the structure of the equipment, method of assembling and dismantling.
- Method and technique on periodical inspection of the equipment

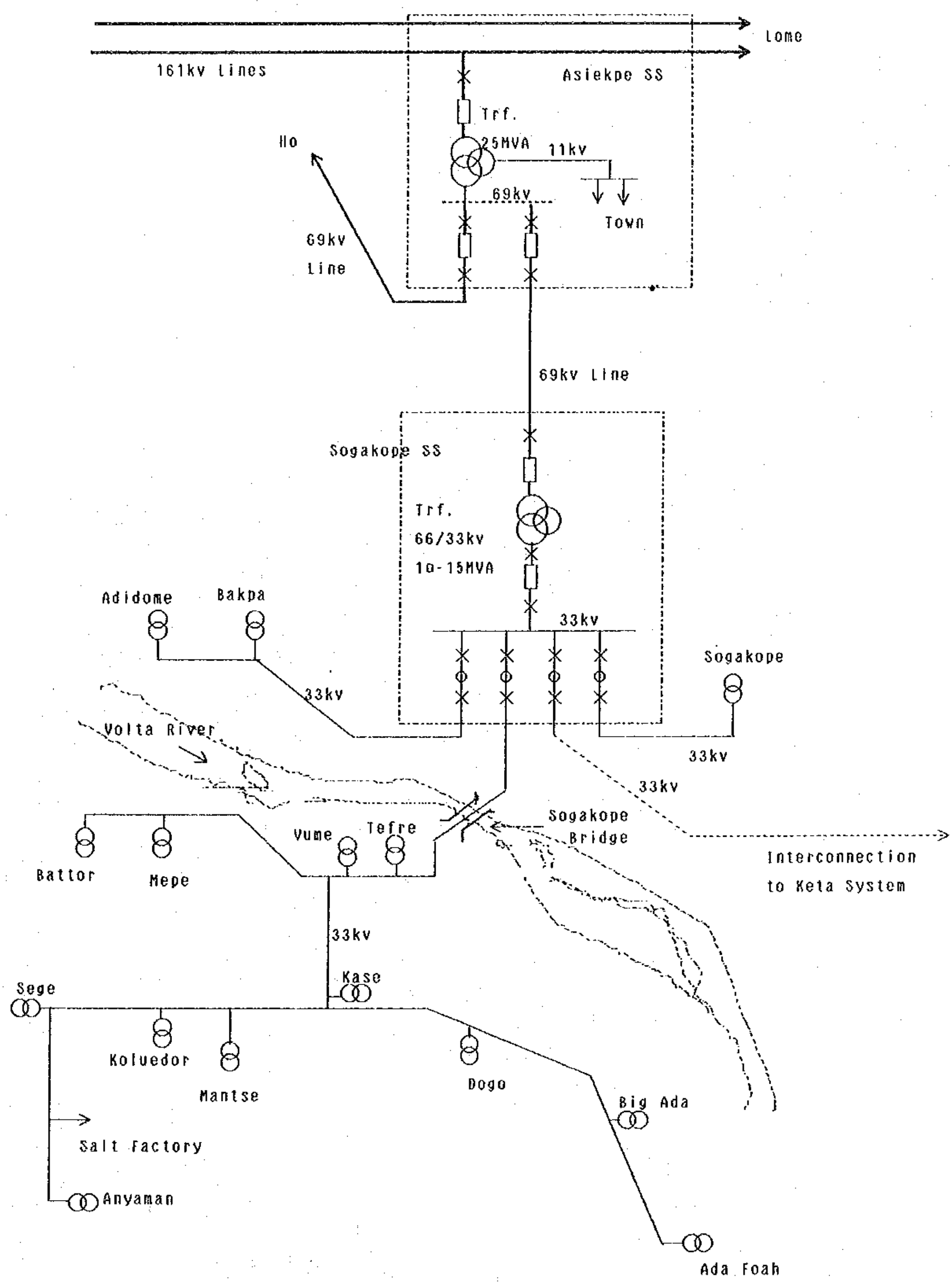

Fig. 4-1
Electrification Proj. in Lower Volta Area
Apr.,11,1993

Fig.4-2(1)

Calculation of voltage drop & losses in case of 33kv 2cct. out-going.

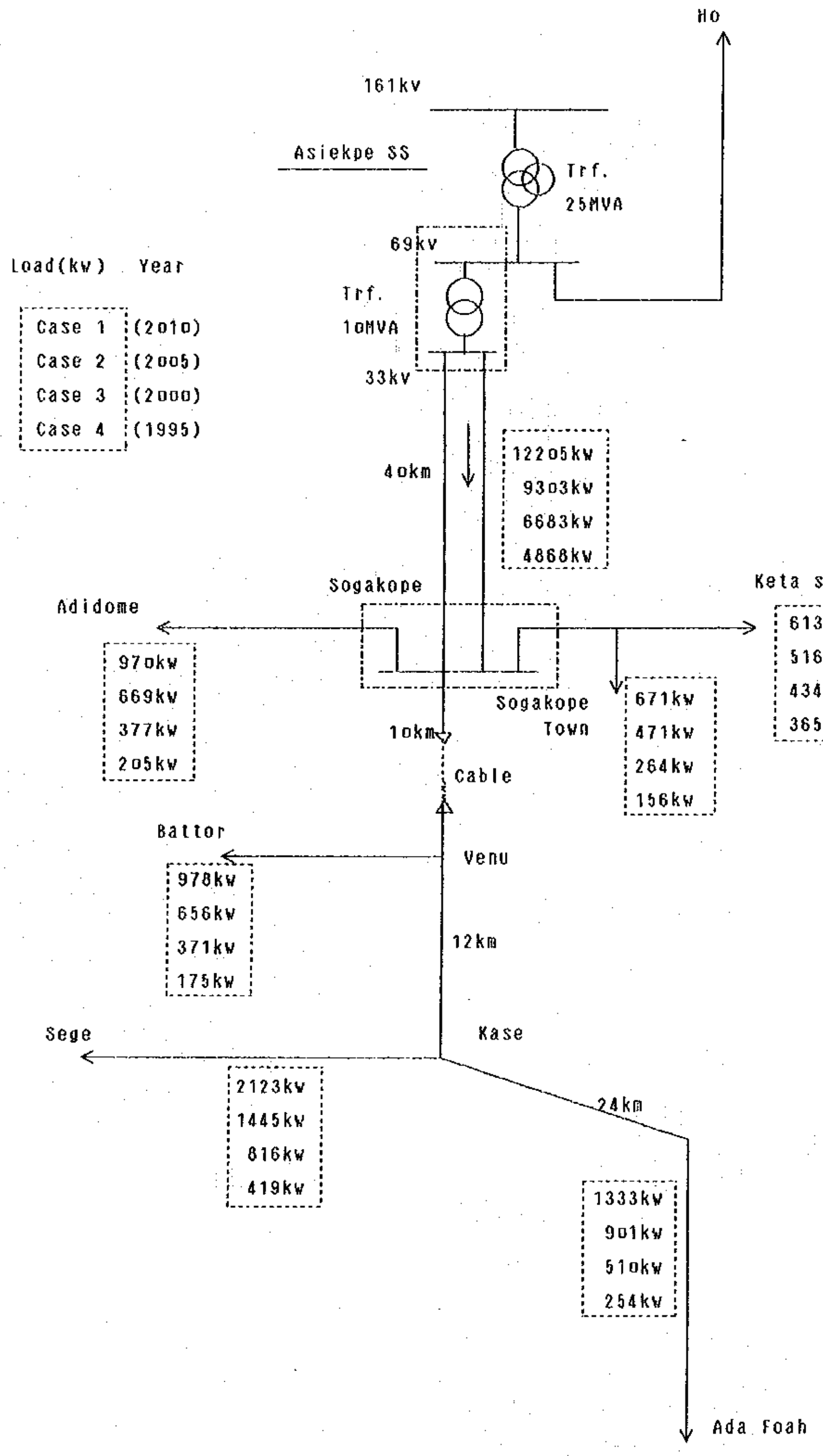

Fig.4-2(2)

'93,3,22
F:ADA-Lr

Power Flow by Branch Points

Branch Point	Direction	Power Flow (KW) (1995) 0	(2000) 5	(2005) 10	(2010) 15
At Sogakope					
	To Adidome	205	377	669	970
	[Interlink:	100% of Aflao		Growth 3.5 %/y]	
	* To Interlink	3659	4345	5161	6130
	To City	156	264	471	671
	S.Ttl.	4020	4986	6301	7771
Main Line					
From Kpotame					
	To Tef,Vume	55	94	168	239
	To Battor	120	277	488	739
	S.Ttl.	175	371	656	978
From Kase					
	To Kase & Vcini	84	142	253	360
	To Sege, Akpl.	335	674	1192	1763
	S.Ttl.	419	816	1445	2123
From Kase to AdaFoah					
	Ada & vicini	254	431	767	1094
	Others	0	79	134	239
	S.Ttl.	254	510	901	1333
Grand Total		4868	6683	9303	12205

Note:
* Assumption on Peak Load for Interlink
Max.Past peak load from Aflao: 3300 kw (1992 Oct.)
Load to be supplied from Sogakope:
100% of total Keta System
Load growth of Keta system: 3.5%

Calculation of V.Drop & Loss in Ada Foah Sys.

'93,3,23
F:Ada-Vr

Case 1 Ttl. Load: 12.2 MW

Premises

System: Asiekpe-Sogakope 33 kv 2 cct.
All Others 33 kv 1 cct.

Wires: 100mm2 ACSR
Distance btw. each wire:
Dab: 1.5 Dbc: 0.9 Dca: 2.4 [m]
D mean = (Dab*Dbc*Dca)^1/3 = 1.47 [m]
Wire dia d: 16.5 [mm]
Induct.L' = 0.4605*log(D/r)+0.05 mH/km /cct.
= 1.087 [mH/km] = 0.34 [Ω/km](per phase)
Resis.:R' = 0.33 [Ω/km](per phase) /cct.
V. drop:(2π f*L*sinφ+R*cosφ)I [kv] per phase

Load:	kw	pf		Km
Ada	1333	0.85	Ka-Ad	24
Kas	2123	0.85	Ve-Ka	12
Ven	978	0.85	So-Ve	10
Sog	7771	0.85	As-So	40
Asi	12205		Total	86

(Abbreviation):
Load':total load upto pt.
l:line length
Il:Load curr.
It:total curr.
Vdx:reac.drop=I*X*sinφ
Vdr:resis.drop=I*R*cosφ

cct Pt.	Load kw	Load' kw	E kv	Pf	Il A	It A	l km	Vdx kv	Vdr kv	Drop kv	Loss kw	Loss' kw
								(per phase)				
Ada	1333	1333	27.8	0.85	32.5	32.5	24	0.14	0.21	0.35	8.40	8.40
Kas	2123	3456	28.4	0.84	50.7	83.3	12	0.18	0.27	0.46	27.4	35.8
Ven	978	4434	29.2	0.84	22.7	106.	10	0.19	0.29	0.48	37.1	72.9
2 Sog	7771	6103	30.0	0.84	87.7	140.	40	1.03	1.56	2.60	523.	596.
Asi	0	12205	34.5	0.82	0	140.				3.91		596.

Case 1
Results: at Asiekpe 14.0 MW, 16.8 MVA

E at Asi 34.5 kv Voltage drop: 6.77 kv (20.5 %)
E at Ada 27.8 kv Line loss: 1788 kw (14.6 %)

Calculation of V.Drop & Losses for Ada Foah Sys. '93,3,23
F:Ada-Vr

Case 2 Ttl. Load: 9.30 MW

Premises
System: Asiekpe-Sogakope 33 kv 2 cct.
All Others 33 kv 1 cct.

Wires: 100mm2 ACSR
Distance btw. each wire:
Dab: 1.5 Dbc: 0.9 Dca: 2.4 [m]
D mean = (Dab*Dbc*Dca)^1/3 = 1.47 [m]
Wire dia d: 16.5 [mm]
Induct.L' = 0.4605*log(D/r)+0.05 mH/km /cct.
= 1.087 [mH/km] = 0.34 [Ω/km](per phase)
Resis.:R' = 0.33 [Ω/km](per phase) /cct.
V. drop:(2π f*L*sinφ +R*cosφ)I [kv] per phase

Load:	kw	pf		Km
Ada	901	0.85	Ka-Ad	24
Kas	1445	0.85	Ve-Ka	12
Ven	656	0.85	So-Ve	10
Sog	6301	0.85	As-So	40
Asi	9303		Total	86

(Abbreviation):
Load':total load upto pt.
l:line length
Il:Load curr.
It:total curr.
Vdx:reac.drop=I*X*sinφ
Vdr:resis.drop=I*R*cosφ

cct	Pt.	Load kw	Load' kw	E kv	Pf	Il A	It A	l km	Vdx kv	Vdr kv	Drop kv	Loss kw	Loss' kw
									(per phase)				
	Ada	901	901	29.9	0.85	20.4	20.4	24	0.08	0.13	0.22	3.31	3.31
	Kas	1445	2346	30.2	0.84	32.4	52.8	12	0.11	0.17	0.29	11.0	14.3
	Ven	656	3002	30.7	0.84	14.4	67.3	10	0.12	0.18	0.31	14.9	29.3
2	Sog	6301	4651.	31.3	0.84	68.2	101.	40	0.74	1.13	1.88	274.	303.
	Asi	0	9303	34.5	0.83	0	101.				2.71		303.

Case 2
Results: at Asiekpe 10.2 MW, 12.2 MVA

E at Asi 34.5 kv Voltage drop: 4.69 kv (14.2 %)
E at Ada 29.9 kv Line loss: 911. kw (9.79 %)

Calculation of V.Drop & Losses for Ada Foah Sys.

'93,3,23
F:Ada-Vr

Case 3 Ttl. Load: 6.68 MW

Premises

System:	Asiekpe-Sogakope	33 kv	2 cct.
	All Others	33 kv	1 cct.

Wires: 100mm2 ACSR
Distance btw. each wire:
Dab: 1.5 Dbc: 0.9 Dca: 2.4 [m]
D mean (Dab*Dbc*Dca)^1/3 = 1.47 [m]
Wire dia d: 16.5 [mm]
Induct.L' = 0.4605*log(D/r)+0.05 mH/km /cct.
= 1.087 [mH/km] = 0.34 [Ω/km](per phase)
Resis.:R' = 0.33 [Ω/km](per phase) /cct.
V. drop:(2π f*L*sinφ +R*cosφ)I [kv] per phase

Load:	kw	pf		Km
Ada	510	0.85	Ka-Ad	24
Kas	816	0.85	Ve-Ka	12
Ven	371	0.85	So-Ve	10
Sog	4986	0.85	As-So	40
Asi	6683		Total	86

(Abbreviation):
Load':total load upto pt.
l:line length
Il:Load curr.
It:total curr.
Vdx:reac.drop=I*X*sinφ
Vdr:resis.drop=I*R*cosφ

cct	Pt.	Load kw	Load' kw	E kv	Pf	Il A	It A	l km	Vdx kv	Vdr kv	Drop kv	Loss kw	Loss' kw
									(per phase)				
	Ada	510	510	31.5	0.85	10.9	10.9	24	0.04	0.07	0.12	0.95	0.95
	Kas	816	1326	31.7	0.84	17.4	28.4	12	0.06	0.09	0.15	3.21	4.16
	Ven	371	1697	32.0	0.84	7.87	36.3	10	0.06	0.10	0.16	4.36	8.53
2	Sog	4986	3341.	32.2	0.84	52.4	70.6	40	0.51	0.79	1.30	131.	140.
	Asi	0	6683	34.5	0.84	0	70.6				1.74		140.

Case 3
Results: at Asiekpe 7.1 MW, 8.45 MVA

E at Asi	34.5 kv	Voltage drop:	3.02 kv	(9.18 %)
E at Ada	31.5 kv	Line loss:	420. kw	(6.29 %)

Calculation of V.Drop & Losses for Ada Foah Sys. '93,3,23
F:Ada-Vr

Case 4 Ttl. Load: 3.40 MW

Premises
System: Asiekpe-Sogakope 33 kv 2 cct.
All Others 33 kv 1 cct.

Wires: 100mm2 ACSR
Distance btw. each wire:
Dab: 1.5 Dbc: 0.9 Dca: 2.4 [m]
D mean = (Dab*Dbc*Dca)^1/3 = 1.47 [m]
Wire dia d: 16.5 [mm]
Induct.L' = 0.4605*log(D/r)+0.05 mH/km /cct.
= 1.087 [mH/km] = 0.34 [Ω/km](per phase)
Resis.:R' = 0.33 [Ω/km](per phase) /cct.
V. drop:(2π f*L*sinφ+R*cosφ)I [kv] per phase

Load:	kw	pf		Km
Ada	254	0.85	Ka-Ad	24
Kas	419	0.85	Ve-Ka	12
Ven	175	0.85	So-Ve	10
Sog	2561	0.85	As-So	40
Asi	3409		Total	86

(Abbreviation):
Load':total load upto pt.
l:line length
Il:Load curr.
It:total curr.
Vdx:reac.drop=I*X*sinφ
Vdr:resis.drop=I*R*cosφ

cct	Pt.	Load kw	Load' kw	E kv	Pf	Il A	It A	l km	Vdx kv	Vdr kv	Drop kv	Loss kw	Loss' kw
										(per phase)			
	Ada	254	254	32.6	0.85	5.29	5.29	24	0.02	0.03	0.05	0.22	0.22
	Kas	419	673	32.7	0.84	8.70	13.9	12	0.03	0.04	0.07	0.77	0.99
	Ven	175	848	32.8	0.84	3.62	17.6	10	0.03	0.04	0.08	1.02	2.02
2	Sog	4020	2434	32.9	0.84	41.4	50.2	40	0.36	0.56	0.92	66.5	68.5
	Asi	0	4868	34.5	0.84	0	50.2				1.14		68.5

Case 4
Results: at Asiekpe 5.1 MW, 6.01 MVA

E at Asi 34.5 kv Voltage drop: 1.97 kv (5.99 %)
E at Ada 32.6 kv Line loss: 205. kw (4.22 %)

Fig.4-2(7)

Calculation of V.Drop & Loss for Ada Foah Sys. '93,3,23
Case of 69kv Sys. for Asi-Sog F:Ada-V69r

Premises: Asi-Sog: 69kv,1cct. Ttl. Load:12.2 MW
Others: 33kv 1cct.

	-33kv Line-	-69kv Line-
Wires:	ACSR 100mm2	ACSR 185mm2
Distance btw. wires:		
Dab,Dbc,Dac:	1.5 0.9 2.4 [m]	2.7 5.4 5.5 [m]
D mean (Dab*Dbc*Dca)^1/3	1.47 [m]	4.31 [m]
Wire dia d:	16.5 [mm]	20 [mm]

Induct.L' = 0.4605*log(D/r)+0.05 mH/km /cct.
= 1.087 [mH/km] = 0.34 [Ω/km] 1.26 mH/km0.39 Ω/km
Resis.:R' = 0.33 [Ω/km](per phase) /cct. 0.16 "
V. drop:(2π f*L*sinφ +R*cosφ)I [kv] (per phase)

Load:	kw	pf		Km	E
Ada	1333	0.85	Ka-Ad	24	33
Kas	2123	0.85	Ve-Ka	12	33
Ven	978	0.85	So-Ve	10	33
Sog	7771	0.85	As-So	40	69
Asi	12205		Total	86	

(Abbreviation):
Load':total load upto pt.
l:line length
Il:Load curr.
It:total curr.
Vdx:reac.drop=I*X*sinφ
Vdr:resis.drop=I*R*cosφ

Pt.	Load kw	Load' kw	E kv	Pf	Il A	It A	l km	Vdx kv	Vdr kv	Drop kv	Loss kw	TLoss kw
								(per phase)				
Ada	1333	1333	32.6	0.85	27.7	27.7	24	0.12	0.18	0.30	6.10	6.10
Kas	2123	3456	33.1	0.84	43.5	71.2	12	0.15	0.23	0.39	20.1	26.2
Ven	978	4434	33.8	0.84	19.6	90.9	10	0.16	0.25	0.41	27.2	53.5
Sog	7771	12205	34.5									
Sog(1ry)			33.0	0.84	76.4	122.	40	1.03	0.65	1.69	95.2	148.
Asi	0	12205	71.9	0.83	0	122.	Vd(Asi-Sog):		1.69			148.
							Vd(Sog-Ada):		1.12			

Results:

at Asiekpe 12.7 MW, 15.2 MVA

E at Asi	71.9 kv	V.drop Ada-Sog:	1.94 kv	(2.81 %)
E at Ada	32.6 kv	V.drop Asi-Sog:	2.93 kv	(4.25 %)
		Line loss:	446. kw	(3.65 %)

Conclusion of Load Forecast

93,3,22
[File:ADA-L]

Poulation Growth Rate :	3.5 %	Population	Factor
Initial Penetration :	35	1995	1.15
5 yr Penetration :	50	2000	1.36
10 yr Penetration :	75	2005	1.62
15 yr Penetration :	90	2010	1.92

Area Name	Ultimate Load('92) (KW)	Forecasted Load (KW) (1995) 0	(2000) 5	(2005) 10	(2010) 15
1) Main Line					
Vume,Tef.	138	55	94	168	239
Kase	208	84	142	253	360
AdaFoah	632	254	431	767	1094
Pute	93		37	63	113
Others	104		42	71	126
S.Ttl	1175	393	746	1322	1931
2) Sege Branch					
K-Sege	156	63	106	189	270
S-Akpl	677	272	461	822	1171
Others	265		106	181	322
S.Ttl	1098	335	674	1192	1763
3) Sogakope					
Sogak	388	156	264	471	671
Others	0				
S.Ttl	388	156	264	471	671
4) Adidome Branch					
Adidome	511	205	348	620	884
Others	71		29	48	86
S.Ttl	582	205	377	669	970
5) Battor Branch					
Battor	300	120	204	364	519
Others	181		73	123	220
S.Ttl	481	120	277	488	739
Total	3724	1209	2338	4141	6075

	1992	1995	2000	2005	(2010)
Keta system	3300	3659	4345	5161	6130

Grand Total		4868	6683	9302	12205

Fig.4-3(2)

Load Forecast Calculation '93,4,14 [File:ADA-T']

	Population '90	Population '92	House Holds	Domes. Engy Mwh	Comm. Engy Mwh	Total Engy Mwh	Peak Demd. Kw	Point Load kw	Ttl. Demand kw
1) Main Line (Sogakope-Adafoah)		R:3.36%	11.05/H						
Sokpoe	870	929	84	77	21	98	22	0	22
* Tefle	1,893	2,022	183	229	73	302	69	0	69
Vume	999	1,067	97	89	24	113	26	0	26
Kpotame	800	855	77	71	19	90	21	0	21
* kasse	3,160	3,376	306	382	122	504	115	0	115
Tamatoku	1,744	1,863	169	155	42	197	45	0	45
Adzomanikop	867	926	84	77	21	98	22	0	22
Bedeku	1,002	1,070	97	89	24	113	26	0	26
Dogo	670	716	65	60	16	76	17	0	17
Togbloku	1,332	1,423	129	118	32	150	34	0	34
* BigAda	5,143	5,494	497	622	199	820	187	0	187
D AdaFoah	6,748	7,209	652	1005	322	1326	303	50	353
Totimekope	1,549	1,655	150	138	37	175	40	0	40
Otorokper	650	694	63	58	16	73	17	0	17
Anyakpor	747	798	72	66	18	84	19	0	19
Pute	2,204	2,355	213	196	53	249	57	0	57
Totope	1,278	1,365	124	114	31	144	33	0	33
Ocansey	1,261	1,347	122	112	30	142	33	0	33
Elavanyo	851	909	82	76	20	96	22	0	22
Alorkpem	628	671	61	56	15	71	16	0	16
Total	34,396	36,746	3,325	3,789	1,135	4,924	1,124	50	1,174
		Demand kw --		865	259	1,124			
2) Sege Branch (Kasseh-Akplabanya)		R:3.64%	11.05/H						
Addo Korpe	955	1,026	93	85	23	108	25	0	25
Amlakpo	865	929	84	77	21	98	22	0	22
Koluedor	3,187	3,423	310	285	77	362	83	0	83
Mantse	1,022	1,098	99	91	25	116	27	0	27
Luhuor	689	740	67	62	17	78	18	0	18
* Sege	2,422	5,000	452	566	181	747	170	300	470
Boni	874	939	85	78	21	99	23	0	23
Akplabanya	3,434	3,822	346	318	86	404	92	0	92
Anyaman	3,394	3,778	342	315	85	399	91	0	91
Goi	4,149	4,457	403	371	100	471	108	0	108
Lolonya	2,830	3,040	275	253	68	321	73	0	73
Wekmagbe	2,561	2,751	249	229	62	291	66	0	66
Total	26,382	31,002	2,806	2730	766	3496	798	300	1,098
		Demand kw --		623	175	798			

3) Sogakope (Keta system interlinkage)

R:3.36% 8.19/H

D	Sogakope	5,206	5,562	679	1046	335	1380	315	50	365
	Agorkpo	648	692	85	78	21	99	23	0	23
	Dabala Jct	652	697	85						
	Dabala	1,538	1,643	201						
	Adutor	2,744	2,931	358						
	Total	10,788	11,525	1,407	1,124	356	1,479	338	50	388
			Demand kw	--	257	81	338			

4) Adidome Branch (Sogakope-Adidome)

R:3.36 8.19/H

	Fieve	600	641	78	72	19	91	21	0	21
	New Bakpa	919	982	120	110	30	140	32	0	32
D	Adidome	4,835	5,165	631	971	311	1282	293	50	343
	Mafi K,S	2,714	2,899	354	326	88	414	94	0	94
	Avakpedome	613	655	80	74	20	93	21	0	21
	Mebiawoe	679	725	89	81	22	103	24	0	24
	Dofor Adido	734	784	96	88	24	112	26	0	26
	Vome	614	656	80	74	20	94	21	0	21
	Total	11,708	12,508	1,527	1,796	534	2,330	532	50	582
			Demand kw	--	410	122	532			

5) Battor Branch (Kpotame-Battor)

R:3.36 8.19/H

	Adidokpu	1,142	1,220	149	137	37	174	40	0	40
	Drakope	959	1,025	125	115	31	146	33	0	33
	Bakpakope	679	725	89	81	22	103	24	0	24
	Mepe	2,210	2,361	288	265	72	337	77	0	77
*	Battor	1,836	1,961	239	299	96	395	90	36	126
	Agbogbla	769	822	100	92	25	117	27	0	27
	Volo	901	963	118	108	29	137	31	0	31
	Kpompko	815	871	106	98	26	124	28	0	28
	Atsiemfo	741	792	97	89	24	113	26	0	26
	Kluma Agawu	714	763	93	86	23	109	25	0	25
	Torgome	634	677	83	76	21	97	22	0	22
	Ngorlikope	615	657	80	74	20	94	21	0	21
	Juapong	?	0	0						
	Total	12,015	12,836	1,567	1,521	426	1,947	444	36	480
			Demand kw	--	347	97	444			
	Grand Ttl.	95,289	104,617	10,633	24.42 Gwh	7.16 Gwh	31.59 Gwh	6.47 MW	0.97 MW	3,722

Note: Consumption Parameters	Domes.Cons. kwh/HH/y	Nonresident %
D: District Capital	1540	32
*: Big Commercial Center	1250	32
: Rural	920	27

Fig. 4-4

'93, 1, 19
File:ADA-T

<u>Distribution Substation</u>

Town Name	Prio rity	Load Ultim.	Area Load kW	Trf. Plan 1 Tentative 50 (units)	100 (units)	Ttl. kVA	Area Capa. kVA	Trf. Plan 2 Revise 50 (units)	100 (units)	Ttl. kVA	Area capa. KVA
1) Main Line (Sogakope-Adafoah)											
Tefle area			138				300				250
Sokpoe	A	22		1		50				0	
* Tefle	A	69		1	1	150		1	-1	-50	
Vume	A	26		1		50				0	
Kpotame	A	21		1		50				0	
Kasse Area			177				350				250
* kasse	A	115		2	1	200		-1		-50	
Tamatoku	A	45			1	100		1	-1	-50	
Dogo	A	17		1		50				0	
Ada Area			580				600				600
* BigAda	A	187		2	1	200				0	
D AdaFoah	A	353		3	2	350				0	
Totimekope	A	40		1		50				0	
Total			895	13	6		1250	1	-2	-150	1100
2) Sege Branch (Kasseh-Akplabanya)											
Ka-Se area			109				100				100
Koluedor	A	83		1		50				0	
Mantse	A	27		1		50				0	
Sege area			470				100				200
* Sege	A	470		2		100			1	100	
Akpla area			183				50				100
Akplabanya	A	92		1		50				0	
Anyaman	A'	91				0		1		50	
Total			763	5	0		250	1	1	150	400
3) Sogakope (Keta system interlinkage)											
Sogakop area			388				150				250
D Sogakope	A	365		3		150			1	100	
Agorkpo	A	23				0				0	
Total			388	3	0		150	0	1	100	250

Fig.4-4 Cont.

Town Name	Pri ori.	Load ultim.	Area Load	Trf.Plan 1 Tentative 50	100	Ttl.	Area Capa.	Trf.Plan 2 Revise 50	100	Ttl.	Area capa.
			kW	units		kVA	kVA	units		kVA	KVA
4) Adidome Branch (Sogakope-Adidome)											
Adidome area			375				300				300
New Bakoba	A'	32		1		50				0	
D Adidome	A	343		3	1	250				0	
Total			375	4	1		300	0	0	0	300
5) Battor Branch (Kpotame-Battor)											
Battor area			266				250				300
Adidokpu	A'	40				0		1		50	
Bakpakope	B	24				0					
Mepe	A	77		2		100				0	
* Battor	A	126		1	1	150				0	
										0	
Total		266	266	3	1		250	1	0	50	300
			Ultim. Load								kvA
Grand Ttl.			2687	28	8		2200	3	0		2350

Trf. plan	Tentative No.of units 50	100	Ttl. Capa. kvA	Revised No.of units 50	100	Ttl. Capa. kvA
Planed	28	8	2200	31	8	2350
Spare Trf.	2	1	200	2	1	200
Total	30	9	2400	33	9	2550

CHAPTER 4
BASIC DESIGN

Chapter 4 Basic Design

4.1 Design Principle

This project is for electrification of 3 district capitals (Ada Foah, Sogakope and Aidome) and nearby towns. To realize this purpose, following facilities for substation, transmission line and distribution lines are to be constructed.

The project planning drawings are shown in Fig. 5-1 and Fig. 5-2.

a. Substation
- Construction of Sogakope substation
- Modification in existing Asiekpe substation

b. Transmission line
- Construction of 69 kV transmission line from Asiekpe substation to Sogakope substation

c. Distribution lines
- Construction of 33 kV distribution lines
- Construction of low voltage lines

In designing these work, the designs and construction plans will be developed with due attention on the condition of the sites and with particular attention on the following matters.

(a) Economical design

The economical design is set as the target, and facilities will be designed on robust and simple structural manner.

(b) Technical standard

The codes and technical standards currently applied in ECG and VRA are taken into account, so that new facilities don not have adverse effect on the standardization efforts.

(c) Simple design

Complicated and sensitive technologies are avoided as much as possible, and introduction of drastically innovative technology in reference to the existing facilities is also avoided. By adopting designs which are coordinated to the existing and current technical levels in Ghana, it is intended to facilitate maintenance and operation of existing facilities.

(d) Consideration on surrounding environment

In case that newly constructed distribution lines will pass through urban and residential areas, full attention will be paid to secure the public safety. Distribution line routes will be designed that it is less necessity to cut trees along street, so that the environment is protected.

(e) Transportation of heavy items

As heavy items will have to be transported for the construction work, the construction plan will be formulated with due consideration on this problem.

4.1.1 Allotment of works to be carried out by Japanese side and Ghanaian side

Concerning construction work of substation, transmission line and 33kV distribution lines, construction work will be done by Japanese contractors on "full turn-key bases", but on low voltage distribution lines, ECG is responsible for construction work by using the materials supplied by Japanese contractor.

Allotment of work is described as follows:

Items	Japan	Ghana	Note
Design, Manufacturing, Transportation	o		
Custody		o	
Land, Clearing		o	
Survey of Transm. & Distrib. Line Route		o	
Construction of 69 kV Transmission Line	o		
Civil Work of Substation Equipment		o	incl. earth work
Installation & Test of SS Equipment	o		
Construction of 33 kV Distrib. Lines	o		incl. Pole Trf.
Construction of Low Voltage Lines		o	from 2ry of P.Trf
Supply of Water & Electricity		o	

4.1.2 Staged Construction Schedule

Considering the scale of the project and the work volume, it is reasonable to that the work should be carried out on by stages. We planned that following contents of work will be included in the first stage and second stage respectively:

a. First stage: (two district capitals will be electrified)

- Construction of 69 kV transmission line
- Construction of 69 kV out going bay at Asiekpe substation
- Construction of Sogakope substation
- Construction of 33 kV interlinkage for Keta system
- Supply of vehicles and work tolls

b. Second Stage: (Ada Foah and other scheduled areas are electrified)

- Construction of 33 kV power cable laying on the Lower Volta Bridge
- Construction of all 33 kV scheduled distribution lines
- Supply of materials for incidental low voltage lines affiliated to the above 33 kV lines
- Supply of work tools

4.2 Design Criteria

Substation and transmission and distribution lines are designed in paying regard to the present standard used by ECG and VRA, also taking into consideration the Japanese standards. Applied standards for equipment and materials are mainly Japanese Standards, but partly ANSI and BS.

4.2.1 Design Criteria

(1) Natural Condition

a.	Altitude	:	less than 1,000 m
b.	Ambient Temperature	:	Max. 40°C, Min. 10°C, Mean 32°C
c.	Wind Velocity	:	Max. 33m/s

(2) Safety Factor

Based on present Japanese criteria,

a.	Structure	:	3
b.	Foundation of structure	:	2
c.	Wires	:	2.5
d.	Insulators	:	2.5
e.	Crossarms	:	2.5
f.	Guy wire	:	2.5

(3) Temperature of conductor

Allowable temperature : 90°C

(4) Load of Wind

Wind pressure by which strength of structures are calculated:

For overhead lines	:	53 kg/m^2
For towers and poles	:	70 kg/m^2

(5) Vertical clearance of overhead line

Place	69 kV	33 kV	LV
Ordinary place	5.0 m	5.0 m	5.0 m
Crossing road	6.0 m	6.0 m	5.0 m
Crossing railroad	9.0 m	9.0 m	9.0 m
Crossing telecomm. line	2.2 m	1.8 m	1.2 m

4.2.2 Basic Principle of Design

Upon designing of substation, transmission line and distribution line, basically following principle are considered.

a. Accommodatability for system enlargement
b. Conciliation with existing facilities
c. Stable supply condition (voltage regulation & small losses)

(1) Power Supply Reliability

In order to rise supply reliability, following measures will be taken:

- Using armor-rods and torsional dampers for 69 kV transmission line
- Installation of surge arresters for all transformers and power cables as lightning protection
- Installation of section switches for 33 kV branch points in order to localize outage area in case of line faults
- Using gas circuit breakers for out going from substations with reclosing device for temporary faults
- Using anti-looseness bolts for 69 kV transmission line towers for protection from vandalism

(2) Voltage Regulation

Main transformer in Sogakope substation is equipped a On-load tap changer ranged ±5%, and distribution transformers are equipped a manual operating tap changers ranged -2.5% +5%, so that voltage regulation can be limited within 5% as a target.

(3) Supply Mode

Power supply mode is adopted a method of 33 kV/415,240V direct step-down in accordance with ECG's standard.

(4) System Configuration and Section Switch

The system is planned one circuit tree branch type system because power flow is one direction, and load density is small. At branch points of distribution lines, air type section switches are installed in order to localize outage range upon the faults and for maintenance work. Protection system and reclosing manner in case of line faults will be designed as same as for existing facilities.

In case of long term outage on 69 kV system, the 33 kV system should function as an emergent provision to supply power for important load from Aflao substation.

4.2.3 Insulation Design

(1) Insulation Design

In order to protect lines and equipment from an inrush of lightning surge and power frequency abnormal voltage, the design was made by putting a coordinated insulation level among them and applied following criteria.

a. For internal abnormal voltage (switching surge, sustained power frequency abnormal voltage etc.), a protection is made by insulation of equipment itself.

b. For external abnormal voltage (lightning surge), a protection is made by an surge arrester or grounding wire.

(2) Insulator Type and Number of Discs of Insulator String

The principal idea of insulation design, as mentioned above, flashover may not occur against an internal abnormal voltage. As to internal abnormal voltage, according to the normal practice employed to insulation of transmission line so far, following values are assumed.

a. Type of grounding system : direct grounding
b. Sustained power frequency abnormal voltage: 0.8 Um
c. Switching surge abnormal voltage : 2.8 Um
where Um: maximum system voltage

In deciding number of discs of insulator string, a flashover characteristics of the insulator in wet condition for switching surge, and the same for power frequency are applied.

The required insulation strength against internal abnormal voltage and the electrical characteristics of the insulators are shown in the following tables (a) - (c).

(a) Required insulation strength against switching surge

a. Nominal voltage (kV)	69	33
b. Maximum system voltage Um (kV)	72.5	36
c. Crest value to the ground (kV)	59.2	29.4
d. Multiple for switching surge	2.8	2.8
e. Switching surge voltage (kV)	165.8	82.3
f. Deterioration factor	1.2	1.2
g. Required withstand voltage (kV)	199	99

(b) Required insulation strength against sustained power frequency abnormal voltage

a. Nominal voltage (kV)	69	33
b. Maximum system voltage Um (kV)	72.5	36
c. Multiple for abnormal voltage	0.8	0.8
d. Sustained abnormal voltage (kV)	58.0	28.8
e. Deterioration factor	1.2	1.2
f. Required withstand voltage (kV)	70	35

(c) Electrical characteristics of insulators

	Standard impulse 50% FOV (kV)	Switching surge		Power frequency	
		50% FOV (kV)	Withstand Voltage (kV)	FOV (kV)	Withstand Voltage (kV)
250mm Suspension					
3 pcs string	330	245	220	115	105
5 pcs string	495	390	350	190	170
33kV Pin Type	290	-	-	95	-

Note:

i) Characteristics of 250 mm suspension insulators string are based on "The Insulation Design Manual for Overhead Transmission Line -Oct.1966" issued by the Japanese Electrotechnical Committee (JEC).

ii) Characteristics of 33kV Pin Type insulators are based on BS 137.

Comparing a withstand voltage of insulators with the required insulation strength in Tables (a), (b) and (c), and considering some tolerance, type of insulators and number of discs for insulator strings have been selected as following table. On more spare piece have been counted upon determination of the number of 250 mm discs for insulator string taking account of maintenance.

Table Type and number of disc insulators

System Voltage	Place	33kV Pin Insulator	250 mm Disc Insulator	
			With Arcing Horn	Without Arc Horn
69 kV	Suspension Tower Angle Tower Jumper	- - 	5 pcs. 5 pcs. 	- - 5 pcs.
33 kV	Straight Angle	0 -	- -	- 3 pcs.

(3) Standard Insulation Clearance (phase to ground)

Standard insulation clearance is specified as equivalent to a rod-to-rod gap in which th 50% flashover would be taken place when standard shape impulse (positive) were impressed an insulator string.

Nominal Voltage (kV)	69	33
No. of 250 mm disc insulator (pcs.)	5	3
50% Impulse FOV of Insulator String *(kV)	495	330
Corresponding Rod-to-Rod Gap *(cm)	79	52
Standard Insulation Clearance (cm)	80	55

*Based on "The Insulation Manual for overhead transmission line - Oct. 1996"

(4) Minimum Insulation Clearance

Minimum insulation clearance is specified as the minimum gap length which withstands both a definite value of switching surge and abnormal power frequency voltage.

Nominal voltage (kV)	69	33
Maximum system voltage Um (kV)	72.5	36
Crest value of phase voltage (kV)	59.2	29.4
Mutiple of switching surge	2.8	2.8
Crest value of switching surge (kV)	165.8	82.3
Required withstand voltage (kV)	182.4	90.5
Required clearance *(cm)	37.0	15.3
Minimum insulation clearance (cm)	40	15

*Based on "The Insulation Design Manual for overhead transmission line - Oct. 1966"

(5) Insulation Clearance in Abnormal Condition

When the maximum wind condition is considered, the clearance shall withstand against maximum system voltage under the wet condition.

Nominal voltage	(kV)	69	33
Maximum system voltage Um	(kV)	72.5	36
Maximum phase voltage (to ground)	(kV)	46.1	22.9
Clearance at abnormal condition	*(cm)	17	9

*Based on "The Insulation Design Manual for overhead transmission line - Oct. 1966"

(6) Minimum Line Spacing

Nominal voltage	(kV)	69	33
Maximum system voltage Um	(kV)	72.5	36
Crest value of phase voltage	(kV)	59.4	29.4
Multiple of switching surge (inter line)		4.5	4.5
Switching surge voltage (inter line)	(kV)	267	133
Required withstand voltage	(kV)	294	146
Minimum insulation clearance	*(kV)	51	26

*Based on "The Insulation Design Manual for overhead transmission line - Oct. 1966"

(7) Basic Lightning Impulse Insulation Level (BIL)

Applied BIL are 325 kV for 69 kV system, and 170 kV for 33 kV system. The reason of said decision is described as below:

Since shielding effect of overhead ground wires and protection by arresters have been anticipated, the BIL shall be selected so as to withstand switching surge as well as lightning surge, by coordinating with protection characteristics of arresters.

That is, assuming that the protection tolerance of arresters and equipment protected against lightning surge to be 20%, BIL should be selected to be of more than arrester's sparkover voltage or 1.2 times of arrester's discharge ceiling voltage. Next table shows the process of decision of BIL by nominal voltages.

		69 kV	33 kV
Arrester			
Rated voltage	(kV)	72.5	36
Rated discharge current	(kA)	10	10
100% sparkover voltage	(kV)	256	135
Required BIL			
Ceiling discharge voltage x 1.2	(kV)	323	168
Basic impulse level	(kV)	350	170

The above mentioned BIL will be applied for design of new equipment to be installed. This value have also been used for VRA's and ECG's existing facilities.

(8) Lightning Protection Design

In the field survey, accurate observation records on IKL (Isokeraunic level: statistical annual thunder days) were not obtained. It is supposed that not so frequent lightning attacks occur in the areas. However, in order to protect the facilities from external abnormal voltage including lightning impulse, arresters will be installed for main transformer of substation, distribution transformers and both side of power cables. Overhead ground wires will also be installed for 69 kV transmission line and substations.

4.3 Substation

4.3.1 Facility Plan

There are two items in the substation work at this time that construction of new substation at Sogakope and extension of new outgoing bay at existing Asiekpe substation as follows:

a. New installation of Sogakope substation

As the power supply source, a 69/33 kV substation will be installed at Sogakope. Receiving power from 69 kV transmission line, voltage is stepped down to 33kV at this substation and 33kV distribution lines for planned electrification areas are to be taken out.

b. Extension of one set of 69 kV outgoing facilities at Asiekpe

One set of 69kV out-going facilities will be installed at existing Asiekpe substation. This is to supply power for the above mentioned Sogakope substation by 69 kV new transmission line.

4.3.2 Sogakope Substation

(1) Selection of Substation Site

Location of Sogakope substation will be selected and decided upon consideration of following conditions:

a. Easiness for in-coming of 69 kV line and out-going of 33kV lines
b. Coordination to surrounding environment
c. Suitable location in view point of all system configuration
d. Ample size of site for future extension
e. Easiness for transportation of heavy goods
f. Good soil condition for foundation of equipment
g. Non trouble about noise of transformer for surrouding environment

(2) Substation Capacity

The capacity of main transformer was decided as 15 MVA according to the calculation described in Chapter 3.

(3) Operation and Maintenance Manner

Control and operation manner of equipment installed in new Sogakope substation should be organized as same as existing Asiekpe substation, that is, at least one operator will be permanently stationed in substation premises and he monitors the condition of equipment and operates them by the control orders from the Load Dispatching Center.

(4) Arrangement of Equipment

Connection system of substation should be simplified as much as possible, considering ratio of fault, frequency of inspection and necessary outage for maintenance of equipment within limits not prejudicial to the power supply reliability.

(5) Pollution-Proof Design

In studying the countermeasure against salt pollution, the decisive factors are the meteorological condition of the site, and the distance from sea shore. In the substation sites of this Project, strong wind is rare, and it is judged that the contamination of insulators by deposition of salt is difficult to develop an accurate counter-contamination design because there is no data on the pollution at the sites which are measured for a long time, it is assumed that the equivalent salt deposition is 0.03 mg/sq.cm, that is the value applied for general area.

(6) Minimum Insulation Clearance for Substation

The minimum line-to-ground and line-to-line insulation clearance values were determined as the length of rod gap with which 50% flashover occurs at 120% and 150% of impulse voltage defined by BIL, respectively.

a.	Nominal voltage	(kV)	69	33
b.	Impulse voltage (BIL)	(kV)	325	170
c.	Minimum line-to-ground clearance	(cm)	55	30
d.	Minimum line-to-line clearance	(cm)	76	48

(7) Protection Device

Protection device for transmission and distribution lines, bus conductor and main transformer are to be installed according to Japanese standard.

The connection schemes of each substation determined are presented in Fig. 5-3. Layout of equipment are shown in Fig. 5-4.

(8) Specification of Main Equipment

Outline of the specification of main equipment for Sogakope substation are as follows:

a. Main transformer

Applied standard	JEC 204 (Transformer)
	JEC 186 (On-load tap changer)
Capacity	15,000 kVA (For all Taps)
Rating	Continuous
Phase	3 phase
Frequency	50 Hz
Cooling	Oil filled, self cooling
Rated voltage	1ry 69,000 / 2ry 33,000 V
Tap voltage (HV)	±10%, 17 taps
BIL	1ry 325 kV, 2ry 170 kV
Connection 1ry	Star
2ry	Star
3ry	Delta
Neutral point	Direct earthing (1ry, 2ry)
Impedance	7.5%
Phase angle deviation	0 deg.
Polarity	Subtractive
Use condition	Outdoor, altitude: less than 1,000m
Tap changer devise	On-load tap changer
Max. ambient temperature	40 deg.C
Altitude	Less than 1,000 m

b. Circuit breaker

Applied standard	JEC 181 (Circuit breaker)	
Rated voltage	72.5 kV	36 kV
Type	Outdoor, SF6 Gas CB	Outdoor, SF6 Gas CB
BIL	325 kV	170 kV
Rated current	800 A	600 A
Rated frequency	50 Hz	50 Hz
Rated rupturing current	25 kA	25 kA
Rated rupturing time	5 cycle	5 cycle
Closing control voltage	DC 110 V, AC 240 V	DC 110 V
Trip control voltage	DC 110 V	DC 110 V

Operating duty	A	A
Operating sequence	O-(1min.)-CO-(3min.)-CO	

c. Disconnecting switch

Applied standard	JEC 196 (isolator)	
Rated voltage	72.5 kV	36 kV
Type	Horizontal double break	
BIL	325 kV	170 kV
Rated current	600 A	600 A
Rated short circuit current	20 kA	25 kA
Use mode	Outdoor	Outdoor
Operation mode	Manual	Manual

d. Current transformer

Applied standard	JEC 185, JEC 190 (instrument transformer)	
Rated voltage	69 kV	33 kV
BIL	325 kV	170 kV
Current ratio	200/5 A	300/5 A
Rated output	40 VA	400/5 (Trf) 200/5 (Feeder)
Accuracy class	5p	5p

e. Lightning arrester

Applied standard	JEC 203 (Arrester)	
Rated voltage	72.5 kV	36 kV
Nominal discharge current	10 kA	10 kA
Max. residual voltage		
8 x 20 10 kA crest	198 kV	99 kV
Switching surge, 125 A	145 kV	73 kV

f. PCT (Metering outfit) for energy selling

Applied standard	JIS C1736
Nominal system voltage	33 kV
Rated frequency	50 Hz

PT side	
Voltage ratio	33,000/110 V
Rated output	2 x 100 VA
CT side	
Current ratio	400/5 A
Rated output	2 x 40 VA
Over current strength	40
Accuracy class	0.5
Polarity	Substractive
Meters	Watt Hour Meter and Max. Demand Meter

g. Protection relays

For main transformer	87T, 51, 51G
For 33kV feeders	51, 51G

4.3.3 Extension Work for Asiekpe Substation

A 69kV outgoing bay for new 69kV transmission line to Sogakope substation shall be installed at existing Asiekpe substation. This bay is consisted of a circuit breaker, two set of isolators, one set of potential divider, lightning arrester, and instrument current transformers. The single line diagram of this extension is shown in Fig. 5-5.

Equipment layout will be arranged at next of Ho line's equipment series. It is necessary to build a new 69 kV bus system from 2ry side of an existing transformer.

The location of Sogakope substation is in opposite direction against Ho. Transmission line for Sogakope must change it's direction 180° just after outlet from the substation, furthermore, it must pass through under the 161 kV existing line. Therefore, it is appropriate idea to use 69 kV power cable for connection to 69 kV transmission line. But considering a reason described in 3.2.5.1) and request of Ghanaian side, overhead arrangement was finally adopted.

The layout of equipment for Asiekpe extension is shown in Fig. 5-6.

Basic design and specifications of equipment to be adopted in this substation are as same as Sogakope substation in general.

4.4 69 kV Transmission Line

4.4.1 Basic Plan

The 69kV transmission line will be constructed in order to supply power to the planned Sogakope substation. This line starts at Asiekpe substation where additional equipments for the new outgoing feeder are to be installed, line length is approximately 40 km and the applied design criteria of the line are as same as the existing Ho line. Judging from the general characteristics of transmission lines and the supports are all steel lattice towers, there is less necessity for frequent maintenance or reconstruction work in comparison with 33 kV distribution lines mentioned later. By this reason it is no need to select the line route always just along the road, therefore, the line route will be decided after due consideration of the following points.

- to avoid the places where there is a possibility to have poor ground conditions by rainfall, or soft soil conditions,
- small difference of elevation
- easiness to acquire the land
- to minimize the length of the line by considering economical point of view.

4.4.2 Design of 69 kV Transmission Line

In designing the 69kV transmission line, necessary considerations are given to the following basic items as well as harmony and coordination with VRA's existing facilities.

a. to ensure stable supply of good quality electricity to Sogakope substation

b. to avoid deterioration of reliability of existing service system

c. to ensure economical feasibility

(1) Conductor

The conductor used in this Project must have sufficient capacity to supply the necessary amount of power, have satisfactory characteristics in terms of mechanical strength and resistance against corrosion, and at the same time advantageous in terms of cost. The hard drawn copper stranded conductor (HDCC), all aluminium conductor (AAC), all aluminium alloy conductor (AAAC), aluminium conductor steel reinforced (ACSR), and aluminium conductor aluminium-clad steel reinforced (ACSR/AS) which is improved of the corrosion resistance characteristics, are the candidates in selection of phase conductors. Except HDCC that is not used widely recently because of its price, the comparison of essential properties of each conductor are as shown on the table below. Based on an overall judgment, ACSR/AS should be selected as this is generally most advantageous. The conductor size of 150 sq.mm is enough, with consideration on current carrying capacity and tensile strength.

: better o: good : standard x: poor

	AAC	AAAC	ACSR	ACSR/AS
1. Corrosion Resistance		o		
2. Tensile Strength	x			
3. Conductivity		o		o
4. Creep Strain		x		
5. Weight				o
6. Sag Characteristics	x			
7. Available Max. Span	x			
Synthetic Evaluation			o	

Note) AAC : All Aluminium Conductor
AAAC : All Aluminium alloy Conductor
ACSR : Aluminium Conductor, Steel Reinforced
ACSR/AS: Aluminium Conductor, Aluminium-clad Steel Reinforced

However, accepting a request of Ghanaian side that same conductor is convenient as Ho line, finally 185 mm^2 AAAC was adopted.

(2) Ground Wire

Although the Study Team could not obtain the lightning observation data of the area concerned during the last expedition, it was informed that lightning occurs. Considering the siting conditions, the IKL (Isokeraunic Level; statistical annual thunder days at the site is expected to be around 10. Therefore, it was decided to provide a single line of aluminium-clad stranded steel wire of 7/9 AWG as the ground wire to shield the lines from lightning stroke.

(3) Support Structure

Steel lattice towers are used for construction of line with concrete foundations. The towers are single circuit galvanized steel, self-supporting with conductors in delta formation and one grounding wire, and the basic design span is 280 m.

Insulator set fittings include pre-formed armor rods and arcing horns. vibration dampers are provided on all conductors and grounding wire. Standard steel lattice towers are as shown on Fig. 5-7, Fig. 5-8 and Fig. 5-9.

(4) Specification of Main Equipment

The outline of major materials/equipments to be used in the 69kV transmission line construction work under this Project are presented below.

a. Conductor

		(ACSR)
Standard		BS 125 Part 2
Type	AAAC	ACSR/AS 150 mm^2
Component wire	19/3.5	Al 30/2.59, AS 7/2.59
Calculated sectional area	185 mm^2	194.9 mm^2
Diameter	17.5 mm	18.13 mm
Weight	500 kg/km	680.7 kg/km
Tensile load	4,035 kg	7,300 kg
D.C resistance at 20°C	0.1694 ohm/km	0.19 ohm/km

b. Ground wire

Standard	ASTM
Type	Aluminium Clad Stranded Steel Wire, 7/9 AWG
Stranding	7/2.91
Calculated sectional area	46.56 mm^2
Diameter	8.73 mm
Weight	309.9 kg/km
Tensile strength	5,724 kg
D.C resistance at 20°C	1.85 ohm/km

c. Disc Insulator

Type	Porcelain 10" disc insulator
Standard	JIS C 3812
Dimension	254 mm x 146 mm
Flashover voltage	
- Power frequency, wet	45 kV
- 50% impulse, positive	215 kV
Failing load	4,000 kg

d. Steel lattice tower

Type	Self-supporting steel lattice tower
Angle iron	Galvanized steel
Tower type	Straight
	Angle
	Terminal

4.5 Volta River Crossing Power Cable Line

4.5.1 Basic Plan

One 33kV feeder newly taking out from Sogakope substation to feed electricity to Ada Foah must cross Volta River. The methods considered of this crossing are laying power cable on the Lower Volta Bridge at Sogakope, submarine cable, long-span overhead line by constructing high steel tower. Based on the result of field survey, it was decided that power cable laying on the bridge is the most advantageous method in view of easiness of installation work and in terms of cost.

There is ongoing rehabilitation plan financed by German Government fund for the piled foundations of the Lower Volta Bridge and it is scheduled that actual work will start 1993, therefore, the power cable should lay on upper part of the bridge. The methods for the power cable laying on the bridge were planned after the field study by considering this condition, namely, laying through inside of handrail on walkway with cable trough and laying through outside of handrail where is space of approximately 12 cm.

Finally the latter idea was approved by GHA (Ghana Highway Authority) as a managing agency of the bridge, because there are no restrictions are to be happened on the walkway in case of laying power cable outside of the handrail. The total length of this power cable line is about 1,000 m.

4.5.2 Design of Power Cable Line

Power cable for this 33kV river crossing line is selected with three-core, cross-linked polyethylene insulated, PVC sheathed, steel wire armored power cable of 70 sq.mm, considering mechanical strength and the effect by strong direct sunlight.

The line will be provided with metal cover to prevent touch on the power cable by a third person, instead of laying the cable in the conduit. This method has the advantages of reducing the weight to be imposed to the bridge and simple vibration-proof measures which is necessary to exclude harmful effect producing by traffic. Technical details of the power cable are shown below;

Type	33 kV XLPE insulted and steel wire armored cable (33kV CVWAZV, 3-core)
Calculated sectional area	70 mm^2
Conductor	Compacted copper stranded conductor
Diameter	79 mm
D.C resistance voltage	0.268 ohm/km (20°C)
Current carrying capacity	270 A (in air)
Weight	10,040 kg/km

Fig. 5-9 shows outline of cable laying structure.

4.6 33 kV Distribution Lines

4.6.1 Basic Plan

For the purpose to electrify rural villages, the project is for extending new 33kV distribution lines from Sogakope substation, feeding power via pole-mounted transformers to villages around the new distribution lines. According to the project plan, 33kV lines coming from the substation will be constructed direct to Ada Foah located at about 40 km southward of Sogakope passing along a main road. Branch lines are extended from this 33kV line at Kpotame to extend 20 km of this line to Battor and at Kaseh to Akplabanya via Sege constructing about 40 km of the line. The total length of the line is about 119 km including branch lines. Following table shows line length and number of pole-mounted transformers for each areas to be electrified.

Lines			Length	Pole-Mounted Transformer	
				50 KVA	100 KVA
Sogakope	-	Adidome	25.7 km	7	2
Sogakope	-	Kasseh	18.8 km	5	2
Kasseh	-	Ada Foah	24.1 km	8	4
Kasseh	-	Sege	20.1 km	5	-
Tefle	-	Battor	20.7 km	5	1
Sege	-	Akplabanya	9.9 km	3	-
			119.3 km	33	9

4.6.2 Design of 33kV Lines

(1) Phase Conductors

The phase conductors of the 33kV lines are AAC 100 sq.mm.

(2) Conductor Arrangement

Although the conductor arrangement could be horizontal, vertical or triangle, etc., existing lines have been constructed by horizontal arrangement because the construction work is easy and the shape of crossarm is simple. The horizontal type is the best conductor arrangement in the area where the right of way can be easily secured, because the connection of lead wires for pole-mounted transformers is easy, and the support structure height is lower than other conductor arrangements, and this is used most widely in distribution lines. In this project, too, the horizontal arrangement has been adopted in order to coordinate with the existing distribution lines. The standard pole configuration is shown in Fig. 5-10 and Fig. 5-11.

(3) Support Structure

The wooden poles locally available are used in principle by considering the economy and coordination with existing facilities. The insulators are pin type insulators for straight line poles and 250 mm disc insulators use in 3 numbers for section and tension poles.

(4) Stays

The following stays will be installed for single poles and H-poles, and shall be designed to bear one-half of the wind pressure.

a. Straight line pole

For places where there is a large difference between spans, a stay shall be installed on eachside. There shall be six four-directional stays for every 10 spans.

b. Angle poles

1 deg. - 15 deg.	:	1 stay
15 deg. - 45 deg.	:	2 stays
45 deg. - 90 deg.	:	3 stays

c. Section poles : 6 stays

d. Terminal poles : 2 stays

(5) Pole-Mounted Transformers

The standard transformers used shall be three-phase 50KVA and 100 KVA. According to the project plan, 33kV lines coming from Sogakope substation will pass along a main road of each of the villages to be serviced. The selection of transformer locations will be determined as indicated below.

a. Transformers will be set up near load centers for demand areas lying along the feeder.

b. In order to meet demand far load centers from the feeder, and to prevent voltage drops, high-voltage branch lines will be extended to these load centers, which will be equipped with transformers.

The following protection will be provided to prevent overloads and short-circuits.

a. To prevent problems resulting from internal short-circuits, transformers will be provided with primary fuse cutout switches.

b. To prevent problems caused by overload or short-circuits on the low voltage lines, transformers will be equipped with secondary fuse cutout switches.

c. Appropriate fuses shall be provided for the primary and secondary cutout switches. Transformer and load capacities shall be considered when determining the provision of these fuses.

(6) Specifications of Main Equipment

The outline of major materials/equipments to be used in the 33kV distribution line construction work under this Project is presented below.

a. Conductor

Standard	BS 215, IEC 207
Type & size	AAC 100 mm^2
Stranding	7/4.39
Calculated sectional area	106.0
Diameter	13.17
Weight	290 kg/km
Tensile load	16.00 KN
D.C resistance	0.2702 ohm/km (20°C)

b. Pin type insulator

Standard	BS 137: Part 1
Nominal voltage	33 kV

Flashover voltage

- Power frequency, wet — 95 kV
- 50% impulse, positive — 215 kV

c. Suspension insulator

Standard	JIS C 812
Dimension	254 mm x 146 mm
Flashover voltage	
- Power frequency, wet	45 kV
- 50% impulse, positive	125 kV
Failing load	4,000 kg

d. Lightning arrestor

Standard	JEC 203
Nominal voltage	42 kV
Power frequency flashover voltage	63 kV
Impulse flashover voltage	135 kV
Nominal discharge current	5 kA
Residual voltage	145 kV

e. Pole-mounted transformer

Nominal voltage	33 kV/415, 240 V
Capacity	50, 100 kVA
Type	out-door use, oil-immersed, self-cooling
Phases	3
Rated frequency	50 Hz

f. Open fuse cutout switch

Standard	ANSI
Rated voltage	36 kV
Rated current	100 A
Rated frequency	50 Hz
BIL	95 kV
Power frequency withstand voltage	36 kV
Breaking current	8 kA

4.7 Provision of the Materials for Low Voltage Lines

(1) Low Voltage Lines

Necessary materials and their quantities for construction work of the low voltage lines to be done by ECG are estimated based on the following conditions.

a. Standard span : 50 m
b. Conductor arrangement : Vertical
c. Conductor : AAC 50 sq.mm
d. Standard line length
   Standard line length for each transformer capacities are as follows:

	50 KVA	100 KVA
number of spans	80 spans	120 spans
main line length (4 wires)	2 km	3 km
branch line length (2 wires)	2 km	3 km

Standard pole configuration are shown in Fig. 5-12.

(2) Watt-Hour Meters

There is a large possibility that some of the many unelectrified areas near the projected route will wish to tie into the supply, even if at their own expense. Accordingly, the extent of service lines and watt-hour meter that will be initially required for each consumer is not clear. However, based on result of site investigation, NEPS data and experience of our former project, it is assumed that penetration factor in 2-3 years is 25~35% for households located in the areas. So, single and 3 phase WHM are supplied as follows:

a. Residential/Commercial : 3,000
b. Industrial : 30

(3) Specifications of Main Materials

The outline of major materials to be used in the 33 kV distribution line construction work under this Project is presented below.

a. Conductor

Standard	BS 215, IEC 207
Type & size	AAC 50 mm^2
Stranding	7/3.10
Calculated sectional area	52.83 mm^2
Diameter	9.30 mm
Weight	145 kg/km
Tensile load	8.28 KN
D.C resistance	0.5419 ohm/km

b. Low voltage fuse cutout switch

Rated voltage	415 V
Rated current	400 A
Rated frequency	50 Hz

c. Insulators and fittings

Insulators	Shackle insulator
Hard ware	D-iron
Stay	Galvanized steel stranded wire

d. Watt-hour meter

Type	1P2W	3P4W
Rated voltage	240 V	415/240 V
Rated current	15(60) A	20(80) A
Rated frequency	50 Hz	50 Hz
Accuracy	Class 2	Class 2

4.8 Vehicles and Tools

Vehicles and Tools at least required for construction work of this project will be provided, and the vehicles and tools are used by the contractors when carrying out this project. The vehicles and tools will be determined by considering the requirement for future maintenance and inspection work after transfer of facilities.

(1) Vehicles

The following vehicles will be supplied for the construction work of this project.

a. 8-ton crane truck : 1
b. 5-ton truck with 3-ton crane : 4
c. Pickup truck : 5
d. Supervisor's vehicle : 3
e. 3-ton forklift truck : 2

(2) Tools and Measuring Instruments

Tools including tensioning hoists, measuring instruments as well as compression tools which is vital for jointing aluminium conductors will be provided.

4.9 Communication Equipment

In this project, construction work involve dangerous operations such as shutdown of facilities and switching of loads, and all construction team engaged in this work must maintain communication between them in order to assure safety and perform tasks completely. For this purpose, it was decided to equip the construction vehicles with VHF/FM transceivers. There seems to be no effective communication facilities such as public telephone in the project areas. Therefore, it is necessary to provide HF transceivers at Sogakope substation since other existing substations and control centers have their own HF-radio link to control their system.

a. HF transceiver

Type	base station type HF transceiver
Frequency	8.315 Mz SSB
RF output	50 W
Antenna	brown antenna
Power supply	AC 240V, re-chargeable battery