FEASIBILITY STUDY REPORT
ON
RURAL ELECTRIFICATION
IN
NORTH-CENTRAL STATE OF NIGERIA

1975 JUNE

JAPAN INTERNATIONAL COOPERATION AGENCY
GOVERNMENT OF JAPAN

FEASIBILITY STUDY REPORT
ON
RURAL ELECTRIFICATION
IN
NORTH-CENTRAL STATE OF NIGERIA

1975 JUNE

JAPAN INTERNATIONAL COOPERATION AGENCY
GOVERNMENT OF JAPAN

PREFACE

In March 1974, the Government of the Federal Republic of Nigeria made a request to the Government of Japan for the dispatch of some experts to study the rural electrification in her North-Central State and North-Eastern State.

In compliance with the Government's decision to meet the request, Japan International Cooperation Agency sent a team comprising four experts headed by Mr. Tatsuo Watanabe of the Tokyo Electric Power Company, Inc. from October 2, 1974 to February 7, 1975. During the above period, the team carried out technical survey and collected necessary informations and also exchanged views with the Nigerian official concerned.

I sincerely hope that this report prepared by the team will contribute to the advancement of the electrification project in Nigeria, and I wish to avail of this opportunity to express my deep appreciation to the officials of both their Federal and State Governments of Nigeria for the cooperations and warm hospitalities extended to the expert-team during their stay in Nigeria.

June 1975

Sinsaku Hogen
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

June , 1975

Mr. Shinsaku Hogen
President
Japan International Cooperation Agency

Drar Mr. Hogen:

The report presented to Nigeria here on has been a final conclusion on feasibility study which was drawn up by the survey team dispatched from the Japan International Cooperation Agency (refers to the former Overseas Technical Cooperation Agency) due to the request from the Federal Republic of Nigeria Government in regard to feasibility study for planning rural electrification in the areas of North-Central and North-Eastern States. The report also includes our advice for state-wide electrification to the North-Central States, and includes designs and specifications additionally required by the North-Eastern State Government.

During the stay of the survey team in Nigeria, the team has carried out research and survey activities as follows.

To begin with, the survey team has negotiated with the both state government staffs, staffs of the National Electric Power Authority (hereafter, refers to as NEPA), and relative staffs of the Japanese Embassy on the spot regarding how to research and survey at this moment, and regarded firmly as an essential organization in response to team activities has to be the both state governments mentioned above.

Recognizing the above matter, the team negotiated the purpose of research and survey and how to carry it out with the executive staffs of both the Ministry of Economic Planning and the Ministry of Works and Housing of the both states.

In compliance with the preparation as mentioned above, field survey in respective towns was carried out based upon relative data collected throughout the state government concerned, NEPA, and others with our best effort.

Getting touch with the structure of the final results surveyed and the contents of the final report, they have been involved in the so-called "Interim Report" which was approved by the both parties at the intermediate reporting conference getting together with the executive staffs of the both states, staffs of the Japanese Embassy on the spot, and out team members.

Such being the case, we, the survey team members, are deeply expecting that, in every aspect, this final report would greatly contribute to the encouragement of rural electrification in the both states in that the report was drawn up in compliance with the survey and recognition as mentioned so far.

In presenting this final report to Nigeria, on behalf of all the team members, I'd like to express our deepest appreciation for the heart-felt and kindest helps and assistances incessantly extended by the relative staffs of Nigeria and Japan as well as the relative persons individually cooperated with the team during the stay period of the team in Nigeria and up to the time of completing the final report after our coming home.

Very faithfully yours,

Tatsuo Watanabe

Tatsuo Watanabe

Team Leader
Survey Team for the Rural Electrification of the North-Central and North-Eastern State of Nigeria.

CONTENTS

I. FOREWORD

1. BAKCGROUND OF RURAL ELECTRIFICATION SURVEY AND DETACHMENT OF SURVEY TEAM FOR RURAL ELECTRIFICATION

The Government of Federal Republic of Nigeria is now making a great effort to modernization of the country and welfare improvement in the livelihood of the nation.

Each state has not only been striving to expand the roads, medical facilities, water supply facilities and to universalize education, but orienting to grow up their economy by encouragement of industrialization in the state as well in order to cope with the above-mentioned national policy.

State government concerned has a strong intention it is indispensable to supply electric power for solving the social atmosphere and for growing up its national economy, and that it is of importance to electrify the residential areas of the state from the viewpoint of social service so as to level up the living atmosphere of the nation.

In Nigeria, the National Electric Power Authority (hereafter refers to as NEPA) has been founded as a power supply organization of which purpose has been for nationwide power supply. NEPA has been making its best to encourage rural electrification, but it has been in a real situation unable to respond enough the request of state government suggested to satisfy a growth rate in power demand running more than twenty per cent. In consequence, each state government has a plan to encourage rural electrification individually for solving this problem of importance.

Under such background, the North-Central and North-Eastern State Governments have presented the offer to the Japanese Government through the Federal Ministry of Economic Development and Reconstruction regarding technical cooperation for rural electrification in their areas.

In compliance with this offer, the Japanese Government has determined to despatch a survey team with four staffs headed by Mr. Watanabe, the team leader, the Tokyo Electric Power Company, Incorporated, Power System Operation and Maintenance Department.

The members of this survey team comprised the following, all employees of the Tokyo Electric Power Co., Inc.:

Tatsuo Watanabe	: Power System Operation and Maintenance Dept.
Nobuchika Inoue	: Power Sales Dept.
Akira Tanaka	: Power Sales Dept.
Haruo Kawada	: Power System Operation and Maintenance Dept.

2. PURPOSE AND RESPONSIBILITY OF SURVEY TEAM

Prior to forwarding actual activity of the survey team, the team has recognized its purpose, mission, and principle on the plan and design as follows in common with the responsible staffs of the both state governments.

2. 1 PURPOSE

The North-Central State has the plan to carry out a detailed study of electricity requirements throughout the state, with the view to providing electricity in many rural areas as well as urban centers for domestic and industrial use.

The survey team has carried out the survey and guidance in regard to towns required on the basis of the plan and got useful to encourage a part of the plan.

2. 2 RESPONSIBILITY OF SURVEY TEAM

The survey team has determined to carry out as follows in the towns undermentioned.

1) Assessment of Demand Forecast

2) Survey and Plan for Power Supply Facilities

3) Economic Evaluation

In addition to the above-mentioned activity, the survey team has suggested as follows on the basis of survey results obtained at this moment.

4) Advice on the Future Rural Electrification in North- Central State.

Designated towns have been as follows:

Kachia, Makarfi, Jibia, Musawa, Zonkwa, Maiadua, Kankara, Soba, Hunkuyi, Kudan, Shika.

In addition, the following four towns designated at first have been acknowledged by the state government and have resulted to be exempted from the survey at this moment for the reason why the arrangement on electrification has been forwarded by NEPA.

Daura, Dutsin-Ma, Bakori, Kankiya

In reference to this, if the state government puts a judgement to electrify the towns to be surveyed by means of diesel generation, the survey team has attached designs and specifications to make the above judgement carry out.

2. 3 PRINCIPLE OF PLAN AND DESIGN

1) It shall be fundamental that electrical facilities are to be equivalent to the power demand foreseeable in 1985. On the other hand, it is needed a diesel electric generator has to be extended in the midst of the above period, and that a power distribution line has also to be newly installed for taking the load of which site is indefinite.

2) The original standard and specification shall be complied those of NEPA currently available.

3. SITUATION OF TEAM ACTIVITY

3. 1 MEMBERS WHO OFFICIALLY PARTOOK WITH THE TEAM

1) North-Central State

Ministry of Economic Planning and Rural Development.

Mr. I Inuwa Permanent Secretary

Mr. Z. A. Oloruntoin

Mr. J. De-Ganga

Ministry of Works and Housing

Mr. G. A. Yarson : Chief Electrical and Mechanical Engineer

Mr. R. J. Patel : Principal Electrical Engineer

Mr. E. A. Andow : Executive Electrical Engineer Zaria. Counter Part

Mr. A. Yakubu : Liaison Officer (Lagos)

2) North-Eastern State

Ministry of Economic Planning and Political Division.

Mr. U. G. Galtenari : Permanent Secretary

Mr. M. L. Mukhtar :

Ministry of Works and Housing

Mr. A. S. Kumar : Chief Electrical and Mechanical Engineer

Mr. M. Kagu : Principal Electrical Engineer

Mr. U. M. Sa'ad : Counter Part

Mr. A. Abubakar : Liaison Officer (Lagos)

3.2 MEMBERS WHO COOPERATED WITH THE TEAM

NEPA

Mr. E. O. Ilmoka : Assistant General Manager

Mr. B. A. O. Adesanya : Manager, Commercial Department

Federal Ministry of Mines and Power

Mr. O. B. Edun : Electrical Inspectorate Division

In addition, the district officers of NEPA at Kaduna and Maiduguri have also taken care of arranging necessary data.

The survey team has got aerial photographs through the arrangement of Mr. M. F. Anderson, Surveyor General, Ministry of Land and Survey, Bauchi, North-Eastern State.

Table I-1 OUTLINE OF SCHEDULE IN NIGERIA

Period	Number of week allocated	Place of sojourn	Breakdown of main jobs carried out	Name of towns surveyed at the site
October 1974	2	Lagos	Getting contact with the staffs concerned Laying hold of the situation Getting contact with the state authorities concerned Acquiring of data	
	1	Kaduna Maiduguri	Visiting with the state government concerned for greeting Consulting with the persons concerned for preparations	
	1	Lagos	Acquiring of data Preparing of materials for site surveys	
November 1974	1	Kaduna	Preparing for site surveys Site surveys	Kachia
	2	Katsina Daura Funtua Zaria	Rural site surveys	Jibiya, Maiadua, Musawa, Kankara, Shika, Kudan, Hunkuyi, Makarfi, Soba,

Period	Number of week allocated	Place of sojourn	Breakdown of main jobs carried out	Name of towns surveyed at the site
November 1974	2	Kaduna.	Site survey Contacting for summarization Arrangement of materials for site surveys	Zonkwa
December 1974			Acquiring of data Preparing to start to the North-Eastern State.	
	2	Bauchi Azare Potiskum	Acquiring of aerial photograph Rural site surveys Inspecting of the situation on electrified works	Tafawa Balewa, Dadin Kowa, Darazo, Ningi, Jama'are, Shira,
	3	Maiduguri	Site surveys Arrangement of materials for site surveys	Damaturu, Monguno, Michika,
January 1975			Acquiring of data Contacting for summarization Preparing to come back to Lagos	
	2	Lagos	Arranging of the interim report Conference for the interim report Preparing to come home	
February 1975			Coming home	

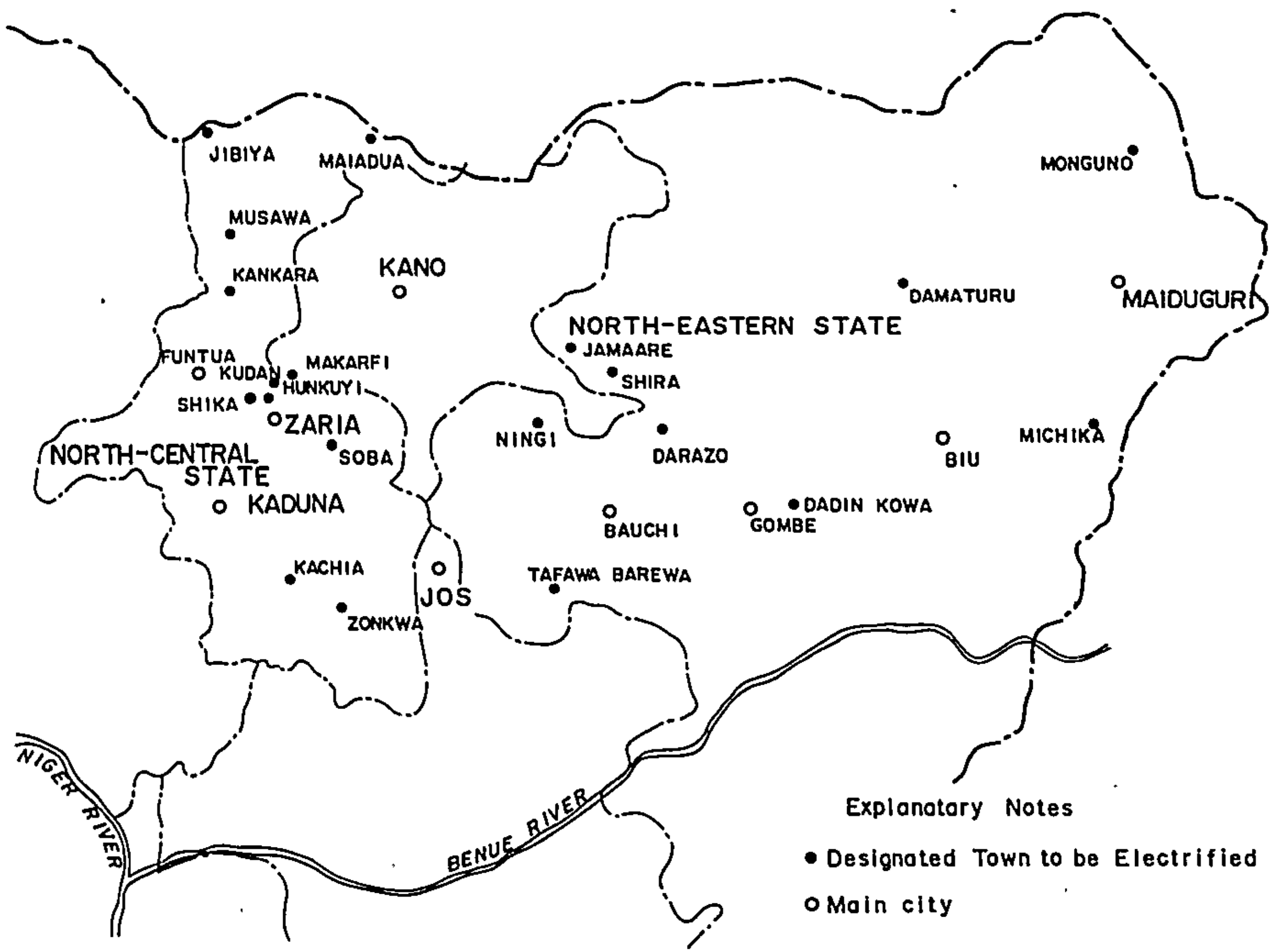


Fig. I-1 TOWNS DESIGNATED TO BE ELECTRIFIED

II. PURPORT AND RECOMMENDATIONS

1. STRUCTURE OF THE REPORT

The structure of the report consists of the following three volumes.

Volume "Feasibility Study Report":

This volume corresponds to the statement of surveyed results and records in which the survey in towns pointed out, power demand forecast, plan and design of facilities, etc. are stated on the key-points as to how to consider, how about the survey results, and what process to be applied, etc.

When making use of the Volumes general and individual specification, or carrying out the same kind of survey activity hereafter, this Volume will grow available as a sort of manual.

In addition, in this Volume, the statement has been partly seen in common with the North-Central and North-Eastern States, so that the structure has some blank pages.

Volume "General Specification":

In this volume, the common parts of technical specifications which are able to be used repeatedly have been involved when rural electrification was carried out by diesel generation as a power source.

Volume "Individual Specification":

In this volume, the design papers have been dealt assembly at this moment concerning the towns pointed out in electrifying them with diesel generation, so that getting the volume together with the Volume "General Specification", this volume has grown as complete designs and specifications. In consequence, putting general conditions together with bid conditions, etc., orders are able to be issued.
In connection with the design papers, we print numerical tables only. Accordingly, regarding the drawings, they can be dealt with by way of making the reprintings from the originals which have been sent.

2. PURPORT AND CONCLUSION

Regarding the volume "Feasibility Study Report", we would like to mention the outline.

2.1 SURVEY OF THE TOWNS DESIGNATED FOR ELECTRIFICATION

Town survey for electrification has been carried out as follows.

1) The following data have been secured beforehand and confirmed at the site.

   i) Present situation of each town to be surveyed and information from the state government in regard to a future plan.

   ii) Aerial photographs or maps of towns to be surveyed.

2) Carrying out site surveys of towns, new informations and necessary data have been looked for.

Through these ways, the survey team secured the demand forecast of towns to be surveyed and the necessary data for the plan and design of facilities to be electrified. Moreover, concerning the power transmission route for above towns to be electrified, it has been dealt to the extent of economic evaluation applicable dependent on the current situation.

2.2 DEMAND FORECAST

1) The power demand forecast has been carried out under the survey results of each town by way of the forecasting process dependent on the following three data.

   i) Survey results on real situation in already electrified towns.

   ii) Statistical data of already electrified towns secured from NEPA.

   iii) Process which were available in several cases of survey for electrification carried out in the past.

In the meantime, the demand forecast has been carried out a little more intensively than usual for the reason why it has been in the period of economic fluctuation at present and rapid economic growth will be foreseeable hereafter.

2) We have estimated the maximum demand in 1985 as follows under the demand forecast.

in the case of big towns	Kachia	(706 kW)
	Zonkwa	(693 kW)
	Jibiya	(506 kW)
	Soba	(506 kW)
in the case of intermediate towns	Makarfi	(487 kW)
	Kankara	(450 kW)
	Musawa	(333 kW)
	Maiadua	(354 kW)
in the case of small towns	Hunkuyi	(256 kW)
	Kudan	(247 kW)
	Shika	(148 kW)

The average in between these towns has run to 426 kW. The average demand per customer is 0.88 kW which is smaller than 2.5 kW (in 1972), the nation-wide. This fact has brought us that in such rural towns, enough load has not been grown up yet. The breakdown of the load has been at present occupied at 60 - 80% to the whole with the load of public facilities such as for education, medical treatment, and water supply, etc.

On the other hand, we have forecasted the universalization at 20%, but this rate has brought us our judgement that an electric tariff payment to the present whole income has occupied at a high rate of above 10% (45 kWH ₦3.1) at ordinary houses and has to be payed in block every month.

In consideration of the fact that power demand is dreadfully high in industrialized, commercialized and electrified towns, a low electric rate policy may bring more increase in consumer's contracts, we think.

2. 3 PLAN OF FACILITIES AND ITS DESIGN AND SPECIFICATION

The plan of facilities shall be, in principle, equivalent to power demand ten years after, and the facilities themselves shall be designed and specified under to the standard of NEPA and criteria of Nigeria.

a) Power Sources

Diesel power stations shall have four diesel electric generators and be on synchronized operation system, and also have enough capacity which is able to operate the system even if one generator is shut down. The number of generators which is constructed for the first time shall be able to take the power demand up to three to four years ahead. In the station building, enough space to erect a generator at one rank higher in capacity has been provided and flexibility has been furnished equivalent to the increase in power demand more than forecasted.

b) Distribution System

Voltage of high tension power distribution lines in towns shall be at 11 kV inconsideration of the situation of being electrified with either diesel generation or transmission lines.

Designs and specification for sustaining materials determine, in principle, to use Nigerian-made concrete poles together with wooden-poles, as the case may be. Looking at the power demand forecast, the load of which place is outstanding hasn't been designed yet. Even in small towns of which power distribution can be dependent upon low voltage only, the constitution at high and low voltage has been applied for the feasibility to future expansion.

2.4 ECONOMIC EVALUATION

2.4.1 Comparison with eleven towns which are to be electrified was made as follows.

a) Purpose

This is for selecting which way is advantageous in power sources for electrification, power source introduction with transmission lines from the grid system of NEPA, and power source supply by diesel generation.

b) Comparison

This means to compare the amount of income and expenditure between the above two ways in five years after electrification. We have applied proper values obtained by the data from the survey of our team for this calculation and have estimated the construction cost dependent upon the values foreseen in 1976.

Calculated results have been as follows.

i) Advantageous case brought about from electrifying the towns by diesel generation.
Kachia, Zonkwa, Jibiya, Musawa

ii) Advantageous case brought about from getting power sources by connecting transmission lines with the grid system of NEPA.
Makarfi, Kankara, Maladua, Soba, Hunkuyi, Kudan, Shika

2.4.2 We have counted the capital cost for eleven towns to electrify them.

Capital cost for power source system	₦1,973,500
Capital cost for power distribution system	₦1,141,900
Total	₦3,115,400

2.5 OUR ADVICE ON THE FUTURE RURAL ELECTRIFICATION IN THE NORTH-CENTRAL STATE

Our team has adviced, as follows, how to encourage rural electrification under our team experiences secured by the survey activity carried out at this moment to the state government planning earnestly to encourage rural electrification.

1) Results of rural electrification look like to be favourable to encourage it upon a integrated electrification plan.

2) A integrated electrification plan to rural electrification needs to be established in order of basic electrification plan and concrete electrification plan in full consideration of the intention of the state government on rural electrification.

3) In addition, for rural electrification plan, it needs to be arranged for making the construction work and the operation of electrified facilities smoothly preparing relative items necessary to electrify.

4) Necessary conditions for putting forward the establishment of electrification plan such as provision for technology and cooperation with NEPA and so forth need.

Based upon the advices mentioned above, we have attached a drastic test plan titled "one Model in North-Central State Rural Electrification" and an outline of "Preparation of Electrification Plan" so that the state government may be able to judge the electrification plan with a concrete image.

3. RECOMMENDATION

3.1 SELECTION OF POWER SOURCES FOR RURAL ELECTRIFICATION

Economic comparison is as mentioned in the column of the conclusion of the Item VI "ECONOMIC EVALUATION".

In this statement, the following points need to be solved for electrifying rurally with transmission lines.

1) The undermentioned points need to be modified by NEPA authority concerned.

   i) Which do transmission lines construct, NEPA or State Government concerned?

   ii) Which do transmission lines operate and maintain, NEPA or State Government concerned?

   iii) How to do technical adjustment between NEPA and State Government concerned.

2) When a State Government carries out the construction, operation and maintenance, security of the staffs, and the training and systemization to them need to be arranged in compliance with the Appendix 1.

If these problems would be solved, electrification works are to be carried out under the detailed survey and the specification of each electrification work in regard to each transmission line on the basis of the power source plan and its basic design as shown in V-2.

In addition, in this case, even if the existing power sources are at 11 kV in the power transmission system, it is favorable to construct a new transmission line of the 33 kV design in consideration of future extension of the transmission system.

When a rapid settlement of such problems is rather difficult, and an intention to forward rural electrification still early exists in the State Government concerned, rural electrification is to be able to be carried out with diesel generation in conformity with the Volumes "General Specification" and "Individual Specification".
However, since the transmission line of NEPA has been installed for the univercity in Shika, the power source of Shika ought to be connected directly with the above NEPA system.

3.2 PROPER REVIEW ON DEMAND FORECAST

At the present time, it seems to be in a serious economical fluctuating period and to grow gradually materialized successively in the arrangement program of public facilities as well as to turn distinct one after another in the factory arrangement program. In consequence, it ought to review the demand forecast at the stage of carrying out the work, to analyse the difference between loaded results after electrification and forecasts, and to try hard to make a proper choice in the scale of the work to be carried out and the capacity and period to be extended.

3.3 ENCOURAGEMENT IN ELECTRIFICATION UPON INTEGRATED ELECTRIFICATION PLAN

Rural electrification in a state area ought to be forwarded under a integrated electrification plan in order that it may be tried to carry out rural electrification more suitably, economically, safely, and also more smoothly.

In the meantime, rural electrification for several towns programmed at this moment is advisable to be carried out because of accumulation with experiences in this field.

3.4 STEADY ADVANCE IN ELECTRIFICATION WORKS

When electrification works are carried out in eleven towns at this moment, it needs to be scheduled smoothly in dealing with the works. For example, adjustment between the capability to carry out the works and the arrangement to the operation and maintenance system needs to be taken account in such cases as electrification is to be carried out in about half of eleven towns at first and, secondly, in remaining towns.

III. SURVEY OF THE TOWNS DESIGNATED FOR ELECTRIFICATION

The survey team surveyed the towns desingated for electrification to estimate the demand and to design the facilities by taking the following steps.

1. DESIGNATION OF TOWNS FOR ELECTRIFICATION

1) The state government designated the towns to be electrified under the present plan mainly from the following viewpoints.

i) Politically important towns:

Administratively important principal towns in which Administrative Headquarters (Development Area Headquarters or Local Authority Headquarters) and District Headquarters are located, and towns with special facilities such as educational facilities.

ii) Industrial towns:

Towns which are important for transportation, commerce, industrialization and agriculture.

iii) Population:
Towns with population of over ten thousands.

iv) Others:
Towns which are easy to be electrified having power sources in the vicinity, etc.

2) The survey team consulted with the state government on whether the towns were included within the "Countrywide Electrification Project" which had recently been ordered by NEPA for installation, and whether it was possible to investigate within the limited time, and the towns to be investigated were decided upon mutual agreements.

2. GENERAL SURVEY OF THE TOWNS

1) The investigation of the present conditions of each town and of various projects.

In order to grasp the characteristics of each town, the size, the population and the existence of facility, planning projects and various data were obtained from the Ministry of Economic Planning and from the Ministry of Work and Housing of the State Government, prior to conducting the field study.

2) Aquisition of maps and sketches

The maps and sketches which were to be used for designing facilities within the towns and in the transmission lines were obtained through Ministry of Land and Survey.

i) Firstly, the existence of maps (1/3,000 - 1/10,000 which are necessary for designing within the towns, and 1/50,000 for designing transmission lines) was checked.

ii) Secondly, the existence of aerial photographs (1/3,000 - 1/10,000) was checked.

iii) When microfilms of aerial photographs were found, they were projected by an enlarging machine and hand-copied.

iv) The outlines of towns and the roads were sketched from aerial photographs of 1/25,000 - 1/50,000, when there were not any aerial photographs of larger size. In addition, enlarged photographs of 1/5,000 were obtained from the original films of aerial photographs of 1/10,000 - 1/40,000 provided by the Air Survey Section of Federal Survey of Federal Ministry of Works and Housing, though it was after the survey.

3. FIELD SURVEY OF EACH TOWN

1) Decision on the field survey plans

i) Schedule:

One or two days per town. One day was spent for intermediate processing of data for every couple of towns surveyed.

ii) Transportation:

One or two passenger cars and one truck were supplied by the State Government.

iii) Personnel:

Four persons of the investigation team, one counterpart of the State Government, one messenger boy, two drivers (with a boy). One officer of the town and one guide at the time of investigating the town.

iv) Place of accommodation: Hotels, catering rest houses, etc.

2) Investigation on the outline of the town

On arriving at the town designated to be electrified, the survey team received explanations from the head of the town using a list of tables concerning the present conditions of the town, main buildings and projects expected in the future. (See Table III-1)

Table III-1 TOWN LIST

1. State Name
2. Town Name
3. Priority
4. Survey Date.
5. Classification of Town (Include projected).
   (1) Political
      - o Administrative Headquarters
      - o Development Area Headquarters
      - o Local Authority Headquarters
      - o District Headquarters

(2) Industrial

- o Agricultural Town
- o Industrial Town
- o Commercial Town
- o General Town

(3) Traffics

- o Main Route Town or Trade Route Town
- o Other Town.

(4) Others

- o Major Border Town
- o Towns Near Major Town
- o Other Town.

6. Population

7. Main Building List (Incluue Proposed or Decided Consumers)

Main Offices

- o Government Office
- o District Office
- o Local Authority Office
- o Other Main Office

Educational Facilities

- o University
- o Secondary School or Teacher's Training College.
- o Primary School
- o Others

Medical Facilities

- o Hospital
- o Health Centre
- o Dispensary
- o Others

Public Utilities

- o Council Hall or Town Hall
- o Court
- o Prison
- o Police Station
- o Library or Reading Room
- o Post Office (Agency)
- o Mosque
- o Church

Water Supply

- o Pump House

House and Residence

- o Emir's Palace
- o Chief's House
- o Officer's Staff Residence
- o Guest House
- o Police Barrocks
- o Hotel

Industry and Others

- o Market
- o Big Factories
- o Local Factories
- o M.O.W. Yard
- o Others

8. Existing Generators (Including Small ones)

3) Investigation on Principal Demand
Based on the list explained by the head of the town, location of main buildings, size of the demand, areas with high demand density and location of sizable proposed consumers were checked and confirmed.
In addition, future plans to enlarge secondary schools and health centres etc. which may become sizable loads after the electrification, and the capacity and the load of the existing generators were investigated.

4) Preparation of sketches

i) When sketches obtained from maps, aerial photographs and microfilms were available, the outline of the town, new areas and the distance were confirmed by driving and walking, and the main landmarks were recorded.

ii) When sketches concerning the town were not available, sketches of the town were prepared by taking the following steps. Firstly, the existence of main roads and branches, the main landmarks and the outline of the town were confirmed and the steps for the survey were decided. Then one of the members sketched freehand confirming the direction by means of a magnet. Another member measured the distance between the centers of the roads by a range finder, a tape-measure and also supplementarily by pacing and by an automobile hodometer

iii) The following main landmarks were recorded on the sketches.
- o direction (showing the north),
- o principal roads and branch roads where distribution lines may pass,
- o the outline of the town, o main buildings, main houses,
- o hills, rivers, ponds, railroads, etc.,
- o existing distribution lines, o location of diesel power plants.

iv) Finally, the conditions of the town were recorded in more than ten photographs.

5) Selection of the location of power station and of the routes of the distribution lines.

i) The proposed sites for the power station were selected so as to locate them in the center of the load, to make transportation of instruments and fuel feasible, and to minimize the effect of noise.

ii) Investigation necessary for laying out the route of the lines was undertaken so that the distribution lines might be supplied from the center of the load, that there would be enough space for installing transformers and that deforestation might be minimized.

4. THE RESULT OF THE INVESTIGATION OF THE TOWNS

The towns to be electrified were studied by the above methods and the results are shown in the Table III-2 and the details are shown in Table Annex.

Table III-2 TOWN LIST (North-Central State)

1. Town Name	KACHIA	MAKARFI	JIBIYA	MUSAWA	ZONKWA	MAI-ADUA	KANKARA	SOBA	HUNKUYI	KUDAN	SHIKA
2. Population (1976 Estimate)	5,700	6,700	14,500	12,600	15,400	20,600	13,900	14,400	14,000	12,800	2,700
3. Survey Date	8/9th 11,'74	21st 11,'74	11th 11,'74	15th 11,'74	29th 11,'74	13th 11,'74	16th 11,'74	22nd 11,'74	19/20th 11,'74	19/20th 11,'74	18th 11,'74
4. Classification of Town											
(1) Political	Ad. H.Q Dis. H.Q.	Dis. H.Q.	Dis. H.Q.	Dis. H.Q.	-	Dis. H.Q.	Dis. H.Q	Dis. H.Q.	-	-	-
(2) Industrial	Agric.	Agric.	Com. Agric.	Agric.	Com. Agric.	Cattle Agric.	Agric.	Agric.	Agric.	Agric.	Agric.
(3) Traffic	Main Route	Main Route	Trade Route	General Route	Main Route Railway	Trade Route	Road Junction	Main Route	Main Route	Main Route	Main Route
(4) Others			Border		Educational	Border					
5. Priority	High	High	Medium	Low	Medium	Medium	Medium	Medium	Medium	Medium	Low
6. Main Loads											
(1) Town Area Future Load Growth 1 - 5th 5 - 10th	High High	Medium High	Medium Medium	Low Low	High High	Low Low	Low Medium	Low Medium	Low Low	Low Low	Low Low
(2) Extension Area (Gov.) (Others)	G.R.A. Existing	G.R.A. -	- -	- -	- Existing	- -	- Existing	- -	- -	- -	- -
(3) Secondary School Number of Students (1974)	Existing 550	Existing 350	(P) -	Existing 140	Existing 270	-	(P)	Existing 510	-	-	-
Other big School Number of Students (1974)	-	-	-	-	Existing (W.T.C.) 330	-	-	Existing (T.S.S.) 650	-	-	-
(4) Health Centre	Existing	(P)	(P)	(P)	Existing	(P)	(P)	(P)	-	-	-
(5) Water Supply	(P) Dam	(P)	(P) Dam	-	(P)	(P)	(P)	(P)	-	-	-
(6) Others	M.O.W. Yard Army Training Centre	-	Custom Post Kaga	-	-	-	-	-	-	-	-

NOTE: Agric - agricultural Ad - administrative Dis - district H.Q. - headquarters G.R.A. - government residential area
L.O.A. - local authority residential area Com - commercial (P) - proposed W.T.C. - women teachers college

IV. DEMAND FORECAST

1. BASIC PHILOSOPHY

1) We investigated on the towns to be electrified to estimate the demand and grasped the present conditions of the towns and the actual situations of various projects now being proceeded. In addition, we obtained various materials of value from NEPA and investigated on the present conditions of the towns already electrified. Also, supplementarily, we referred to T. Ingledow (1970), and Merz and Mclelan (1970), which are the rural town electrification program reports consisting mainly of data in the growth period of 1960's and Gapac (1973), Motor Columbus (1973), which are the enforcement program reports.

2) Based on these results, load requirement was estimated as follows.

Further, due to the recent new trends that the state government is putting hand on its priority policies to expand public facilities of educational, medical, water service, roads and offices, electrification to help these purposes are being urged. By electrifying the town, construction of factories is to be encouraged, which brings forth an expectation for the development of the town and for the improvement of the living standard and productivity. The income of the public is expected to increase, which will result in higher distribution of electricity. The demand was estimated taking these things fully into consideration.

3) Thus, the demand was estimated to be rather on a higher side, but it is hoped that the reliability of the estimation shall be improved by checking it at the stage of construction and by checking the regular load after electricity is supplied.

2. METHODS OF ESTIMATION

2.1 ITEMS ESTIMATED

Estimation was made for the following items.

1) Maximum demand

In order to decide the output of generators, the capacity of transformers and the organization of distribution systems.

2) Number of consumers

In order to estimate kWH sales and installation expenses.

3) Energy consumption (sales)

In order to grasp the actual power demand, the expenditure and the income from the sales.

2. 2 ESTIMATION OF DEMAND

We estimate power demand from actual existing undertaking data and other considerations as following chart.

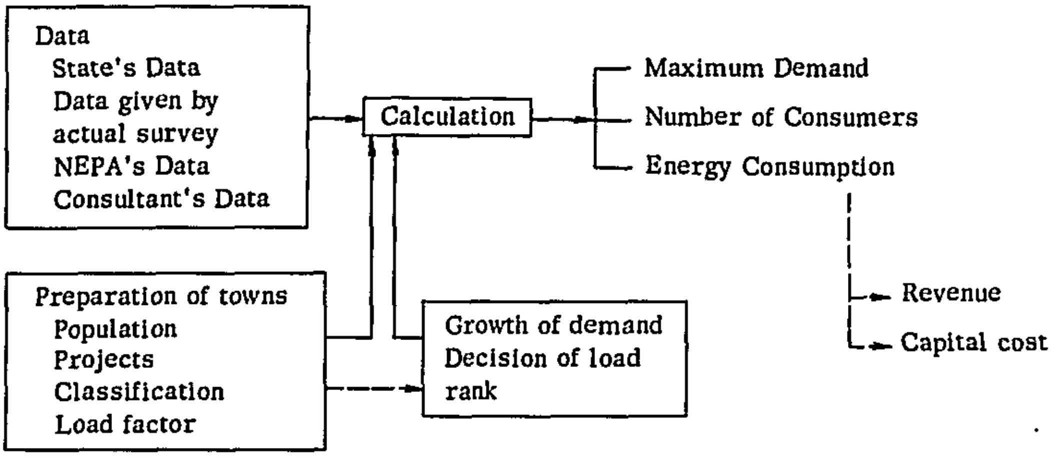


Fig. IV-1 Estimation of Power Demand

2. 3 CLASSIFICATION OF LOAD

The breakdown of load by each town is as follows.

1) Existing town area where the demand for electrification is made up of many small consumers.

2) Government residential area, local authority residential area and the extension area developed by the town.

3) Boarding educational facilities such as secondary schools and teacher's colleges.

4) Medical facilities like rural health centers with about 35 beds.

5) Water supply for towns, hospitals and agricultures.

6) Other big loads.

7) Street lightings.

8) Miscellaneous

2. 4 THE YEARS FOR WHICH THE DEMAND IS ESTIMATED

We estimated the demand for the following years.

Starting year 1976

Estimate years .... Every year from 1976 through 1985

The estimation was made for each of the following breakdowns of the load

1) Existing load .... from 1976 through 1985

2) Those under construction and those to be constructed in the near future .... from 1976 through 1985

3) Proposed load

   Extension area .... from 1978 through 1985

   Educational facilities ... from 1976 through 1985

   Health centers .... from 1978 through 1985

   Water supply .... from 1978 through 1985

4) Not yet proposed

   Educational facilities ... from 1981 through 1985

   Health centers .... from 1983 through 1985

   Water supply .... from 1983 through 1985

2. 5 THE GROWTH OF DEMAND

The growth rate of the demand in the towns already electrified has actually been accerelated to around 20%. Therefore we have postulated that the demand increases annually at a fixed rate rather than the constant annual addition to the load as presently conducted by the state.

2. 6 POPULATION

The growth of the population after 1976 is assumed to be 3.5%, which consists of the regular population growth of 2. 9% and the expected growth by electrification of 0. 6%.

2. 7 ESTIMATION OF DEMAND FOR EACH TOWN

The results of demand estimation was obtained by adding the amount for each breakdown of the load. Also in the calculation the following points were considered.

1) Distribution lines will be connected to the consumers who have their own generators before the electrification.

2) As to the maximum demand, we assumed that the distribution loss would offset the diversity factor and it was not taken into consideration.

3) Projects with big factory loads are decided after the electrification, and therefore the installed capacity of the power station and of the distribution lines are to be estimated in accordance with the demand after the construction is completed. Thus the demand for these loads was not estimated.

3. ESTIMATION FOR EACH BREAKDOWN OF THE LOAD

3. 1 EXISTING TOWN AREA

1) General description of the load

The categories of the predicted power demand are contained in the presently administered charging system, i. e. , residential, small commercial and industrial groups:

i) Residential:

The inhabitants of the town are mostly engaged in agriculture composing a low income class. Standard families with seven members and with three or four rooms are selected for electrification. While the current costs for lighting lamps are ₦2. 1 per month (7 kobo/day), the electricity charge will amount to ₦3. 1 (45 kWH).

Assuming the income of a family to be ₦30 a month, the electricity charge corresponds to 10% of the income. In addition, connection fees and indoor service construction fees are expensive and these must be paid in a lamp sum for each month, rendering the burden still heavier. Consequently, a fairly large number of consumers may give up installing electricity, although the number of consumers will increase with the improvement of personal income. Thus, except for the public facilities, the consumers will mainly consist of officers, traders, merchants, big farmers, etc. , who receive relatively high income.

As to the load peak, evening peaks are expected because consumption will be limited only to lighting for some time for the prices of electric appliances are expensive for the income.

ii) Commercial:

Consumers will mainly consist of public facilities and shops which are opened at evening.

iii) Industrial:

Small local factories use gasoline engines for generators, and the fuel requirements are usually 2ℓ/H below 3 kVA and 3. 8 /H for 5 kVA. When electrified, the cost of electricity will be around the same or less, and there will be less noise. Therefore, the electrification is expected to proceed except within the farming fields where there is no power source. The consumption of electricity will be during the daytime and the effect on the evening peak demand will be small.

Under these circumstances of the town, the following points are to be considered as the factors to help judge the future development.

i) Politics:

If the town is politically important as the town is the centre of the wider area or important town in the State, various facilities will be planned, many person will visit or stay, then the town will be prospered, and income of the individual shall be rapidly increased so the growth rate of load will be very high as well.

ii) Transport:

The most important transport method is by road. Towns near the important road crossing, therefore, tends to have more traders and marchants shall be accelerated to increase in these towns.

iii) Industry:

These towns are almost all agricultural towns where people will use the smaller size of motor (2-3 kW at most 10 kW) for their factories such as local sugar cane factories or cotton seed factories etc.

iv) Special load:

Town area load increase shall be expected where hospital, secondary school etc. are established.

v) Merchants and shops:

We studied the towns which had been already electrified main consumers for electricity consist of shops or houses of big merchants and traders except public facilities.

vi) Houses:

As the electrification will start from some permanent buildings and big houses in each towns we made these houses as important check point.

2) Demand (kW)

i) Calculation

demand (kW) = average kW per consumer x number of consumers

ii) Average kW per consumer 0.3 kW

Since large demands for supply is expected in the first and the second years after the electrification, the average kW per consumer was assumed to be 0.35 kW and 0.32 kW, respectively, with reference to Ingledow Report.

Note 1: The number of kW per consumer will increase as consumers purchase new appliances. On the other hand the increase in the number of consumers invites the decrease in the demand rate and also the new consumers will come from the low income class. Therefore no growth is predicted in the general average.

Note 2: The average kW per consumer of 0.3 kW was assumed to belong to the "medium" in the rankings of the towns and the "high" was assumed to be medium plus 10% and the "low" medium minus 10%. Also the ranking of high, medium and low for each town was predicted by dividing the future developments into the short term (1 - 5 years) and the long term (5 - 10 years) with reference to the actual conditions of the towns previously explained in the general description of the load.

Short term (1976-1980): merchants, shops, houses and special loads which represent the present state of the towns.

Long term (1981-1985): politics, transport, industry and special loads which predict future development of the towns.

Refer to Table III-2 for the ranking of each town surveyed.

3) Number of consumers

i) Calculation

Number of consumers = average number of consumers per population x population (1 + annual growth ratio)^n

ii) Average number of consumers per population: 21.8×10^{-3}

Also by the same reason expressed in 3. 1. 2) ii), 12.8×10^{-3} and 18.0×10^{-3} were assumed for 1976 and for 1977, respectively.

iii) Annual growth rate after the third year: 8%

The details are as follows:

population growth	2.9%	3.5%
new consumer growth after electrification	0.6%	
new request to electrification increase of personal income increase of commercial and industrial consumers others		4.5%

iv) The above figures belong to the medium in the ranking of the town. The "high" is medium plus 20% and the "low" is medium minus 20%.

v) n ; the number of years after the electrification - 2

For the first and the second year, n is supposed to be 0.

4) Energy consumption (kWH sales)

i) Calculation

kWH sales (kWH) = consumption per consumer per year x number of consumers (1 + annual growth ratio)^n

ii) Consumption per year: 750 kWH

Note 1: By the same reason expressed in 3. 1-2) ii), the amount was assumed to be 400 kWH for 1976 and 700 kWH for 1977.

Note 2: The above figures belong to the "medium". The "high" is medium plus 10% and the "low" is medium minum 10%.

iii) Number of consumers See 3. 1. 3)

iv) Annual growth rate: 3%

Note: The town belongs to the "medium" in the ranking. The "high" is medium plus 10% and the "low" is medium minus 10%.

v) n ; the number of years after the electrification - 2.

For the first year and the second year, n is assumed to be 0.

3.2 EXTENSION AREAS

1) General description of the load

Public facilities like offices, courts, guest houses, police stations, officers' houses and police barracks comprise the main consumers. Many of them are now being proposed or being constructed and they will make up a new urbane district. As a whole, many of them will be private houses.

According to the survey of the towns already electrified, the appliances which are used in individual loads are those highly electrified such as lighting, water heaters, refrigerators, air conditioners, fans, cookers, washing machines, etc. Therefore, the monthly charge for electricity to be paid amounts to around ₦20.

From this figure, we assumed the maximum load per consumer to be 8 kW in G. R. A. (Government Residential Area) and 5 kW in other areas and the calculation was made with the demand ratio of 0. 6.

2) Demand (kW)

i) Calculation

demand (kW) = average kW per consumer x number of consumers

ii) Average kW per consumer

G. R. A.	4. 8 kW
other areas	3 kW

Note: By the same assumption expressed in 3. 1-2) ii), no growth is predicted.

3) Number of consumers

The growth of consumers will be as follows:

G. R. A.	3 x number of year after installation
other areas	2 x number of year after installation

4) Energy consumption (kWH sales)

i) Calculation

kWH sales (kWH) = 365 x demand x load factor x hour x $(1 + \text{annual growth ratio})^n$

ii) Demand See 3. 2. 2)

iii) Load factor x hour

Since electricity will be used for 24 hours a day, we assumed that the total load factor per day is 0. 21 with 0. 1 x 12 hours for the day, 0. 7 x 5 hours for evenings and 0. 05 x 7 hours for the night.

iv) Annual growth rate

Note: Identical as with that of the existing town area.

v) n ; the number of years after the electrification - 1.

3.3 EDUCATIONAL FACILITIES

1) General description of the load

Secondary schools and teachers' colleges are now being constructed urgently under the educational policies of the state.

Table IV-1 NUMBER OF STUDENTS PER SCHOOL
(Secondary School and Teachers College)

Item	1968	1969	1970	1971	1972	1973	1974
N. E. State. Number of Students per 1 School	230	223	211	239	243	266	332
Growth percentage		△ 3	△ 5	3	2	9	25
N. C. State. Number of Students per 1 School	191	235	246	267	306	430	N. D.
Growth percentage		23	5	9	15	41	-

Table IV-2 SUMMARY OF BIG SCHOOL
(Example of Surveyed Town)

1974

Classification of School		Capacity of Generator kVA	Peak Load kVA	Number of Students 1974	Number of Students 5 years Estimate	Note
A	S.S.	N. O. N.	N. O. N.	140	1000	
B	S.S.	65.7	7	350	1000	New school
C	T.S.S.	138	N. D.	650	1000	
D	G.S.S.			510	1500	
E	S.S.	65	55	550	N. A.	some classrooms are not electrified
F	W.T.C.	25	N. D.	330	700	
G	G.S.S.	25	N. D.	270	N. A.	
H	S.S.	25	25	450	800	Generator will be changed to bigger one soon
I	S.S.	N. O. N.	-	300	N. A.	
J	S.S.	N. O. N.	-	50	N. A.	
K	S.S.	5	N. D.	150	N. A.	

Note: N. D. : no data N. A.: no answer N. O. N. : no existing

These educational facilities can be divided into school load which includes offices, classrooms, water supply, dining rooms and dormitories for all students and residence load which includes residence for main staffs and teachers.

The residence is highly electrified to guarantee the living for the teachers who work in secluded areas. Electricity for lighting is now supplied by a small generator for about two hours in the early morning and for about five hours in the evening, but many places suffer from insufficient supply because of the rapid increase in the number of students and teachers.

2) Demand (kW)

i) Calculation

demand (kW) = kW per student x number of students

ii) kW per student 0. 12 kW

Note: Judged from the data actually collected in the field investigation.

iii) Number of students

i) Already electrified schools

Number of students = number of students at 1974 x $(1 + \text{annual growth rage})^n$

Note 1: annual growth rate 0. 1 (10%)

2: maximum number of students 1,000

This figure is assumed to be the upper limit.

ii) Schools not yet electrified

Number of students at 1976 = 1. 5 (number of students at 1974 + 50 x 2) x $(1 + \text{annual growth rate})^n$

Note: The number of students after the electrification is assumed to be 1. 5 times of the existing number, since the improved equipment is predicted to bring about the increase in the number.

iii) Proposed schools

The number of students was assumed to be 150 for the first year, 250 for the second year and 300 for the third year with the annual growth rate identical with that in 1).

iv) n : the number of years after the electrification - 1

3) Number of consumers (for reference)

The residential load in the school load forms the consumers to whom the distribution lines are connected after the electrification. Since rapid increase in the number of students is predicted in the future, the number of consumers is assumed to be 0. 04 for one student with reference to the actual conditions shown in Table III-3.

Table IV-3 NUMBER OF TEACHERS PER NUMBER OF STUDENTS (Secondary School and Teachers College)

	1968	1969	1970	1971	1972	1973	1974
N-E State	0. 050	0. 058	0. 057	0. 049	0. 049	0. 047	0. 045
N-C State	0. 063	0. 053	0. 053	0. 053	N. D.	0. 024	N. D.

4) Energy consumption (kWH sales)

i) Calculation

$$\text{kWH sales (kWH)} = 365 \times \text{demand} \times \text{load factor} \times \text{hour} \times (1 + \text{annual growth ratio})^n$$

ii) Demand See 2)

iii) Load factor x hour

Since electricity will be used for 24 hours a day, we assumed that the total load factor per day is 0.3 with 0.2 x 12 hours for the day, 0.8 x 5 hours for evenings and 0.1 x 7 hours for the night.

iv) Annual growth rate 3%

Note: Identical with that of the existing town area

v) n : the number of years after the electrification - 1

3.4 MEDICAL FACILITIES

1) General description of the load

In the towns investigated rural health centers are now being constructed urgently. The content of the load is offices, wards, machine equipment rooms, dining rooms, residence for main staffs, doctors and nurses, and water supply. Residence is highly electrified. In a certain newly established hospital, they are planning to expand medical equipments like sterilizers to three times as much as the existing equipment. With a load of 6 - 10 kW for an X-ray apparatus, the peak will be five to six times as much as the existing one in many equipment. Therefore it is required to construct electric equipments with sufficient capacity. Electricity is now supplied by generators of 50 - 100 kVA for a limited period of hours, but after the electrification it will be switched to round the clock operation. Water supply for medical facilities is included in that of the town.

2) Demand (kW)

i) Calculation

$$\text{demand (kW)} = \text{demand at the third year } (1 + \text{annual growth rate})^n$$

ii) Demand at the third year 45 kW

The demand at the first year and the second year is assumed to be 25 kW and 35 kW since the rapid increase in load is predicted from the actual conditions of the towns investigated.

iii) Annual growth rate: 0.1

The figure was assumed from the predicted increase in the number of beds in the state.

iv) n : the number of years after the electrification - 3.

3) Number of consumers (for reference)

Doctors, a part of clerks and nurses will make up the consumers. From the present conditions, we assumed the number to be six at the beginning stage. It was also assumed that the number will increase in accordance with the demand.

4) Energy consumption (kWH sales)

i) Calculation

kWH sales (kWH) = 365 x demand x load factor x hour x $(1 + \text{annual growth ratio})^n$

ii) Demand — See 2)

iii) Load factor x hour

The total load factor was assumed to be 0.51 with 0.6 x 11 for the day, 0.8 x 5 for evenings and 0.2 x 8 for the night.

iv) Annual growth rate — 13%

Note: Identical with that of the existing town area

v) n : the number of years after the electrification - 1

3.5 WATER SUPPLIES

1) General description of the load

Water is now supplied from wells and rivers and carried by hand or by trucks. After the electrification water will be pumped up by motors and supplied individually for use in towns, hospitals, plant fields and livestock ponds by reservoir tank systems or by continuously pressurized systems.

The load of the electricity is predicted based on the reservoir systems in which peaks appear in a short time. Initially, calculation was made with the operating time of 3 hours per day, and with the height of the water pumped up 10 meters above the ground and 10 meters below the ground making the total height of 20 meters. Electricity for the water supply is mainly used in daytime and usually it will not affect the peak demand. Since the worst case of the evening operation was foreseeable, it was calculated as an evening load.

2) Demand (kW)

demand (kW) = kW for towns + kW for hospitals + kW for others

i) kW for towns

The volume of water used was estimated as per capita water consumption x population + losses and the corresponding capacity of electric motors (initially with an operating time of 3 hours a day) was estimated.

- per capita water consumption

  In a rural town where water supply has already begun, the actual record of the volume of water used per person per day is 1 - 2 gallons (0.0045 m^3 - 0.009 m^3)

at the beginning stage of the supply. However, rapid increase in use will double the consumption in 4 - 5 years, and so it is estimated to be 5 gallon/day (0.023 m^3/day) with some margin.

- o losses:

  Loss in the water supply was estimated to be 100% of the minimum volume of water required.

- o correlation between the volume of water required and the output of electric motors:

  The following correlation which is generally used was adopted.

Output of electric motors	Volume of water pumped per minute	Volume of water for three hours
3.73 kW	0.6 m^3	110 m^3
5.6	0.9	160
7.46	1.4	250
11.2	2.1	380
15	3.0	540
20	4.1	740
25	5.5	990
30	7.0	1,260
40	9.0	1,620
50	12.0	2,160
75	17.0	3,060
100	23.0	4,140
150	32.0	5,760

ii) kW for hospital

After the field investigation, it was estimated to be 15 kW, since the required volume of water is 500 m^3 for the initial operating time of three hours per day.

iii) kW for other use

The figures were assumed to be identical with those in town areas.

3) Number of consumers

This was estimated to be one for each purpose for which water is used.

4) Energy consumption (kWH sales)

i) Calculation

kWH sales (kWH) = (kW for town use + kW for other uses) x 3 x (1 + annual growth rate)^n + kW for hospitals x 3 x (1 + annual growth rate)^n

ii) Annual growth rates

for town and other uses	0.2
for hospital use	0.1

iii) n : the number of years after the electrification - 1

3.6 STREET LIGHTINGS

1) General description of the load

Main roads, shopping streets and much crowded areas shall be equipped with street lightings for the evening and night time illumination and to provide the low income class with the benefit of electrification which they still can not enjoy. Street lightings could use mercury lamps, sodium lamps, fluorescent lamps or incandescent lamps. We have, however, decided to use fluorescent lamps because of their low capacity and costs.

2) Demand

i) Calculation .

demand = kW per street light x number of street lighting x m.

ii) kW per street light 0.06 kW (0.03 kW x 2)

Note: The power factor was not taken into consideration.

iii) Number of street lights

Individual estimation on each town

3) m. 1 (1 - 5 years), 1.5 (5 - 10 years)

3) Energy consumption (kWH)

i) Calculation

kWH = demand x N x 3.65

ii) n : (consumption hour per day) 12

from 6.00 p.m. through 6.00 a.m.

3.7 OTHER LOADS

The contents of the demand were investigated respectively and then decided were made.

4. RESULTS OF THE ESTIMATION

1) We estimated the maximum demand, number of consumers, and energy consumption of the towns surveyed by the method of demand forecast. The results are shown in Table IV-4. The details are listed in Table Annex 1-1 - 1-11.

2) In order to comprehend the changes, summary of the demand forecast is given in Table IV-5. Further, the changes for a period of 10 years are shown in Fig. IV-2, for a typical town of Kachia with many public facilities and for Maiadua with much general demand.

3) As a result, the load will remarkably increase due to the increase in the number of public facilities like educational facilities, but the maximum demand is still pretty small even ten years later and is below 1,000 kW. The average demand per consumer is 0.71 kW in 1976 and 0.88 kW in 1985 against 2.5 kW (1972) in the whole Nigeria.

As to the breakdown of the load, public facility loads like those for the educational facilities, medical facilities and water supply account for about 70% of the total load.

The percentage of the electrified households will be 20% for the family of seven and considerable number of consumers will continue to use oil lamps. This is because the connection fee and the charge of electricity are still expensive and because the payment must be done in a lump sum. On the other hand, momentary saturation of loads of new facilities is observed in large towns and demand can be excited when personal income becomes higher. Thus, the future subject of importance to be considered is to help the low income class.

Besides this, high reliability in electrification will invite active electrification in both agriculture and industry thus exciting the demand and the development of the towns, which will lead again to the increase in demand.

Table IV-4 DEMAND FORECAST

Maximum Demand: kW
kWH Sales: 10^3 kWH

Town Name	Item	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
	Max. Demand	271	329	393	419	487	528	570	613	658	706
Kachia	No. of Consumer	152	196	234	258	285	309	335	363	392	424
	kWH Sales	676	846	1,017	1,172	1,345	1,508	1,684	1,883	2,085	2,339
	Max. Demand	112	139	225	268	304	342	375	412	449	487
Makarfi	No. of Consumer	115	155	194	214	235	258	283	311	341	373
	kWH Sales	230	324	560	687	825	952	1,089	1,249	1,416	1,607
	Max. Demand	120	161	276	306	339	367	397	430	466	506
Jibiya	No. of Consumer	249	349	431	465	500	538	579	622	669	723
	kWH Sales	197	375	657	790	935	1,071	1,219	1,388	1,581	1,801
	Max. Demand	84	101	153	172	192	207	224	292	311	333
Musawa	No. of Consumer	148	202	249	267	287	306	327	351	375	400
	kWH Sales	161	246	424	507	599	673	754	898	1,009	1,139
	Max. Demand	264	308	384	417	454	495	537	585	636	693
Zonkwa	No. of Consumer	293	395	474	519	566	626	685	756	827	909
	kWH Sales	618	842	1,060	1,210	1,374	1,567	1,782	2,026	2,302	2,674
	Max. Demand	64	85	205	222	239	269	295	315	334	354
Maiadua	No. of Consumer	205	289	358	382	407	441	474	505	538	572
	kWH Sales	79	187	432	518	611	738	857	975	1,099	1,239
	Max. Demand	75	107	232	260	287	326	354	383	416	450
Kankara	No. of Consumer	154	220	275	296	317	343	372	402	435	470
	kWH Sales	128	248	497	603	712	819	935	1,061	1,206	1,369
	Max. Demand	216	244	363	393	417	448	461	475	489	506
Soba	No. of Consumer	218	286	347	371	394	422	448	476	506	538
	kWH Sales	499	635	920	1,060	1,188	1,314	1,417	1,530	1,651	1,801
	Max. Demand	45	60	67	71	76	99	116	217	237	256
Hunkuyi	No. of Consumer	144	203	245	261	278	310	336	363	387	412
	kWH Sales	57	133	169	185	205	270	323	545	645	750
	Max. Demand	41	54	61	65	69	91	108	208	228	247
Kudan	No. of Consumer	131	185	224	238	253	277	299	328	351	375
	kWH Sales	53	122	155	169	184	251	302	521	620	722
	Max. Demand	13	17	20	21	23	41	57	117	133	148
Shika	No. of Consumer	36	51	64	69	74	88	100	118	129	140
	kWH Sales	17	36	46	51	56	110	150	317	393	469
	Max. Demand	1,305	1,605	2,379	2,665	2,887	3,213	3,494	4,047	4,357	4,686
Total	No. of Consumer	1,845	2,531	3,095	3,340	3.596	3,918	4,238	4,595	4,950	5,336
	kWH Sales	2,715	3,994	5,937	6,952	8,034	9,273	10,512	12,393	14,007	15,910

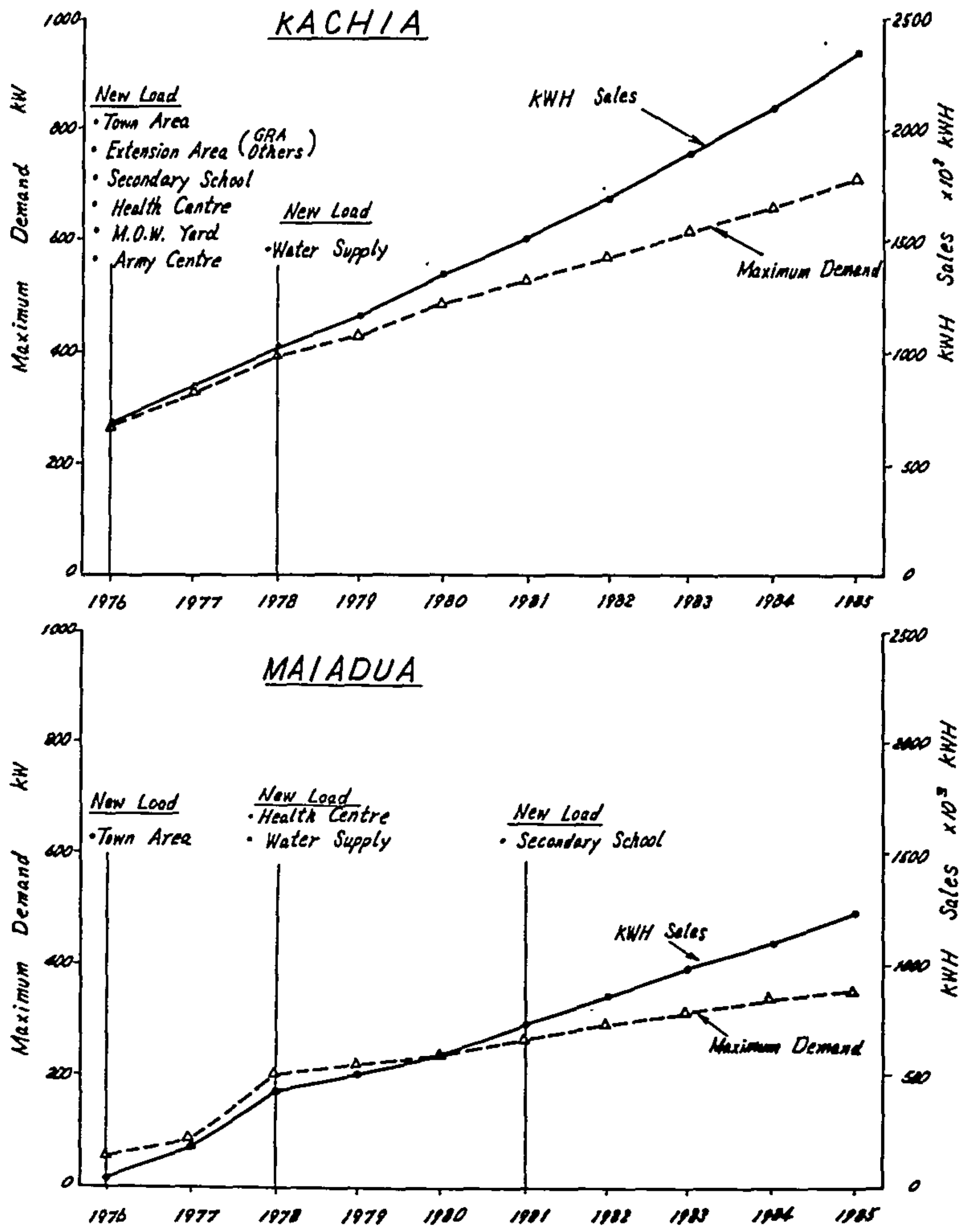


Fig. Ⅳ-2 EXAMPLE OF LOAD TRANSITION

Table IV-5 SUMMARY OF DEMAND FORECAST

		1976	1985
Maximum Demand			
Maximum Demand per town (kW)	Max.	271	706
	Min.	13	148
	Ave.	179	426
Average Demand per consumer (kW)		0.71	0.88
Average Demand per person (W)		10	26
Number of Consumers			
Average Number of Consumers per town		168	485
Average Percentage of Electrification (%)		9.7	20.7
Energy Consumption			
Average kWH Sales per Consumer per year (kWH)		1470	2980
Load Factor		0.24	0.39
Average Population per town		12.1	16.4

V. SUMMARY OF INSTALLATION PLAN DESIGN AND SPECIFICATIONS

1. GENERAL

In compliance with existing power systems in Nigeria, the installation plan, design and specifications are considered to ease construction, operation and maintenance of the project.

1.1 SYSTEM CHARACTERISTICS

Frequency	50 Hz	
Generating voltage	415/240 V	
High voltage	33 kV (for transmission line) 11 kV (for transmission and distribution lines)	
Low voltage	415/240 V	
Insulation level for high voltage line		
BIL (peak)	75 kV	
One-minute power frequency withstanding voltage (r. m. s.)	35 kV	
Grounding system	415/240 V	Multi-grounding common neutral system
	11 kV	Non-grounding system

1.2 STANDARDS

Planned design and installation practice comply with the Recommendations of International Electrotechnical Commission (I. E. C.) and the Laws of the Federation of Nigeria and Lagos (Chapter 57).

1.3 COORDINATION OF INSULATION

In order to provide economy for system cost, the coordination of insulation is much severer for series devices (insulator, line switches, power cables) which give influence to the customers in wide area, and the grade of the coordination is lowered to some extent for devices to be operated in parallel (distribution transformers, capacitors and so on) which may give rather local influence at operation failure.

Devices of lower insulation are protected by arrestors. Individual unit of diesel engine generators is protected by surge absorbers.

1.4 PROTECTIVE COORDINATION

In order to limit influence of a device failure to a very local area, by disconnecting the device in failure quickly from the system, close coordination must be provided for operating time of fuse-free breakers and relays in diesel power station and drop-out fuses and switches in substation.

1. 5 SHORT-CIRCUIT STRENGTH

The short-circuit strength of 11 kV system is determined by impedance of devices such as diesel generator, transmission line and step-down transformer. At present, the diesel electric generator provides a comparatively small short-circuit capacity, but in future, when the power will be supplied from transmission line, the short-circuit capacity of power source will be able to reach some 50 MVA. Therefore, a 50 MVA short-circuit strength must be given to the 11 kV system.

1. 6 CLIMATIC CONDITION

The design and installation practice for all devices comply with requirements in tropical zone.

1. 7 SELECTION OF DEVICES AND MATERIAL

1) Construction materials are selected, as much as practical, for ease of procurement and supply.

   Example: Supporters - concrete poles made in Nigeria.

2) An emphasis is placed on interchangeability and compatibility so that spareparts for maintenance are effectively reduced.

   Example: Unit capacity of diesel generators - 346 kW, 229 kW, 115 kW, 75 kW

   Wire size - 50 mm^2, 100 mm^2

2. POWER SOURCE

2. 1 POWER SOURCE SUPPLY SYSTEM

2. 1. 1 General

In electrification of rural towns by a 11 kV distribution system, either of the following power source systems would be possible:

1) A diesel power station in individual town.

2) Extension of transmission line from existing, under construction or planned NEPA's grid.

   i) Where existing under construction or planned grid is a 33 kV system, a 33 kV transmission line can be extended and the power can be introduced to a town through a tie transformer (33 kV/11 kV) to be installed at inlet of the town.

   ii) Where existing under construction or planned grid is a 11 kV system, the power can be directly introduced to a town through a 11 kV extension transmission line. (But, design of 11 kV transmission line has better to be 33 kV design.)

These possible approaches is examined for towns included in this project.

2. 1. 2 Individual Diesel Power Station Plan

Assuming that the power is supplied from individual diesel power station installed in each town, capacity and number of generators can be determined as follows:

a) Conditions to Determine Capacity and Number of Generators

1). In capacity, type of diesel engine generators have to unified for ease of construction, operation and maintenance. The type and capacity of diesel engine generators comply with the NEPA unified capacity standards. (Note 1)

The capacity of generators is limited to the following:

346 kW 229 kW 115 kW 75 kW (Note 2)

Note 1: In this report, the capacity of generators is selected from NEPA's Unified Standards, but, in order to assure freedom of device selection at actual procurement, it seems feasible that certain allowance (some -10% to +15%) may be given to the capacity of generators.

Note 2: The 75 kW generator is not listed in NEPA's Unified Standards, but, the small power generator seems advantageous, by the following reason, for use in towns for which very small load is foreseen.

- o At starting of system operation, some towns such as Hunkuyi or Shipa seems as small as 30 to 40 kW. If a 115 kW generator is selected, the small load will make the initial investment excessively large and operation efficiency will be lowered because of the excessively low load rate.

- o Estimated future load in these towns, 10 years after, will range 150 to 260 kW. If 115 kW generators are installed, excessive investment will be seen in the final installation which would be 115 kW x 4 = 460 kW. (The 75 kW generators would make the final capacity appropriate as 75 kW x 4 = 360 kW.)

2) Considering the ease of operation, interchangeability of devices and common use of spare parts, the capacity of diesel engine generators in a station is unified to the same type. The power house is designed to be capable of installing additional diesel engine generators of 1-rank larger, or to ensure replacement of generators with these larger generators, considering a possibility that the customers demand may exceed the forecasted load.

3) Considering overall conditions, such as reliability, economy and technical condition, generators is operated in parallel, as given in V-2. 1. 2 e).

4) It is our principle to make the final number of installation to 4 generators per plant. Even when the estimated load for 1985 is covered by 3 engine generators, the power house is designed to be capable of installing 4 generators considering the possibility that the future load demand may exceed the estimated one.

5) Reliability design

Since diesel engine generator is a rotary machine, periodical inspection, at comparatively short intervals, is essential to expect high-performance for a long period of time. (Note 1) For this purpose, number of generators in power station is determined so that a generator is left as a stand-by machine. The stand-by machine is no only operated at the perildical inspection, but, operate when a generator failure occured in the station.

Note 1: For the periodical inspection, a diesel engine generator will have to be stopped for 3 weeks at every 6000 hr. operation (approximately every 8 months, when continuously operated).

b) Decision of Diesel Electric Generator Capacity

Capacity of diesel generator is determined for each station, as given below:

- o Final installation at 1985 - 4 generators.
- o Capacity of station - capable of covering the estimated final load (P_{10} .... load in 1985) in 10 years later.
- o Employed reliability design - 2. 1. 2-a)-5)

From these conditions, capacity required for a diesel engine generator (P_{GO}) is given as follows:

$$P_{GO} = \frac{P_{10}}{4 - 1}$$

Basing on the calculated value for P_{GO}, capacity of generator is selected from the closest one in the Unified Standard capacities in 2. 1. 2-a)-1). (Note 1)

Note 1: When determining actual diesel generator capacity (P_G) for the calculated capacity (P_{GO}) from the Unified Standards (346 kW, 229 kW, 115 kW and 75 kW), a generator having 1-rank larger capacity should be selected, if the calculated value for P_{GO} exceeds one of the standard generator capacity, even some kilowatts. However, the load estimated in this report is an accummulation of individual load (schools, hospitals and so on), and diversity factor and economy must be taken in consideration. In some cases, actual load in future can be smaller than the estimated one. Therefore, a generator is selected from the Unified Standards, until the calculated P_{GO} exceeds 120% of rated capacity for the generator.

In case, 1.2×346 kW (415 kW) $\geqq P_{GO} > 1.2 \times 229$ kW (= 275 kW), a 346 kW generator is selected.
Similarly, the selection will be as follows:

$1.2 \times 229 \geqq P_{GO} > 1.2 \times 115$ kW (138 kW) .... 229 kW

$1.2 \times 115 \geqq P_{GO} > 1.2 \times 75$ kW (90 kW) .... 115 kW

$1.2 \times 75 \geqq P_{GO}$ .... 75 kW

c) Decision of Number of Diesel Electric Generators

The number of generators to be installed at starting of operation (1976) is determined as follows, so that the load in the 2nd year (P_2 ..... load in 1977) may be covered (see Note 1) and reliability design in 2. 1. 2-a)-5) may be satisfied.

$3 \geqq \frac{P_2}{P_G} > 2$ 4 generators are installed.

$2 \geqq \frac{P_2}{P_G} > 1$ 3 generators are installed.

$1 \geqq \frac{P_2}{P_G} > 0$ 2 generators are installed.

P_G : Capacity of a diesel engine generator determined in item b) above and selected from the Unified Standards.

Note 1: In some of the present estimate of loads, the estimated load for the 3rd year (1978) increases greatly from that for the 2nd year (1977) by scheduled increase of load in public facilities (secondary schools, hospital and water supply). However, most of these scheduled public facilities are not under construction, and some deviation in date of completion seem feasible. It leads to an excessive investment, if generators are installed in 1976 so that they will cover the currently estimated load in these public facilities to be completed in 1978. It will be sufficiently in-time, if expansion of diesel generator plants may be started when starting of construction of these public facilities is made much clearer. Therefore, the initial number of diesel engine generators is determined basing on the load estimated for 1977.

d) Result of Examination

Table V-1 CAPACITY AND NO. OF DIESEL ELECTRIC GENERATORS

	Capacity			No. of generators at starting			
	Load in 1985 (P_{10} (kW))	$P_{GO} = \frac{P_{10}}{4-1}$ (kW)	Final capacity (kW)	Load in 1977 P_2 (kW)	No. of generators $(\frac{P_2}{P_G})$	No. of generators	No. of generators in 1985
Kachia	706	235	229	329	1.44	3	4
Makarfi	487	162	229	139	0.61	2	4
Jibiya	506	169	229	161	0.70	2	4
Musawa	333	111	115	101	0.88	2	4
Zonkwa	693	231	229	308	1.34	3	4
Maiadva	354	118	115	85	0.74	2	4
Kankara	450	150	229	107	0.47	2	3
Soba	506	169	229	244	1.07	3	4
Hunkuyi	256	85	75	60	0.80	2	4
Kudan	247	82	75	54	0 72	2	4
Shika	148	49	75	17	0.23	2	3

Note : No. of generators in 1985 $P_{10} \geqq 2P_G$ ..... 4 generators

$P_{10} \geqq 1P_G$ ..... 3 generators

e) Merits Obtained from Parallel Running Generators of the Same Capacity

In a conventional approach, generators were not operated in parallel, but a generator was operated at peak load time, and the other generator was operated for off peak service. As shown in calculation below, however, the parallel running of generators of the same capacity has the following merits and it recommended for this project:

- o Number of generators can be reduced.
- o Saving in equipment investment.
- o Simplyfied operation technique.

Example of calculation:

Assuming that the required power can be supplied from non-failure generators, in case of failure of the maximum capacity's generator, calculation shown below gives merits for parallel running of generators (of the same capacity).

Table V-2

		Xth year	X +αth year
Demand	At peak load	200 kW	400 kW
	At off peak load	100 kW	200 kW
Conventional method	Capacity and No. of generators	200 x 1 100 x 2 400	400 x 1 200 x 1 100 x 2 800
			(Addition of a 400 kW generator in (X +α)th year.)
	Operation mode At peak load	200 x 1 (100 x 2)	400 x 1 (200 x 1 + 100 x 2)
	At off peak load	100 x 1 (100 x 1 and 200 x 1)	200 x 1 (100 x 2 and 400 x 1)
Method of parallel running of same generators	Capacity and No. of generators	200 x 2 400	200 x 3 600 (Addition of a 200 kW generator in (X +α)th year.)
	Operation mode At peak load	200 x 1 (200 x 1)	200 x 2 (200 x 1)
	At off peak load	200 x 1 (200 x 1)	200 x 1 (200 x 2)

Generator in ( ) is a spare machine.

As seen in the table, the parallel running of the same generators can reduce number of required generators in Xth year and (X +α)th year. It also saves total capacity. It is our conclusion that the separate operation of peak load generator and off peak generators will lead to excessive investment.

2. 1. 3 The Alternate Plan to Extend Transmission Lines from NEPA Grid

a) Voltage, Routing and Distance of Transmission Lines

When extending transmission lines from existing, under construction or being planned grid of NEPA, the extension plan must be oriented toward future increase of loads, as shown in Fig. NC 100. The proposed plan is listed below.

Table V-i VOLTAGE, ROUTE AND DISTANCE OF TRANSMISSION LINES

Town	Voltage (kV)	Connection to grid	Estimated distance to town (km)	Tie transformer (33/11 kV)
Kachia	33	(Kafanchan-) Zonkwa-Kachia	49. 1	Required
Makarfi	11	(Zaria-Hunkuyi-) Kudan-Makarfi	17. 3	Not required
Jibiya	33	Katsina	48. 8	Required
Musawa	33	Kankiya	69. 0	"
Zonkwa	33	Kafanchan-Zonkwa (-Kachia)	49. 1	"
Maiadua	33	Daura	24. 0	"
Kankara	33	Near Malumfashi	27. 9	"
Soba	11	Zaria	39. 0	Not required
Hunkuyi	11	Zaria-Hunkuyi (-Kudan-Makarfi)	15. 2	"
Kudan	11	(Zaria-) Hunkuyi-Kudan(-Makarfi)	11. 0	"
Shika	11	University site in Shika	0. 36	"

Towns given in parenthesis ( ) must be electricified, if the extension line plan is applied, simultaneously with described other towns. The distance shown in table above does not include extension distance to towns in ( ).

The distance estimated for towns includes a 5% allowance which is added to the distance measured along roads.

b) Conductor Size of Transmission Line

The ACSR conductor (Aluminum Conductors Steel Reinforced) is used for the extension transmission lines. The conductor size is, as a principle, the 100 mm^2 section. When existing transmission line to which the extension line will be connected, is thinner than the standard size, 100 mm^2, the thinner size is applied to the extension.

Since it's conductor bears a current density, 2 kVA or more, as shown in Table V-ii, this size is sufficent to supply the power to the towns.

Table V-ii ALLOWABLE CAPACITY OF CONDUCTOR

Conductor size	Allowable current (tropical) (A)	Allowable capacity (tropical) (MVA) 11 kV	33 kV
ACSR 50 mm^2	112	2.1	6.4
ACSR 100 mm^2	158	3.0	9.0

When planning extension of transmission line for a long-distance line, the voltage received at the town will:

increase at small load, and
drop at heavy load.

Therefore, load condition must be simulated considering the extension length, and if required, a phase coordination device (static condensor, shunt reactor and so on) will have to be installed at the load end of extension so that terminal voltage may be adequately adjusted. (See Appendix II)

2 1.4 Consideration for Power Source

a) Determination of Type of Power Source

An economic evaluation, made as given in item VI-3 for conditions in items V-2.1.2 and V-2.1.3 suggested possible advantage to select the type of power source for individual load destination, as given below:

- o Kachia : A 11 kV, 229 kW x 3 diesel power station will be installed in the town.
- o Makarfi, Hunkuyi and Kudan : The power will be supplied to these towns from existing NEPA's grid in Zaria through 11 kV transmission lines. Total length of the extension line will be approximately 43.5 km. Conductor size (ACSR) will be 100 mm2.
- o Jibiya : A 11 kV, 229 kW x 2, diesel power station will be installed in this town.
- o Musawa : A 11 kV, 115 kW x 2, diesel power station will be installed in this town.
- o Zonkwa : A 11 kV, 229 kW x 3, diesel power station will be installed in this town.
- o Maiadua : The power will be supplied from the NEPA's 33 kV system planned for Daura, through a 33 kV transmission line (conductor size : ACSR 50 mm^2). The extension transmission line will be approximately 24 km in length. A 33/11 kV step down transformer (300 kVA) will be installed in Maiadua town to distribute 11 kV power to the town.
- o Kankara : The power will be supplied to Kankara town from NEPA's 33 kV system planned for Malumfashi, through an extension transmission line which will require approximately 28 km. The extension will be an ACSR 100 mm^2. A 33/11 kV step down transformer (500 kVA) will be installed in Kankara town to distribute 11 kV power to this town.

- o Soba : The power will be supplied to Soba town from NEPA's existing 11 kV system in Zaria through a 11 kV extension transmission line (approximately 39 km in length, and 100 mm2 ACSR in conductor size).
- o Shika : The power will be branched to this town from existing 11 kV system in university site in Shika.

b) Coordination with NEPA

The power supply plan mentioned above is proposed considering the best balancing between merits of diesel generation system and transmission line in terms of power generation cost at 5th year (1980) after commissioning.

When the proposed system is examined, attention must be paid for coordination with NEPA on close discussion and adjustment for towns to which transmission lines will be extended from existing NEPA systems (towns; Makarfi, Hunkuyi, Kudan, Maiadua, Kankara, Soba and Shika). In particular, conventional economic evaluation system indicates a huge red figures on financial balance in the 5th year (1980) after commissioning as shown in VI-4 . A close coordination and adjustment is essential between authorities concerned, for example, on share of construction cost and so on.

c) Capital Cost

The proposed power supply system is determined basing on possible financial balance in 5th year (1980) after commissioning, however, comparison of capital 1 cost indicates a gain of diesel generation system for towns other than Shika, as shown in Table Annex. 2-1 ~ 2-9, 2-20.

d) Adjustment for Distribution Voltage

For towns to which 2-33 kV transmission lines will be extended (Maiadua and Kankara), a proposal is made to install a step down transformer (33/11 kV) at inlet to the town, however, the 33 kV transmission line may be introduced directly in the town and the power may be distributed through 33/0.415 kV distribution transformers.

2.2 BASIC DESIGN FOR DIESEL POWER STATION

2.2.1 One Line Diagram

The basic connection system is those shown in Fig. Annex-1 (One Line Diagram) and Table Annex-2 (Ratings of 415 V bus, fuse free breakers, knife switches and current transformers).

The basic design for this system includes the following:

- o Parallel operation of diesel electric generators at 415 V bus.
- o 11 kV transmission from 415 V bus, through step up transformer.
- o Provision for separated 415 V emergency feeder.

2.2.2 Diesel Power House

Diesel power station shall be designed taking into consideration the matter described hereafter. Standard type design of diesel power station, which is minimum requirement for the station, is stated in the attached Fig. Annex-2.

a) Location of Diesel Power Station

The proposed preliminary locations of each power station is mentioned in each attached town map. The exact location of each station shall be decided through discussion with the Government.

Location of each diesel power station will be so selected so as to satisfy the following conditions.

1) to be located close to the area of load center.

2) to be located at a sufficient distance away from houses to prevent noise trouble.

3) to be located near the main load to enable machinery and fuel transportation.

b) Site Area of the Power Station

About 1600 m^2 of the site area of the standard type design includes the necessary area for future extension of diesel power house.

In case that a local administration office or other required building is provided, the site area mentioned above shall be increased. The actual site area may adjusting accordingly as the situation demands due to site surveying/investigation.

c) Area and Location of Power House

A sufficient area shall be kept free on the D/G room side for future power house extension.

d) Outline of Site Preparation

The stations shall be constructed on additional soil placements which will be added to the natural soil level to prevent rainwater from causing any damage. All station sites shall be with proper drainage methods (e. g. ditches, etc.) to prevent rainwater from causing any damage.

e) Outline of Power House

The power house shall consists of at least C/G room, control room, office, wash room, store room and battery room. D/G room shall be of pre-fabricated steel structure and service area shall be of reinforced concrete structure.

f) Fuel Storage Tanks

The fuel storage tanks shall be located so as to allow easy access of tank filling by oil trucks. Concrete oil fences or dikes shall be provided around oil tanks to prevent fuel flow out in case of accident.

2. 2. 3 Electrical Devices

a) Step up Transformer

1) Conditions to determine transformer capacity

i) Since the transmission system voltage is unified to 11 kV, a step up transformer (415 V/11 kV) is installed in each diesel power station.

ii) As shown in the one line diagram, (Annex-1), the step up transformer receives power output of diesel electric generators operated in parallel on the 415 V bus. At commissioning, each power station has a step up transformer. This system is much more advantageous than the 11 kV parallel system in which a step up transformer will be installed for each generator and transformer outputs (11 kV) are operated in parallel, in the following terms:

Reduced special high tension circuits (11 kV), and improved safety.
Reduced number of step up transformers which improves economy of system.

iii) Capacity of step up transformer must match capacity of diesel electric generators to be operated. Power factor of 11 kV distribution system is assumed as 0. 85. An overload operation, at 110% for several hours, is affect the service life of transformers, provided that the overload is removed within several hours. Therefore, assuming that full power operation of diesel electric generators end within several hours, capacity of step up transformers is set to allow 110% overload operation for several hours.

Capacity of step up transformers

- A power station with 3 x 229 kW generators

  $229 \times 3 \times \frac{1}{0.85} \times \frac{1}{1.1} = 735$ (kVA) 1 x 700 kVA transformer is used.

- With 2 x 229 kW generators

  $229 \times 2 \times \frac{1}{0.85} \times \frac{1}{1.1} = 490$ (kVA) 1 x 500 kVA transformer is used.

- With 2 x 115 kW generator

  $115 \times 2 \times \frac{1}{0.85} \times \frac{1}{1.1} = 246$ (kVA) 1 x 300 kVA transformer is used.

- With 2 x 75 kVA generator

  $75 \times 2 \times \frac{1}{0.85} \times \frac{1}{1.1} = 160$ (kVA) 1 x 200 kVA transformer is used.

2) Reliability design

The transformer is a stationary device which ensures higher reliability than diesel generator, thus, at commissioning and early stage of operation, each diesel power station will have a step up transformer. The step up transformer must be protected well from thunder (by arrestors) and from short-circuit failure (by circuit breakers). Should the transformer or other series device fails to operate, power supply must be continued, to the minimum extent, through a low voltage emergency feeder. This emergency feeder is not operated in normal cases, and terminals from power station and from feeder must be left opened. In an emergency case, these terminals are connected to supply the emergency power. Handling of this connection must comply with the V-3. 1. 2-b), and must be operated cautiously.

In proposed final situation, the power will be supplied to 2-11 kV feeders from two step up transformers. In case of a transformer failure, the power will be supplied from live transformer to the 2-feeders (see Fig. V-1).

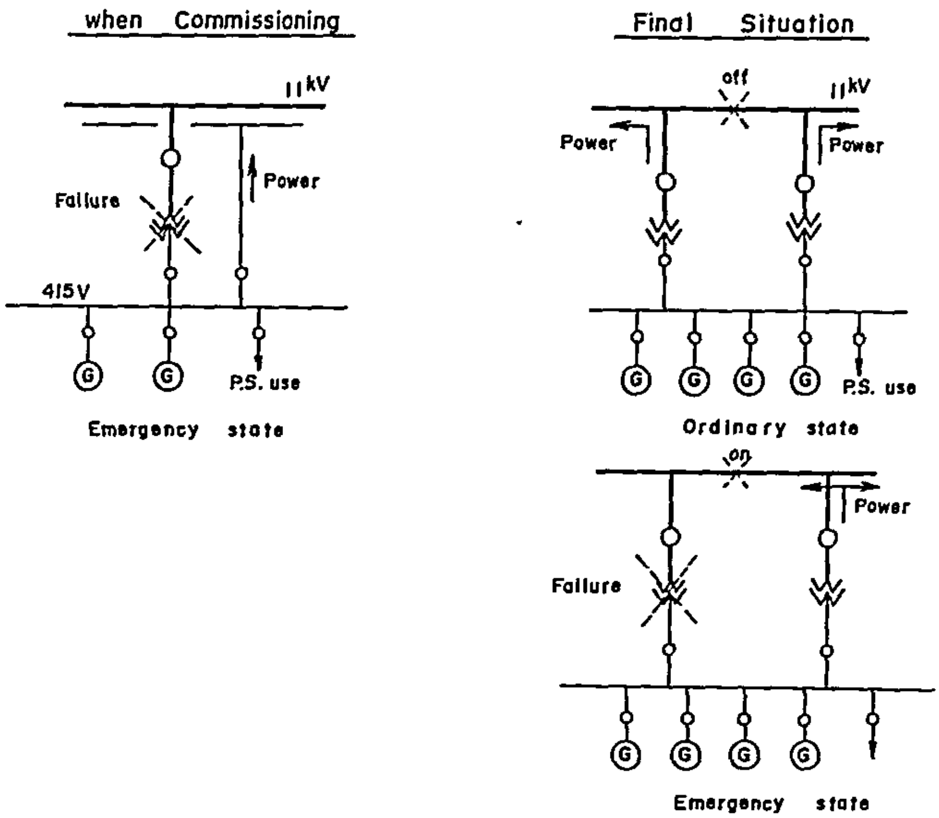


Fig. V- 1

3) Result of Examination

Table V-3 CAPACITY OF STEP UP TRANSFORMERS

	Capacity at commissioning (kVA)
Kachia	700
Makarfi	500
Jibiya	500
Musawa	300
Zonkwa	700
Maiadua	300
Kankara	500
Soba	700
Hunkuyi	200
Kudan	200
Shika	200

b) Fuel System

1) Basic composition

i) As shown in Fig. Annex-3, a daily service tank is prepared for each diesel generator, and two outdoor storage tanks is installed.

Note: Considering inspection, two storage tanks is required for each station.

ii) In addition to the fuel transfer pump, a magnetic valve is installed to prevent leakage of fuel to daily service tank and to return overflown fuel to storage tank with a return pump.

2) Selection of storage tank capacity

Capacity of storage tank is selected so that fuel required for the possible load in 1985, for 15 days with two tanks.

Calculation formula

- o Fuel - low calory fuel (10, 200 kcal/kg)
- o Average fuel consumption of engine - 0. 170 kg/PSH
- o Average engine efficiency - 0. 92
- o Specific density of fuel - 0. 98
- o Daily power consumption in 1985 - H_{10} (kWH)
- o Required tank capacity per a tank - V_T (m^3)
- o Conversion factor for PSH and kWH - $\frac{1}{0.7355}$

The power consumption to be generated daily is given as:

$$H_{10} \times \frac{1}{0.92} \times \frac{1}{0.7355} \text{ (PSH)}$$

Volume of fuel required daily, is:

$$0.170 \times H_{10} \times \frac{1}{0.92} \times \frac{1}{0.7355} \text{ (kg)}$$

Required volume for V_T (m^3) is given as:

$$V_T = \frac{1}{2} \times 0.170 \times H_{10} \times \frac{1}{0.92} \times \frac{1}{0.7355} \times \frac{1}{0.98} \times \frac{1}{1000} \times 15$$
$$= 0.00192\, H_{10} \text{ } (m^3)$$

3) Result of Examination

Table V-4 CAPACITY OF FUEL STORAGE TANK

	Power consumption per day (kWH)	Necessary Tank capacity V_T(m^3)	Tank to be installed (m^3)
Kachia	6385	12. 26 x 2	15 x 2
Makarfi	4387	8. 42 x 2	10 x 2
Jibiya	4930	9. 47 x 2	10 x 2
Musawa	3109	5. 97 x 2	10 x 2
Zonkwa	7300	14. 02 x 2	15 x 2
Maiadua	3382	6. 49 x 2	10 x 2
Kankara	3737	7. 18 x 2	10 x 2
Soba	4919	9. 44 x 2	10 x 2
Hankuyi	2048	3. 93 x 2	5 x 2
Kudan	1971	3. 78 x 2	5 x 2
Shika	1280	2. 46 x 2	5 x 2

c) Pneumatic Starting System

1) Basic composition

i) The electric diesel generators may be started by either of cell-motor or pneumatic (compressed air) starter. Considering reliability, ease of operation and so on, the pneumatic starter system is used.

ii) As shown in Fig. Annex-4, system composition common to plants includes the following:

- o Two air compressors driven by electric motor and an auxiliary air-compressor driven by a small diesel engine in emergency case (when the whole plant system is in failure).
- o A storage air tank (capacity of this tank is equal to that of unit air tank for individual diesel engine).

Each diesel engine has an air tank (unit tank). Capacity of this tank is sufficient to start mated diesel engine three times or more, without any supply of external air.

d) Cooling System

1) Basic composition

i) Since proposed site for diesel generating plant will not always be supported with ample fresh water, the proposed cooling by radiator system will be suitable because the system can cool diesel engine with small quantity of water.

ii) As shown in the cooling system diagram, Fig. Annex-5, hot water exhausted from engine is returned to the upper tank of radiator, and cooled by a blower fan while it passes through capillary in the radiator. The heat exchange effect lowers water temperature but a temperature rise occurs in the cooling air, thus, the radiator has to be installed close to air exhaust port so that the hot air may be directly exhausted to open air.

e) Lubrication System

1) Basic composition

As shown in Fig. Annex-6, lubricant oil is forced to circulate by a lubricant pump driven by crank shaft. The oil is supplied to parts of engine through an oil cooler and a filter.

f) DC Power System

1) Basic composition

A DC power system for protection and control is composed of the following devices:

- o Battery
- o Battery charger
- o Emergency DC generator
- o DC distribution panel

Connection of the DC power system is as shown in Fig. Annex-7.

2) Battery

Considering the recovery characteristics after discharging, alkaline batteries are suitable for the protection and control purpose. However, the alkaline batteries have critical thermal characteristics, thus, the battery room should be ventilated well.

3) Battery Charger

The power is charged into the battery by a silicon rectifier which float-charges the batteries.

4) Emergency DC Generator

Considering the worst case in which all diesel electric generators in a plant may lose normal functioning, by any reason, and the failure may continue long exceeding service capacity of alkaline batteries, a small engine generator (approximately 2 kW) is installed in each plant.

2. 3 BASIC DESIGN FOR TRANSMISSION LINE AND STEP-DOWN SUBSTATION

Since the transmission lines will be extended from existing NEPA systems, a close coordination will have to be made with NEPA for basic design of transmission lines and step-down substations. The plan discussed below is a proposed recommendation. The designs transmission lines will be 33 kV as well as the NEPA's fundamental plan.

2. 3. 1 Basic Routing

Proposed basic routing of transmission lines to Makarfi, Hunkuyi, Kudan, Maiadua, Kankara and Soba is as shown in Figs. NC 101 105.

2. 3. 2 Conductor

Principally, the conductor is the ACSR 100 mm^2 which contribute to electrification of towns adjacent to the transmission lines in future.

An exception is the Daura-Maiadua section for which ACSR 50 mm^2 conductor is used, because line between Kankiya and Daura employs 0. 75 in^2 conductor to be planned by NEPA (equivalent to 50 mm^2 conductor).

2. 3. 3 Average Span

The average span of new transmission line is approximately 120 m.

2. 3. 4 Standard Pole Structure

As shown in Fig. NC 106, 107 the standard pole is a single pole with 2 stays. A section pole (H pole) is erected at 1. 5 km intervals. The pole is a concrete pole or wood pole. The insulator is a line post insulator with arcing horn, which is supported by armor rod.

2. 3. 5 Step-down Transformer

a) Capacity and Number of Step-down Transformers (33/11 kV)

The capacity and number of step-down transformers in step-down substation are equal to those of step-up transformers described in 2. 2. 3 (a).. At commissioning, a step-down transformer is installed in a substation, and in the final stage, each substation will have 2 step-down transformers.

Maiadua .... 33/11 kV 300 kVA

Kankara .... 33/11 kV 500 kVA

b) Basic One Line Diagram of Step-down Substation

o The basic one line diagram for step-down substation will be as shown in Fig. NC 200.

o Matching is made between transformer primary CB and transmission CB in power substation (330, 132/33 kV s. s.), considering protective coordination for these devices. When a failure occurred in a step-down transformer, the primary CB in step-down substation cuts the transformer in failure so that the transmission CB in power substation may not operate. In case where a series trip is inevitable, the transformer primary CB must open any time, and the device in trouble must be removed from the transmission system before the power supply from power substation is restarted.

c) Step-down Substation Devices

The step-down transformer is installed on the ground, and connected to transmission line and load line with cables.

The circuit breaker for substation is the outdoor type oil circuit breaker.

The current transformer is a bushing C. T. for transformer or circuit breaker.

The step-down substation is provided with arrestors, potential transformer, relays and so on. It is desirable to concentrate circuit breakers and current transformer in a cubicle.

d) Position of Step-down Substation

In principle, the position of the step-down substation is equal to the position of the diesel power station shown in each attached town map.

2.3.6 Introduction of 11 kV Transmission Line in Town

When introducing a 11 kV transmission line in a town, T-branching from 11 kV transmission line is made as shown in Fig. V-1. The 11 kV distribution system in the town is connected to the T-branch, which is provided with a disconnecting switch and fuse so that failure in the distribution system does not affect operation of the transmission system.

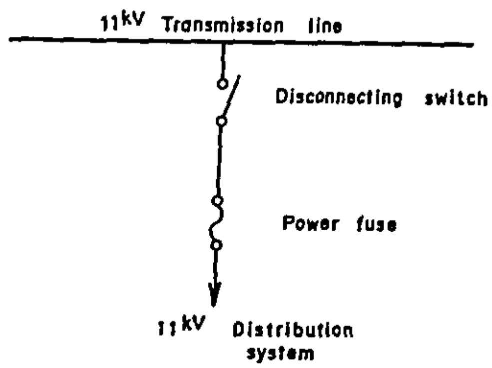


Fig. V-1

3. DISTRIBUTION

3.1 DISTRIBUTION SYSTEM PLANNING

3.1.1 High Voltage Distribution

a) Choice of Voltage

The demand of electricity of the towns estimated in this survey is approximately 800 kW for a large town in the year 1985. Judging from the capacity of power distribution and other items, we shall adopt 11 kV three-phase three-wire nongrounding system as the distribution voltage which is commonly used in Nigeria for the ease of operation and maintenance of facilities and for the economy of construction.

b) System Design

We recommend a radial system since the demand is estimated as described above, and initially only one circuit of high voltage feeder shall be used. At the time when diesel generators are to be added, two step-up transformers and two feeders shall be constructed to improve reliability; isolators shall then be set to individual feeding points and in between.

c) Choice of Conductor

All aluminum conductors are recommended from the viewpoint of material properties. Price of aluminum is cheaper than that of copper and all aluminum conductors are the most favoured type for use in construction of relatively short span distribution systems. In addition, all aluminum conductors have an advantage of having a homogeneous quality, and easier to joint and clamp when compared with A. C. S. R. As to the cross-section area of the conductor, we recommend 50 mm^2, which is larger than the minimum size prescribed by the Laws of Federation of Nigeria and Lagos, Chapter 57, and is easily available on the market. This size, however, is larger than that which can handle the permissible current for the maximum load of 1985, and smaller one may be used from the point of view of voltage drop.

3.1.2 Low Voltage Distribution

a) Choice of Voltage

The voltage for the low voltage distribution of a country is determined by the historical reasons of the country. We shall adopt 240/415 V three-phase four-wire multiple grounding system which is most commonly used system in Nigeria.

b) System Design

The low voltage system shall use a radial system. In order to increase the reliability of supply for economical reasons, two or three feeders shall be extended from transformer depending on the condition of the route, and one or two connections shall be made possible between individual feeding points and between adjacent distribution lines so that in case of a line failure, switch over of the distribution line is possible using sound lines, and in case of inspection and other instances, the area of blackout is made as small as possible. For the transmission in a reverse direction through an interconnection, it is necessary to make it clear to open the circuits on the other side without fail by taking appropriate maintenance procedures. Each feeder shall be three-phase four-wire system throughout to respond to the demand of three-phase 415 V that may arise from any point on the route.

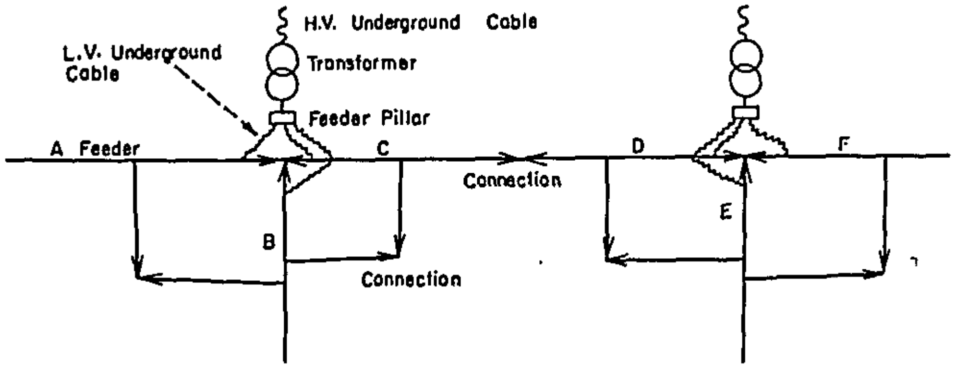


Fig. V-2 L.V. DISTRIBUTION SYSTEM

c) Choice of Conductor

For the reasons stated previously, all aluminum conductors are recommended from the viewpoint of the material property. The nominal cross-section area of all aluminum conductor shall be 50 mm^2 or 100 mm^2.

3.1.3 Line Routes

Routes of the overhead distribution lines shall be selected upon consideration of the following items:

1) The line routes shall be either on vacant lands along the road or on the side of the road. If the routes are selected on the vacant lands along the road or on the road side even for cases of only 11 kV distribution lines, future increase in the demand can be met by simply extending the low voltage lines or by adding transformers and low voltage lines. Then the construction of poles and high voltage lines will be unnecessary, which gives econimic advantage to this method.

2) The arrangement of the line routes shall be simple and there shall be no interwinding of the routes.

3) Connections between the routes and the future extension of the routes and switchovers should be easy. In practice this is realized by using the same side for a particular road.

4) Crossing the road center lines shall be minimized.

5) Approach to places where woods grow densely shall be avoided as much as possible.

6) Routing on roads that are overflowed in the rainy season shall be avoided.

3. 1. 4 Length of Span

The maximum length of span should be less than 50 m within a township according to the Laws of Federation of Nigeria and Lagos, Chapter 57; we have however adopted an average span of 40 m for the ease of setting up service lines and for less requirement on the strength of supports. For transmitting to remote demand locations from the town (the center of the demand) by high voltage, the average span shall be 80 m so that when the demand increases in future with the expansion of the town, one pole may be added to each span so that the service shall be possible as in the town.

3. 1. 5 Supports

The supports shall be mainly concrete poles, but wooden poles may also be used. 10 m poles shall be the standard for high voltage lines or for poles supporting both high and low voltage lines, and 8 m poles for low voltage lines. For towns in which extension area's demand will definitely add in the near future, 10 m poles shall be set for the lines to the extension area with only low voltage lines and spare the upper portion for the future use of high voltage lines, even though only the low voltage lines are required at the present time.

3. 1. 6 Voltage Drop

Since the voltage drop on the low voltage lines will be within 5% at the consumer's main switchboard, the voltage drop as a rule shall be distributed such that it is 4. 5% for the low voltage feeder and 0. 5% for the service line. The voltage drop (per phase) is expressed by the following equation if the load conditions are balanced for each phase, and if the load is the same for all poles:

$$V = \frac{Re \ell I (n-1)}{2000} \quad (V)$$

where Re: equivalent resistance, (Ω/km)
I : phase current, (A)
n : number of service poles.
ℓ : length of the span (m)

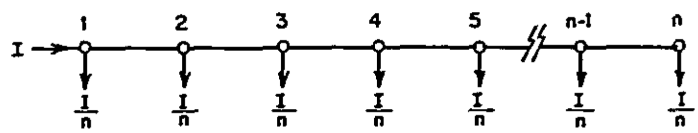


Fig. V-3

The possible number of spans to be serviced is given by n-1, and the possible service length by ℓ(n-1). As an example, the number of spans and the length for the currently planned system with a 100 KVA transformer, voltage drop limit of 4. 5%, wire cross-section of 50 mm^2 (0. 604Ω/km), and span length of 40 m will be as shown in Table V-5 for the cases of two feeders and three feeders.

Table V-5

Number of L. V. feeder	Number of span n - 1	Sercive length ℓ(n - 1)
2	12	480
3	19	760

The facility shall be constructed taking these numbers as the standards.

3. 1. 7 Demand Forecast and Supply Facilities

a) The existing town areas shall be considered the sum of the electricity demand of existing town area, town area demand for the water supply, and the street lighting and planned the supply facility to serve the entire area.

b) The existing schools shall be supplied by individual transformers, but those proposed or to which decisions are made for construction but uncertain of the sites are excluded from the planning of the facility construction. These shall be supplied by extending the high voltage lines when concrete decisions are made for construction.

c) Existing health centers shall also be supplied by individual transformers together with water supply as in the case of schools. Those proposed or decided but with uncertain sites shall be supplied when concrete decisions are made.

d) The water supply for agriculture and others shall be supplied when concrete decisions are established.

e) Street lighting shall be administered for the main streets and its demand shall be added to the demands of the existing area and of the water supply.

f) For other demands, large demands shall be supplied by specific transformers, and small loads by nearby transformers.

g) For the demand of each town, refer to the note in the table of demand forecast.

3. 2 DESIGN

The designs of the system planning stated in 3. 1 are materialized as in the following. When 33 kV is to be introduced for the high voltage, basic designs for 11 kV can be normally used by changing only those facilities which are affected by the change of the voltage (cables, transformers, insulators, drop out fuse switches, arresters, etc.), clearances and crossing etc.

3. 2. 1 Poles

As a rule concrete poles shall be used. Wooden poles may be used when concrete poles are difficult to obtain under the circumstances, or when those are economically less expensive.

a) Length and Strength of Poles

The standard length of the high voltage poles and the low voltage poles shall be as described below. These are set upon consideration of the future extension of housing to higher levels and addition of facilities such as TV antennas. For the strength of the poles, the followings shall be the standards upon consideration on the economy of the support structure, average span length, and the conductors used.

High voltage poles and poles supporting both high and low voltage lines	10 m,design load 300 kg
Low voltage poles	8 m,design load 150 kg

b) Pole Types and Loading Condition

1) The basic pole types are as shown below:

Intermediate pole	up to 5°
Angle pole	up to 20°
	up to 45°
Tee-off pole	
Terminal pole	

Section poles shall be erected at least at an interval of 1.5 km for lines extended for several kilometers.

2) Wind pressure

The wind pressure on poles shall be assumed to be 146.5 kg/m^2 (30 lb/sq foot) of plane surface and 87.9 kg/m^2 (18 lb/sq foot) of diametrical plane of a cylindrical surface.

In case of compound structures (H-Poles) the wind pressure on the leeward-side members can be reduced to one-half of the wind pressure on the windward-side members.

c) Safety Factor

The safety factor for each support structure shall be two point five (2.5) for concrete poles and four (4) for wooden poles, over the calculated crippling-loads of the structure.

d) Concrete Poles

In the southern part of Nigeria some prestressed and one reinforced concrete pole factories are working and some of them already supply NEPA and some states with concrete poles. Concrete poles produced in Nigeria shall be used as much as possible.

e) Wooden Poles

In Nigeria the usual species for wooden poles are the Opepe, Teak and Idigbo. The basis for the preparation of wooden poles is "the specification for wood poles (Nigerian Standards Organization)".

Table V-6 POLE DIMENSIONS FOR CLASSES AND SPECIES

Pole Class			Ex:H.	V. H.	H	M	L	V. L.	Ex:L.
			Extra Heavy	Very Heavy	Heavy	Medium	Light	Very Light	Extra Light
Load Applied 61 cm from Top (KN)			24. 5	20. 0	15. 6	11. 1	8. 9	6. 7	5. 3
Minimum Top Diameter (cm)			22. 9	20. 3	17. 8	15. 2	14. 0	12. 7	10. 2
Pole Length (m)	Butt to Ground Line (m)	Species	Minimum Pole Diameter 1. 52 m from Butt (cm)						
8. 54	1. 52	ID	34. 9	32. 4	29. 8	26. 7	24. 8	22. 9	20. 9
		OP	28. 6	26. 7	24. 8	22. 2	20. 3	18. 4	17. 1
		TE	26. 7	24. 8	22. 9	20. 3	19. 1	17. 1	15. 9
10. 06	1. 84	ID	36. 8	34. 3	31. 8	28. 6	26. 0	24. 1	22. 2
		OP	29. 8	27. 9	27. 3	23. 5	21. 6	19. 7	18. 4
		TE	28. 6	26. 7	24. 1	21. 6	20. 3	19. 7	17. 1

Abbreviation: ID - Idigbo; OP - Opepe; TE - Teak.

f) Attachment of Fittings

The provision of holes for the attachment of fittings is given in the detailed drawing in the Fig. A-8, A-9, A-10.

g) Cross-arms

The material to be used for cross-arms has been fixed for each pole-type and is specified in the drawings in the Fig. A-8, A-9, A-10.

The size and the strength of cross-arms (including the distance between phases) for long spans shall be determined by the Contractor on the conditions of wind pressure, etc. as previously stated in V-3. 2. 1-b) and V-3. 2. 2-b).

h) Accessories

Each pole shall be equipped with the pole number, danger warning sign, and a preventive device against pole climbing. Reference should be made to Fig. A-11 for details.

i) Galvanization

All steel parts including tie straps, bolts, nuts, washers, cross-arms etc, shall be galvanized by the hot-dip process after all shearing, sawing, drilling, punching, bending and machining are completed.

j) Stay Wires

Stay wires shall be equipped when the load exceeds the design load of 300 kg for high voltage poles and for poles supporting both high voltage and low voltage lines, and 150 kg for low voltage lines.

Flying stay wires shall be considered when the interference from the traffic etc, is expected. The safety factor for the stay wire shall be greater than 2.5.

k) Foundation

When the safety factor of over 2.5 is difficult to realize because of the ground condition, foundation of the support structure should be strengthened.

3.2.2 Conductors

a) Cross-section

For high voltage lines, all aluminum conductor of nominal area 50 mm^2 (Ant) is recommended. For low voltage lines, all aluminum conductors of nominal area 50 mm^2 (Ant) and 100 mm^2 (Wasp) are recommended.

The following table gives the technical data of the chosen conductors.

Table V-7 TECHNICAL DATA FOR ALL ALUMINUM CONDUCTORS

Code name	Nominal aluminum area	Equivalent copper area	Stranding wire diameter	Approximate overall diameter	Total area	Weight	Nominal breaking load	Maximum D.C. resistance at 20°C
	mm^2	mm^2	mm	mm	mm^2	kg/km	kgf	ohm/km
Ant	50	32.3	7/3.10	9.3	52.8	145	846	0.5419
Wasp	100	64.5	7/4.39	13.2	106.0	290	1632	0.2702

b) Mechanical Design of Conductor

1) The following basic assumptions shall be used for the design temperatures.

minimum temperature	5°C
maximum temperature	65°C
average temperature	25°C

2) The wind pressure shall be as follows after the Laws of the Federation of Nigeria and Lagos.

inside towns	58.6 kg/m^2 (12 lb/ft^2)
outside towns	87.9 kg/m^2 (18 lb/ft^2)

c) Sagging

The maximum stresses are given at minimum temperature with wind load and the maximum sags at maximum temperature without wind load. It is recommended to the stringing work so that the maximum stresses on lines shall be less than 8 kg/mm^2.

d) Clearances and Crossings

The definite clearances at maximum sag given in the following table are kept:

Table V-8 CLEARANCES AND CROSSINGS

Item	0. 4 kV		11 kV	
	m	ft.	m	ft.
Bare conductor to ground level across streets and roads	5. 80	19	5. 80	19
Bare conductor to ground level along streets and roads	5. 19	17	5. 49	18
Bare conductor to ground level in places inaccessible to vehicular traffic	4. 58	15	4. 88	16
Bare conductor to any part of a fence, wall, building or other structure upon which a man may stand or against which ladder may be placed.	3. 05	10	3. 05	10
Over-head line phase centres	0. 21	2/3	0. 76	2½
Vertical clearance between different voltage on the same support. 11 kV and L. V.	-	-	1. 22	4

The horizontal clearance shall be kept not only at maximum sag but also at conductor deflections due to wind.

e) River Crossings

The distance between maximum conductor sag and high water level shall be provided by the Chief Electrical Inspector.

f) Railway Crossing

Before erecting an overhead electric line across a railway, a permission must be obtained from the Nigerian Railway Authority. Overhead crossings shall be used for the most part, but underground crossings shall also be considered as an alternative.

g) Crossing Post and Telegraph Lines

The minimum clearance between the nearest conductors of the overhead line and a P & T line shall be in vertical and horizontal direction not less than 2. 44 m (8 feet) for 11 kV and 1. 22 m (4 feet) for 0. 4 kV This minimum clearance is to be kept under the most unfavourable operating conditions.

For cases not mentioned in this chapter "The Laws of the Federation of Nigeria and Lagos", Chapter 57 (Electricity) shall apply.

3.2.3 Insulators

As a standard, insulators for 11 kV lines shall be pin type insulators for intermediate poles, angle poles and some of the tee-off poles; and disc type insulators for some of the tee-off poles and terminal poles. For the insulation of lines, the following shall be used as the standards, with a little higher insulation level for disc type insulators:

Table V-9 TECHNICAL DATA

		Pin type	Disc type
Power frequency withstand (one-minute)	dry	75 kV	78 kV
	Wet	50 kV	45 kV
Impulse withstand		95 kV	105 kV

Bindings shall be employed for pin type insulator and four bolt clamp shall be employed for disc type insulator. Low voltage insulators shall be the single groove type shackle insulator.

The following table gives the main characteristics low voltage insulator.

Table V-10 TECHNICAL DATA

Dry flashover	23 kV
Wet flashover	11 kV

3.2.4 Substation

1) A substation shall consist of a ground-mounted transformer which shall be installed outdoors.

2) A ground-mounted transformer shall be surrounded by a fence 2 m high and equipped with a lockable door.

3) H-poles shall be used for substations, and the H. V. lines shall be anchored by tension insulators on steel cross-arms.

4) Lightning arresters, drop-out fuse switches, cable heads, etc. shall be mounted on iron supports.

5) Standard lightning arresters shall be designed against 10 kA, and fuses against 50 MVA.

6) The terminal of transformer shall be cable joint type.

7) Transformers shall be mounted on the foundations.

8) Three feeders shall be provided for four wire low voltage overhead lines.

The low voltage distribution feeder pillar shall be mounted at operation height on foundation.

Each pillar shall contain:

3 fuse sets	3 phases and a neutral for overhead line feeders.
1 fuse set	3 phases and a neutral for input cable from transformer.

To facilitate the control of transformer loading, ammeters, voltmeters, and power meters equipped with maximum indicators shall be installed.

3.2.5 Transformers

a) Type

The transformers shall be of the three-phase, oil-immersed, naturally cooled, outdoor type for tropical climate.

b) Capacity

To meet the demand of the next decade and for the ease of maintenance, the standard transformers to be used in the present project shall be of the ground mounting type with capacity of 100 kVA and 200 kVA rather than the pole mounting type of lesser capacity of 50 kVA etc., which need maintenance work on the pole.

c) Technical Data

1)	High voltage winding	11 kV $\pm$ 2 x 2.5% in delta connection, tap changing at off-load
2)	Low voltage winding	415/240 V at full load and cos ϕ = 0.9, in star connection, with neutral brought out and sized for rated current.
3)	Vector group for distribution transformers	Dy 11
4)	Frequency	50 Hz
5)	Impedance voltage	4%
6)	Material of windings	copper
7)	Maximum ambient temperature	40°C
8)	Maximum hot spot temperature rise	55°C

3.2.6 Underground Cables

Underground distribution is generally used when it is impossible to set up overhead lines as restricted by laws, or instructed by the road management officials as well as for lines in places of importance, busy streets, government office areas and other business building areas. Underground cables have the advantage of improving city beautification, reliability of supply in case of general calamities such as storms, lightnings or fires, and of improving the safety of equipments and persons. On the other hand, they have demerits of having higher construction costs, taking longer times for the recovery of accidents, etc.

In this project, underground cables shall be used for the following with main emphasis on personal safety:

(1) outgoing lines from diesel power plants

(2) high voltage lines to substations and low voltage outgoing lines from them

(3) service lines for high voltage consumers.

The conductor shall be copper wire, and use paper insulated cables or C.V. cables for H.V. and P.V.C. insulated cables for L.V.

3.2.7 Lightning Arrester

Thunderstorms may occur at any time of the year, but they are most frequent and most violent at the beginning of the rainy season. They are accompanied by heavy rain and by strong winds that sometimes cause much damage. The velocity of these thunderstorms may exceed 120 km/h.

For this reason, we shall install lightning arresters in the following locations to cope with the lightning damage.

(1) feeding points from diesel power plants

(2) substation poles

(3) service poles for high voltage consumers

(4) at every 500 m on the distribution lines

3.2.8 Street Lighting

Street lighting shall be equipped on every pole in the main streets with heavy passenger traffic. The electric system shall use exclusive lines, and the lighting loads shall be connected between the exclusive lines and neutral line. As a rule, switching shall be operated within the feeder pillar. The size of the exclusive lines shall be the same as that of the low voltage main lines to prevent accidents which may occur due to the differences in sagging.
A minimum illuminant of 1 lux shall be guaranteed on the ground.

3.2.9 Earthing

a) The Neutral of Low Voltage System

The earthing for the L.V. neutral conductors shall be made at the supply points (of transformers), at every terminal, and at every 200 m along the routes of the distribution lines.

b) Lightning Arrester

The arrester shall be earthed by means of an independent earthing-lead and earthing rod. The rod of arrester shall be placed not less than 2 m from any other earthing rod.

c) Steel Works

All steel works shall be required to be earthed.

d) Transformer

The cases of all transformers shall be earthed.

e) Earthing Leads

Earthing leads shall be copper and cross-section shall be not less than 25 mm^2. Earthing lead shall be protected from mechanical damage by wooden capping for a distance of 3 m above ground level and 15 cm below ground level.

f) Earth Resistance

In all cases, the valve of earth resistance shall not exceed 10 ohms for distribution system.

4. SUMMARY OF EQUIPMENT PLAN

According to aforementioned plan and design for power source and distribution system, equipment plan for individual town is summarized as shown in Table V-11.

Design for diesel power station and distribution system is shown in the maps of each town.

Table V-11 SUMMARY OF FACILITIES

Name of Town	Power Source					Distribution System				
	By isolated diesel generator		By transmission line							
	Diesel electric generator (kW)	Step-up transformer (kVA)	Transmission voltage (kV)	Distance approx. (km)	Step-down transformer (33/11 kV) (kVA)	Substation (kVA)	Length of H. V. lines (km)	Length of H. V. + L. V. lines (km)	Length of L. V. lines (km)	Length of street lighting lines (km)
Kachia	229 x 3	700 x 1	33	Note 1) 49.1	700 x 1	100 x 4	1.0	2.3	4.6	0.8
Makarfi	229 x 2	500 x 1	11	Note 2) 17.3	-	100 x 3	2.5	1.3	3.8	0.7
Jibiya	229 x 2	500 x 1	33	48.8	500 x 1	100 x 4	4.2	0.7	11.1	0.6
Musawa	115 x 2	300 x 1	33	69.0	300 x 1	100 x 2	3.0	0.4	5.0	0.7
Zonkwa	229 x 3	700 x 1	33	49.1	700 x 1	100 x 7	2.9	2.6	5.3	0.8
Maiadua	115 x 2	300 x 1	33	24.0	300 x 1	100 x 2	-	0.6	4.4	0.6
Kankara	229 x 2	500 x 1	33	27.9	500 x 1	100 x 3	1.4	1.0	4.1	0.8
Soba	229 x 3	700 x 1	11	39.0	-	100 x 4	0.4	1.1	3.8	0.5
Hunkuyi	75 x 2	200 x 1	11	15.2	-	100 x 1	-	0.3	3.4	0.3
Kudan	75 x 2	200 x 1	11	Note 3) 11.0	-	100 x 1	-	0.4	5.0	0.8
Shika	75 x 2	200 x 1	11	0.36	-	100 x 1	0.2	0.2	2.6	0.5

Note 1) between Zonkwa and Kachia

Note 2) between Kudan and Makarfi

Note 3) between Hunkuyi and Kudan

VI. ECONOMIC EVALUATION

1. GENERAL

Material cost, construction cost and transportation cost are calculated for the year 1976, basing on the market price in Nigeria, as of 1975. An econimic evaluation is made for the proposed system, in accordance with the calculated costs.

The economic evaluation is essential to the following purposes:

i) Selection of a feasible power source system (grid powers transmission method or diesel generation method).

ii) Understanding on financial balance of electrification of towns.

2. PARAMETERS IN ECONOMIC EVALUATION

2. 1 TRAFFIC AND REVENUE

Calculation of revenue is made in compliance with NEPA "Electricity Tariff".

Possible revenue is classified into the following two types, and will be paid to state every year after the electrification of a town is completed.

i) Revenue from kWH sales

ii) Connection fees

For ease of calculation, demands are assumed to be the supply from low voltage line, and the other assumption is made that the State Government will charge to the Government users, such as secondary schools, health centers or teacher's or doctor's residence.

2. 1. 1 Revenue from kWH Sales

The revenue from kWH sales is calculated for each town by using the following equation:

Total revenue per year

= Σ (Each load's kWH sales x tariff per kWH) + street lighting revenue

a) Each Load's kWH Sales

This revenue is shown in Table Annex 1.

b) Tariff per kWH

o Town area

Assumption made for calculation of tariff per kWH is that most of the users will receive, for the first 10 year period, the single phase service.

1st year ₦0. 078/kWH
2nd year ₦0. 065/kWH
3rd year and later ₦0. 06/kWH

These values are calculated assuming that the average monthly demand per user (demand rank - medium) will be 33 kWH in the 1st year, 58 kWH in the 2nd year, 63 kWH in the 3rd year, 66 kWH in the 5th year and 77 kWH in the 10th year.

o Extension area ₦0. 035/kWH

Assumption made for average monthly demand for the power per user in extension area is 400 to 1,000 kWH.

o Education facilities (including teacher's residence)

₦0. 035/kWH

A three-phase service is assumed. Also the ratio of school demand (including dormitory) and residence demand is assumed to be 50 : 50.

o Health center (including doctor's residence) and water supply

₦0. 03/kWH

A three-phase service is assumed for this demand. The residence demand is also assumed to be smaller than other demands in health center.

c) Street Lighting Tariff

The street lighting (by fluorescent lamps) tariff is assumed to be ₦1. 29/month/lamp.

2. 1. 2 Connection Fees

The connection fee is charged to the user, as a charge to power meter for the user This fee is assumed to be ₦2 per user.

This fee will be charged to the teacher's residence and doctor's residence too, which currently receive power supply from school's or health center's own isolated diesel generator, and will receive power supply from town distribution system.

2. 2 ENERGY COST

As shown in Fig. VI-1, the proposed supply system is the supply from grid system through transmission line or the supply from isolated diesel generation, the energy cost is examined for both of these systems.

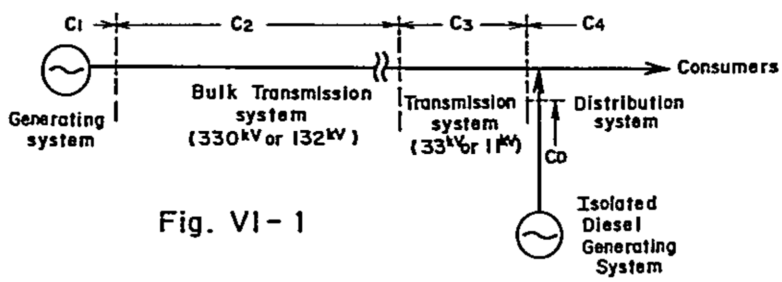


Fig. VI - 1

2.2.1 Cost of Grid Power

The cost of grid power is classified into

1) Cost of generation system,

2) Cost of bulk transmission system.

a) Cost of Generating System

In the present NEPA's system, most of the power to grid is supplied from Kainji Power Station. The generating cost of this plant is estimated to be approximately 0.45 kobo/kWH. However, the power consumption will increase in years later than 1976, thus, power supply from new thermal station will increase. (Generating cost of the new plant is extimated to be approximately 1.8 kobo/kWH.) Therefore, total generating cost will increase gradually.

In this report, the cost of generating system (C_1) is calculated by using the following equation, for which the supply from Kanji Power Station will cover 2/3 of total supply, and the new thermal plant will share 1/3.

$$C_1 = 0.45 \times 2/3 + 1.8 \times 1/3 = 0.9 \text{ (kobo/kWH)}$$

b) Cost of Bulk Transmission System

Considering a 10% transmission loss for cost of bulk transmission system, which is estimated to be approximately 0.34 kobo/kWH.

Cost of bulk transmission system (C2) = 0.34/0.9 = 0.38 kobo/kWH

2.2.2 Fuel Cost for Isolated Diesel Generation

As of 1973, price of fuel in North Central State was approximately 7.5 kobo/liter, however, considering rise of commodity price, the fuel cost in 1976 and later will increase to 9 kobo/liter.

Average fuel consumption of a diesel engine		0.170 kg/PS.H (with a fuel 10200 kcal/kg)
Specific density of fuel	0.98	
Average efficiency of generator	0.92	

Then, fuel cost of isolated diesel generation

$$= 9 \text{ (kobo}/\ell) \times 0.170 \text{ (kg/PS.H)} \times \frac{1}{0.7355} \text{ (PS/kW)} \times \frac{1}{0.92} \times \frac{1}{0.98} (\ell/\text{kg})$$

$$= 2.31 \text{ kobo/kWH}$$

2.3 MAINTENANCE AND OPERATION COST OF TRANSMISSION LINE, DISTRIBUTION SYSTEM AND ISOLATED DIESEL GENERATION

The maintenance and operation cost is determined by type, quantity and quality of equipment and device involved, and not always correlated with quality of power sales. The following values seem feasible as annual cost of maintenance and operation.

2. 3. 1 Maintenance and Operation Cost of Transmission Line and Distribution System

2%/capital cost year

2. 3. 2 Maintenance and Operation Cost of Isolated Diesel Generation

11%/capital cost year

2. 4 COST OF LOCAL ADMINISTRATION AND COLLECTION

Since the cost of local administration and collection mainly cinsists of personnel expenses, this cost is proportional to quantity of power sales.

0. 27 kobo/kWH

2. 5 DEPRECIATION

2. 5. 1 Depreciation of Transmission System

The average life for transmission equipments (transmission lines and step-down substation) is assumed as 40 years, and the straight line depreciation at 2. 5% per annum is applied.

2. 5. 2 Depreciation of Isolated Diesel Generating System

The average life for diesel generating equipment (except power house) is assumed as 20 years (40 years for power house). Thus, a straight line depreciation at 5% is applied to equipment (2. 5% for power house).

2. 5. 3 Depreciation of Distribution System

The average life of distribution equipment is assumed as 25 years. Thus, a straight line depreciation at 4% per annum is applied.

2. 6 CAPITAL COST

The capital cost for transmission system, power station and distrivution system is estimated basing on the following cost parameters which include the survey cost, administration and supervision cost, interest to be paid in the construction period and bush clearing cost.

2. 6. 1 Capital Cost of Transmission System

Basing on data given in V-2. 1. 3-a), the following values are applied to capital cost of transmission system:

o	33 kV transmission line	₦ 10,500/km
	11 kV transmission line	₦ 9,000/km
o	33/11 kV 700 kVA Step-down substation	₦ 15,000/unit
	500 kVA	₦ 13,500/unit

300 kVA	₦ 12,500/unit
200 kVA	₦ 12,000/unit

2.6.2 Capital Cost of Isolated Power Station

According to the result of examination given in V-2.1.2, the following values are applied to the capital cost of isolated power stations.

Diesel electric generator	229 kW	₦ 30,000/unit
	115 kW	₦ 17,000/unit
	75 kW	₦ 10,000/unit
Step-up transformer	700 kW	₦ 6,700/unit
	500 kW	₦ 5,700/unit
	300 kW	₦ 4,500/unit
	200 kW	₦ 3,500/unit
Power house		₦ 90/m^2

Cost of auxiliary devices such as storage tank and batteries is calculated for individual device and accumulated.

2.6.3 Capital Cost of Distribution System

Basing on data in V-3, the following values are applied to capital cost of distribution system:

H.V. Line (span 80m)	₦ 5,800/km
H.V., L.V. Line (span 40m)	₦ 13,400/km
H.V. Line (span 40m)	₦ 9,100/km
Substation (100 kVA)	
L.V. circuit 3 ways	₦ 9,200/unit
L.V. circuit 4 ways	₦ 10,300/unit
Street Lighting	₦ 70/set

Assuming use of concrete poles and AAC 50 mm^2 conductors, these values are estimated.

The cost required to service wires from distribution line to individual user is assumed as ₦ 40/customer.

This cost is accumulated considering a year-by-year increase of the customer.

2.7 INTEREST

A 5% interest is assumed for the interest to annual debit balance.

3. SELECTION OF A POWER SOURCE SYSTEM BY ECONOMIC EVALUATION

3.1 GENERAL

Financial balance of the transmission line system and isolated diesel generation system must be compared before selecting a suitable power source system by economic evaluation. Since some uncertain factors will involved in the proposed system, if a long-term estimation is required, this examination makes a power source system advantageous if the system seems to gain in financial balancing in 1980 (the 5th year).

3.2 POWER SOURCE COST

The cost of power source system is accumulated for the following items:

1) Transmission line system

- o Cost of grid power
- o Maintenance and operation cost of transmission line and step-down substation.
- o Depreciation
- o Interest

2) Isolated diesel generation system

- o Fuel cost
- o Maintenance and operation cost of isolated diesel generation
- o Depreciation
- o Interest

3.3 CALCULATION

The result of calculation is shown in Table Annex 2-1~2-9.

3.4 RESULT OF EVALUATION

According to the result of calculation, an economic evaluation is made as given below:

1) Towns for which the transmission line system will be advantageous.

Makarfi, Kudan, Hunkuyi
Maiadua
Kankara
Soba
Shika

2) Towns for which the isolated diesel generation system will be advantageous.

Kachia
Jibiya
Musawa
Zonkawa

4. UNDERSTANDING ON FINANCIAL BALANCE

4.1 GENERAL

A general understanding on financial balancing of proposed electrification of towns has to be considered.

From viewpoint of net income, financial balancing of the project is examined for the 5th year of electrification (1980).

4. 2 NET INCOME

The net income is given from the following equation:

Net income = A - B

where A : Revenue from electricity sold and from connection fees

B : Expense of power source system (transmission line system or isolated diesel generation system whichever financially advantageous), Expenses of distribution system and Cost of administration and collection.

4. 3 CALCULATION

Calculation of these figures is shown in Table Annex 2-10~2-20.

5. ECONOMIC EVALUATION OF THIS PROJECT

5. 1 FINANCIAL BALANCING

1) A red figure larger than ₦200, 000 will result yearly from the project, according to the examination of financial balancing made by selecting a suitable power source system for each town involved, as given in VI-3 Selection of Power Source System by Economic Evaluation.

The red figure, which will be accumulated for five years will reach some ₦1, 300, 000. The financial balancing seems to turn benefittable in years later than 1985 (10 years after commissioning.)

Though the read figure from this project is huge, these losses will have to be compensated for, from social view point, by subsidy from the State Government or other governmental agent.

The red figure in 1980 is estimated to reach approximately ₦220, 000, including approximately ₦90, 000 interest for capital cost. If governmental subsidy is given to the capital cost (at no interest), the red figure in each year will be considerably reduced.

2) If all towns in this project are electrified by diesel generation system, the red figure will increase. In this case, the red figure in 1980 will reach approximately ₦270, 000.

5. 2 CAPITAL COST

The capital cost for all towns involved will be approximately ₦3, 100, 000 in 1976 (see Table Annex- 2-20). If the capital cost can be reduced by using the diesel generation system for all towns, it will reduce the capital cost to approximately ₦2, 400, 000.

The diesel generation system may seem an easier way, but it gives a large load to financial balancing of later years. Therefore, the power source system will have to be examined closely.

APPENDIX I

OUR ADVICE ON THE FUTURE RURAL ELECTRIFICATION IN THE NORTH-CENTRAL STATE

1. PREFACE

Our survey team made a feasibility study of electrification in the eleven towns which were designated by the State Government. The team felt that the State Government has an enthusiastic attitude toward the promotion of rural electrification.

The team proposed to present private views on recommendable methods of rural electrification and the State Government welcomed our proposal.

2. PROPOSALS

The State Government has considerable experiences in electrification of governmental facilities. However, they are yet to start electrification works of an entire town or an entire state. For this reason, we added "Preparation of Integrated Electrification Plan" and "A Model for Rural Electrification of North-Central State" to our private views in efforts to give a concrete image of our proposal. (See Appendix I-1, I-2)

2.1 PROMOTION OF ELECTRIFICATION BASED OF INTEGRATED ELECTRIFICATION PLAN

North-Central State is working for the improvement of social facilities and for economic developments. Electric power will be the base for these developments. Therefore, the State Government should promote rural electrification by preparing a basic electrification plan on the basis of the State Development Plan and by developing it into concrete enforcement plans.

If this policy is adopted, electrification work will not only be balanced well with various plans of the State Government, but also be economically advantageous. It will allow to predict approximate earnings and expenses and to employ and train operation and maintenance workers.

2.2 PREPARATION OF INTEGRATED ELECTRIFICATION PLAN

The survey team rather bravely prepared "A Model for Rural Electrification of North-Central State" and "Preparation of Integrated Electrification Plan" on the basis of the field investigation of eleven towns and of data and materials obtained elsewhere.

The State Government is advised to study "A Model for Rural Electrification of North-Central State". If they decide that the proposed model is worth a thorough study even with some changes in scale and period, they should prepare a "basic electrification plan" on their own initiative by following "Preparation of Integrated Electrification Plan". Finally, they are advised to prepare an integrated electrification plan.

2.3 SATISFACTION OF CONDITIONS FOR PREPARATION OF INTEGRATED ELECTRIFICATION PLAN

The following conditions must be considered for adequate preparation of an integrated electrification plan.

2.3.1 Abilities for Preparation of Plan

The following methods are recommended for obtaining staff with abilities to prepare plans.

a) Training

The related officials and electric power engineers of the State Government to be engaged in the preparation of an electrification plan should be trained at NEPA or in foreign countries.

b) Experience of Electrification Work

The State Government should obtain experiences and records of electrification by electrifying several of the towns which were investigated by our survey team.

c) Use of Foreign Technology

Additionally, the State Government should ask for technical cooperation of a survey team capable of taking leadership in the preparation of an electrification plán or leave planning to a consultant.

2.3.2 Organization of System for Preparation of Electrification Plan

An electrification plan must not only sufficiently reflect the State Government's policy and the State Development Plan, but also be evaluated and corrected in the process. This requires to organize a system, such as an electrification committee, to facilitate discussions between the members of the State Government and a planning task force comprising a survey team.

2.3.3 NEPA's Agreement for Cooperation

For the preparation of integrated electrification plan, NEPA must be consulted with on various items, including a substation plan of power source, the distribution of works related to construction, operation and maintenance of transmission lines, technical conditions, wholesale power rates. It is important to obtain NEPA's agreement to cooperate with the planning by the State in advance so that a discussion can be made and a conclusion can be obtained on any subject at anytime.

APPENDIX I-1

A MODEL FOR RURAL ELECTRIFICATION OF NORTH-CENTRAL STATE

1. PURPOSE

One model is used here to estimate electrification scale, expenses and financial balance. It will facilitate the study of an integrated electrification plan for the State and give an image of electrification.

2. GENERAL

2.1 TOWNS FOR ELECTRIFICATION

If five hundred towns in the State are considered for electrification, they can be roughly divided into the following three groups.

1) About forty towns of district headquarter (to be called as A group)

2) About one hundred and sixty towns with population exceeding 10,000 (to be called as B group)

3) About three hundred towns with population of 3,000 - 10,000 (to be called as C group)

2.2 ELECTRIFICATION METHOD

One of the possible electrification methods consists of constructing about ten substations as electric power sources in the State. They are to receive power from NEPA's grid by transmission lines of at least 132 KV. The towns within approximately 80 km from power source substation are connected them by transmission lines as Fig. Appendix-I-1. High voltage lines (11 KV) and low voltage lines (415V/240V) are to be used for power distribution within each town.

2.3 COSTS OF ELECTRIFICATION WORKS

The approximate capital costs of electrification by this method are given in Table Appendix-I-1. The costs for A group, B group and C group are ₦17,000,000, ₦37,000,000 and ₦28,000,000, respectively. The costs for A and B groups are ₦55,000,000, while the costs for all the three groups are ₦83,000,000. However, these figures do not include works of 132 KV transmission lines and power source substations. They are considered as wholesale power rates.

Table Appendix-I-1 MODEL ELECTRIFICATION WORKS

Item	Town classification			
	A group	B group	C group	Total
Transmission line				
Overall length (km)	1,200	2,800	1,500	5,500
Capital cost (₦x10^6)	12.6	29.4	15.8	57.8
Distribution system capital cost (₦x10^6)	4.8	8.0	12.0	24.8
Capital cost total (₦x10^6)	17.4	37.4	27.8	82.6
Number of towns	40	160	300	500
Population (1974) (x10^3)	550	1,800	2,200	4,500
Capital cost per town (₦x10^3)	435	234	93	165
Capital cost per capita (₦)	32	21	13	18

2.4 ELECTRIFICATION SPEED AND EARNINGS AND EXPENSES

There are various possibilities as electrification speed for the three groups of towns. It is assumed that A and B groups should be electrified during the first ten years and C group during the next ten years. The earnings and expenses under this assumption are summarized in Table Appendix-I-2.

Remarks : This drawing represents the configuration of substations for power source and the situation of connecting 33kv transmission lines in respective A group towns which are to be electrified.

Explanatory Notes

- ○ : Existing substation for power source
- ◌ : Additionally needed substation
- △ : A group towns
- 330kv Transmission line
- 132kv Transmission line
- 33kv Transmission line

Chain lines represent additionally needed transmission lines.

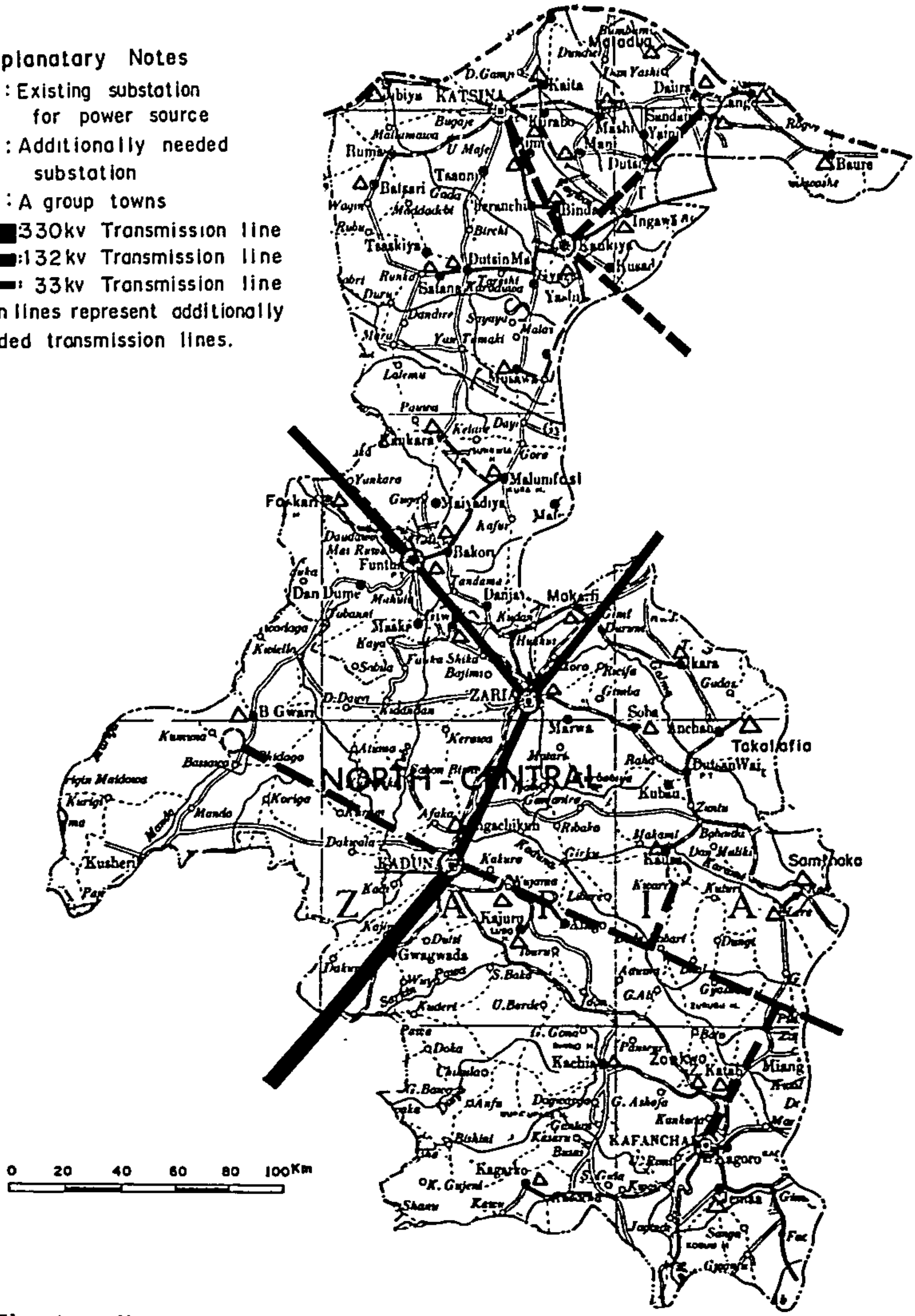


Fig. Appendix-I-1 Map of Power Transmission System on North-Central State Electrification Model

Table Appendix-I-2 COMPARISON OF EARNINGS AND EXPENSES

(Unit: ₦x10⁶)

Period of power supply	5th year	10th year	15th year	20th year	Conditions
A group	Δ 0.61	Δ 0.80	0.03	0.84	See Item 6.1
B group	Δ 1.22	Δ 2.03	Δ 1.22	Δ 0.41	
C group	0	0	Δ 0.85	Δ 1.31	
Total	Δ 1.83	Δ 2.83	Δ 2.04	Δ 0.88	

In other words, the red figure will amount to ₦3,000,000 in the worst year and ₦2,000,000 on the average. However, they are equivalent to the interests in Table Appendix-I-3. The red figure is higher than the interest by about 500,000/year during the first ten years. However, it will become lower than the interest by 500,000/year in the 15th year. The red figure with be one third of the interest in the 20th year.

The interests in the table were estimated by assuming the annual interest rate of 5%. However, interests could be lower in consideration of the possibilities of investment in kind to NEPA and of the State Government's investment of fund on hand as social services. Therefore, electrification works pay well as business.

No rise in prices is considered in the above estimates.

3. CURRENT STAGE OF ELECTRIFICATION AND A MODEL OF ELECTRIFICATION

3.1 CURRENT STAGE OF ELECTRIFICATION

In North-Central State, five cities (Kaduna, Zaria, Funtua, Katsina, Marumfashi) comprising the population of 424,000 have been already electrified as of 1974. Five additional towns (Kafanchan, Dutsin-Ma, Daura, Kankiya and Bakori) are also to be electrified by NEPA in the near future.

1) Thirty-eight district headquarter towns are yet to be electrified. It is assumed that they have an urgent need for electrification for improving education and medical services. These towns are named as A group.

2) About one hundred and sixty towns which are equivalent to district headquarters in population are found in the map of 1/5,000,000. The population of these towns is estimated to be at least 10,000. They are named as B group.

3) In addition to the towns of the above two groups, there are about three hundred towns with the population exceeding 3,000. The average population is estimated to be about 7,000. They are named as C group.

   B and C groups also will need some electrification. The towns are divided into these three ranks for electrification planning.

3.2 ELECTRIFICATION MODEL

a) Adoption of Electrification by Connection to Grid by Transmission Lines

There are various electrification methods, including the adoption of isolated diesel generation, the connection to a grid, a combination of the two and a change from diesel generation at start to grid connection. The present model

Table Appendix-I-3 DETAILED COMPARISON OF EARNINGS AND EXPENSES

Period of power services		5th year	10th year	15th year	20th year	Remarks
kWH Sales	A group	9.00	33.00	63.00	93.00	
	B group	15.60	40.20	58.20	76.20	
	C group	0	0	14.60	37.70	
	Total	24.60	73.20	135.80	206.90	
Income Revenue (₦x10⁶)	A group	0.36	1.32	2.52	3.72	Unit 4kobo/ kWH
	B group	0.78	2.01	2.91	3.81	" 5 "
	C group	0	0	0.73	1.89	" 5 "
	Total	1.14	3.33	6.16	9.42	
Expenditure Wholesale power rates (₦x10⁶)	A group	0.12	0.43	0.82	1.21	Unit 1.3 kobo/kWH
	B group	0.20	0.52	0.76	0.99	
	C group	0	0	0.19	0.49	
	Total	0.32	0.95	1.77	2.69	
Maintenance and operation cost (₦x10⁶)	A group	0.17	0.35	0.35	0.35	Capital cost x 2%
	B group	0.37	0.75	0.75	0.75	
	C group	0	0	0.28	0.56	
	Total	0.54	1.10	1.38	1.66	
Management cost (₦x10⁶)	A group	0.02	0.09	0.17	0.25	kWH sales x 0.27 kobo/kWH
	B group	0.04	0.11	0.16	0.21	
	C group	0	0	0.04	0.10	
	Total	0.06	0.20	0.37	0.56	
Depreciation cost (₦x10⁶)	A group	0.26	0.51	0.51	0.51	Transmission line 40 yrs
	B group	0.53	1.06	1.06	1.06	Distribution line 25 yrs
	C group	0	0	0.44	0.88	
	Total	0.79	1.57	2.01	2.45	
Interest (₦x10⁶)	A group	0.40	0.74	0.64	0.56	Annual interest rate 5%
	B group	0.86	1.60	1.40	1.21	
	C group	0	0	0.63	1.17	
	Total	1.26	2.34	2.67	2.94	
Total of expenditures	A group	0.97	2.12	2.49	2.88	
	B group	2.00	4.04	4.13	4.22	
	C group	0	0	1.58	3.20	
	Total	2.97	6.16	8.20	10.30	
Difference (₦x10⁶)	A group	Δ0.61	Δ0.80	0.03	0.84	
	B group	Δ1.22	Δ2.03	Δ1.22	Δ0.41	
	C group	0	0	Δ0.85	Δ1.31	
	Total	Δ1.83	Δ2.83	Δ2.04	Δ0.88	

is based on a grid connection system, which seems practical for the electrification of a large number of towns.

b) Priority Order and Electrification Method

The towns of A group (district headquarters) are assumed to have the highest priority. They are to be electrified by means of connection to a grid.

The towns of B group are to be electrified either by connection to the transmission lines for A group or by connection by branch lines, or by extension or installation of transmission lines.

The transmission lines for A or B group will nearly cover the entire State. Therefore, the towns of C group are to be electrified mainly by connection to the transmission lines for A or B group or by branch lines.

c) Length of Required Transmission Lines

i) The length of the transmission lines to connect the towns of A group is obtained from the distance of individual towns to grid power source substations in Kadura, Zaria (already in operation), Funtua (ready for operation in near future), Kankiya, Katsina and Kauru (under plan). About 1,200 km long transmission line is required, excluding the 220 km long transmission line (33 kV) being planned by NEPA.

ii) The length of the transmission lines to connect the one hundred and sixty towns of B group is estimated by the following method. The main roads along which most of these towns are located are approximately 3,800 km long. The length of the transmission lines for A group (i), namely 1,400 km, is subtracted from it and 400 km is added to it for the towns not located along the main roads. In sum, 2,800 km long transmission line is required for connection.

iii) The length of the transmission line required for the three-hundred towns of C group is estimated to be 1,500 km on the assumption that each town can be connected by a 5 km long line on the average branched from transmission lines for A or B group towns.

d) Distribution System

The distribution systems within towns are to be of 11 kV (high voltage) and 415V/240V (low voltage) and are equivalent to the systems which were designed by our survey team.

4. ASSUMPTION OF ELECTRIFICATION PROCESS AND CAPITAL COST

The State Government's policy must determine the details of electrification. The following plans are adopted for the present model.

4.1 PERIOD

Since the total investments amount to ₦83,000,000, the entire plan is to be completed in twenty years. A and B groups are to be electrified during the first ten years and C group is to be electrified during the next ten years.

4.2 UNIT PRICE OF CAPITAL COST

The unit prices given below are applicable to 1976. They were used for the entire period for estimating capital costs.

1) 33KV transmission line .... ₦10,500/km

2) Distribution system

A group .... ₦120,000/town
B group .... ₦50,000/town
C group .... ₦40,000/town

4.3 CAPITAL COST BY YEARS AND TOTAL CAPITAL COST

Table Appendix-I-4 shows the capital cost and coverage by years, total capital cost and coverage based on 4.1 and 4.2.

Table Appendix-I-4 CAPITAL COST AND COVERAGE BY YEARS AND TOTAL

Town classification		First 10 years		Latter 10 years		Total	
		Coverage/year	Capital cost/year (₦x10^6)	Coverage/year	Capital cost/year (₦x10^6)	Coverage	Capital cost (₦x10^6)
A group	T.L.	120 km	1.26	-	-	1200 km	12.6
	D.S.	4 town	0.48	-	-	40 town	4.8
	Total	-	1.74	-	-	-	17.4
B group	T.L.	280 km	2.94	-	-	2800 km	29.4
	D.S.	16 town	0.80	-	-	160 town	8.0
	Total	-	3.74	-	-	-	37.4
C group	T.L.	-	-	150 km	1.58	1500 km	15.8
	D.S.	-	-	30 town	1.20	300 town	12.0
	Total	-	-	-	2.78	-	27.8
Total	T.L.	400 km	4.20	150 km	1.58	5500 km	57.8
	D.S.	20 town	1.28	30 town	1.20	500 town	24.8
	Total	-	5.48	-	2.78	-	82.6

Note: T.L.---Transmission Line D.S.---Distribution System

5. ESTIMATE OF POWER DEMAND

The demands by the towns of the three groups were assumed as given below on the basis of the results of the survey.

5.1 FORECAST OF kWH

a) kWH of A group Towns

An approximately middle value of Fig. Appendix-I-2 was taken for the forty towns of A group.

1st year ....150,000 kWH/year/town
Growth after second year ...150,000 kWH/year/town

b) kWH of B group Towns

Neither schools nor medical facilities were considered for B group towns. The following values were taken by assuming the value of kWH for existing town area and water supply use in surveyed towns with equivalent population. (Fig. Appendix-I-3)

1st year ....150,000 kWH/year/town
Growth after second year ... 22,500 kWH/year/town

c) kWH of C group Towns

The average population of C group towns is about 7,000, which is slightly larger than one half of the average population of B group towns. However, their demand was assumed to be one half of that of B group towns.

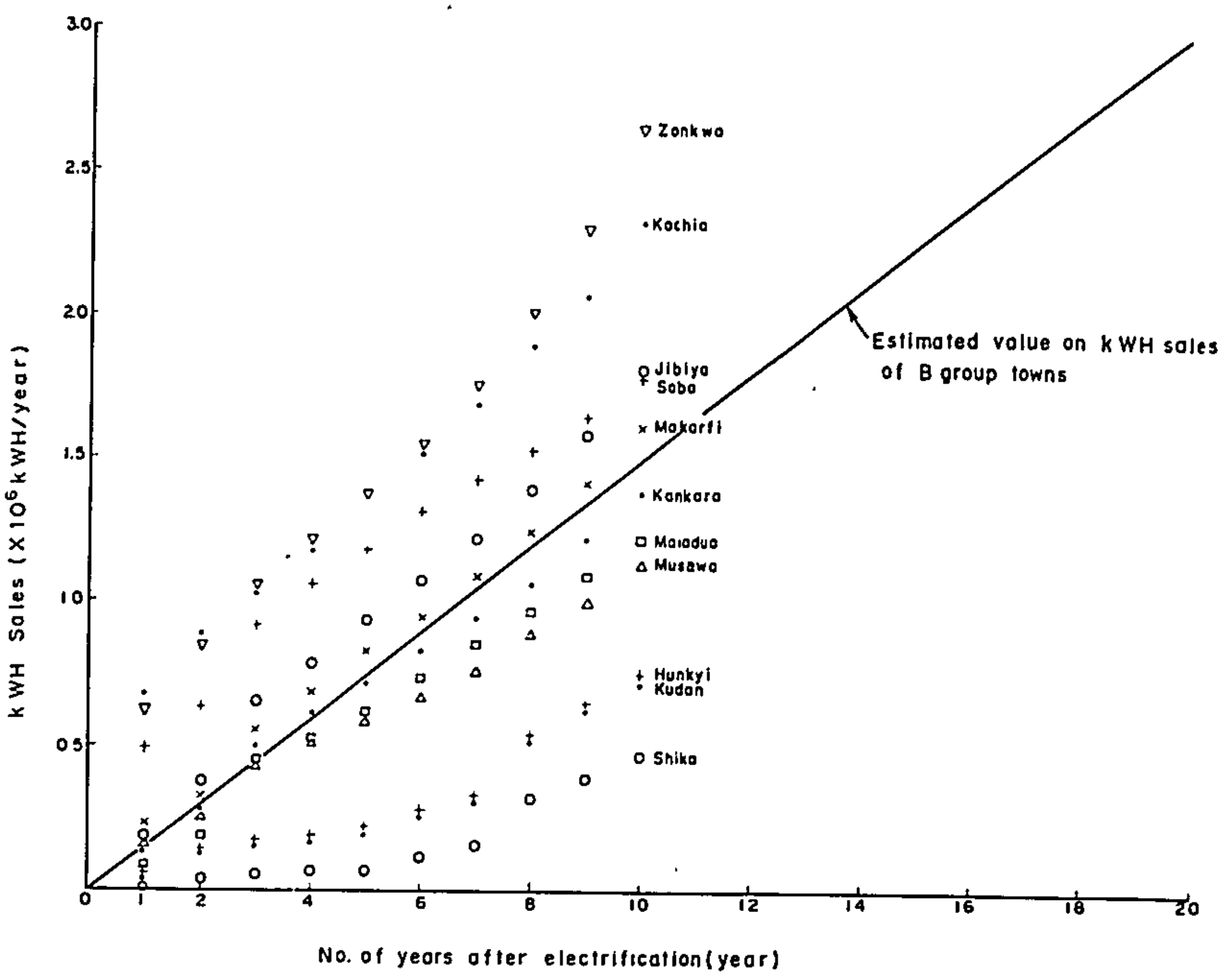


Fig. Appendix-I-2 Estimated Value on kWH Sales of A Group Towns

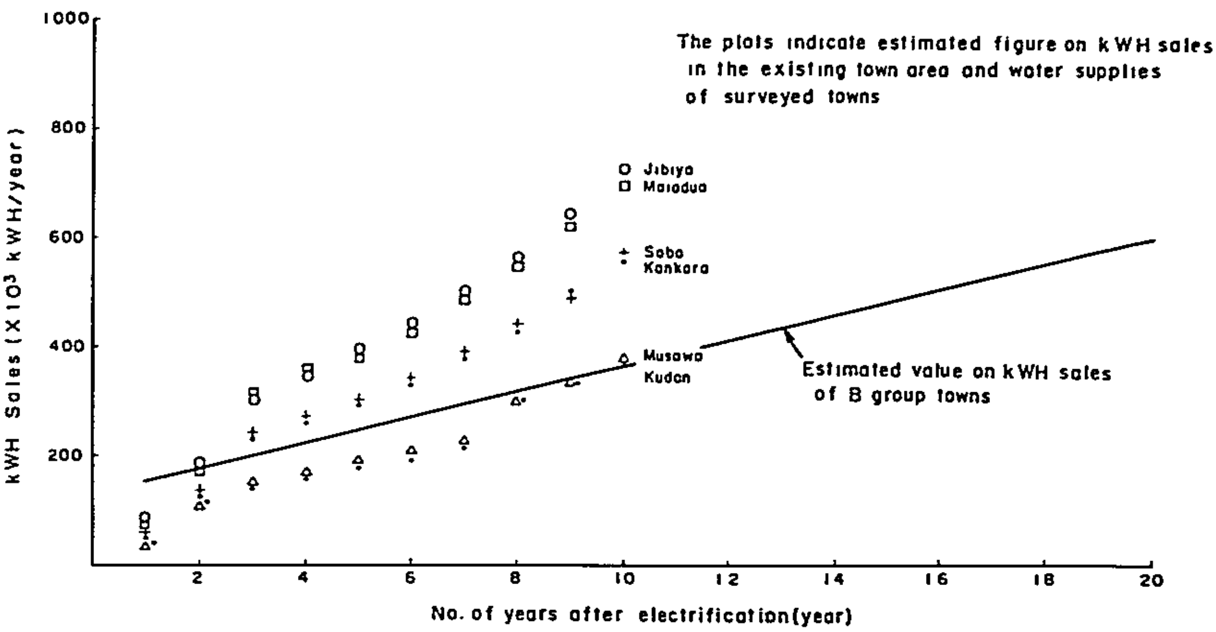


Fig. Appendix-I-3 Estimated Value on kWH Sales of B Group Towns

1st year .... 75,000 kWH/year/town
Growth after second year ... 11,250 kWH/year/town

d) Transition of kWH

The following table roughly shows the transition of kWH based on the above assumptions.

Table Appendix-I-5 TRANSITION OF kWH OF RURAL ELECTRIFICATION

Town classification \ Item	Period after electrification							
	5th year		10th year		15th year		20th year	
	No. of electrified towns	kWH $x10^6$ kWH/year	No. of electrified towns	kWH $x10^6$ kWH/year	No. of electrified towns	kWH $x10^6$ kWH/year	No. of electrified towns	kWH $x10^6$ kWH/year
A group	20	9.0	40	33.0	40	63.0	40	93.0
B group	80	15.6	160	40.2	160	58.2	160	76.2
C group	-	-	-	-	150	14.6	300	37.7
Total	100	24.6	200	73.2	350	135.8	500	206.9

5.2 ASSUMPTION OF MAXIMUM DEMAND

Maximum demand is estimated by the method used for estimating kWH.

a) Maximum Demand of A Group Towns

The maximum demand of A group towns is assumed as below on the basis of Fig. Appendix-I-4.

1st year ....100 kW/town
Annual growth .... 20 kW/year/town

b) Maximum Demand of B Group Towns

The maximum demand of B group towns, including water supply, is assumed as given below from Fig. Appendix-I-5.

1st year .... 60 kW/town
Annual growth ....7.5 kW/year/town

c) Maximum Demand of C Group Towns

The maximum demand of C group towns is assumed to be one half of that of B group towns.

1st year .... 30 kW/town
Annual growth .... 3.75 kW/year/town

d) Transition of Maximum Demand

The following table shows the transition of maximum demand obtained from the above assumptions.

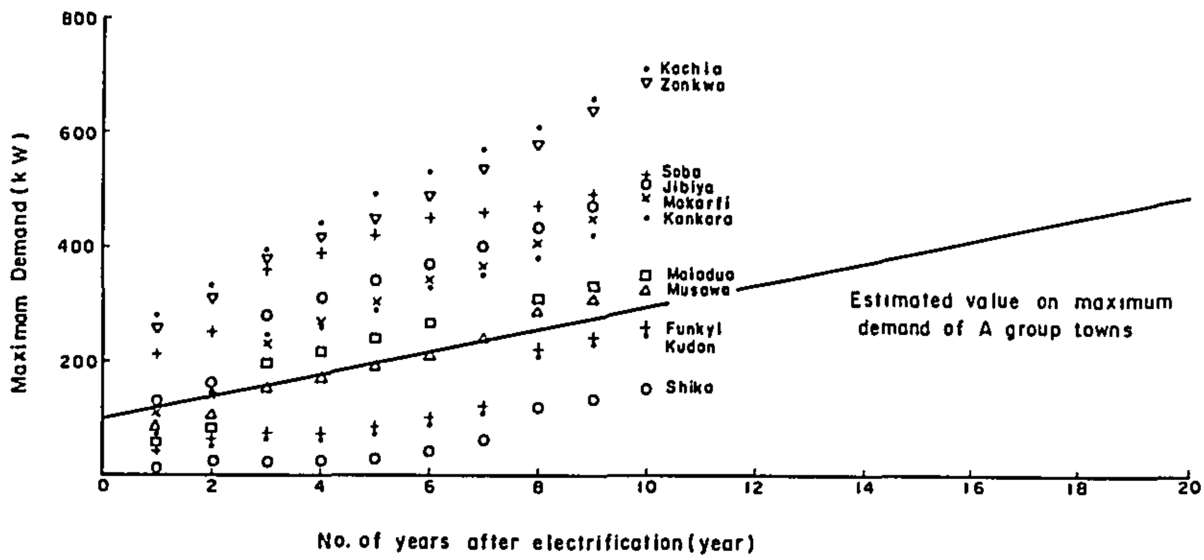


Fig. Appendix-I-4 Estimated Value on Maximum Demand of A Group Towns

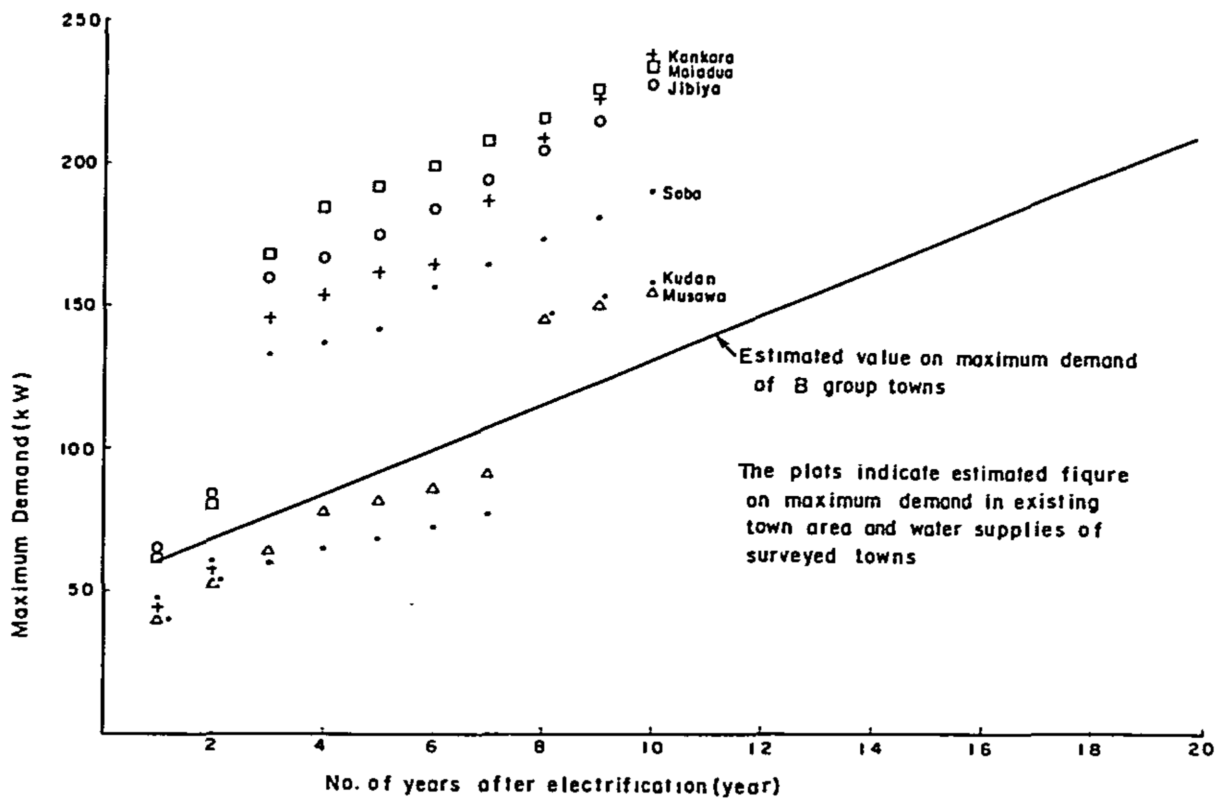


Fig. Appendix-I-5 Estimated Value on Maximum Demand of B Group Towns

Table Appendix-I-6 TRANSITION OF MAXIMUM DEMAND OF RURAL ELECTRIFICATION

Town classification	5th year: No. of electrified towns	5th year: Maximum demand MW	10th year: No. of electrified towns	10th year: Maximum demand MW	15th year: No. of electrified towns	15th year: Maximum demand MW	20th year: No. of electrified towns	20th year: Maximum demand MW
A group	20	2.8	40	7.6	40	11.6	40	15.6
B group	80	6.0	160	15.0	160	19.8	160	27.0
C group	-	-	-	-	150	5.7	300	14.1
Total	100	8.8	200	22.6	350	37.1	500	56.7

(Period after electrification)

5.3 DISCUSSION ON ASSUMPTIONS

1) It is highly difficult to make assumptions of long-range power demand. It is influenced by the political and economic factors of the State, the country and the world. Even greater difficulty is involved under rapidly changing conditions, especially in the case of first electrification. Therefore, assumptions must be corrected gradually according to the progress of electrification works and various changing conditions.

2) Since the demand that is determined by the business plan of the State Government is a large factor, the assumptions of demand must be reviewed by referring to every new business plan.

3) The following table shows the maximum demand that is predicted on the basis of the relation between the trend of power demand in entire Nigeria and the present rural electrification.

Table Appendix-I-7 TRANSITION OF MAXIMUM DEMAND IN ENTIRE STATE

(Unit: MW)

Period after electrification	5th year 1982	10th year 1987	15th year 1992	20th year 1997
Entire Nigeria	1,300	2,500	4,500	7,500
Entire N.C.S.	100	200	350	600
Kaduna, Zaria and other major towns	90	175	310	540
Rural electrification	10	25	40	60

This table is based on the following assumptions.

i) It was assumed that the power demand in entire Nigeria should continue to grow at the current growth rate (20%/year) for the next twenty years.

ii) The power demand in North-Central State was assumed to be approximately one twelfth of the demand in entire Nigeria according to the population ratio.

iii) Therefore, there is a large difference between the power demand in the entire State and rural electrification.

This is probably accounted by the power demand on the basis of both the development of about ten administrative headquarter towns exclusive Kaduna, Zaria into commercial and industrial cities and the dispersion of industries to A group towns.

4) When these factors are considered, the assumed demand for rural electrification is never excessive. The demand could be even larger under some economic conditions of the country and the State.

6. ECONOMIC EVALUATION

6.1 FIGURES USED FOR ECONOMIC EVALUATION

The figures used in VI ECONOMIC EVALUATION were used again.

1) Unit price of power purchased from grid.

1.28 kobo/kWH

2) Maintenance and operation cost of transmission line and distribution system.

2% of capital cost/year

3) Administration cost and collection expenses.

0.27 kobo/kWH

4) Sales unit price of power

Average unit price calculated from consumption on the basis of NEPA's rates system.

A group .... 4 kobo/kWH
B and C groups .... 5 kobo/kWH

5) Depreciation

The service life of transmission lines and distribution systems is assumed to be 40 years and 25 years, respectively under straight line depreciation system.

6) Interest

Since the State Government undertakes rural electrification as social service, an interest rate of 5% is assumed. The evaluation is to be based on the difference between interest payment and balance of earnings and expenses.

6.2 BALANCE OF EARNINGS AND EXPENSES

The following results are obtained by using the figures for the economic evaluation in 6.1, and by assuming electrification works according to the schedule of 4.1 and the power supply given in 5.1 from the next year. (See Table Appendix-I-3)

The red figure remains close to interest payment until the 10th year of power supply. The red figure becomes one third of interest payment around in the 15th year. The income becomes equal to the expenditure after the 20th year.

As long as the State Government bears the red figure within interest payment during red figure period and allows low interest on the condition of investment in kind to NEPA, rural electrification will pay as a business.

The income will balance with the expenditure in the 10th year in the case of A group towns, and will probably balance in the 30th year in the case of B group towns and even later in the case of C group towns. However, these factors should be considered as unknown since they are based on long-range forecast of demand.

It is possible to change power rates for improving the balance of income and expenditure. However, no rates increase was assumed here since the current rates system is already quite high for small consumer and the rural electrification is done as social services.

7. EVALUATION AND DISCUSSION ON PRESENT MODEL

7.1 COMPARISON OF PRESENT MODEL WITH SURVEY RESULTS

Table Appendix-I-8 COMPARISON OF ELECTRIFICATION MODEL WITH SURVEY RESULTS

		No.of towns	Total population (in thousands)	Average population/town (in thousands)	Total cost of electrification works (in million ₦)	Cost of electrification works/town (in million ₦)	Investment per capita (of local population (₦)
Survey results	Electrification by diesel generation	11	133	12	2.9	0.26	22
	Electrification by transmission lines	11	133	12	4.9	0.45	37
electrification model	A group	40	520	13	17.4	0.43	33
	B group	200	2,200	11	37.4	0.19	17
	C group	300	1,800	6	27.8	0.09	16
	Sum or means	(S) 500	(S) 4,520	(M) 9.1	(S) 80.2	(M) 0.16	(M) 18

Note: (S)---Sum, (M)---Means

When the electrification methods for the eleven surveyed towns is compared with this electrification model, the following conclusions can be drawn.

1) The investment per capita of local population is ₦22/capita in the case of diesel generation of the eleven towns, but is ₦18/capita in the case of this electrification model (mean). A long range comparison reveals that the present electrification model not only has larger supply capacity and longer useful life, but also requires lower operation cost. In sum, this model has advantages over diesel generation.

2) The cost of electrification works for A group is about ₦430,000/town, which is close to the cost for the electrification of the eleven towns by transmission lines. This because the connection of A group by transmission lines was planned regardless of the electrification of B and C group towns.

According to the results of VI ECONOMIC EVALUATION, the cost of electrification works by transmission lines exceeds ₦530,000/town in those towns where diesel generation system is advantageous. On the other hand. The cost of electrification works never exceeds ₦510,000/town in those towns where transmission line system is advantageous. For this reason, the use of transmission lines is generally more advantageous for the electrification of A group towns.

3) With regard to B and C groups, the cost of electrification works amounts to about ₦230,000/town and ₦90,000/town, respectively. Since it is equal to or lower than the cost of electrification works by diesel generation, this model is more advantageous.

7.2 STUDY OF PRESENT MODEL

This model is based on rather brave assumptions, private views and simple methods. It requires a further study in the following respects.

a) Relation with State Government's Economic Development Plan

This model is not based on the State's Development Plan, but simply is a model. To be adopted as a plan, it must reflect the State's Development Plan.

b) Electrification by Transmission Lines and Relation Between NEPA and the State

With this model, transmission lines are used for connection to NEPA grid. A decision must be made as to who is in charge of the construction, operation and maintenance of transmission lines. Some possibilities are listed.

1) NEPA constructs, operates and maintains transmission lines under the State Government's investment.

2) The State Government constructs transmission lines under sufficient coordination with NEPA and leaves operation and maintenance to NEPA under investment in kind.

3) The State Government is in charge of constructing, operating and maintaining transmission lines.

Decisions on them must be made according to the State Government's policy and arrangements with NEPA.

APPENDIX I-2

PREPARATION OF INTEGRATED ELECTRIFICATION PLAN

1. INTRODUCTION

The following suggestions are based on the experiences of our electrification survey and intended to facilitate the planning of electrification in North-Central State.

It has the following three features.

1) A plan should be developed from a basic plan into concrete plans.

2) Various items do not require a study with uniform thoroughness at all the steps of planning.

3) Items in a wide range of fields should be considered.

2. ITEMS TO BE STUDIED

The items to be studied for the planning of electrification can be roughly classified into four groups, as shown in Table Appendix-I-9.

1) Determination of electrification policy, 2) Preparation of electrification facility plan and 4) Evaluation of electrification plan are directly connected with an electrification plan. On the other hand, 3) Preparation of conditions for electrification must be studied together with an electrification plan.

The study of 3) should never be omitted in the case of the first full-scale electrification. Numerous items come under 3), but only basic and important items are taken up here.

2.1 PROCESS OF PLANNING

To prepare a large and complicated plan, such as "Integrated Electrification Plan", it is recommended to make a simple basic plan and develop it into a detailed plan through studies and evaluations. In other words, a practical plan should be prepared on the basis of a basic vision-oriented plan.

"One Model of Rural Electrification of North-Central State" prepared by the survey team represents the first step of planning. The State Government is advised to start with it and prepare "Basic Electrification Plan" on its initiative for establishing its basic policy on electrification.

As the next step, the State Government is advised to prepare "Concrete Electrification Plan" in full consideration of their development plan. This plan should clarify the towns to be electrified during the next several years, facilities to be constructed, budgets for them, etc.

"Concrete Electrification Plan" for the next term is to be prepared according to the progress of time and the progress of electrification. Plans are to be prepared regularly or according to needs in consideration of the State Development Plan, the progress of electrification works and changes in various factors.

3. EXPLANATION ON HOW TO STUDY OF ITEMS

3.1 STAGES OF PLANNING AND STUDY OF ITEMS

It is more efficient and adequate to study individual items with adequate thoroughness and methods at each stage of planning rather than to study them uniformly at all the stages of planning. The items to be studied can be classified into the following four groups in this respect.

1) Items requiring thorough study and having special importance (Symbol ◎)

2) Items requiring thorough study (Symbol O)

3) Items requiring rough study (Symbol Δ)

4) Items to be studied at another stage (Symbol X)

Our classification of various items is shown in Table Appendix-I-10.

3.2 DIFFERENCE IN CONTENT OF STUDY

The individual items also have slight difference among one another in the content of required studies. For example, it will not be adequate to leave the study of all the items to a task force consisting of a consultant or a foreign technical cooperation team and members of the State Government. The items can be classified as below from this view point.

1) Items requiring detailed answers and decisions

   Examples include 2.1 Survey of objects of electrification, 2.3 Preparation of electrification facility plan and 4.3 Economic evaluation in Table Appendix-I-9. These items require to study and give answers on the basis of a principal policy.

2) Items requiring general study for a plan and separate detailed preparation

   Examples include 3.4 Organization, 3.4 and 3.5. These items require a general study or a rough schedule and need concrete planning separately at adequate time.

3) Items oriented to policy and evaluation

   For example, 3.1 Division of responsibilities in electrification works as well as 4.1, 4.2 and 4.4 are oriented mainly to the State Government's policy and evaluation.

   In sum, the individual items classified into these three groups must be studied and promoted by adequate means.

3.3 FEEDBACK FOR PLANNING AND STUDY METHOD

Generally speaking, three steps (Plan, Do, See) are repeated for most undertakings. This integrated electrification plan is not an exception. "Electrification Model," "Basic Electrification Plan" and "Concrete Electrification Plan" are to advance gradually by repeating these steps.

To make adequate plans complying with the policy of the State Government, it is important to set a policy, to work, to evaluate, to correct problems and to work again and evaluate again at every step. In other words, the results of works must be evaluated and feedback.

Therefore, both 3.2 and 3.3 must be considered in determining the method of study and promotion.

Table Appendix-I-9 ITEMS REQUIRING STUDY FOR ELECTRIFICATION PLANNING

Item	Explanation
1. Preparation of electrification policy	It should be based on State Government's Development Plan
1.1 Determination of range and time of electrification	It should be based on plan of business requiring power, industrialization plan and social service policy, etc.
1.2 Investment for electrification	Determination of financially probable frame
2. Preparation of electrification facility plan	
2.1 Survey of objects of electrification	Survey for predicting demand and for planning facilities
2.2 Study of electrification system	Standardization of plan (facility planning standards), compliance with NEPA plan
2.3 Preparation of electrification facility plan	
2.4 Summary of State in electrification facility plan	Including the division of responsibilities with NEPA (3.1)
3. Arrangement of conditions related to electrification	
3.1 Division of responsibilities in electrification works	Division with NEPA
3.2 Plan of use of foreign technology	Scheduling of use and switching to the State
3.3 Plan of staff and organization	Including education and training plan
3.4 Plan of operation and maintenance system and facility plan	
3.5 Plan of standards and criteria	Standard design, standard specifications operation and maintenance standards, etc.
4. Evaluation of electrification plan	
4.1 Evaluation based on policy	Evaluation based on need for realization of economic development plan, evaluation based on social services
4.2 Evaluation based on possibility	Evaluation based on budget and staff availability, technology, engineering capacity
4.3 Economic evaluation	Evaluation based on income and expenditure, power rates policy
4.4 General evaluation	Correction policy and determination of adoption

Table Appendix-I-10 ITEMS REQUIRING STUDY FOR ELECTRIFICATION PLANNING CONTENT AND HANDLING AT EACH STEP

Item No.	Main content of work	Basic electrification plan		Concrete electrification plan		Subsequent
		Handling	Explanation	Handling	Explanation	Handling
1.1	Policy	◎	Electrification model is corrected by collation with the State Government's policy and economic development plan	○	Five year operation policy complying with economic development plan is made on the basis of basic electrification plan	○
1.2	"	◎	A financial policy complying with the above is made	○	Budget frame for five years is determined	○
2.1	Preparation	△	Sampling survey, study of data	◎	Survey of areas to be electrified during five years	◎
2.2	"	◎	Emphasis is laid on selection of electrification method	○	Emphasis is laid on concrete standardization (Correction at subsequent step, if necessary)	×
2.3	"	○	Emphasis to be placed on basic composition and long range deployment method	◎	Emphasis to be placed on areas of electrification in five years	◎
2.4	"	○		◎		◎
3.1	Policy, Negociation	◎	Basic policy	△	Addition of details, when necessary	×
3.2	Policy, Plan	○	Basic policy	○	Study on method of ordering designing and works	×
3.3	"	△	Basic configuration and general plan	○	Five year plan	△
3.4	"	△	Basic plan	○	Facility plan for adopted system	△
3.5	Plan	×		○	Plan complying with work schedule	△
4.1	Evaluation	○		○		△
4.2	"	○		○		△
4.3	"	◎		○		△
4.4	"	◎	Necessary corrections are made. If promotion of plan is desirable, it is adopted as basic plan. Proceed to the next step with instructions for concrete plan	○	Necessary corrections are made and plan is adopted	○

Appendix II System Voltage Drop in 11kV and 33kV System

1. Analysis Practice (simplyfied method)

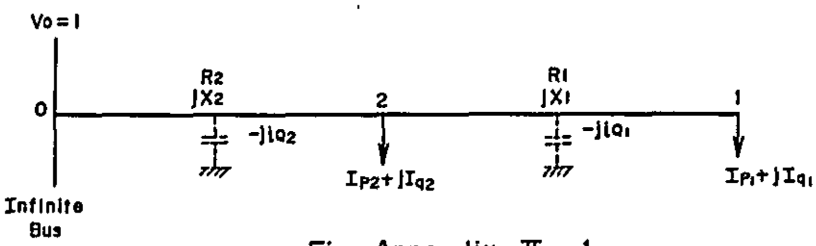


Fig. Appendix II - 1

When a transmission line has two load points, as shown in Fig Appendix II-1, the line constants are determined as given below:

Load .... $Ip_1 + jIq_1$ and $Ip_2 + jIq_2$

Impedance .. $R_1 + jX_1$ and $R_2 + jX_2$

Charging capacity current ... $-jIQ_1$ and $-jIQ_2$

The charging capacity is a distribution load, but, it can be assumed to be IQ_1 and IQ_2 in figure above. In order to simplify the calculation, location of the charging capacity is assumed to be distributed at each load point as shown in the Fig. Appendix II-2.

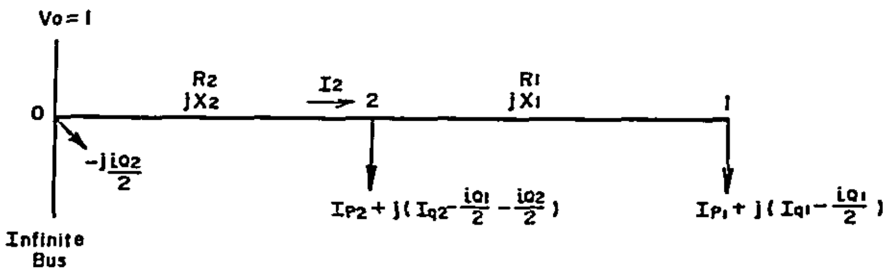


Fig. Appendix II-2

1) Voltage drop in section 1 - 2 ($\triangle E_1$)

The load current at point 1 is

$$(Ip_1 - j(Iq_1 - \frac{IQ_1}{2})) \quad .... \quad (1)$$

Thus, the voltage drop in section 1-2 ($\triangle E_1$) is given as:

$$\triangle E_1 = R_1 \times Ip_1 + X_1 \times (Iq_1 - \frac{IQ_1}{2}) \quad .... \quad (2)$$

2) Voltage drop in section 2-0 ($\triangle E_2$)

The current at point 2 is given by the sum of current which flows 1 to 2 section ($= Ip + j(Iq_1 - \frac{IQ_1}{2})$) and load current at point 2 ($= Ip_2 + j(Iq_2 - \frac{iQ_1}{2} - \frac{iQ_2}{2})$

$$I2 = (Ip_1 + Ip_2) + j(Iq_1 + Iq_2 - IQ_1 - \frac{IQ_2}{2}) \quad ... \quad (6)$$

Thus, the voltage drop $\triangle E2$ in section 0-2 is given as:

$$\triangle E2 = R2 \times (Ip_1 - Ip_2) - X_2 \times (Iq_1 + Iq_2 - IQ_1 - \frac{IQ_2}{2}) \quad ... \quad (7)$$

3) Total Voltage Drop

It gives the total voltage drop $\triangle E$ as the sum of equations (2) and (7):

$$\triangle E = \triangle E_1 + \triangle E_2 \quad ..... \quad (8)$$

When a number of loads are given to a transmission line, the total voltage drop can be calculated by repeating these steps starting from the far-end load side.

2. Analysis by Actual System

An analysis was made for peak load and off peak load in 1976 (at commissioning) and 1987 (10 years later), for the following towns for which the transmission line system seems advantageous in out economic evaluation:

33kV system :	Kankara	68km ASCR 0.15 inch^2	Kazaure	45km ASCR 0.075 inch^2	Daura	24km ASCR 50mm^2	Maiadua
11kV system :	Zaria	19km ACSR 100mm^2	Hunkuyi	11km ACSR 100mm^2	Kudan	17km ACSR 100mm^2	Makarfi

The off peak load was assumed as 10% of peak load, and the load in Kankara, Maiadua, Zaria, Hunkuyi, Kudan and Makarfi was based on demand forecast (Table Annex 1), and the load in Kazaure and Daura was estimated basing on population and other factors.

The calculation was made by using the unit method (10MVA base) assuming the power factor as 0.9.

2.1 33kV Kankiya - Kazaure - Daura - Maiadua system

2.1.1 Load

Table Appendix II-1 (10MVA Base)

·	Kazaure	Daura	Maiadua
1976 peak load Ip	0.006	0.040	0.006
Iq	j0.003	j0.017	j0.003
off peak load Ip	0.001	0.004	0.001
Iq	-	j0.002	-
1986 peak load Ip	0.035	0.106	0.035
Iq	j0.015	j0.046	j0.015
off peak load Ip	0.004	0.011	0.004
Iq	j0.002	j0.005	j0.002

2.1.2 Line constants

Table Appendix II-2 (33kV, 10MVA Base)

	ACSR 0.15 inch² (100 mm²)	ACSR 0.075 inch² (50 mm²)
R	0.265×10^{-2}	0.530×10^{-2}
X	0.333×10^{-2}	0.356×10^{-2}
Y	0.0349×10^{-2}	0.0326×10^{-2}

2.1.3 Determination of impedance in actual line

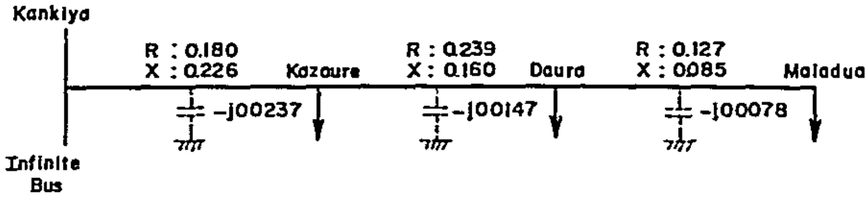


Fig. Appendix II-3

2.1.4 Calculation

1) At initial stage (peak load in 1976)

Current at each point, and voltage drop were given as shown in Fig. Appendix II-4.

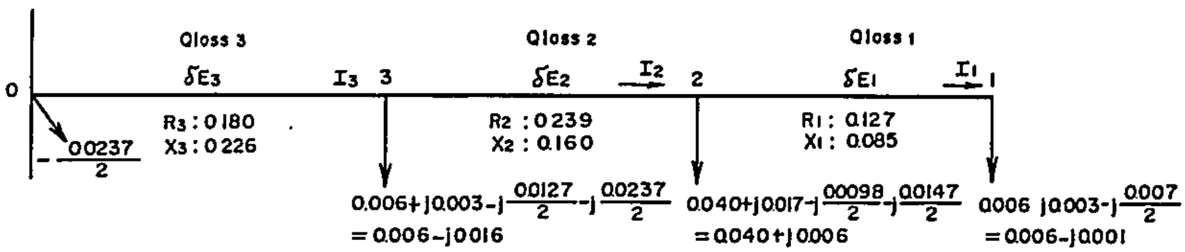


Fig. Appendix II - 4

- 1-2 Section

$$\delta E_1 = 0.127 \times 0.006 + 0.085 \times (-0.001)$$

$$= 0.0006$$

- 2-3 Section

$$\delta E_2 = 0.239 \times 0.046 + 0.160 \times 0.005$$

$$= 0.0118$$

- 3-0 Section

$$\delta E_3 = 0.180 \times 0.052 + 0.226 \times (-0.011)$$

$$= 0.0069$$

2) Off peak load in 1976

3) Peak load in 1985

4) Off peak load in 1985

Calculation steps for these values are equal to those given above 1).

2.1.5 Result of calculation

Table Appendix II-3

	Voltage Drop (%)			
	Kankiya - Kazaure	Kazaure - Daura	Daura - Maiadua	Entire System (Kankiya-Maiadua)
1976				
at peak load	0.69	1.18	0.06	1.93
at off peak load	-0.59	-0.07	-0.04	-0.70
1985				
at peak load	4.58	4.12	0.43	9.13
at off peak load	-0.18	0.25	0.03	0.10

2.2 11kV Zaria - Hunkuyi - Kudan - Makarfi system

2.2.1 Load

Table Appendix II-4 (10MVA Base)

	Hunkuyi	Kudan	Makarfi
1976			
at peak load Ip	0.004	0.004	0.011
Iq	j0.002	j0.002	j0.005
at off peak load Ip	-	-	0.001
Iq	-	-	-
1985			
at peak load Ip	0.026	0.025	0.049
Iq	j0.011	j0.011	j0.021
at off peak load Ip	0.003	0.003	0.005
Iq	j0.001	j0.001	j0.002

2.2.2 Line constant

11kV 10MVA Base

ACSR 100 mm^2 { R 1.89; X 3.00; Y 0.00388 }

2.2.3 Determination of actual line impedance

See Fig. II-5

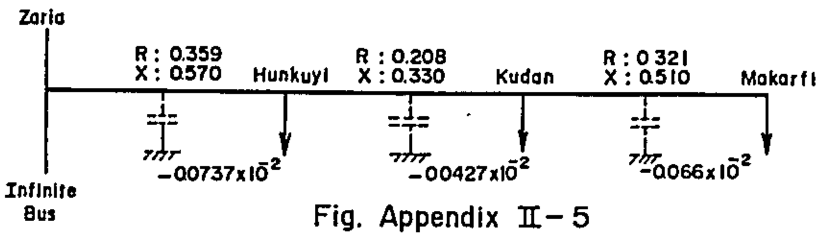


Fig. Appendix II-5

2.2.4 Result

Calculation steps are equal to those given in 2.1.4.

Result of calculation is following:

Table Appendix II-5

	Voltage Drop (%)			
	Zaria ~ Hunkuyi	Hunkuyi ~ Kudan	Kudan ~ Makarfi	Entire System (Zaria~Makarfi)
1976				
at peak load	1.11	0.51	0.59	2.21
at off peak load	-0.05	0.01	0.01	-0.05
1985				
at peak load	5.94	2.56	2.63	11.13
at off peak load	0.54	0.24	0.25	1.03

Table Annex 1-1

K A C H I A

I. Town: Kachia

II. Population:

A.	1963	4,006
B.	1973 (Estimated)	5,266
C.	1976 (")	5,700

III. Classification of Town:

A.	Political	-	Administrative Head-quarter District Headquarter
B.	Industrial	-	Agricultural Town
C.	Traffic	-	Main Route Town

IV. General Information:

Rather small but important administrative town. Educational Institutions have recently shown evidence of a rising town. Should be encouraged to maintain present rate growth.

V. Priority: High

VI. Survey Date: 8/9th November, 1974

VII. Main Load:

A. Residential and Small Commercial Load:

1. Existing Town Area

1) Consumption (Evening Load) — Small Main Consumers, Houses, Street Lights

2) Future Load Growth Rank

a) 1st year - 5th year High
b) 5th year - 10th year High

Details:

Politics	High
Transport	Medium
Industry	Few Local Factories
Special Load	(1 proposed)
Merchants, Shops	Many
Houses	Medium

2. Extension Area

Another side of the river. Some houses like administration office, Rest House, etc., already constructed. Another one is now under construction.

B. Special Load:

1. Secondary School

1)	Consumption (Evening Load)	Classroom Staff's Residence Student's Quarters
2)	Future Load growth Number of Students	High 550 (Now)

Some classrooms are not electrified now for fear of overloading the generator.

2. Rural Health Centre — 1.1 km from Kachia

1)	Consumption (All Day Load)	Main Building, Water Supply, Wards Staff's Residence, Nurses Quarters
2)	Future Load Growth	High

More medical instruments will be purchased about three times the present quantity. (Day Time Load) but the main load is for residence and wards (Evening Load)

3. Water Supply (Dam Proposed)
4. Ministry of Works Yard
5. Army Training Centre

VIII. Isolated Existing Generating Set

A. Secondary School:

65KVA	(94AMP)	400/230V
Load	80A	(Evening Load)

B. Health Centre:

1.	75KVA	(109AMP)	400/230V
	Load	(R) 10AMP (Y) 20AMP (B) 25AMP (All Day Load)	
2.	38KVA (Spare)	(55AMP)	400/230V

IX. Main Building List:

A. Main Office:

- o Administration Office (Temporary)
- o District Office
- o Administration Office (New)
- o Police Office

B. Education Facilities:

- o Government Secondary School
- o Primary School

C. Medical Facilities:

- o Health Centre

D. Public Utilities:

- o Military Training Centre
- o Military Training Centre (proposed new building)
- o Court
- o Prison
- o Post Office and Reading Room
- o Mosque
- o Church
- o Dispensary
- o Town Hall
- o Library

E. Water Facilities:

- o Pump House (proposed)

F. House and Residence:

- o Police Barracks
- o Chairman House (District Council)
- o District Head House
- o Emir's House
- o Rest House
- o Guest House
- o Personal Houses

G. Industry and Others:

- o Market
- o Chicken House (small)
- o Agricultural Centre (small)
- o Mechanical Workshop
- o M.O.W. Yard
- o Street Lights

DEMAND FORECAST

KACHIA

Item			1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	Note
Population(10^3)			5.7	5.9	6.1	6.3	6.5	6.7	6.9	7.1	7.3	7.6	
Maximum Demand (kW)	Existing Town Area		34	43	49	54	59	65	71	78	85	93	No.1 100 kVA
	Extension Area	G.R.A.	43	58	72	86	100	115	130	144	158	173	Present No.4 future 200 kVA
		Others	18	24	30	36	42	48	54	60	66	72	No.3 100 kVA
		Sub Total	51	82	102	112	142	163	184	204	224	245	
	Education Facilities	S.S.	80	89	97	107	118	120	120	120	120	120	No.2 100 kVA
		T.C.											
		Sub Total	80	89	97	107	118	120	120	120	120	120	
	Health Centre		50	55	61	67	74	81	89	98	108	119	No 4 100 kVA
	Water Supplies	Town Area			10	10	10	10	10	10	10	10	No.1
		Agric. etc.			10	10	10	10	10	10	10	10	
		Health Centre	15	15	15	15	15	15	15	15	15	15	No.4
		Sub Total	15	15	35	35	35	35	35	35	35	35	
	M.O.W. Yard		10	11	12	13	14	15	17	19	21	23	No.3
	Army Training Centre		30	33	36	40	44	48	53	58	64	70	Present No.3 future 100 kVA
	Street Lights		1	1	1	1	1	1	1	1	1	1	
	Total		271	329	393	419	487	528	570	613	658	706	
Number of Consumers	Existing Town Area		88	123	149	163	179	196	215	236	258	283	
	Extension Area	G.R.A.	9	12	15	18	21	24	27	30	33	36	
		Others	6	8	10	12	14	16	18	20	22	24	
		Sub Total	15	20	25	30	35	40	45	50	55	60	
	Education Facilities	S.S.	34	37	41	45	50	50	50	50	50	50	
		T.C.											
		Sub Total	34	37	41	45	50	50	50	50	50	50	
	Health Centre		11	12	13	14	15	17	19	21	23	25	
	Water Supplies	Town Area			1	1	1	1	1	1	1	1	
		Agric.etc.			1	1	1	1	1	1	1	1	
		Health Centre	1	1	1	1	1	1	1	1	1	1	
		Sub Total	1	1	3	3	3	3	3	3	3	3	
	M.O.W. Yard		1	1	1	1	1	1	1	1	1	1	
	Army Training Centre		1	1	1	1	1	1	1	1	1	1	
	Street Lights		1	1	1	1	1	1	1	1	1	1	
	Total		152	196	234	258	285	309	335	363	392	424	
	Number of New Consumers		152	44	38	24	27	24	26	28	29	28	
kWH Sales (kWH) x 10^3	Existing Town Area		39	95	124	140	158	179	203	230	260	315	
	Extension Area	G.R.A.	79	110	141	173	208	246	286	326	369	416	
		Others	33	46	59	73	87	103	119	136	154	173	
		Sub Total	112	156	200	246	295	349	405	462	523	589	
	Education Facilities	S.S.	207	238	267	303	344	360	371	382	394	406	
		T.C.											
		Sub Total	207	238	267	303	344	360	371	382	394	406	
	Health Centre		223	252	288	326	371	418	473	537	609	691	
	Water Supplies	Town Area			11	13	16	19	23	27	33	39	
		Agric.etc.			11	13	16	19	23	37	33	39	
		Health Centre	22	24	26	29	32	35	39	43	47	52	
		Sub Total	22	24	48	55	64	73	85	107	113	130	
	M.O.W. Yard		26	29	33	37	41	45	53	61	69	78	
	Army Training Centre		39	44	49	57	64	72	82	92	105	118	
	Street Lights		8	8	8	8	8	12	12	12	12	12	
	Total		676	846	1017	1172	1345	1508	1684	1883	2085	2339	
Revenue (₦) x 10^3	kWH Sales		24.2	30.5	36.8	42.6	48.6	54.8	61.2	67.9	75.6	85.3	
	Connection Fee		0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
	Total		24.5	30.6	36.9	42.7	48.7	54.9	61.3	68.0	75.7	85.4	

Note: 1. G.R.A. ......Government Residential Area
S.S. ....Secondary School
T.C. ....Teachers College
2. The note represents the number of transformers and their capacities in the designing drawing of supply facilities.

Table Annex 1-2

MAKARFI

I. Town: Makarfi

II. Population:

A.	1963	4,665
B.	1973 (Estimated)	6,106
C.	1976 (")	6,700

III. Classification of Town:

A.	Political	-	District Head-quarter
B.	Industrial	-	Agricultural Town
C.	Traffic	-	Main Route Town (Kaduna - Kano)

IV. General Information:

An important sugar cane producing town at which a sugar industry is long overdue. 'On the condition that plans for such an industry are already under way, this town is highly recommended. Good road of transportation.

V. Priority: High

VI. Survey Date: 21st November, 1974

VII. Main Load:

A. Residential and Small Commercial Load:

1. Existing Town Area

1) Consumption (Evening Load) — Small Main Consumers Houses, Street Lights

2) Future Load Growth Rank

a) 1st year - 5th year — Medium
b) 5th year - 10th year — High

Details:

Politics	High
Transport	High
Industry	Few Local Factories
Special Load	One (one proposed)
Merchants, Shops	Some
Houses	Low

2. Extension Area:

New area has been already surveyed.

B. Special Load

1. Secondary School: 2.3 km from Makarfi

a) Consumption (Evening Load): Classroom, Staff's Residence, Student's Quarters

b) Future Load Growth: Very High
Number of Students: 350 (Now), over 1,000 (Five Year estimated)

More Staff Quarters are now under construction.

2. Rural Health Centre (Proposed)

Area not yet decided.

VIII. Isolated Existing Generating Sets

A. Secondary School

65.7KVA	(94.6AMP)	400/230V
Peak load	Red-10AMP	
Peak	Day and Evening	

B. Small Generator

T.V. House

IX. Main Building List

A. Main Offices

- District Head Office

B. Educational Facilities

- Secondary School
- Primary School

C. Medical Facilities

- Clinic
- Leprosy Clinic

D. Public Utilities

- Court
- Police Station
- Prison
- Home Economics
- Council Hall
- Dispensary
- Reading Room
- Treasury (Proposed)
- Mosque

E. Water Supply (Proposed)

F. Houses and Residences

- o District Head House
- o Guest House
- o Small Hotel
- o Police Barracks (Proposed)
- o Personal Houses

G. Industry and Others

- o Market
- o Veterinary Office
- o Local Sugar-cane Factory (small)
- o Street Lights (Proposed)

DEMAND FORECAST

MAKARFI

Item			1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	Note
Population(10^3)			6.7	6.9	7.1	7.3	7.6	7.9	8.2	8.5	8.8	9.1	
Maximum Demand (kW)	Existing Town Area		30	39	44	47	51	62	68	74	82	89	No.1 100 kVA No.2 100 kVA
	Extension Area	G.R.A.	29	43	58	72	86	101	115	130	144	158	Present No.2 future 200 kVA
		Others											
		Sub Total	29	43	58	72	86	101	115	130	144	158	
	Education Facilities	S.S.	52	56	62	68	76	83	91	101	110	120	No.3 100 kVA
		T.C.											
		Sub Total	52	56	62	68	76	83	91	101	110	120	
	Health Centre				25	35	45	50	55	61	67	74	
	Water Supplies	Town Area			15	15	15	15	15	15	15	15	
		Agric. etc.			15	15	15	15	15	15	15	15	
		Health Centre			15	15	15	15	15	15	15	15	
		Sub Total			45	45	45	45	45	45	45	45	
	M.O.W. Yard Army Training Centre												
	Street Lights		1	1	1	1	1	1	1	1	1	1	
	Total		112	139	225	268	304	342	375	412	449	487	
Number of Consumers	Existing Town Area		86	121	146	158	171	187	205	225	247	271	
	Extension Area	G.R.A.	6	9	12	15	18	21	24	27	30	33	
		Others											
		Sub Total	6	9	12	15	18	21	24	27	30	33	
	Education Facilities	S.S.	22	24	26	29	32	35	38	42	46	50	
		T.C.											
		Sub Total	22	24	26	29	32	35	38	42	46	50	
	Health Centre				6	8	10	11	12	13	14	15	
	Water Supplies	Town Area			1	1	1	1	1	1	1	1	
		Agric. etc.			1	1	1	1	1	1	1	1	
		Health Centre			1	1	1	1	1	1	1	1	
		Sub Total			3	3	3	3	3	3	3	3	
	M.O.W. Yard Army Training Centre												
	Street Lights		1	1	1	1	1	1	1	1	1	1	
	Total		115	155	194	214	235	258	283	311	341	373	
	Number of New Consumers		115	40	39	20	21	23	25	28	30	32	
kWH Sales (kWH) x 10^3	Existing Town Area		34	85	110	122	136	154	174	197	224	254	
	Extension Area	G.R.A.	53	82	113	145	178	216	253	295	336	380	
		Others											
		Sub Total	53	82	113	145	178	216	253	295	336	380	
	Education Facilities	S.S.	135	149	170	193	222	249	282	322	361	406	
		T.C.											
		Sub Total	135	149	170	193	222	249	282	322	361	406	
	Health Centre				111	161	213	243	276	315	356	405	
	Water Supplies	Town Area			16	20	24	28	34	41	49	59	
		Agric. etc.			16	20	24	28	34	41	49	59	
		Health Centre			16	18	20	22	24	26	29	32	
		Sub Total			48	58	68	78	92	108	127	150	
	M.O.W. Yard Army Training Centre												
	Street Lights		8	8	8	8	8	12	12	12	12	12	
	Total		230	324	560	687	825	952	1089	1249	1416	1607	
Revenue (₦) x 10^3	kWH Sales		9.9	14.2	22.0	26.3	31.2	36.0	41.1	46.9	53.2	60.4	
	Connection Fee		0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
	Total		10.1	14.3	22.1	26.4	31.3	36.1	41.2	47.0	53.3	60.5	

Note: 1. G.R.A. ......Government Residential Area
S.S. ....Secondary School
T.C. ....Teachers College
2. The note represents the number of transformers and their capacities in the designing drawing of supply facilities.

Table Annex 1-3

J I B I Y A

I. Town: Jibiya (Include Kaga Village and Custom Post)

II. Population:

A.	1963	10,123
B.	1973 (Estimated)	13,261
C.	1976 (")	14,500

III. Classification of Town:

A.	Political	-	District Head-quarter
B.	Industrial	-	Commercial Town Agricultural Town
C.	Traffic	-	Trade Route Town
D.	Others	-	Major Border Town

IV. General Information:

Border Town of considerable importance especially because of its commercial significance. Permanent Buildings, reasonable water supply. Good road of transportation Gateways into the Niger Republic Customs town - becoming increasingly popular with the urban population as a weekend town.

V. Priority: Medium

VI. Survey Date: 11th November, 1974.

VII. Main Load:

A. Residential and Small Commercial Load

1. Existing Town Area

1) Consumption (Evening Load) . Small Main Consumers Houses, Street Lights

2) Future Load Growth Rank:

a) 1st year - 5th year Medium
b) 5th year - 10th year Medium

Details:

Politics	Medium
Transport	High
Industry	Few Local Factories
Special Load	Custom Post (3 Proposed)
Merchants, Shops	Some
Houses	Low

2. Extension Area: Few

3. Kaga Village: 3.5 km from Jibiya town

   Demand is only small main consumers and street lights, but very important village as the entrance to Jibiya town and the Custome Post.

B. Special Load:

1. Custom Post: 1.2 km from Kaga

   a) Consumption (Evening Load) — Custome House (Office), Staff Quarters, Police Office

   b) Future Load growth — High

   Government intends to expand the Custom House three times. Equally, the staff quarters will be extended. Police Office not electrified now.

2. Girls Secondary School (Proposed)

   Girls Secondary School will be established in a few years time and will expand like other secondary schools.

3. Health Centre (Proposed)

4. Water Supply (Dam Proposed)

VIII. Isolated Existing Generating Sets:

A. Custom Post

20KVA (28.9AMP) 400/230V
Peak Load 29A (Evening Load)

B. Small Generators

Two Personal Houses

One Small Hotel

IX. Main Building List

A. Main Offices

- o District Office
- o Police Office
- o Custom Post
- o Police Post

B. Educational Facilities

- o 2 Primary Schools
- o Girls Secondary School (Proposed)

C. Medical Facilities

- o Health Centre (Proposed)

D. Public Utilities

- o Court
- o Prison
- o Mosque
- o Mosque (Kaga)
- o Dispensary
- o Council Hall
- o Reading Room
- o Post Office (Proposed)

E. Water Supply (Proposed)

F. House and Residences

- o Police Barracks
- o Village Head House (Kaga)
- o Small Hotel (Kaga)
- o Personal Houses

G. Industry and Others:

- o Cattle Centre
- o Market
- o Small Textile Mill (Local)
- o Local Corn Mill (Kaga)
- o Motor Park (Kaga)
- o Street Lights (Proposed)

DEMAND FORECAST

JIBIYA

Item			1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	Note
Population(10^3)			14.5	15.0	15.5	16.0	16.6	17.2	17.8	18.4	19.0	19.7	
Maximum Demand (kW)	Existing Town Area		65	84	95	102	110	119	129	139	150	162	No 1 100 kVA No.2 100 kVA
	Extension Area	G.R.A.											
		Others											
		Sub Total											
	Education Facilities	S.S.	18	30	36	40	43	48	53	58	64	70	
		T.C.											
		Sub Total	18	30	36	40	43	48	53	58	64	70	
	Health Centre				25	35	45	50	55	61	67	74	
	Water Supplies	Town Area			25	25	25	25	25	25	25	25	No. 1, No. 2
		Agric. etc.			25	25	25	25	25	25	25	25	
		Health Centre			15	15	15	15	15	15	15	15	
		Sub Total			65	65	65	65	65	65	65	65	
	Kaga Village		15	20	22	23	25	26	27	29	30	32	No. 3 100 kVA
	Custom Post		21	26	32	40	50	58	67	77	89	102	No. 4 100 kVA
	Street Lights		1	1	1	1	1	1	1	1	1	1	
	Total		120	161	276	306	339	367	397	430	466	506	
Number of Consumers	Existing Town Area		186	261	316	341	368	397	429	463	500	540	
	Extension Area	G.R.A.											
		Others											
		Sub Total											
	Education Facilities	S.S.	8	13	15	17	18	20	22	24	27	29	
		T.C.											
		Sub Total	8	13	15	17	18	20	22	24	27	29	
	Health Centre				6	8	10	11	12	13	14	15	
	Water Supplies	Town Area			1	1	1	1	1	1	1	1	
		Agric. etc.			1	1	1	1	1	1	1	1	
		Health Centre			1	1	1	1	1	1	1	1	
		Sub Total			3	3	3	3	3	3	3	3	
	Kaga Village		49	69	83	87	91	96	101	106	111	117	
	Custom Post		5	6	7	8	9	10	11	12	13	14	
	Street Lights		1	1	1	1	1	1	1	1	1	1	
	Total		249	349	431	465	500	538	579	622	669	723	
	Number of New Consumers		249	100	82	34	35	38	41	43	47	54	
kWH Sales (kWH) x 10^3	Existing Town Area		74	183	237	264	293	326	363	403	448	498	
	Extension Area	G.R.A.											
		Others											
		Sub Total											
	Education Facilities	S.S.	47	80	99	113	125	144	164	185	210	237	
		T.C.											
		Sub Total	47	80	99	113	125	144	164	185	210	237	
	Health Centre				111	161	213	243	276	315	356	405	
	Water Supplies	Town Area			27	33	39	47	57	68	82	98	
		Agric. etc.			27	33	39	47	57	68	82	98	
		Health Centre			16	18	20	22	24	26	29	32	
		Sub Total			70	84	98	116	138	162	193	228	
	Kaga Village		14	35	44	47	52	56	59	66	70	76	
	Custom Post		54	69	88	113	146	174	207	245	292	345	
	Street Lights		8	8	8	8	8	12	12	12	12	12	
	Total		197	375	657	790	935	1071	1219	1388	1581	1801	
Revenue (₦) x 10^3	kWH Sales		10.7	19.7	28.9	33.9	39.5	44.9	50.5	57.3	64.8	73.1	
	Connection Fee		0.5	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
	Total		11.2	19.9	29.1	34.0	29.6	45.0	50.6	57.4	64.9	73.2	

Note: 1. G.R.A. ......Government Residential Area
S.S. ....Secondary School
T.C. ....Teachers College
2. The note represents the number of transformers and their capacities in the designing drawing of supply facilities.

Table Annex 1-4

M U S A W A

I. Town: Musawa

II. Population:

A.	1963	8,782
B.	1973 (Estimated)	11,544
C.	1976 (")	12,600

III. Classification of Town

A.	Political	-	District Headquarter
B.	Industrial	-	Agricultural Town
C.	Traffic	-	General Route Town

IV. General Information:

Important agricultural town in the heart of the North Central State. Significant local industries such as poteries, metal works, textiles etc. Very dynamic town with good road for transportation.

V. Priority: Low

VI. Survey Date: 15th November, 1974

VII. Main Load:

A. Residential and Small Commercial Load:

1. Existing Town Area:

1) Consumption (Evening Load) — Samll Main Consumers, Houses, Street Lights

2) Future Load Growth Rank

a) 1st year - 5th year — Low
b) 5th year - 10th year — Low

Details:

Politics	Medium
Transport	Medium
Industry	Few Local Factories
Special Load	One (one proposed)
Merchants, Shops	Few
Houses	Low

2. Extension Area: None

B. Special Load

1. Secondary School: 3 km from Musawa

   1) Consumption (Evening Load): Classroom, Staff's Residence, Student's Quarters

   2) Future Load Growth: Very High
      Number of Students: 140 (Now); 1,000 (Five years estimate)

   Now some of the students have been transferred to Kachia Secondary School for temporary accommodation. More staff quarters are now under construction.

2. Health Centre (Proposed)

VIII. Isolated Existing Generating Sets:

None

IX. Main Building List

A. Main Offices

- o District Office

B. Educational Facilities

- o Secondary School
- o 2 Primary Schools

C. Medical Facilities

- o Clinic (Dispensary)
- o Leprosy Clinic
- o Health Centre (Proposed)

D. Public Utilities

- o Court
- o Prison
- o Mosque
- o Council Hall
- o Youth Centre
- o Reading Room

E. House and Residences

- o District Head House
- o Police Barracks (Proposed)
- o Personal Houses

F. Industry and Others:

- o Market
- o Local Factories
- o Street Lights (Proposed)

DEMAND FORECAST

MUSAWA

Item			1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	Note
Population(10^3)			12.6	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.6	17.2	
Maximum Demand (kW)	Existing Town Area		40	52	59	63	67	71	76	81	86	91	No. 1 100 kVA
	Extension Area	G.R.A.											
		Others											
		Sub Total											
	Education Facilities	S.S.	43	48	53	58	64	70	77	84	92	102	No. 2 100 kVA
		T.C.											
		Sub Total	43	48	53	58	64	70	77	84	92	102	
	Health Centre				25	35	45	50	55	61	67	74	
	Water Supplies	Town Area								25	25	25	No. 1
		Agric. etc.								25	25	25	
		Health Centre			15	15	15	15	15	15	15	15	
		Sub Total			15	15	15	15	15	65	65	65	
	M.O.W. Yard												
	Army Training Centre												
	Street Lights		1	1	1	1	1	1	1	1	1	1	
	Total		84	101	153	172	192	207	224	292	311	333	
Number of Consumers	Existing Town Area		129	181	219	233	248	264	281	299	318	338	
	Extension Area	G.R.A.											
		Others											
		Sub Total											
	Education Facilities	S.S.	18	20	22	24	27	29	32	35	39	43	
		T.C.											
		Sub Total	18	20	22	24	27	29	32	35	39	43	
	Health Centre				6	8	10	11	12	13	14	15	
	Water Supplies	Town Area								1	1	1	
		Agric. etc.								1	1	1	
		Health Centre			1	1	1	1	1	1	1	1	
		Sub Total			1	1	1	1	1	3	3	3	
	M.O.W. Yard												
	Army Training Centre												
	Street Lights		1	1	1	1	1	1	1	1	1	1	
	Total		148	202	249	267	287	306	327	351	375	400	
	Number of New Consumers		148	54	47	18	20	19	21	24	24	25	
KWH Sales (KWH) x 10^3	Existing Town Area		42	110	143	156	169	186	204	223	244	267	
	Extension Area	G.R.A.											
		Others											
		Sub Total											
	Education Facilities	S.S.	111	128	146	164	187	210	238	268	302	345	
		T.C.											
		Sub Total	111	128	146	164	187	210	238	268	302	345	
	Health Centre				111	161	213	243	276	315	356	405	
	Water Supplies	Town Area								27	33	39	
		Agric. etc.								27	33	39	
		Health Centre			16	18	20	22	24	26	29	32	
		Sub Total			16	18	20	22	24	80	95	110	
	M.O.W. Yard												
	Army Training Centre												
	Street Lights		8	8	8	8	8	12	12	12	12	12	
	Total		161	246	424	507	599	673	754	898	1009	1139	
Revenue (₦) x 10^3	kWH Sales		7.8	12.2	18.0	20.9	24.3	27.3	30.3	35.4	39.6	44.5	
	Connection Fee		0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
	Total		8.1	12.3	18.1	30.1	24.4	27.4	30.4	35.5	39.7	44.6	

Note: 1. G.R.A. ......Government Residential Area
S.S. ....Secondary School
T.C. ....Teachers College
2. The note represents the number of transformers and their capacities in the designing drawing of supply facilities.

Table Annex 1-5

ZONKWA

I. Town: Zonkwa

II. Population:

A.	1963	10,735
B.	1973 (Estimated)	14,111
C.	1976 (")	15,400

III. Classification of Town:

A.	Political		
B.	Industrial	-	Commercial Town Agricultural Town
C.	Traffic	-	Main Route Town Railway Town
D.	Others	-	Educational Town

IV. General Information:

Another of those rising agricultural towns likely to suffer from the ill-effects of the present rapid urbanisation unless it is industrialised. Situated on the Kaduna Kafanchan rail road. Permanent buildings are educational and agricultural institutions. (Missionary sub-centre).

V. Priority: Medium

VI. Survey Date: 29th November, 1974

VII. Main Load:

A. Residential and Samll Commercial Load

1. Existing Town Area:

1) Consumption (Evening Load) — Small Main Consumers, Shops, Houses, Street Lights

2) Future Load Growth Rank:

a) 1st year - 5th year High
b) 5th year - 10th year High

Details:

Politics	Low
Transport	Medium
Industry	Some Local Factories

Special Load	3 (1 Proposed)
Merchants, Shops	Many
Houses	Medium

2. Extension Area:

   Another side of the main road.

B. Special Load:

1. Women Teachers' College

   1) Consumption (Evening Load) — Classroom, Staff's Residence, Students' Quarters

   2) Future Load Growth — High
      Number of Students — 330 (Now), 700 (Five Years)

2. Girls Secondary School:

   1) Consumption (Evening Load) — Classroom, Staff's Residence, Students Wuarters

   2) Future Load — High
      Number of Students — 270 (Now)

3. Hospital and Nurse Training School:

   1) Consumption (All Day Load) — Hospital, Wards, Nurse Training School, Staff's Quarters

   2) Future Load Growth — High

4. Water Supply (Proposed)

VIII. Isolated Existing Generating Sets:

A. Women, Teachers'College

   about 25 KVA

B. Girls Secondary School

   about 25 KVA

C. Hospital and Nurse Training School

   21.9 KVA
   another big set is now being overhauled.

IX. Main Building List

A. Educational Facilities

- o Women Teachers' College
- o Nurse Training School
- o 7 Primary Schools
- o Girls Secondary School

B. Medical Facilities

- o Hospital
- o 2 Dispensaries

C. Public Utilities

- o Court
- o Reading Room
- o Post Office
- o Mosque
- o 3 Churchs
- o Council Hall
- o Police Office

D. Houses and Residences

- o District Head House
- o Village Head House
- o Police Barracks
- o Guest House
- o 4 Hotels (Small)

E. Industries and others

- o Market
- o Veterinary
- o Ministry of Work Yard
- o Street Lights (Proposed)

DEMAND FORECAST

ZONKWA

Item			1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	Note
Population(10^3)			15.4	15.9	16.5	17.1	17.7	18.3	18.9	19.6	20.3	21.0	
Maximum Demand (kW)	Existing Town Area		92	117	121	131	144	159	174	192	210	231	No.1 100kVA, No 2 100kVA No 3 100kVA, No 4 100kVA
	Extension Area	G.R.A.											
		Others	18	24	30	36	42	48	54	60	66	72	
		Sub Total	18	24	30	36	42	48	54	60	66	72	
	Education Facilities	S.S.	40	43	48	53	58	64	70	77	84	92	No 5 100 kVA
		W.T.C.	48	53	58	64	70	77	84	92	102	113	No. 6 100 kVA
		Sub Total	88	96	106	117	128	141	154	169	186	205	
	Health Centre		50	55	61	67	74	81	89	98	108	119	No. 7 100 kVA
	Water Supplies	Town Area			25	25	25	25	25	25	25	25	No.1, No.2, No 3, No.4
		Agric. etc.			25	25	25	25	25	25	25	25	
		Health Centre	15	15	15	15	15	15	15	15	15	15	No. 7
		Sub Total	15	15	65	65	65	65	65	65	65	65	
	M.O.W. Yard Army Training Centre												
	Street Lights		1	1	1	1	1	1	1	1	1	1	
	Total		264	308	384	417	454	495	537	585	636	693	
Number of Consumers	Existing Town Area		237	333	403	440	480	530	580	640	700	770	
	Extension Area	G.R.A.											
		Others	6	8	10	12	14	16	18	20	22	24	
		Sub Total	6	8	10	12	14	16	18	20	22	24	
	Education Facilities	S.S.	17	18	20	22	24	27	29	32	35	39	
		W.T.C.	20	22	24	27	29	32	35	39	43	47	
		Sub Total	37	40	44	49	53	59	64	71	78	86	
	Health Centre		11	12	13	14	15	17	19	21	23	25	
	Water Supplies	Town Area			1	1	1	1	1	1	1	1	
		Agric. etc.			1	1	1	1	1	1	1	1	
		Health Centre	1	1	1	1	1	1	1	1	1	1	
		Sub Total	1	1	3	3	3	3	3	3	3	3	
	M.O.W. Yard Army Training Centre												
	Street Lights		1	1	1	1	1	1	1	1	1	1	
	Total		293	395	474	519	566	626	685	756	827	909	
	Number of New Consumers		293	102	79	45	47	60	59	71	71	72	
kWH Sales (kWH) x 10^3	Existing Town Area		104	256	334	377	425	484	548	624	705	857	
	Extension Area	G.R.A.											
		Others	33	46	59	73	87	103	119	136	154	173	
		Sub Total	33	46	59	73	87	103	119	136	154	173	
	Education Facilities	S.S.	104	115	132	150	169	192	217	245	276	311	
		W.T.C.	124	141	159	181	204	231	260	293	335	382	
		Sub Total	228	256	291	331	373	423	477	538	611	693	
	Health Centre		223	252	288	326	371	418	473	537	609	691	
	Water Supplies	Town Area			27	33	39	47	57	68	82	98	
		Agric. etc.			27	33	39	47	57	68	82	98	
		Health Centre	22	24	26	29	32	35	39	43	47	52	
		Sub Total	22	24	80	95	110	129	153	179	211	248	
	M.O.W. Yard Army Training Centre												
	Street Lights		8	8	8	8	8	12	12	12	12	12	
	Total		618	842	1060	1210	1374	1569	1782	2026	2302	2674	
Revenue (₦) x 10^3	kWH Sales		25.2	36.0	43.9	50.1	56.6	64.7	73.5	83.4	94.7	109.9	
	Connection Fee		0.6	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
	Total		25.8	36.2	44.1	50.2	56.7	64.8	73.6	83.5	94.8	110.0	

Note: 1. G.R.A. ......Government Residential Area

S.S. ....Secondary School

T.C. ....Teachers College

2. The note represents the number of transformers and their capacities in the designing drawing of supply facilities.

Table Annex 1-6

M A I A D U A

I. Town: Maiadua

II. Population:

A.	1963	14,028
B.	1973 (Estimated)	18,876
C.	1976 (")	20,600

III. Classification of Town:

A.	Political	-	District Headquarter
B.	Industrial	-	Cattle Breeding Town Agricultural Town
C.	Traffic	-	Trade Route Town
D.	Others	-	Border Town

IV. General Information:

A very large town by our standard but relatively undeveloped. An agricultural town whose future would depend to a very large extent on mechanisation which is yet to come.

V. Priority: Medium

VI. Survey Date: 13th November, 1974

VII. Main Load:

A. Residential and Small Commercial Load

1. Existing Town Area

1) Consumpation (Evening Load) — Small Main Consumers, Houses, Street Lights

2) Future Load Growth Rank

a) 1st year - 5th year Low
b) 5th year - 10th year Low

Details:

Politics	Medium
Transport	Low
Industry	Few Load Industries
Special Loads	None (2 Proposed)
Merchants, Shops	Few
Houses	Medium

2. Extension Area

None

B. Special Load:

1. Health Centre (Proposed)
2. Water Pump (Proposed)

VIII. Isolated Existing Generating Sets:

None.

IX. Main Building List

A. Main Offices

- District Office

B. Educational Facilities

- Primary School
- Primary School (Site Decided)

C. Medical Facilities

- Clinic (Dispensary)
- Health Centre (Proposed)

D. Public Utilities

- Court
- Prison
- Council Hall (Town Hall)
- Veterinary Office
- Reading Room (Proposed)
- Mosque

E. Water Supply

- Water Pump (Proposed)

F. Houses and Residences

- District Head House
- Crop Store
- Personal House

G. Industries and Others

- Market
- Slaughter Slab
- Motor Park
- Meat Processing Factory
- Carpenter Workshop
- Agricultural Office (small)
- Street Lights (Proposed)

DEMAND FORECAST

MAIADUA

Item			1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	Note
Population(10^3)			20.0	20.7	21.4	22.1	22.9	23.7	24.5	25.4	26 3	27.2	
Maximum Demand (kW)	Existing Town Area		63	84	104	111	118	125	134	142	151	161	No.1 100kVA No.2 100kVA
	Extension Area	G.R.A.											
		Others											
		Sub Total											
	Education Facilities	S.S.						18	30	36	40	43	
		T.C.											
		Sub Total						18	30	36	40	43	
	Health Centre				25	35	46	50	55	61	67	74	
	Water Supplies	Town Area			30	30	30	30	30	30	30	30	No. 1, No. 2
		Agric. etc.			30	30	30	30	30	30	30	30	
		Health Centre			15	15	15	15	15	15	15	15	
		Sub Total			75	75	75	75	75	75	75	75	
	M.O.W. Yard												
	Army Training Centre												
	Street Lights		1	1	1	1	1	1	1	1	1	1	
	Total		64	85	205	222	239	269	295	315	334	354	
Number of Consumers	Existing Town Area		204	288	348	370	393	418	445	473	503	535	
	Extension Area	G.R.A.											
		Others											
		Sub Total											
	Education Facilities	S.S.						8	13	15	17	18	
		T.C.											
		Sub Total						8	13	15	17	18	
	Health Centre				6	8	10	11	12	13	14	15	
	Water Supplies	Town Area			1	1	1	1	1	1	1	1	
		Agric. etc.			1	1	1	1	1	1	1	1	
		Health Centre			1	1	1	1	1	1	1	1	
		Sub Total			3	3	3	3	3	3	3	3	
	M.O.W. Yard												
	Army Training Centre												
	Street Lights		1	1	1	1	1	1	1	1	1	1	
	Total		205	289	358	382	407	441	474	505	538	572	
	Number of New Consumers		205	84	69	24	25	36	33	31	33	34	
kWH Sales (kWH) x 10^3	Existing Town Area		73	181	233	255	278	303	332	362	396	432	
	Extension Area	G.R.A.											
		Others											
		Sub Total											
	Education Facilities	S.S.						47	80	99	113	125	
		T.C.											
		Sub Total						47	80	99	113	125	
	Health Cenrre				111	161	213	243	276	315	356	405	
	Water Supplies	Town Area			33	39	47	57	68	82	98	118	
		Agric. etc.			33	39	47	57	68	82	98	118	
		Health Centre			16	18	20	22	24	26	29	32	
		Sub Total			82	96	114	136	160	190	225	268	
	M.O.W. Yard												
	Army Training Centre												
	Street Lights		6	6	6	6	6	9	9	9	9	9	
	Total		79	187	432	518	611	738	857	975	1099	1239	
Revenue (₦) x 10^3	kWH Sales		6.2	12.3	20.3	23.5	27.0	31.9	36.4	41.2	45.9	51.2	
	Connection Fee		0.4	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
	Total		6.6	12.5	20.4	23.6	27.1	32.0	36.5	41.3	46.0	51.3	

Note: 1. G.R.A. ......Government Residential Area
S.S. ....Secondary School
T.C. ....Teachers College
2. The note represents the number of transformers and their capacities in the designing drawing of supply facilities.

Table Annex 1-7

K A N K A R A

I. Town: Kankara

II. Population:

A.	1963		9,724
B.	1973	(Estimated)	12,782
C.	1976	(")	13,900

III. Classification of Town:

A.	Political	-	District Head quarter
B.	Industrial	-	Agricultural Town
C.	Traffic	-	Road Junction Town

IV. General Information:

Old agricultural Town but losing rapidly to Funtua, Malumfashi and Musawa. International road crosspoint (Proposed)

V. Priority: Low

VI. Survey Date: 16th November, 1974

VII. Main Load:

A. Residential and Small Commercial Load:

1. Existing Town Area:

   1) Consumption (Evening Load) — Small Main Consumers Houses, Street Lights

   2) Future Load Growth Rank:

      a) 1st year - 5th year — Low
      b) 5th year - 10th year — Medium

   Details:

Politics	Medium
Transport	Medium
Industry	Few Local Factories
Special Load	1 (Two Proposed)
Merchants, Shops	Some
Houses	Low

2. Extension Area:

   Another side of the main road (Proposed)

B. Special Load:

1. Secondary School: 1.5 km from Kankara

   Secondary School will be established next year, and will extend like other Secondary Schools.

2. Health Centre (Proposed)

3. Water Supply (Proposed)

VIII. Isolated Existing Generating Sets:

1 Personal House (include Mosque)

IX. Main Building List

A. Main Office

- o District Office

B. Educational Facilities

- o Secondary School (Proposed)
- o Primary School

C. Medical Facilities

- o Clinic (Dispensary)

D. Public Utilities

- o Court
- o Prison
- o Counsil Hall (Reading Room)
- o Youth Hall
- o Mosque

E. Water Supply (Proposed)

F. Houses and Residences

- o District Head House
- o Guest House
- o Small Hotel
- o Personal House

G. Industries and Others

- o Agricultural Office (Small)
- o Veterinary Office (Small)
- o Local Textile Mill (Small)
- o Local Market
- o Street Lights (Proposed)

DEMAND FORECAST

KANKARA

Item			1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	Note
Population(10^3)			13.9	14.4	14.9	15.4	15.9	16.5	17.1	17.7	18.3	18.9	
Maximum Demand (kW)	Existing Town Area		44	58	81	89	97	120	132	144	159	174	No.1 100 kVA No.2 100 kVA
	Extension Area	G.R.A.											
		Others	12	18	24	30	36	42	48	54	60	66	
		Sub Total	12	18	24	30	36	42	48	54	60	66	
	Education Facilities	S.S.	18	30	36	40	43	48	53	58	64	70	No. 3 100 kVA
		T.C.											
		Sub Total	18	30	36	40	43	48	53	58	64	70	
	Health Centre				25	35	45	50	55	61	67	74	
	Water Supplies	Town Area			25	25	25	25	25	25	25	25	No. 1, No. 2
		Agric. etc.			25	25	25	25	25	25	25	25	
		Health Centre			15	15	15	15	15	15	15	15	
		Sub Total			65	65	65	65	65	65	65	65	
	M.O.W. Yard Army Training Centre												
	Street Lights		1	1	1	1	1	1	1	1	1	1	
	Total		75	107	232	260	287	326	354	383	416	450	
Number of Consumers	Existing Town Area		142	200	242	257	273	294	318	343	370	400	
	Extension Area	G.R.A.											
		Others	4	6	8	10	12	14	16	18	20	22	
		Sub Total	4	6	8	10	12	14	16	18	20	22	
	Education Facilities	S.S.	8	13	15	17	18	20	22	24	27	29	
		T.C.											
		Sub Total	8	13	15	17	18	20	22	24	27	29	
	Health Centre				6	8	10	11	12	13	14	15	
	Water Supplies	Town Area			1	1	1	1	1	1	1	1	
		Agric.etc.			1	1	1	1	1	1	1	1	
		Health Centre			1	1	1	1	1	1	1	1	
		Sub Total			3	3	3	3	3	3	3	3	
	M.O.W. Yard Army Training Centre												
	Street Lights		1	1	1	1	1	1	1	1	1	1	
	Total		154	220	275	296	317	343	372	402	435	470	
	Number of New Consumers		154	66	55	41	21	26	29	30	33	35	
kWH Sales (kWH) x 10^3	Existing Town Area		51	126	162	177	193	214	239	265	295	328	
	Extension Area	G.R.A.											
		Others	22	34	47	60	75	90	106	122	140	159	
		Sub Total	22	34	47	60	75	90	106	122	140	159	
	Education Facilities	S.S.	47	80	99	113	125	144	164	185	210	237	
		T.C.											
		Sub Total	47	80	99	113	125	144	164	185	210	237	
	Health Centre				111	161	213	243	276	315	356	405	
	Water Supplies	Town Area			27	33	39	47	57	68	82	98	
		Agric.etc.			27	33	39	47	57	68	82	98	
		Health Centre			16	18	20	22	24	26	29	32	
		Sub Total			70	84	98	116	138	162	193	228	
	M.O.W. Yard Army Training Centre												
	Street Lights		8	8	8	8	8	12	12	12	12	12	
	Total		128	248	497	603	712	819	935	1061	1206	1369	
Revenue (₦) x 10^3	kWH Sales		7.0	12.8	20.8	24.6	28.6	32.7	37.0	41.9	47.5	53.5	
	Connection Fee		0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
	Total		7.3	12.9	20.9	24.7	28.7	32.8	37.1	42.0	47.6	53.6	

Note: 1. G.R.A. ......Government Residential Area
S.S. ....Secondary School
T.C. ....Teachers College
2. The note represents the number of transformers and their capacities in the designing drawing of supply facilities.

Table Annex 1-8

S O B A

I. Town: Soba

II. Population:

A.	1963	10,104
B.	1973 (Estimated)	13,236
C.	1976 (")	14,400

III. Classification:

A.	Political	-	District Head quarter
B.	Industrial	-	Agricultural Town
C.	Traffice	-	Main Route Town

IV. General Information:

Important agricultural town on the Zaria - Jos road. Reasonably good road system: adequate water supply; permanent buildings. Educational and medical institutions. Reasonably near Zaria.

V. Priority: Medium

VI. Survey Date: 22nd November, 1974

VII. Main Load:

A. Residential and Samll Commercial Load

1. Existing Town Area

1) Consumption (Evening Load) — Small Main Consumers, Houses, Street Lights

2) Future Loand Growth Rank

a) 1st year - 5th yea — Low
b) 5th year - 10th year — Medium

Details:

Politics	Medium
Transport	Medium
Industry	Few Local Factories
Special Load	2 (2 Proposed)
Merchants, Shops	Some
Houses	Low

2. Extension Area

None

B. Special Load

1. Technical Secondary Scool (T.S.S.) and Girls Secondary School (G.S.S.)

a)	Consumption (Evening Load)	Classroom, Staff's Residence Student's Quarters
b)	Future Load Growth	Very High
	Number of Students	
	T.S.S.	650 (Now)
		1,000 (Five years estimate)
	G.S.S.	510 (Now)
		1,500 (Five years estimate)

Now more Staff Quarters of G.S.S. under construction.

2. Health Centre (Proposed)
3. Water Supply (Dam Proposed)

VIII. Isolated Existing Generating Sets:

A. T.S.S. and G.S.S.

138 KVA 400/230V

IX. Main Building List

A. Main Offices

- District Office

B. Educational Facilities

- Technical Secondary School
- Girls Secondary School
- Primary School

C. Medical Facilities

- Clinic
- Health Centre (Proposed)

D. Public Utilities

- Court
- Prison
- Dispensary
- Council Hall
- Reading Room
- Mosque
- T.V. House
- Post Office (Proposed)

E. Water Facilities

- Pump House (Proposed)

F. Houses and Residences

- o District Head House
- o Guest House
- o Small Hotels
- o Personal Houses

G. Indutries and Others

- o Market
- o Street Lights (Proposed)

DEMAND FORECAST

SOBA

Item			1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	Note
Population(10^3)			14.4	14.9	15.4	15.9	16.5	17.1	17.7	18.3	18.9	19.6	
Maximum Demand (kW)	Existing Town Area		46	60	68	72	77	92	100	108	116	126	No.1 100 kVA No.2 100 kVA
	Extension Area	G.R.A.											
		Others											
		Sub Total											
	Education Facilities	S.S.	95	104	115	120	120	120	120	120	120	120	No.3 100 kVA
		T.S.S.	74	82	90	100	109	120	120	120	120	120	No.4 100 kVA
		Sub Total	169	186	205	220	229	240	240	240	240	240	
	Health Centre				25	35	45	50	55	61	67	74	
	Water Supplies	Town Area			25	25	25	25	25	25	25	25	No.1, No.2
		Agric. etc.			25	25	25	25	25	25	25	25	
		Health Centre			15	15	15	15	15	15	15	15	
		Sub Total			65	65	65	65	65	65	65	65	
	M.O.W. Yard Army Training Centre												
	Street Lights		1	1	1	1	1	1	1	1	1	1	
	Total		216	244	363	393	417	448	461	475	489	506	
Number of Consumers	Existing Town Area		147	207	251	267	284	307	332	359	388	419	
	Extension Area	G.R.A.											
		Others											
		Sub Total											
	Education Facilities	S.S.	40	44	48	50	50	50	50	50	50	50	
		T.S.S.	31	34	38	42	46	50	50	50	50	50	
		Sub Total	71	78	86	92	96	100	100	100	100	100	
	Health Centre				6	8	10	11	12	13	14	15	
	Water Supplies	Town Area			1	1	1	1	1	1	1	1	
		Agric.etc.			1	1	1	1	1	1	1	1	
		Health Centre			1	1	1	1	1	1	1	1	
		Sub Total			3	3	3	3	3	3	3	3	
	M.O.W. Yard Army Training Centre												
	Street Lights		1	1	1	1	1	1	1	1	1	1	
	Total		218	286	347	371	394	422	448	476	506	538	
	Number of New Consumers		218	78	61	24	23	28	26	28	30	32	
kWH Sales (kWH) x 10^3	Existing Town Area		55	132	170	186	203	225	251	279	305	346	
	Extension Area	G.R.A.											
		Others											
		Sub Total											
	Education Facilities	S.S.	246	278	316	340	350	360	371	382	394	406	
		T.S.S.	192	219	247	283	318	360	371	382	394	406	
		Sub Total	438	497	563	623	668	720	742	764	788	812	
	Health Centre				111	161	213	243	276	315	356	405	
	Water Supplies	Town Area			27	33	39	47	57	68	82	98	
		Agric.etc.			27	33	39	47	57	68	82	98	
		Health Centre			16	18	20	22	24	26	29	32	
		Sub Total			70	84	98	116	138	162	193	228	
	M.O.W. Yard Army Training Centre												
	Street Lights		6	6	6	6	6	10	10	10	10	10	
	Total		499	635	920	1060	1188	1314	1417	1530	1651	1801	
Revenue (₦) x 10^3	kWH Sales		20.0	26.5	35.8	40.7	44.5	50.3	54.2	58.6	63.2	68.9	
	Connection Fee		0.4	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
	Total		20.4	26.7	35.9	40.8	44.6	50.4	54.3	58.7	63.3	69.0	

Note: 1. G.R.A. ......Government Residential Area
S.S. ....Secondary School
T.C. ....Teachers College
2. The note represents the number of transformers and their capacities in the designing drawing of supply facilities.

Table Annex 1-9

H U N K U Y I

I. Town: Hunkyui

II. Population:

A.	1963		9,771
B.	1973	(Estimated)	12,844
C.	1976	(")	14,000

III. Classification of Town:

A.	Political		----
B.	Industrial	-	Agricultural Town
C.	Traffic	-	Main Route Town (Kaduna - Kano)

IV. General Information

Agricultural town; very ancient and contains fair number of permanent buildings. Like Makarfi and Kudan, it is reasonably near the national grid-line and has obvious potentialities for market gardening. It could exploit the Zaria Market as well as set up its own light industry.

V. Priority: Medium

VI. Survey Date: 19/20th November, 1974

VII. Main Load:

A. Residential and Small Commercial Load

1. Existing Town Area:

1) Consumption (Evening Load) — Small Main Consumers Houses, Street Lights

2) Future Load Growth Rank:

a) 1st year - 5th year — Low
b) 5th year - 10th year — Low

Details:

Politics	Low
Transport	Medium
Industry	Few Local Factories
Special Load	None
Merchants, Shops	Few
Houses	Low

2. Extension Area

None

B. Special Load: None

VIII. Isolated Existing Generating Sets:

A. Small Generator

T.V. House

IX. Main Building List

A. Main Offices

None

B. Educational Facilities

- o Primary School

C. Medical Facilities

- o Dispensary

D. Public Utilities

- o Mosque
- o Television House

E. Houses and Residences

- o Village Head House
- o Personal House

F. Industries and Others

- o Market
- o Street Lights (Proposed)

DEMAND FORECAST

HUNKUYI

Item			1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	Note
Population(10^3)			14.0	14.5	15.0	15.5	16.1	16.7	17.3	17.9	18.5	19.1	
Maximum Demand (kW)	Existing Town Area		44	59	66	70	75	80	85	90	96	102	No. 1 100 kVA
	Extension Area	G.R.A.											
		Others											
		Sub Total											
	Education Facilities	S.S.						18	30	36	40	43	
		T.C.											
		Sub Total						18	30	36	40	43	
	Health Centre									25	35	45	
	Water Supplies	Town Area								25	25	25	No. 1
		Agric. etc.								25	25	25	
		Health Centre								15	15	15	
		Sub Total								65	65	65	
	M.O.W. Yard Army Training Centre												
	Street Lights		1	1	1	1	1	1	1	1	1	1	
	Total		45	60	67	71	76	99	116	217	237	256	
Number of Consumers	Existing Town Area		143	202	244	260	277	295	314	334	355	378	
	Extension Area	G.R.A.											
		Others											
		Sub Total											
	Education Facilities	S.S.						8	13	15	17	18	
		T.C.											
		Sub Total						8	13	15	17	18	
	Health Centre							6	8	10	11	12	
	Water Supplies	Town Area								1	1	1	
		Agric.etc.								1	1	1	
		Health Centre								1	1	1	
		Sub Total								3	3	3	
	M.O.W. Yard Army Training Centre												
	Street Lights		1	1	1	1	1	1	1	1	1	1	
	Total		144	203	245	261	278	310	336	363	387	412	
	Number of New Consumers		144	59	42	16	17	32	26	27	24	25	
kWH Sales (kWH) x 10^3	Existing Town Area		51	127	163	179	196	214	234	256	279	305	
	Extension Area	G.R.A.											
		Others											
		Sub Total											
	Education Facilities	S.S.						47	80	99	113	125	
		T.C.											
		Sub Total						47	80	99	113	125	
	Health Centre									111	161	213	
	Water Supplies	Town Area								27	33	39	
		Agric.etc.								27	33	39	
		Health Centre								16	18	20	
		Sub Total								70	84	98	
	M.O.W. Yard Army Training Centre												
	Street Lights		6	6	6	6	6	9	9	9	9	9	
	Total		57	133	169	185	205	270	323	545	646	750	
Revenue (₦) x 10^3	kWH Sales		4.4	8.7	10.2	11.1	12.2	15.1	17.5	25.0	28.7	32.8	
	Connection Fee		0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
	Total		4.7	8.8	10.3	11.2	12.3	15.2	17.6	25.1	28.8	32.9	

Note: 1. G.R.A. ......Government Residential Area
S.S. ....Secondary School
T.C. ....Teachers College
2. The note represents the number of transformers and their capacities in the designing drawing of supply facilities.

Table Annex 1-10

K U D A N

I.	Town: Kudan	
II.	Population:	
A.	1963	8,919
B.	1973 (Estimated)	11,724
C.	1976 (")	12,800
III.	Classification of Town:	
A.	Political -	----
B.	Industrial -	Agricultural Town
C.	Traffic -	Main Route Town (Kaduna - Kano)

IV. General Information:

Agricultural town, which is only 5 miles away from Hunkuyi could be served by the same undertaking.

V. Priority — Medium

VI. Survey Date: — 19/20th November, 1974

VII. Main Load:

A. Residential and Small Commercial Load:

1. Existing Town Area

1) Consumption (Evening Load) — Small Main Consumers, Houses, Streets Lights

2) Future Load Growth Rank:

a) 1st year - 5th year — Low
b) 5th year - 10th year — Low

Details:

Politics	Low
Transport	Medium
Industry	Few Local Factories
Special Load	None
Merchants, Shops.	Few
Houses	Low

2. Extension Area:

None

B. Special Load: — None

VIII. Isolated Existing Generating Sets:

A. Small Generator

T.V. House

IX. Main Building List

A. Main Offices

None

B. Educational Facilities

- Primary School
- Primary School (Proposed)

C. Medical Facilities

- Dispensary
- Leprosy Clinic

D. Public Utilities

- Mosque
- Television House
- Local Factories (Sugar Cane) etc.,

E. Houses and Residences

- Village Head House
- Guest House
- Personal House

F. Industries and Others

- Market
- Street Lights (Proposed)

DEMAND FORECAST

KUDAN

Item			1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	Note
Population(10^3)			12.8	13.2	13.7	14.2	14.7	15.2	15.7	16.2	16.8	17.4	
Maximum Demand (kW)	Existing Town Area		40	53	60	64	68	72	77	81	87	93	No. 1 100 kVA
	Extension Area	G.R.A.											
		Others											
		Sub Total											
	Education Facilities	S.S.						18	30	36	40	43	
		T.C.											
		Sub Total						18	30	36	40	43	
	Health Centre									25	35	45	
	Water Supplies	Town Area								25	25	25	No. 1
		Agric. etc.								25	25	25	
		Health Centre								15	15	15	
		Sub Total								65	65	65	
	M.O.W. Yard Army Training Centre												
	Street Lights		1	1	1	1	1	1	1	1	1	1	
	Total		41	54	61	65	69	91	108	208	228	247	
Number of Consumers	Existing Town Area		130	184	223	237	252	268	285	303	322	343	
	Extension Area	G.R.A.											
		Others											
		Sub Total											
	Education Facilities	S.S.						8	13	15	17	18	
		T.C.											
		Sub Total						8	13	15	17	18	
	Health Centre									6	8	10	
	Water Supplies	Town Area								1	1	1	
		Agric. etc.								1	1	1	
		Health Centre								1	1	1	
		Sub Total								3	3	3	
	M.O.W. Yard Army Training Centre												
	Street Lights		1	1	1	1	1	1	1	1	1	1	
	Total		131	185	224	238	253	277	299	328	351	375	
	Number of New Consumers		131	54	39	14	15	24	22	29	23	24	
kWH Sales (kWH) x 10^3	Existing Town Area		45	114	147	161	176	192	210	229	250	274	
	Extension Area	G.R.A.											
		Others											
		Sub Total											
	Education Facilities	S.S.						47	80	99	113	125	
		T.C.											
		Sub Total						47	80	90	113	125	
	Health Centre									111	161	213	
	Water Supplies	Town Area								27	33	39	
		Agric. etc.								27	33	39	
		Health Centre								16	18	20	
		Sub Total								70	84	98	
	M.O.W. Yard Army Training Centre												
	Street Lights		8	8	8	8	8	12	12	12	12	12	
	Total		53	122	155	169	184	251	302	521	620	722	
Revenue (₦) x 10^3	kWH Sales		4.1	7.9	9.3	10.2	11.1	14.0	16.3	23.5	27.2	31.1	
	Connection Fee		0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
	Total		4.4	8.0	9.4	10.3	11.2	14.1	16.4	23.6	27.3	31.2	

Note: 1. G.R.A. ......Government Residential Area
S.S. ....Secondary School
T.C. ....Teachers College
2. The note represents the number of transformers and their capacities in the designing drawing of supply facilities.

Table Annex 1-11

S H I K A

I. Town: Shika

II. Population:

A.	1963	973
B.	1973 (Estimated)	2,473
C.	1976 (")	2,700

III. Classification of Town:

A.	Political		----
B.	Industrial	-	Agricultural Town
C.	Traffic	-	Main Route Town (Zaria - Sokoto)
D.	Others	-	University Branch Town

IV. General Information:

Large agricultural station. Not many permanent buildings. Many persons concerned the A.B.U. University Branch.

V. Priority: Low

VI. Survey Date: 18th November, 1974

VII. Main Load:

A. Residential and Small Commercial Load

1. Existing Town Area:

1) Consumption (Evening Load) — Small Main Consumers Houses, Street Lights

2) Future Load Growth Rank:

a) 1st year - 5th year Low
b) 5th year - 10th year Low

Details:

Politics	Low
Transport	Medium
Industry	Few Local Factories
Special Load	1
Merchants, Shops,	Few
Houses	Low

2. Extension Area:

None

B. Special Load

1. A.B.U. University Branch

A.B.U. branch has already been electrified by the transmission line from the Zaria Substation through Samaru. So, exclude this Load

VIII. Isolated Existing Generating Sets:

None

IX. Main Building List

A. Main Offices

None

B. Educational Facilities

- Primary School

C. Medical Facilities

- Dispensary (Clinic)

D. Public Utilities

- Mosque
- 2 Churches

E. House and Residences

- Village Head House
- Guest House
- Personal Houses

F. Industry and Others

- Market
- Small Cotton Seed Factory (Local)
- Street Lights

DEMAND FORECAST

SHIKA

Item			1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	Note
Population(10^3)			2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	
Maximum Demand (kW)	Existing Town Area		12	16	19	20	22	24	26	28	30	32	No. 1 100 kVA
	Extension Area	G.R.A.											
		Others											
		Sub Total											
	Education Facilities	S.S.						18	30	36	40	43	
		T.C.											
		Sub Total						18	30	36	40	43	
	Health Centre									25	35	45	
	Water Supplies	Town Area								6	6	6	No. 1
		Agric. etc.								6	6	6	
		Health Centre								15	15	15	
		Sub Total								27	27	27	
	M.O.W. Yard												
	Army Training Centre												
	Street Lights		1	1	1	1	1	1	1	1	1	1	
	Total		13	17	20	21	23	41	57	117	133	148	
Number of Consumers	Existing Town Area		35	50	63	68	73	79	86	93	100	108	
	Extension Area	G.R.A.											
		Others											
		Sub Total											
	Education Facilities	S.S.						8	13	15	17	18	
		T.C.											
		Sub Total						8	13	15	17	18	
	Health Centre									6	8	10	
	Water Supplies	Town Area								1	1	1	
		Agric. etc.								1	1	1	
		Health Centre								1	1	1	
		Sub Total								3	3	3	
	M.O.W. Yard												
	Army Training Centre												
	Street Lights		1	1	1	1	1	1	1	1	1	1	
	Total		36	51	64	69	74	88	100	118	129	140	
	Number of New Consumers		36	15	13	5	5	14	12	18	11	11	
kWH Sales (kWH) x 10^3	Existing Town Area		12	31	41	46	51	55	62	69	77	85	
	Extension Area	G.R.A.											
		Others											
		Sub Total											
	Education Facilities	S.S.						47	80	99	113	125	
		T.C.											
		Sub Total						47	80	99	113	125	
	Health Centre									111	161	213	
	Water Supplies	Town Area								7	8	9	
		Agric. etc.								7	8	9	
		Health Centre								16	18	20	
		Sub Total								30	34	38	
	M.O.W. Yard												
	Army Training Centre												
	Street Lights		5	5	5	5	5	8	8	8	8	8	
	Total		17	36	46	51	56	110	150	317	393	469	
Revenue (₦) x 10^3	kWH Sales		1.3	2.4	2.8	3.1	3.4	5.4	7.0	12.4	14.9	17.6	
	Connection Fee		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
	Total		1.4	2.5	2.9	3.2	3.5	5.5	7.1	12.5	15.0	17.7	

Note: 1. G.R.A. ......Government Residential Area
S.S. ....Secondary School
T.C. ....Teachers College
2. The note represents the number of transformers and their capacities in the designing drawing of supply facilities.

TABLE Annex-2-1 SELECTION OF POWER SOURCE

KACHIA

	1976	1977	1978	1979	1980
Energy Sales (MWH)	676	846	1,017	1,172	1,345
Transmission System					
Capital Cost of Transmission System (N)	530,700				
Cost of Grid Power (N)	8,653	10,829	13,018	15,002	17,217
Cost of Maintenance and Operation (N)	10,614	10,614	10,614	10,614	10,614
Depreciation (N)	13,268	13,268	13,268	13,268	13,268
Interest (N)	26,535	25,872	25,209	24,546	23,883
Total Annual Cost (N)	59,070	60,583	62,109	63,420	64,982
Isolated Diesel Generation					
Capital Cost of Diesel Generating Plant (N)	157,000				
Cost of Fuel (N)	15,616	19,543	23,493	27,073	31,070
Cost of Maintenance and Operation (N)	17,270	17,270	17,270	17,270	17,270
Depreciation (N)	7,125	7,125	7,125	7,125	7,125
Interest (N)	7,850	7,494	7,138	6,782	6,426
Total Annual Cost (N)	47,861	51,432	55,126	58,250	61,891

TABLE Annex-2-2 SELECTION OF POWER SOURCE

MAKARFI HUNKUYI KUDAN

	1976	1977	1978	1979	1980	
Energy Sales (MWH)	230	324	560	687	825	(Makarfi)
	57	133	169	185	205	(Hunkuyi)
	53	122	155	169	184	(Kudan)
	340	579	884	1,041	1,214	
Transmission System						
Capital Cost of Transmission System (₦)	456,800					
Cost of Grid Power (₦)	4,352	7,411	11,315	13,324	15,539	
Cost of Maintenance and Operation (₦)	9,136	9,136	9,136	9,136	9,136	
Depreciation (₦)	11,420	11,420	11,420	11,420	11,420	
Interest (₦)	22,840	22,266	21,698	21,127	20,556	
Total Annual Cost (₦)	47,748	50,233	53,569	55,007	56,651	
Isolated Diesel Generation						
Capital Cost of Diesel Generating Plant (₦)	128,000					(Makarfi)
	75,000					(Hunkuyi)
	75,000					(Kudan)
Cost of Fuel (₦)	5,313	7,484	12,936	15,870	19,058	
	1,317	3,072	3,904	4,274	4,736	
	1,224	2,818	3,581	3,904	4,250	
Cost of Maintenance and Operation (₦)	14,080	14,080	14,080	14,080	14,080	
	8,250	8,250	8,250	8,250	8,250	
	8,250	8,250	8,250	8,250	8,250	
Depreciation (₦)	5,675	5,675	5,675	5,675	5,675	
	3,125	3,125	3,125	3,125	3,125	
	3,125	3,125	3,125	3,125	3,125	
Interest (₦)	6,400	6,116	5,832	5,548	5,264	
	3,750	3,594	3,478	3,282	3,126	
	3,750	3,594	3,478	3,282	3,126	
Total Annual Cost	64,259	69,183	75,714	78,665	82,065	

TABLE Annex-2-3 SELECTION OF POWER SOURCE

JIBIYA

	1976	1977	1978	1979	1980	
Energy Sales (MWH)	197	375	657	796	935	
Transmission System						
Capital Cost of Transmission System (₦)	526,500					
Cost of Grid Power (₦)	2,522	4,800	8,410	10,189	11,968	
Cost of Maintenance and Operation (₦)	10,530	10,530	10,530	10,530	10,530	
Depreciation (₦)	13,163	13,163	13,163	13,163	13,163	
Interest (₦)	26,325	25,667	25,009	24,351	23,693	
Total Annual Cost (₦)	52,540	54,160	57,112	58,233	59,354	
Isolated Diesel Generation						
Capital Cost of Diesel Generating Plant (₦)	128,000					
Cost of Fuel (₦)	4,551	8,663	15,177	18,249	21,599	
Cost of Maintenance and Operation (₦)	14,080	14,080	14,080	14,080	14,080	
Depreciation (₦)	5,675	5,675	5,675	5,675	5,675	
Interest (₦)	6,400	6,116	5,832	5,548	5,264	
Total Annual Cost (₦)	30,706	34,534	40,764	43,552	46,618	

TABLE Annex-2-4 SELECTION OF POWER SOURCE

MUSAWA

	1976	1977	1978	1979	1980	
Energy Sales (MWH)	161	246	424	507	599	
Transmission System						
Capital Cost of Transmission System (₦)	736,500					
Cost of Grid Power (₦)	2,061	3,149	5,427	6,490	7,667	
Cost of Maintenance and Operation (₦)	14,730	14,730	14,730	14,730	14,730	
Depreciation (₦)	18,413	18,413	18,413	18,413	18,413	
Interest (₦)	36,825	35,904	34,983	34,062	33,141	
Total Annual Cost (₦)	72,029	72,196	73,553	73,655	73,951	
Isolated Diesel Generation						
Capital Cost of Diesel Generating Plant (₦)	92,000			15,200		115 kW generator will be added in 1979.
Cost of Fuel (₦)	3,719	5,683	9,794	11,712	13,837	
Cost of Maintenance and Operation (₦)	10,120	'0,120	10,120	11,792	11,792	
Depreciation (₦)	3,925	3,925	3,925	4,685	4,685	
Interest (₦)	4,600	4,404	4,208	4,771	4,537	
Total Annual Cost (₦)	22,364	24,132	28,047	32,960	34,851	

TABLE Annex-2-5 SELECTION OF POWER SOURCE

ZONKWA

	1976	1977	1978	1979	1980	
Energy Sales (MWH)	618	842	1,060	1,210	1,374	
Transmission System						
Capital Cost of Transmission System (₦)	530,700					
Cost of Grid Power (₦)	7,910	10,778	13,568	15,488	17,587	
Cost of Maintenance and Operation (₦)	10 614	10,614	10,614	10,614	10,614	
Depreciation (₦)	13 268	13,268	13,268	13,268	13,268	
Interest (₦)	26 535	25,872	25,209	24,546	23,883	
Total Annual Cost (₦)	58,327	60,532	62,659	63,916	65,352	
Isolated Diesel Generation						
Capital Cost of Diesel Generating Plant (₦)	157,000					
Cost of Fuel (₦)	14,276	19,451	24,486	27,951	31,739	
Cost of Maintenance and Operation (₦)	17,270	17,270	17,270	17,270	17,270	
Depreciation (₦)	7,125	7,125	7,125	7,125	7,125	
Interest (₦)	7,850	7,494	7,138	6,782	6,426	
Total Annual Cost (₦)	46,521	51,340	56,019	59,128	62,560	

TABLE Annex-2-6 SELECTION OF POWER SOURCE

MAIADUA

	1976	1977	1978	1979	1980	
Energy Sales (MWH)	79	187	432	518	611	
Transmission System						
Capital Cost of Transmission System (₦)	264,000					
Cost of Grid Power (₦)	1,011	2,394	5,530	6,630	7,821	
Cost of Maintenance and Operation (₦)	5,280	5,280	5 280	5,280	5,280	
Depreciation (₦)	6,600	6,600	6,600	6,600	6,600	
Interest (₦)	13,200	12,870	12,540	12,210	11,880	
Total Annual Cost (₦)	26,091	27,144	29,950	30,720	31,581	
Isolated Diesel Generation						
Capital Cost of Diesel Generating Plant (₦)	92,000			15,200		115 kW generator will be added in 1979.
Cost of Fuel (₦)	1,824	4,320	9,979	11,966	14,114	
Cost of Maintenance and Operation (₦)	10,120	10,120	10,120	11,792	11,792	
Depreciation (₦)	3,925	3,925	3,925	4,685	4,685	
Interest (₦)	4,600	4,404	4,208	4,771	4,537	
Total Annual Cost (₦)	20,469	22,769	28,232	33,214	35,128	

TABLE Annex-2-7 SELECTION OF POWER SOURCE

KANKARA

	1976	1977	1978	1979	1980
Energy Sales (MWH)	128	248	492	603	712
Transmission System					
Capital Cost of Transmission System (₦)	306,000				
Cost of Grid Power (₦)	1,638	3,174	6,298	7,718	9,114
Cost of Maintenance and Operation (₦)	6,120	6,120	6,120	6,120	6,120
Depreciation (₦)	7,650	7,650	7,650	7,650	7,650
Interest (₦)	15,300	14,917	14,534	14,151	13,768
Total Annual Cost (₦)	30,708	31,861	34,602	35,639	36,652
Isolated Diesel Generation					
Capital Cost of Diesel Generating Plant (₦)	128,000				
Cost of Fuel (₦)	2,957	5,729	11,365	13,929	16,447
Cost of Maintenance and Operation (₦)	14,080	14,080	14,080	14,080	14,080
Depreciation (₦)	5,675	5,675	5,675	5,675	5,675
Interest (₦)	6,400	6,116	5,832	5,548	5,264
Total Annual Cost (₦)	29,112	31,600	36,952	39,232	41,466

TABLE Annex-2-8 SELECTION OF POWER SOURCE

SOBA

	1976	1977	1978	1979	1980
Energy Sales (MWH)	499	635	920	1,060	1,180
Transmission System					
Capital Cost of Transmission System (₦)	409,500				
Cost of Grid Power (₦)	6,387	8,128	11,776	13,568	15,104
Cost of Maintenance and Operation (₦)	8,190	8,190	8,190	8,190	8,190
Depreciation (₦)	10,238	10,238	10,238	10,238	10,238
Interest (₦)	20,475	19,963	19,451	18,939	18,427
Total Annual Cost (₦)	45,290	46,519	49,655	50,935	51,959
Isolated Diesel Generation					
Capital Cost of Diesel Generating Plant (₦)	157,000				
Cost of Fuel (₦)	11,527	14,669	21,252	24,486	27,258
Cost of Maintenance and Operation (₦)	17,270	17,270	17,270	17,270	17,270
Depreciation (₦)	7,125	7,125	7,125	7,125	7,125
Interest (₦)	7,850	7,494	7,138	6,782	6,426
Total Annual Cost (₦)	43,772	46,558	52,785	55,663	58,079

TABLE Annex-2-9 SELECTION OF POWER SOURCE.

SHIKA

	1976	1977	1978	1979	1980
Energy Sales (MWH)	17	36	46	51	56
Transmission System					
Capital Cost of Transmission System (₦)	3,200				
Cost of Grid Power (₦)	218	461	589	653	717
Cost of Maintenance and Operation (₦)	64	64	64	64	64
Depreciation (₦)	80	80	80	80	80
Interest (₦)	160	156	152	148	144
Total Annual Cost (₦)	522	761	885	945	1,005
Isolated Diesel Generation					
Capital Cost of Diesel Generating Plant (₦)	75,000				
Cost of Fuel (₦)	393	832	1,063	1,178	1,294
Cost of Maintenance and Operation (₦)	8,250	8,250	8,250	8,250	8,250
Depreciation (₦)	3,125	3,125	3,125	3,125	3,125
Interest (₦)	3,750	3,594	3,478	3,282	3,126
Total Annual Cost (₦)	15,518	15,801	15,916	15,835	15,795

TABLE Annex-2-10 NET INCOME

KACHIA

	1976	1977	1978	1979	1980	
Energy Sales (kWH)	676	846	1,017	1,172	1,345	
Revenue (Including Connection Fee) (₦)	24,500	30,600	36,900	42,700	48,700	table Annex 1-1
Annual Cost of Power Source (₦)	47,861	51,432	55,126	58,250	61,891	table Annex-2-1 Diesel Generation
Distribution System						
Capital Cost of Distribution System (₦)	119,900	31,900	1,800	4,000	6,500	
Capital Cost of Connection to Customers	6,080	1,760	1,520	960	1,080	
Cost of Maintenance and Operation (₦)	2,520	3,193	3,259	3,358	3,510	
Depereciation (₦)	5,040	6,386	6,518	6,718	7,020	
Interest (₦)	6,299	7,730	7,577	7,499	7,542	
Annual Cost of Distribution System (₦)	13,859	17,309	17 354	17,575	18,072	
Cost of Local Administration and Collection (₦)	1 825	2,284	2,746	3,164	3,632	
Total Annual Cost (₦)	63,545	71,025	75,226	78,989	83,595	
Net Income (₦)	-39,045	-40,425	-38,326	-36,289	-34,895	

TABLE Annex-2-11 NET INCOME

MAKARFI HUNKUYI KUDAN

	1976	1977	1978	1979	1980	
Enerby Sales (kWH)	230	324	560	687	825	(Makarfi)
	57	133	169	185	205	(Hunkuyi)
	53	122	155	169	184	(Kudan)
Revenue (Including Connection Fee) (₦)	19,200	31,100	41,800	47,900	54,800	table Annex 1-2, 1-9, 1-10
Annual Cost of Power Source (₦)	47,748	50,233	53,569	55,007	56,651	table Annex-2-2, Transmission Line
Distribution System						
Capital Cost of Distribution System (₦)	99,900		11,400			
	46,700					
	66,600					
Capital Cost of Connection to Customers (₦)	4,600	1,600	1,560	800	840	
	5,760	2,360	1,680	640	680	
	5,240	2,160	1,560	560	600	
Cost of Maintenance and Operation (₦)	2,090	2,122	2,153	2,169	2,186	
	1,049	1,096	1,130	1,143	1,156	
	1,437	1,480	1,511	1,522	1,534	
Depreciation (₦)	4,180	4,244	4,306	4,338	4,372	
	2,098	2,192	2,260	2,286	2,312	
	2,874	2,960	3,022	3,044	3,068	
Interest (₦)	5,225	5,096	4,962	4,787	4,612	
	2,623	2,636	2,611	2,530	2,449	
	3,592	3,556	3,486	3,363	3,241	
Annual Cost of Distribution System (₦)	11,495	11,462	11,421	11,294	11,170	
	5,770	5,924	6,001	5,959	5,917	
	7,903	7,996	8,019	7,929	7,843	
(Total)	25,168	25,382	25,441	25,182	24,930	
Cost of Local Administration and Collection (₦)	621	875	1,512	1,855	2,228	
	154	359	456	500	554	
	143	329	419	456	497	
Total Annual Cost (₦)	73,834	77,178	81,397	83,000	84,860	
Net Income (₦)	-54,634	-46,078	-39,597	-35,100	-30,060	

TABLE Annex-2-12 NET INCOME

JIBIYA

	1976	1977	1978	1979	1980	
Energy Sales (kWH)	197	375	657	796	935	
Revenue (Including Connection Fee) (₦)	11,200	19,900	29,100	34,000	39,600	table Annex 1-3
Annual Cost of Power Source (₦)	30,706	34,534	40,764	43,552	46,618	table Annex-2-3 Diesel generation
Distribution System						
Capital Cost of Distribution System (₦)	182,300	10,200	10,200			
Capital Cost of Connection to Customers	9,960	4,000	3,280	1,360	1,400	
Cost of Maintenance and Operation (₦)	3,845	4,129	4,399	4,426	4,454	
Depereciation (₦)	7,690	8,258	8,798	8,852	8,908	
Interest (₦)	9,613	9,939	10,200	9,828	9,455	
Annual Cost of Distribution System (₦)	21,148	22,326	23,397	23,106	22,817	
Cost of Local Administration and Collection (₦)	532	1,013	1,774	2,149	2,525	
Total Annual Cost (₦)	52,386	57,873	65,935	68,807	71,960	
Net Income (₦)	-41,186	-37,937	-36,835	-34,807	-32,360	

TABLE Annex-2-13 NET INCOME

MUSAWA

	1976	1977	1978	1979	1980	
Energy Sales (kWH)	161	246	424	507	599	
Revenue (Including Connection Fee) (₦)	8,100	12,300	18,100	21,000	24,400	table Annex 1-4
Annual Cost of Power Source (₦)	22,364	24,132	28,047	32,960	34,851	table Annex-2-4 Diesel generation
Distribution System						
Capital Cost of Distribution System (₦)	93,500		10,200			
Capital Cost of Connection to Customers	5,920	2,160	1,880	720	800	
Cost of Maintenance and Operation (₦)	1,988	2,032	2,273	2,288	2,304	
Depereciation (₦)	3,976	4,064	4,546	4,576	4,608	
Interest (₦)	4,971	4,880	5,281	5,090	4,901	
Annual Cost of Distribution System (₦)	10,935	10,976	12,100	11,954	11,813	
Cost of Local Administration and Collection (₦)	435	664	1,145	1,369	1,617	
Total Annual Cost (₦)	33,734	35,772	41,292	46,283	48,281	
Net Income (₦)	-25,634	-23,472	23,192	25,283	23,881	

TABLE Annex-2-14 NET INCOME

ZONKWA

	1976	1977	1978	1979	1980	
Energy Sales (kWH)	618	842	1,060	1,210	1,374	
Revenue (Including Connection Fee) (₦)	25,800	36,200	44,100	50,200	56,700	table Annex 1-5
Annual Cost of Power Source (₦)	46,521	51,340	56,019	59,128	62,560	table Annex-2-5 Diesel generation
Distribution System						
Capital Cost of Distribution System (₦)	162,200	27,500	1,800	4,000	6,500	
Capital Cost of Connection to Customers	11,720	4,080	3 160	1,800	1,880	
Cost of Maintenance and Operation (₦)	3,478	4,110	4,209	4,325	4,493	
Depereciation (₦)	6,956	8,220	8,418	8,650	8,986	
Interest (₦)	8,696	9,927	9,764	9,633	9,620	
Annual Cost of Distribution System (₦)	19,130	22,257	22,391	22,608	23,099	
Cost of Local Administration and Collection (₦)	1,669	2,273	2,862	3,267	3,710	
Total Annual Cost (₦)	67,320	75,870	81,272	85,003	89,369	
Net Income (₦)	-41,520	-39,670	-37,172	-34,803	-32,669	

TABLE Annex-2-15 NET INCOME

MAIADUA

	1976	1977	1978	1979	1980	
Energy Sales (kWH)	79	187	432	518	611	
Revenue (Including Connection Fee) (₦)	6,600	12,500	20,400	23,600	27,100	table Annex 1-6
Annual Cost of Power Source (₦)	26,091	27,144	29,950	30,720	31,581	table Annex-2-6 Transmission line
Distribution System						
Capital Cost of Distribution System (₦)	74,100		13,700			
Capital Cost of Connection to Customers	8,200	3,360	2,760	960	1,000	
Cost of Maintenance and Operation (₦)	1,646	1,713	2,042	2,062	2,082	
Depereciation (₦)	3,292	3,426	4,084	4,124	4,164	
Interest (₦)	4,115	4,118	4,770	4,614	4,458	
Annual Cost of Distribution System (₦)	9,053	9,257	10,896	10,800	10,704	
Cost of Local Administration and Collection (₦)	213	505	1,166	1,399	1,650	
Total Annual Cost (₦)	35,357	36,906	42,012	42,919	43,935	
Net Income (₦)	-28,757	-24,406	-21,612	-19,319	-16,835	

TABLE Annex-2-16 NET INCOME

KANKARA

	1976	1977	1978	1979	1980	
Energy Sales (kWH)	128	248	492	603	712	
Revenue (Including Connection Fee) (₦)	7,300	12,900	20,900	24,700	28,700	table Annex 1-7
Annual Cost of Power Source (₦)	30,708	31,861	34,602	35,639	36,652	table Annex-2-7 Transmission line
Distribution System						
Capital Cost of Distribution System (₦)	93,200		11,900	14,700	500	
Capital Cost of Connection to Customers	6,160	2,640	2,200	1,640	840	
Cost of Maintenance and Operation (₦)	1,987	2,040	2,322	2,649	2,676	
Depereciation (₦)	3,974	4,080	4,644	5,298	5,352	
Interest (₦)	4 968	4,901	5,402	5,987	5,789	
Annual Cost of Distribution System (₦)	10,929	11,021	12,368	13,934	13,817	
Cost of Local Administration and Collection (₦)	346	670	1,328	1,628	1,922	
Total Annual Cost (₦)	41,983	43,552	48,298	51,201	52,391	
Net Income (₦)	-34,683	-30,652	-27,398	-26,501	-23,691	

TABLE Annex-2-17 NET INCOME

SOBA

	1976	1977	1978	1979	1980	
Energy Sales (kWH)	499	635	920	1,060	1,180	
Revenue (Including Connection Fee) (₦)	20,400	26,700	35,900	40,800	44,600	table Annex 1-8
Annual Cost of Power Source (₦)	45,290	46,519	49,655	50,935	51,959	table Annex-2-8 Transmission line
Distribution System						
Capital Cost of Distribution System (₦)	91,400		10,200			
Capital Cost of Connection to Customers	8,720	3,120	2,440	960	920	
Cost of Maintenance and Operation (₦)	2,002	2,065	2,318	2,337	2,355	
Depereciation (₦)	4,004	4,130	4,636	4,674	4,710	
Interest (₦)	5,006	4,962	5,387	5,204	5,016	
Annual Cost of Distribution System (₦)	11,012	11,157	12,341	12,215	12,081	
Cost of Local Administration and Collection (₦)	1,347	1,715	2,484	2,862	3,186	
Total Annual Cost (₦)	57,649	59,391	64,480	66,012	67,226	
Net Income (₦)	-37,249	-32,691	-28,580	-25,212	-22,626	

TABLE Annex-2-18 NET INCOME

SHIKA

	1976	1977	1978	1979	1980	
Energy Sales (kWH)	17	36	46	51	56	
Revenue (Including Connection Fee) (₦)	1,400	2,500	2,900	3,200	3,500	table Annex 1-11
Annual Cost of Power Source (₦)	522	761	885	945	1,005	table Annex-2-9 Transmission line
Distribution System						
Capital Cost of Distribution System (₦)	38,300					
Capital Cost of Connection to Customers	1,440	600	520	200	200	
Cost of Maintenance and Operation (₦)	795	807	817	821	825	
Depereciation (₦)	1,590	1,614	1,634	1,642	1,650	
Interest (₦)	1,987	1,938	1,883	1,811	1,739	
: Annual Cost of Distribution System (₦)	4,372	4,359	4,334	4,274	4,214	
Cost of Local Administration and Collection (₦)	46	97	124	138	151	
Total Annual Cost (₦)	4,940	5,217	5,343	5,357	5,370	
Net Income (₦)	-3,540	-2,717	-2,443	-2,157	-1,870	

TABLE Annex-2-19 TOTAL NET INCOME

	1976	1977	1978	1979	1980
Total Revenue (₦)	124,500	184,700	250,100	288,100	328,100
Annual Cost of Power Source (₦)	297,811	317,956	348,617	367,136	383,768
Annual Cost of Distribution System (₦)	125,606	134,044	140,622	141,648	141,547
Annual Cost of Local Administration and Collection (₦)	7,331	10,748	16,016	18,787	21,672
Total Annual Cost (₦)	430,748	462,784	505,255	527,571	546,987
Total Net Income (₦)	-306,248	-278,084	-255,155	-239,471	-218,887

(Reference) When all towns are electrified by isolated diesel generation

	1976	1977	1978	1979	1980
Total Revenue (₦)	124,500	184,700	250,100	288,100	328,100
Annual Cost of Power Source (₦)	320,582	347,349	389,555	416,499	438,453
Annual Cost of Distribution System (₦)	125,606	134,044	140,622	141,648	141,547
Annual Cost of Local Administration and Collection (₦)	7,331	10,748	16,016	18,787	21,672
Total Annual Cost (₦)	453,519	492,141	546,193	576,934	601,672
Total Net Income (₦)	-329,019	-307,441	-296,093	-288,834	-273,572

Table Annex-2-20 TOTAL CAPITAL COST FOR ALL TOWNS
(Before commissioning)

1)

Total capital cost of power source	(₦)	1,973,500
Total capital cost of distribution system	(₦)	1,141,900
Total capital cost	(₦)	3,115,400

Reference

2) Electrification of all towns by isolated diesel generation system

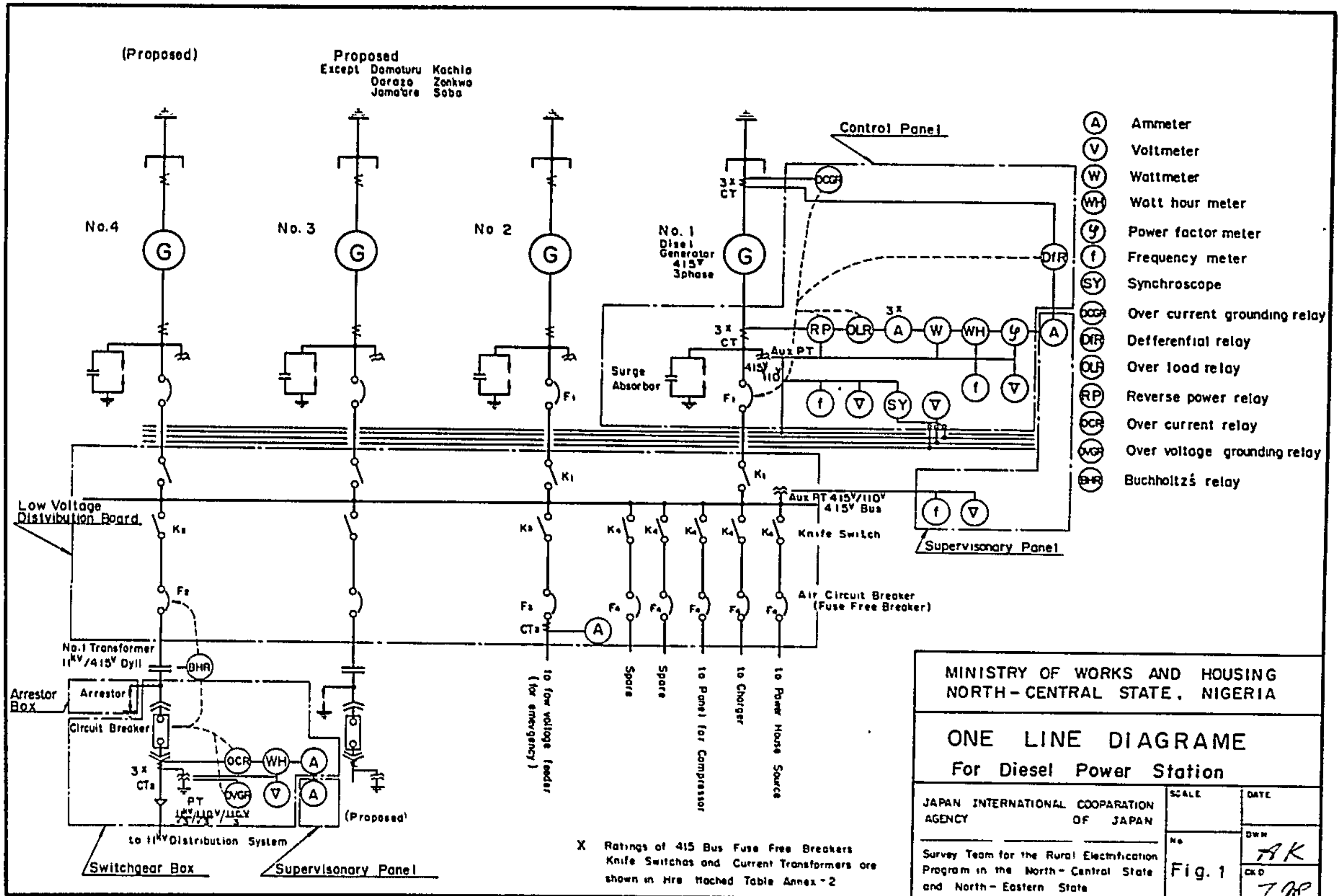
Total capital cost of power source	(₦)	1,264,000
Total capital cost of distribution system	(₦)	1,141,900
Total capital cost	(₦)	2,405,900

3) Electrification of all towns by transmission lines

Total capital cost of power source	(₦)	3,763,900
Total capital cost of distribution system	(₦)	1,141,900
Total capital cost	(₦)	4,905,800

DRAWINGS

DRAWINGS



X Ratings of 415 Bus Fuse Free Breakers Knife Switches and Current Transformers are shown in the Hached Table Annex - 2

MINISTRY OF WORKS AND HOUSING
NORTH - CENTRAL STATE, NIGERIA

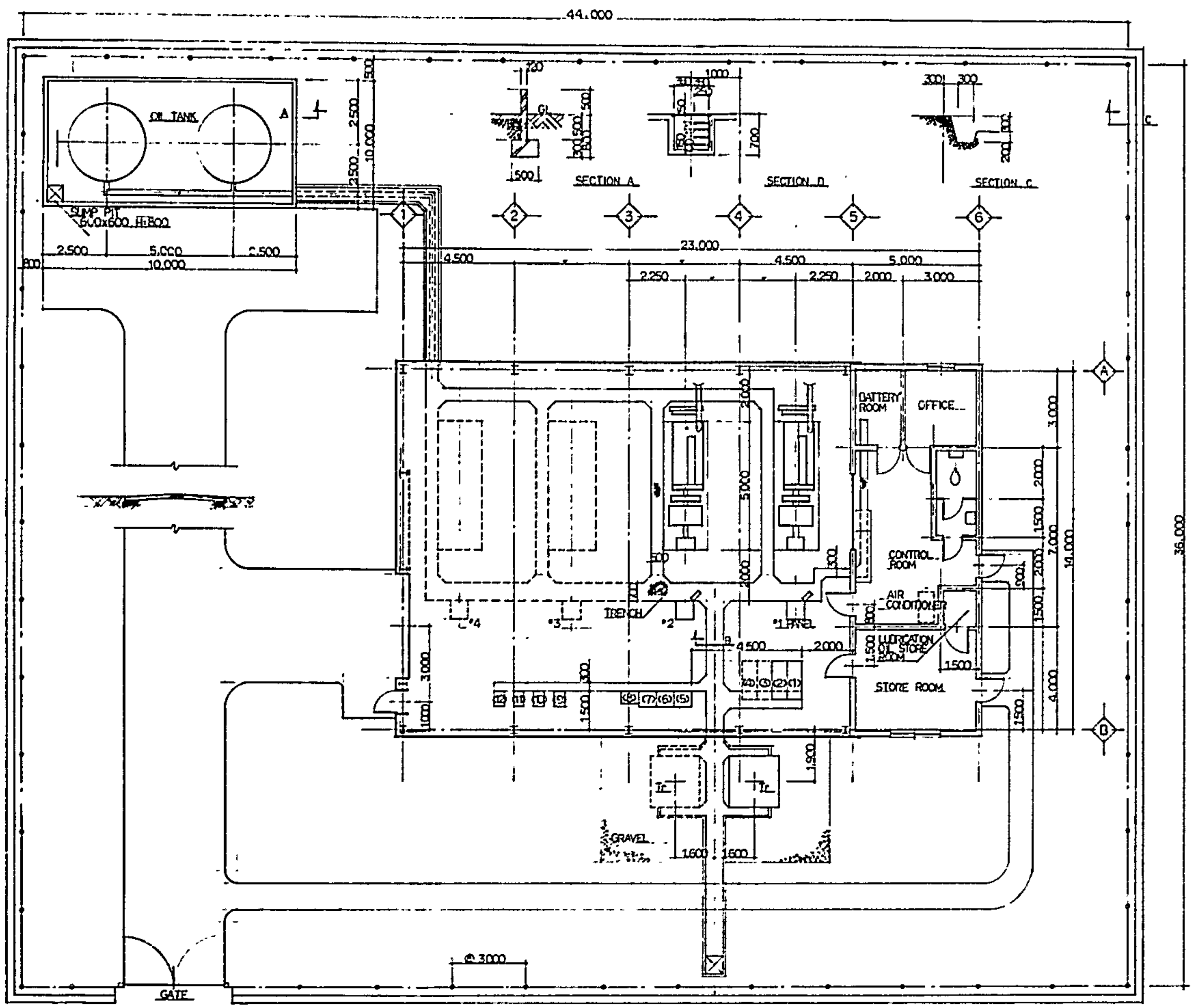
ONE LINE DIAGRAME

For Diesel Power Station

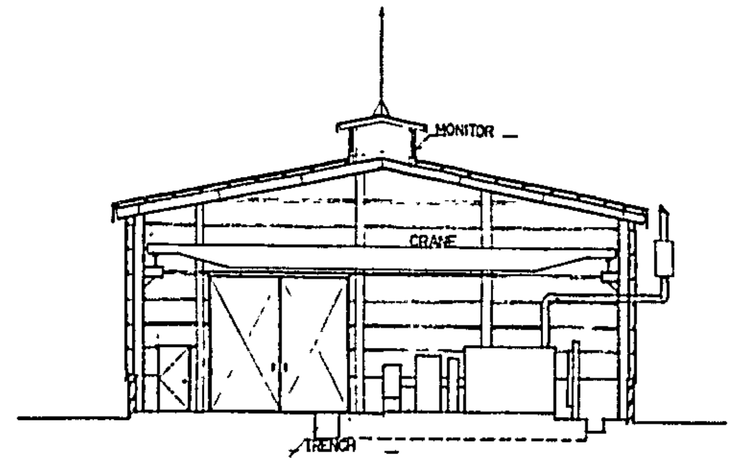
JAPAN INTERNATIONAL COOPARATION AGENCY OF JAPAN

Survey Team for the Rural Electrification Program in the North - Central State and North - Eastern State

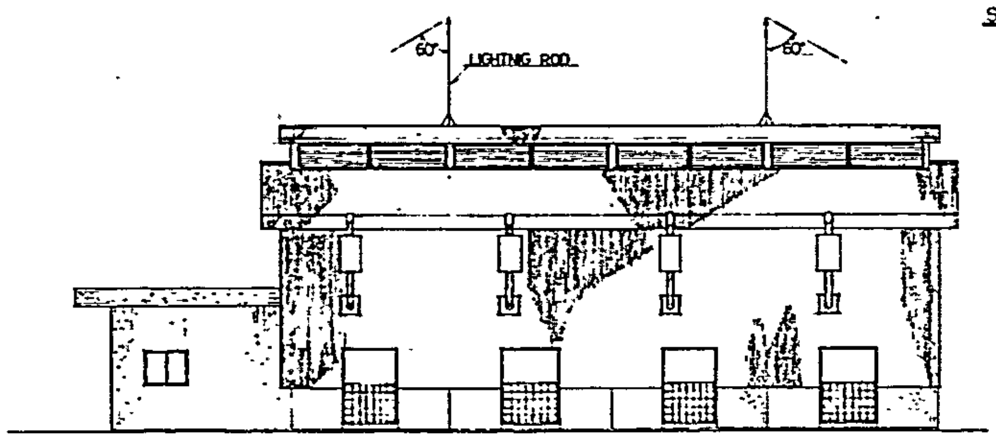
SCALE | DATE | No | Fig. 1 | DWN AK | CKD TH



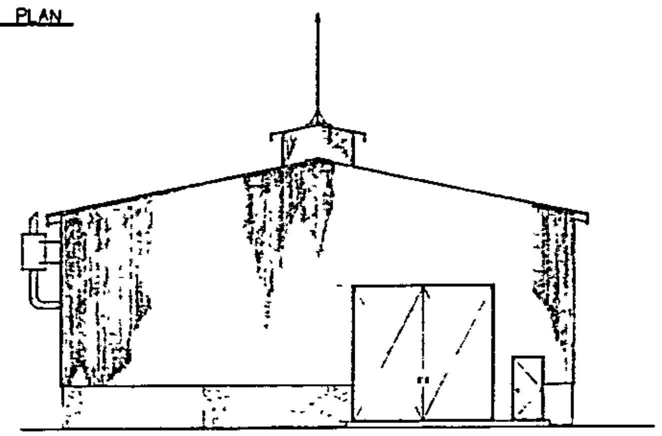
SITE PLAN



SECTION



ELEVATION 1



ELEVATION 2

NOTES

1 PANEL AND SWITCHING BOARD
(1) 11Kv FEEDER SWITCHING BOARD
(2) 11Kv PT. LA BOARD
(3) SPARE
(4) SPARE
(5) LT SWITCHING BOARD
(6) DC CHARGER
(7) D.C DISTRIBUTION BOARD
(8) D.G STARTING BOARD
(9) SURPER VISION PANEL
(10) AIR COMPRESSOR A.C. MOTOR DRIVEN
(11) AIR COMPRESSOR ENGINE DRIVEN
(12) D C EMERGENCY GENERATOR

MINISTRY OF WORKS AND HOUSING NORTH - CENTRAL STATE, NIGERIA		
SITE LAYOUT PLAN FOR PS		
JAPAN INTERNATIONAL COOPARATION AGENCY GOVERNMENT OF JAPAN Survey Team for the Rural Electrification Program in the North-Central State and North-Eastern State	SCALE	DATE
	NO. Fig.2	DWN H K CKD T.N

Fig. 3 SYSTEM OF FUEL

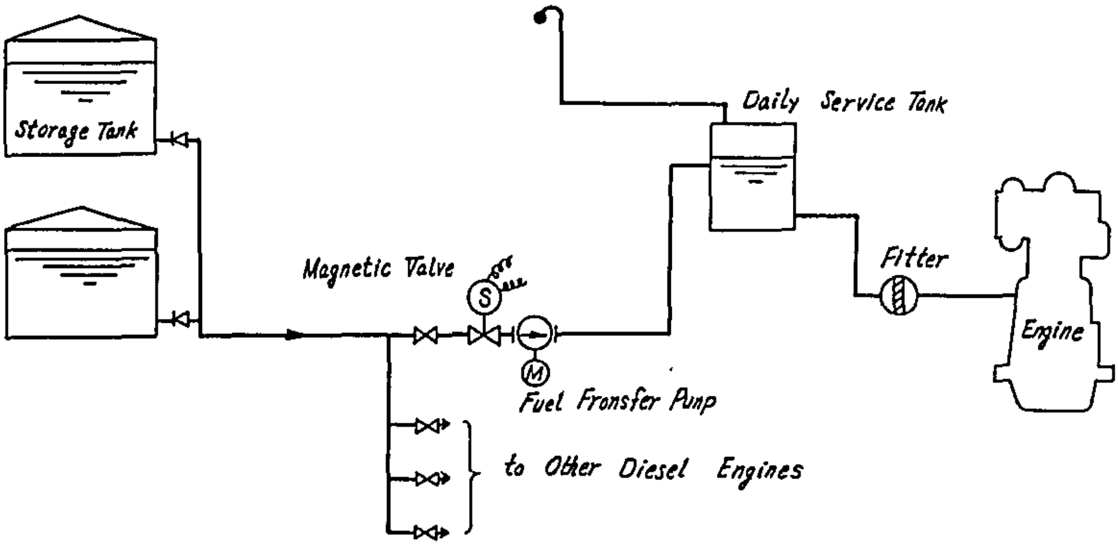


Fig. 4 SYSTEM OF COMPRESSED AIR

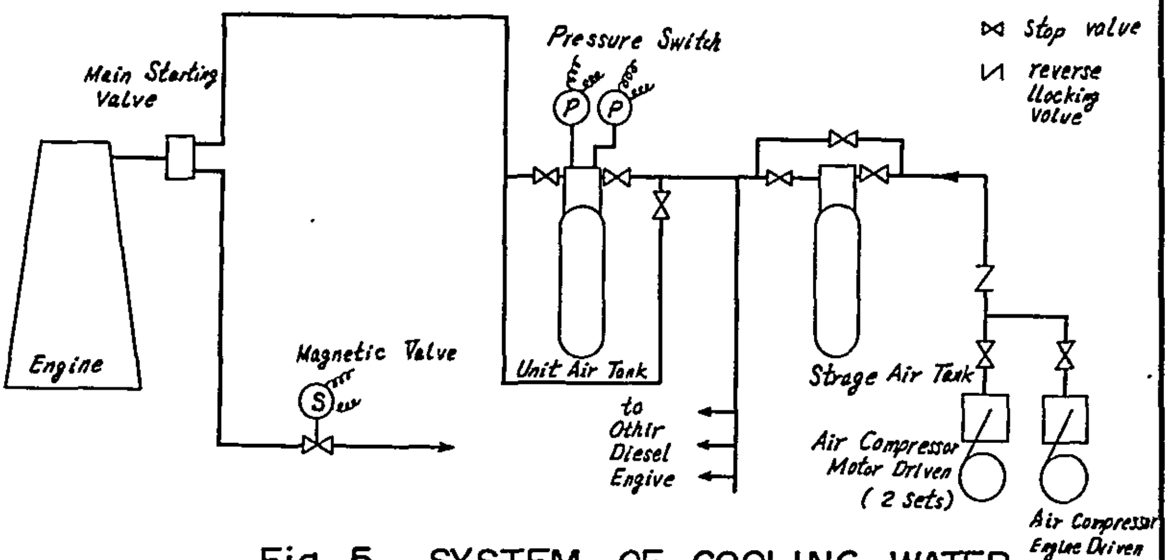


Fig. 5 SYSTEM OF COOLING WATER

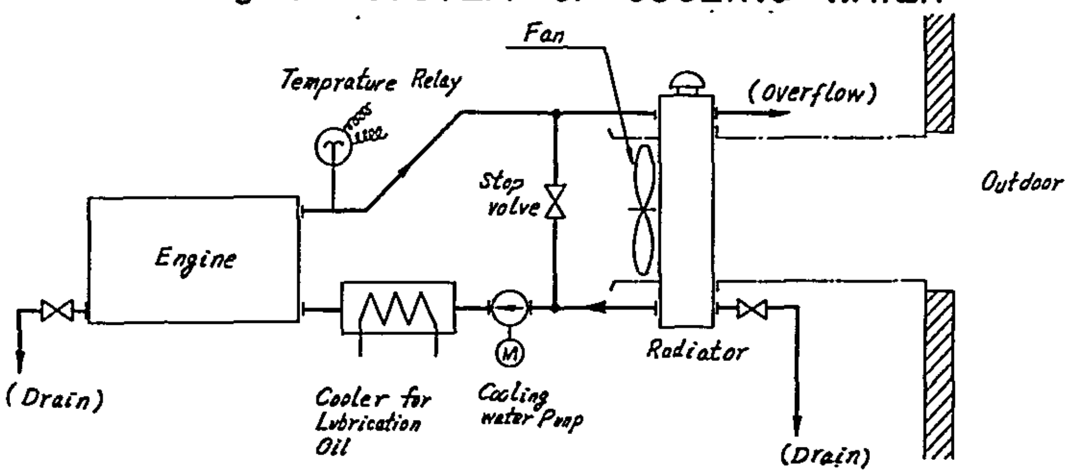


Fig. 6 SYSTEM OF LUBRICATION OIL

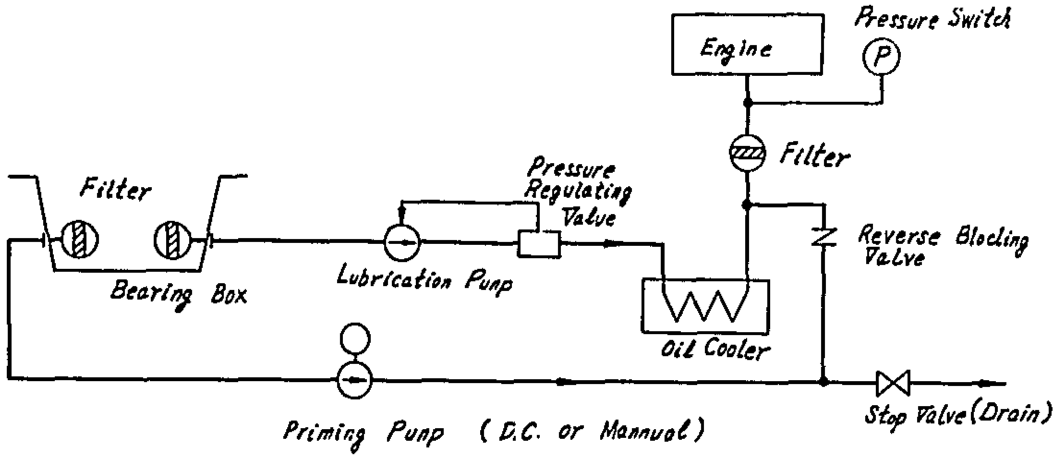


Fig. 7 SYSTEM OF D.C. SUPPLY

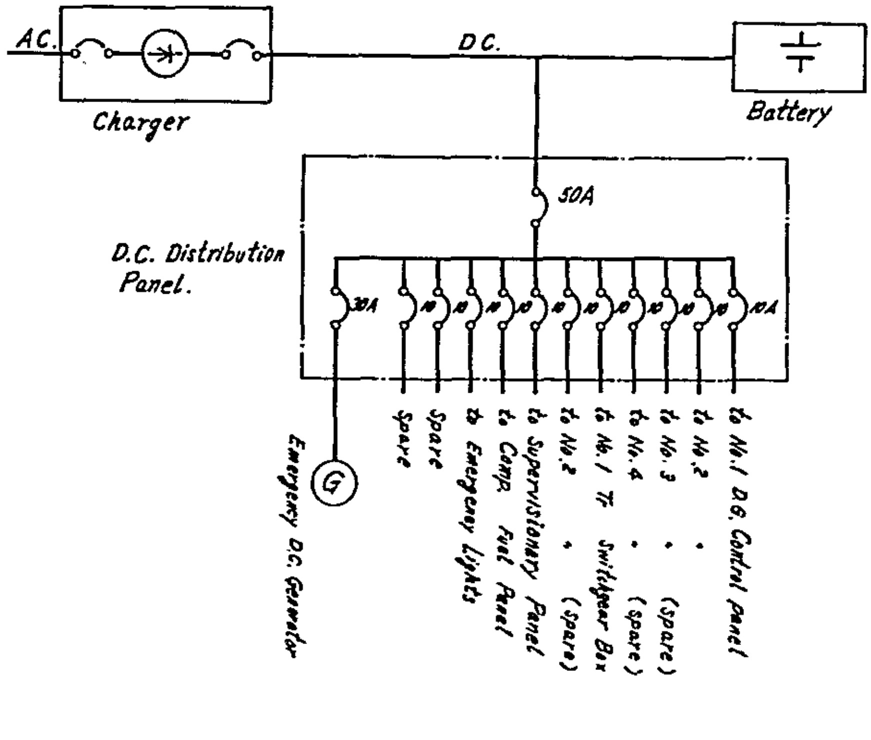
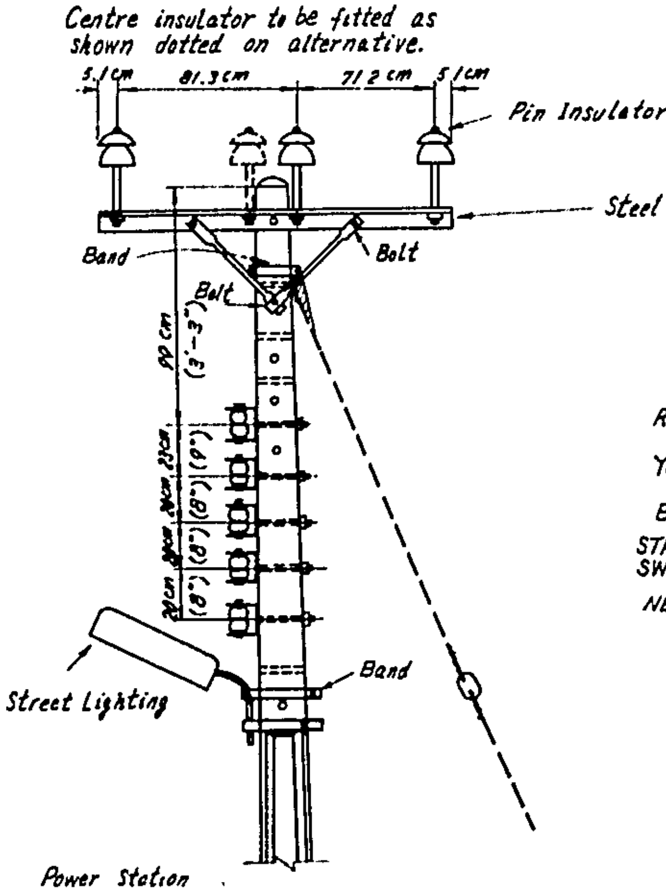
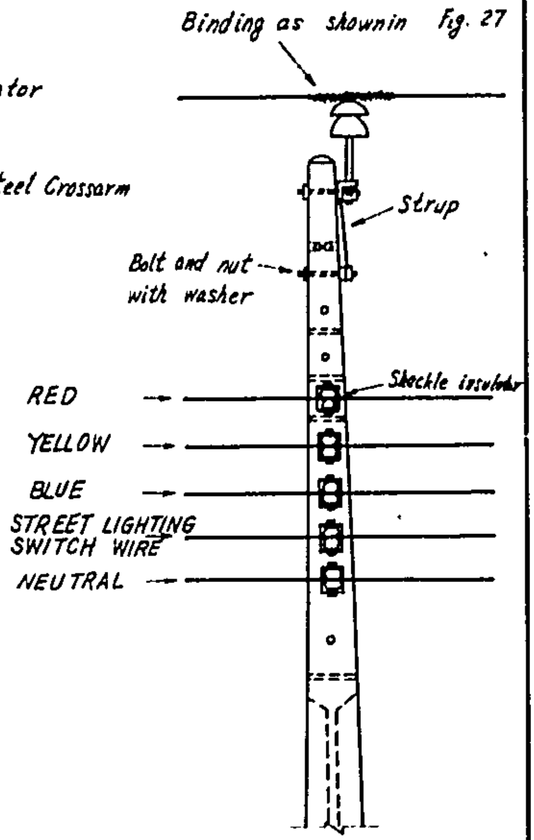
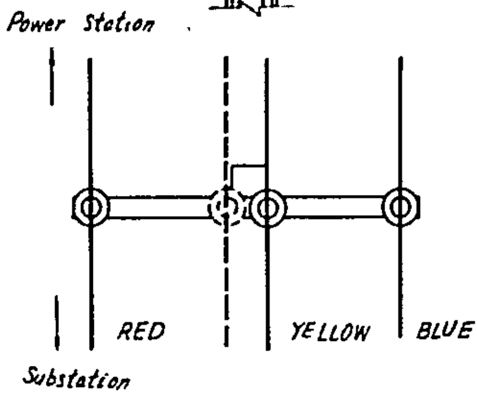


Fig. 8 INTERMEDIATE AND ANGLE POLE

(Up to 20° line deviation)





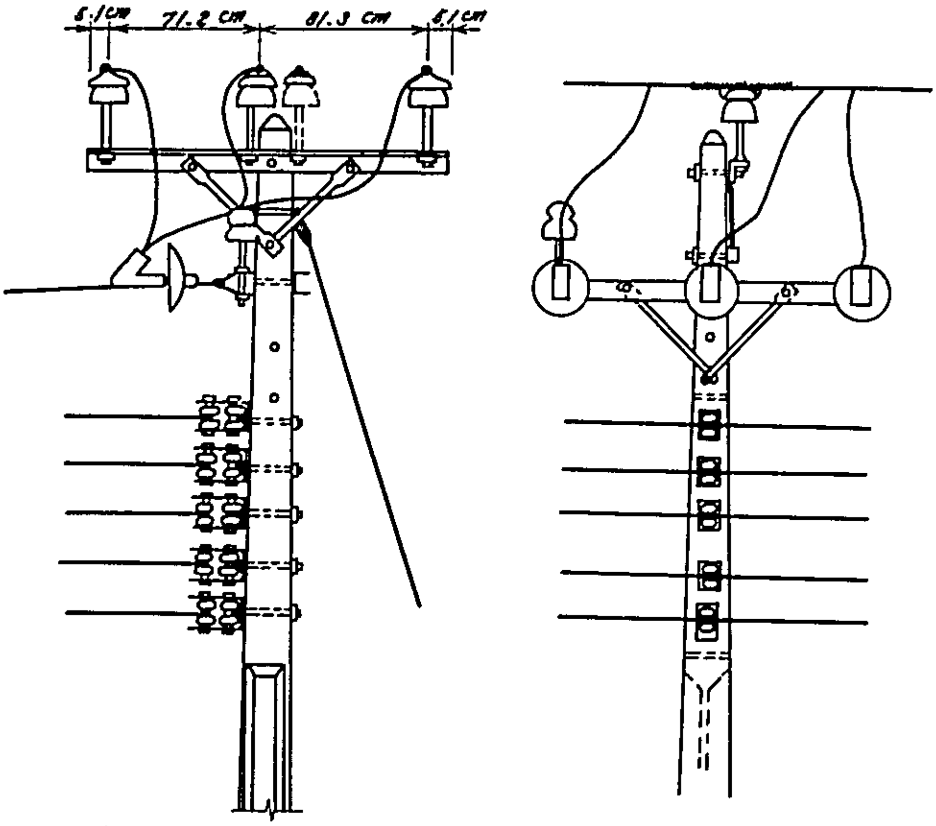


NOTE

1. This type of poles are commonly used for H.V. lines and L.V. lines and otherwise shall be applied to H.V. Line only

2. The type of cross arms are either of "L" or "C" type

Fig. 9 TEE OFF POLE



NOTE Tee Off poles shall be single pole or H pole

Fig. 10 SUBSTATION POLE
(Terminal Pole)

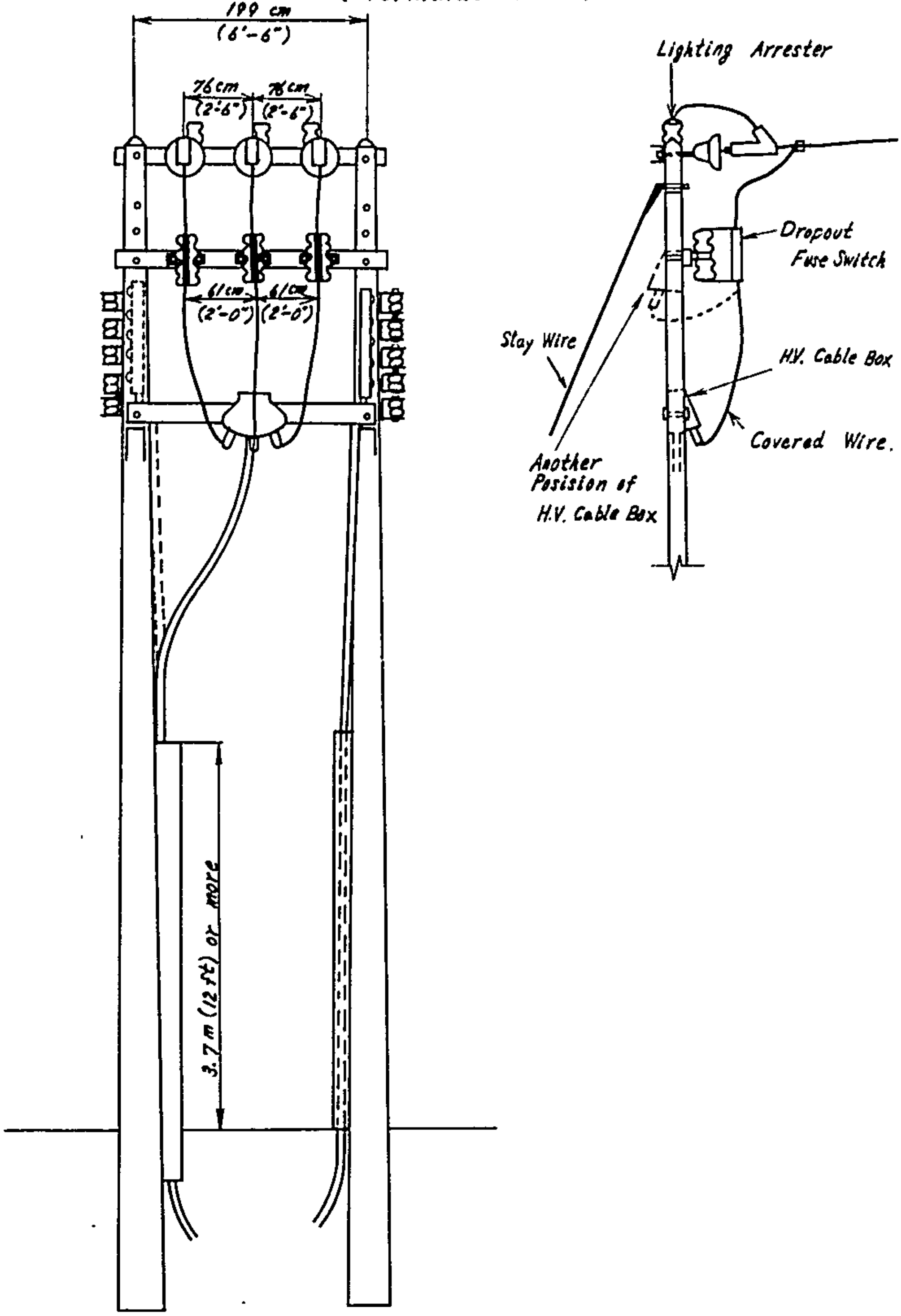
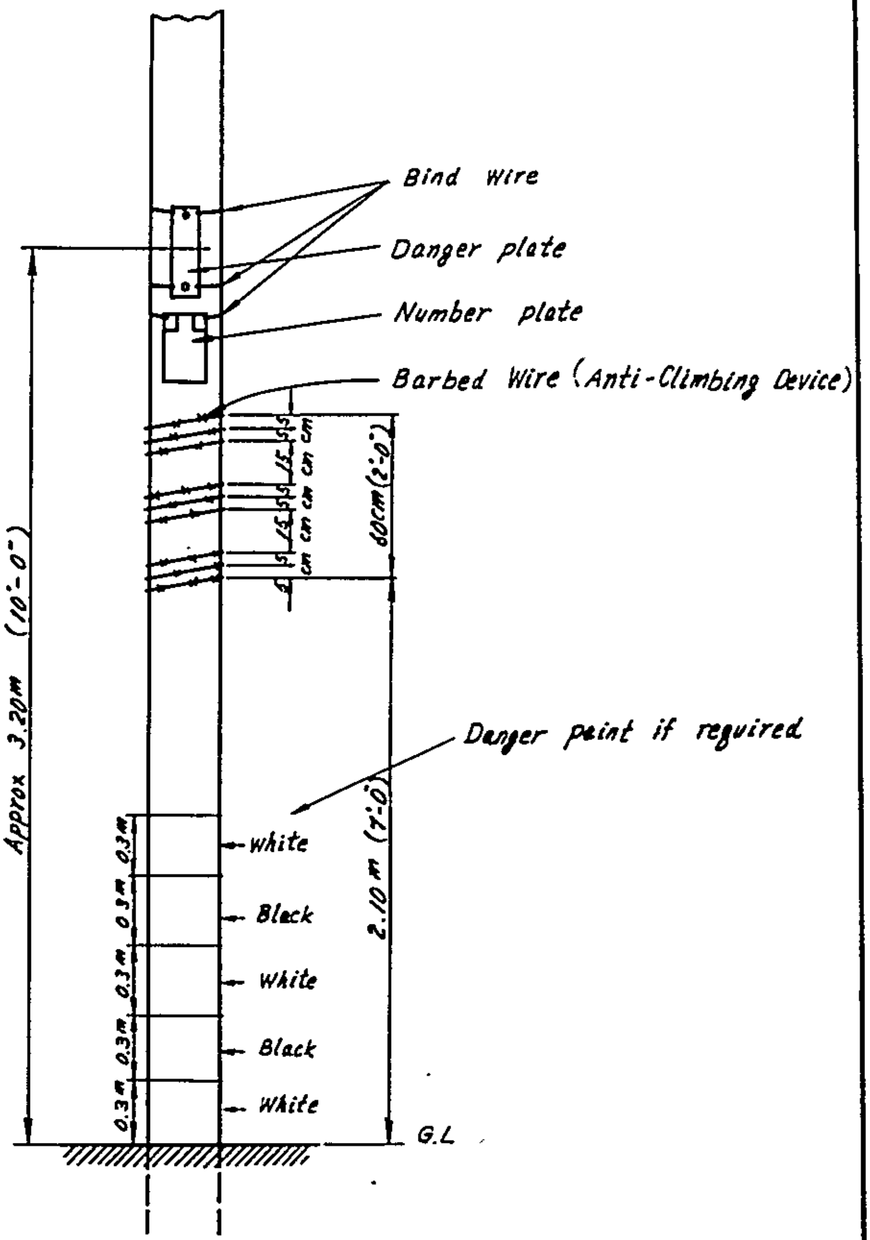
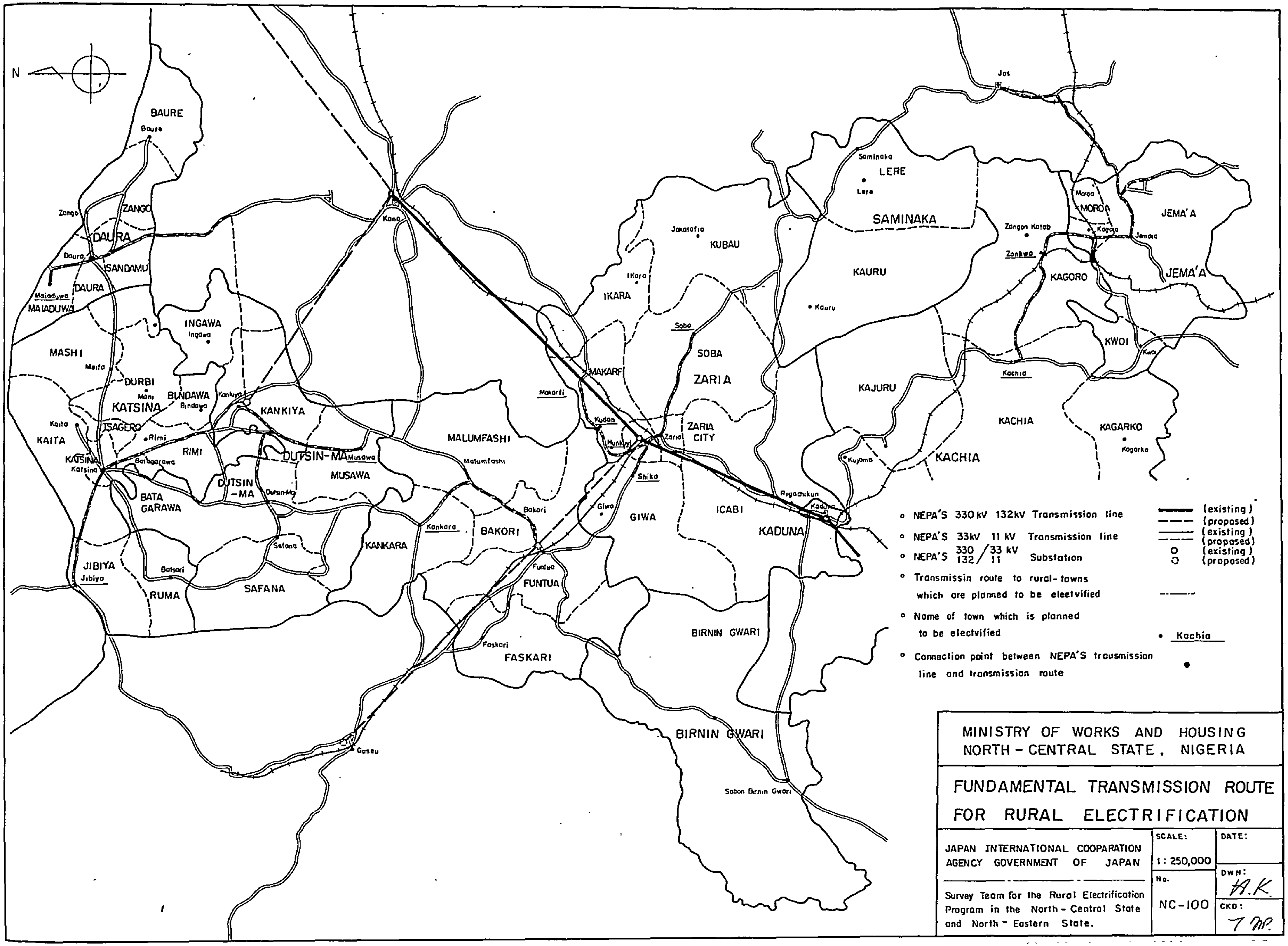


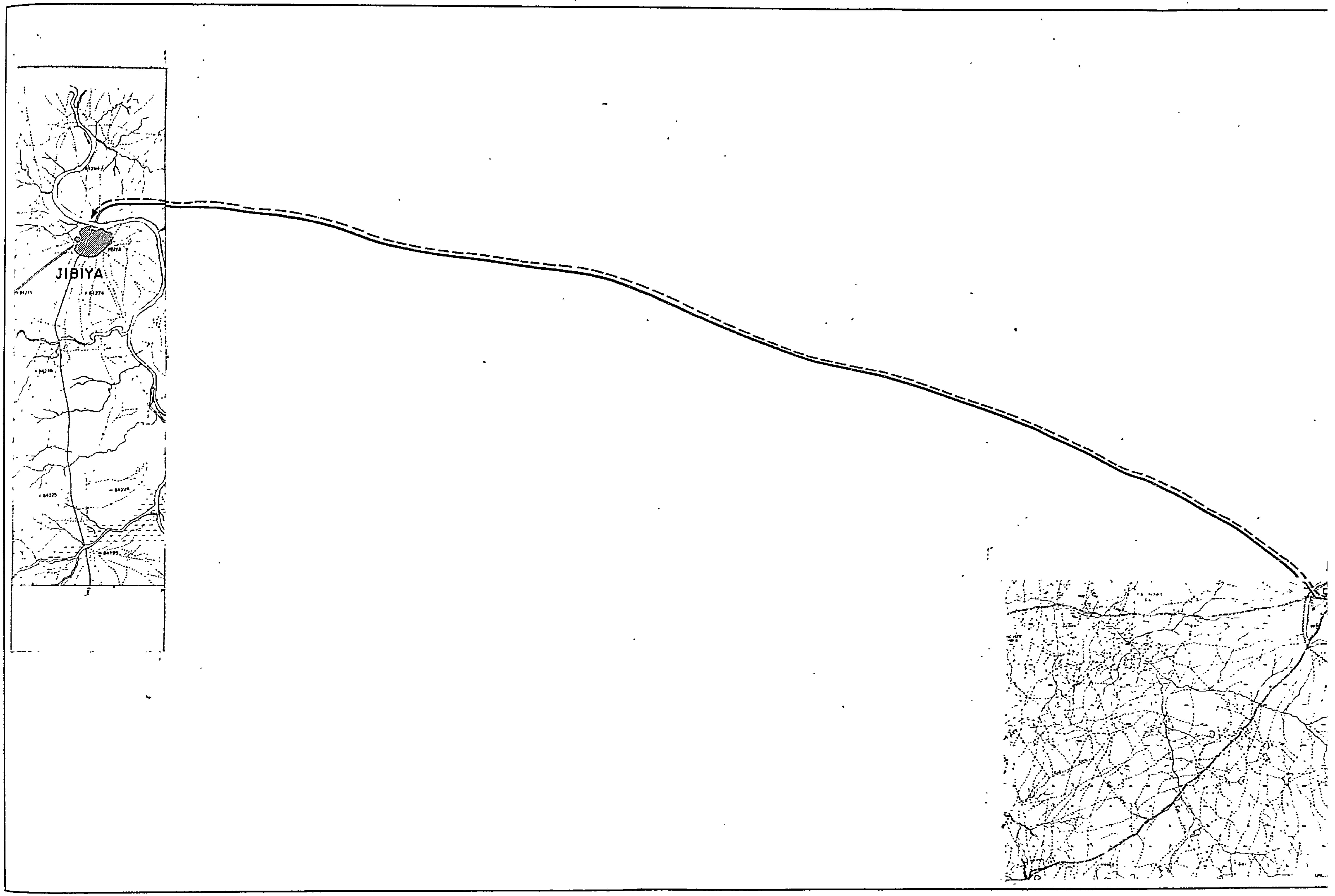
Fig. 11 ACCESSARIES OF POLE

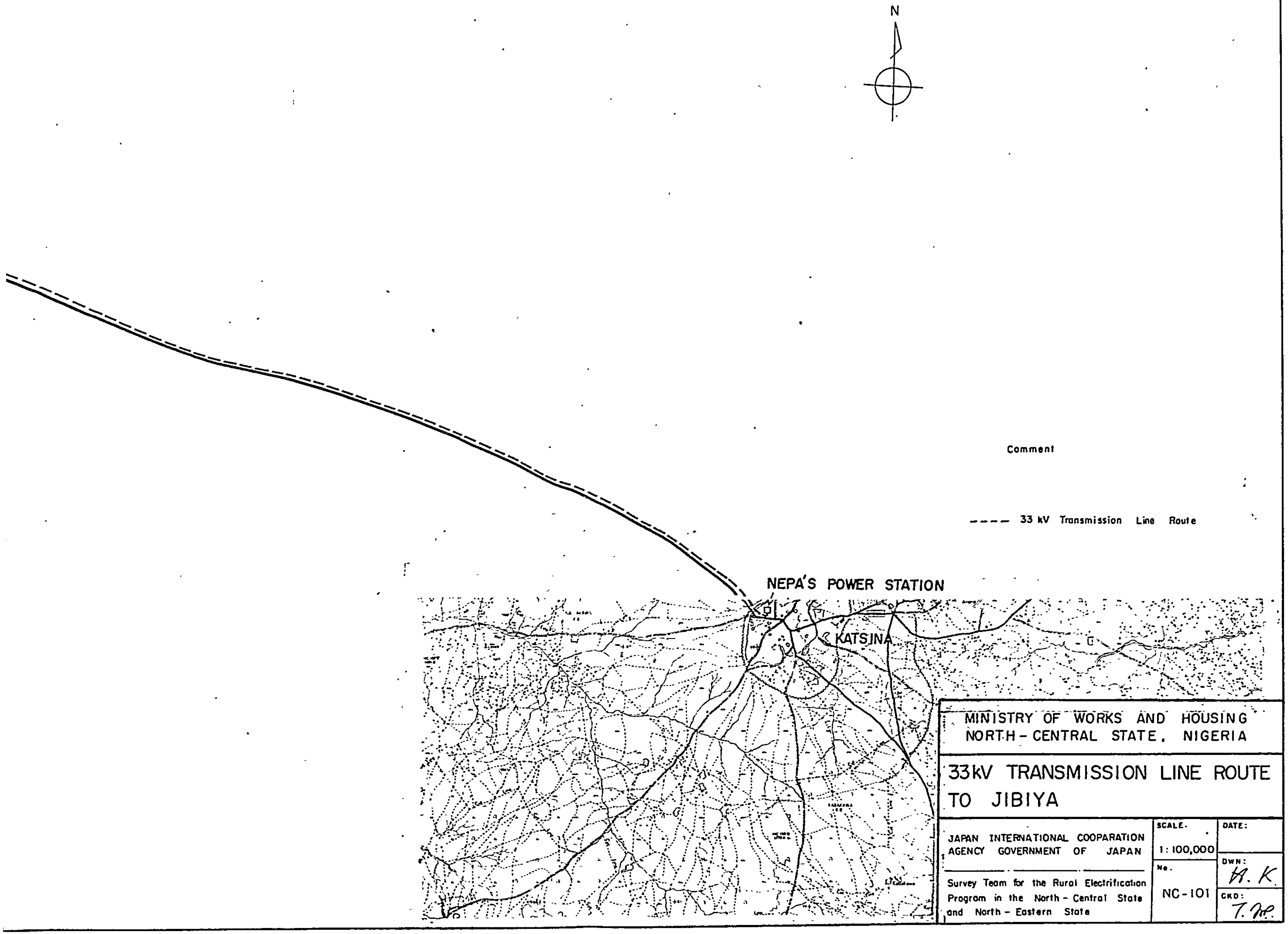


NOTE Anti-climbing device shall be installed at each 11 kV pole.



N
BAURE
Baure
ZANGO
Zango
DAURA
Daura
SANDAMU
DAURA
Maiadua
MAIADUWA
INGAWA
Ingawa
MASHI
DURBI
BINDAWA
Bindawa
KATSINA
KANKIYA
Kankiya
TSAGERO
KAITA
Kaita
Rimi
RIMI
KATSINA
Katsina
Batagarawa
DUTSIN-MA
Musawa
MUSAWA
DUTSIN -MA
Dutsin-Ma
BATA GARAWA
JIBIYA
Jibiya
Batsari
RUMA
Safana
SAFANA
KANKARA
Kankara
BAKORI
Bakori
MALUMFASHI
Malumfashi
Funtua
FUNTUA
Faskari
FASKARI
Kano
Guseu
IKARA
Ikara
Jakalafia
KUBAU
MAKARFI
Makarfi
Kudan
Hunkuyi
Zaria
ZARIA CITY
SOBA
Soba
ZARIA
Shika
Giwa
GIWA
ICABI
KADUNA
Kaduna
Rigachikun
BIRNIN GWARI
BIRNIN GWARI
Sabon Birnin Gwari
Saminaka
LERE
Lere
SAMINAKA
KAURU
Kauru
KAJURU
Kujama
KACHIA
KACHIA
Kachia
KAGARKO
Kagarko
Jos
Zangon Katab
Zonkwa
KAGORO
MOROA
Moroa
Kagoro
Jemaa
JEMA'A
JEMA'A
KWOI
Kwoi
NEPA'S 330kV 132kV Transmission line — (existing) (proposed)
NEPA'S 33kV 11 kV Transmission line — (existing) (proposed)
NEPA'S 330/132 33/11 kV Substation — (existing) (proposed)
Transmissin route to rural-towns which are planned to be eleetvified
Name of town which is planned to be electvified — Kachia
Connection point between NEPA'S trausmission line and transmission route
MINISTRY OF WORKS AND HOUSING
NORTH - CENTRAL STATE, NIGERIA
FUNDAMENTAL TRANSMISSION ROUTE
FOR RURAL ELECTRIFICATION
JAPAN INTERNATIONAL COOPARATION AGENCY GOVERNMENT OF JAPAN
Survey Team for the Rural Electrification Program in the North - Central State and North - Eastern State.
SCALE: 1: 250,000
DATE:
DWN: H.K.
No. NC-100
CKD: T M.

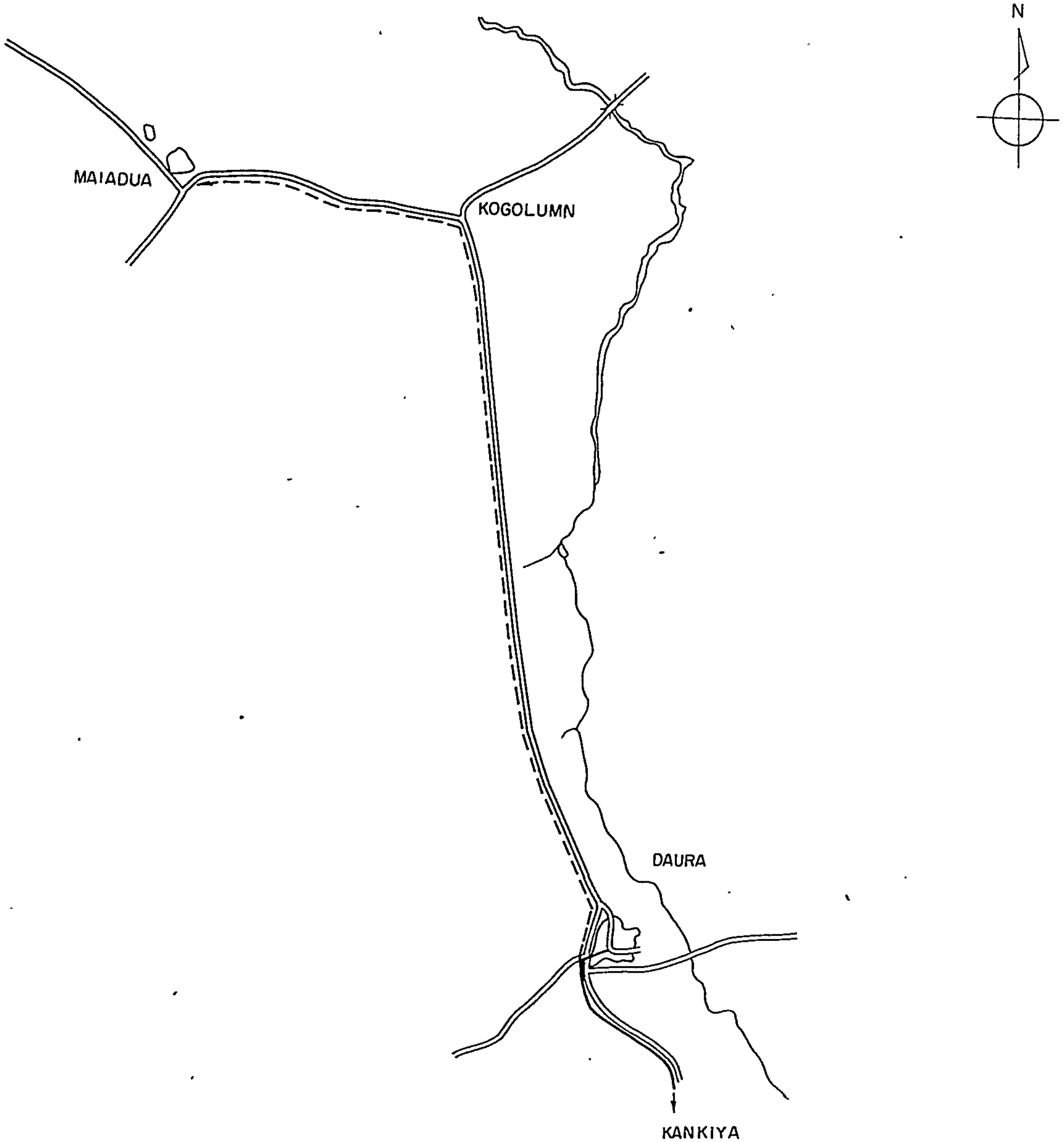

JIBIYA



MINISTRY OF WORKS AND HOUSING
NORTH - CENTRAL STATE, NIGERIA

33kV TRANSMISSION LINE ROUTE TO JIBIYA

JAPAN INTERNATIONAL COOPARATION AGENCY GOVERNMENT OF JAPAN	SCALE. 1 : 100,000	DATE:
Survey Team for the Rural Electrification Program in the North - Central State and North - Eastern State	No. NC-101	DWN: H. K CKD: T. M.



Comment

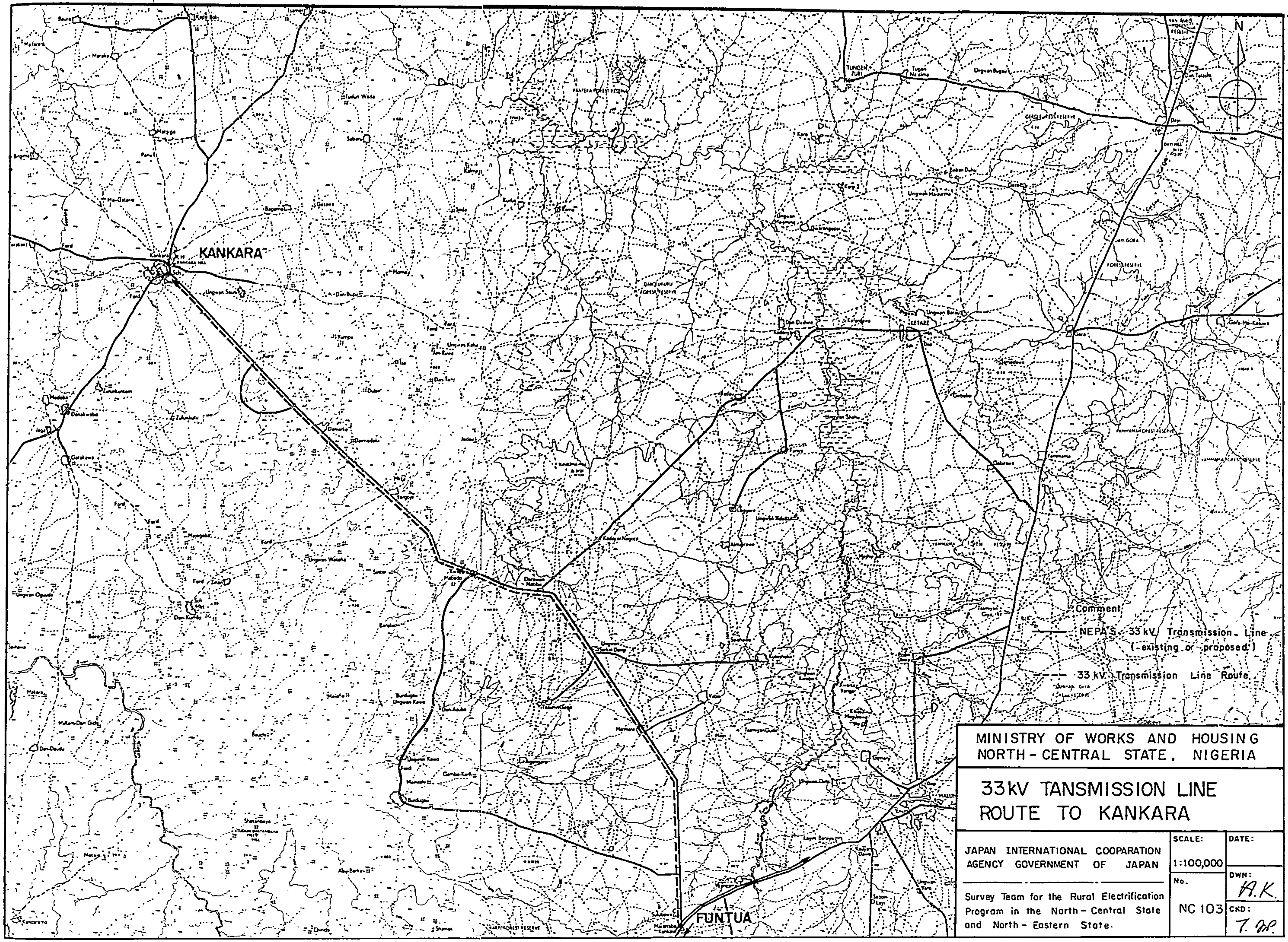
NEPA'S 33 kV Transmission Line
(existing or proposed)

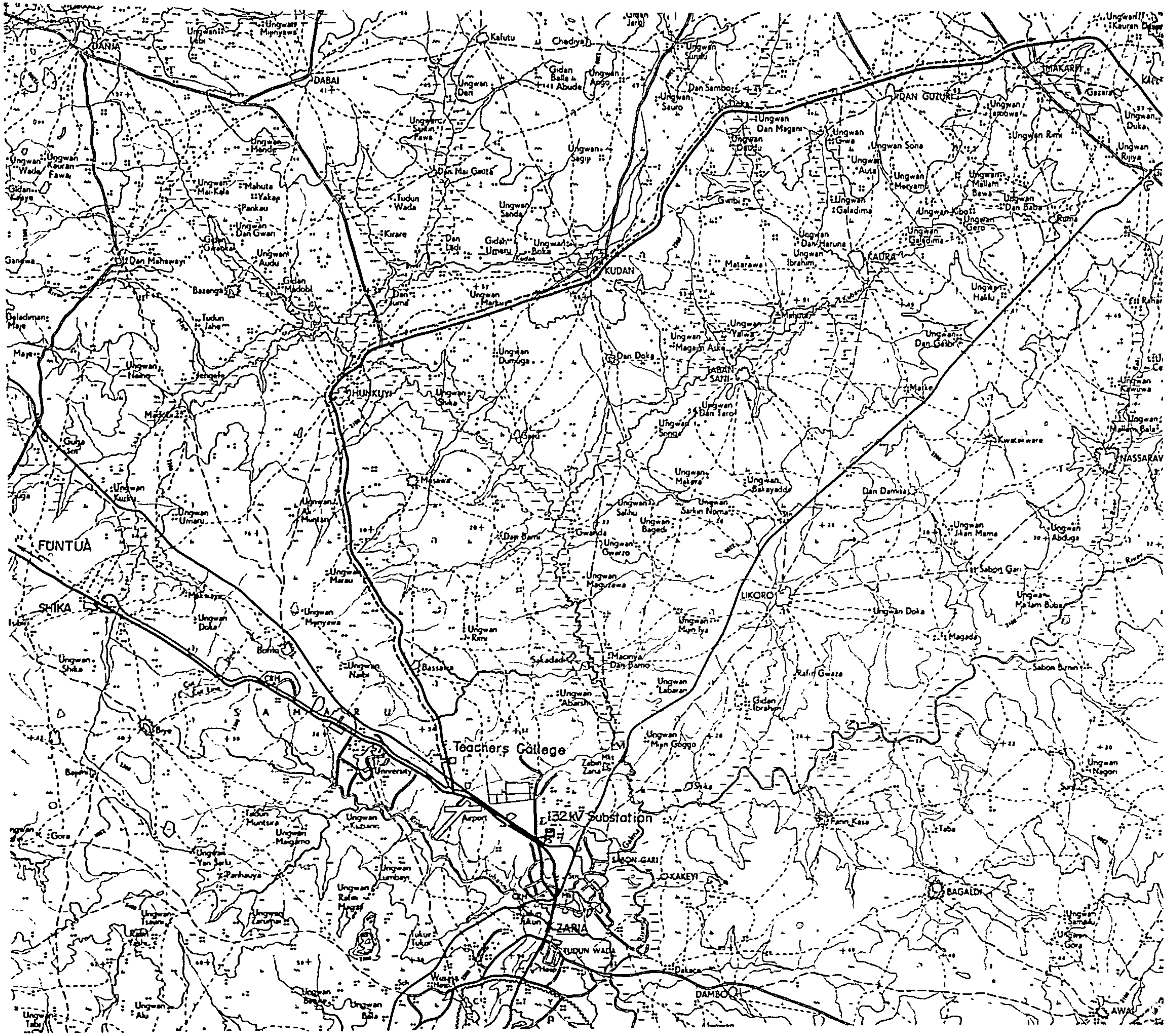
33 kV Transmission Line Route

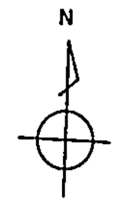
MINISTRY OF WORKS AND HOUSING
NORTH - CENTRAL STATE, NIGERIA

33kV TRANSMISSION LINE ROUTE TO MAIADUA

JAPAN INTERNATIONAL COOPARATION AGENCY GOVERNMENT OF JAPAN	SCALE: 1 : 100,000	DATE:
Survey Team for the Rural Electrification Program in the North - Central State and North - Eastern State.	No. NC 102	DWN: H.K. CKD: T.M.


N
KANKARA
FUNTUA
Comment
NEPA'S 33kV Transmission Line
(existing or proposed)
33 kV Transmission Line Route
MINISTRY OF WORKS AND HOUSING
NORTH-CENTRAL STATE, NIGERIA
33kV TANSMISSION LINE
ROUTE TO KANKARA
JAPAN INTERNATIONAL COOPARATION
AGENCY GOVERNMENT OF JAPAN
Survey Team for the Rural Electrification
Program in the North-Central State
and North-Eastern State.
SCALE:
1:100,000
DATE:
No.
NC 103
DWN:
H.K.
CKD:
T. M.





Comment

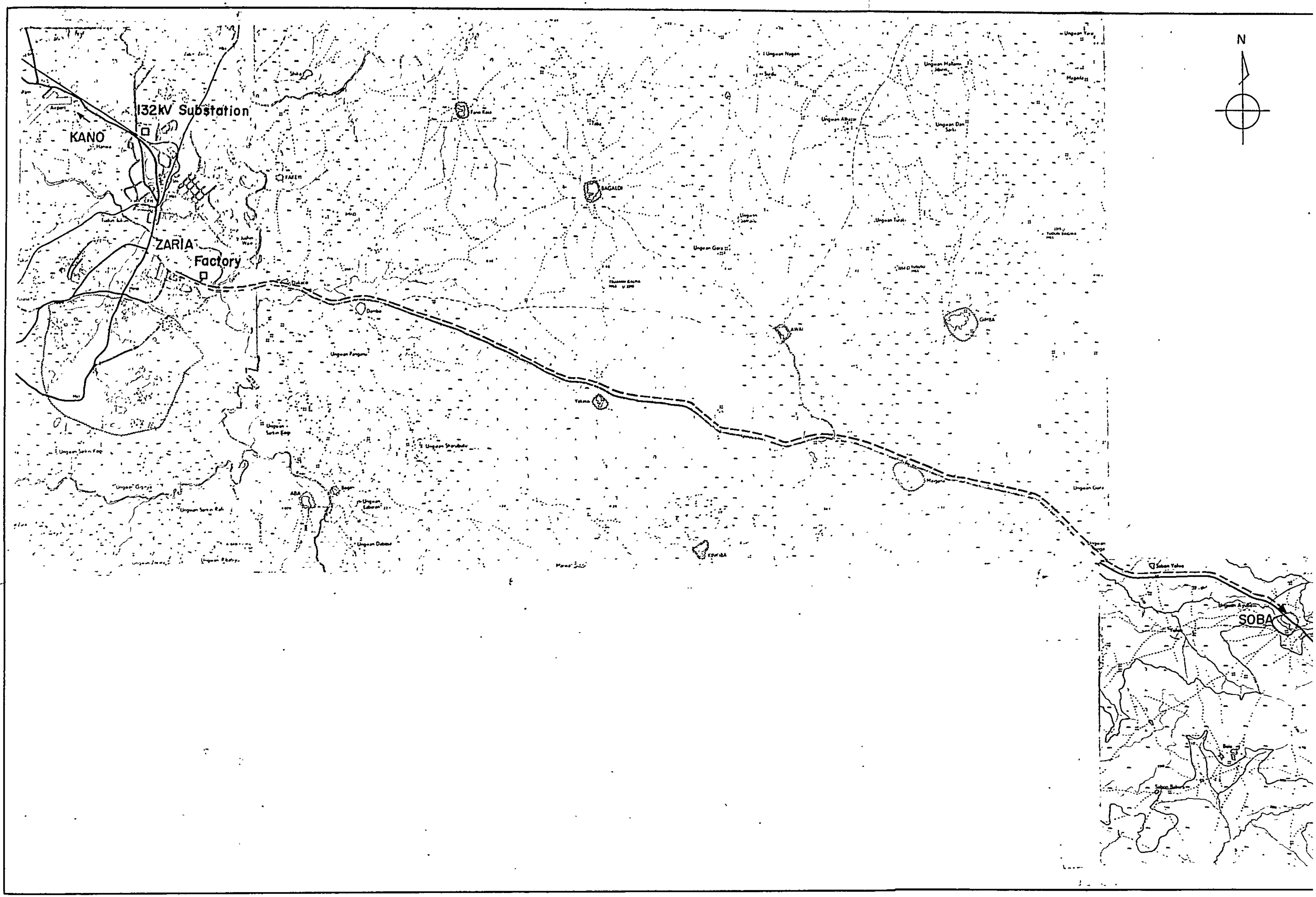
——— NEPA'S 11 kV Transmission Line (existing or proposed)

– – – 11 kV Transmission Line Route

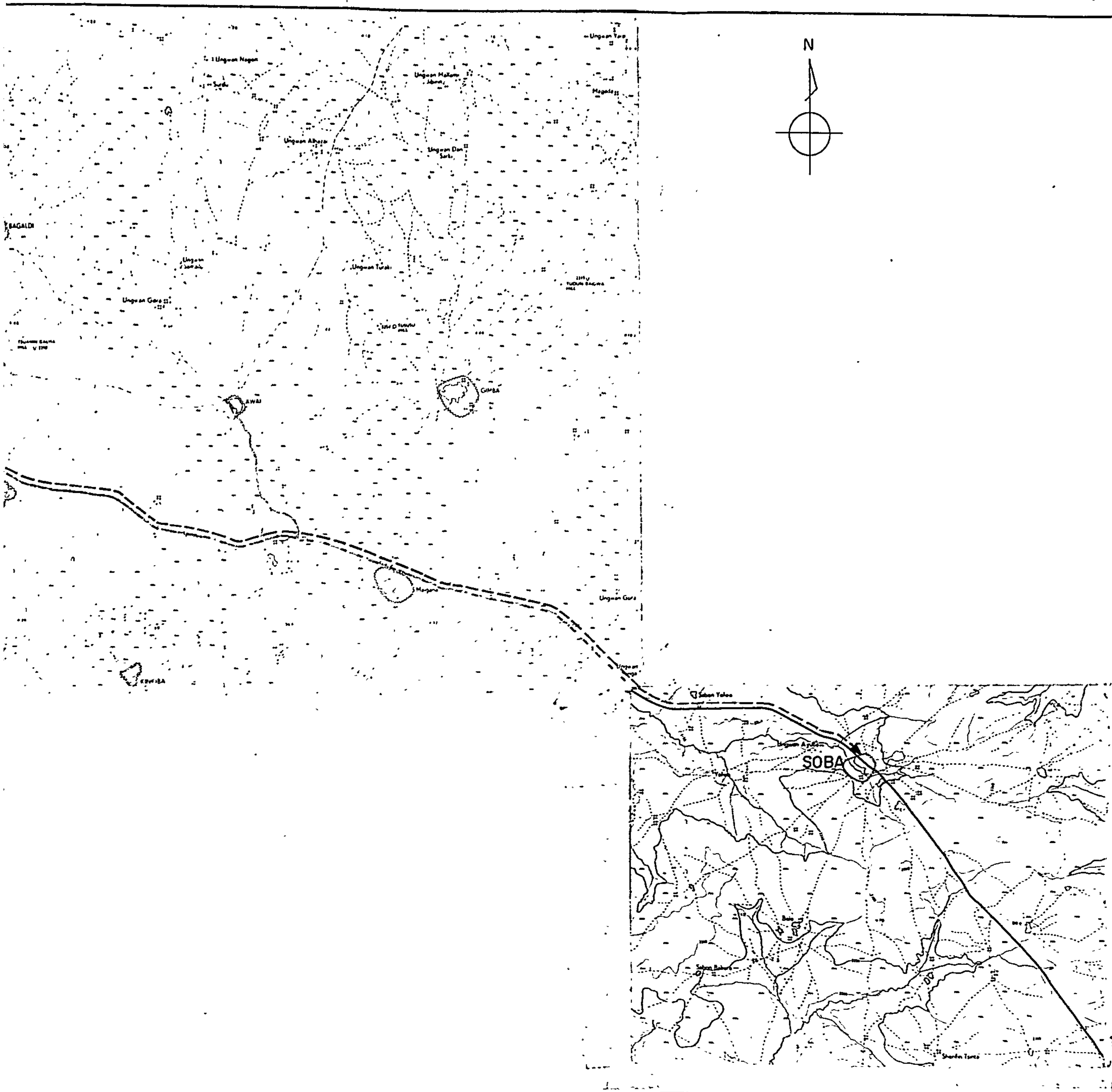
MINISTRY OF WORKS AND HOUSING
NORTH-CENTRAL STATE, NIGERIA

11 kV TRANSMISSION LINE ROUTE TO HUNKUYI KUDAN MAKARFI AND TO SHIKA

JAPAN INTERNATIONAL COOPARATION AGENCY GOVERNMENT OF JAPAN	SCALE 1:100,000	DATE
Survey Team for the Rural Electrification Program in the North-Central State and North-Eastern State	No NC 104	DWN H.K. CKD T.Th.



N
132kV Substation
KANO
ZARIA
Factory
SOBA



Comment.

---- 11 kV Transmission Line Route

MINISTRY OF WORKS AND HOUSING NORTH – CENTRAL STATE, NIGERIA		
11kV TRANSMISSION LINE ROUTE TO SOBA		
JAPAN INTERNATIONAL COOPARATION AGENCY GOVERNMENT OF JAPAN	SCALE: 1:100,000	DATE:
Survey Team for the Rural Electrification Program in the North – Central State and North – Eastern State.	No. NC 105	DWN: H.K.
		CKD: T.H.

Fig. N.C.106 INTERMEDIATE POLE (33kV LINE)

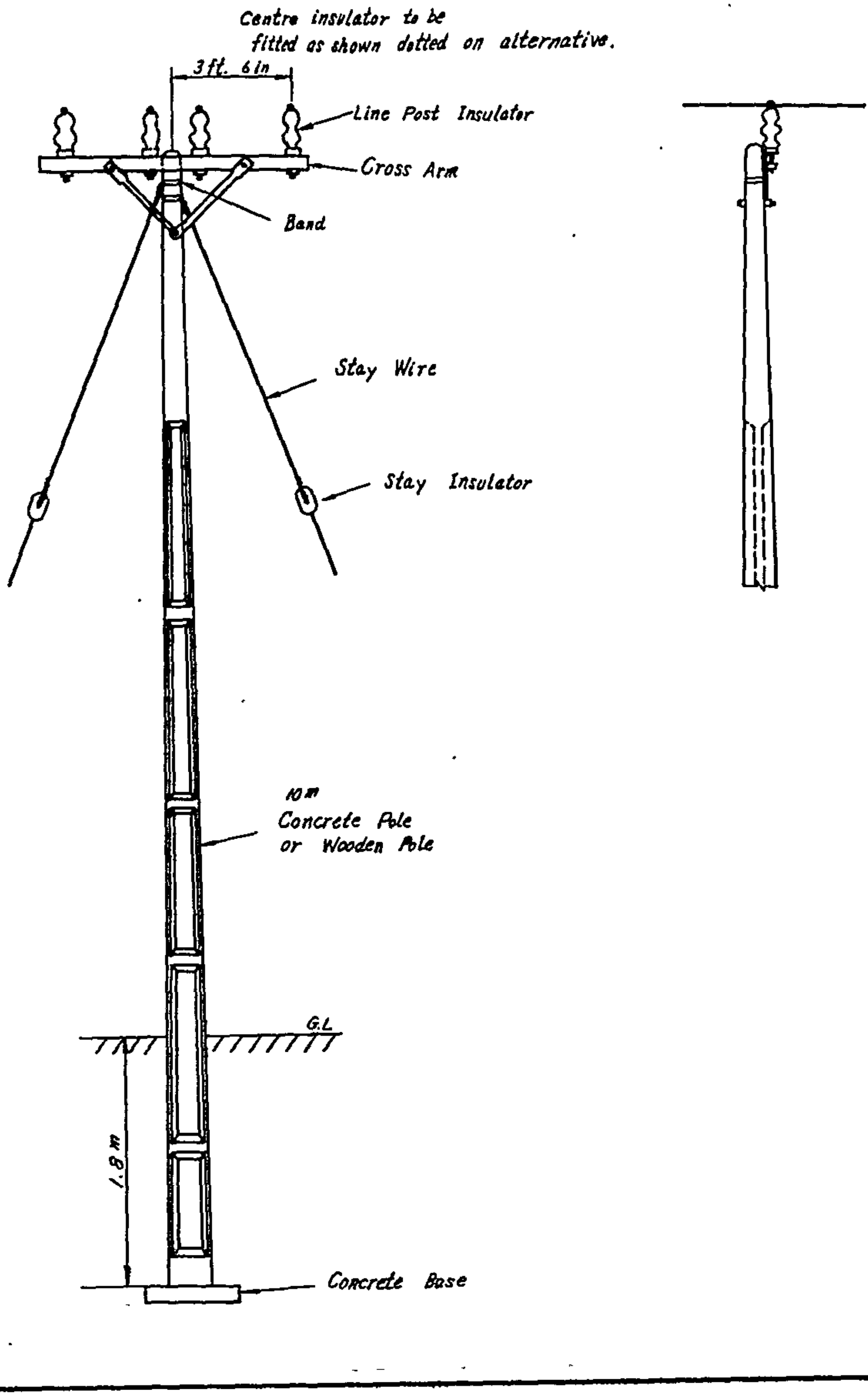


Fig. N.C. 107 SECTION POLE (33kV LINE)

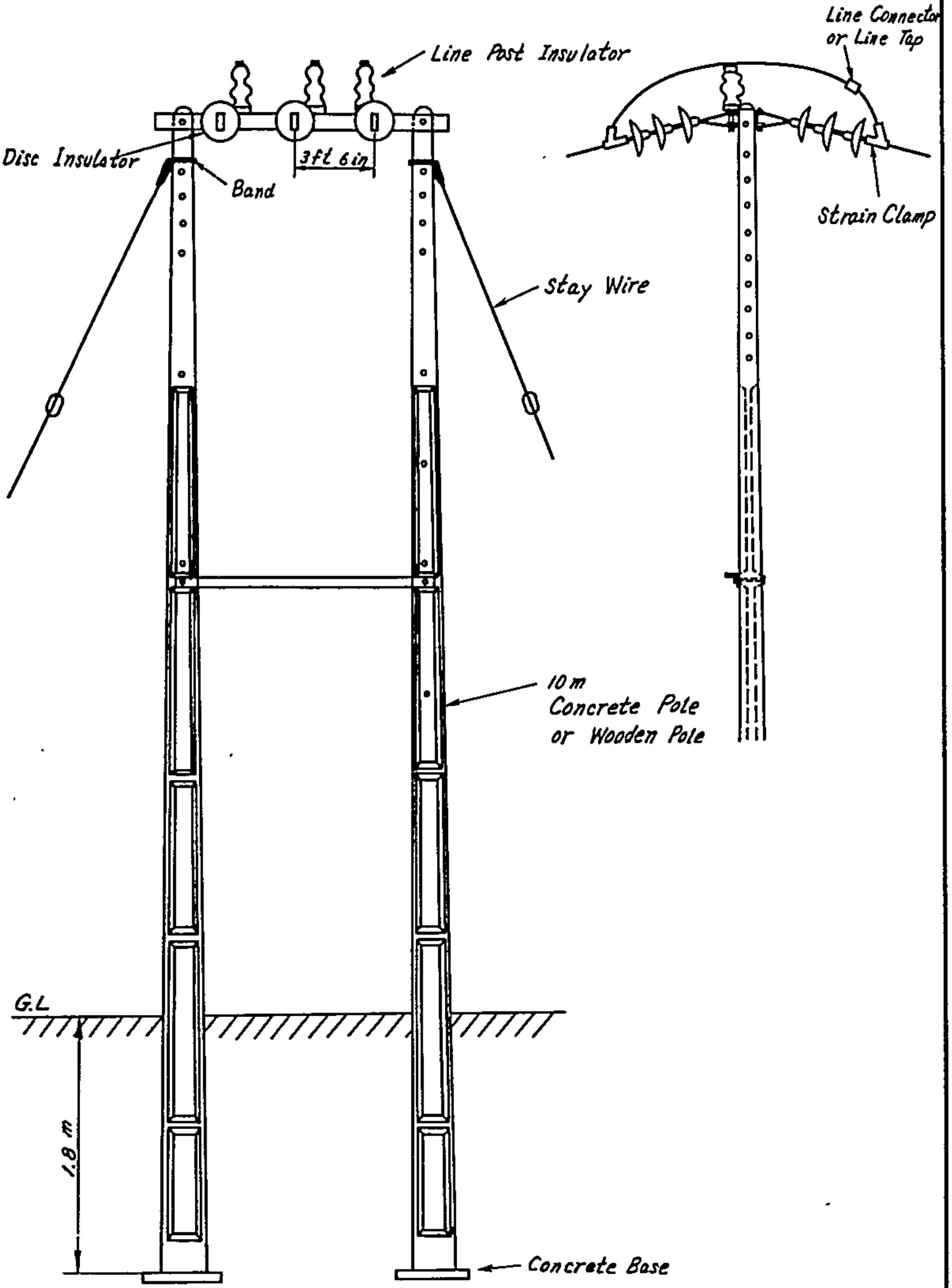
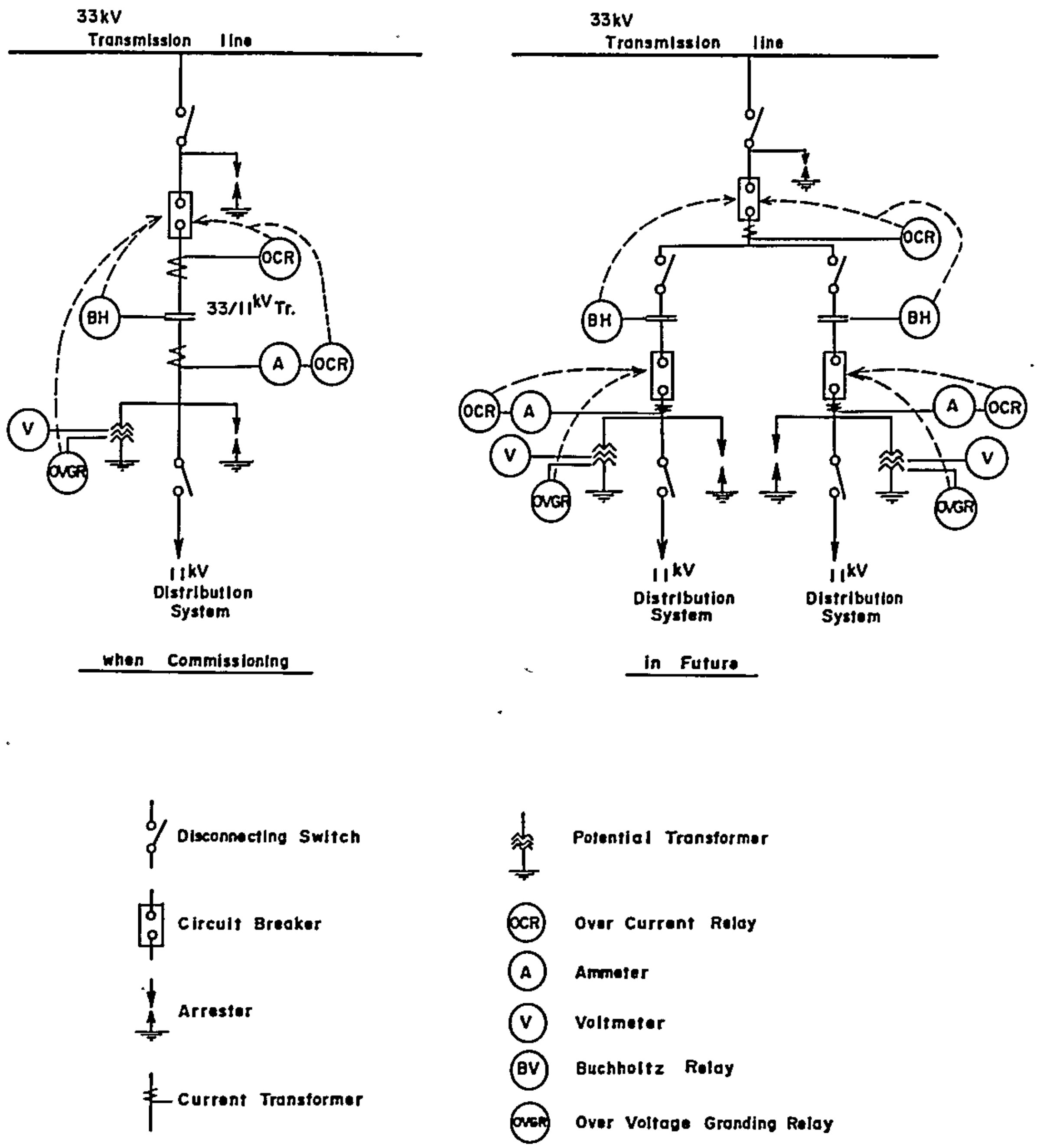
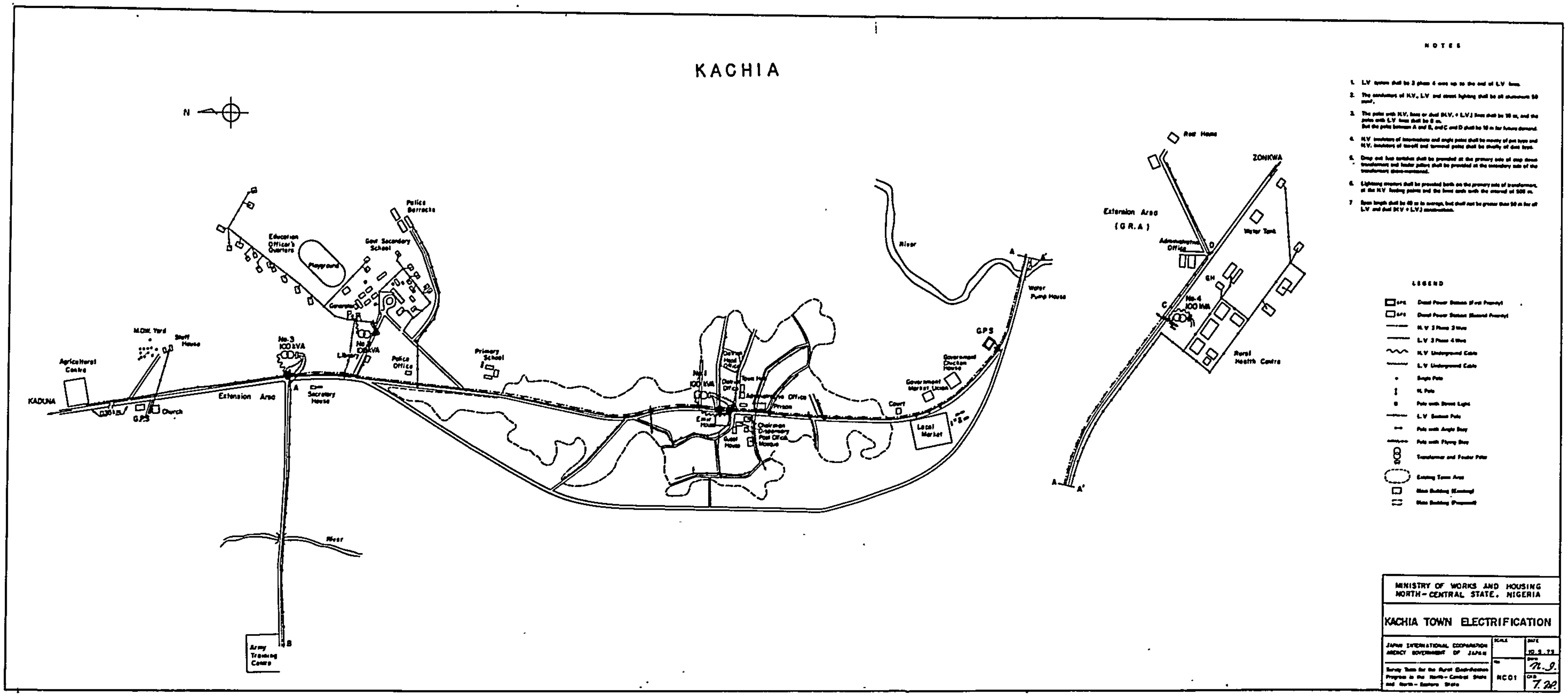
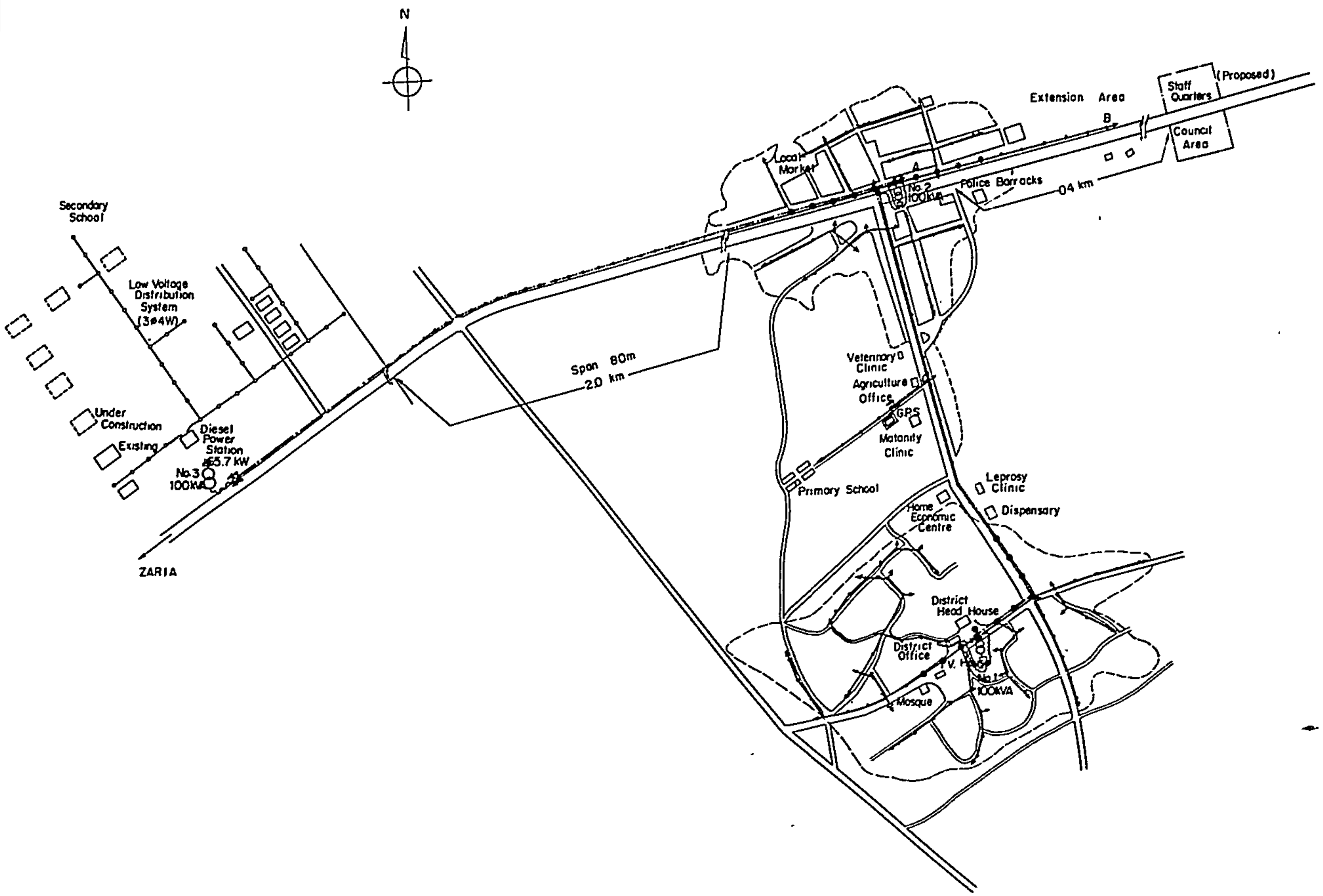


Fig. NC-200, One Line Diagram of 33/11kV Substation




KACHIA
N
NOTES
LEGEND
Police Barracks
Education Officer's Quarters
Playground
Govt Secondary School
Generator
Library
Police Office
Primary School
M.O.W. Yard
Staff House
Agricultural Centre
KADUNA
G.P.S
Church
Extension Area
No.3 100kVA
Secretary House
River
Army Training Centre
Emir House
Guest House
Chairman Dispensary Post Office Mosque
Administrative Office
Prison
Court
Government Market Union
Government Chairman House
Local Market
G.P.S
Water Pump House
Rest House
ZONKWA
Extension Area (G.R.A)
Administrative Office
Water Tank
No.4 100kVA
Rural Health Centre
MINISTRY OF WORKS AND HOUSING
NORTH-CENTRAL STATE, NIGERIA
KACHIA TOWN ELECTRIFICATION
RC01

MAKARFI



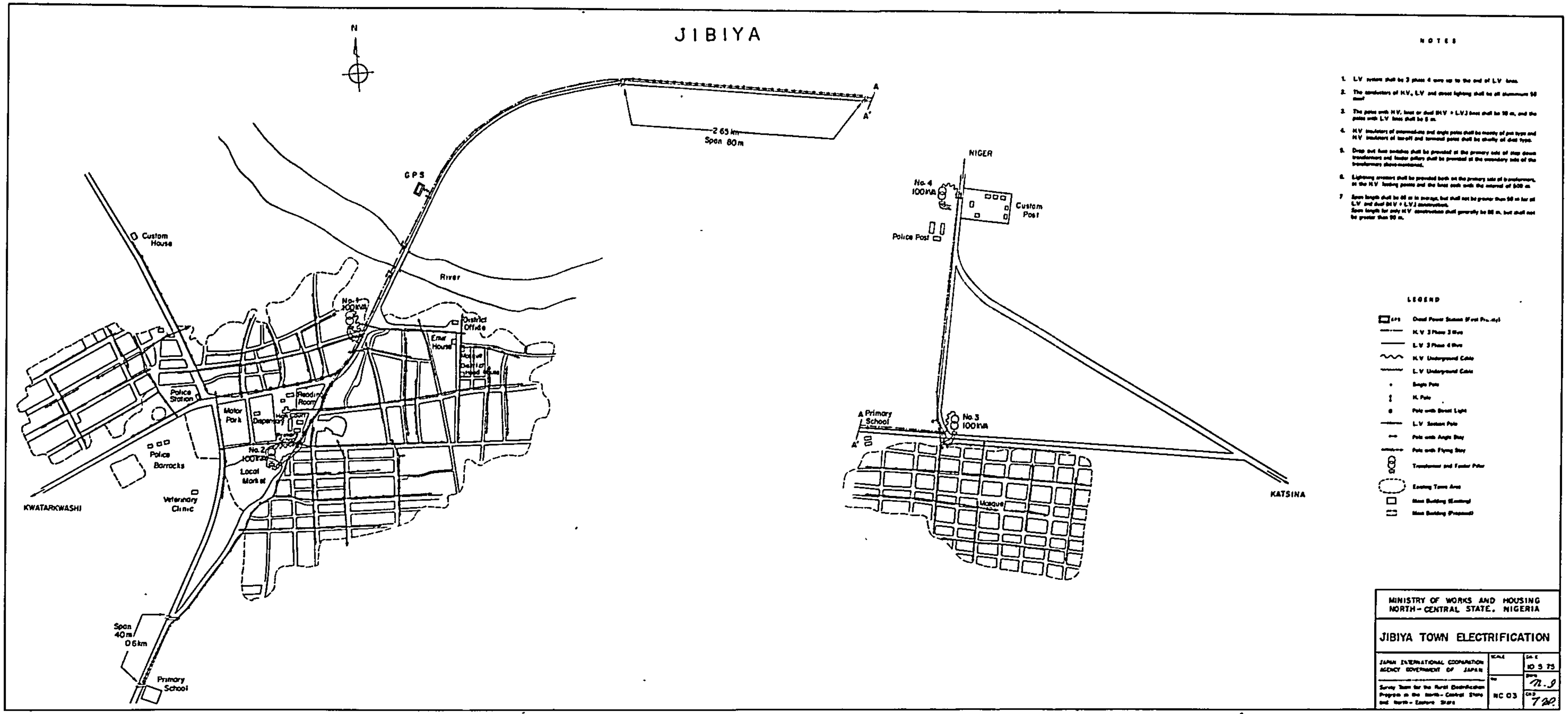
NOTES

1. L.V. system shall be 3 phase 4 wire up to the end of L.V. lines.
2. The conductors of H.V., L.V. and street lighting shall be all aluminium 50 mm².
3. The poles with H.V. lines or dual (H.V. + L.V.) lines shall be 10 m, and the poles with L.V. lines shall be 8 m.
   But the poles between A and B shall be 10 m for future demand.
4. H.V. insulators of intermediate and angle poles shall be mainly of pin type and H.V. insulators of tee-off and terminal poles shall be chiefly of disc type.
5. Drop out fuse switches shall be provided at the primary side of step down transformers and feeder pillars shall be provided at the secondary side of the transformers above-mentioned.
6. Lightning arresters shall be provided both on the primary side of transformers, at the H.V. feeding points and the lines each with the interval of 500 m.
7. Span length shall be 40 m in average, but shall not be greater than 50 m for all L.V. and dual (H.V. + L.V.) construction.
   Span length for only H.V. construction shall generally be 80 m, but shall not be greater than 90 m.

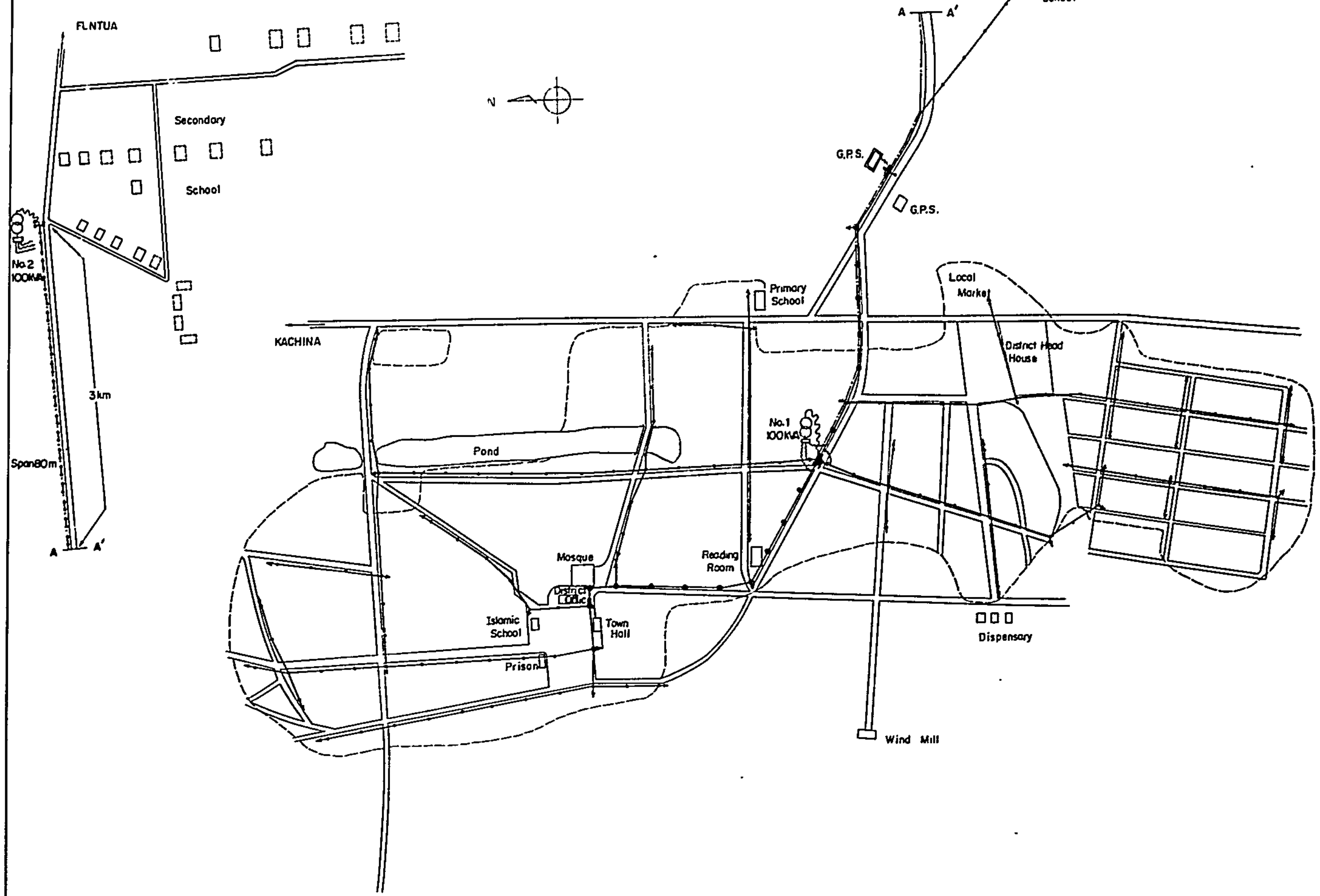
LEGEND

- GPS — Diesel Power Station (First Priority)
- GPS — Diesel Power Station (Second Priority)
- H. V. 3 Phase 3 Wire
- L. V. 3 Phase 4 Wire
- H. V. Underground Cable
- L. V. Underground Cable
- Single Pole
- H. Pole
- Pole with Street Light
- L. V. Section Pole
- Pole with Angle Stay
- Pole with Flying Stay
- Transformer and Feeder Pillar
- Existing Town Area
- Main Building (Existing)
- Main Building (Proposed)

MINISTRY OF WORKS AND HOUSING NORTH-CENTRAL STATE. NIGERIA		
MAKARFI TOWN ELECTRIFICATION		
JAPAN INTERNATIONAL COOPARATION AGENCY GOVERNMENT OF JAPAN	SCALE:	DATE 10 5. 75
Survey Team for the Rural Electrification Program in the North-Central State and North-Eastern State	No NC 02	DWN N. I. / CKD T. W.


JIBIYA
N
GPS
2.65 km
Span 80 m
A
A'
River
Custom House
Police Station
Motor Park
Dispensary
Reading Room
No.1 100kVA
District Office
Emir House
No.2 100kVA
Local Market
Police Barracks
Veterinary Clinic
KWATARKWASHI
Span 40m/ 0.6km
Primary School
NIGER
No.4 100kVA
Custom Post
Police Post
Primary School
No.3 100kVA
Mosque
KATSINA
NOTES
LEGEND
MINISTRY OF WORKS AND HOUSING
NORTH-CENTRAL STATE, NIGERIA
JIBIYA TOWN ELECTRIFICATION
10 5 75
NC 03

MUSAWA



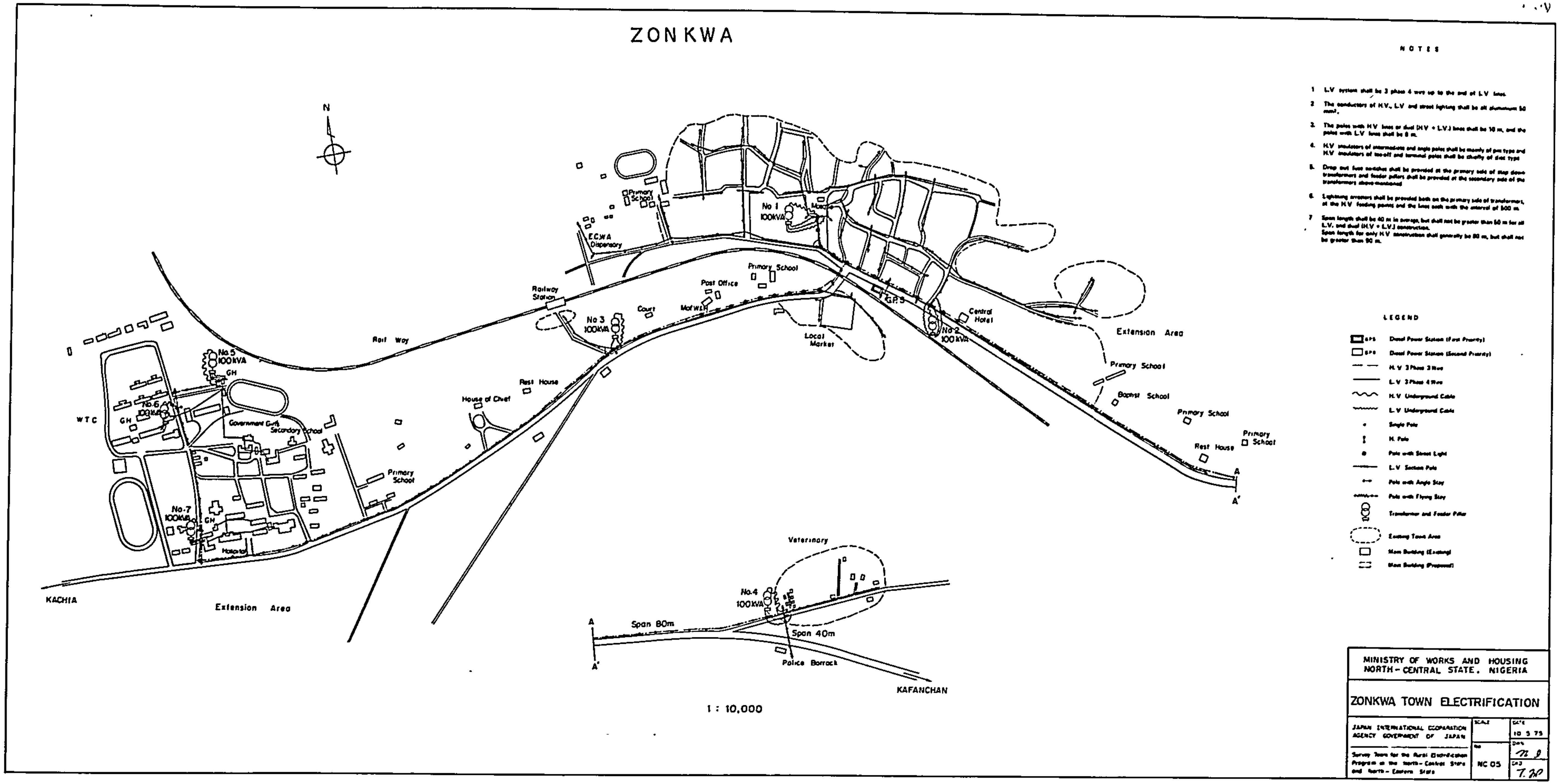
NOTES

1. L.V. system shall be 3 phase 4 wire up to the end of L.V. lines.
2. The conductors of H.V., L.V. and street lighting shall be all aluminum 50 mm².
3. The poles with H.V. lines or dual (H.V. + L.V.) lines shall be 10 m, and the poles with L.V. lines shall be 8 m.
4. H.V. insulators of intermediate and angle poles shall be mainly of pin type and H.V. insulators of tee-off and terminal poles shall be chiefly of disc type.
5. Drop out fuse switches shall be provided at the primary side of step down transformers and feeder pillars shall be provided at the secondary side of the transformers above-mentioned.
6. Lightning arresters shall be provided both on the primary side of transformers, at the H.V. feeding points and the lines each with the interval of 500 m.
7. Span length shall be 40 m in average, but shall not be greater than 50 m for all L.V. and dual (H.V. + L.V.) construction.
Span length for only H.V. construction shall generally be 80 m, but shall not be greater than 90 m.

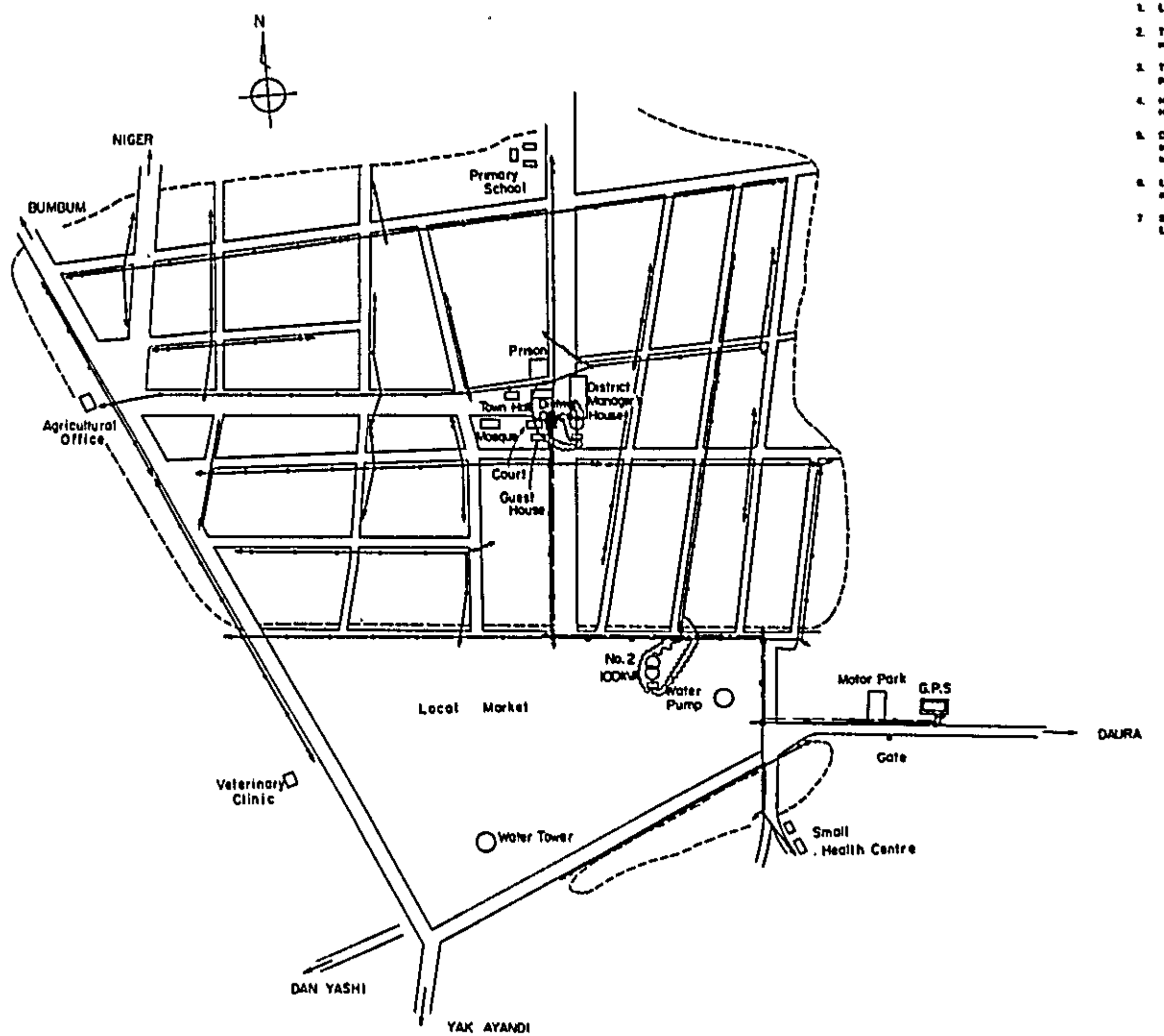
LEGEND

- G.P.S. Diesel Power Station (First Priority)
- G.P.S. Diesel Power Station (Second Priority)
- H. V. 3 Phase 3 Wire
- L. V. 3 Phase 4 Wire
- H. V. Underground Cable
- L. V. Underground Cable
- Single Pole
- H. Pole
- Pole with Street Light
- L. V. Section Pole
- Pole with Angle Stay
- Pole with Flying Stay
- Transformer and Feeder Pillar
- Existing Town Area
- Main Building (Existing)
- Main Building (Proposed)

MINISTRY OF WORKS AND HOUSING NORTH-CENTRAL STATE. NIGERIA		
MUSAWA TOWN ELECTRIFICATION		
JAPAN INTERNATIONAL COOPARATION AGENCY GOVERNMENT OF JAPAN	SCALE.	DATE 10.5.75
Survey Team for the Rural Electrification Program in the North-Central State and North-Eastern State	No NC 04	DWN N.J. / CKD T.H.


ZONKWA
N
NOTES
1 L.V system shall be 3 phase 4 wire up to the end of L.V lines.
2 The conductors of H.V., L.V and street lighting shall be all aluminium 50 mm².
3 The poles with H.V lines or dual (H.V + L.V.) lines shall be 10 m, and the poles with L.V lines shall be 8 m.
4 H.V insulators of intermediate and angle poles shall be mainly of pin type and H.V insulators of tee-off and terminal poles shall be chiefly of disc type
5 Drop out fuse switches shall be provided at the primary side of step down transformers and feeder pillars shall be provided at the secondary side of the transformers above-mentioned
6 Lightning arresters shall be provided both on the primary side of transformers, at the H.V feeding points and the lines each with the interval of 500 m.
7 Span length shall be 40 m in average, but shall not be greater than 50 m for all L.V. and dual (H.V + L.V.) construction.
Span length for only H.V construction shall generally be 80 m, but shall not be greater than 90 m.
LEGEND
DPS Diesel Power Station (First Priority)
DPS Diesel Power Station (Second Priority)
H.V 3 Phase 3 Wire
L.V 3 Phase 4 Wire
H.V Underground Cable
L.V Underground Cable
Single Pole
H. Pole
Pole with Street Light
L.V Section Pole
Pole with Angle Stay
Pole with Flying Stay
Transformer and Feeder Pillar
Existing Town Area
Main Building (Existing)
Main Building (Proposed)
Primary School
E.C.W.A Dispensary
No 1 100KVA
Mosque
Railway Station
Primary School
Post Office
No 3 100KVA
Court
Mof W&H
GPS
Local Market
Central Hotel
No 2 100KVA
Extension Area
Primary School
Baptist School
Primary School
Primary School
Rest House
A
A'
Rail Way
No 5 100kVA
GH
WTC
GH
No 6 100kVA
Government Girls Secondary School
Rest House
House of Chief
Primary School
No 7 100kVA
GH
Hospital
KACHIA
Extension Area
Veterinary
No 4 100KVA
A
Span 80m
Span 40m
A'
Police Barrack
KAFANCHAN
1 : 10,000
MINISTRY OF WORKS AND HOUSING
NORTH-CENTRAL STATE, NIGERIA
ZONKWA TOWN ELECTRIFICATION
JAPAN INTERNATIONAL COOPERATION AGENCY GOVERNMENT OF JAPAN
Survey Team for the Rural Electrification Program in the North-Central State and North-Eastern State
SCALE
DATE 10 3 75
NC 05

MAIADUA



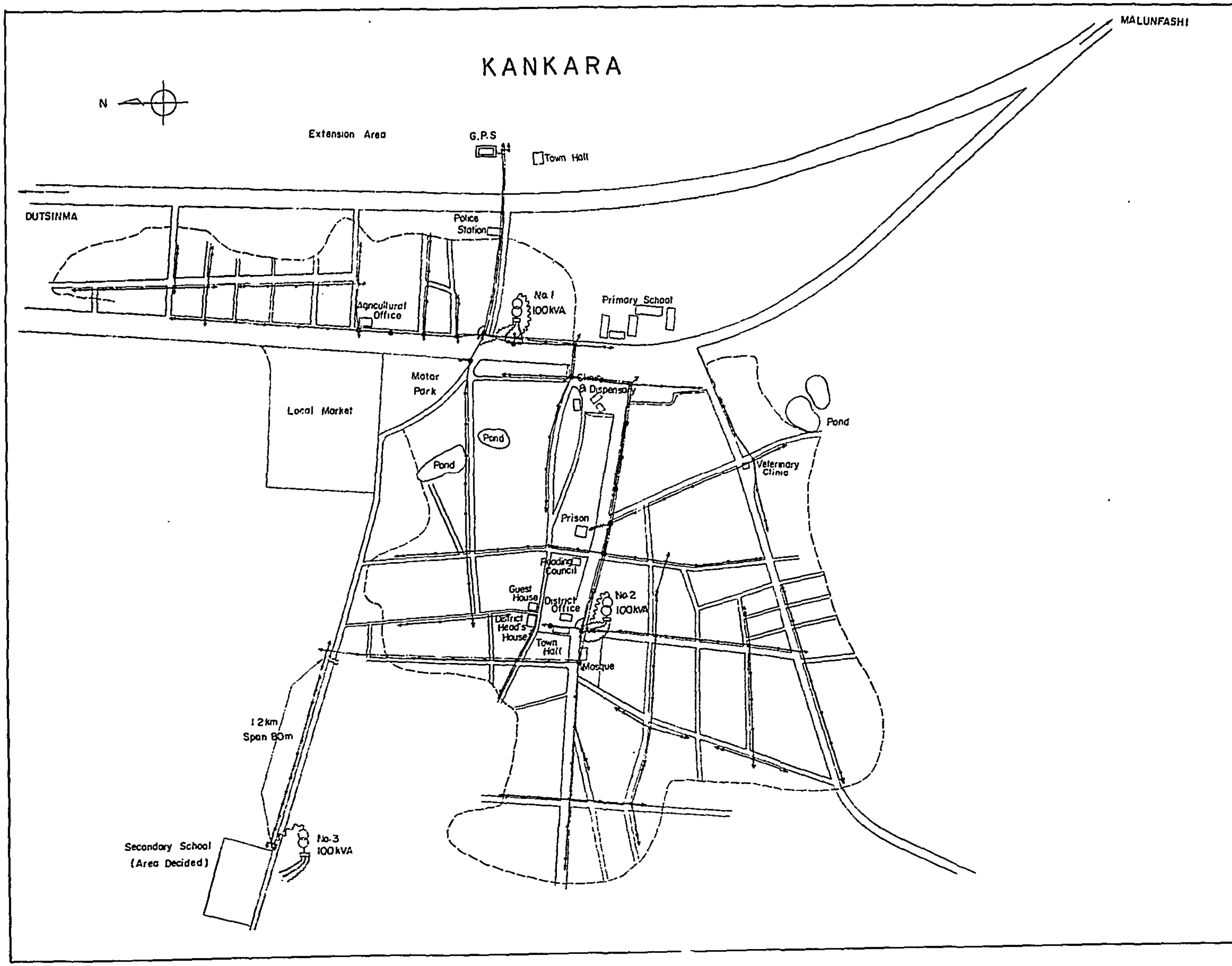
NOTES

1. LV system shall be 3 phase 4 wire up to the end of LV lines.
2. The conductors of HV, LV and street lighting shall be all aluminium 50 mm²
3. The poles with HV lines or dual (HV + LV) lines shall be 10 m, and the poles with LV lines shall be 8 m.
4. HV insulators of intermediate and angle poles shall be mainly of pin type and HV insulators of tee-off and terminal poles shall be chiefly of disc type.
5. Drop out fuse switches shall be provided at the primary side of step down transformers and feeder pillars shall be provided at the secondary side of the transformers above-mentioned.
6. Lightning arresters shall be provided both on the primary side of transformers, at the HV feeding points and the lines each with the interval of 500 m.
7. Span length shall be 40 m in average, but shall not be greater than 50 m for all LV and dual (HV + LV) construction.

LEGEND

- G.P.S — Diesel Power Station (First Priority)
- H.V 3 Phase 3 Wire
- L.V 3 Phase 4 Wire
- H.V Underground Cable
- L.V Underground Cable
- Single Pole
- H. Pole
- Pole with Street Light
- L.V Section Pole
- Pole with Angle Stay
- Pole with Flying Stay
- Transformer and Feeder Pillar
- Existing Town Area
- Main Building (Existing)
- Main Building (Proposed)

MINISTRY OF WORKS AND HOUSING NORTH-CENTRAL STATE, NIGERIA		
MAIADUA TOWN ELECTRIFICATION		
JAPAN INTERNATIONAL COOPERATION AGENCY GOVERNMENT OF JAPAN	SCALE	DATE 10.5.75
Survey Team for the Rural Electrification Program in the North-Central State and North-Eastern State	No. NC06	DRN N. I. / CHD T. W.



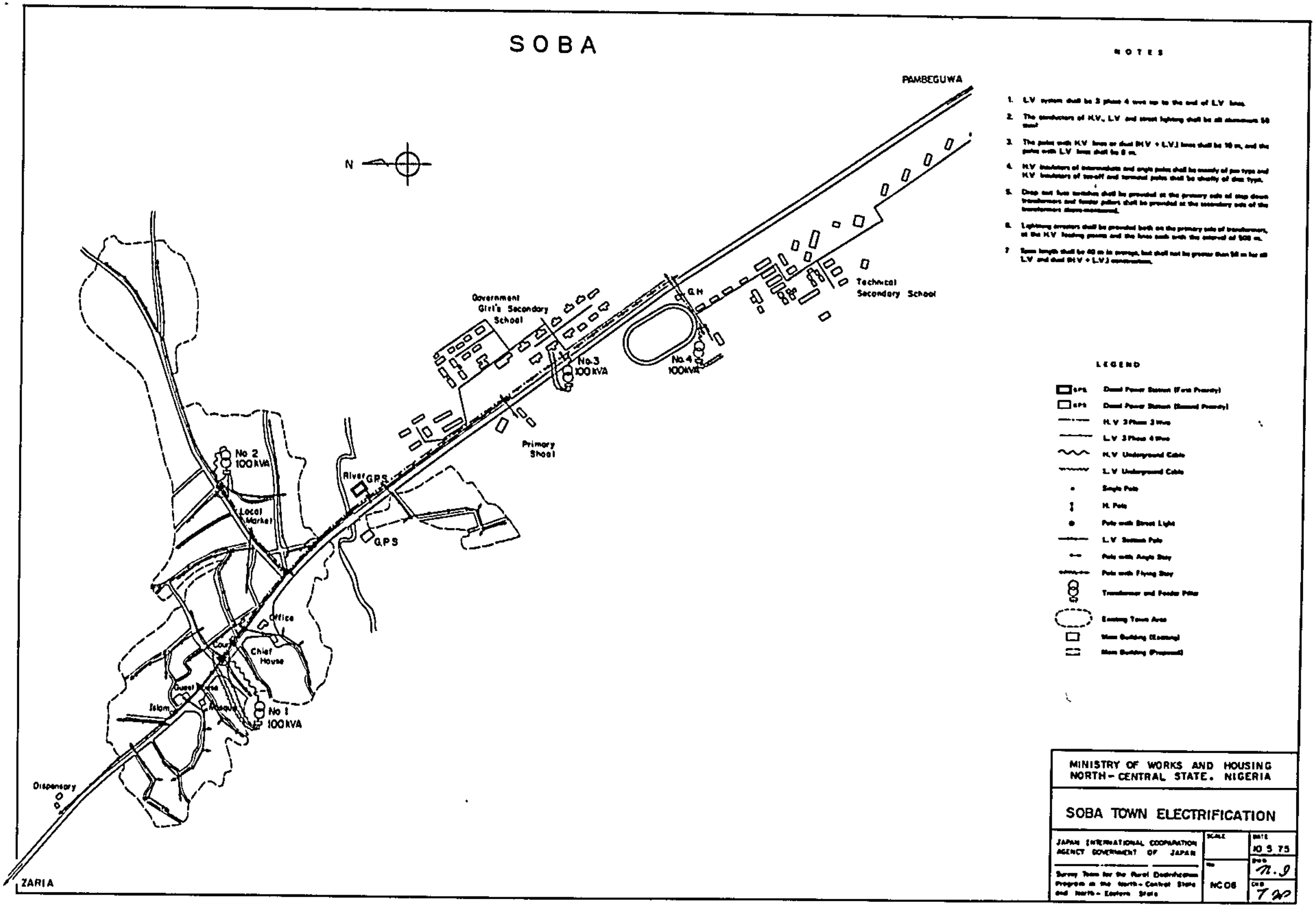
NOTES

1. L.V. system shall be 3 phase 4 wire up to the end of L.V lines.
2. The conductors of H.V., L.V. and street lighting shall be all aluminium 50 mm².
3. The poles with H.V. lines or dual (H.V. + L.V.) lines shall be 10 m, and the poles with L.V. lines shall be 8 m.
4. H.V. insulators of intermediate and angle poles shall be mainly of pin type and H.V. insulators of tee-off and terminal poles shall be chiefly of disc type.
5. Drop out fuse switches shall be provided at the primary side of step down transformers and feeder pillars shall be provided at the secondary side of the transformers above-mentioned
6. Lightning arresters shall be provided both on the primary side of transformers, at the H.V. feeding points and the lines each with the interval of 500 m.
7. Span length shall be 40 m in average, but shall not be greater than 50 m for all L.V. and dual (H V. + L.V.) construction.
Span length for only H.V. construction shall generally be 80 m, but shall not be greater than 90 m.

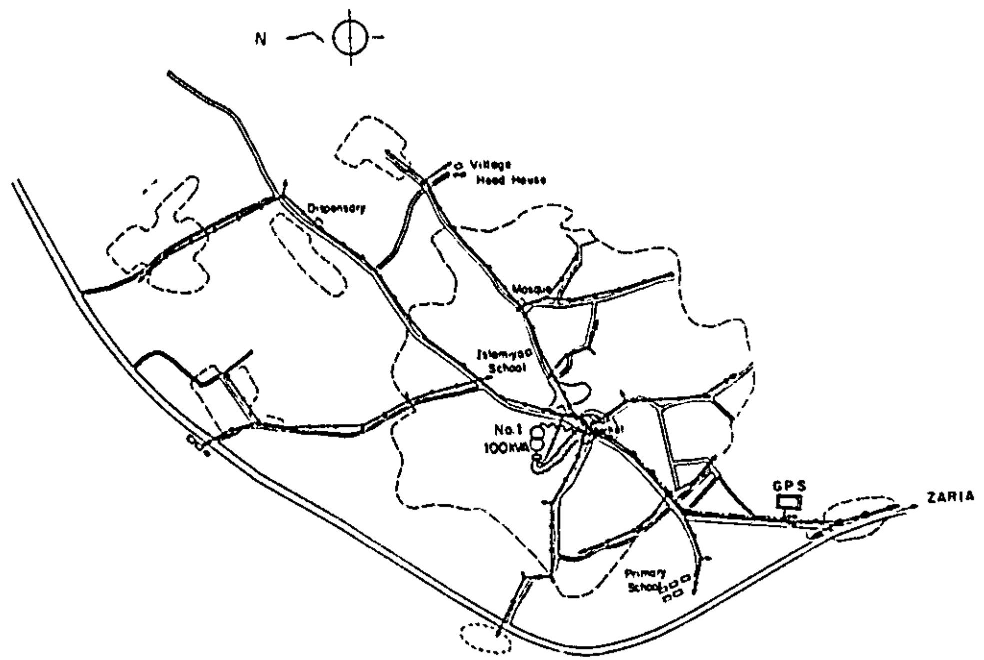
LEGEND

- GPS — Diesel Power Station (First Priority)
- H.V. 3 Phase 3 Wire
- L.V. 3 Phase 4 Wire
- H.V. Underground Cable
- L.V. Underground Cable
- Single Pole
- H. Pole
- Pole with Street Light
- L.V. Section Pole
- Pole with Angle Stay
- Pole with Flying Stay
- Transformer and Feeder Pillar
- Existing Town Area
- Main Building (Existing)
- Main Building (Proposed)

MINISTRY OF WORKS AND HOUSING NORTH-CENTRAL STATE, NIGERIA		
KANKARA TOWN ELECTRIFICATION		
JAPAN INTERNATIONAL COOPARATION AGENCY GOVERNMENT OF JAPAN	SCALE -	DATE 10.5.75
Survey Team for the Rural Electrification Program in the North-Central State and North-Eastern State	No NC 07	DRN N.I. / CKD T.W.


SOBA
N
PAMBEGUWA
NOTES
LEGEND
Technical Secondary School
G.H
No.4 100KVA
Government Girl's Secondary School
No.3 100KVA
Primary Shool
River
GPS
G.P.S
No 2 100KVA
Local Market
Office
Court
Chief House
Guest House
Islam
Mosque
No 1 100KVA
Dispensary
ZARIA
MINISTRY OF WORKS AND HOUSING
NORTH-CENTRAL STATE. NIGERIA
SOBA TOWN ELECTRIFICATION
JAPAN INTERNATIONAL COOPERATION AGENCY GOVERNMENT OF JAPAN
SCALE
DATE
10 5 75
NC06

HUNKUYI



NOTES

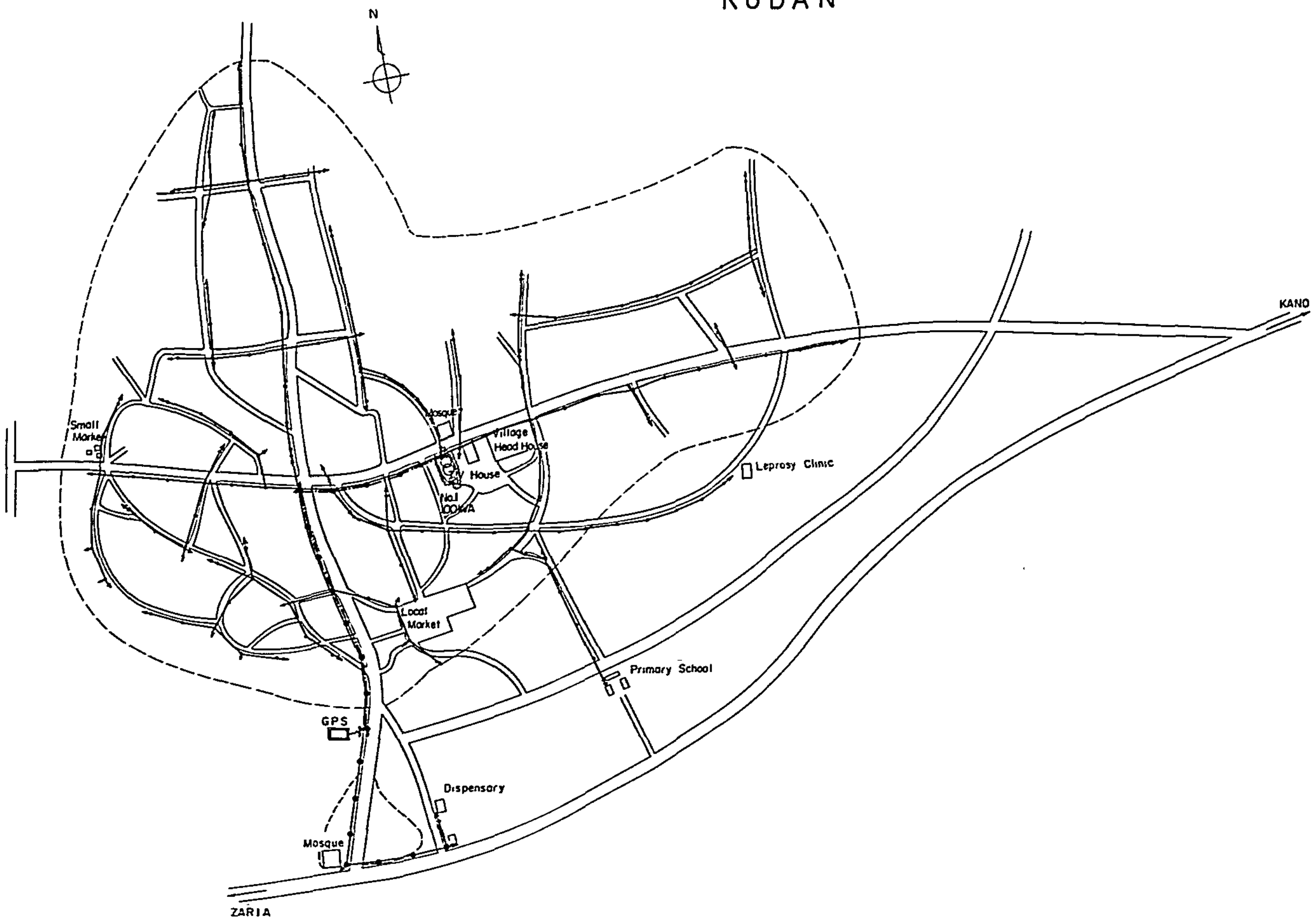
1. LV system shall be 3 phase 4 wire up to the end of LV lines.
2. The conductors of HV, LV and street lighting shall be all aluminium 50 mm²
3. The poles with HV lines or dual (HV + LV) lines shall be 10 m, and the poles with LV lines shall be 9 m.
4. HV insulators of intermediate and angle poles shall be mainly of pin type and HV insulators of tee-off and terminal poles shall be chiefly of disc type.
5. Drop out fuse switches shall be provided at the primary side of step down transformer and feeder pillar shall be provided at the secondary side of the transformer above-mentioned.
6. Lightning arresters shall be provided both on the primary side of transformer at the HV feeding points and the lines each with the interval of 500 m.
7. Span length shall be 40 m in average, but shall not be greater than 50 m for all LV and dual (HV + LV) construction.

LEGEND

- GPS — Diesel Power Station (First Priority)
- H V 3 Phase 3 Wire
- L V 3 Phase 4 Wire
- H V Underground Cable
- L V Underground Cable
- Single Pole
- H Pole
- Pole with Street Light
- L V Section Pole
- Pole with Angle Stay
- Pole with Flying Stay
- Transformer and Feeder Pillar
- Existing Town Area
- Main Building (Existing)
- Main Building (Proposed)

MINISTRY OF WORKS AND HOUSING NORTH-CENTRAL STATE, NIGERIA		
HUNKUYI TOWN ELECTRIFICATION		
JAPAN INTERNATIONAL COOPERATION AGENCY GOVERNMENT OF JAPAN	SCALE	DATE 10 5 75
Survey Team for the Rural Electrification Program in the North-Central State and North-Eastern State	No. NC 09	DRN *M. I* / CKD *T. M.*

KUDAN



NOTES

1 L.V. system shall be 3 phase 4 wire up to the end of L.V. lines.
2 The conductors of H.V., L.V. and street lighting shall be all aluminium 50 mm².
3. The poles with H.V. lines or dual (H.V. + L.V.) lines shall be 10 m, and the poles with L.V. lines shall be 8 m.
4. H.V. insulators of intermediate and angle poles shall be mainly of pin type and H.V. insulators of tee-off and terminal poles shall be chiefly of disc type.
5. Drop out fuse switches shall be provided at the primary side of step down transformer and feeder pillar shall be provided at the secondary side of the transformer above mentioned.
6. Lightning arresters shall be provided both on the primary side of transformer, at the H.V. feeding points and the lines each with the interval of 500 m.
7. Span length shall be 40 m in average, but shall not be greater than 50 m for all L.V. and dual (H.V. + L.V.) construction.

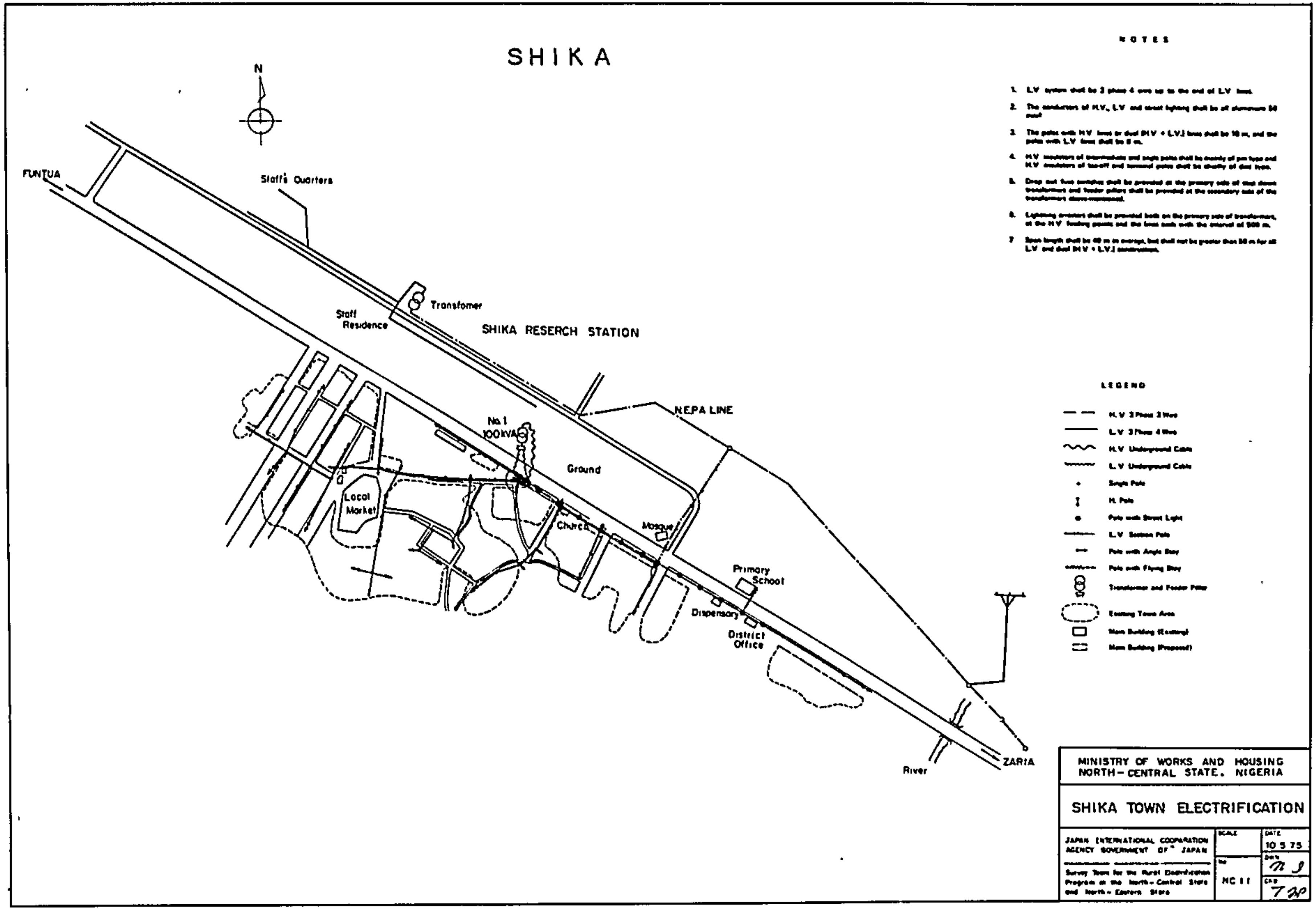
LEGEND

- GPS — Diesel Power Station (First Priority)
- H.V. 3 Phase 3 Wire
- L.V. 3 Phase 4 Wire
- H.V. Underground Cable
- L.V. Underground Cable
- Single Pole
- H. Pole
- Pole with Street Light
- L.V. Section Pole
- Pole with Angle Stay
- Pole with Flying Stay
- Transformer and Feeder Pillar
- Existing Town Area
- Main Building (Existing)
- Main Building (Proposed)

MINISTRY OF WORKS AND HOUSING
NORTH - CENTRAL STATE, NIGERIA

KUDAN TOWN ELECTRIFICATION

JAPAN INTERNATIONAL COOPERATION AGENCY GOVERNMENT OF JAPAN	SCALE	DATE 10.5.75
		DRN N. I.
Survey Team for the Rural Electrification Program in the North - Central State and North - Eastern State	No NC 10	CHD T. H.


SHIKA
N
FUNTUA
Staff's Quarters
Transfomer
Staff Residence
SHIKA RESERCH STATION
NEPA LINE
No.1 100KVA
Ground
Local Market
Church
Mosque
Primary School
Dispensory
District Office
River
ZARIA
NOTES
LEGEND
H.V 3 Phase 3 Wire
L.V 3 Phase 4 Wire
H.V Underground Cable
L.V Underground Cable
Single Pole
H. Pole
Pole with Street Light
L.V Section Pole
Pole with Angle Stay
Pole with Flying Stay
Transformer and Feeder Pillar
Existing Town Area
Main Building (Existing)
Main Building (Proposed)
MINISTRY OF WORKS AND HOUSING
NORTH-CENTRAL STATE, NIGERIA
SHIKA TOWN ELECTRIFICATION
JAPAN INTERNATIONAL COOPERATION AGENCY GOVERNMENT OF JAPAN
SCALE
DATE
10 5 75
NC 11

[illegible]