No. 1

BASIC DESIGN STUDY REPORT

ON

THE PROJECT

FOR

REINFORCEMENT OF POWER DISTRIBUTION NETWORK

IN

DAR ES SALAAM (PHASE III)

IN

THE UNITED REPUBLIC OF TANZANIA

SEPTEMBER 1991

JAPAN INTERNATIONAL COOPERATION AGENCY

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国際協力事業団
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マイクロ
フィルム作成

PREFACE

In response to a request from the Government of the United Republic of Tanzania, the Government of Japan has decided to conduct a basic design study on the Project for Reinforcement of Power Distribution Network in Dar Es Salaam and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Tanzania a study team headed by Mr. Masahiro Kumomi, Resident Representative, JICA Tanzania Office, from 20th March to 18th April, 1991.

The team held discussions with the officials concerned of the Government of Tanzania, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Tanzania in order to discuss a draft report and the present report was prepared.

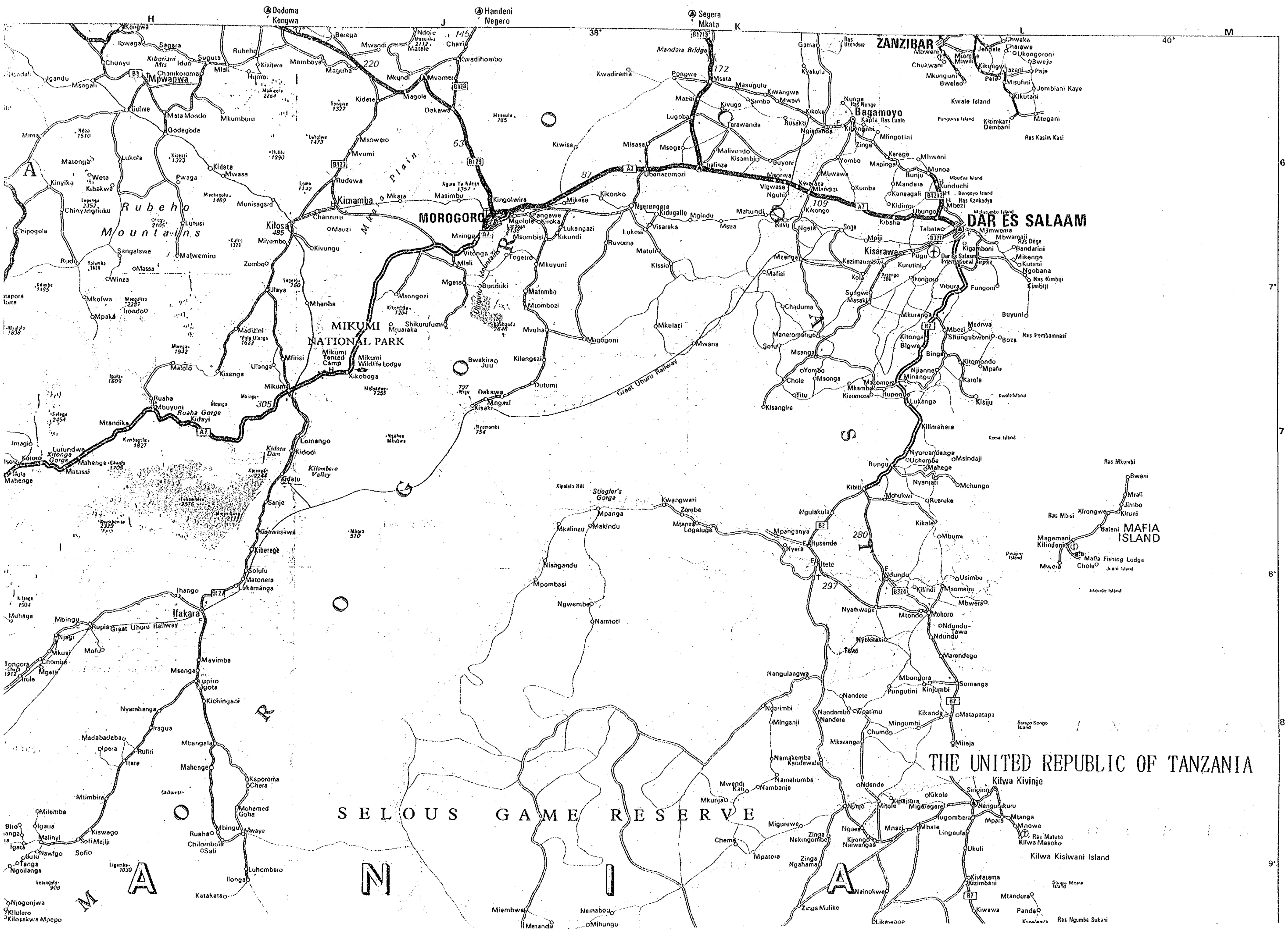
I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the United Republic of Tanzania for their close cooperation extended to the teams.

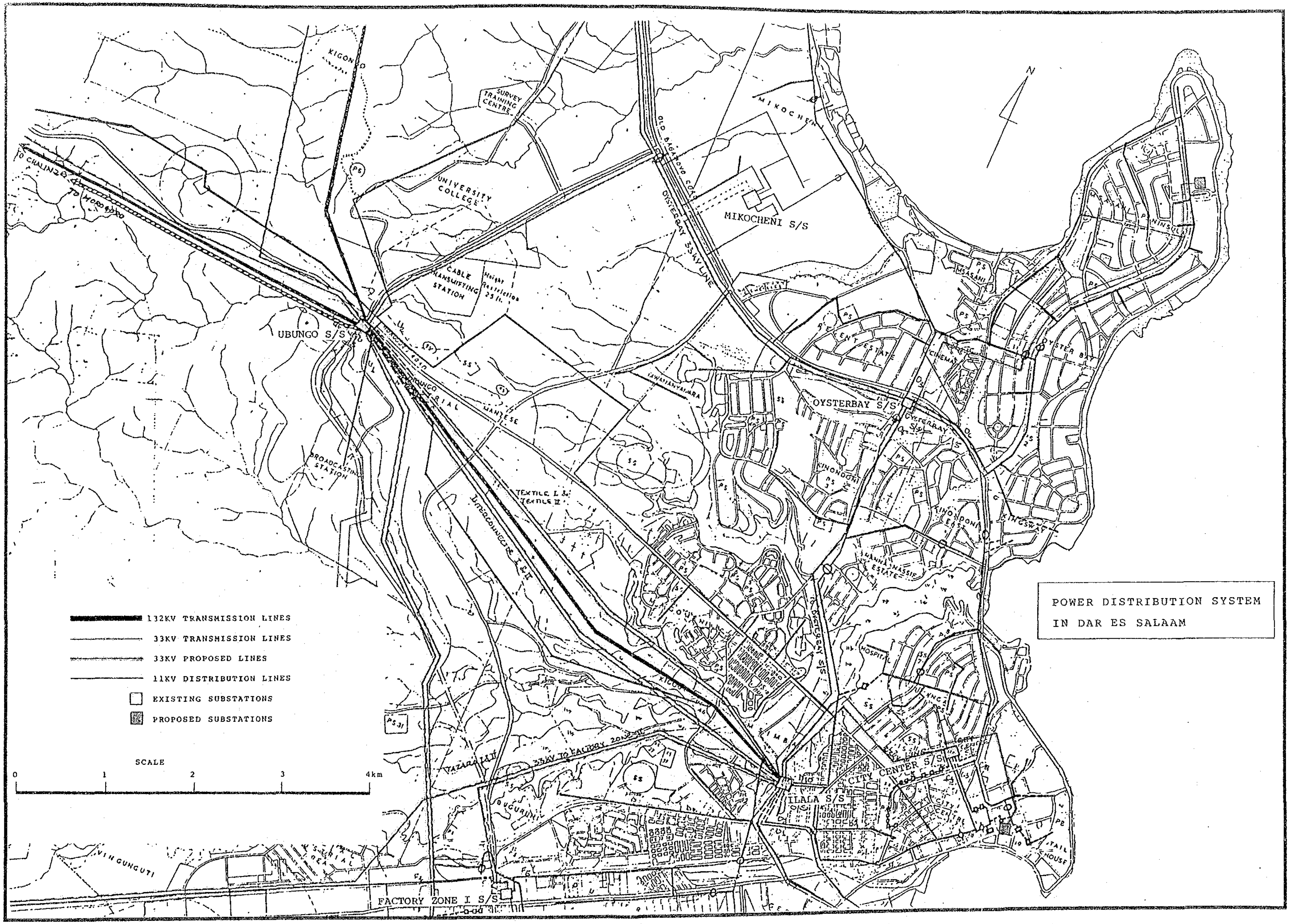
September, 1991

Kensuke Yanagiya

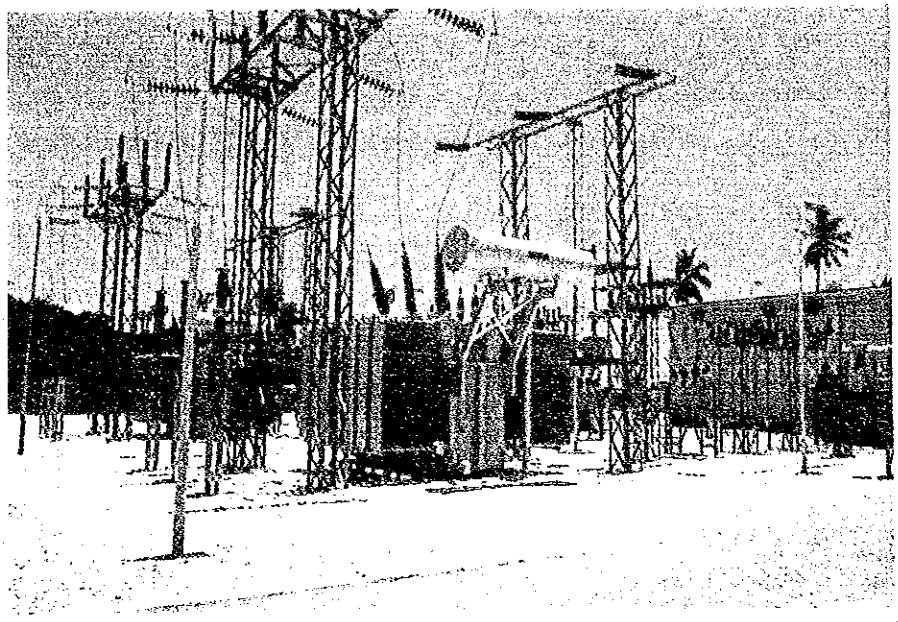
Kensuke Yanagiya
President
Japan International Cooperation Agency



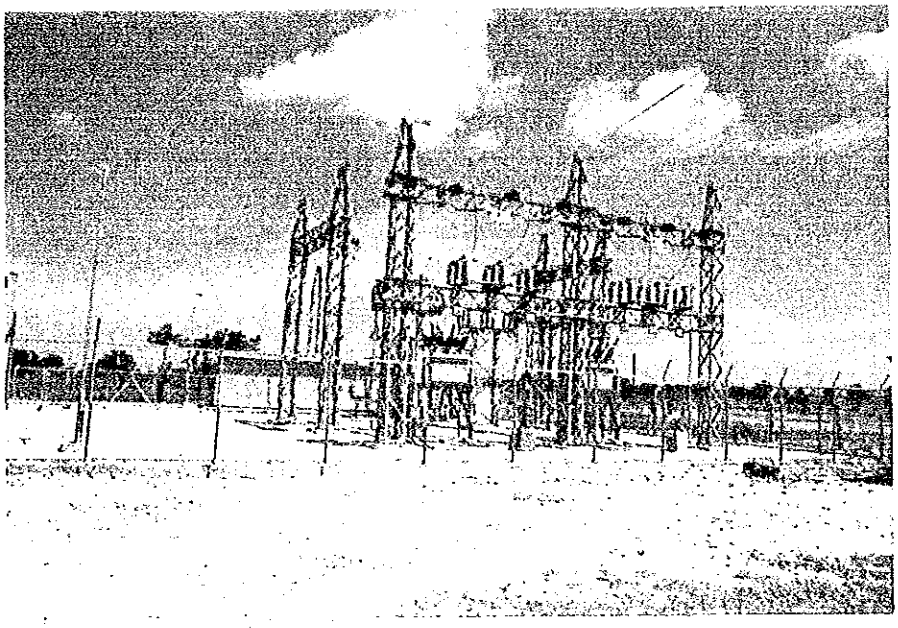
Dodoma
Kongwa
Handeni
Negero
Segera
Mkata
ZANZIBAR
Kwale Island
Bagamoyo
DAR ES SALAAM
MOROGORO
Rubeho
Mountains
Kilosa
Mpwapwa
Gulwe
Chunyu
Kimamba
Mkata Plain
Uluguru Mountains
MIKUMI
NATIONAL PARK
Mikumi Tented Camp
Mikumi Wildlife Lodge
Ruaha Gorge
Kidatu Dam
Kilombero Valley
Ifakara
Great Uhuru Railway
Stiegler's Gorge
Mafia Fishing Lodge
MAFIA
ISLAND
Kilwa Kivinje
Kilwa Masoko
Kilwa Kisiwani Island
SELOUS GAME RESERVE
THE UNITED REPUBLIC OF TANZANIA
T A N Z A N I A
M O R O G O R O
Kisarawe
Dar Es Salaam International Airport
Mahenge
Kibiti
Utete
Rufiji
Mkuranga
Kimbiji
Lukenga
Nyamwage
Somanga
Miteja



POWER DISTRIBUTION SYSTEM
IN DAR ES SALAAM
132KV TRANSMISSION LINES
33KV TRANSMISSION LINES
33KV PROPOSED LINES
11KV DISTRIBUTION LINES
EXISTING SUBSTATIONS
PROPOSED SUBSTATIONS
SCALE
0
1
2
3
4km
N
UBUNGO S/S
MIKOCHENI S/S
OYSTERBAY S/S
CITY CENTER S/S
ILALA S/S
FACTORY ZONE I S/S
UNIVERSITY COLLEGE
SURVEY TRAINING CENTRE
CABLE TRANSMITTING STATION
BROADCASTING STATION
MIKOCHENI
OYSTERBAY
KINONDONI
KINGSWAY
HOSPITAL
VINGUNGUTI



Ilala Subsation



Mikocheni Subsation

SUMMARY

The power distribution networks of Dar es Salaam City, the capital city of Tanzania, had once been in very poor condition due to aging of the facilities. Today, this condition is improved as three improvement projects under the grant aid of the Japanese Government have been implemented since 1985.

However, the power loads on these distribution networks have grown rapidly in recent years as the economic activity of the Republic of Tanzania has grown. In particular, the problems with power supply, such as over-loading of transformers in existing substations, drop of service voltage at end users, heavy loading of distribution line and excessive distribution line loss, are recurring in the central and northeastern areas of the city.

These areas of the city include the most important power loads in the city such as the supply to government offices, as well as Msasani residential district where the growth of power demand is especially large, thereby making the Government of Tanzania very conscious of the importance of this problem in view of its administrative activity and for the welfare of the citizens.

Therefore, the Government of Tanzania has decided to take a prompt action to deal with this problem. With the understanding that this problem is deeply related to the Distribution Network Improvement Projects implemented in the past, the Government of Tanzania has requested the Government of Japan a grant aid for the power distribution supply improvement project of this area.

In response to this request, the Government of Japan has decided to conduct a basic design study for the Project for Reinforcement of Power Distribution Network in Dar es Salaam (Phase-3) for the above two areas of the City as the next stage of the preceding projects implemented in 1985 (supply of urgently needed equipment/materials), in 1986 (Phase-1; mainly expansion of substations) and in 1987 (Phase-2; mainly improvement of distribution lines).

Based on this decision of the Government of Japan, the Japan International Cooperation Agency (JICA) has dispatched the Basic Design Study Team to the United Republic of Tanzania from March 20 to April 18 of 1991.

The Team has, while it was stationed in Tanzania, conducted field surveys on the current status of power supply in the two areas of the city mentioned above in cooperation with engineers of the Tanzania Electric Supply Company Limited (TANESCO), to confirm the necessity of the project requested and the suitability of this project as a grant aid project, and collected data, materials and information which are required in formulating the project plan. The Team also held discussions with TANESCO to confirm the basic items related to the implementation of this project, including the scope of this project, the method of implementation, and the operation of the completed facilities.

After returning to Japan, the Team has conducted analytical studies and formulated the optimal plan for implementation of this Project based on the materials collected during the site investigations and the discussions with TANESCO staff. The Team again visited Tanzania from July 22 to August 2, 1991, to explain the content of the Draft Final Report prepared by the Team. This Final Report has been completed through the above process based on the results of discussions with the Tanzanian authorities.

The entity which implements this project is TANESCO (Tanzania Electric Supply Company Limited), which is a nationally owned electric utility company of Tanzania.

TANESCO supplies electric power to all consumers in Tanzania. It operates 400 MW of power generation facility, 2000 km of transmission lines and power distribution networks of all cities in the country, and sells 1.3 billion kWh of electric energy. Judging from the performance of TANESCO in operating the power facilities supplied by the preceding three grant aid projects, there should be no problem in managing and operating the power facilities to be supplied by this Grant Aid Project after their completion.

The outline of study results are as presented below.

(1) The capacity of existing City Center substation that supply the center of the city consists of 2 units of 15 MVA transformers, but the power demand on this substation already exceeds 30 MVA at peak hours of summer season.

(2) There are two existing substations supplying the northeastern part of the City, which are Oyster Bay and Mikocheni Substations, each having

capacity of 15 MVA, or total capacity of 30 MVA. These substations are also very heavily loaded, and in evening peak hours they are near the rated capacity throughout the year.

(3) In recent years, the growth of power demand is remarkable, and it is necessary to assume 5 to 6% annual growth in the future.

(4) For these reasons, it is obvious that expansion of substation capacity is required. However, if the new substations will be constructed near the load center, rather than installing additional transformers in existing substations, it would be more effective in resolving the current problems with distribution networks, such as reduction of heavy load on existing distribution lines, reduction of distribution network power loss, and elimination of voltage fluctuation problems encountered by customers.

(5) Based on this concept, it is planned to construct Sokoine Substation and Msasani Substation, which will be respectively located at Sokoine Drive district in the City center and Msasani district in the northeastern district of the City.

(6) New 33 kV transmission lines are required to supply these new substations. In view of power system reliability, it is most suitable to supply 33 kV power to Sokoine Substation from City Center Substation, and to Msasani Substation from the transmission line that interconnect Oyster Bay and Mikocheni Substations. With this power system configuration, 17.7 km of 33 kV transmission lines will be newly constructed or expanded.

(7) The 11 kV distribution trunk lines which are supplied from the new substations must be appropriately interconnected with existing distribution lines and pass through appropriate locations for power distribution. For this purpose, 20 km of new 11 kV distribution lines will be constructed.

(8) As a measure to prepare for the future increase of loads on existing substations, replacement of two, 15 MVA transformers is requested. This request has been examined, and these transformers are included in the Project plan according to the request because such a measure is appropriate as preparation for future load increase.

(9) Installation of capacitors at Ilala Substation has been requested. However, a similar plan is in progress at a nearby substation of higher voltage under an assistance program of a foreign nation, and this request was eliminated from the Project as it duplicates with the above program.

(10) The Team surveyed the secondary circuit breaker facilities (11 kV switchgears) in existing substations other than those constructed in the previous Grant Projects, and discovered that these circuit breakers are extremely aged and dangerous. Therefore, replacement of these circuit breakers was included in this Project.

(11) The Team studied the types and numbers of construction vehicles and tools in stock, and decided the required amounts as presented in (5) which follows.

The contents of the Project planned in the basic design are presented below.

(1) New Substation Construction

Name	:	Sokoine Substation	Msasani Substation
Capacity	:	15 MVA	15 MVA
Voltage	:	33 kV/11 kV	33 kV/11 kV
Transmission Line	:	33 kV, 1 circuit	33 kV, 1 circuit
Distribution Line	:	4 circuit	3 circuit
Space for Expansion	:	15 MVA, 1 unit	15 MVA, 1 unit

(2) Related Transmission Lines

a. Substation Line		Sokoine Line	Msasani Line
Voltage	:	33 kV	33 kV
Section	:	City Center - Sokoine	Near Oyster Bay - Msasani
Conductor	:	150 mm2, 1 circuit	150 mm2, 1 circuit
Length	:	2.2 km	5.3 km
Type	:	Overhead line and underground cable	Overhead line

b. Interconnection Line

		City Center Line No.2	Oyster Bay Line
Voltage	:	33 kV	33 kV
Section	:	Ilala - City Center	Ilala - Oyster Bay
Conductor	:	150 mm2, 2 circuits, new	150 mm2, 1 circuit, extension
Length	:	3.9 km	6.3 km
Type	:	Overhead line	Overhead line

c. Related Distribution Line

		For Sokoine	For Msasani
Voltage	:	11 kV	11 kV
Underground Lie	:	400 m	300 m
Overhead Line	:	15 km	5 km
Conductor	:	100 mm2 ACSR	100 mm2 ACSR

(3) Replacement of Main Transformer

Place	:	Oyster Bay, Factory Zone 1 Substations
Capacity	:	15 MVA
Voltage	:	33 kV/11 kV
Number of Units	:	2 units

(4) 11 kV Switchgear

Location	:	Ilala, Oyster Bay, Factory Zone 1, Kurasini Substations
Current	:	Receiving line; 1200 A, feeder; 600A
Number	:	21 units in total
Type	:	Indoor type, vacuum circuit breaker

(5) Construction Vehicles and Tools

a. Vehicles

Type	Number
7-ton crane vehicle	1
5-ton truck with crane	2
Pickup truck	3
Small jeep	1
3-ton fork lift	1
Supervisor's car	1

b. Tools and Instruments

General construction tools for 4 construction teams.

COMPARISON OF THE ITEMS REQUESTED AND CONFIRMED

Items Requested	Items Confirmed
1. Construction of new substations a. Sokoine (15 MVA) b. Msasani (15 MVA)	Same as requested
2. Construction of related power lines Provision of necessary materials for the new transmission lines of new substations and for reinforcement of distribution lines for increased capacity of substations	Provision of necessary materials for; 1) 17.7 km of 33 kV transmission lines 2) 20 km of 11 kV distribution lines
3. Provision of two units of main transformers	Replacement of main transformers at Oysterbay and Factory Zone 1 substations (15 MVA x 1 each)
4. Provision of switching capacitors in order to improve power factor for loss reduction	Changed to replacement of 11 kV switch gears at existing substations eliminating the capacitors requested
5. Provision of vehicles and Tools	Provision of vehicles and tools necessary for four construction gangs

The period required for construction works is 12 months if this Project is implemented under Japanese grant cooperation.

In this Project, the scopes of works to be undertaken by Japan and Tanzania are as described below.

(1) Substation

Tanzania : Acquisition of land, land preparation, water supply and drainage, foundation works (including installation of ground wires).

Japan : Design, transportation of materials and equipments, equipment assembly, installation, adjustment, test, construction supervision.

(2) Transmission and Distribution Lines

Tanzania : Implementation of construction work.

Japan : Design, delivery of materials and equipments to the depot of TANESCO, construction planning, design guidance, construction work guidance.

Expected benefits by this project are as follows:

The total capacity of substations in the Project Area, which is currently 60 MVA (City Center; 30 MVA, Oyster Bay; 15 MVA, Mikocheni; 15 MVA), is increased by 30 MVA by the new substations of this Project (Sokoine; 15 MVA, Msasani; 15 MVA), that is, the capacity is increased by 50% from the current capacity by this Project. With this increase, no new substation will be required for the coming 7 years even if the demand growth in the future is 6% per annum.

By construction of these new substations, the problems with the power supply in this area, such as supply disruption due to heavy load, voltage drop, excessively large power loss, etc. can be resolved when this Project is completed.

More than 80% of the consumers who receive the benefit of this Project are common citizens, whose number amounts to 250 thousands. In addition, since

the Project Area is the key districts of Dar es Salaam City, where there are many government offices, banks, schools, hospitals, etc., the stability of electric power supply in this area will contribute to the security, welfare and economy of the district.

For TANESCO, who is the owner of this Project, revenues will be increased by this project, which will amount to 1.44 billion TSh per annum in 8 years after the completion of the Project when the facilities will be operated at full capacity, thereby bringing about substantial benefit in the income of this company. The improvement in TANESCO's financial position will enable TANESCO to suppress upward revision of electricity rate which is made sharply every year. Accordingly, from this point the project will result in benefit for the people of the country.

This Project is expected to bring about substantial benefit, and is also in line with the objective of grant aid of the Government of Japan. Considering, in addition, the strong wish of Tanzania in requesting this grant, it would be reasonable to realize this Project as soon as possible.

CONTENTS

APPENDIX:

CHAPTER 1

INTRODUCTION

CHAPTER 1 INTRODUCTION

The power distribution networks of Dar es Salaam City, the capital city of Tanzania, had once been in very poor condition due to aging of the facilities. Today, this condition is remarkably improved as three improvement projects under the grant of the Japanese Government have been implemented since 1985.

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(Headed by Mr. Akihiro Kumomi, Manager of JICA Tanzania Office) to the United Republic of Tanzania from March 20 to April 18 of 1991.

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The members of the Team, the itinerary of field survey, the list of persons interviewed, minutes of discussions, and the list of materials collected are presented in the Volume of Reference Materials attached to this Report.

CHAPTER 2

BACKGROUND OF PROJECT

CHAPTER 2 BACKGROUND OF PROJECT

2.1 GENERAL DESCRIPTION OF THE REPUBLIC OF TANZANIA

(1) Organization for Electric Power Supply
(Outline of The Tanzania Electric Supply Company Ltd.)

Name : Tanzania Electric Supply Company Limited (TANESCO)

Establishment : In 1964, the Government of Tanzania entered into an Agreement with East African Power & Lighting Company Limited of Kenya to purchase shares owned by the said company.

Activity : TANESCO is a state monopoly on electric power supply activity in Tanzania, that is, responsible for generation, transmission and distribution of electric power for energy consumers throughout Tanzania under the supervision of the Ministry of Water, Energy and Mining.

Organization : TANESCO is operated by the organization shown in Figure 4.3-1, under management of the director board headed by the minister of the Ministry of Water, Energy and Mining.

Financial statement (Abstract):

(MTSh)	1988	1989	1990
Fixed Assets:	48,316	51,961	60,629
Long term Liability:	41,762	63,017	67,669
Sales Income:	4,410	8,108	13,174
Operation Cost:	2,960	3,728	6,645
Gross Profit:	1,449	4,380	6,529
Administrative Expenses:	778	1,024	1,435
Provision for obsolete losses:	1,314	1,314	1,314
Net Operating Profit:	-675	1,861	3,779
Outstanding Interest etc.:	-2,634	-994	-1,472
Net Profit before Tax:	-3,229	867	2,306
Tax:		420	988
Net Profit after Tax:	-3,952	447	1,318

The scale of operation of TANESCO:

	1988	1989	1990
Energy produced (GWh):	1,265	1,436	1,565
Energy sold (GWh):	1,060	1,188	1,565
Sales Income (MTSh):	4,410	8,108	13,174
Number of employees:	5,000	5,300	5,500
Number of consumers:	153,108	162,059	176,214

Power sources owned (MW) as of 1990:

Hydro: 333.2 (in Grid)

Thermal: 97.1 (in Grid), 41.0 (isolated)

Transmission lines as of 1990:

220 kV 1,620 km

132 kV 410 km

(2) Power Sources

At present, all loads of the power system are being supplied by hydroelectric power. In addition to the major hydroelectric power sources of Kidatu (200 MW) and Mtera (80 MW), the three hydroelectric power stations (with total output of 46 MW) on Pangani River System are interconnected to the nation-wide interconnection power system (the grid system) to supply power.

However, the local cities which are not interconnected to the national grid have their own diesel power plants, thereby constituting independent power supply systems.

In addition, diesel power plants with total capacity of 97 MW are located in Dar es Salaam City, Mwanza City, Arusha City, etc., but these diesel plants are shut down normally to form reserve supply capacity, as all loads can be supplied by hydroelectric power as discussed above.

The major power sources of the Republic of Tanzania are presented in the table below.

Name	Power Plant Type	Potential Output	Note
Kidatu	Regulating Pond Hydro	200	
Mtera	Reservoir Type Hydro	80	
Hale	Regulating Pond Hydro	21	
Pangani Falls	Run-of-River Hydro	17.5	
Nyumbaya Mungu	Reservoir Type Hydro	8	
Ubungo	Diesel	24	Repair completed (7.5x2, 4.5x2)
Arusha	Diesel	5.2	
Mwanza	Diesel	20	Under repair

(3) Power System

The national grid, comprising the major power stations of Kidatu and Mtera, consists of 220 kV extra-high voltage transmission lines. This power grid has been recently extended to the inland areas, thereby enabling almost all major cities to receive hydroelectric power by this grid.

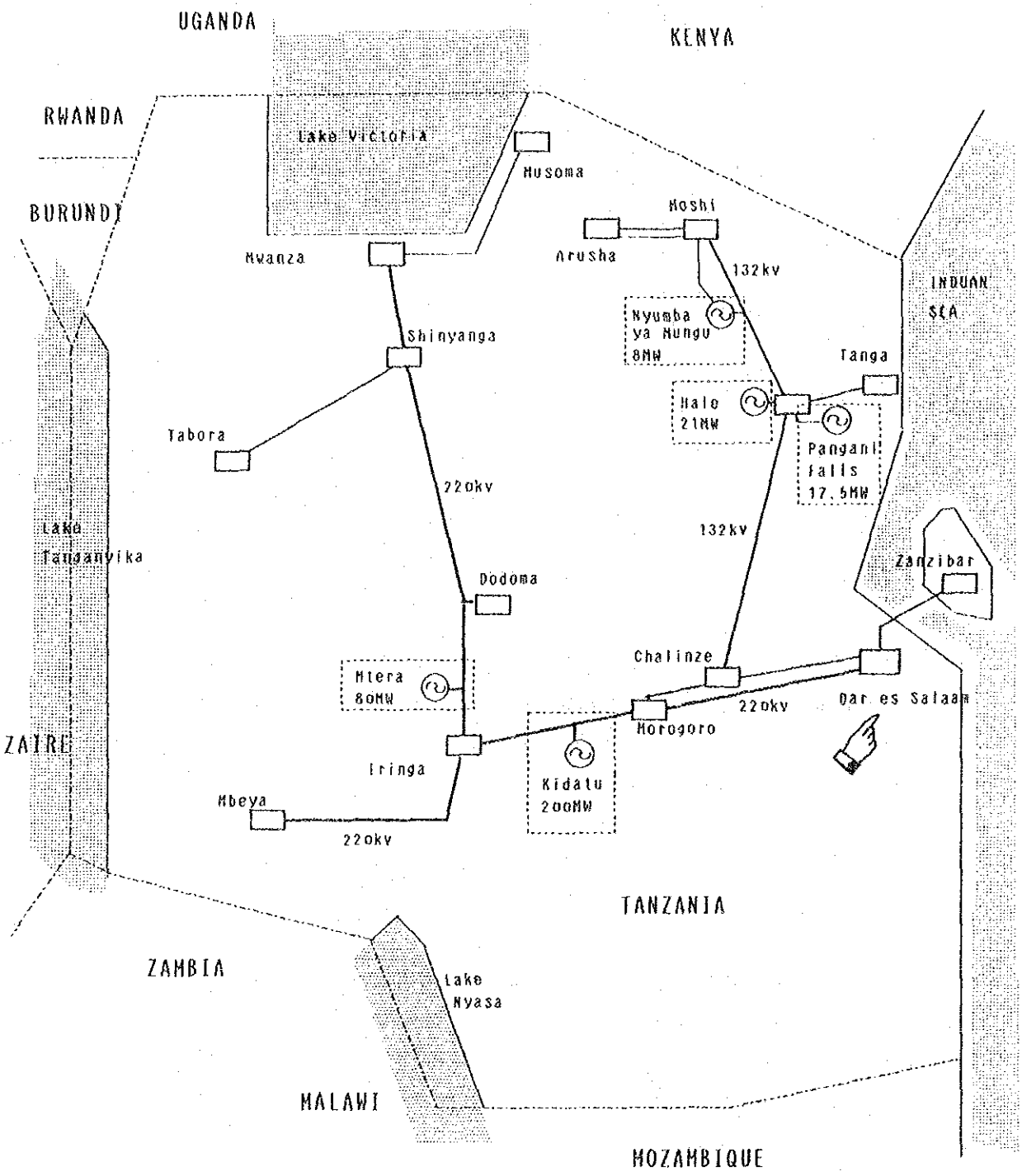
The cities in the northern states in Tanzania are supplied with power by means of 132 kV transmission system. As this system is interconnected to the 220 kV system at Morogoro, the whole nation is covered by an interconnected grid.

The outline of power systems of Tanzania is presented in Figure 2.2-1.

(4) Status of Power Supply/Demand Balance

The electric power demand is increasing rapidly due to growing economic activities of recent years, but the power supply potential of hydroelectric power stations is currently more than sufficient in meeting the power demand.

Fig.2.2-1



LEGEND

- 220KV Lines
- 132KV Lines
- 66kv Lines
- Loads
- Power Stations (Hydro)

POWER SYSTEM IN TANZANIA
Jan.,24,1991
EPDC International

(5) Problems with Electric Utility and Development Program

1) Electric Power Development

The development of new power sources is being accelerated in order to deal with the recent growth of power demand, and the following projects are now under way.

- Pangani Falls Hydroelectric Power Station Re-development Project
  The current output of 17.5 MW will be increased to 60 MW.

- Kihanshi Hydroelectric Power Station Construction Project
  A 200 MW hydroelectric power station will be constructed on upstream of Rufiji River.

2) Power System Expansion

All 220 kV transmission lines are single circuit lines, and shortage of reactive power during the peak time has become apparent. At present, the 220 kV system voltage at Ubungo Substation (at entrance of Dar es Salaam City) sometimes drop down to 175 kV at an extreme peak, and measures to control voltage is urgently needed. Serious voltage reduction is also observed at peak time at Arusha site which is at the end of 132 kV systems. On the other hand, the voltage at the southwestern end of 220 kV systems, such as Mufindi and Iringa, the voltage rises sharply at off-peak time at midnight, and it is required to install reactors.

Under the circumstances, TANESCO is implementing a plan of installing condensers under grant of Scandinavian nations, and the reactive power control measure is scheduled to be completed within this year.

3) Rehabilitation of Distribution System

The aging of distribution system is proceeding all over the nation, resulting in increase of power line loss, overloading of facilities, reduced voltage and frequent supply outage due to line failures.

To deal with situation, TANESCO has implemented the rehabilitation and expansion of distribution facility under Japanese grant for

the central districts of Dar es Salaam, and under the National Rehabilitation Plan financed by the World bank for the nation as a whole. Although problems with distribution systems have been improved substantially, it is still necessary to implement a project of substantial scale in order to improve power factor, losses, etc.

4) Loss Reduction Measure

At present, the loss ratio between the sold kWh to the generated kWh is around 17%. The ESMAP (Energy Sector Management Assistant Program) team has been organized under guidance of the world bank, and this team is working on the measures to reduce power loss.

2.2 BACKGROUND OF AND CONTENT OF REQUEST

(1) Background of Request for Grant

Although the distribution network facilities of Dar es Salaam City, the capital city of Tanzania, had been in an extremely dilapidated condition due to aging, they have been substantially improved by present time owing to the implementation of rehabilitation plans for which grant cooperation of the Government of Japan have been provided for three times.

However, the growth of power demand is remarkable in the two districts referred to above, and problems such as reduced voltage at end users, heavy loading of distribution lines and excessive line losses are occurring. As these districts include the most important area in the City for the Government activities, the Government of Tanzania felt the need for urgent action. The Government of Tanzania regarded that this problem are closely as an extension of the past rehabilitation plans, and placed this request for grant aid for rehabilitation of power distribution facilities in these areas as the concluding phase of the series of rehabilitation programs.

(2) Content of Request

This plan is composed of the following project items.

- Construction of Two, New Substations
  Two substations will be built in City Center District and Msasani District.

- Construction of Related Transmission and Distribution Lines
  Connection of transmission lines to new substations. Connection to existing power systems. Expansion of capacity of existing transmission and distribution lines in relation to this connection.

- Grant of Two Transformers
  Existing main transformers in Oyster Bay and Factory Zone 1 substation are obsolete and replacement of them are required.

- Installation of Condensers
  Installation of reactive power compensation facilities to deal with reduction of voltage at peak hours and for improvement of power factor.

- Grant of Vehicles and Tools for Construction
  Vehicles required for construction work such as crane truck and construction tools, etc.

The content of request referred to above has been partially modified based on the on-site surveys and discussions held in Tanzania (omission of condenser installation, and addition of repair of 11 kV switchgear). These corrective measures are generally appropriate, and the methods of implementing these measures are described in the later part of this report.

CHAPTER 3

GENERAL DESCRIPTION OF PROJECT SITE

CHAPTER 3 GENERAL DESCRIPTION OF PROJECT SITE

3.1 LOCATION OF PROJECT SITE AND ITS SOCIAL/ECONOMIC STATUS

Dar es Salaam is located at 6°50' south latitude and faces the Indian Ocean. The annual precipitation is approximately 1,130 mm, the highest temperature is around 32°C, and the lowest temperature is around 18°C. Dar es Salaam is the center of economic activity of Tanzania, where most of nation's economic activities excluding agriculture and forestry, which accounts for one half of gross domestic product, that is, commercial and industrial activities, as well as administrative activities are concentrated to this city. The population of Dar es Salaam is 1.4 millions as of 1987, as against the total national population of 23.89 millions.

3.2 NATURAL CONDITIONS

Dar es Salaam, which is situated on the coast of Tanzania has high temperature and humidity. There is a very heavy rainy season from late March to mid-May, and a light rainy season from late November to early December. The annual average of highest temperature is 30oC, and the lowest temperature around 22oC. The season from June to September is relatively cool, but it is very warm from December to February, with temperature exceeding 30oC every day. The annual average humidity is around 70 to 80%. The geography is such that a plain extends for 15 to 60 km from the coast, and then the land rises gradually to a plateau.

3.3 SOCIAL ENVIRONMENT

The districts which are the object of this Project are the Government office area and a congested residential area, where, although roads, telephone service, city water and sewage are provided, but their conditions are not quite good. Some roads are damaged, and disruption of telephone service and city water service occurs routinely, and electric power facilities need to be rehabilitated in many locations.

3.4 OUTLINE OF POWER SECTOR

(1) Outline of Distribution System of Dar es Salaam City

1) The electric power is supplied to Dar es Salaam City by the 220 kV national grid, and its voltage is stepped down to 132 kV and 33 kV at Ubungo Substation, and then transmitted to eight substations inside the city and three substations in the suburban area. There, the voltage is again stepped down to 11 kV, and the power is supplied to the distribution networks. The transmission and distribution system of Dar es Salaam are illustrated in Figure 3.3-1 and Figure 3.3-2.

2) Substations

Ilala Substation	:	132/33 kV, 90 MVA (45 MVA x 2 unit)
		33/11 kV, 30 MVA (15 MVA x 2 unit)
City Center Substation	:	33/11 kV, 30 MVA (15 MVA x 2 unit)
Oyster Bay Substation	:	33/11 kV, 30 MVA (5 MVA x 3 unit)
Factory Zone I Substation	:	33/11 kV, 15 MVA (5 MVA x 3 unit)
Factory Zone III Substation	:	33/11 kV, 15 MVA (15 MVA x 1 unit)
Mikocheni Substation	:	33/11 kV, 15 MVA (15 MVA x 1 unit)
Kurasini Substation	:	33/11 kV, 15 MVA (15 MVA x 1 unit)

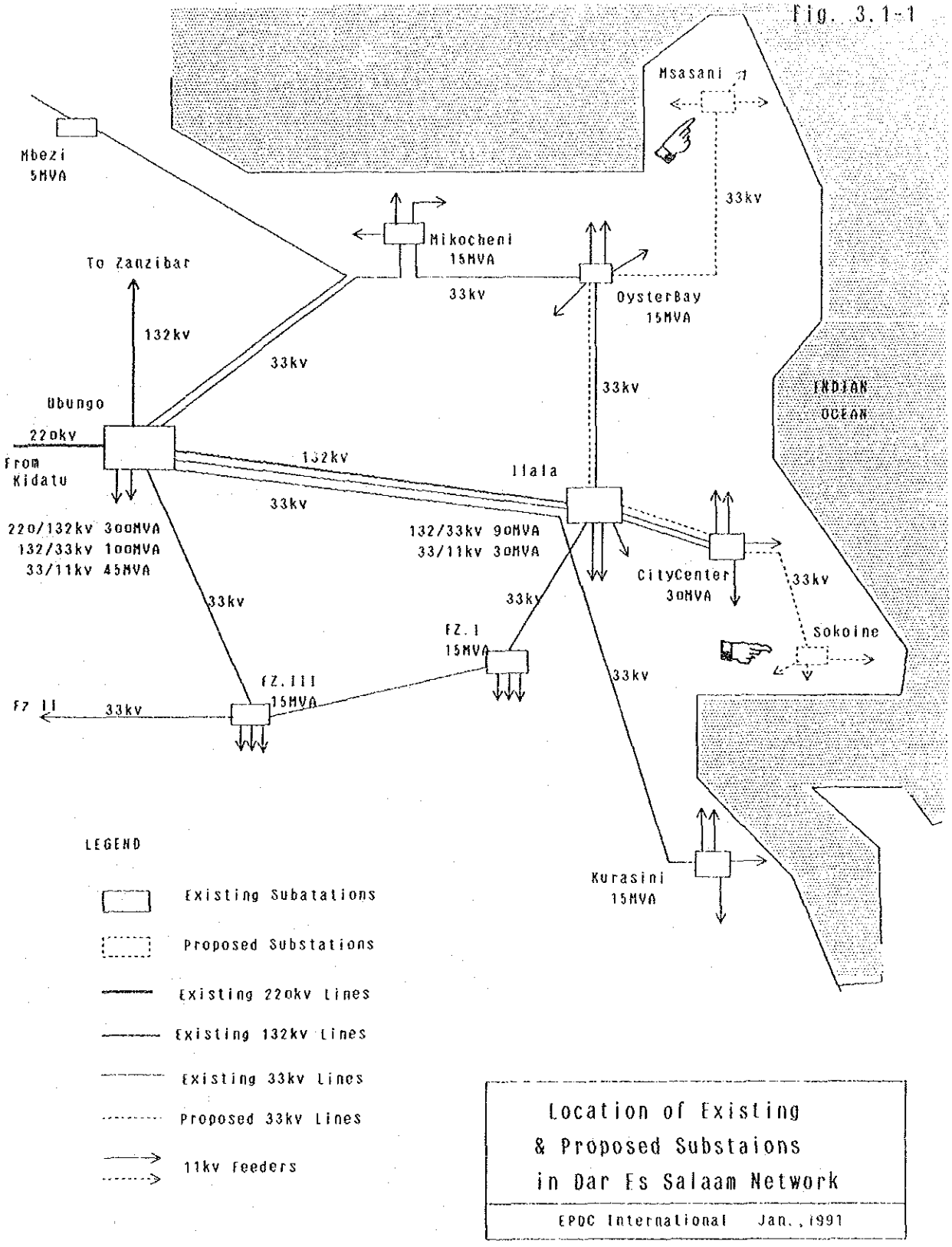
3) Distribution Lines

The 11 kV distribution lines supplied from each substation constitutes networks inside the city, to which pole distribution transformers or distribution transformers installed on ground are connected to supply general customers with 3-phase, 4-wire system low voltage distribution lines of 3-phase 400 kV and single phase 230 V rating. The frequency is 50 Hz.

4) Current Status of Project Area

The districts to which this Project is to be applied are the two areas, one being the northeastern part of the city, including Msasani Peninsula, which is mainly the residential district of Dar es Salaam City, and another the city center that include the area around Sokoine Road, which is the Government office district. The

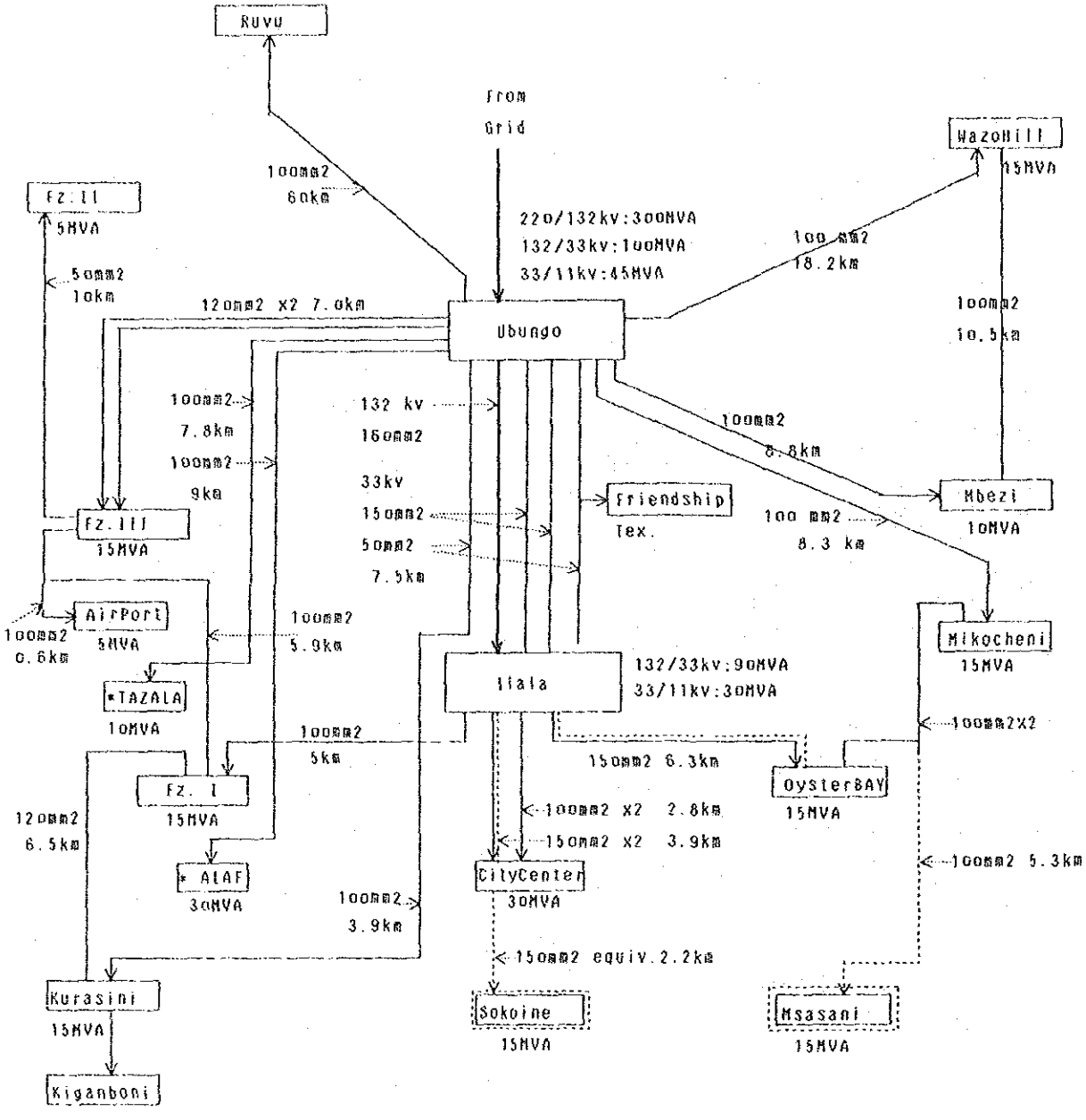
Fig. 3.1-1



Location of Existing
& Proposed Substaions
in Dar Es Salaam Network

EPDC International Jan., 1991

Fig.3.1-2



LEGEND

15MVA — Existing Substation Capacity

Proposed Substation

* — Private Substation

132kv Line

33kv Lines

Proposed 33kv Lines

Schematic Diagram of 33KV Network in DAR es SALAAM

July,8,1991

EPDC International

growth of power demand is remarkable in these two areas. At present, the power is being supplied from Oyster Bay Substation and Mikocheni Substation to the former district, and from City Center Substation to the latter district.

5) Current Status of Power Supply

At present, the total power supply capacity in Tanzania exceeds the total demand, and there is no problem of supply shortage in overall. However, there are local bottlenecks in distribution systems, and voltage drop due to heavy loading, frequent supply failure and other troubles are being experienced in certain areas. The two districts which is to be covered by this Project as referred to above are suffering from rather serious problems such as shortage in transformer capacity, overloading of distribution lines, voltage drop and fluctuation at end users and excessive power loss, and therefore requires immediate expansion of power facilities.

(2) Number of Customers

The areas covered by this Project are the business territories of Kurasini and Magomeni Service Offices of TANESCO. The office which controls these service offices is Coastal Zonal Office which is directly subject to the Operations Department of Head Office, and Coastal Zonal Office non charge of power supply for consumers living in Dar es Salaam City and its suburban areas. The city is supervised by dividing it to 22 Billing Sections each for collection of electric charges. The number of customers in each of these Sections are given in the table below.

Section	Name	Number of Customers
00	City Center	5,690
01	Kariakoo	4,948
02	Ilala	3,278
03	Chagombe	2,391
04	Tabata	4,621
05	Kurasini	2,671
06	Mbagara	5,185
07	Upanga	4,035
08	Kiwalani	2,369
09	Ocean Road	1,514
10	Ukonga	878
11	Power Book	323
12	Ikwiriri	131
16	Msasani	7,991
17	Mikocheni	6,257
18	Ubungo	12,317
19	Mbezi	769
20	University	2,011
21	Kibaha	1,368
22	Bagamoya	758
23	Wazo Hill	115
55	Mafia	366

The Sections which are covered by this Project are those having the Section numbers 00, 07, 09, 16 and 17, and the details of the customers in these sections are given in Figure 3.4-1. The growth of the number of customers and power demand from 1988 to 1990 is illustrated in Figure 3.4-2. Number of consumers by tariff category is illustrated in Figure 3.4-3 and big consumers in Dar Es Salaam and main public facilities in the objective areas are listed in Figure 3.4-4 and Figure 3.4-5 respectively.

Fig. 3.4-1 NUMBER OF CONSUMERS BY CATEGORIES

ZONE	1988	1989	GROWTH/88	1990	GROWTH/89	GROWTH/88
City Center Area						
00	5,465	5,575	2.01%	5,690	2.06%	4.12%
07	4,007	4,043	0.90%	4,035	-0.20%	0.70%
09	1,921	1,627	-15.30%	1,514	-6.95%	-21.19%
S-TTL	11,393	11,245	-1.30%	11,239	-0.05%	-1.35%
North West Area						
16	6,185	7,652	23.72%	7,991	4.43%	29.20%
17	3,665	5,700	55.53%	6,257	9.77%	70.72%
S-TTL	9,850	13,352	35.55%	14,248	6.71%	44.65%
TOTAL	21,243	24,597	15.79%	25,487	3.62%	19.98%

Fig. 3.4-2 POWER CONSUMPTION BY CATEGORIES

ZONE	1988	1989	GROWTH/88	1990	GROWTH/89	GROWTH/88
City Center Area						
00	13,101MWH	34,846MWH	165.98%	36,934MWH	5.99%	181.92%
07	28,359MWH	30,420MWH	7.27%	30,831MWH	1.35%	8.72%
09	MWH	MWH		MWH		
S-TTL	41,460MWH	65,266MWH	57.42%	67,765MWH	3.83%	63.45%
North West Area						
16	41,413MWH	46,892MWH	13.23%	61,353MWH	30.84%	48.15%
17	MWH	MWH		MWH		
S-TTL	41,413MWH	46,892MWH	13.23%	61,353MWH	30.84%	48.15%
TOTAL	82,873MWH	112,158MWH	35.34%	129,118MWH	15.12%	55.80%

No. of Consumers by Tariff category

Fig.3.4- 3

(1) As of 1990, Dec.

Catego. / Zone	T1	(%)	T2	(%)	T3	(%)	T6	(%)	T7	(%)	Total
City Center (Zone No. 00, 07, 09)											
00	3514	61.8	2122	37.3	27	0.5	25	0.4	2	0.0	5690
07	3763	93.3	244	6.0	12	0.3	13	0.3	3	0.1	4035
09	984	24.4	467	11.6	34	0.8	15	0.4	13	0.3	1513
Sb.Ttl	8261	73.5	2833	25.2	73	0.6	53	0.5	18	0.2	11238
North East (Zone No. 16, 17)											
16	6995	87.5	887	11.1	64	0.8	37	0.5	8	0.1	7991
17	5560	88.9	570	9.1	102	1.6	22	0.4	1	0.0	6255
Sb.Ttl	12555	88.1	1457	10.2	166	1.2	59	0.4	9	0.1	14246
Total	20816	81.7	4290	16.8	239	0.9	112	0.4	27	0.1	25484

(2) As of 1989, Dec.

Catego / Zone	T1	(%)	T2	(%)	T3	(%)	T6	(%)	T7	(%)	Total
City Center (Zone No. 00, 07, 09)											
00	3505	62.8	2018	36.2	27	0.5	27	0.5	2	0.0	5579
07	3793	93.8	224	5.5	10	0.2	13	0.3	3	0.1	4043
09	1054	64.9	499	30.7	41	2.5	17	1.0	13	0.8	1624
Sb.Ttl	8352	74.3	2741	24.4	78	0.7	57	0.5	18	0.2	11246
North East (Zone No. 16, 17)											
16	6703	88.1	852	11.2	15	0.2	30	0.4	9	0.1	7609
17	5073	89.0	520	9.1	83	1.5	21	0.4	1	0.0	5698
Sb.Ttl	11776	88.5	1372	10.3	98	0.7	51	0.4	10	0.1	13307
G.Ttl.	20128	82.0	4113	16.8	176	0.7	108	0.4	28	0.1	24553

(3) As of 1988, Nov.

Catego / Zone	T1	(%)	T2	(%)	T3	(%)	T6	(%)	T7	(%)	Total
City Center (Zone No. 00, 07, 09)											
00	3506	64.2	1904	34.8	27	0.5	26	0.5	2	0.0	5465
07	3775	94.2	208	5.2	9	0.2	12	0.3	3	0.1	4007
09	1287	67.3	535	28.0	52	2.7	23	1.2	16	0.8	1913
Sb.Ttl	8568	75.3	2647	23.2	88	0.8	61	0.5	21	0.2	11385
North East (Zone No. 16, 17)											
16	5565	90.0	556	9.0	30	0.5	24	0.4	9	0.1	6184
17	3309	90.3	308	8.4	35	1.0	12	0.3	1	0.0	3665
Sb.Ttl	8874	90.1	864	8.8	65	0.7	36	0.4	10	0.1	9849
G.Ttl.	17442	82.1	3511	16.5	153	0.7	97	0.5	31	0.1	21234

Fig.3.4- 4

List of Big Consumers in Dar es Salaam (1990)

Item No.	Account No.	Tar-iff Catg	Ave. Consump. KWh/M	Ave. Load KVA	Customer's Name
1	11-00-33001	5	246640	611	Tanzania Post & Telecommunication
2	11-01-10001	5	34749	116	Kariakoo Market Corporation
3	11-01-40001	5	650620	1642	Tanzania Breweries Ltd
4	11-03-12001	4	56827	235	Tanzania Bottlers Ltd
5	11-03-16001	5	54959	186	Keko Pharmacentical
6	11-03- 31	5	58952	230	Simba Plastic Co.Ltd
7	11-03-56001	5	126001	324	Tanganika Sisal Spinning Co.Ltd
8	11-03-67001	5	210134	509	Tanzania Oxygen Ltd
9	11-04-02001	5	175000	799	Tanzania Shoe Co.Ltd
10	11-04-03001	5	30000	401	Tanzania Cigarrette Co.Ltd
11	11-04-06001	5	1300000	9346	Alminium Africa
12	11-04-12001	5	900000	1803	Kioo Ltd
13	11-04-22001	5	190000	738	Tazara
14	11-04-25001	5	150000	783	Kibo Paper Mill Ltd
15	11-04-35001	5	80000	466	Calico Textile Industries Ltd
16	11-04-44001	5	80000	467	NMC Bakery Project
17	11-05-01501	5	46294	241	BP Tanzania Ltd
18	11-05-01551	5	13573	53	Tanzania Shell Ltd
19	11-05-05051	5	261500	1120	Tanzania Harbours Authority
20	11-05-12001	5	21886	150	Agip Tanzania Ltd
21	11-06-42001	5	10220	57	Saruji Corpo. Mbagala glass Factory
22	11-08-01001	5	9500	371	JV Synthetics Ltd
23	11-08-01051	5	8700	270	JV Synthetics Ltd
24	11-08-08001	5	135000	515	Fahan Bottlers Ltd
25	11-08-16001	5	150000	388	Air Port Terminal I
26	11-08-20001	5	550000	1274	Air Port Terminal II
27	11-08-43001	5	160000	767	Metal Products
28	11-09-30001	5	153170	327	Embassy Hotel
29	11-09-32001	5	63164	208	Registrar of Buildings -IPS Building
30	11-09-46001	5	280000	796	Kilimanjaro Hotel Ltd
31	11-09-48501	5	187800	820	Bank of Tanzania
32	11-10-10001	5	60000	270	Tasini Textiles Ltd
33	11-10-11001	5	210000	975	Tang Sying & Wearing Mills Ltd
34	23-17-40001	4	34630	227	National Bicycle Co.Ltd
35	23-18-32001	5	149510	624	Ubungo Spinning Mill
36	23-18-36001	5	847400	3000	Friendship Textile Mill Ltd
37	23-18-42001	5	150647	901	Ubungo Farm Impliments Ltd
38	23-18-48001	5	58461	201	Tanzania Bureau of Standards
39	23-19-40001	5	10387160	9543	Tanzania Portland Cement
40	23-19-42001	5	32029	279	Asbesco Ltd
41	23-19-43001	5	15069	102	Trailers & Low Loaders
42	23-17-22001	4	16897	322	Tan-Pack Industries
43	23-17-45001	4	152672	294	Soza Plastic
44	23-18-32001	5	148510	624	Ubungo Spinning Mill
45	23-20-10401	5	94000	275	UDSM - Faculty of Engineering
	Total		18751674	43650	Aver. LF: 59.7 %

Fig.3.4-5 PUBLIC INSTITUTION IN THE PROJECT AREA

City Center (Zone 00, 07, 09)	
No.	Name
1	Bank of Tanzania H.Q
2	Kilimanjaro Hotel
3	Embassy Hotel
4	Twiger Hotel
5	Treasury
6	Ministry of Land
7	State House
8	Ocean Road Hospital
9	Aga-Kharn Hospital
10	TANESCO H.Q
11	Embassy of Japan
12	National Museum
13	Ministry of Water & Energy
14	Hobors Authority
15	Public Library
16	International School
17	TPTC
18	Extelecom House
19	Police Office
20	Immigration Office
21	Daily News
22	Central Post Office
23	Railway Corporation
24	Trafiic Office
25	TAFICO Refrigeration Plant
26	NUWA H.Q
27	Cinema (5)
28	Schools (6)
29	Ministry of Justice
30	Fire Department

North East (Zone 16, 17)	
No.	Name
1	JICA Tanzania Office
2	Ambassador's Residence
3	Embassy of USA
4	Embassy of France
5	Embassy of USSR
6	Central Church
7	Oysterbay Police Office
8	Msasani Shopping Center
9	Kinondoni Market
10	Oysterbay Hotel
11	Peninsula Hotel
12	Karibu Hotel
13	Casanova Hotel
14	Msasani Hospital
15	Nwanayamaia Hospital
16	TPTC Training Center
17	Drive inn Chinema
18	Schools (5)
19	Military Establishments
20	International School (Upper)
21	Small Boat Repairing Shop

CHAPTER 4

CONTENT OF PROJECT

CHAPTER 4 CONTENT OF PROJECT

4.1 OBJECTIVE

The rehabilitation projects for the distribution networks of Dar es Salaam City that have been implemented for three times in the past has substantially improved the power supply condition of the City which had once been very poor, and these projects have brought about a lot of benefit to the City and the Republic of Tanzania. After these projects have been completed, the power demand has grown remarkably in some parts of the city, and this again created certain inconvenient situation in terms of electric power supply.

The following problems have arisen in the central part of the city including Sokoine Drive where the Governmental offices are concentrated, and the northeastern part of the city which include the residential district of Msasani Peninsula, and the request for the grant cooperation has been placed for these two areas.

- Overloading of main transformers in existing substations which supply power to the areas in question.
- Heavy loading of distribution lines.
- Drop of supply voltage at users' ends.
- Frequent scheduled shutdowns for prevention of overloading and power supply failures due to faults.

The objective of this Project is to formulate a distribution facility expansion plan including construction of two new substations, in order to resolve the problems with power distribution in the two areas of City.

4.2 EXAMINATION OF REQUEST

4.2.1 Examination of Suitability and Necessity of the Project

(1) Necessity of Constructing New Substations

The main feature of the Project for which the grant was requested is the construction of new substation at Sokoine and Msasani districts, and it is intended to resolve the problems with the distribution power supply to the city center area and northeastern area as referred to above by construction of these new substations.

In the two areas in question, the most serious problem in distribution power supply is that the main transformers in existing substations supplying these areas carry extremely heavy load, and the limit of transformer rated capacity has already been reached. For this reason, some measure of increasing the transformer capacity must be realized any way.

Three measures are conceivable for this purpose:

i) Installing new transformers in existing substations.
ii) Replacing transformers in existing substations with larger ones.
iii) Constructing new substations at suitable locations.

Based on the following reasons, it is appropriate to adopt "Alternative iii)" and construct new substations.

Study of Adequacy of Constructing New Substations

- Power demand in Sokonei district is currently being supplied by City Center Substation (15 MVA x 2), but the premises of this substation is narrow, and there is no space for installation of additional transformers.

- The substations that supply Msasani district are Mikocheni (15 MVA) and Oyster Bay (15 MVA), where there are spaces for installation of additional transformers. However, as these substations are located at far distance from the load center at Msasani Peninsula, the length of distribution lines is long, and installation of additional transformers can not be regarded as the optimal plan in view of line

loss and voltage drop. For this reason, it is more adequate to select a new site at center of the peninsula near the load center and construct a new substation.

A loss comparison study was made as shown in Fig. 4.2-11(1), (2), (3). It clearly shows that around 3.8 GWh loss saving will be expected annually in Case 2 in which power is supplied from new substation located in the center of Msasani peninsula, compared to Case 1 in which power is supplied from existing Oysterbay and Mikocheni substations, the same method adopted at the present time for load of the Msasani area.

- "Alternative ii)", by which the existing transformer is to be replaced by a new, larger transformer, can not be practically implemented, because the existing transformer is being operated at full load, and power supply has to be interrupted for a long time if it is attempted to replace the existing transformer without an additional stand-by transformer.

- As a new substation is constructed near load center, the existing distribution line which extends from existing substations at long distance can be relieved from heavy loading, and voltage drop and distribution loss will be improved. For most of customers, the power will flow from the new substation in the direction which is the reversal of the current direction, and these distribution lines will be utilized more effectively.

For the above reasons, it is deemed most adequate to construct new substations in attempting to expand the substation capacity.

(2) Land for New Substation

The areas being studied for this Project are located at the center of Dar es Salaam City, and it is very difficult to acquire a land. Fortunately, there is a lot which TANESCO has been permitted to use, and this place could be utilized (see Section 3 of this Chapter).

The area of the lot which is being contemplated for use for Sokoine Substation is barely wide enough, and there would be no problem if a good equipment layout is worked out. The lot planned for construction

of Msasani Substation is wide enough. These lot are so situated that there would be no problem in connecting distribution line feeders. These lots are located right in the middle of load center, and they are ideal places.

For the connection of transmission lines to these substations, substantial efforts will be required in selecting the routes, but this is inevitable in constructing substations in the areas where residential houses are congested.

Therefore, it is deemed that these lots are used as the premises of the new substations.

(3) Adequacy of Project in Terms of Benefit

The number of customers in the areas covered by this Project is 11,239 in the city center district (No. 0, 7 and 9 in terms of Zones for collection of electric charge), and 14,248 in the northeastern district (Zone No. 16 and 17). (Based on a material in 1990. The details are presented in Section 3, Chapter 4, "Outline of Project".)

Of these customers, the general residential loads account for 81.6% of the total, and light industrial and commercial loads 16.8%. Therefore, it can be said that the sector which benefits most from this Project is the general citizen.

That is, if the current condition of power supply failures is rectified by implementation of this Project, it is the general public who benefits most from this Project.

At the same time, when we consider on the industry, economy and security of the nation, the stable supply of electricity is the most essential factor for nation's development, and the benefit to be brought about by this Project is in measurable.

Therefore, this Project can be regarded as an adequate grant aid.

4.2.2 Study of Project Implementation and Operation Plan

TANESCO, which implements this project, is the largest public corporation (Para-statal) in Tanzania, which annually earns electricity sales revenue of 4.4 billion TSh, spends operation expenditures of 2.9 billion TSh (data of 1988), has employee of 4,500, and engaged in all phases of power generation, transmission and distribution operations of the nation. TANESCO has a well organized corporate system as illustrated on the separate chart. When the facilities under this Project is completed, the maintenance and repair of these facilities will be under the jurisdiction of the Zonal Office (Coastal), and operations of the facilities will be controlled by the Load Dispatching Office under Operation Department of the Head Office. The facilities to be built under this Project will be operated by the existing organization and personnel, and there is scarcely need to increase the number of employees or to provide additional budget.

As we observe the manner by which the new facilities were operated after completion of the past three projects, there was no particular problem concerning maintenance and operation.

4.2.3 Relations with Assistance Projects of Other Nations

Currently, there are the following assistance programs sponsored by foreign nations other than Japan which have some relation with this Project.

- The countermeasure against voltage drop of Ubungo Substation and others which under an assistance program of Scandinavian nations.
- The nation-wide distribution facility rehabilitation program assisted by the World Bank.
- Kihanshi Hydroelectric Development Project.
- Conversion of Kidatu-Ubungo transmission line to a double circuit line under assistance of Germany.
  (The content of this program is described in Chapter 2, "Background of Project".)

Among above assistance programs, the countermeasure against voltage drop of Ubungo Substation is particularly related to this Project. This program is

designed to deal with the shortage of reactive power supply of the power system which has become rapidly pronounced in recent years, and its main objective is to improve the voltage conditions by installing condenser banks (with 55 MVAR capacity) to the bus of Ubungo Substation to supply VAR. It is said that this project will be completed within this year.

On the other hand, the request for grant on this Project contained an item which is installation of condenser facility (30 MVA capacity) at Ilala Substation.

Apparently, this item has the same objective as the program under Scandinavian sponsorship and duplicates with it in nature. The Study Mission pointed out this fact during the expedition, and it has been confirmed in discussion with TANESCO that this item can be eliminated.

At the same time, it was identified during the on-site survey that many 11 kV switchgears on the secondary systems of existing substations are extremely aged, and these switchgears constitute the most vulnerable points in the power system. Concerning these switchgears, TANESCO requested that the replacement of these switchgears are included in the Project Items to be requested.

4.2.4 Examination of Project Items

(1) Study of Capacity of New Substations

1) Current Condition of Heavy Load on Existing Substations

The existing substation that supplies power to the city center, which is one of the areas to be covered by the proposed Project, is City Center Substation, which capacity is 30 MVA.

For the other area covered by this Project, the northeastern district of the City is supplied by Oyster Bay and Mikocheni Substation, both having capacity of 15 MVA.

The trend in the past 3 years of the monthly maximum peak power on City Center Substation is illustrated in Figure 4.2-1 and -2.

It can be seen clearly that, with increase of air conditioner demand, the peak power flow in in high temperature season of

December, January and February, when the maximum value of demand is usually observed, exceeded the rated capacity of the substation of 30 MVA every year since 1990.

The data of monthly maximum power of Oyster Bay Substation are presented in Figure 4.2-3. The data of 1990 tells that the rated capacity of this substation of 15 MVA is routinely exceeded.

The supply territory of this substation mostly consists of residential loads. As the peak power appears in the evening when cooking is done, the peak power is relatively unaffected by temperature, and remains almost constant throughout the year without seasonal change.

The data like the above are not available for Mikocheni Substation. However, the Study Mission collected the daily load record of February 25, 1991, which is illustrated in Figure 4.2-4, and a load of 12 MVA is recorded. Other data which we obtained by measuring on site survey show that the peak demand of this substation is supposed to be more than 13 MVA. The data are filed on Figure 4.2-5 (1) and (2).

Therefore, this substation does not have sufficient capacity margin with its 15 MVA rated capacity. In general, all of the three existing substations in the area covered by this Project are very heavily loaded, having little margin. Urgent measures are required to expand the rated capacity of these substations. Figure 4.2-6 (1), (2) are daily load fluctuation curves for each substation.

It clearly shows that office time peak demand appears in City Center substation and evening peak in Oyster Bay and Mikocheni substation.

2) Selection of Capacity of New Substations

Since 1984, the unit capacity of 33/11 kV transformers installed in substations of the City are standardized to 15 MVA. Considering the total size of load of the City, this size is adequate for secondary substations, and in selecting the

transformer capacity of the new substations, there is no reason to modify this standard.

Therefore, 1 bank of 15 MVA transformer shall be installed in Sokoine Substation and Msasani Substation.

In both areas, the total transformer capacity of existing substations is 30 MVA. As 15 MVA transformer is added to the system, the supply capacity to both areas will be increased by 50%.

3) Relation with Projected Future Demand

As the power demand will increase every year, we have to examine how many years the demand can be met by the substation capacity which will be increased under this Project. Although the growth of power demand of Dar es Salaam City is rapid in recent years, we can find that the average growth rate is 4.6% by analyzing the figures given in Table 4.2-7.

Assuming that the future demand growth is 6% per annum, the demand will reach 150% of the current level in 7 years, and no expansion of power facility is required during that period. The length of this period seems to be appropriate in planning expansion of transformer capacity in distribution systems.

However, a projection of power demand growth based on past trend may not be correct for such areas as those under this Project, where the load growth rate may change abruptly due to changes in various factors. On the other hand, it is not appropriate to assume too large a demand growth rate in formulating a project plan.

Accordingly, it has been decided to design the equipment layout of the two new substations in such a manner that there remains spaces for installation of additional one transformer each, and to actually install only one transformer each of 15 MVA capacity at this stage.

(2) Related Transmission and Distribution Lines

1) Study of Power System Configuration

It is necessary to connect 33 kV transmission lines to the two substations newly constructed. The power system configuration concerning the connection of these transmission lines was discussed in detail during the site expedition.

Two plans were studied concerning the 33 kV system to be connected to Sokoine Substation. The two plans studied are illustrated in Figure 4.2.8.

Alternative 2 is a concept of utilizing the 33 kV transmission line between Ubungo and Ilala which is currently idle, to receive the power directly from Ubungo Substation. The construction cost is low with this concept, but operation of the facility is a little inconvenient. The transmission loss is less than that of Alternative 1, although the difference is small. Calculation of loss comparison for two alternatives are shown in Fig. 4.2-9.

Alternative 1 is a conventional concept in which a new transmission line is constructed from a nearby existing substation. With this concept, the construction cost is higher as new facilities have to be added to the existing substation, but TANESCO recommended this Alternative 1. The Study Mission agreed with TANESCO, because this plan can be modified to Alternative 2 in future when the capacity margin of Ilala Substation is decreased in future, and therefore this plan is more flexible. The power system configuration agreed is illustrated in Figure 4.2-10.

2) Feeder Distribution Lines

As both substations are located in load centers, the feeders can be connected to existing distribution lines in appropriate manners, and no long distance distribution line is required. However, care should be exercised in selecting the points where distribution networks are isolated, and isolation switches need to be procured.

(3) Replacement of 11 kV Switchgears in Existing Substations

1) Necessity of Replacement

Among existing substations in Dar es Salaam City, those who have historically existed are five substations; Ilala, City Center, Factory Zone 1, Oyster Bay and Kurasini. All circuit breaker cubicles of distribution feeders of these substations are products of 1960's (oil circuit breakers made by Reyroll of Britain), which are very aged. Procurement of spare parts is difficult today, and their function is extremely unstable. Already, one circuit breaker was burnt at Ilala, and a circuit breaker of another feeder is used in common.

It looks that operators are trying not to use circuit breakers as far as possible, because the rupturing capability is uncertain. Today that other equipments have been refurbished, these circuit breakers remain as the most vulnerable point in the whole power system, and it is appropriate to replace them in this Project.

In this Project, the vacuum circuit breakers will be adopted instead of oil circuit breakers, so that less maintenance work will be required.

2) Details of Replacement Plan

In this Project, all existing 11 kV circuit breaker cubicles being used in the above mentioned substations will be replaced. However, since all these circuit breakers are currently in use, the same number of new, indoor type cubicles will be installed, and existing feeders will be switched to new cubicles one by one in order to reduce the time of power supply interruption.

In City Center Substation, the existing 11 kV switchgears are well maintained. However, it is necessary to grant two spares of cubicle internals (circuit breakers) to prepare for failure of existing circuit breakers.

(4) Replacement of Existing Two Transformers

The replacement of two, 33/11 kV, 15 MVA transformers have been requested because the existing main transformers of Oyster Bay and Factory Zone 1 substations are obsolete and consist of three 5 MVA transformers, not 15 MVA units like other substations. At present, these transformers are fully loaded and no repairing measures can be done because stop of supply for the areas cannot be allowed.

On the results of site survey for those substations, it is confirmed that this requirement is reasonable to be included to the scope of the project from the view of following points:

1) Oyster Bay substation was established in 1964 and initially only 2 units of 5 MVA were installed. Another 5 MVA unit was added on 5 years later, responding to the load increase. No. 2 unit is now in bad situation with oil leaking. All the transformers of Factory Zone 1 substation were of different makers and installed one by one from 1963. No. 1 unit is oldest and oil leaking is severe.

2) On-Load-Tap changers are not correctly working for both substations. Manual operation is occasionally needed.

3) Those transformers with different impedance characteristics are always parallel running and substantial reactive circulating current were observed.

Replacement work will be carried out when the present loads can be shifted to new substations, that is, after the Sokoine and Msasani substations will have been in service.

But since new transformers can be installed on the space of eliminating of only one 5 MVA existing transformer for both substation, it is not necessary to choose the light demand season for the work.

(5) Construction Vehicles and Construction Tools

Although the economic conditions of Tanzania has recovered substantially and the equipment and materials that can be locally procured have increased, it is still necessary to supply the necessary amounts of construction vehicles and tools for electric works. Appropriate types and amounts of these vehicles and tools ought to be granted by considering those currently possessed by TANESCO and available for this Project.

4.2.5 Technical Cooperation

In the previous cooperation, TANESCO requested for Japanese Government Experts as advisers on management of distribution network after the project completion and four experts were dispatched in three missions.

4.2.6 Basic Principle in Providing Cooperation

Based on the above studies concerning implementation of this Project, the effect and realism of the Project, as well as the ability to implement this Project by the recipient nation have been confirmed, and since the effect of the Project conforms to the objective of grant aid, it has been judged that it is appropriate to implement the Project by the grand funding of the Government of Japan. In the remaining Chapters of this Report, the outline of Project is studied and the basic designs are described.

Fig.4.2- 1

Peak Demand Data of City Center SS

	Peak Demand (MW)				Peak Loading (MVA)			
	1988	1989	1990	1991	1988	1989	1990	1991
Jan	20.5	19.0	28.5	24.5	22.9	23.7	32.0	29.7
Feb	21.0	21.5	27.9	23.5	22.9	26.9	32.0	30.0
Mar	19.0	21.5	22.0	23.0	22.3	26.9	26.9	30.3
Apr	17.7	20.0	22.0		21.1	22.9	26.9	
May	17.5	19.0	20.0		21.7	22.0	24.6	
Jun	21.0	18.5	19.5		22.9	21.7	22.9	
Jul	22.0	15.0	17.5		22.9	17.7	22.3	
Aug	19.7	15.0	18.5		22.9	18.3	22.3	
Sep	20.0	16.5	21.0		22.3	22.6	25.1	
Oct	19.5	21.5	22.0		22.9	25.7	26.9	
Nov	21.5	20.0	23.0		22.9	24.6	27.4	
Dec	22.0	22.0	24.0		24.6	27.1	30.9	
Average	20.1	19.1	22.2		22.7	23.3	26.7	
Growth(%)		-4.9	15.9			2.9	14.3	

Fig. 4.2-2

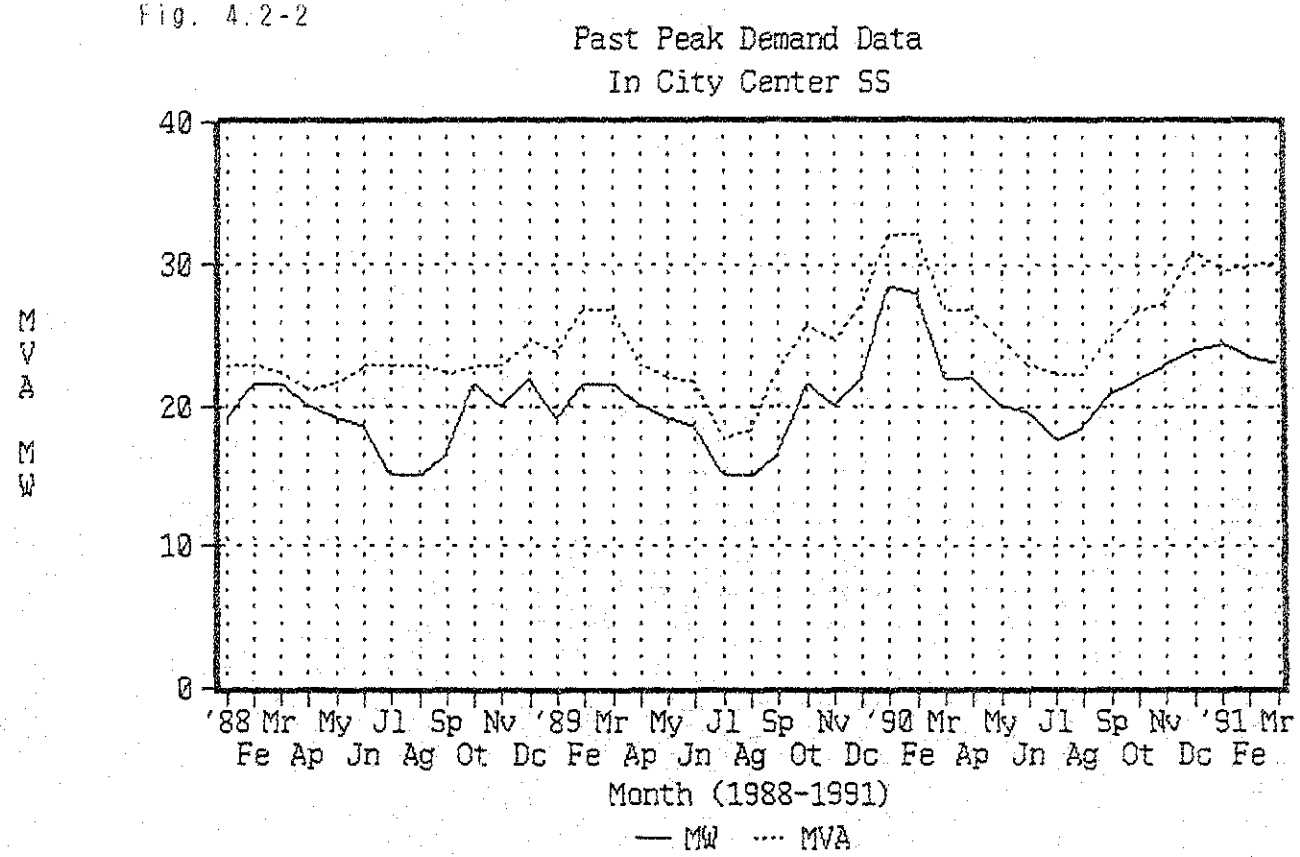

Past Peak Demand Data
In City Center SS
MVA MW
40
30
20
10
0
'88 Mr My Jl Sp Nv '89 Mr My Jl Sp Nv '90 Mr My Jl Sp Nv '91 Mr
Fe Ap Jn Ag Ot Dc Fe Ap Jn Ag Ot Dc Fe Ap Jn Ag Ot Dc Fe
Month (1988-1991)
— MW ···· MVA

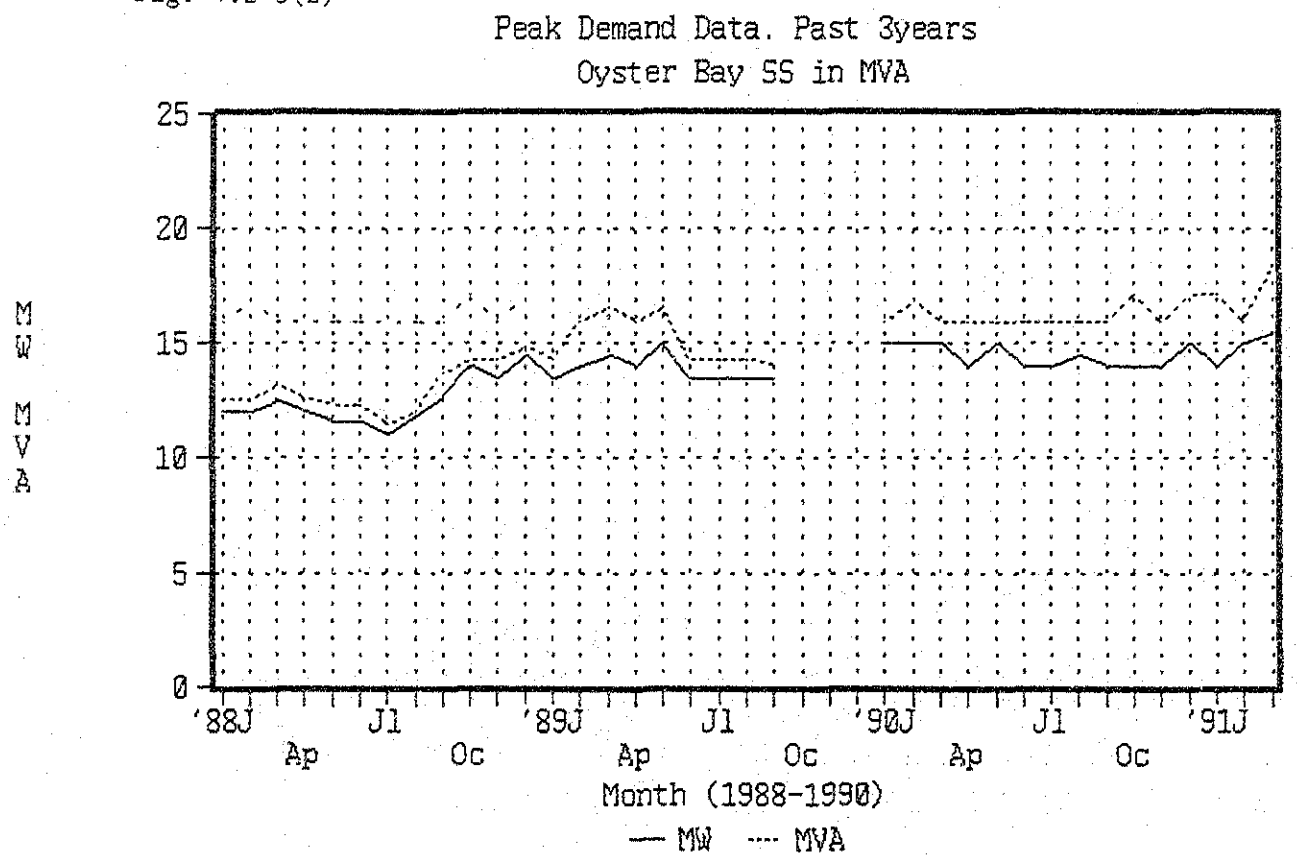
Fig.4.2- 3(1)

Peak Demand Data of Oyster Bay SS

Month	1988 MW	A	MVA	1989 MW	A	MVA	1990 MW	A	MVA
Jan	12.0	220	12.6	13.5	250	14.3	15.0	280	16.0
Feb	12.0	220	12.6	14.0	280	16.0	15.0	295	16.9
Mar	12.5	230	13.1	14.5	290	16.6	15.0	280	16.0
Apr	12.0	220	12.6	14.0	280	16.0	14.0	280	16.0
May	11.5	215	12.3	15.0	290	16.6	15.0	280	16.0
Jun	11.5	215	12.3	13.5	250	14.3	14.0	280	16.0
Jul	11.0	200	11.4	13.5	250	14.3	14.0	280	16.0
Aug	11.8	210	12.0	13.5	250	14.3	14.5	280	16.0
Sep	12.6	240	13.7	13.5	245	14.0	14.0	280	16.0
Oct	14.0	250	14.3	23.0	400	22.9	14.0	300	17.1
Nov	13.5	250	14.3	23.0	400	22.9	14.0	280	16.0
Dec	14.5	260	14.9	23.0	400	22.9	15.0	300	17.1
Average (MVA)			13.0			15.1			16.3
Growth (%)						16.5			7.4

Note:
These data were measured at 33kv OysterBay line at Ilala SS.
Generally, this line data show load of Oyster Bay SS.
But occasionally, Mikocheni substation was supplied by this line, too.
Data of Oct-Dec in 1989 are too large which may be summed-up one.
So, these data are not applicable.

Fig. 4.2-3(2)


Peak Demand Data. Past 3years
Oyster Bay SS in MVA
MW MVA
25
20
15
10
5
0
'88J
Ap
Jl
Oc
'89J
Ap
Jl
Oc
'90J
Ap
Jl
Oc
'91J
Month (1988-1990)
— MW ···· MVA

Daily Load Fluctuation Data of each Substation
(at a working day of Feb. 1991)
in MVA

SS Name:	CtyC.	Ilala	OysBay	Mikoche	Fz.1	Fz.3	Kurasi	Ubungo	Oys+Miko
SS Capa:	30	30	15	15	15	15	15	15	(30)
Date	27/2(W)	1/3(F)	15/2(F)	25/2(M)	21/2(W)	26/2Tu	5/3(Tu)	1/3(F)	
Hour									
1	12.2	11.4	9.6	7.7	2.5	4.0	6.0	4.8	17.3
2	11.9	10.8	9.2	7.5	2.5	3.9	5.8	4.4	16.7
3	11.6	10.6	9.0	7.5	2.4	3.7	5.8	4.2	16.5
4	11.5	10.7	8.9	7.5	2.3	3.8	5.8	4.6	16.4
5	11.4	10.9	9.1	7.4	2.3	3.7	6.7	5.0	16.5
6	12.4	11.9	10.1	8.8	2.7	4.0	7.0	5.6	18.9
7	14.6	12.6	9.8	7.9	2.8	4.0	7.1	5.5	17.7
8	19.1	14.7	9.1	8.4	3.2	6.0	7.5	5.5	17.5
9	22.8	16.5	8.7	8.9	4.2	7.4	7.9	5.4	17.7
10	23.3	17.4	9.0	9.0	4.3	7.7	7.9	5.6	18.0
11	23.6	17.4	9.2	9.3	4.4	7.5	8.2	5.8	18.4
12	23.8	17.4	9.7	9.4	4.2	7.1	8.3	5.7	19.1
13	22.4	16.0	9.7	9.3	4.0	6.9	8.1	5.4	19.0
14	22.5	16.0	8.9	8.8	4.2	7.1	8.2	5.1	17.7
15	21.6	16.0	8.6	8.6	4.2	7.0	7.7	4.9	17.2
16	19.7	15.7	8.5	8.2	3.7	6.5	7.4	4.7	16.6
17	16.2	13.3	8.6	8.3	3.2	5.4	6.3	5.0	17.0
18	13.7	14.8	9.2	8.4	3.0	5.0	6.0	5.0	17.6
19	15.0	15.4	12.1	10.4	3.2	4.4	9.2	7.2	22.5
20	15.5	16.2	14.3	11.9	3.2	4.5	9.7	7.6	26.2
21	14.8	16.0	13.3	11.3	3.1	4.3	8.9	7.1	24.6
22	14.5	14.5	12.5	10.6	2.9	4.7	8.6	6.5	23.2
23	13.7	14.5	11.1	9.1	2.8	4.1	7.1	5.5	20.1
24	12.8	13.7	10.1	8.2	2.5	4.1	6.3	5.0	18.3
Total	400.6	344.1	238.3	212.4	77.8	127.0	177.4	131.1	450.6
Max	23.8	17.4	14.3	11.9	4.4	7.7	9.7	7.6	26.2
Mean	16.7	14.3	9.9	8.8	3.2	5.3	7.4	5.5	18.8

	C.C	Ila	Oys	Mik	Fz1	Fz3	Kra	Ubu	Oy+Mk
LF %	70.1	82.4	69.4	74.4	73.6	68.7	76.2	71.9	71.7
Avl.F1 %	55.6	47.8	66.2	59.0	21.6	35.3	49.3	36.4	62.6
Avl.F2 %	0.79	0.58	0.95	0.79	0.29	0.51	0.65	0.51	0.79

N.B.1: Load Factor (LF): Average KW / Max.KW
Availability Factor 1 (Avl.F1): Average KW / Installed KW
Availability: Max.Load KVA / Installed capacity KVA

N.B.2: These Data were collected from operation log which show KWh data in each hour, accordingly, instant peak demand will be larger than this.

Load data measured at site survey for each SS　　Fig.4.2- 5(1)

[Mar.25 (Mo)]

Ilala SS　(11h 15)

Voltage(kv): 33kvSide 31.0　　11kvSide 11.0

	A	MW	MVAR	MVA	P.F(%)	Modifi.to Peak
Trf.132/33kv		54.0	34.0	63.8	84.6	
Trf.33/11kv		15.0	8.0	17.0	88.2	
33kv Lines						
Krasini	165	7.5		8.9	84.7	
Fz 1	165	7.5		8.9	84.7	
Oyst Bay	170	8.0		9.1	87.6	(45%Up):13.2MVA
Cty Ctr	485	21.5		26.0	82.6	
11kv Feeder						
D0(Brewary)	80			1.5		
D1(Azania)	110			2.1		
D2(Town1)	215			4.1		
D3(Kurasi)	110			2.1		
D8(Indust)	75			1.4		
D9(Town2)	155			3.0		
D10(Magome)	175			3.3		
(Total)	920			17.5		

Oyster Bay SS　(11h 55)

Voltage (kv)　33kv: 30.5　11kv: 10.9 (Mikocheni line : Open)

	A	MW	MVAR	MVA	P.F(%)	Modifi.to Peak
Trf.(Incoming-11kv side)						
Trf.No1	165			3.1		
Trf.No2	155			2.9		
Trf.No3	175			3.3		
(Total)				9.3		(45%Up):13.5MVA
11kv Feeders						
02	50			0.9		
03	133			2.5		
04	128			2.4		
05	93			1.8		
06	84			1.6		
(Total)				9.2		

City Center SS　(12h 27)

Voltage (kv)　11kv : 10.5

	A	MW	MVAR	MVA	P.F(%)	Modifi.to Peak
Trf.(Incoming-11kv side)						
Trf.No1	640			11.6		
Trf.No2	630			11.5		
(Total)				23.1		(9%Up):25.2MVA
11kv Feeders						
C2	87			1.6		
C3	220			4.0		
C4	230			4.2		
C5	280			5.1		
C6	100			1.8		
C8	230			4.2		
				20.9		

[Apr.2 (Tu)] Fig.4.2- 5(2)

Factory Zone 3 SS (10h)
Voltage (kv) 33kv: 11kv: 11.5

	A	MW	MVAR	MVA	P.F(%)
Trf.(Incoming-11kv side)					
Incoming		7.0	5.0	8.6	81.4

Factory Zone 1 SS (10h 30)
Voltage (kv) 33kv: 33.0 11kv: 11.5

	A	MW	MVAR	MVA	P.F(%)
Trf.(Incoming-33kv side)					
Incoming	150			8.6	

Mikocheni SS (12h 15)
Voltage (kv) 33kv: 11kv: 11.5

	A	MW	MVAR	MVA	P.F(%)	Modifi.to Peak
Trf.(Incoming-11kv side)						
Incoming		9.5	4.4	10.5	90.7	(25%Up):13.1MVA

Oyster Bay SS (12h 30)
Voltage (kv) 33kv: 32.0 11kv: 11.0 Miko line: Off

	A	MW	MVAR	MVA	P.F(%)	Modifi.to Peak
Incoming-11kv side						
Trf.No.1	165	2.9		3.1	92.3	
Trf.No.2	170	3.2		3.2	98.8	
Trf.No.3	170	3.0		3.2	92.6	
(Total)		9.1		9.6		(45%Up):13.9MVA

Ubungo SS (Mar.25, 12h 00)
Voltage: 33kv: 34.0

	MW	MVAR	MVA	PF(%)	Modifi.to Peak
33kv Sub-Tra.Lines					
Wazo Hill 1	3.5				
Nordic	2.8				
Tazala	2.0				
Fz 3	8.5				
Textile	2.0				
WazoH.2(Miko,Mbez)	11.2				
Trf.No4(132/33kv)	17.0	13.0	21.4	79.4	
Trf.No5(132/33kv)	15.0	12.0	19.2	78.1	
Ilala 132kv T/L	56.0	44.0	71.2	78.6	
(Total)			111.8		(25%Up:14MVA)

Note:
Modification factor for peak time can be obtained from each daily load fluctuation curve.

Fig. 4.2-6(1)

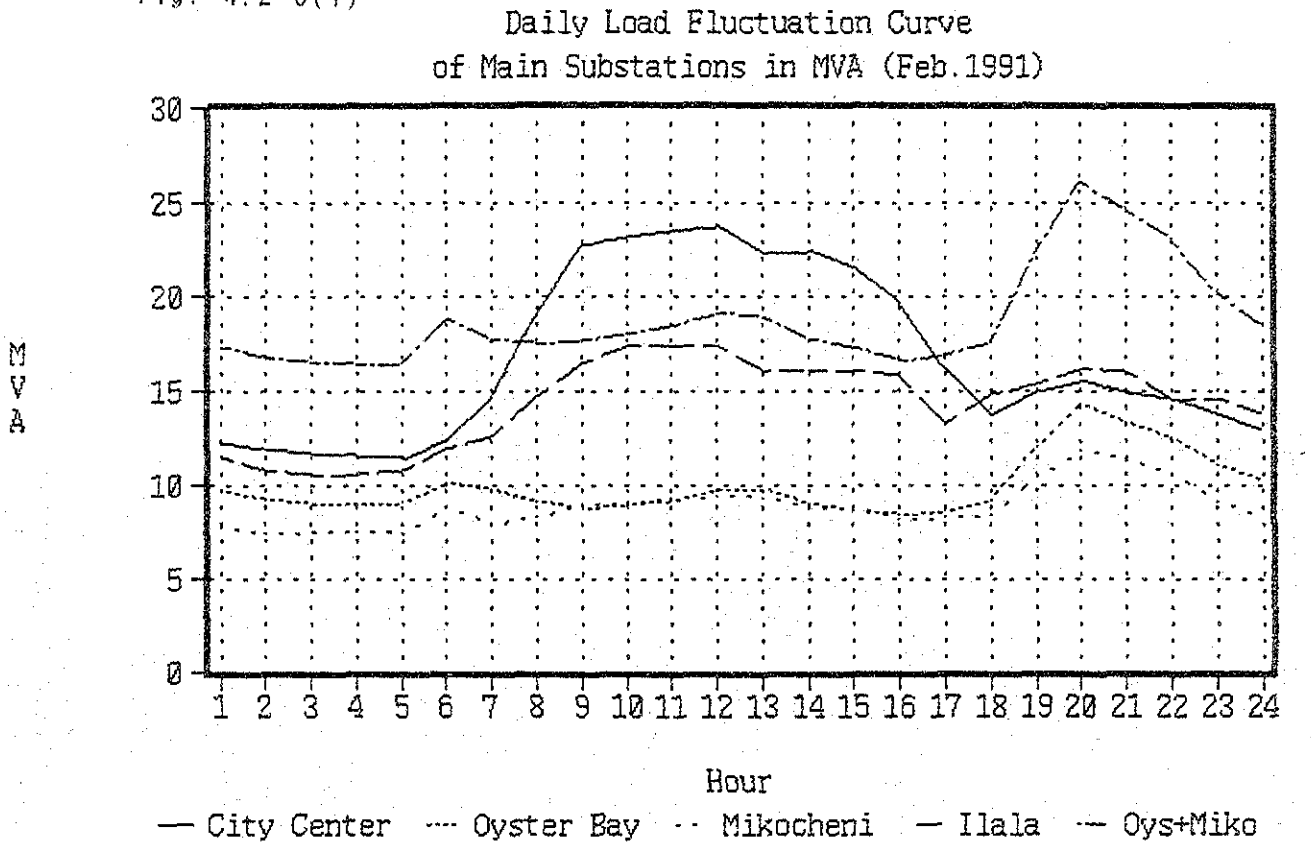

Daily Load Fluctuation Curve
of Main Substations in MVA (Feb.1991)
MVA
30
25
20
15
10
5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour
City Center
Oyster Bay
Mikocheni
Ilala
Oys+Miko

Fig. 4.2-6(2)

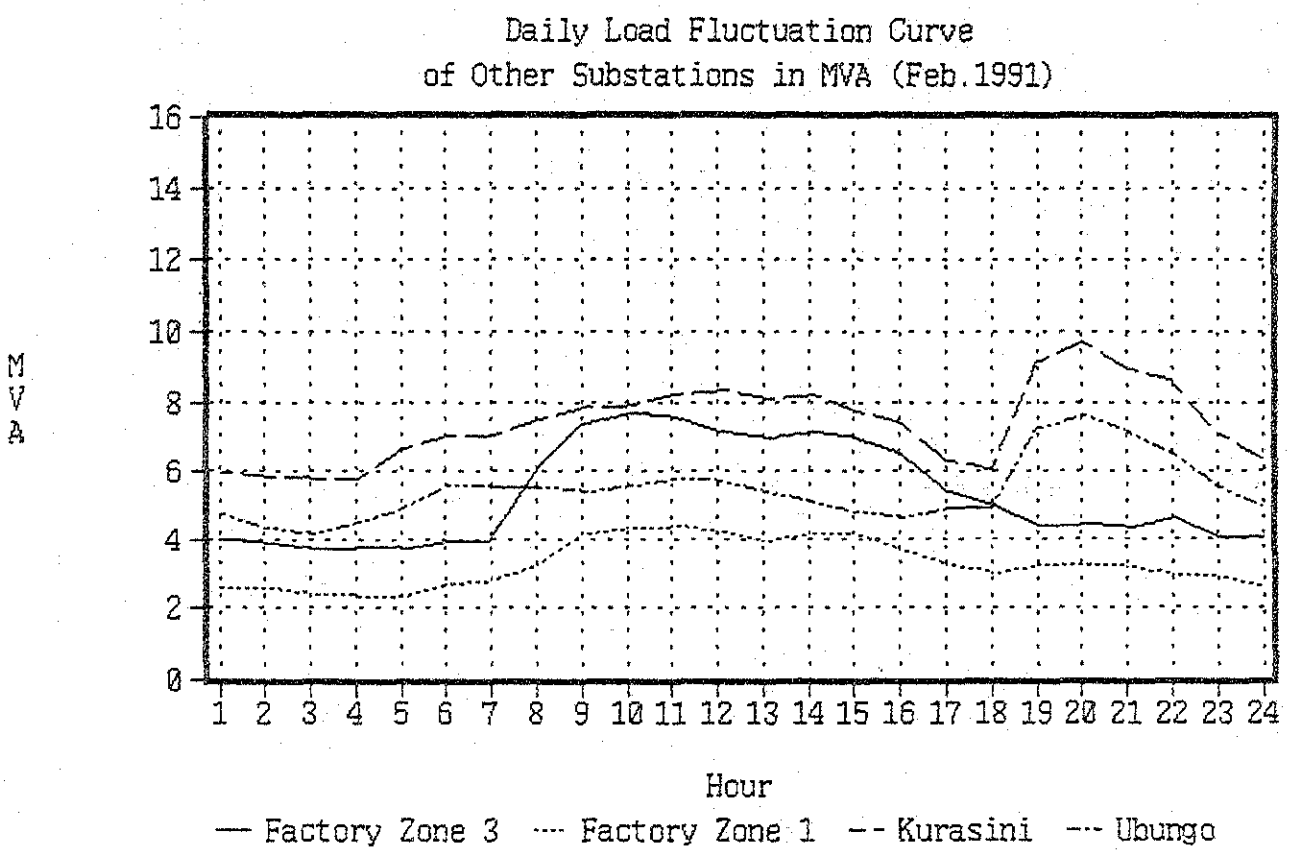

Daily Load Fluctuation Curve
of Other Substations in MVA (Feb.1991)
MVA
16
14
12
10
8
6
4
2
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour
Factory Zone 3
Factory Zone 1
Kurasini
Ubungo

Fig.4.2- 7

Distributed Energy Data for DAR city & Distr.

	1987 GWh	1988 GWh	MW	1989 GWh	MW	1990 GWh	MW	1991 GWh	MW
Jan		52.4		50.1	95.9	49.3	101.7	55.6	104.4
Feb				48.7		46.9	97.3	51.0	102.9
Mar				52.3		51.0	106.0	57.7	106.5
Apr				50.0		47.9	92.3		
May				50.0		51.0	91.8		
Jun				47.1		50.0	103.2		
Jul				48.6		49.0	97.5		
Aug				48.9		46.2	95.6		
Sep				44.0		47.6	95.7		
Oct				46.2		52.7	99.0		
Nov				47.2		52.3	99.6		
Dec	51.5	51.9	96.2	50.5	103.6	55.2	104.0		
Total	559.6	576.6		583.6		599.1		Up to Mar.	
Increase(%)		3.0		1.2		2.7		11.6	

Average growth rate: 4.6 %

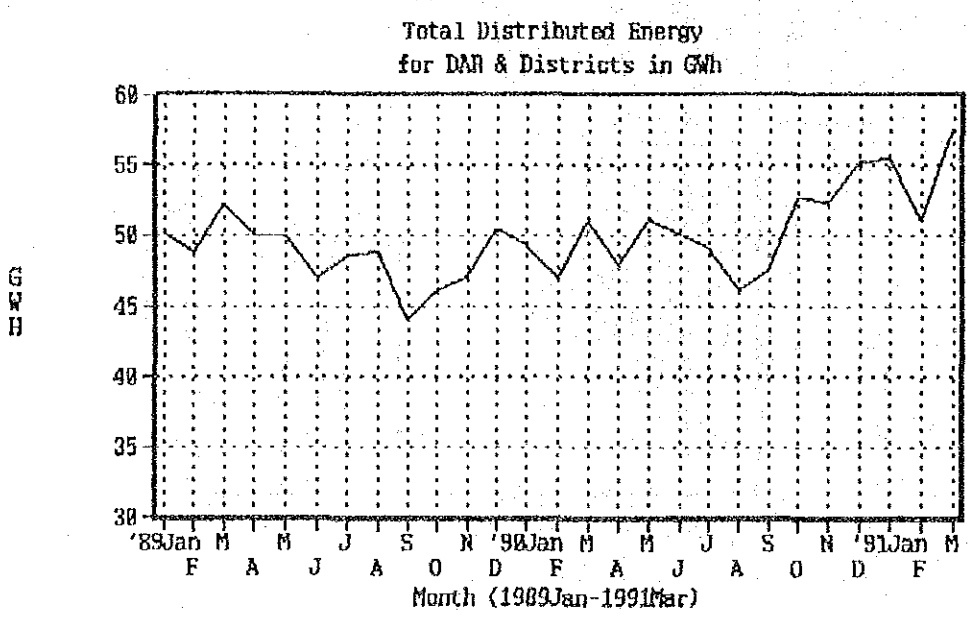
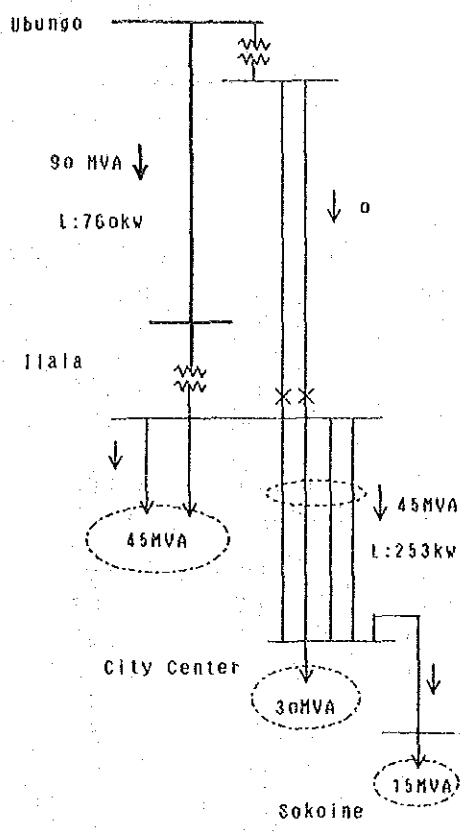


Fig.4.2- 8

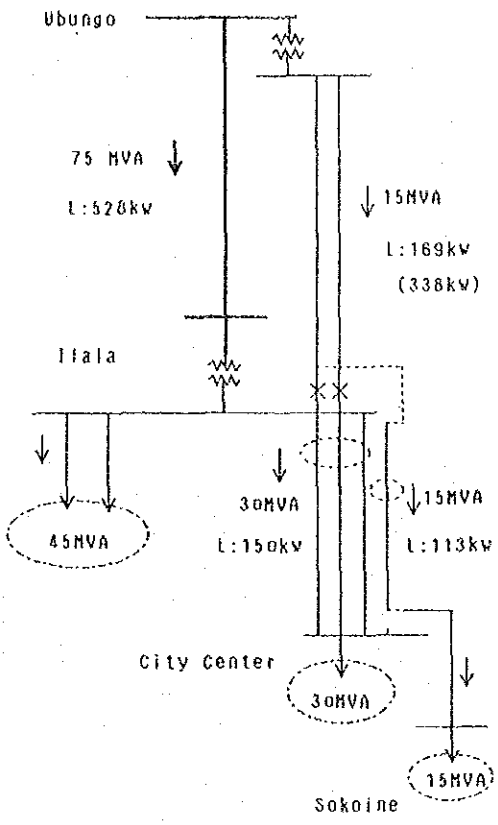
PLAN 1



Loss :

760+253 = 1013 kw

PLAN 2



Loss :

528+169+113+150 = 997 kw

(1166 kw)

Comparison of loss between Alternative 1 and 2
EPDC International Apr.,6,1991

Fig.4.2- 9

Loss comparison between Alternatives

For 150mm2 Al. X = 0.294 [Ohm/km] R = 0.218 [Ohm/km]

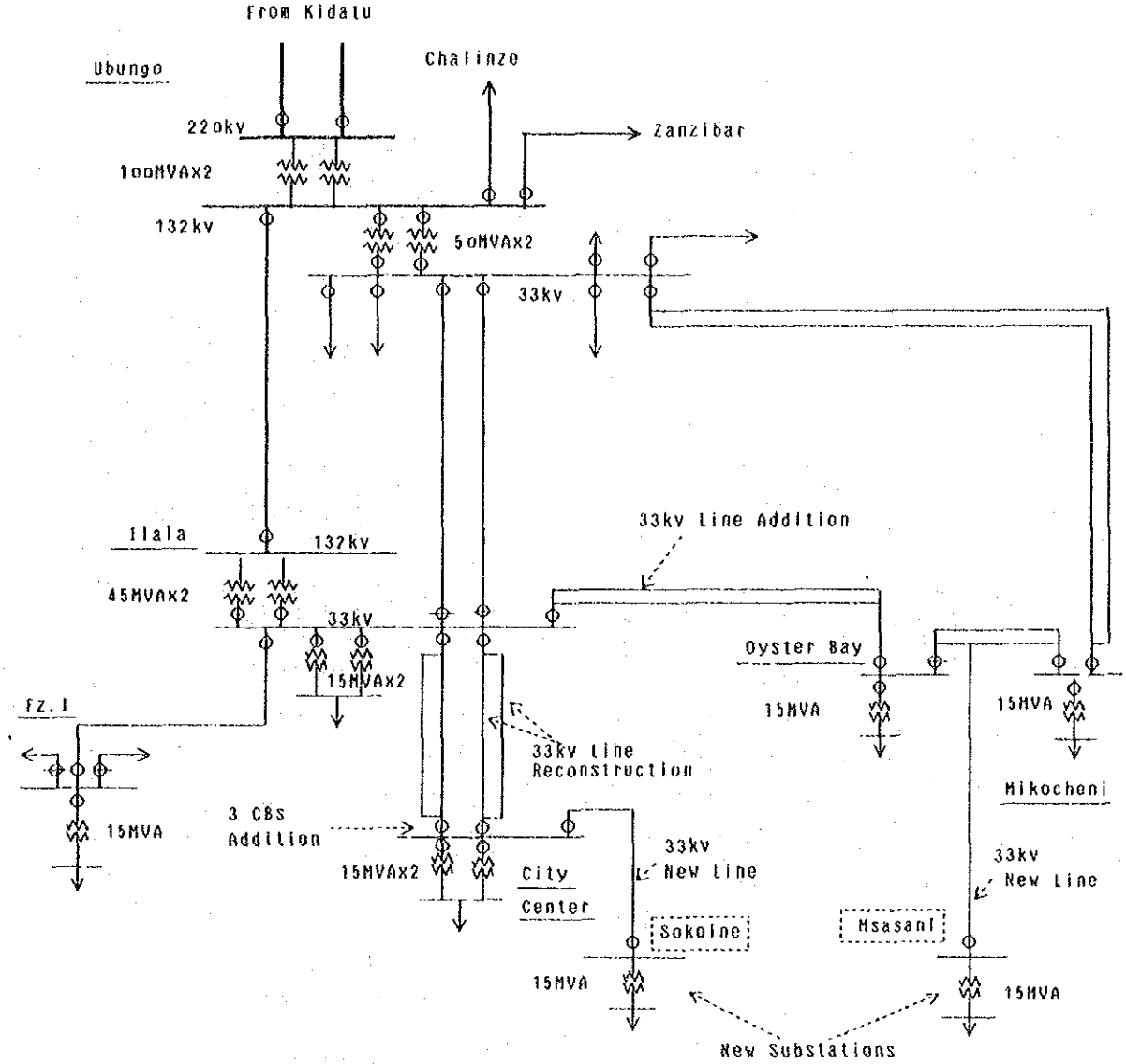
Plan I	*				*	
Plan II		*	*	*		*
(Plan II')		*	*/2	*		*

	132kvLine Ub-IIa 150mm2	132kvLine Ub-IIa "	33kv line Ub-IIa 150mm2	33kv Line IIa-CC 150mm2	33kv Line IIa-CC "x4	33kv Line IIa-CC "x3
Length [km]	7.5	7.5	7.5	2.5	2.5	2.5
X [ohm]	2.201	2.201	2.201	0.734	0.183	0.245
R [ohm]	1.635	1.635	1.635	0.545	0.136	0.182
Load [KVA]	90000	75000	15000	15000	45000	30000
P.F	0.85	0.85	0.85	0.85	0.85	0.85
Vr. [kv]	132	132	33	33	33	33
I [A]	394	328	262	262	787	525
V.Drop/phas	1004	836	669	223	167	149
V.Drop [V]	1738	1449	1159	386	290	258
Vs. [v]	133.74	133.45	34.16	33.39	33.29	33.26
V.Drop [%]	1.30	1.09	3.39	1.16	0.87	0.77
Load [KW]	76500	63750	12750	12750	38250	25500
Reac.P[KVAR	47410	39509	7902	7902	23705	15803
Loss [KW]	760	528	338	113	253	150
Loss [%]	1.0	0.8	2.6	0.9	0.7	0.6

		Loss(kw)	Power(kw)	Loss(%)
Loss of Plan I	760 +253 =	1013	76500	1.32
Loss of Plan II	528 +338 +113 +150=	1166	76500	1.52
(Plan II')	528 +338/2 +113 +150=	997	76500	1.30

Result of loss comparison : Almost same.

Fig.4.2- 10



Power Distribution Network System Configuration
Apr.,6,1991 EPDC International

Fig.4.2- 11(1)

Calculation of Voltage Drop & Loss for Msasani Load

1)33kv Side

Conductor: Al 150mm2		Formula
d ConductorDia[mm]	18	
D LineDistance[mm]	1670	μ ↓
L [mH/km]	0.796	0.05*0.61+0.4605*Log(D/d/2)
x [Ω/km]	0.250	2*3.14*f*L/1000
r at20℃ [Ω/km]	0.194	
r' at60℃ [Ω/km]	0.224	r*(1+0.0039(60-20))

Section	Oys-Msa	
l length [km]	6.0	
X [Ω/Phase]	1.500	l*x
R [Ω/Phase]	1.346	l*r'
KVA load [KVA]	15000	
cosφ P.F of load	0.80	
Vr V.at SS[kv]	32	
I [A]	271	KVA/√3/Vr
Vd' Drop/phase [v]	535	I(R*cosφ+X*sinφ)
Vd Drop [v]	926	√3*Vd'
Vs V.at 1ry SS[v]	32.93	Vr+Vd/1000
Vd% Drop [%]	2.81	Vd/1000/Vs*100
P Power [KW]	12000	KVA*cosφ
Q Reac.Power[kVAR]	9000	KVA*sinφ
Loss [KW]	296	3*R*I^2
Loss% [%]	2.5	Loss/P*100

Fig.4.2- 11(2)

2)11kv Line Side

Conductor:	Al 100mm2				
d ConductorDia[mm]	14	14	14	14	14
D LineAveSpace[mm]	1240	1240	1240	1240	1240
l [mH/km]	0.796	0.789	0.796	0.789	0.789
x [Ω/km]	0.250	0.248	0.250	0.248	0.248
r at20℃ [Ω/km]	0.286	0.286	0.286	0.286	0.286
r' at60℃ [Ω/km]	0.331	0.331	0.331	0.331	0.331

Section	Oys-Msa	Mik-Msa	Msa-Load1	Msa-Load2	Msa-Load3
l length [km]	6.0	8.0	1.0	2.0	3.0
X [Ω]	1.500	1.982	0.250	0.495	0.743
R [Ω]	1.984	2.645	0.331	0.661	0.992
KVA Load [KVA]	7500	7500	4000	7500	3500
cosφ P.F of Load	0.80	0.80	0.80	0.80	0.80
Vr V.at SS[kv]	10.5	10.5	10.5	10.5	10.5
I [A]	412	412	220	412	192
Vd' Drop/phase [v]	1026	1363	91	341	239
Vd Drop [v]	1776	2361	158	590	413
Vs V.at 1ry SS[v]	12.28	12.86	10.66	11.09	10.91
Vd% Drop [%]	14.47	18.36	1.48	5.32	3.79
P Power [KW]	6000	6000	3200	6000	2800
Q Reac.Power[kVAR]	4500	4500	2400	4500	2100
Loss [KW]	1012	1349	48	337	110
Loss% [%]	16.9	22.5	1.5	5.6	3.9

Fig.4.2- 11(3)

3)Comparison of Loss

Sending Power : Max 15MVA

	Case 1 From Oys,Mik	Case 2 From Msa
Loss at 33kv side [kW]	0	296
Loss 11kv Side [kW]	1012 :FromOys	48 :No1Feeder
	1349 :FromMik	337 :No2 "
		110 :No3 "
Total Loss [kW]	2362	791
" [%]	15.7	6.9

Comparison:

Differnece at Full	1570	[kW]	
Energy Loss/annum	3869	[MWh]	Note: Avail.Factor 0.53
Income Loss assume	46	[MTSh]	12 TSh/kWh
" "	32	[M¥]	1 US$ = 202 TSh = 138¥

Note:

	Case 1	Case 2
Load [kVA]	15000	15000
33kv Line Section	no	Oys - Msa SS
" " Length [km]		6.0
11kv Line Section 1	Oys - LoadCenter	Msa - Load 1
" " Length [km]	6.0	1.0
" " Load [MVA]	7500	4000
11kv Line Section 2	Miko- LoadCenter	Msa - Load 2
" " Length [km]	8.0	2.0
" " Load [MVA]	7500	7500
11kv Line Section 3	no	Msa - Load 3
" " Length [km]		3.0
" " Load [MVA]		3500