5.1.2 Present State of Transmission Line Facilities

(1) Present State of Existing Transmission Line Facilities

1) Summary

The grid system of TANESCO is composed of 220 kV, 132 kV and 66 kV transmission lines. Electric power generated mainly hydro-electric power stations is transmitted to load center through these transmission lines. And 33 kV transmission lines are employed for power transmission to distribution substation and interconnection between distribution substations in Dar Es Salaam area. The existing line length as of February, 1993, is shown below for each transmission voltage.

- 220 kV transmission line: 1,602 km
- 132 kV transmission line: 1,220 km (including 38 km of submarine cable from Ubungo to Zanzibar)
- 66 kV transmission line: 131 km
- 33 kV transmission line: 125 km (only Dar Es Salaam area, including 33 kV distribution line to big consumers)

220 kV, 132 kV and 66 kV transmission lines are designed as single-circuit, and arranged in a radial configuration.

The power supply to Dar Es Salaam, which is the center of load in the grid system and is the capital of Tanzania, is provided mainly from Kidatu hydro-electric power station through a single-circuit transmission line. In this situation, a 220 kV single-circuit transmission line was planned to be constructed between Kidatu hydro-electric power station and Morogoro substation, and it commenced commercial operation in March, 1993.

This transmission line is routed in parallel to the existing 220 kV transmission line along a different route. The new transmission line has enabled the 2-circuit interconnection between Kidatu and Morogoro, and contributed to the increase in transmission capacity, the reduction of transmission loss, and the improvement of the power supply reliability.

In addition, another one circuit of 220 kV transmission line is being planned between Morogoro and Ubungo and route survey is under way. On the other hand, 33 kV transmission lines in Dar Es Salaam area are mainly constructed along main road.

2) Present State of Existing Transmission Line Facilities

In the 132 kV transmission lines from Ubungo to Ilala and from Ubungo to Zanzibar, aluminium conductor steel reinforced (ACSR) is employed as line conductor and glass-made suspension insulator is employed. The supports are guyed towers in straight section and self-supporting towers at angle points and dead-end.

The present state of each section is as shown below.

(a) Ubungo - Ilala

The outline of facilities in this section is as follows.

Transmission line length: 7 km
Supports: Self-supporting tower and guyed tower
Number of towers : 25
Line conductors : ACSR 150 mm2 (Wolf)
Insulators: 250 mm ball & socket type suspension insulators (glass-made)
- Tension insulator string : 10 discs
- Suspension insulator string: 9 discs
Width of right of way : 40 m

According to the field survey, the present state of each section in this district was as follows.

- Kigogo District (Between towers Nos. 6 and 7)

Towers are located in a swampy area, sugar cane and rapidly-growing tropical vegetation are growing under the line conductors.

These plants have grown to a height of approximately 2.5 - 3 m and the clearance to the line conductors has been reduced to approximately 3 m. The plants under the line conductors should be cut or trimmed as soon as possible.

These plants can grow further under favorable conditions, and in this situation, it is difficult to find out troubles in the lower part of steel towers during patroling. The sites of steel towers should be managed at least to ensure clear visibility of the ground at the foot of steel tower and at the rising of guys.

- Mburahati District (Between towers Nos. 13 and 14)

A private house is being built between towers Nos. 13 and 14 with an approximately 2 m distance from a line conductor. It is obviously located within the right of way of the transmission line, and a safe clearance from the line conductor may not be ensured depending on the height of the house. For the sake of the security of the transmission line and for the sake of the safety of inhabitants, it is necessary for TANESCO to conduct field inspection promptly and take adequate countermeasures.

Similarly to Kigoro District, tropical plants are growing in the swamp and the lower parts of steel towers and the rising of guys are invisible.

- Mburahati District (Observed from tower No. 11)

A private house is being built between towers Nos. 9 and 10 with an approximately 2 m distance from a line conductor. It is obviously located within the right of way of the transmission line, and a safe clearance from the line may not be ensured depending on the height of the house. For the sake of the security of the transmission line and for the sake of the safety of inhabitants, it is necessary for TANESCO to conduct field inspection promptly and take adequate countermeasures.

Since the right of way toward Ilala substation is passed through in a hill area with few trees, inspection during patroling seems to be easy.

- Manzese (Tip-Top)
  (Neighborhood of Mpakani Elementary School)

  Tower No. 17 is located near a part of the playground of the elementary school. The neighborhood is a hill area with few trees and plants.

  However, for the sake of the safety of children playing in the right of way, reinforcement of insulator strings and other countermeasures should be considered.

- UFI (Ubungo Farm Implement, Neighborhood of Tower No. 21)

  A fence is located in parallel to the line conductor at a distance of approximately 3 m. Although no safety problem is identified, the fence is suspected to be located in the right of way of transmission line, and confirmation by field survey is required.

  In the transmission line from Ubungo to Ilala, there is no signs of the breakage of insulators, rusting and corrosion of tower members, or other problems in terms of line conductors, insulator strings, overhead earth-wires, and steel towers. However, since the lower parts of guyed towers are extended to the ground, it is necessary to trim or cut plants in tower sites so that corrosion of the lower members of towers and the lower parts of guys can be inspected.

(b) Ubungo - Zanzibar

The outline of facilities in this section is as follows.

Line length	: 79 km (overhead: 41km, submarine: 38km)
Type of towers	: self-supporting towers
Line conductors	: overhead part: ACSR 150 mm² (Wolf)
Submarine part	: Cu 95 mm² (OF cable)
Insulators	: 250 mm ball & socket type suspension insulators (glass-made)

- Tension insulator string : 12 discs
- Suspension insulator string: 11 discs

Width of right of way: 40 m

The electric power to Zanzibar is supplied from Ubungo sub-station through this transmission line. A submarine cable is installed in the strait-crossing section. Therefore, salt contamination has been reported as follows on the insulators of overhead transmission line near the coast and on the cable heads .

- Hot-line cleaning of insulators is conducted once a year on the 10 towers located nearest to the coast due to heavy salt contamination on the insulators.

- Terminal Equipment of the Submarine Cable to Zanzibar

  The terminal equipment of the 132 kV submarine cable is located near the sea and suffers severe rusting and corrosion. Salt contamination on insulators is also severe, and insulator cleaning is conducted every month.

  The generation of corona is also severe, and cable bushing is almost always in the flashover condition. The problem is particularly severe in the dry season, when washing by rain can not be expected.

  In order to improve the situation, it is planned to relocate the terminal equipment of the cable to a site which is located about 1 km farther from the sea. While the existing submarine cable is OF cable, XLPE cable is planned to be employed in the part.

  The aid from Norwegian Government has been expected.

Despite the above problems in the transmission line from Ubungo to Zanzibar, no signs of the breakage of insulators, rusting and corrosion of tower members, and other problems were identified in the neighborhood of Tegeta, which is the project site of North Grid Station.

(c) 33 kV Transmission Lines

The outline of existing 33 kV transmission line facilities in Dar Es Salaam are shown in Table 5.1.2 (1)-1, and supports with one circuit and two circuits pole assembly are employed. Double conductor is also employed based on transmission capacity of lines.

Wooden poles are mainly used for supports, and 100 mm^2 and 150 mm^2 ACSR are mainly employed as line conductors.

The followings show supports, line conductors and insulators employed for 33 kV transmission lines.

- Supports : Wooden poles (eucalyptus)
  : Steel pipe pole (used in a part of city area)

- Line conductors : Aluminum Conductor Steel Reinforced (ACSR) 50, 100, 120, 150 mm^2

- Insulators : Suspension insulators, LP insulators, pin insulators

The 33 kV transmission lines can be classified as follows according to their roles:

- Power supply from Ubungo and Ilala substations to distribution substations.

- Interconnection among distribution substations.

- Power supply to big consumers (as distribution line)

3) Problems of Existing Transmission Line Facilities

The existing 132 kV transmission line facilities did not show problems of the corrosion of tower members, disruption of guys, irregularity of conductor sag, insufficient clearance due to the growth of trees, or the breakage of insulators. However, the following general problems were identified.

(a) Corrosion of the Foundation Members of Steel Towers

The main members in the lower parts of steel towers are extended into the ground and not protected by concrete at the ground level. Although the members near the ground level are protected by anti-corrosive coating, this coating is not expected to provide sufficient protection from corrosion for a long time. There is particular concern about the corrosion at the ground level. Therefore, the state of the lower members of steel towers should be checked by regular patrolling. For this sake, trimming or cutting of trees and plants in the tower sites should be conducted to ensure clear visibility.

(b) Right of Way

Right of way with a width of about 30 - 40 m have been secured for existing 132 kV transmission lines. However, in some section, houses are built within the right of way, and a safe clearance from a line conductor may not be ensured depending on the height of the house. These houses pose a problem of the security of the transmission line, as well as the safety of inhabitants. It is necessary to conduct field survey promptly in relevant locations and take adequate countermeasures for the safety of inhabitants.

(c) Problems of existing 33 kV transmission lines are:

- Tilting of supports (wooden poles) due to improper construction works or the influence of other works.

- Tilting of pin insulators and bending of arms due to unbalanced tension of conductors.

- Application to different voltages of same type of insulators (near Kigamboni S/S).

- Inadequate clearance for the trees under line conductors.

(d) Completion Reports

Generally speaking, completion reports include design condition of conductors, insulators, supports, foundation, construction cost, and construction term, and provides useful information for the following purposes:

- Information for repair works and branch works.
- Countermeasure study at the occurrence of problems.
- Planning, designing, and cost estimation of similar transmission lines.
- Coordination with other transmission line facilities (insulation design, lightning protection design, etc.)

As mentioned above, information concerning a transmission line facility is summarized in the completion report. Therefore, it is desirable to prepare these reports for each transmission line and make them readily available.

Even if these reports have not been prepared in previous projects, these should be prepared in future projects.

4) Fault Records due to Salt Contamination

Faults of transmission lines due to salt contamination have been reported in the Grid System of TANESCO. The dropping of line conductors due to the pin corrosion of suspension insulators which is considered to be the most serious faults among these faults from the standpoint of the operation of transmission lines. Faults of this type are summarized as follows:

(a) Hale P/S - Chalinze - Ubungo - Ilala (132 kV)

This transmission line had commenced its operation in 1963. The outline of the facilities is as follows:

Supports	:	Suspension tower:	guyed towers
		tension tower :	self-supporting towers

Line conductors: wolf (British Standard Size)

Insulators : Suspension insulators (glass-made, Doulton, UK)

This transmission line facility have been operated without a trouble from commencement of operation to 1987. However, fault due to the dropping of line conductors occurred in 1978. In this fault, the line conductor dropped because of the the breakage of pins due to pin corrosion of suspension insulators. Pin corrosion was particularly serious in a section between Ubungo and Ilala, and all insulator strings in this section were replaced in 1978.

In addition, the insulator strings on all towers between Hale and Chalinze (535 towers, line length 175 km) were replaced in 1989.

Pin corrosion to some extent has been reported in the area of about 60 km extending toward inland from Ubungo. Severely corroded insulators were replaced in 1979, and all insulator strings in this section were replaced in 1992.

(b) Kidatu - Ubungo (220 kV)

This transmission line had commenced its operation in 1975. Dropping of line conductors due to the breakage of corroded pins of suspension insulators occurred in 1990, and the insulators were replaced with insulators having pins with zinc sleeves.

As summarized above, faults of transmission lines due to the breakage of the pins of suspension insulators caused by salt contamination have been reported in the area about 60 km from the coast.

At present, the measurement of salt contamination on pilot insulators is not conducted by TANESCO. However, because Dar es Salaam is located close to the sea, and as mentioned previously, dropping of suspension insulator due to pin corrosion in the existing 132 kV transmission lines is recorded, therefore, it is recommended to measure the level of salt deposit on pilot insulators to know the polluted condition of insulators used on the existing transmission lines. It can be judged that these accumulated data will contribute to the design of new transmission line in the future.

5) Theft of Tower Members

Theft of tower members, guys, etc. may directly lead to the collapse of towers. In order to prevent stealing of tower members, nuts used on towers have been punched so that tower members cannot be removed. However, collapse of towers due to the theft of tower members or guys occurs occasionally even at present. It can be considered that it is not possible to prevent these theft of tower members only by improving the assembly method of steel towers. Therefore, it is considered necessary to conduct PR activities toward inhabitants how important the transmission lines are.

A recent case of tower collapse is as follows:

Name of T/L	:	Shinyanga - Tabora Line
Voltage	:	132 kV
Tower No.	:	No. 35
Date	:	Jan. 8, 1993

6) Present State of Patrol, Inspection and Maintenance

(a) Patrolling

At present, in TANESCO, patrolling and inspection are executed in the following cases.

- Ordinary patrol/inspection conducted once in 3 months.
- After a transmission line fault.
- After heavy rain and storm.

Table 5.1.2 (1)-2 shows a form of patrol and inspection used by TANESCO at present.

(b) Maintenance

Fig.7.1.1-1 shows the organization chart of TANESCO related to the maintenance works of transmission lines.

The actual works are executed under the supervision of the engineers and supervisors at Shinyanga, Iringa, Tanga, and Morogoro Base.

The procedure of maintenance works defined by TANESCO is as follows:

(i) Occurrence of a transmission line fault.

(ii) Reporting from Control Staff (operator) to engineers and supervisors.

(iii) Dispatch of maintenance work team to the site of fault.

(iv) Confirmation of the state of line fault and execution of maintenance works.

The maintenance personnel in charge of transmission lines and those in charge of distribution line works belong to different divisions. In terms of the maintenance of lines, transmission line and distribution line divisions are separated completely from each other.

7) Right of Way and Compensation

The width of right of way of existing transmission lines for each line voltage employed by TANESCO is as shown below:

220 kV transmission lines ..... 60 m
132 kV transmission lines ..... 40 m
66 kV transmission lines ...... 15 m
33 kV transmission lines ...... 10 m

On the other hand, 30m-wide right of way is emploed for Morogoro-Ubungo 2nd Line (220 kV) which is being constructed.

Because all land in Tanzania is owned by the Government, there is no need for the compensation for the land in which transmission lines are constructed. However, compensation must be made for houses, fences, and crops in plantations, which are private properties.

8) Design Conditions

(a) Wind Load on Steel Tower

Various values of wind load on steel tower are employed in the design of towers of transmission lines, because consultants in charge of design used different design criteria. Accidents derived from the difference in design criteria, such as the collapse of a steel tower due to insufficient strength, have not been reported so far.

It is necessary to determine appropriate design criteria based on the climate data covering entire Tanzania and the present state of existing transmission lines.
And, following figures are employed as wind load on steel towers.

266 kg/m^2 ...... Kidatu - Morogoro Line
120 kg/m^2 ...... Shinyanga - Tabora Line

However, wind velocity of 35 m/sec (126 km/h) is applied in the Pangani Falls Redevelopment Project.

(b) Wind Load on Strung Wire and Insulator

Similarly to wind load on steel tower, various values are employed because of the same reason as mentioned in (a) above.

58.6 kg/m^2 ..... Shinyanga - Tabora Line (132 kV)
90.0 kg/m^2 ..... Hale - Tanga Line (132 kV)
57.5 kg/m^2 ..... Kidatu - Mufindi Line (220 kV)

72.0 kg/m² ..... Kidatu - Morogoro 2nd Line (220 kV) (for conductors)

87.0 kg/m² ..... Kidatu - Morogoro 2nd Line (220 kV) (for earthwire)

(c) Current Capacity (Ampacity)

Transmission capacity of comparatively short distance of transmission line is mainly decided based on the thermal capacity of conductors, that is, based on the continuous allowable current of conductors.

In case of the study of existing facilities, it is necessary to know the design condition at the construction time such as calculation condition of current capacity. However, in TANESCO, construction records of existing transmission lines are not prepared, therefore, the study of existing facilities will be done based on the data acquired in TANESCO as shown below.

Ambient temperature	:	35°C
Continuous allowable temperature	:	60°C
Solar radiation	:	0.1 W/cm²
Wind relocity	:	0.6 m/sec

Figures specified in JEAC-6001 (Regulation for Overhead Transmission Lines) are shown below for reference.

Ambient temperature	:	40°C
Continuous allowable temperature	:	90°C
Solar radiation	:	0.1 W/cm²
Wind velocity	:	0.5 m/sec

Calculation example of current capacity of conductors is shown in clause 5.3.1(3).

9) Supports

Existing transmission line facilities of TANESCO near and around Dar Es Salaam are classified as follows based on the shape of supports and number of circuit.

a. Ubungo - Ilala 132 kV Transmission Line (1 cct, horizontal arrangement)
   - Combination of self-supporting tower and guyed tower
     Dead end and angle tower: self-supporting tower
     Suspension tower : guyed tower

b. Ubungo - Zanzibar 132 kV Transmission Line (1 cct, horizontal arrangement)
   - self-supporting tower

c. 33 kV Transmission Line (1 cct and 2 cct arrangement)
   - Wooden pole
   - Steel pipe pole

In the 33 kV transmission lines, double conductor is also employed based on transmission capacity of lines.

10) Insulators

In the 132 kV transmission lines near and around Dar Es Salaam, 250 mm ball & socket type suspension insulators are employed. Almost all insulators installed in and around Dar Es Salaam are made of glass.

Dropping of conductors due to the pin corrosion of insulators have been reported in the area located near the sea. In particular, salt contamination on insulators is posing a problem in the coastal area of Ubungo - Zanzibar Line.

At present, hot-line cleaning of insulators is conducted once a year. However, it is recommended to confirm salt contamination using pilot insulators.

The following insulators are employed for 33 kV transmission lines in and around Dar Es Salaam.

- 250 mm suspension insulator (glass-made)
- Pin insulator
- Line post insulator

In the 33 kV transmission lines, no problem have been reported due to salt contamination on insulators.

11) Conductors

In the existing transmission lines of TANESCO, following conductors are employed for each transmission voltage.

a. 220 kV transmission Line
   - Bluejay (ASTM)
   - Bison (BS)

b. 132 kV Transmission Line
   - Hawk (ASTM)
   - Wolf (BS)

c. 33 kV Transmission Line
   - Wolf (BS)
   - Dog (BS)
   - Rabbit (BS)

ASTM: ASTM Standard, American Society for Testing and Materials, USA

BS : BS Standard, British Standards Institution (BSI), UK

Table 5.1.2(1)-3 shows specification of above conductors.

12) Fault Records

Based on power outage records due to line faults and due to planned works of 220 kV and 132 kV transmission lines, which are acquired at TANESCO, power outages which have influenced in Dar Es Salaam area are shown in Tables 5.1.2(1)-4 and 5.1.2(1)-5. The cause of power outage due to line faults is as follows.

- Earth fault
- Broken insulator

- Overcurrent
- Fallen tower

No cause of tower collapse was mentioned in the records, however, tower collapse is caused by:

- if, by theft of tower members, improvement of assembling method, and
- if, by other reason, study of design condition including foundation design, etc. will be required.

Table 5.1.2(1)-1 Existing 33kV Transmission Lines

No.	Line/Feeder Name	Length (km)	Conductor Type/size	Remarks
	A. From Ilala Substation			
1	City Center I	2.80	ACSR 100	
2	City Center II	3.90	ACSR 150	
3	Kurasini	7.10	ACSR 100/50/150	
4	Oysterbay	6.30	ACSR 150	
5	Factory Zone I	5.00	ACSR 100	
	Sub-total	25.10		
	B. From Ubungo Substation			
1	Alaf	9.24	ACSR 100	D/L feeder
2	Wazo I	19.30	ACSR 100	**
3	Wazo II	18.20	ACSR 100	
4	Tazara	7.85	ACSR 100	D/L feeder
5	Mikocheni	8.30	ACSR 100	
6	Factory Zone III	7.00	ACSR 120	
7	Friendship Textile II	7.50	ACSR 50	D/L feeder
8	Nordic	60.00	ACSR 100	D/L feeder
9	Mbezi	8.80	ACSR 100	Included in **
10	Ilala	7.50	ACSR 150	
11	Ilala	7.50	ACSR 150	
12	Kurasini	7.20	ACSR 50	
13	Kurasini	3.20	ACSR 150	
14	Kurasini	3.90	ACSR 100	
	Sub-total	166.69		
	C. Between Distribution Substations			
1	Factory Zone III - F.Z I	5.90	ACSR 100	
2	F.Z I - Kurasini	6.50	ACSR 120	
3	Mbezi - Wazo Cement	10.50	ACSR 100	Included in **
4	Michocheni - Oyster bay	5.30	ACSR 100	
5	Kurasini-Kigamboni	4.00	ACSR 100	
6	Factory Zone III-F.Z II	10.00	ACSR 100	
	Sub-total	42.20		
	Total	233.99		

Table 5.1.2(1)-2 Sample of Line Inspection Form

TANZANIA ELECTRIC SUPPLY COMPANY LIMITED

LINE INSPECTION FORM

Line Inspected ____________________ Line Voltage ____________________

Inspected by ____________________ Date Inspected ____________________

Tower Number					
Tower Leaning					
Missing Members					
Anti-Climbing Guard					
Missing Signs					
Foundation Problems					
Soil Erosion					
Insulators Broken					
Dampers					
Armor Rods					
Clamps and Fittings					
Hardware					
Staywires					
Preformed Grips					
Stay Rods					
Conductor Clearance					
Conductor Condition					
Skywire conditions					
Vegetation Condition					
Visible Corrosion					
Soil Condition					
Re. Corrosion Problem					
Access conditions					
Loose Ferrules					
Soil Erosion					

B/I ; Broken Insulator
D/C ; Damaged Conductor
P/A ; Poor Access
S/S ; Slack Stay
W/S ; Wet Soil Conditions
L/F ; Loose Ferrules

S/E ; Soil Erosion
T/L ; Tower Leaning
L/H ; Loose Hardware
L/D ; Loose Damper
S/T ; Soil Tests
P/C ; Poor Cond. Clearance

N/M ; Number Missing
M/S ; Missing Sign
V/C ; Corrosion
C/T ; Cut Trees

Table 5.1.2(1)-3 Specification of Conductors

Kind of conductors	Bluejay	Bison	Hawk	Wolf	Dog	Rabbit
No. and diameter of wires						
HAL (No./mm)	45/3.995	54/3.00	26/3.439	30/2.59	6/4.72	6/3.35
GN (No./mm)	7/2.664	7/3.00	7/2.675	7/2.59	7/1.57	1/3.35
Sectional area						
HAL (sqmm)	564.1	381.7	241.5	158.1	105.0	52.88
GN (sqmm)	39.02	49.48	39.34	36.88	13.55	8.814
Diameter						
HAL (mm)	31.96	27.0	21.78	18.13	14.15	10.05
GN (mm)	7.992	9.0	8.025	7.77	4.71	3.35
DC resistance at 20℃(Ω/km)	0.05119	0.07573	0.1196	0.1828	0.2733	0.5426

Table 5.1.2(1)-4 Power Outage due to Transmission Line Faults

No.	Line Section	No. of Outages	Outage Duration	Remarks
	(1990)			
1	220kV, Kidatu/Morogoro	6	5hrs.-56min.	
2	220kV, Morogoro/Ubungo	5	2hrs.-12min.	
	& 132kV Morogoro/Chalinze			
3	132kV, Ubungo/Zanzibar	6	5hrs.	
4	132kV, Ubungo/Chalinze	2	1hr.-7min.	
5	132kV, Ubungo/Ilala	1	1hr.-7min.	
	(1991)			
1	220kV, Kidatu/Morogoro	5	5hrs.-2min.	Earth fault, Distance Protection
2	220kV, Morogoro/Ubungo	2	3hrs.-3min.	Earth fault, Distance Protection
3	132kV, Ubungo/Chalinze	5	42hrs.-31min.	Broken insulator
4	132kV, Chalinze/Hale	8	2hrs.-48min.	Earth fault, Tripping relay
5	132kV, Chalinze/Morogoro	2	55hrs.-03min.	Fallen tower No.25
6	132kV, Hale/Kiyungi/Tanga	9	6hrs.-47min.	Over current, Fallen pole
7	132kV, Ubungo/Zanzibar	3	1hr.-33min.	Tripping relay
8	132kV, Ubungo/Ilala	2	0hr.-06min.	Over current

Table 5.1.2(1)-5 Power Outage on Transmission Lines due to Planned Works

No.	Line Section	No. of Outages	Outage Duration	Remarks
	(1990)			
1	220kV, Kidatu/Morogoro	1	4hrs.-50min.	Prior to SF6 CB replacement at Morogoro.
2	132kV, Ubungo/Zanzibar	4	30hrs.-29min.	Reactor reposition works at Ubungo.
		3	17hrs.-14min.	CVT check-up, replacement and servicing OCBs at Mtoni.
	(1991)			
1	220kV, Kidatu/Morogoro /Ubungo	4	25hrs.-53min.	Replacement of Delle Alsthom SF6 CB. with Siemens SF6 CB at Morogoro & Kidatu.
2	220kV, Kidatu/Morogoro /Ubungo	2	10hrs.-22min.	Installation of earthing clamps on 220kV bays and replacement of defective CVT at Singida.
3	132kV, Ubungo/Zanzibar	5	27hrs.-12min.	Replacement of lightning arresters at Ras Kiromoni, leaning of insulators at Ras Kiromoni. Maintenance works at Ras Fumba & Ras Kiromoni.

(2) Present State of Substation Facilities

Among the power supply facilities in Dar Es Salaam operated by TANESCO, substation facilities including the grid substation, secondary substation, and distribution substations were studied and the following facts were identified as the present state of these facilities.

Power supply to Dar Es Salaam City is assured through the 220 kV transmission line from the Substation with the Grid Substation Ubungo as the receiving point. A first local study executed in Jan.-Feb. 1993 has shown the following results.

1) Grid Substation (Ubungo)

Ubungo Substation receives electric power via a 220 kV single-circuit transmission line (2-circuit in 1994). This substation is equipped with electric power equipment consisting of single-bus 220/132 kV bank (capacity 150 MVA x 2 units), 132 kV split double-bus 132/33 kV bank (capacity 50 MVA x 2 units), 33/11 kV bank (capacity 15 MVA x 3 units). In addition, 8 units of diesel generators and a gas turbine generator are connected to the 11 kV single bus.

The load dispatching office and the control center are located at Ubungo. The former monitors the entire system by means of SCADA, while the latter monitors and controls the 220 kV, 132 kV, 33 kV, and 11 kV lines. The present equipment is a mixture of new units and old units with various modification. As for the type of substation, Ubungo is an ordinary outdoor type substation using tension bus type.

2) Secondary Substation (Ilala)

Ilala Substation receives electric power via a 132 kV single-circuit transmission line (2-circuit in future). It has electric power equipment consisting of single-bus 132/33 kV bank (capacity 45 MVA x 2 units) and 33 kV single-bus 33/11 kV bank (capacity 15 MVA x 2 units).

The load dispatching office of the distribution system is located at Ilala. It has SCADA equipment and monitors the entire distribution system.

3) Distribution Substations (9 substations including City Centre)

City Centre and most of other distribution substations receive electric power from 33 kV transmission lines via single-circuit lines or T branchs. Bank unit capacity is 5, 7.5, and 15 MVA in most cases. Electricity is supplied to individual loads via 11 kV distribution lines.

The present equipment is a mixture of new units and old units. As for the type of substation, these are ordinary outdoor type substations using tension bus type, and cubicles are used as 11 kV feeder in some substations.

4) Characteristics of Main Transformers

The electric power consumed in Dar Es Salaam is supplied by the grid substation, secondary substation, and distribution substations. Table 5.1.2(2)-1 shows the installed capacity and other technical characteristics of main transformers installed at these substations.

Table 5.1.2(2)-1 Characteristic of Main Transformers on each Substations 1/4

Name of Substation	UBUNGO	UBUNGO	UBUNGO	UBUNGO	UBUNGO	UBUNGO	UBUNGO
TR No.	TR 1	TR 2	TR 3	TR 4	TR 5	TR 6	TR 7
Manu-facturer		FULLER ELECTRIC	FULLER ELECTRIC	TELK	TELK	ASEA	ASEA
Nation-ality	INDIA	ENGLAND	ENGLAND	INDIA	INDIA	SWEDEN	SWEDEN
	1959	1959	1959	1970	1970	1970	1970
Capacity	15	15	15	50	50	150	150
H.V. (kV/A)	33	33	33	132	132	220	220
M.V. (kV/A)	—	—	—	33	33	132	132
L.V. (kV/A)	11	11	11	11	11	—	—
%IZ(HV/MV)	—	—	16.8	9.89	10.19	9.5	9.6
(HV/LV)	10.0	16.4	—	11.48	11.79	9.6	9.6
(MV/LV)	—	—	6.05	3.2	3.2	6.0	6.0

2/4

Name of Substation	ILALA	ILALA	ILALA	ILALA	CITY CENTRE	CITY CENTRE	CITY CENTRE
TR No.	TR 1	TR 2	TR 3	TR 4	TR 1	TR 2	TR 3
Manu-facturer	TAKAOKA	TAKAOKA	TAKAOKA	TAKAOKA	BONAR LONG&CO	BONAR LONG&CO	A/S NATIONAL IND.
Nation-ality	JAPAN	JAPAN	JAPAN	JAPAN	U.K.	U.K.	SWEDEN
	1987	1987	1987	1987	1979	1979	1980
Capacity	45MVA	45MVA	15MVA	15MVA	15MVA	15MVA	15MVA
H.V. (kV/A)	132/197	132/197	33/262	33/262	33/262.4	33/262.4	33/262
M.V. (kV/A)							
L.V. (kV/A)	33/787	33/787	11/787	11/787	11/787.3	11/787.3	11/787
%IZ(HV/MV)							
(HV/LV)	11.5	11.5	9.79	9.82	10.36	10.41	10.6
(MV/LV)							

3/4

Name of Substation	OYSTER BAY	OYSTER BAY	OYSTER BAY	FACTORY ZONE I	FACTORY ZONE I	FACTORY ZONE I	FACTORY ZONE III
TR No.	TR 1	TR 2	TR 3	TR 1	TR 2	TR 3	TR 1
Manu-facturer	BRYCE TRANSFORM	EB/NATIONAL IND.	BRYCE TRANSFORM	HACKBRIDG HEWITTIC	BRUSH TRANSFORM	BRYCE TRANSFORM	TAKAOKA
Nation-ality	U. K.	NORWAY	U. K.	INDIA	U. K.	U. K.	JAPAN
	1963	1988	1967	1972	1975	1963	1987
Capacity	5MVA	5MVA	5MVA	5MVA	5MVA	5MVA	15MVA
H. V. (kV/A)	33/87. 3	33/87. 5	33/87. 5	33/87. 5	33/87. 48	33/87. 3	33/262
M. V. (kV/A)	11/263	11/262	11/263		11/262. 4	11/263	
L. V. (kV/A)	3. 3/292	3. 3/97. 2	3. 3/292	11/262. 5	3. 3/168	3. 3/292	11/787
%IZ(HV/MV)	7. 59	7. 9	7. 23		7. 9	7. 64	
(HV/LV)	12. 8	4. 1	12. 0	7. 29	10. 9	13. 38	9. 82
(MV/LV)	3. 32	1. 1	3. 19		3. 91	3. 32	

4/4

Name of Substation	MIKOCHENI	MSASANI	SOKOINE	KURASINI	FACTORY ZONE II	KIGAMBONI	MBEZI
TR No.	TR 1	TR 1	TR 1	TR 1	TR 1	TR 1	TR 1
Manu-facturer	TAKAOKA	TAKAOKA	TAKAOKA	BONAR LONG&CO	BRYCE TRANS-FORMERS		
Nation-ality	JAPAN	JAPAN	JAPAN	U. K.	U. K.		
	1987	1993	1993	1979	1967	1970	1962
Capacity	15MVA	15MVA	15MVA	15MVA	5MVA	5MVA	7. 5MVA
H. V. (kV/A)	33/262	33/262	33/262	33/262. 4	33/87. 5	33/87. 5	33/131
M. V. (kV/A)					11/263		11/394
L. V. (kV/A)	11/787	11/787	11/787	11/787. 3	3. 3/292	11/263	3. 3/ -
%IZ(HV/MV)					7. 2		8. 09
(HV/LV)	9. 88	7. 5(*)	7. 5(*)	10. 34	12. 03	7. 3	13. 52
(MV/LV)					3. 18		3. 78

(*) shows under factory test

As shown by the above findings, most of the substation equipment in Dar Es Salaam has been introduced under various foreign aid programs, and expansion and improvement have been conducted beginning from older units.

Despite the crucial role in substation equipment, main transformers, except for some new units, also suffer oil leakage and other troubles due to frequent overload operation. In the future optimization of power supply facilities, sufficient study must be done in order to prepare plans that can ensure satisfactory performance for a long period.

5) Scale of Equipment

(a) Demand Density

The scale of equipment at distribution substations is as described in the section concerning the present state of existing equipment constructed based on the plans of TANESCO. As a method for analyzing these data, notable differences from generally accepted standard values should be improved so that optimized plans can be executed in future. The amount of electric power transmitted by distribution lines derived from distribution substations is shown in Table 5.1.2(2)-2, according to the data provided by TANESCO. The density of demand (kVA/km^2) calculated from the area of coverage is also summarized in the Table 5.1.2(2)-2.

Table 5.1.2(2)-2 Density of Demand (1991)

No.	Name of Substation	Density of Demand kVA/km²		Remarks	
		Max.	Mini.	Average	
1	Ubungo	499 469kW	210	309	pf=0.94
2	Ilala	4,319 4,060kW	63	1,978	
3	City Centre	10,102 9,496kW	1,011	4,310	
4	Oyster Bay	1,315 1,236kW	704	1,001	
5	Factory Zone I	1,590 1,495kW	935	1,267	
6	Mikocheni	1,290 1,213kW	244	716	
7	Mbezi	352 331kW	171	237	
8	Factory Zone III				
9	Kurasini	1,093 1,027kW	83	621	
10	Wazo Cement	—	—	—	

As long as shown by available data, the scale of 33 kV/11 kV substations that should be constructed in Dar Es Salaam is roughly considered to be as follows:

Density of Demand (kVA/km²)	Scale of Substation (MVA)	Final Installed Capacity (MVA)
10,000	3 φTr 15~20x3	45~60
3,000	3 φTr 20x2 15x3	40 45
1,000	3 φTr 10x3	30
100	3 φTr 5x2	10

If there is a large difference from the above values, more detailed study will be necessary.

2) Installed Capacity of 33 kV/11 kV Transformers at Distribution Substations

Table 5.1.2(2)-3 shows the installed capacity of transformers at distribution substations which have been constructed in Dar Es Salaam area at present.

Table 5.1.2(2)-3 Installed Capacity of 33kV/11 kV Transformers at Distribution Substations

Name of Substation and Customer	Capacity x Number of Transformers	Total Capacity
(Substations supplied from Ubungo S.S.)		
In the premises of Ubungo	15MVA x 3 units	45MVA
Oyster bay	5 x 3	15
Factory zone II	5 x 1	5
Mbezi	7.5 x 1	7.5
Factory zone III	15 x 1	15
Mikocheni	15 x 1	15
Sub-total		102.5
(Substations supplied from Ilala S.S.)		
In the premises of Ilala	15MVA x 2 units	30MVA
City Centre	15 x 3	45
Factory zone I	5 x 3	15
New airport	5 x 1	5
Kurasini	15 x 1	15
Kigamboni	5 x 1	5
Sub-total		115
(Large customers supplied from Ubungo S.S.)		
ALAF	10MVA x 3 units	30MVA
Wazo Hill	5 x 3	15
Friendship Textile	3.15 x 2	6.3
TAZARA	3.15 x 2	6.3
NORDIC	Unknown	
Sub-total		57.6
Total		275.1MVA

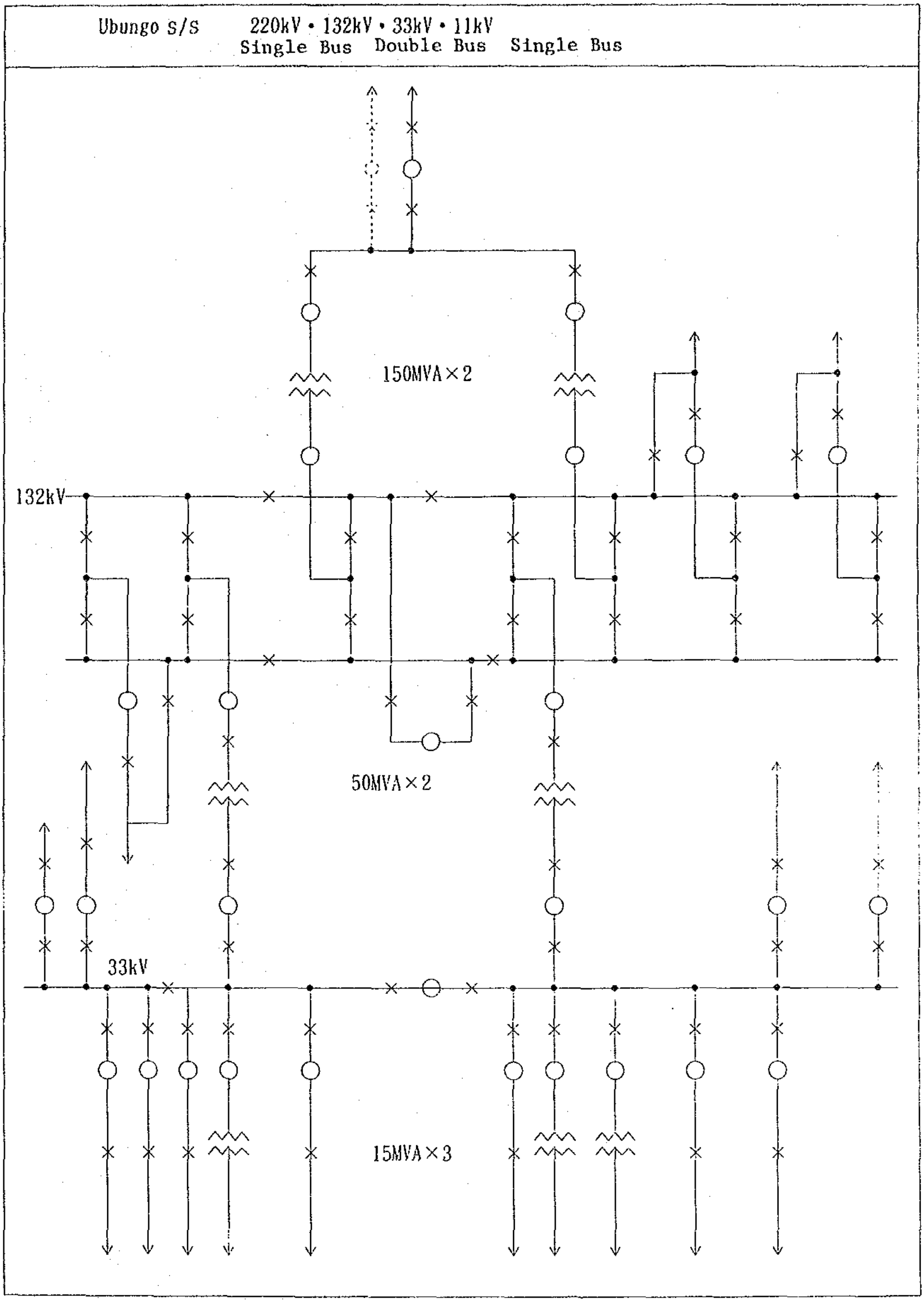
3) Form of Substation

The form of equipment at distribution substations that have been constructed in Dar Es Salaam area was studied. Equipment with 33 kV or larger capacity consists of feeder cubicles which are installed outdoors and containing 11 kV circuit breakers. Older units are "semi-outdoor" type installed indoors, and newer units are "outdoor" type installed outdoors.

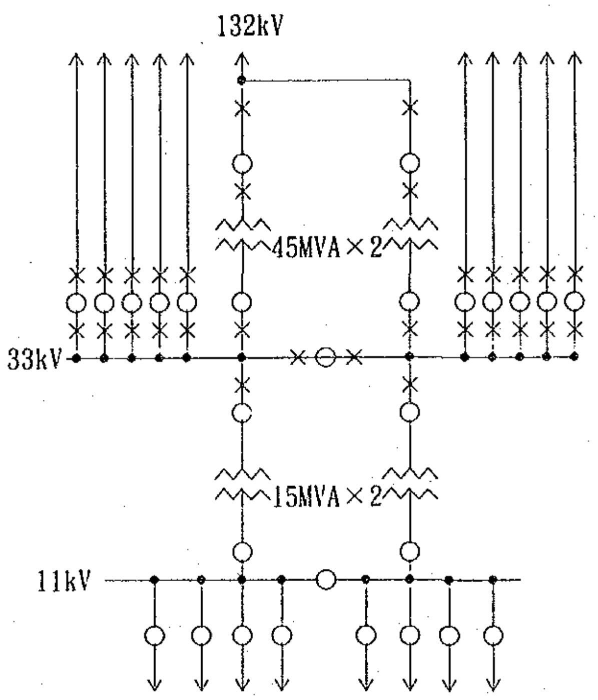
4) Buses and Method of Connection

The bus structures of outdoor switch yards at substations all consist of overhead tension buses. The method of the connection of main circuits used for each bus is shown in Fig. 5.1.2(2)-1.

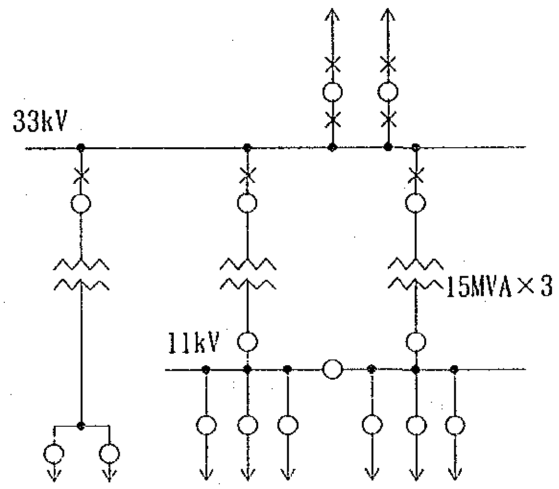
Fig. 5. 1. 2 (2)-1 Connection Diagram



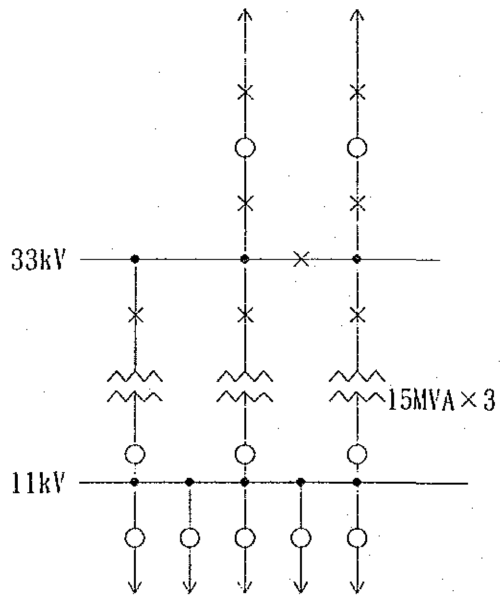
Ilala S/S — 33kV 11kV both Section Bus



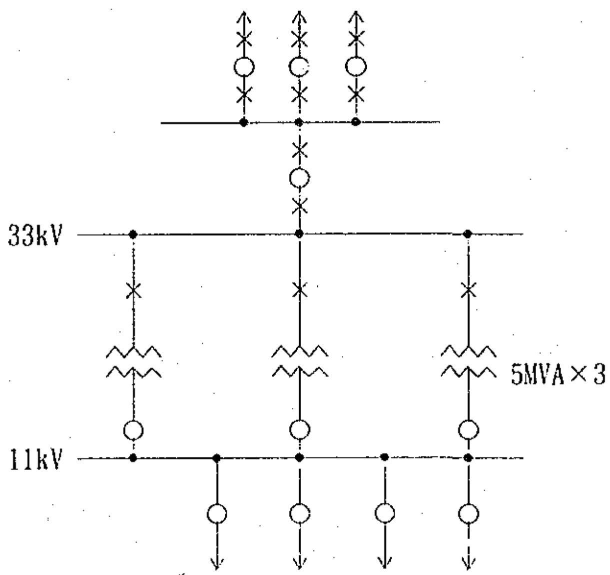
City Center S/S — 33kV Single Bus, 11kV Section Bus



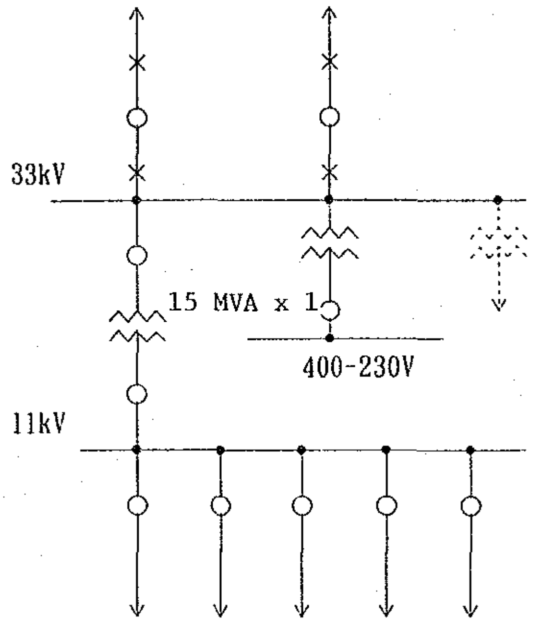
Oyster Bay S/S — 33kV Section Bus, 11kV Single Bus



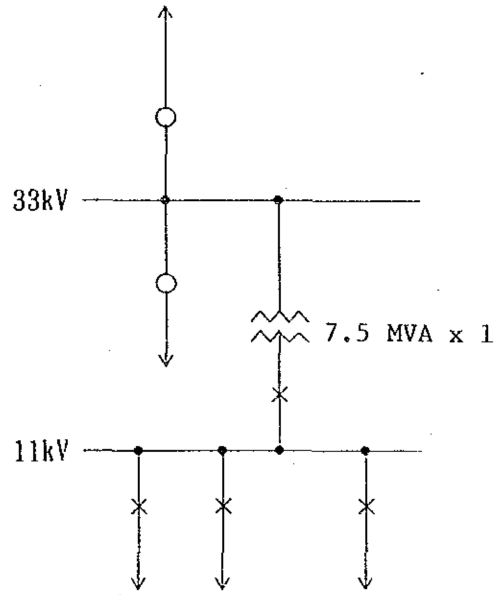
Factory Zone I S/S — 33kV・11kV both Single Bus



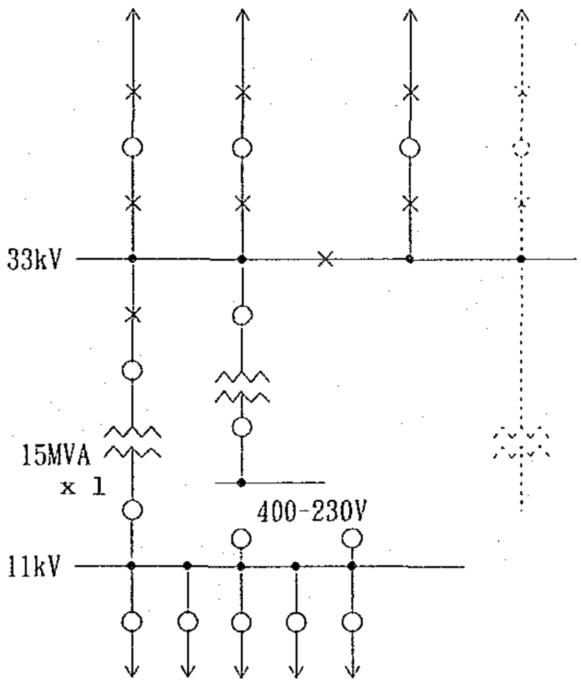
Mikocheni S/S — 33kV・11kV both Single Bus



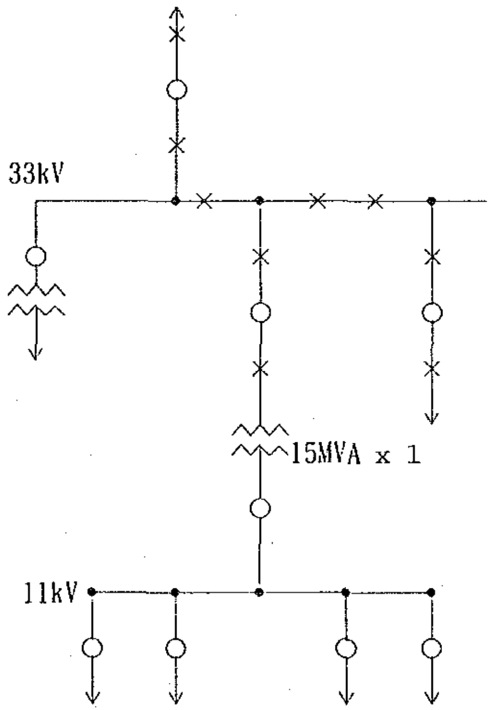
Mbezi S/S — 33kV・11kV both Single Bus



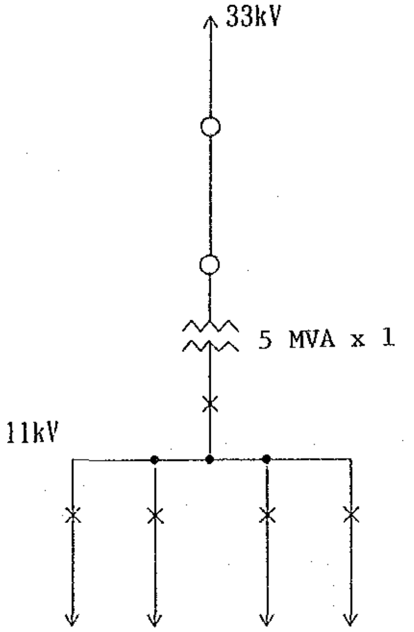
Factory Zone-Ⅲ S/S — 33kV Section Bus, 11kV Single



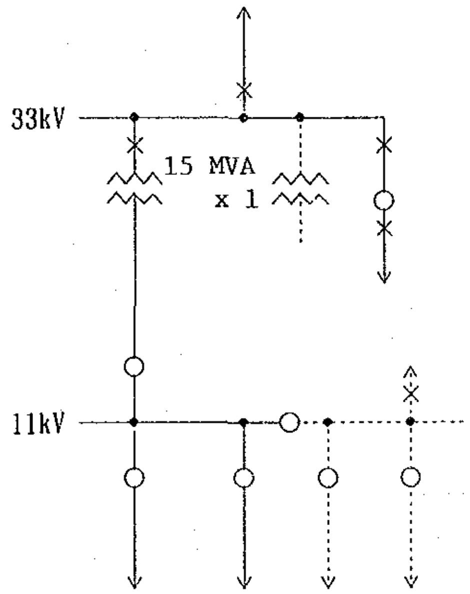
Kurasini S/S — 33kV Section Bus, 11kV Single Bus



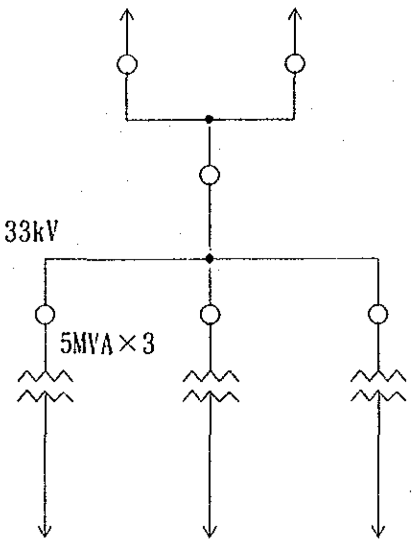
Factory Zone-II S/S 11kV Single Bus



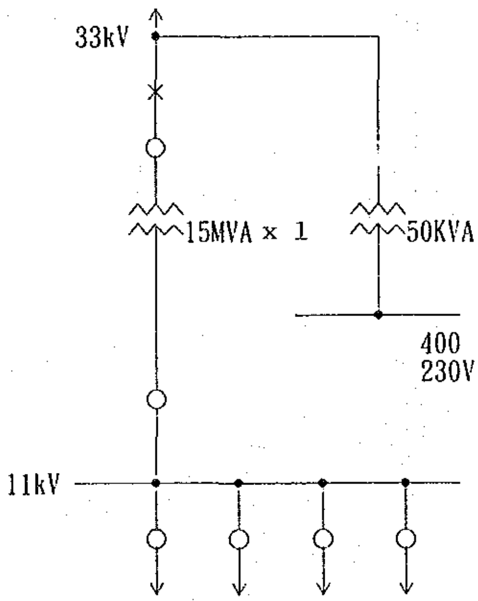
Kigamboni S/S 33kV 11kV Single Bus Section Bus



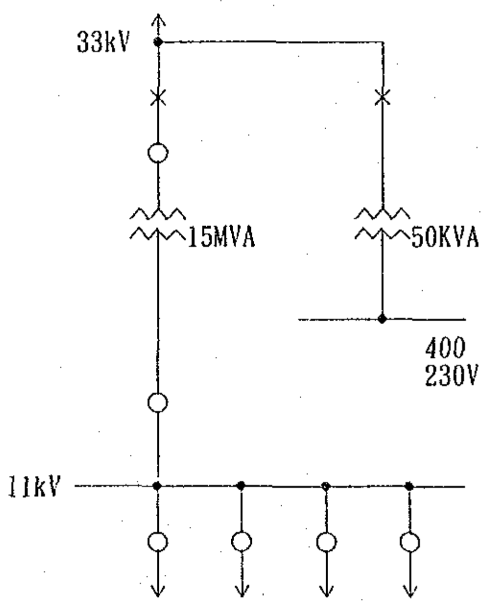
Wazo Hill S/S 33kV Single Bus



Sokoine S/S 11kV Single Bus



Msasani S/S	33kV・11kV Single Bus (both)	



(3) Present State and Problems of Distribution Line Facilities

1) 11 kV Distribution Lines

Although most of these lines are ACSR 100 mm2, ACSR 50 mm2 (5 cct) and Cu 25 mm2 (1 cct) are installed in some parts. In particular, Kunduchi Feeder of Mbezi S/S consists of 50 mm2 cables from the beginning to the end, despite the heavy load and long line distance (about 13.5 km). Because of this reason, this line is showing a voltage drop as large as about 1,900 V and a loss factor of about 11.5%.

A problem in the system configuration is the insufficient number of normally open section switches. As the result, effective interchange of power is prevented.

Reflecting the age of the structures, lead-in cables are occasionally made of PILC armored, rubber insulation, polyethylene sheath, or other types of 3-core cables. However, protection tubes are not used in the parts rising from the ground.

2) 11 kV and 33 kV Distribution Transformers

The distribution transformers operated by TANESCO have been assembled at TANELEC, a company operated jointly by Norway (National Industrie, Ltd.) and TANELEC. The parts are made in Norway.

Standard specifications are described as follows:

Max. primary voltage: 12 and 36 kV
Max. secondary voltage: 443 V with 100% neutral load
Tapping range: $\pm$2.5% for 15 and 25 kVA
Vector group : Yzn II for 50 - 100 kVA, 33 kV
Dyn II for above 100 kVA, 33 kV and 11 kV all ratings

Manufacturing and testing are specified to be conducted in compliance with IEC 76. Single-phase ratings are 15 and 25 kVA, and 3-phase ratings are 50, 100, 200, 315, and 500 kVA. These transformers are not for installation on poles but for installation on transformer stands. TANESCO does not use single-phase.

Equipment having a capacity of 200 kVA or more represents about 82% of all equipment (equipment with a capacity of 500 kVA represents about 23%). Thus, the present system is mainly based on transformers with large capacities.

3) Low-Voltage Distribution Lines (400/230 V, 3-phase, 4-wire)

Low-voltage cables used by TANESCO are produced in Tanzania by Tanzania Cables Ltd. according to 2 different specifications. One is "PVC INSULATED CABLES (NON-ARMOURED) TO B.S. 600:1975" TCL CODE 7011 non-sheathed general purpose (450/750 V) single core cable, and the other is TCL CODE 5122E PVC insulated, PVC sheathed (300/500 V), flat twin cable with earth continuity conductor.

Many of the installed cables are superannuated and involve many connections. Materials and methods used for connection are poor in quality.

Because of the use of large transformers, low-voltage lines have excessively long line distances. Although we cannot overlook the influence of the higher system including 11 kV feeders, the equipment on low-voltage lines is responsible for most of voltage fluctuation.

4) Form of Pole Assemblies

Various forms of pole assemblies are found. In summary, these are classified as follows and 11 kV facilities are in compliance with B.S. (British Standards) 1320 (1946).

1 Pin insulators supported by horizontal pole assembly
2 Line post insulators supported by horizontal pole assembly
3 Tension insulators supported by horizontal pole assembly
4 Side type support insulators supported by vertical pole assembly
5 Tension insulators supported by vertical pole assembly
6 Pin insulators supported by triangle pole assembly
7 Line post insulators supported by triangle pole assembly
8 Tension insulators supported by triangle pole assembly

5) Poles

Steel Poles: These are installed in some parts of City Centre area.

Wood Poles : These are installed in most 11 kV lines.

Generally, wood poles installed in the suburbs are warped and somewhat slender. Span is about 70 m.

6) Section Switches

Pole-mount isolating switchgear according to B.S. (British Standards) and vacuum switches supplied by Japanese governmental aid have been installed. These are used for the purpose of load shedding, which is exercised routinely, rather than the original purpose of section switches.

7) Grounding Works

1. Except for the pole assemblies for distribution transformers, supporting poles are not equipped with grounding works.

2. Grounding wires are installed along 33 kV lines. The metal parts of the pole assemblies are grounded via the grounding wires. (This method is reportedly the standard method of work in Ireland.)

8) Maintenance Services

We do not believe that organized services are conducted. The following situations are observed at many locations:

1. Sag of cables
2. Poor contact of cables (especially, neutral cables of low-voltage lines)
3. Tilting of poles (especially, 11 kV Kilwa Road Feeder)
4. Dirty insulators
5. Tilting of arms and line post insulators
6. Oil leakage of distribution transformers

7. Trees excessively close to bare wires and needing trimming, and creeper plants creeping around poles

Although these situations are reported by field workers, regional managers are not able to take adequate measures because of the lack of funds.

9) Trends in Distribution Plans

TANESCO tends to plan the construction of new substations without examining the ability of existing line capacities to cope with the increase in load and without conducting the necessary replacement of cables. Their plans sometimes lack sufficient data to confirm future increase in load. These problems should be addressed in future.

10) Actions

As measures against the problems described in the sections concerning the present state, future projects should include the use of insulated cables, the addition of section switches, the installation of protection tubes in the rising parts of cables, etc.

(4) Present state of telecommunication facilities

1) Distribution monitoring telecommunication facilities

(a) Present state of distribution monitoring telecommunication facilities

Dar Es Salaam city which is a part of the planned areas and its surrounding districts, consist of 300 MHz zone UHF radio circuits which connect the 10 distribution substations to the central Ilala substation in a radial pattern as shown in Fig.5.1.2(4)-1 Multiplex telecommunication are not applied to this radio system but a duplex operation type in which three frequencies are combined is applied to transmit feed maintenance telephone and SCADA signals.

- Down lines from Ilala substation to each distribution substation

  Load dispatching telephone and SCADA signals are transmitted via single 383.42 MHz circuit. (Of voice frequency band, 0 to 2000 Hz is for voice and 2000 to 3480 is for SCADA.)

- Up lines from each distribution substation to Ilala substation

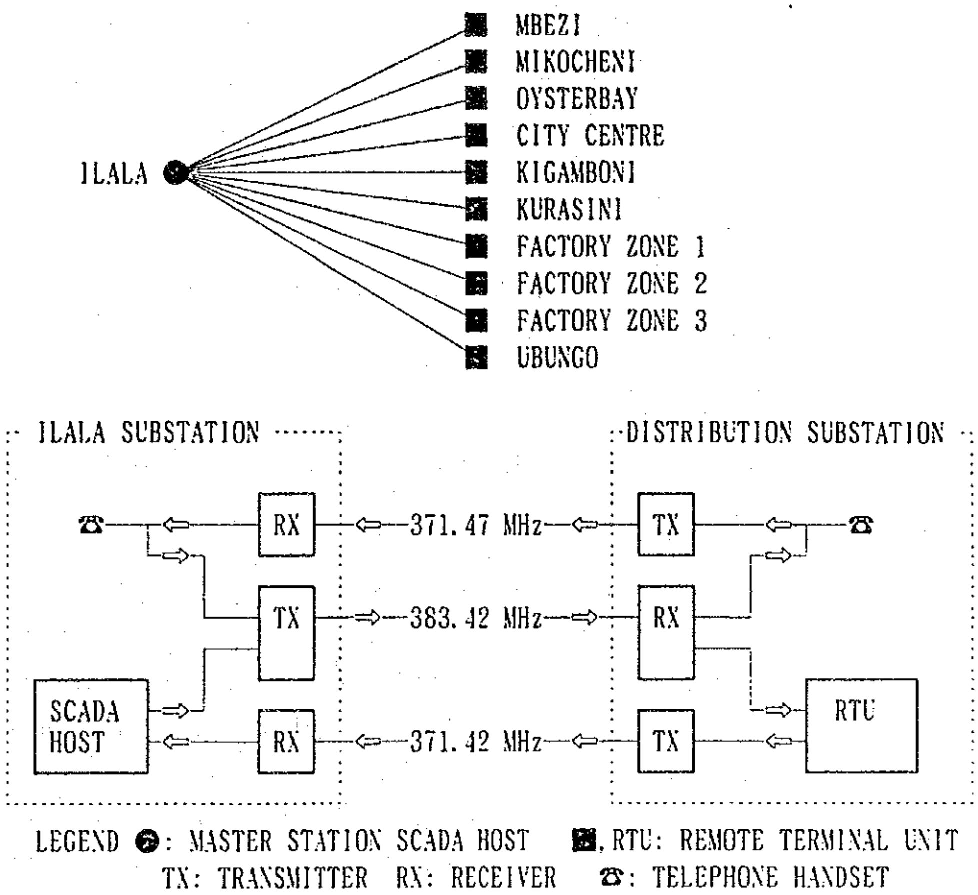
  371.42 MHz and 371.47 MHz two circuits are exclusively used to transmit load dispatching telephone and SCADA signals, respectively.

  Load dispatching telephone equipment are installed at Ilala load-dispatching office as well as at all distribution substations thus enabling communication between Ilala substation and each distribution substation and among those substations.

(b) Problems posed by distribution monitoring telecommunication facilities and review thereof

Presently, load dispatching telephone line is still a single circuit thus it is quite difficult to get in touch with other substations if certain substations are on the line. To improve it, it is desirable to increase the number of circuits because the lack of telecommunication circuits may take place in near future after construction of new distribution substations.

Fig. 5.1.2(4)-1 Distribution monitoring radio communication system



2) Distribution monitoring SCADA system

(a) Present state of distribution monitoring SCADA system

SCADA system is set up based on a computer and a master equipment which is located at Ilala substation. The master equipment is a polling type and receives at 600 baud the operating condition (circuit breaker ON or OFF state) and information on impeded equipment from RTU device of each distribution substation. Hence, at load-dispatching office, such measurement information as voltage, current, frequency or the like are not monitored, nor are they controlled. The number of slave stations which can be monitored by master station is limited to only 30 stations at the maximum. Accordingly, when installing RTU devices at newly constructed distribution substations, it is indispensable to increase number of seating or otherwise remodel the software. Manufacturer of the equipment is BBC and the whole SCADA system was set up collectively in 1987.

As for 33 kV facility of Ubungo substation, measurement values like voltage, current, frequency, power, etc. are recorded daily at noon time in the operation control room by the operator on the premises of Ubungo substation; hence the data can not be grasped at Ilala load-dispatching office.

(b) Problems posed by distribution monitoring SCADA system and review thereof

Such measurement values and operating conditions as are obtained from the facilities located on the premises of Ilala substation or the measurement values as are recorded for 33 kV facility at Ubungo substation are not inputted to this SCADA system. For this reason, comprehensive distribution system operation management is made quite difficult to conduct. While, on the other hand, the recording of the measurement values by the operator at each substation may cause efficient operation or correct grasp of power supply and demand to be impeded. Under the circumstances, it may inevitably be said that the SCADA system is out of proper function. It is indispensable to input the data of Ilala substation and Ubungo substation to the system, and in addition, such improvements as, for example, automated recording of the measurement values or the like are urgently needed for the system.

3) Grid system monitoring telecommunication system

(a) Present state of grid system monitoring telecommunication system

Nationwide monitoring of the grid system is undertaken by National Control Center located on the premises of Ubungo substation. Communication from National Control Center to each power station and substation is almost entirely performed via power line carrier-current circuits except for Ubungo to Ilala and Ubungo to Mtoni where radio communication is in use. The power line carrier-current equipment are mostly 2 CH type, and out of voice frequency band, 0 to 2000 Hz is assigned to voice and transmission line protection signals and 2000 to 3480 is to SCADA signals.

Feed maintenance telephone is made via the same carrier-current circuits as mentioned above, i.e. in common use with other daily business telephone among substations because of the lack of the circuits. Accordingly, at time of releasing load-dispatch instruction during the hours when lines are busy with ordinary business conversation, an interrupt is forcibly made by pressing a push button in the load-dispatching office.

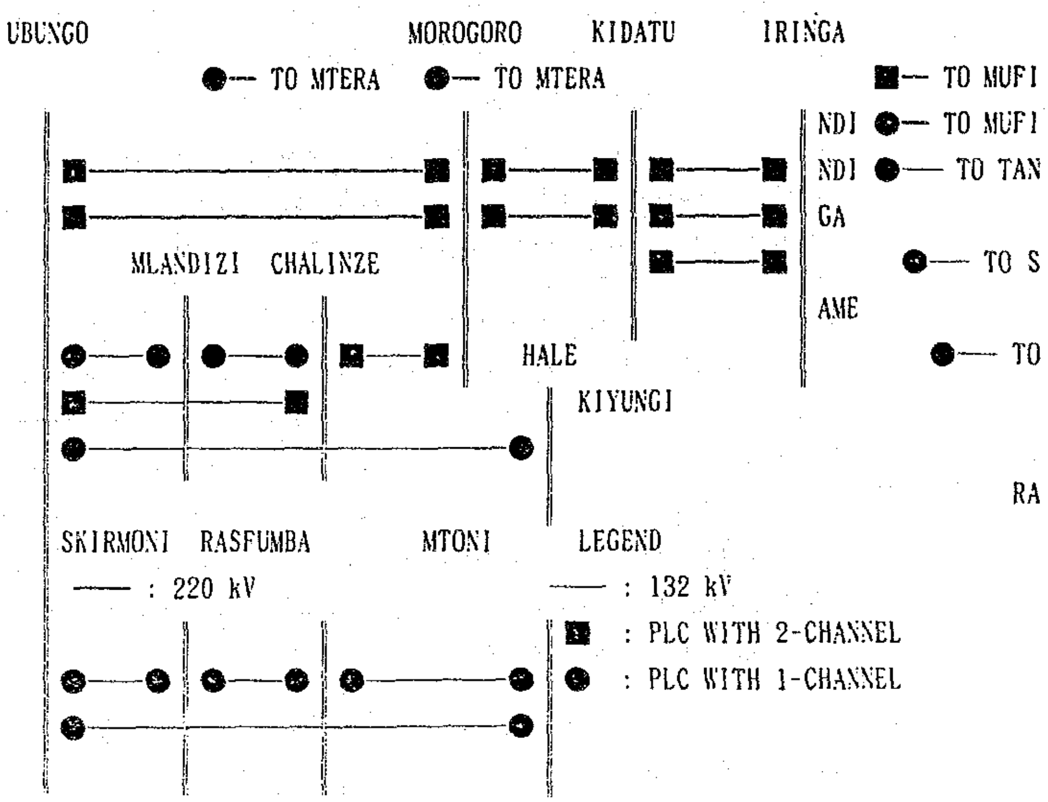
Fig.5.1.2(4)-2 shows summary of power line carrier-current telecommunication.

(b) Problems posed by grid system monitoring telecommunication system and review thereof

Because of the lack of circuits, as mentioned above, a single circuit is commonly used for voice, transmission line protection signals, and SCADA signals. However, since it may surely enlarge the influence at the time of telecommunication equipment failure or transmission line accident, it is indispensable to increase number of circuits so that adequate assignment that matches purpose of usage can be implemented. Also, it is desirable to provide a direct line to be exclusively used for load-dispatch instruction.

In future, it is likewise necessary, for proper control, to enhance the reliability of telecommunication circuits by adopting multi-route telecommunication lines or the like by using other measures than the power line carrier-current telecommunication.

Fig. 5.1.2(4)-2 Power line carrier-current telecommunication networks



4) Grid system monitoring SCADA system

(a) Present state of grid system monitoring SCADA system

SCADA system is set up by using a computer and a master equipment which is located at Ubungo substation. The master equipment is a polling type and receives at 200 baud such measurement values as voltage, current, frequency, power, as well as operating condition (ON or OFF state of power equipment such as circuit breaker, etc.) and information on impeded equipment from the RTU devices of each distribution substation. Display of measurement values and monitoring of operating condition are performed by the operator in the Ubungo load-dispatching office by using simulation monitor panel on the front face of instruction console as well as built-in CRT of the instruction console. Details of monitored data can also be printed out as necessary. The master equipment and RTU devices of this SCADA system are provided with remote control functions but these controls are not used presently.

The number of slave stations which can be monitored by master station is 68 at the maximum and the existing number of slave stations are 22. When adding more slave stations in future, it is necessary to increase number of seating or otherwise remodel the software on the side of master station. Manufacturer of the equipment is BBC and this SCADA system was set up in 1987.

Fig.5.1.2(4)-3 shows summary of the SCADA system

(b) Problems posed by grid system monitoring SCADA system and review thereof

As for grid system monitoring SCADA system, telecommunication circuits must likewise be increased in the same manner as mentioned in the previous section about telecommunication facilities so that a dedicated line can be assigned to SCADA signals thereby much enhancing the reliability.

Fig. 5.1.2(4)-3 Grid system monitoring SCADA system

UBUNGO MS SCADA SYSTEM	STATION	NUMBER
PS1 ●	■ PS1 MOROGORO, KIDATU	2-STATION
PS2 ●	■ PS2 IRINGA, MUFINDI, MBEYA	3-STATION
PS3 ●	■ PS3 MTERA, DODOMA, SINGIDA	3-STATION
PS4 ●	■ PS4 HALE, TANGA, SAME	3-STATION
PS5 ●	■ PS5 KIYUNGI, NJIRO	2-STATION
PS6 ●	■ PS6 MTONI	1-STATION
PS7 ●	■ PS7 ILALA, MLANDIZI, CHALINZE	3-STATION
PS8 ●	■ PS8 SHINYANGA, TABORA, MWANZA, MUSOMA	4-STATION
		21-STATION EXCEPT UBUNGO

LEGEND MS:MASTER STATION ●:PART SYSTEM FOR MASTER STATION
PS:PART SYSTEM ■:REMOTE TERMINAL UNIT

5) Mobile radio facility for maintenance of transmission and distribution lines

(a) Present state of mobile radio facility for maintenance of transmission and distribution lines

A duplex operation type 150 MHz band VHF radio circuit is provided between base station and each mobile station as shown in Fig.5.1.2(4)-1 in order to perform maintenance service of transmission and distribution lines in the vicinity of the planned areas.

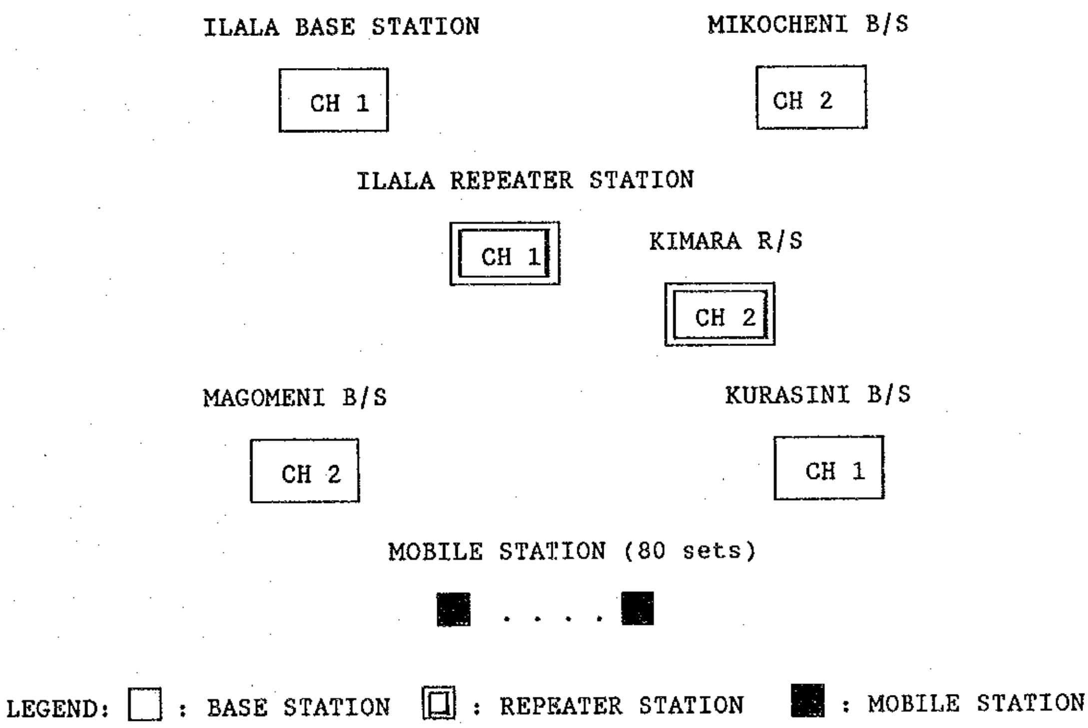
(b) Problems posed by mobile radio facility for maintenance of transmission and distribution lines and review thereof

This radio circuit poses such problems as:

1. A single circuit is commonly used with other departments; hence it often fails to undertake a lot of phone calls from many mobile stations.

2. Because of collective call requests, attention must always be paid to who is being called.

These problems usually cause work efficiency to drop or often result in obstructing other maintenance service telecommunication.



FREQUENCY CONFIGURATION WHICH IS ALLOCATED FOR TANESCO

	CH1	CH2	CH3
TX	157.700 MHz	157.675 MHz	157.725 MHz
RX	149.260 MHz	149.285 MHz	149.235 MHz

Table 5.1.2(4)-1 Mobile radio system for maintenance of transmission and distribution lines

(5) Present State of Protection System

1) Current Conditions

The protective relay systems which are currently used in the transmission and distribution systems in Dar Es Salaam City are as presented in the table below.

a) Protective Relay Systems of Transmission and Distribution Lines

	Primary Protection		Back-up Protection	
	Short	Ground	Short	Ground
22 kV Transmission Lines	DZ x 3(*1)	DG(*1)	OC x 3	OCG
132 kV Transmission Lines	DZ x 3	DG	OC x 3	OCG
33 kV Transmission Lines	OC x 3	OCG	-	-
11 kV Distribution Lines	OC x 2	OCG	-	-

*1: For the Primary Protection of 220 kV Transmission lines, a Carrier Relay System is used.

Notes: DZ : Shortcircuiting Distance Relay
DG : Directional Ground Relay
OC/OCG : Overcurrent/Overcurrent Ground Relay

b) Bus Protection Relay System

For the protection of buses at substations of Ubungo Power System, the differential voltage relay system is adopted for the 132 kV buses, and the overcurrent relay systems for 33 kV buses. For the bus protection of Ilala Secondary

Substation, the overcurrent relay system is used for 33 kV buses.

The bus protection of distribution substations, the overcurrent relay system is used for the 11 kV buses. The 33 kV buses are not protected by a bus protection system, but the buses are included in the protection zones of 33 kV transmission lines.

c) Transformer Protection System

Voltage	Electrical Protection							Mechanical Protection
	Short-circuit Fault			Ground Fault			Internal Fault	
	High-voltage Winding	Low-voltage Winding	Terti-ary Winding	High-voltage Winding	Low-voltage Winding	Terti-ary Winding		
220/132 kV	OC x 3	OC x 3	-	OCG	OCG	-	RDf x 3	Pr T(Winding, Oil)
LTC	-	-	-	-	-	-	-	Pr
132/33 kV	OC x 3	OC x 3	-	OCG	OCG	-	RDf x 3	Pr T(Winding, Oil)
LTC	-	-	-	-	-	-	-	Pr
33/11 kV (Over than 5 MVA)	-	OC x 3	-	OCG	OCG		RDf x 3	Pr T(Winding, Oil)
LTC	-	-	-	-	-	-	-	Pr
33/11 kV (Less than 5 MVA)	-	OC x 2	-	-	OCG	-	RDf	Pr T(Winding, Oil)
LTC	-	-	-	-	-	-	-	Pr

Note: RDf : Ratio Differential relay
Pr : Pressure relay
T : Temperature relay
LTC : Load Tap Changer

d) Conditions of Installation of Protective Relay System

At substation of Ubungo Power System and Ilala Secondary Substation, the protective relay rooms are provided with the temperature control systems and dust prevention measures. However, disorders such as damaged relay covers have been observed.

Although protective relay rooms are provided at distribution substations, there is no temperature control nor dust prevention measure is provided. The temperature inside the relay room was sometimes over 35°C, and dusts were accumulated on relay covers and the inside of relay boards.

2) Problems

a) There is no particular problem with the protective relay systems.

b) Concerning the conditions of installation of protective relays, temperature control and dust prevention measure is not provided at distribution substations, thereby exposing the relay systems to high temperature and dusts. Since Dar Es Salaam City is located near the sea coast, it is feared that the relays as well as their connections and terminal boards inside relay boards may be exposed to salt damage and other adverse effects.

3) Evaluation of Current Relay Systems

a) Protective Relay Systems of Transmission and Distribution lines

As we evaluated the collected data on the short circuit faults and ground faults on transmission and distribution lines, it was observed that these faults did not expand to serious system failures due to incorrect operations or failures of operation by improper setting of protective relay systems or protective relays. Therefore, it can be concluded that there is no problem with the protective relay systems currently used.

b) Bus Protection Relay Systems

The current protective relay systems can deal with faults occurring in substations, and there is no problem.

c) Transformer Protective Relay System

Concerning the transformer protective relay system, the current protective relay system can deal with the electrical faults (internal short circuit or grounding fault) and mechanical faults (temperature rise of winding or insulation oil, abnormal internal pressure), and there is no problem.

d) Conditions of Installation of Protective Relays

In order to protect the protective relays and in-board wiring from high temperature, dust and salt pollution in the protective relay rooms of distribution substations, such provisions as:

1) Sealing of openings to shut out salt and dust from outside.

2) Installation of air conditioning facilities to prevent high temperatures or temperature differences inside the rooms.

are required.

5.1.3 Review of TANESCO Plan

(1) Transmission Line Plan

1) General

Power stations are often located at remote areas from the place where power is actually consumed. Therefore it is necessary to transmit the generated power by transmission line.

The main function of transmission line is to transmit electric power to the place where power is actually consumed from hydroelectric power stations in mountainous areas or from thermal power station in urban areas. The transmission line also connects two substations i.e. interconnection among substations.

There are two kinds of transmission lines, overhead transmission line and underground transmission line. The overhead transmission line has several advantages, such as, low construction cost, high transmission capacity, easy to construct branch line, and easy to find the fault points. Underground transmission line has high reliability because it is not affected by the weather like thunderstorm, strong wind or snowfall. Also it does not affect the environmental appearance of the city where power is consumed.

The target district taken up in this master plan is Dar Es Salaam city and its surroundings, therefore it is particularly important to consider the following points at the planning stage of transmission line in the urban area.

a) The life span of the transmission line facility is some 30 to 40 years. Therefore it is difficult to change the location of the facility once it is constructed. When the facility is planned in the city area, it is necessary to consider the future city planning and road planning.

b) The overhead transmission line is exposed to the open air. In other words, safety clearance should be kept between the conductors and nearby buildings or trees for the safety reason inposing restriction on effective usage of urban districts. Safety measures for the residents are also indispensable.

c) Although the stable power supply is beneficial to our daily life, the transmission line facility is often taken as harmful to the natural environment and obstacle to the daily life of the people. In fact, construction of overhead transmission line affects the utilization of the land by:

- physically occupying a space needed for construction of supports
- restricting usage of area under the high-tension line.

Inspite of these disadvantages mentioned above overhead transmission line is used in the urban area because of the low construction cost and technical aspects. For this reason, employment of supports, which will match to the appearance of the city and will be accepted by the public, is recommended lately.

2) Review of TANESCO's Plan

The present state and problems of the planned transmission line route prepared by TANESCO are described hereunder.
(See Fig. 5.1.3-1 TANESCO's Transmission Lines Expansion Plan)

(a) Ubungo-Factory Zone III

As shown in Fig. 5.1.3-1, two transmission lines of 132 kV and 220 kV have to be constructed on the planned transmission line route, since the construction of 220 kV Morogoro - Ubungo 2nd Line is planned. (Route survey of 220 kV transmission line is under way as of September, 1993) Therefore, re-allocation of houses may be required in the going-out section from Ubungo substation.

In the hill area near point A, there is a hollow which was made by excavating earth during construction work of Morogoro Road, accordingly, the transmission line route should be selected so as to avoid this hollow, and re-allocation of houses may be required since houses are scattered in this area.

There also is Military Camp between Point A and Factory Zone III, the setting of center line to confirm the approximate transmission line length was executed by avoiding this Military Camp. Though swamp areas are indicated on the map acquired in TANZANIA, conditions such as water level in the rainy season was not confirmed because the setting of center line was executed in the dry season.

In Tabata area where ground condition seemed to be inferior, geological survey using cone penetrometer was executed, and survey results are shown in Table XXXXX.

According to the survey results, it may not be necessary to employ special foundation such as pile foundation for steel tower. And, in the paddy field area near Factory Zone III where ground condition seemed to be the worst area, no geological survey was executed due to the limitation of the period of field survey.

(b) Ubungo-Oyster Bay

Many houses are built along this planned line route, and there is a lowlands area called Valley through which a small river runs. It might be possible to construct the line along the river. However, it is inevitable to re-allocate a lot of existing houses. Accordingly, it is necessary to compare the construction cost and the cost of compensation for the re-allocation of the houses to draw the final conclusion. The problems posed by this area are:

- It may be difficult to connect an overhead line into Oyster Bay S/S because it is located at a corner of an intersection of high traffic streets inside the city. Accordingly, it can be considered that connection by overhead line will not be better selection. Also to obtain necessary spaces for overhead going-in line of 132 kV transmission line may not be easy.

- Cable termination facilities of underground cable is required near O.B substation when going-out from Ubungo S/S is overhead line and going-in to O.B S/S is underground cable. The possible candidate will be at a corner of Ada Estate.

- Accurate map which shows exact roads and houses of this area is not available. It is necessary to obtain informations from air photograph in order to save man power and time for route selection.

- The planned transmission line route runs along the river in Valley. The steel tower is planned to be constructed on the bank of the river. It may be necessary to reinforce the river bank in order to protect the tower foundation from flood and to employ the pile foundation despite high construction cost.

(c) Ubungo-Ilala

There are one circuit of 132 kV transmission line and 4 circuits of 33 kV transmission line in this section, and 40 m-wide right of way have been secured along these lines. However, houses are constructed within this right of way at some section.

Present situation and comments for the tower site of existing 132 kV transmission line are described below.

- Tower Nos. 10, 12, 13 are constructed at the bottom part of the Valley.

- Tower Nos. 2, 3, 4, 6, 7, 8 are constructed in the swap area.

- Other towers other than above are constructed in the good ground condition, however, tower No.16 is constructed in the cemetery so that careful attention should be paid at the selection of tower site for new transmission line.

Geological survey using cone penetrometer was executed at tower Nos. 2, 12, 13 and between 6 and 7, and survey results are shown in Table xxxxx.

At tower No.2, load bearing layer was not confirmed by the survey to 4 m-deep. Therefore, the employment of pile foundation can be considered for tower Nos. 2, 3 and 4 where these ground condition seems to be similar.

(d) Ilala-Oyster Bay

The planned route is the same as the route of existing 33 kV transmission line. 15-m-wide right of way underneath the line conductors is already secured from Oyster Bay S/S to Bazaar near Kinondoni, however, many temporary houses are built in this area. The area from Bazaar to Morogoro road is crowded with houses and even bus terminals are found, the right of way under the existing 33 kV transmission line is not obeyed. From Morogoro road to Ilala S/S, right of way is secured, therefore no problem will exist in this section. As stated above, to secure the right of way is not easy when overhead transmission line is constructed along the planned route.

Accordingly, following route can be considered as alternative plan:

- From Ilala S/S to Ada Estate (Ilala S/S--through Valley--crosses Morogoro road--through Valley again and crosses Morogoro road--through Valley close to Kisiwani--to Ada Estate).

  Problems posed by this route are that almost all supports will inevitably be constructed in Valley (swamp) so it is necessary to reinforce the bank against flood. In addition, since pile foundation may also be necessary, and the cost of construction will be higher.

- From Ilala S/S to Oyster Bay S/S (Ilala S/S--through Valley--crosses Morogoro road--through Valley again--to reach Morogoro road--along Morocco road--to (Oyster Bay S/S).

(e) (Ubungo-Zanzibar) - Mbezi

A steel tower for branch line will be constructed somewhere in between Ubungo substation to Zanzibar, and 132 kV transmission line is newly constructed from the branch point to Mbezi S/S. It seems that no problem will be posed, concerning the route to Mbezi S/S.

(f) Ilala-Kurasini

Houses are crowded near Ilala S/S. It may be difficult to construct overhead line in this area, but there still be left a possibility to build an overhead line after re-allocation of some houses. The existing 33 kV transmission line passes through the premises of factories located in industrial zone near the bay. It might be impossible to construct the 132 kV transmission line through the factory premises merely because TANESCO has planned so. Though it is difficult to concluded before conducting a site survey, alternative routes can be considered.

(g) F.Z III-South Grid Station

The point to be considered are;

- To pass crowded house area near F.Z III.
- To avoid passing off-limit zone of Dar Es Salaam International Airport
- According to the map, this area contains swamps, accordingly carefully select appropriate sites for construction of steel towers.

(h) South Grid Station - Mbagala

Proposed sites for South Grid Station and Mbagala S/S are still open space and have no problem at all. However, carefully select the sites for steel towers since there are a lot of swamps between the two points.

(i) South Grid Station - Kurasini

Much of the area is occupied with swamps. It is necessary to select appropriate sites for the construction of steel towers. To secure the right of way for the going-out lines from Kurasini S/S is also important.

(j) 33 kV transmission line

It can be considered that there is no serious problem for the planned 33 kV transmission lines, and outline of the routes is as follows.

i) Msasani Line (Oyster Bay S/S - Msasani S/S)

Phase III project is in progress so comments omitted.

ii) Sokoine Line (City Centre S/S - Sokoine S/S)

Phase III project is in progress so comments omitted.

iii) Kunduchi Line (Tegeta 132/33 kV S/S - Kunduchi S/S)

Tegeta 132/33 kV substation will be constructed near tower No.51 of Ubungo - Zanzibar 132 kV transmission line with the assistance of Norway Government. This 33 kV transmission line is constructed along the existing 132 kV transmission line. Accordingly, no problem will arise for securing the right of way, only one problem is a Valley-crossing between tower Nos. 52 and 53. The span length to cross this Valley is estimated to be approx. 150 m, so the employment of steel tower may be required.

iv) Mburahati S/S (to be branched from Ubungo-Ilala 33 kV transmission line)

The space for the construction is located at a corner of the presmises of an elementary school. The new route will pass under the existing 132 kV transmission line but there is no particular problems concerning the right of way.

v) Kariakoo Line (Ilala S/S - Kariakoo S/S)

In the going-out section between Ilala S/S and Uhuru Road, existing 33 kV transmission lines and distribution lines are constructed, so it is difficult to construct another 33 kV transmission line on the same route. Accordingly, the employment of underground transmission line is considered.
The width of Lindi Road, on the way to Kariakoo S/S, is narrow and there are many houses on both sides, PR activities may be necessary to the residents at the time of construction work.

vi) Chang'ombe Line (FZI - Chang'ombe S/S - Kurasini S/S)

This line is π-connected to new Chang'ombe S/S branched from FZI - Kurasini Line, so new line is to be approx. 2 km.
The road width at the section between factories near planned substation site is narrow, it seems difficult to secure the right of way.

vii) Tabata Line (to be branched from Ubungo - FZ III 33 kV transmission line)

Tabata S/S is planned to be constructed along the existing 33 kV transmission line from Ubungo S/S to FZ III S/S. No particular problems concerning to the line route may arise.

viii) Temeke Line (to be branched from FZ 3 - Kurasini 33 kV transmission line, South Grid Station - Temeke)

To be constructed on the residential quarters near South Grid Station. The problem will be posed as to cutting of the trees growing under the 33 kV transmission line between South Grid Station and Temeke S/S.

ix) Mbagala Line (Kurasini S/S - Mbagala S/S)

There is a railway at a going-out section from Kurasini S/S, and the span length of transmission line to cross this railway is estimated to be approx. 120 m, and the sea side ground level of railway is approx. 8-m lower than the level of railway, therefore, the height of supports (height to the lowest arm) is estimated to be approx. 17 m, and also, it is not recommended to employ supports with guy wire since there are many houses near and around planned point.
The place, where Kilwa Road and railway are crossed, is a Valley area and ground level is also lower than other part. Furthermore, the span length of transmission line to cross the Valley becomes longer so that the employment of steel towers to cross the railway and to cross the Valley near Kilwa Road can be considered.

x) Kitunda Line (South Grid Station - Kitunda S/S)

Almost all part of the route is an open unused land. The cutting of the trees growing under planned 33 kV transmission line will pose problems.

xi) Tandale Line (to be branched from Ubungo - Friendship Textile Line)

New transmission line is constructed along the existing road at the section between the branching point of existing 33 kV Friendship Textile Line and Tandale S/S, no problems concerning to the right of way may arise.

However, the conductor size used for existing 33 kV transmission line is 50 sqmm, replacement of existing line is required.

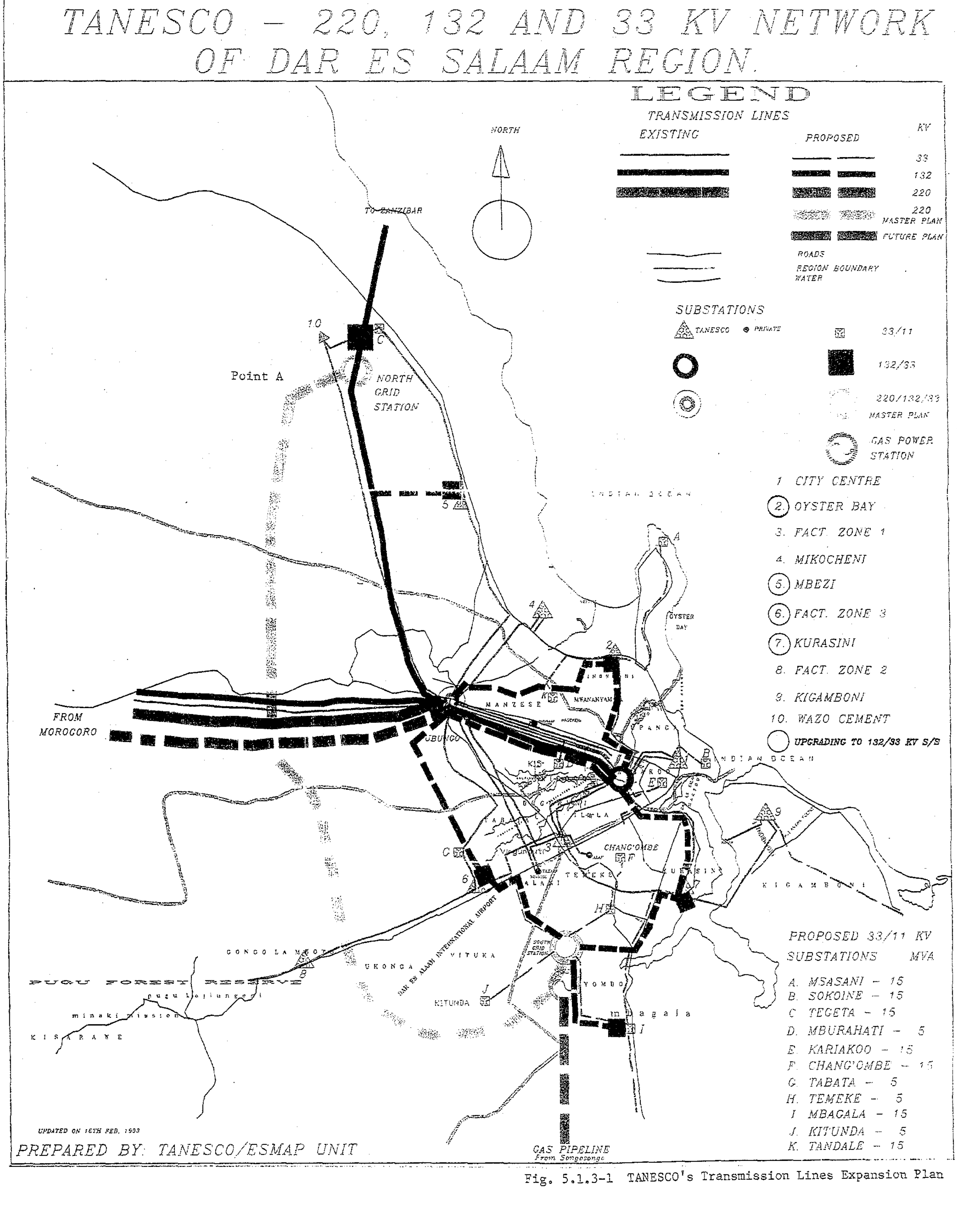


Fig. 5.1.3-1 TANESCO's Transmission Lines Expansion Plan

(2) Substation facilities

1) General

In the previous section, suggestions offered from TANESCO was discussed in detail. In this section, out of the summary of site survey in respect of the present situation of TANESCO's power facilities being made by JICA survey group, the items related to TANESCO's offer are enumerated, the problems are worked out and solved thus facilitating setting out the optimum plan which is hereafter discussed.

In Table 5.1.3(2)-1, the present situation of the substation facilities are shown as to problems concerning securing land for incoming distribution lines, possibility of expansion or improvement of the facilities in respect of the space available on the premises of the such station, and state of negotiation of the purchase of land for the construction of new substation.

Table 5.1.3.(2)-1 Site Survey of Existing Facilities for Substation

No.	Name of Substation		Items to be considered
1.	Ubungo	150MVAx2 220/132kV 50MVAx2 132/ 33kV 15MVAx3 33/ 11kV	TANESCO has purchased the land for the construction of 220 kV incoming 2nd line. Design of switching station is not completed yet but poses no problem. Oil leakage from many transformer is observed. Diesel engine Nos. 1,2,3,5,7 and 8 are operative but 6, 9 are inoperative. Space for 132/33 kV S/Y (switching station) is available but only for one line. SCADA is well maintained except control.
2.	Ilala	45MVAx2 132/33kV 15MVAx2 33/11kV	Space for further construction for 132 kV is available (almost satisfactory for S/Y). Panels are improved through modification, and becomes more better in future. SCADA is slightly poor compared to that of Ubungo but acceptable except control. CB can not be operated from panel and this is under improvement. There is a beer brewery and private houses next to substation. this may especially affect the transportation of materials and equipment for construction slightly.
3.	City Centre	15MVAx3 33/11kV	Nearly no extra space for expansion. It may be difficult to accept incoming line from Sokoine. It is better to use power cable or to move this station to other location for load transfer. The station is surrounded by many roads and buildings. The facilities are built 40 years ago.

No.	Substation Name		Items to be considered
4.	Oyster Bay	5MVAx3 33/11kV	Removal of houses will provide leading-in space for upgrading. 132/33 kV Tr.(transformer) and facilities pose no problem except for incoming transmission line. It will be better to construct a new S/S for load transfer. Foundation of the transformer is sinking. Future expansion may be impossible.
5.	Factory Zone I	5MVAx3 33/11kV	11 kV cable and cubicle are planned to be added and no problem are found. Oil leakage and noise from transformer are rather high.
6.	Factory Zone II	5MVAx1 33/11kV	Foundation of the transformer is sinking. Oil leakage from transformer is observed. There is a factory not in operation nearby but posing no problem.
7.	Factory Zone III	15MVAx1 33/11kV	Scheduled to be upgraded to 132/33 kV. Enough space is available for the construction, but power cables should be used for incoming line from transmission line.
8.	Mbezi	7.5MVAx1 33/11kV	Scheduled to be upgraded to 132/33 kV. Enough space is available. TANESCO provides the land.
9.	Mikocheni	15MVAx1 33/11kV	Enough space for expansion. The station is surrounded by many private houses.
10.	Kurasini	15MVAx1 33/11kV	Enough space for panel and circuit expansion. Oil leakage from transformer. Foundation of transformer is sinking. There is a plan to upgrade to 132/33 kV. TANESCO provides the land.
11.	Kigamboni	5MVAx1 33/11kV	No surrounding houses are founded thus no problem.

2) Securing the land for construction of substations

As to the space for expansion of existing substation is already discussed in the previous section in respect of site survey records. The land for the construction of new substations in TANESCO plan is now under negotiation. According to the information, all the land is national property in the Republic of Tanzania and no private land is allowed to possess in this country. This is an advantage to TANESCO in purchasing land for public use. As is in the current worldwide trend, the environmental problems become controversy day by day nowadays, and TANESCO is addressing the purchase negotiation with utmost care with fully taking it into consideration. Table 5.1.3(2)-2 shows site survey records in respect of such substations as are scheduled to be newly established.

Table 5.1.3(2)-2 Site survey records for newly established substation

	No.	Name of Substation			
Phase-III	1.	Sokoine	15MVAx1	33/11kV	Available space is narrow but no particular problems.
	2.	Msasani	15MVAx1	33/11kV	Enough space but coral soil causes hard construction works. No other problems.
Proposed	3.	North Grid (Tegeta)		--	Planning to construct the line close to the existing 132 kV line. Several private houses are found but no problem.
	4.	South Grid (Yombo)		--	Enough space with sandy soil. A large river runs nearby. It is necessary to check the level of the land, etc. There is a construction plan of gas turbine P.S (power station).
	5.	Kunduchi	15MVAx1	33/11kV	A land available (50 x 20 m) owned by TANESCO for construction site. For this evaluation, the plan is such that 11 kV distribution lines are doubled. Hence tertiary 11 kV should be drawn from Tr. of 132 kV S/S to be constructed or 33/11 kV Tr. must be installed at this substation.
	6.	Tandale	15MVAx1	33/11kV	Space is too narrow for Tandale but TANESCO provide the space of 30x30m through negotiation.
	7.	Mburahati	5MVAx1	33/11kV	The location is at a corner of the premises of an elementary school. Negotiation is already settled with 20x20m space but it must be increased to 30x30m. Mr. K.K. Iranga is in negotiation.
	8.	Kariakoo	15MWx1	33/11kV	The land is the site of a demolished and children's playground. Available space is 20x20m. (But it must be increased to 30x30m.) A few problems are posed for construction of high building.

	No.	Substation Name			
Proposed	9.	Chang'ombe	15MVAx1	33/11kV	No problem as to the space. Factories (radio, dry cell, tobacco) and Radio Tanzania is located nearby.
	10.	Tabata	5MVAx1	33/11kV	No problem as to the space. Survey is needed. There are small factories around.
	11.	Temeke	5MVAx1	33/11kV	Available space is 30x30m and no problem. There are apartments nearby. Pay attention to route of leading-in line.
	12.	Mbagala	15MVAx1	33/11kV	Sandy soil. Available space 30x30m is enough. Temporary market is open nearby. Development of industries is expected. No special problems.
	13.	Kitunda	5MVAx1	33/11kV	Land is defined and negotiation will be started soon. Oil pipelines to Zambia pass nearby.

3) Problems posed by facilities

According to the results of the site survey conducted this time and materials obtained from the meeting with TANESCO's staffs in charge, the summary of the problems posed by the substation facilities in respect of grid substation, secondary substation, and distribution substation are as shown in the following table.

Table 5.1.3(2)-3 Problems posed by existing facilities

No.	Item	Remarks
1.	Oil leakage from many main transformer of substations.	
2.	Sinking of the foundation and ground under main transformer of substations.	
3.	Expansion space for substation are not enough.	
4.	Facilities of substations are badly worn out.	
5.	Inspection and maintenance of substation facilities are not sufficient.	
6.	Vehicles, tools and construction material and equipment are lacking.	
7.	Operation and maintenance staffs are lacking.	
8.	A variety of foreign standards are used.	
9.	Technical drawings and facility ledgers are not fully prepared yet.	

4) Review

The plans of expansion, improvement and construction of new substations are as a matter of course set out based on the present state of existing facilities.

The plans are often changed from the initial plans as a result of demand forecast and system analysis.

The area to be supplied with power in this plan is estimated to be about 350 km^2. Therefore judging from the demand density capacity of standard substation should be 5, 10 and 15 MVA for 1 Bank. In future, 2 Bank will be employed. The major goal of the plan is to establish the network of 132 kV transmission lines which extend from grid substations and secondary substations and which maximize the reliability of some supply and minimize voltage drop. The effect of upgrading to 132 kV on the station is not small at all.

In view of it, the upgrading time of the substations offered by TANESCO ,as well as resultant problems are reviewed as follows based on the result of the site survey.

(a) TEGETA S/S

As for TEGETA substation, 33/11 kV substation, 15 MVA x 1, and 132/33 kV substation, 45 MVA x 1 are planned to be constructed in 1996 as upgraded substation which receive power from 132 kV at a location where 132 kV Zanzibar and 33 kV transmission line crosses.

According to the site survey, there are several small houses with which TANESCO is already in negotiation to purchase the land. No particular problems are foreseen. The problem may be posed depending upon the forecast of demand. In view of these, the construction of upgrading 132 kV station will be delayed. The construction of 33/11 kV Tegeta station will be considered in advance.

(b) Factory Zone III S/S

Present capacity of this station of Factory Zone III is 15 MVA (15 MVA x 1).
Additional 15 MVA 1 Bank is planned to be constructed in 1994 through Phase III resulting in the total capacity of 30 MVA. In 1996, upgrading to 132 kV is planned and 132/33 kV Bank capacity will increase to 45 x 2 = 90 MVA.

Space for the upgrading to 132 kV can be secured by TANESCO according to the result of the survey. Power cable should be used for lead-in line, depending on the route of the 132 kV transmission line.

(c) Oyster Bay S/S

Existing transformer capacity at the Oyster Bay substation stands at 15 MVA (5 MVA x 3). These facilities are to be expanded under the improvement scheme to achieve a 33/11 kV bank capacity of 30 MVA (15 MVA x 2) by 1996. In the future, the plans envision the additional erection of a 45 MVA bank by way of expansion to achieve a voltage upgrading to 132 kV by the year 2000.

The survey conducted as part of the present plan suggest that the addition of new capacity and the replacement of existing transformer facilities, now be set with oil leak and ground subsidence problems, would be adequate to provide the space required for the 33/11 kV expansion scheme. The problem which will still remain lies in the difficulty of securing the installation space needed for the erection of the temporary transformers during the construction phase and the installation of the distribution cubicles. While the timing for the construction work will ultimately depend on the results of the demand forecasts, it is felt wise to commence the construction work at the earliest possible time.

With respect to the 132 kV voltage upgrading scheme, it appears that there is no problem seeing that TANESCO has already embarked upon negotiations for the acquisition by TANESCO of the necessary land. Yet, the lead-in connection to the substation will be made using a power cable in accordance with the 132 kV transmission line route, similar to the above.

(d) Yombo S/S

Not being an existing facility, the Yombo Substation will act as a power supply substation in conjunction with the gas-turbine operated thermal power station, a project currently in the planning phase for future power development. The plan as it now stands envisages the year 2000 for the scheduled construction timing and anticipates the creation of 45 MVA (45 MVA x 1) capacity facilities with 132/33 kV transformer station. The survey results have demonstrated that the available construction space is adequate so that there is no problem with the TANESCO plan.

The timing of the construction work will be dependent upon the rate of progress achieved with the Songo Songo Gas Project, and judging on present conditions it appears that the plan as it exists is satisfactory.

(e) City Centre S/S

Installed capacity at the City Centre Substation totals 30 MVA (15 MVA x 2) at present. This capacity is being expanded to 45 MVA (15 MVA x 3) under the Phase III of the project currently executed by Japan. The project also include the improvement of the bus bar facilities by 1998.

The results of the survey have demonstrated that the City Centre substation has exhausted its space availability and that there is no space for further equipment installation. The possibility of achieving the planned upgrading to 132 kV will depend on whether or not it will be possible to feed the transmission line into the substation, in much the same manner as has been described earlier. Yet, even though it may have been found possible to make the line lead-in connection, it is not possible to establish a plan that will minimize the power outage required for the improvement work associated with the installation of the 132 kV transformer. This will therefore necessitate the decision to establish a new substation in the vicinity.

This, in turn, will require the selection of a prospective site of land for the construction of the new substation and the selection of a lead-in route for the 132 kV line to the substation.

For the timing of study execution, it is felt that the construction of the upgraded 132 kV substation should taken in hand as early as possible. The year 2002 proposed by TANESCO will be too late. The way in which the space requirement for the 132 kV voltage upgrading will be seen as a problem will very much depend on the philosophy adopted for the selection of the leald-in route for the transmission line.

However, if the lead-in connection for the 132 kV transmission line should prove physically impossible, it may then be necessary to build a new substation in a suitable nearby location to make the connection to the City Centre substation from this new substation through a 33 kV feeder line. The solution, if embraced, does offer a contribution to easing the load on the City Centre substation in that the regional load will be spread out through the use of an 11 kV distribution line run from the new substation. The only problem will be whether a suitable site can be found in the vicinity.

(f) Kurasini S/S

Installed capacity at the Kurasini Substation totals 15 MVA (15 MVA X 1), 33/11 kV at present. This capacity is schedule for upgrading to 132/33 kV bank 45 MVA (45 MA x 1) output capacity as part of the 132 kV voltage upgrading program to be achieved by the year 2002.

The results of the survey conducted in connection with this plan have demonstrated that there is adequate space available for the scheduled upgrading of voltage. Yet, the problem shared with the substations above will be the question as to whether the 132 kV power transmission line can be fed to the Kurasini substation. If it should prove feasible to make the lead-in connection of the power line to the substation, it will be possible to make do with the tension bus system type has been used in the past. Although the timing for the 132 kV upgrading work is on a rather generous time scale, it will be necessary to make the necessary arrangements for the acquisition of the site, including the land for the transmission line, at a fairly early time.

(g) Mbagala S/S

Mbagala will be a new substation and does not exist at present. The new Mbagala substation will have 33/11 kV transformer of a total capacity of 15 MVA (15 MVA x 1) and in connection with the 132 kV upgrading scheme, the plans are to expand capacity at Mbagala to 45 MVA (45 MVA x 1) by the year 2006.

The results of the survey conducted in connection with this plan have demonstrated that there is adequate space available for the construction of the new substation, with TANESCO currently being engaged in negotiations for the acquisition of the land. Yet, the problem shared with the substations above will be the question as to whether or not the 132 kV power transmission line can be fed to the scheduled location for the Mbagala substation. If it should prove feasible to make the lead-in connection of the power line to the substation, it will be possible to make do with the tension bus type that has been used in the past. Although the timing for the 132 kV upgrading work is on a rather generous time scale, it will be necessary to make the necessary arrangements for the acquisition of the land, including the land for the transmission line, at a fairly early time.

(h) Mbezi S/S

Existing capacity at the present 33/11 kV Mbezi substation totals 7.5 MVA (7.5 MVA x 1). In connection with the present capacity expansion plan, the Mbezi substation is to be expanded to 30 MVA (15 MVA x 2) capacity by 1998. The survey has shown that there is sufficient space available for the additional installation of one more transformer unit, seeing that one unit will be removed for replacement.

The present plan envisages a voltage upgrading program to 132 kV by the year 2004, with the creation of 132/33 kV station capacity of 45 MVA (45 MVA X 1). The space already in the possession of TANESCO will be fully adequate to meet the space requirements for the upgrading study. Although the timing for the 132 kV upgrading work is on a rather generous time scale, it will be necessary to make the necessary arrangements for the acquisition of the land, including the land for the transmission line, at a fairly early time.

(3) Power Distribution Facility

Out of the measures to be taken to cope with overload imposed on 11 kV distribution line and to improve voltage thereof, the most efficient measures to be taken from the view point of short-term investment is the load interchange among the distribution lines.

According to TANESCO's proposal, such distribution lines as with heavy load or large voltage drop should be improved through construction of new substations. With this concept at its core, the plan is drawn on a time series basis.

As for the comprehensive review of the distribution facility, it is certainly conceivable, as a first stage of it, that the existing small size distribution lines must be replaced with large size ones, and moreover the load changeover from heavily loaded distribution line to other lines by additively installing new switches. However, these challenges seem to be left unsolved nor reviewed. In addition, the concept for repair of the 11 kV feeder which is out of operation because of failure of circuit breaker for outgoing line is also unclear yet.

5.2 POWER EXPANSION PLAN

5.2.1 Present Power Network Plan

The City of Dar Es Salaam is Tanzania's major consumer area of electric power. While part of the power requirement is being met from the diesel generator installed at the Ubungo substation, practically all of the City's power is supplied from the hydroelectric power plants located in the northern and western parts of Tanzania.

The power generated by these hydroelectric plants is transmitted through a 220 kV transmission line (with one line now being added) to the Ubungo substation in the City. The Ubungo substation and the distribution substations are interconnected by 132 kV and 33 kV transmission lines. The distribution voltage is 11 kV, and power is supplied to the consumers through 400/230V distribution lines.

The City's load in 1991 is given as 117 MW (a figure not including the 11 MW load of Zanzibar). This includes 15 MW consumed by four major power users: ALAF (aluminum smelting works), TAZARA (Tanzania's national railway), the Wazo Hill Cement factory, and the Friendship textile factory. Power to these industrial consumers is supplied directly through 33 kV of transmission lines.

The obselescence and inadequacy of the power equipment and facilities is causing serious problems to increasing power losses and a rising frequency of power failures.

According to TANESCO's data, the following lines have reported serious voltage drops and power losses in the 11 kV distribution network in 1991. Without expansion, these lines will see a continuing increase in load so that they are bound to give rise to even greater voltage drop and power loss problems. This makes it clear that the implementation of urgent measures will be of vital importance.

Name of Substation	Name of Transmission Line/ Distribution Line	Power Drop Rate (%)	Power Loss Rate (%)
Ubungo	U1	5.92	3.49
Kurasini	K4	10.02	7.32
Mikocheni	MK2	8.03	4.72
Oyster Bay	O_3	8.87	6.07
Oyster Bay	O_4	6.50	6.42
Mbezi	Kunduchi	16.92	11.43

The following are the main problems in the power network.

(1) Increased proneness to accidents due to the obselescence of the electrical equipment (transformers, power lines, insulators, breakers, etc.)

(2) Lack of spare parts for repair and lack of maintenance materials and equipment

(3) Increased rate of power losses and voltage drops due to insufficient line capacity (power lines are to small).

(4) Expanding range subject to power outages as a result of the inappropriate installation of protective devices (such as breakers, section breakers, protective relays, etc.)

(5) Inadequate transformer capacity at the substations

(6) The radial arrangement of the distribution lines from the Ubungo substation to all distribution substations entails that power supply to the City has to be severely restricted in the even that an accident has occurred at the Ubungo substation. If a major breakdown has occurred at the Ubungo substation, the result would be complete power outage.

5.2.2 Electric Power Supply Expansion Plan

This plan examines the power system in Dar Es Salaam for a period of 15 years from 1993 to 2007. The results are shown in Table 5.2-1. The basic concepts of this project are as follows:

1. Construction of a looped power network system

2. Elimination of heavily-loaded substations and distribution lines, and expansion of distribution lines to new centers of consumption.

5.2.3 Configuration of the Looped Power Network System

(1) In order to cope with the future increase in the demand for electric power, main substations should be inter-connected in a loop through 132 kV transmission lines, because existing 33 kV transmission system is considered to be insufficient in terms of power transmission capacity and system stability.

In specific terms, these substations should be linked through 132 kV transmission lines as follows:

* Ubungo S/S - Oyster Bay S/S - Ilala S/S - Kurasini S/S - Factory Zone 3 S/S - Ubungo S/S
* 132 kV Zanzibar Transmission Line - Mbezi S/S
* 132 kV Zanzibar Transmission Line - Tegeta S/S
* Ilala S/S - City Center S/S
* Ubungo S/S - Ilala S/S

(2) Since most of the 11 kV distribution lines are arranged radially from substations, the area of service interruption may expand at the time of an accident. Circuit breakers and section switches should be used and a looped distribution network should be constructed in order to minimize the area of service interruption. The new system should cover not only for newly constructed distribution lines but also existing distribution lines.

5.2.4 Elimination of Heavily-Loaded Substations and Distribution Lines and the Expansion of Distribution Lines to New Centers of Consumption

As discussed in 5.2-1, 7 transmission and distribution lines are showing a voltage drop of 5% or more. In addition, many other lines are expected to show a voltage drop of 5% or more in the immediate future. (A line with a large voltage drop will have a large power loss.)

In order to solve this problem, new substations and distribution lines should be constructed to allow the allocation of load and the supply to new centers of consumption.

Substations suffering from insufficient capacity of transformers should be improved by the addition or replacement of transformers.

(1) Planned new substations and the year of their first operation are as follows:

Name of Substation	Capacity (MVA)	Year of Planned Operation
Tandale	15 x 1	1994
Chang'ombe	15 x 1	1994
Kariakoo	15 x 1	1996
Tegeta	10 x 1	1996
Mbagala	10 x 1	1998
Tabata	5 x 1	1998
Temeke	15 x 1	2000
Mburahati	15 x 1	2000
Kitunda	5 x 1	2000
Upanga	15 x 1	2002

(2) Planned increase in the capacity of transformers at substations and the year of increase

Name of Substation	Increase in Capacity (MVA)	Year of Increase
(Increase in the capacity of 33 kV/11 kV transformers)		
Ilala	15 x 1	1994
Mbezi	15 x 1	1994
Mbezi	15 x 1	2004
Kigamboni	5 x 1	1996
	5 x 1	2002
Mikocheni	15 x 1	1998
	5 x 1	2004
FZ-2	5 x 1	2000
(Increase in the capacity of 132 kV/33 kV transformers)		
Ilala	45 x 1	1996

(3) Substations to be linked via 132 kV transmission lines, their capacities, and the year of implementation

Name of Substation	Transformer Capacity (MVA)	Year
Ilala	45 x 1	1994
Tegeta	45 x 1	1996
FZ-3	45 x 2	1996
Oyster Bay	45 x 1	2000
Yombo	45 x 1	2000
Kurasini	45 x 1	2004
Mbezi	45 x 1	2004
City Center	45 x 1	2004
Mbagala	45 x 1	2004

PLANSYSR Table 5.2-1 MASTER PLAN FOR POWER SYSTEM IN DAR ES SALAAM CITY (1/2)

S/S & LINE	STATUS	PRIORITY	SPECIFICATION	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
ILALA S/S	EXP.	(1)	132/33KV Tr.	45 MVA*1													
	EXP.	(1)	33/11KV Tr.	15 MVA*1													
	NEW	(1)	132 KV LINE	1cct. (Ubungo s/s-Ilala s/s)													
TANDALE S/S	NEW	(2)	33/11KV Tr.	15 MVA*1													
	NEW	(2)	33 KV LINE	1cct. (Branch from Ubungo s/s-Textile Factory Line)													
CHANGOMBE S/S	NEW	(3)	33/11KV Tr.	15 MVA*1													
	NEW	(3)	33 KV LINE	1cct. (Branch from Fz1 s/s-Kurasini s/s Line)													
MBEJI S/S	EXP.	(4)	33/11KV Tr.	15 MVA*1										15 MVA*1			
	NEW		132/33KV Tr.											45 MVA*1			
	NEW		132 KV LINE											1cct. (Branch from Ubungo s/s-Zanzibar)			
KUNDUCHI S/S (TEGETA)	NEW	(5)	33/11KV Tr.			15 MVA*1											
	NEW	(5)	33 KV LINE			1cct. (Tegeta s/s-Kunduchi s/s)											
FZ-3 S/S	EXP.		33/11KV Tr.												15 MVA*1		
	NEW	(6)	132/33KV Tr.			45 MVA*2											
	NEW	(6)	132 KV LINE			1cct. (Ubungo s/s-Fz3 s/s)											
KARIAKOO S/S	NEW	(7)	33/11KV Tr.			15 MVA*1						15 MVA*1					
	NEW	(7)	33 KV LINE			1cct. (Ilala s/s-Kariakoo s/s)											
MBAGALA S/S	NEW	(8)	33/11KV Tr.			15 MVA*1											
	NEW		132/33KV Tr.													45 MVA*1	
	NEW	(8)	33KV LINE			1cct. (Kurasini s/s-Mbagara s/s)											
	NEW		132KV LINE													1cct (Yombo s/s-Mbagala s/s)	
TABATA S/S	NEW	(9)	33/11KV Tr.			5 MVA*1											
	NEW	(9)	33 KV LINE			1cct. (Branch from Ubungo s/s -Fz 3 s/s Line)											
MIKOCHENI S/S	EXP.		33/11KV Tr.					15 MVA*1						15 MVA*1			
KIGANBONI S/S	EXP.		33/11KV Tr.					5 MVA*1				5 MVA*1					

PLANSYSR MASTER PLAN FOR POWER SYSTEM IN DAR ES SALAAM CITY (2/2)

S/S & LINE	STATUS	PRIORITY	SPECIFICATION	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
TEMEKE S/S	NEW		33/11KV Tr.							15 MVA*1							
	NEW		33KV LINE							1cct. (Yombo s/s-Temeke s/s)							
MBURAHATI S/S	NEW		33/11KV Tr.							15 MVA*1							
	NEW		33KV LINE							1cct. (Branch from Ubungo s/s-Ilala s/s Line)							
KITUNDA S/S	NEW		33/11KV Tr.							5 MVA*1							
	NEW		33KV LINE							1cct. (Yombo s/s-Kitunda s/s)							
YOMBO S/S	NEW		132/33KV Tr.							45 MVA*1							
	NEW		132KV LINE							1cct. (Fz 3 s/s-Yombo s/s)							
FZ-2 S/S	EXP.		33/11KV Tr.							5 MVA*1							
OYSTER BAY S/S	EXP.		33/11KV Tr.	1*15 MVA (Under construction)									15 MVA*1				
	NEW		132/33KV Tr.							45 MVA*1							
	NEW		132 KV LINE							1cct. (Ubungo s/s-Oysterbay s/s)							
KURASINI S/S	NEW		132/33KV Tr.									45 MVA*1					
	NEW		132KV LINE									1cct. (Yombo s/s-Kurasini s/s)					
CITY CENTER S/S	EXP		132/33KV Tr.											45 MVA*1			
	NEW		132KV LINE											1cct. (Ilala s/s-Citycenter s/s)			
UPANGA S/S	NEW		33/11KV Tr.											15 MVA*1			
	NEW		33 KV LINE											1cct. (Citycenter s/s-Upanga s/s)			
MSASANI	NEW		33/11KV Tr.	15 MVA*1 (Under construction)												15 MVA*1	
SOKOINE	NEW		33/11KV Tr.	15 MVA*1 (Under construction)													
FZ-1 S/S	EXP.		33/11KV Tr.	15 MVA*1 (Under construction)													

5.3 OPTIMIZED TRANSMISSION LINE PLAN (LONG TERM/SHORT TERM)

5.3.1 Long-term Plan of Transmission Line

(1) Summary

The roles of transmission lines are:

(a) Power transmission from hydropower stations located in the mountaneous area or thermal power stations located near cities to substations in load center;

(b) Power interchange among substations;

(c) System interconnection with other grid systems; etc.

The role of the transmission lines planned this time is the power supply to proposed new substations and existing substations based on the results of power demand forecast.

(2) Existing Transmission Line Facilities

1) 132 kV Transmission Lines

An outline of the existing 132 kV transmission lines in the project area is shown in the followings:

(a) Ubungo - Ilala Line

- Line length : 7 km
- Supports : self-supporting towers and guyed towers
- Line conductors: ACSR 150 mm^2 (Wolf)
- Insulators : 250 mm ball & socket type suspension insulators (glass-made)
- Width of right of way: 40 m

(b) Ubungo - Zanzibar Line

- Line length : 79 km (overhead: 41 km, submarine: 38 km)
- Supports : self-supporting towers
- Line conductors: overhead section: ACSR 150 mm^2 (Wolf)
  submarine section: Cu 95 mm^2 (OF cable)

- Insulators : 250 mm ball & socket type suspension insulators (glass-made)
- Width of right of way: 40 m

2) 33 kV Transmission Lines

From Ubungo substation and Ilala substation to distribution substations and among distribution substations are interconnected with 33 kV transmission lines.

The outline of the 33 kV transmission line facilities is shown below, and the line length are shown in Table 5.1.2 (1)-1.

- Supports: wooden poles, steel pipe pole
- Line conductors: Aluminum cable steel reinforced (ACSR 50, 100, 120, 150 mm^2)
- Insulators : 250 mm suspension insulators, LP insulators, and pin insulators

3) Routes of Transmission Lines

Figs. 5.3-1 and 5.3-2 show the existing routes of transmission lines as of August, 1993. Fig. 5.3-2 is the enlarged view of the urban area, which is also shown in Fig. 5.3-1.

(3) Plan of Transmission Line

1) Height of Line Conductors

It can be considered that the height of line conductors is one of main factors to determine tower height, so that the height of line conductors should be decided prior to design of transmission lines. In the 132 kV Pangani Falls transmission line, which is being constructed at present, figures shown below are employed as the height of line conductors.

	Height from ground (m)
Ordinary places	6.7
Road	8.0
Railroad	9.0

	Height from ground (m)
Waterways	10.0
Buildings/structures	
- Horizontal	4.5
- Vertical	4.5
Other lines	6.0

And, as for the height of line conductors of 33 kV transmission lines, figures employed in the Phase-III Project are shown below.

	Height from ground (m)
Ordinary places	5.0
Road	6.7
Railroad	9.0
Telephone line	1.8

Figures specified in JEAC-6001 (Regulation for Overhead Transmission Lines) are shown in the following for reference.

Line voltage (kV)	Height from Ground (more than m)				
	Crossing over Road	Crossing over Railroad or Track	Over Pedestrian Bridge	Ordinary Places	Less Accessible Places, e.g., in Mountains
35 or less	6	5.5	4 *	5	5
35 - 160	6	6	6	6	5
Over 160	h = 6 + 0.12 x (1 for each 10 kV or a fraction of 10 kV in excess of 160 kV)				h' = h - 1

Note: Asterisk indicate the case in which insulated conductor or cable is used.

In addition, Fig. 5.3-3 shows the comparison of the height of line conductors of transmission lines specified in JEAC-6001, NESC and VDE.

In this planning, figures actually employed by TANESCO and specified in JEAC-6001 are taken into consideration, following figures are employed as the height of line conductors of transmission lines.

	Height of line conductors (m)	
Voltage (kV)	132	33
Ordinary places	6.7	5.0
Road	8.0	6.7
Railroad	9.0	9.0
Waterways	10.0	10.0

2) Clearance

As shown in 1) above, TANESCO has employed a clearance of 4.5 meters between transmission lines and building/structures in the Pangani Falls Line which is being constructed at present. Clearance specified in JEAC-6001 (Regulation for Overhead Transmission Lines) is shown below for reference.

Line Voltage	Clearance
35,000 V or less	3 m
Over 35,000 V	3 m plus 15 cm for each 10,000 V or a fraction of 10,000 V in excess of 35,000 V

In addition, Fig. 5.3-4 shows the comparison of clearance specified in JEAC-6001, NESC and VDE.
The followings are brief explanation of the terms such as nearness and clearance.

(a) Primary Nearness (Proximity)

When a transmission line is in nearness with other structures, "primary nearness" means a situation that the overhead transmission line is installed above or on a side of other structures within the distance equivalent to the support height from ground, and the conductors of overhead transmission line is likely to come in contact with other structures due to collapse of supports or breaking of line conductor. Situations under secondary nearness are excluded.

(b) Secondary Nearness (Proximity)

When a transmission line is in nearness with other structures, "secondary nearness" means a situation that the overhead line is installed above or on a side of the other structures within a horizontal distance of 3 m.

(c) Clearance

Clearance is the minimum distance that must be kept.

Fig. 5.3-5 illustrates the situations explained above.

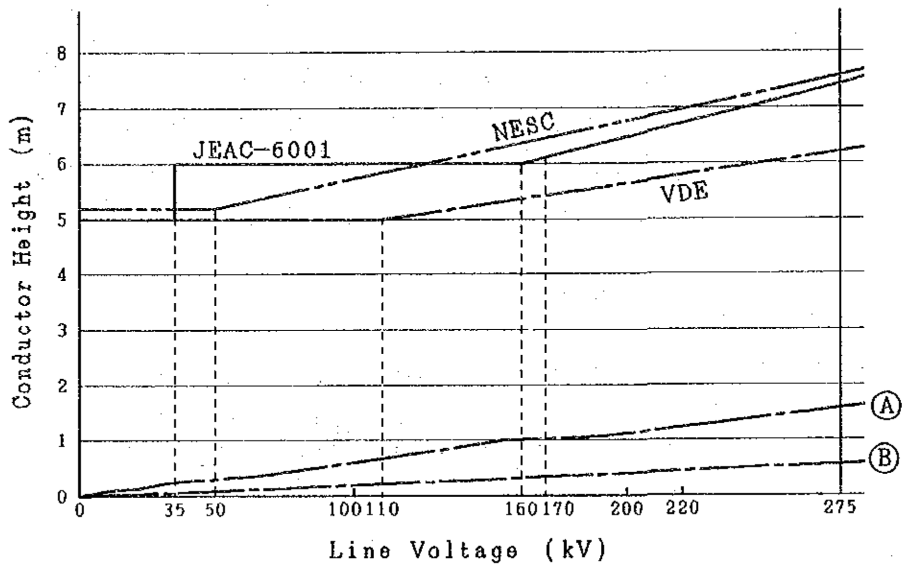


Fig 5.3-3 Comparison of Conductor Height between Standards

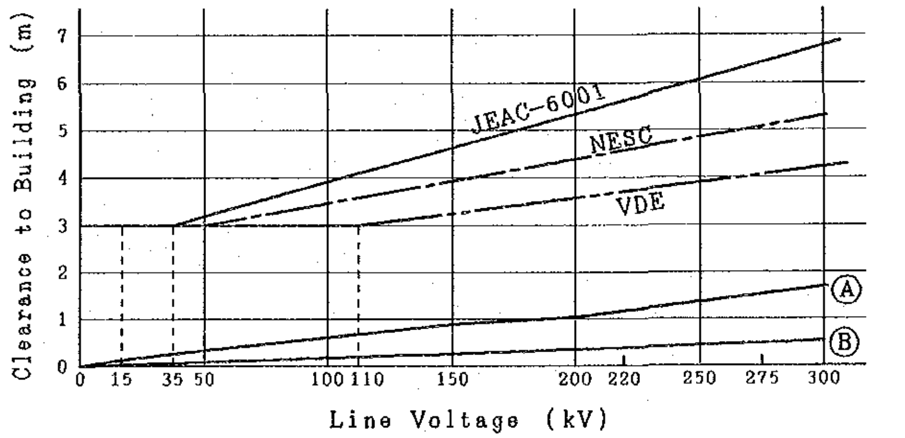
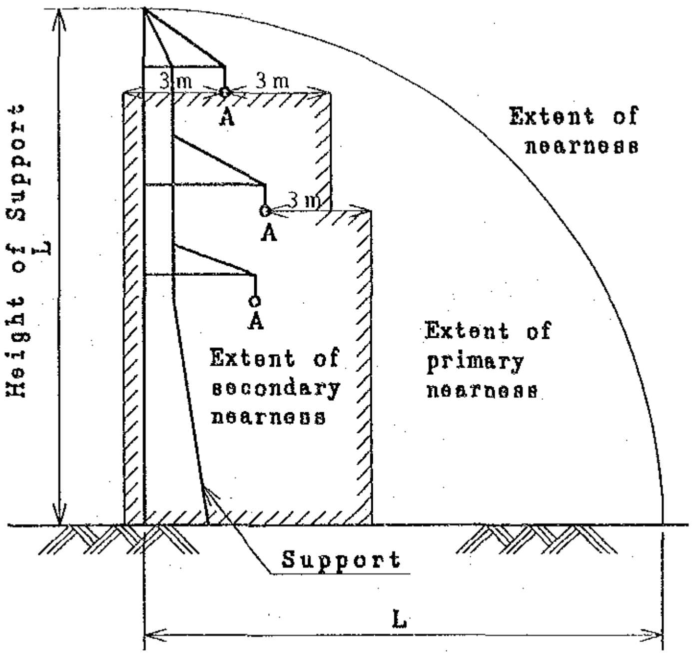


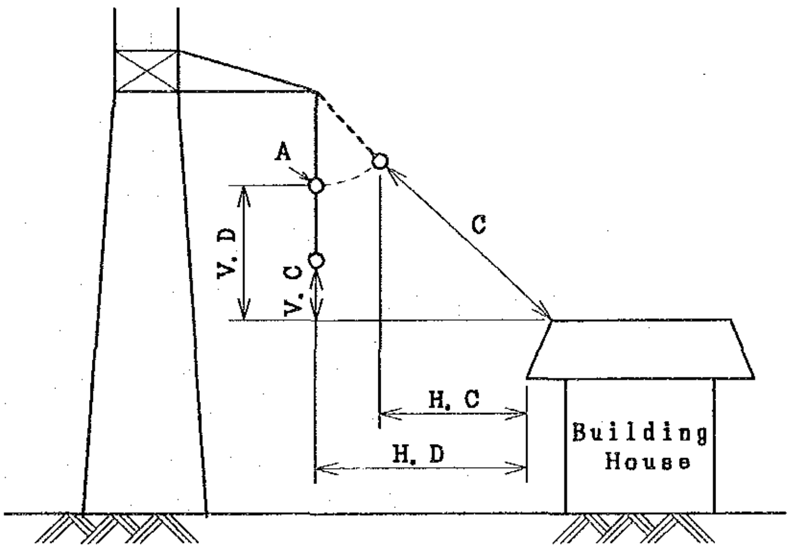
Fig 5.3-4 Comparison of Clearance between Standards

NOTE :

Ⓐ : Clearance withstanding for Internal Abnormal Voltage
Ⓑ : Clearance withstanding for Normal Voltage to Ground
JEAC-6001 (Regulation of Overhead Transmission Line, Japan)
NESC (National Electrical Safety Code, USA)
VBE (Verband Deutscher Electrotechniker, Germany)



A : Conductor
L : Height of Support



A : Conductor
C : Clearance
V. C : Vertical Clearance
V. D : Vertical Distance
H. C : Horizontal Clearance
H. D : Horizontal Distance

Fig. 5. 3-5 Explanation of Clearance

3) Supports

(a) Supports

In the existing 132 kV transmission lines of TANESCO, self-supporting towers and guyed towers are employed as supports. In both cases, line conductors are arranged horizontally and 40-m wide right of way is secured. In the construction of planned transmission lines, difficulties are anticipated in securing the right of way, since these lines are located relatively near urban areas.

Therefore, the employment of supports with vertical or triangular arrangement, which require smaller right of way, is recommended.

On the other hand, wooden poles are employed as the supports for existing 33 kV transmission lines, and line conductors are arranged horizontally.

It is also possible to employ vertical arrangement on concrete poles or steel pipe poles in urban areas.

(b) Wind Load

The wind load on steel towers and conductors represents a large factor in the design of steel towers.
The wind loads employed in the existing transmission lines of TANESCO are as follows.

- On steel towers	266 kg/m²	Kidatu - Morogoro Line	(220 kV)
	120 kg/m²	Shinyanga - Tabora Line	(132 kV)
- On wooden poles	40 kg/m²	Phase III Project	(33 kV)
- On conductors	57.5 kg/m² ...	Kidatu - Mufindi Line	(220 kV)
	72.0 kg/m² ...	Kidatu - Morogoro Line	(220 kV) (for conductor)
	87.0 kg/m² ...	Kidatu - Morogoro Line	(220 kV) (for ground wire)
	58.6 kg/m² ...	Shinyanga - Tabora Line	(132 kV)
	90.0 kg/m² ...	Hale - Tanga Line	(132 kV)
	50.0 kg/m² ...	Phase III Project	(33 kV)

And, standard wind velocity of 35 m/sec is employed to estimate wind load in the Pangani Falls Line which is being constructed.

The followings show the figures specified in JEAC-6001 (Regulation for Overhead Transmission Lines) for reference.

- Standard wind velocity 40 m/sec.
- Wind load

on steel towers	290 kg/m^2
on wooden poles	80 kg/m^2
on conductors	100 kg/m^2

Design condition of supports, especially wind load is a main factor to decide construction cost of transmission lines, this may be determined based on the weather data in Tanzania, local characteristics, and operation records of existing transmission line facilities.

In this planning, figures actually employed by IANESCO and specified in JEAC-6001 are taken into consideration, following values are employed as design condition of supports.

And, JEAC-6001 may be applied for the design, wind loads on wooden poles and conductors are converted value specified in JEAC-6001 based on the wind load on steel towers of 266 kg/m^2.

Wind load

- on steel towers	266 kg/m^2
- on wooden poles, concrete poles	73 kg/m^2
- on conductors	92 kg/m^2

(c) Protection Facilities

In TANESCO, collapse of towers due to the theft of bolts or guys on towers have been reported. To prevent theft, it is necessary to execute line patrol frequently along transmission lines, as well as PR activities to local inhabitants.

4) Conductors

At present, following conductors are employed by TANESCO for 33 kV and 132 kV transmission lines.

Kind of Conductor	Nominal Sectional Area (sqmm)	Code Name	Voltage (kV)
ACSR	564	Bluejay	220
ACSR	350	Bison	220
ACSR	240	Hawk	132
ACSR	150	Wolf	132, 33
ACSR	120	-	33
ACSR	100	Dog	33
ACSR	50	Rabbit	33

As shown above, conductors employed by TANESCO are classified for each transmission line voltage, however, bigger size conductors are employed for transmission lines which were constructed recently or are being constructed.

Planned project areas are located near the coastline, and as stated in 5.1.2 salt contamination is also reported so that the employment of ACSR with anti-corrosive steel core for 132 kV transmission line is recommended.

Application criteria of conductors by the degree of salt contamination is shown below for reference.

Application Criteria of Conductor by Degree of Salt Contamination

Use	Degree of Salt Contamination	A			B			C			D			E
	Distance from Coast	Over 5km			1.5-5.0km			0.5-1.5km			Within 0.5km			Areas subjected to splash from sea
	*Zone *1*	1	2	3	1	2	3	1	2	3	1	2	3	
Line Conductor	HDCC	o	o	o	o	o	o	o	o	o	o	o	o	o
	ACSR	x	x	o	x	x	o	x	x	x	x	x	x	x
	ACSR/AX	o	o	√	o	o	√	x	o	o	x	x	o	x
	ACSR (1)	√	√	√	√	√	√	o	√	√	x	o	√	x
	ACSR (2)	√	√	√	√	√	√	√	√	√	o	√	√	o

*1 1) Industrial
2) Semi-industrial
3) Other

Key o Usable
√ Usable but not recommended
x Not usable

Notes:
- ACSR : Aluminum conductor steel reinforced
- ACSR/AX : Aluminum-covered ACSR
- AX : Aluminum-clad steel strands
- ACSR (1): Corrosion-proof ACSR (medium)
- ACSR (2): Corrosion proof ACSR (heavy)
- Industrial zone : The area within 1 km from the line enveloping a group of factories. In the case of isolated factories, the area within 1 km from the outer borders of factories.
- Semi-industrial zone: The area within 1.5 km from the outer borders of an industrial zone.
- Other : Areas other than industrial zones and semi-industrial zones.

To study the transmission capacity, it is necessary to know the continuous allowable current of each conductor. The followings show the formula, which is specified in JEAC-6001, to calculate the continuous allowable current of bare conductors and calculation results.

(a) Continuous Allowable Current of Bare Conductor

$$Ic = \frac{\sqrt{\{hw + (hr - \frac{Ws}{\pi\theta})\eta\}\ \pi D\theta}}{\beta Rdc \times 10^{-5}} \quad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Ic: Allowable current (A)
D : Outside diameter of wire (cm)
θ : Allowable temperature rise (°C)
hr: Coefficient of heat dissipation by radiation
(Stefan-Botzmann Law)

$$hr = 0.000567 \frac{(\frac{273 + T + \theta}{100})^4 - (\frac{273 + T}{100})^4}{\theta} \ (W/°Ccm2)\ldots(2)$$

T : Ambient temperature
hw: Coefficient of heat dissipation by convection and conduction (Rice's empirical formula)

$$hw = 0.00572 \frac{\sqrt{\frac{V}{D}}}{(273 + T + \frac{\theta}{2})^{0.123}} \ (W/°C\ cm^2) \ \ldots\ldots\ldots \ (3)$$

V : Wind velocity (m/sec)
Rdc: DC resistance of conductor at operating temperature (Ω/km)
β : AC/DC resistance ratio

In the case of AC, AC/DC resistance ratio β composed of the coefficient of skin effect $\beta 1$ and the coefficient of iron loss $\beta 2$ should be taken into consideration.

$\beta = \beta 1 \cdot \beta 2$

A. Single-conductor and Single-strand conductor

a. Coefficient of skin effect: $\beta 1$

The coefficient of skin effect $\beta 1$ is determined by the following formula:

$$\beta 1 = 0.99609 + 0.018578x - 0.030263x^2 + 0.020735x^3 \ ..(4)$$

where, $x = 0.01 \times \sqrt{\frac{8\pi.f}{Rdc}}$

f: Frequency (Hz)

b. Coefficient of iron loss: $\beta 2$
Coefficient of iron loss, $\beta 2 = 1$

B. AC/DC Resistance Ratio β of a compound conductor which is a aluminium conductor steel reinforced having 2 or more layers of aluminium strand: β

a. Coefficient of skin effect: $\beta 1$

The coefficient of skin effect $\beta 1$ is determined by the formula (4) using the value of x determined from the following formula:

$$x = \frac{D+2d}{D+d} \times 0.01 \times \sqrt{\frac{8\pi . f \ (D-d)}{(D+d) \ Rdc}} \quad \text{..............(5)}$$

d: Outer diameter of steel-core (cm)

b. Coefficient of iron loss: $\beta 2$

(a) Coefficient of iron loss for conductors having an even number of aluminum layers: $\beta 2$

Coefficient of core loss $\beta 2 = 1$

(b) Coefficient of iron loss $\beta 2$ for conductors having an odd number (3 or more) of aluminum layers is determined by the following formula: $\beta 2$

$$\beta 2 = 0.99947 + 0.028895y - 0.0059348y^2 + 0.00042259y^3$$

where y = 1/A.
I: Current (A)
A: Cross sectional area of conductor (mm^2)
Ws: Solar radiation (W/cm^2)
η : Ratio of the radiation from conductor surface to that of ideal black body (0.9)

(b) Conditions for the Calculation of Allowable Current

According to JEAC-6001, conditions for the calculation of allowable current are specified as follows.

i) Maximum allowable temperature

The maximum allowable temperature of bare conductor in continuous use is classified into continuous, short time, and instantaneous. Although these should be defined depending on the conditions of use, the values in the following table are generally employed.

Type of Wire	Mark	Max. Allowable Temp. $(T + \theta)$°C		
		Cont.	Short-time	Inst.
Copper conductor				
Hard Cu	H	90	100	200
Heat resistant hard Cu	-	150	180	300
Aluminium conductor				
Hard Al	HAℓ	90	120	180
Heat resistant hard Al	TAℓ	150	180	260

ii) Ambient temperature, T = 40°C

iii) Minimum wind velocity, v = 0.5 m/sec
Wind direction is assumed to be perpendicular to the conductor.

iv) Solar radiation, Ws = 0.1 W/cm^2
The direction of sunshine is assumed to be perpendicular to the conductor.

On the other hand, following values for the calculation of allowable current are employed according to the data obtained from TANESCO.

i) Maximum allowable temperature
Continuous: 60°C
Short time: 80°C

ii) Ambient temperature, T = 35°C

iii) Minimum wind velocity, v = 0.6 m/sec

iv) Solar radiation, Ws = 0.1 W/cm^2

(c) Allowable Current

Table 5.3-1 (1) and Fig. 5.3-6 (1) show the allowable current which is calculated based on the conditions specified in JEAC-6001, and Table 5.3-1 (2) and Fig. 5.3-6 (2) show the allowable current which is calculated by substituting the conditions collected at TANESCO to the formula specified in JEAC-6001.

Table 5.3-1(1) Ampacity of Conductors

Unit : (A)

Kind of Conductor	Conductor Temperature (℃)						
	60	70	80	90	100	110	120
ACSR 50sqmm (Rabbit)	111.5	159.3	194.5	223.2	247.7	269.5	289.0
ACSR 100sqmm (Dog)	161.2	241.4	299.0	345.6	385.5	420.7	452.5
ACSR 120sqmm	169.5	263.8	330.2	383.6	429.3	469.6	505.9
ACSR 150sqmm (Wolf)	198.2	310.6	389.5	453.0	507.2	555.0	598.2
ACSR 240sqmm (Hawk)	250.2	409.0	518.2	605.7	680.2	746.0	805.4
ACSR 350sqmm (Bison)	295.9	512.9	657.3	771.9	869.3	955.2	1,032.8
ACSR 560sqmm (Bluejay)	347.0	642.2	833.1	983.8	1,111.6	1,224.2	1,325.9

Note : Ambient temperature 40℃, Conductor temperature 90℃, Solar radiation 0.1 W/sqcm
Wind velosity 0.5 m/sec

Fig. 5.3-6(1) Ampacity of Conductors

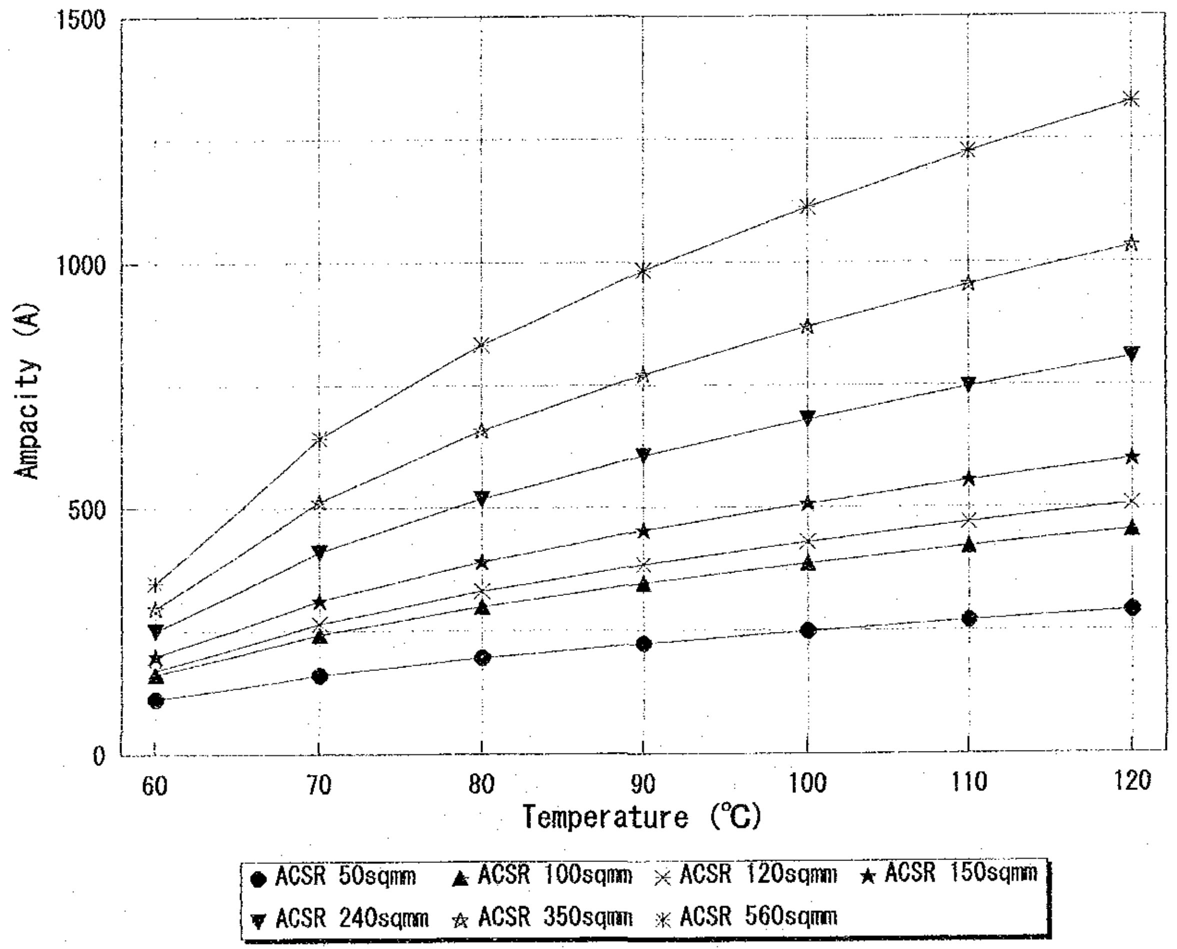


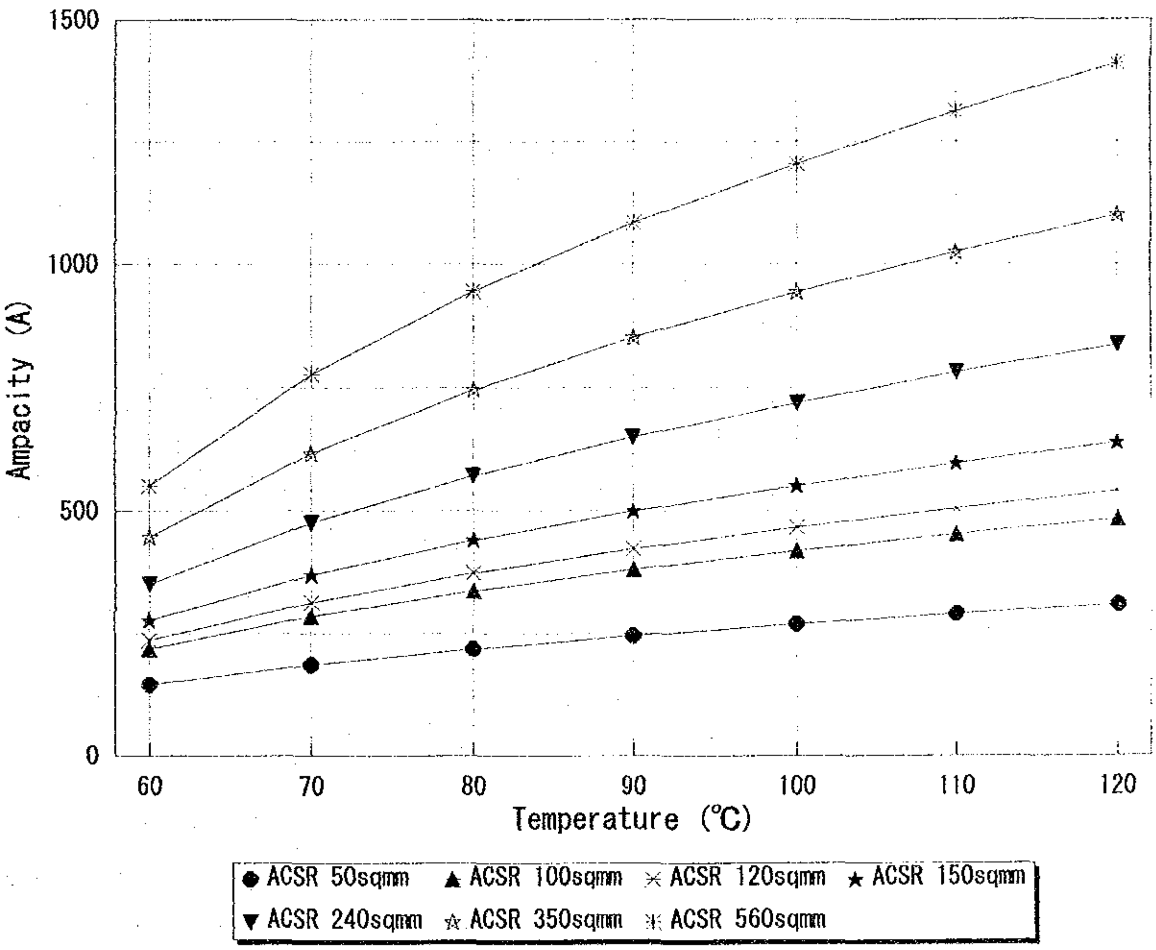
Table 5.3-1(2) Ampacity of Conductors

Unit : (A)

Kind of Conductor	Conductor Temperature (℃)						
	60	70	80	90	100	110	120
ACSR 50sqmm (Rabbit)	146.0	186.8	218.9	245.8	269.3	290.2	309.1
ACSR 100sqmm (Dog)	218.2	285.2	337.3	380.9	418.8	452.6	483.3
ACSR 120sqmm	235.9	313.4	373.1	422.9	466.2	504.6	540.0
ACSR 150sqmm (Wolf)	277.2	369.4	440.3	499.4	550.8	596.6	638.3
ACSR 240sqmm (Hawk)	351.3	476.0	571.2	650.2	718.9	780.2	835.9
ACSR 350sqmm (Bison)	446.3	616.6	744.8	850.9	942.9	1,025.0	1,099.8
ACSR 560sqmm (Bluejay)	550.6	777.1	945.7	1,084.8	1,205.2	1,312.7	1,410.5

Note : Ambient temperature 35℃, Conductor temperature 60℃, Solar radiation 0.1 W/sqcm
Wind velosity 0.6 m/sec

Fig. 5.3-6(2) Ampacity of Conductors



5) Overhead Ground Wire

Overhead ground wire is installed to prevent direct lightning to line conductors.

Since overhead ground wire generally does not carry much current, galvanized steel strands are used in areas where the problem of salt contamination is small. Aluminum-clad steel strands are used in coastal areas and other areas where salt contamination is expected.

At present, TANESCO is using the following strands as the overhead ground wire for 220 kV and 132 kV transmission lines.

Kind	Size (sqmm)	Name of Transmission Line	Voltage (kV)
AAAC	62.4	Hale - Tanga	132
ACS	65.81	Kidatu - Morogoro	220
GSW	38.32	Shinyanga - Tabora	132
GSW	50.0	Hale - Moshi	132

(Note) AAAC: Hard All Alminium Conductor
ACS : Aluminium-clad Steel strands
GSW : Galvanized Steel Wire

Planned project areas are located near the coastline, and as stated in 5.1.2 salt contamination is also reported so that the employment of anti-corrosive overhead ground wire is recommended.

6) Insulators

The following insulators are employed on the existing transmission lines of TANESCO.

132 kV transmission lines: 250 mm suspension insulators (glass-made)
33 kV transmission lines: 250 mm suspension insulators (glass-made)
LP insulators, pin insulators.

No faults attributable to insulators themselves have been reported in 33 kV transmission lines. However, in 132 kV transmission lines, dropping of conductors due to the corrosion of the pins of insulators have been reported as described before. Since such faults involving the dropping of line conductors occurred along the entire length of the lines, all insulators has been replaced in the section of: Hale - Chalinze, Ubungo - Ilala and Kidatu - Ubungo (partly).

Because of the single-circuit structure of TANESCO's grid system, replacement of insulators on these lines causes direct impediment of power supply to load center, even though the work can be completed in a short period.

In addition, replacement of insulators only 12 years after the commencement of operation of transmission lines poses severe financial burden on TANESCO.

On the other hand, it has been reported that the corrosion of pin insulators was caused by the DC component of AC leakage currents. If salt contamination on insulators is expected, insulators must be selected carefully.

At present, suspension insulators using pins with zinc sleeves have been developed as a countermeasure against pin corrosion. These insulators have much supply record in DC transmission lines and their performance is highly evaluated.

In FANESCO, the employment of insulators of this type is recommended, if the salt contamination is expected on the transmission lines.

In addition, it is recommended to perform the measurement of salt deposition using pilot insulators so that the timing of insulator cleaning on existing transmission lines and substations can be judged properly.

7) Surveys, Patrol and Inspection

A. Surveys

The following surveys concerning the environment around planned routes will be conducted at the construction of transmission lines.

(a) Basic Surveys

i) Surveys on Legal Limitations

- National parks, nature parks
- Historical sites, scenic spots, natural monuments, remains, important cultural properties
- Forest reserves
- Areas specified for the prevention of landslides
- Areas specified for erosion and sediment control, and scarp
- Rivers and ports
- Airfields
- Natural environment conservation areas, wild life preservation sanctuaries
- Urbanization promotion area, green space conservation area
- Microwave transmission routes, radio transmitting and receiving stations
- Main telecommunication lines
- Others

ii) Surveys on Competing Projects

- City planning
- Road and railroad construction projects
- River and port projects
- Projects for airport and other public facilities
- Preparation of housing site
- Industrial development projects
- Land improvement and pilot projects

- Projects for construction of leisure facilities
- Large-scale forestation projects
- Plans for establishment of mining areas
- Others

iii) Surveys on Land Use in Vicinities

- Orchards, plantations, and other land having high productivity

iv) Surveys on Environmental Impacts

- Effects of noise and vibration
- Effects on buildings
- Effects on road traffic
- Effects on ground in vicinities
- Effects on underground water
- Effects on underground installation
- Effects of drainage to rivers
- Effects on radio and TV broadcasting
- Effects on landscape
- Others

v) Outline Surveys on Topographic and Geological Features

- Understanding of main topographical features using topographical maps (1:50,000 and 1:25,000)
- Understanding of general geological features using basic land classification maps and other information

(b) Geological Surveys

General topographical and geological features will be studied to decide or select preliminary route, and physical or mechanical properties of the ground, which are required for design and construction work, will be studied.

i) Preliminary Study

<u>Preparatory Study</u>

- Understanding of general topography based on topographical maps (1:2,000 - 1:10,000)

- Study on topographical changes, landslides, collapse, fracture zones, fault, etc. using aerial photographs.

- Understanding of geological features, levels of ground water, etc. based on existing information.

<u>Field Surveys</u>

- Verification of the data obtained from data study and preparatory study
- Study on the type and quality of rocks, degree of weathering, etc. using outcrops of rocks.
- Estimation of quality of rocks using boulder stones
- Estimation of top soil thickness based on the kind and growth of trees
- Estimation of the risk of landslide and collapse based on the kind and form of trees
- Study on the conditions of stratification, sloping and strike of bedrock, etc. based on observation of excavation slope of road
- Occurrence of landslide around the planned route and the situation of landslide, if any
- Presence of geological folds, slopings, cracks, etc.
- Collapse, crack, and bulging of retaining walls, masonry works, etc.
- Information from local inhabitants (ground water, soil conditions, etc.)

ii) Main Survey

In the main survey, design characteristics related to the ground and the bedrock will be identified and the foundation type will be selected.

Execution of Main Survey

- Locations where detailed survey is required as the result of preliminary study.

- Main survey will be conducted in the following cases at all tower sites:

  a. Towers constructed in the class B and C ground in urban or urbanization promotion area.
  b. Towers constructed in landslide zone.
  c. Towers constructed on soft ground such as reclaimed land or river bed.

(c) Surveys Related to Atmospheric Phenomena

i) Meteorological Surveys

Types of Surveys

- Wind velocity, wind direction, ambient temperature
- Lightning
- Rainfall

Methods of Survey

Meteorological surveys will be based on observational data obtained at weather stations and other organizations in the relevant area. Actual measurements will be performed, if necessary.

ii) Survey on Salt Contamination

If salt contamination on insulators is expected and the survey of salt contamination is required, pilot insulators will be installed along the neighborhood of the planned route and salt contamination will be studied.

Measurement Interval of Pilot Insulators

Measurement should be repeated at intervals of 1 month and 3 months, and the study should be continued for at least 2 years.

Supplementary Data to be Studied in the Study of Salt Contamination

- Distance form coast
- Meteorological study including rainfall, wind velocity, and wind direction
- Topographical study
- Type of pilot insulators and elevation from ground

B. Patrol and Inspection

As mentioned in 5.1.2 (1) Present State of Transmission Line Facilities, TANESCO has been executed patrol and inspection according to the form shown in Table 5.1.2 (1)-2.

Patrol and inspection are essential to detect all impediment to transmission lines in an early stage and to prevent faults. The followings are the form of patrol and inspection of a electric utility in Japan.

i) Patrol

The types, sections, period, and method of patrol are as follows:

Type	Section	Period	Method
Regular patrol Ground/Aerial	All lines	Once/2 months	All lines are patrolled regularly to detect troubles in and around the lines.
Specific patrol Ground/Aerial	Specified lines and sections	As necessary	Specific lines and sections are patrolled chiefly to detect troubles around the lines.
Preventive patrol Ground/Aerial	Lines and sections where fault may occur	As necessary	When faults are likely to occur, patrol is conducted in necessary sections to detect troubles.
Fault patrol Surface/Aerial	Lines and sections where fault has occurred	As necessary	After fault, patrol is conducted in necessary sections to examine the site of trouble.

The items and contents of survey are as described below for each patrol.

(a) Regular Patrol (ground)

Item	Contents of Survey	Remarks
Troubles in Equipment		
-Tower	Tilting, bending and falling of member, etc.	Pay attention to troubles that may affect insulation and strength and may lead to faults, if left untreated.
-Concrete pole, Wooden pole	.Tilting, bending and falling of member, etc. .Crack, breakage, etc.	
-Foundation	Collapse, crack, etc.	
-Guy	Breaking, digging, lifting, etc.	
-Insulator	Breakage, pollution, etc.	
-Conductor, ground wire, guard wire, switches	Breaking of strand, change of sag, contact with foreing objects, abnormal appearance, etc.	
Troubles around Line		
-Trees in proximity	Degree of proximity	
-Building/houses	Clearance from transmission line	
-Other lines such as distribution lines	Clearance from transmission line	
-Arable land, land readjustment, construction works of roads, rivers, etc.	Effects on supports and foundations	
-Landslide, changes in topography	Effects on supports and foundations, and countermeasures	
Others		
-Maintenance road, signs boards, etc.	.Obstruction of traffic .Installation and breakage of signs boards, etc.	

(b) Regular Patrol (Aerial)

The main purpose of regular patrol (aerial) is to detect breakage of insulators, breaking of strands, and abnormal proximity to trees of line conductors.

(c) Specific Patrol (Ground)

Specific patrol (ground) is conducted according to the items shown below:

Item	Contents of survey	Remark
Troubles around Line Building/houses	Degree of proximity, construction plan, owner, builder, time, method of construction, etc.	These should be detected and corrected in early stages such a land preparation and foundation works.
Bamboo shoot	Degree of proximity	* If there is a possibility of faults due to the proximity to the line, remove the causes and promote PR for the prevention of faults. * In particular, pay attention to the operation of crane trucks.
Kite	Situation of kite flying	
Others	Situation of other lines such as distribution lines and construction works in vicinities	

(d) Specific Patrol (aerial)

Specific patrol (aerial) is conducted similarly to specific patrol (ground).

(e) Preventive Patrol (ground)

When the following troubles are likely to occur, preventive patrol (ground) is conducted at locations where surveyes are considered necessary depending on the situation of special weather conditions and the situation of areas along the line.

- Electrical fault due to fire.

- Landslide near foundations due to heavy rain or earthquake.
- Fault due to salt contamination under strong wind and other conditions.

(f) Preventive Patrol (aerial)

Preventive patrol (aerial) is conducted when landslide and other hazards are likely to occur in a wide area due to a typhoon or other special weather conditions.

(g) Fault Patrol (ground)

Fault patrol (ground) is conducted when the occurrence of a fault is reported or perceived. However, patrol may be postponed or a part of patrol may be omitted in the case as described below:

- Patrol may be postponed if power transmission has been restored successfully and prompt patrol is considered unnecessary in view of the situation of equipment.

- Even the restoration of power transmission has been unsatisfactory, patrol may be postponed if power supply is not impeded and no trouble is found in the system operation.

- If the site of fault can be located by fault locators or other means, patrol of such sections may be omitted.

(h) Fault Patrol (Aerial)

Fault patrol (Aerial) is conducted in the following situations:

- Restoration of power transmission is unsuccessful and the fault point must be found urgently.

- Faults are occurring successively in various places and prompt detection of fault by ground patrol is impossible.

ii) Inspection

The purpose of regular and initial inspection is:

- to detect troubles in power facilities,
- to take appropriate measures,
- to grasp actual situation of power facilities, and
- to reflect in future maintenance plans.

The types and period of inspection are as shown below:

Type	Division	Period
Initial inspection	Particular lines within 2 years after construction	--
Regular inspection	Inspection of supports	
	- Towers	Once/5 years
	- Concrete poles	"
	- Wooden poles	Once/3 years
	Detection of defective insulators	
	- Insulators	Once/4 years
	Inspection of conductors	
	- Wooden poles	Once/3 years
	- Other than wooden poles	Once/5 years
	Inspection of switches	
	- Switches	Once/3 years
	Measurement of grounding resistance	
	- Positions specified in technical regulation	Once/3 years
	- Ordinary positions	Once/6 years

The subjects and items of inspection examined at initial inspection and regular inspection are as described below:

(a) Initial Inspection

Initial inspection will be executed to grasp the actual situation of new transmission line facilities, and inspecting items are according to the standards for regular inspection.

(b) Regular Inspection

Subject			Inspection Item	Remarks
Inspection of Supports	Foundation	In and around the sites of foundation	1. Changes of ground conditions due to heavy rain, landslide, etc. 2. Soil erosion and soil pressure around foundation 3. Burying of the concrete and tower foundation by sediments 4. Condition of drainage ditch	The possibility of collapse of supports
		Concrete foundation	1. Deterioration and breakage of concrete	
	Steel tower	Tower and pillar body	1. Twisting, bending, tilting distortion, crack	
		Member	1. Falling, bending, distortion, crack 2. Rust 3. Corrosion at ground level	
		Bolt	1. Falling, Loosening 2. Length of bolt 3. Rust	
	Concrete pole		1. Deterioration, crack, and breakage of concrete 2. Tilting, bending	Corrosion of reinforcing bars inside the crack

Subject			Inspection Item	Remarks
Inspection of Supports	Wooden pole		1. Corrosion at the top, arm mounting, around pole steps, and at ground level 2. Crack, bird damage, tilting	
	Guy	Concrete pole Wooden pole	1. Corrosion of guy 2. Loosening at the top, lifting at the bottom, appropriateness of soil pressure 3. Appropriateness and corrosion of wire clips, stay hardware, and other metal parts	Pay attention to inclination of supports
	Grounding wire Counterpoise		1. Corrosion 2. Breaking of conductor and strands 3. Exposure	
	Insulator		1. Inclination of insulator string 2. Crack, breakage, arc mark, or peeling of glaze of porcelain parts 3. Insulator pollution 4. Appropriateness of fixation, corrosion, and breakage of isolator hardware, line hardware, and arcing horns	Examine the cause of the tilting of supports, sag, slipping of clamps, etc.

Subject			Inspection Item	Remarks
Inspection of Supports	Conductors near supports	Srung wire and connections	1. Breakage of strands, arc mark, kink mark, corrosion 2. Corrosion of connection such as jumper connection and loosening of bolts 3. Overheating of connections	
		Sag, clamps	1. Evenness and appropriateness of sag 2. Slipping and loosening of conductor in cramps	
		Jumper	1. Appropriateness of clearance to ground 2. Shape 3. Loosening, falling, and breakage of fixture on reinforcing device	
		Vibration of strung wire	1. Generation of vibration 2. Appropriateness of fixation and corrosion of damper and spacer 3. Breaking of strands and breakage of armor rod	Breaking of strands near clamps
Detection of Defective Insulator	Insulator		1. Check the insulation resistance using faulty insulator detector 2. Insulator pollution 3. Crack, breakage, arc mark, or peeling of glaze of porcelain parts 4. Appropriateness of fixation, corrosion, and breakage of isolator hardware, line hardware, and arcing horns	
Inspection of Strung Wire	Line conductor Overhead ground wire Guard wire (net) Shielding wire		1. Foreign object on conductor 2. Height from ground 3. Clearance from other structures and trees	

(4) Construction Plans of Transmission Lines

Table 5.2-1 shows the construction plan of transmission lines and substations for each year based on power demand forecast. The routes of these planned transmission lines are shown in Figs. 5.3-7 through 5.3-12 by year.

Since these routes have been planned by desk work, they may be changed as the result of the discussion with TANESCO and depending on the situation of the sites.

The length of transmission lines is estimated according to the drawings. And Table 5.3-2 shows the line length and number of circuit of 132 kV and 33 kV transmission lines planned for each year. Approximate construction cost is estimated based on Table 5.3-2.

Table 5.3-2 List of Planned Transmission Lines

No.	Year	Name of Line	Transmission line	Status	cct	Line Length (km) 132kV O.H	33kV O.H	33kV U.G	Remarks
1	1994	Ilala Line	Ubungo - Ilala	New	1	7.0			
2		Tandale Line	Branch from Ubungo - Friend. TX Line	New	1		5.2		Including replacement of 1.2km line.
3		Chang'ombe Line	FZ-1 - Chang'ombe - Kurasini (π-connect.)	New	1		2.0		1.1 + 0.9 = 2.0km
4	1996	Kunduchi Line	New Tegeta 132/33kV S/S - Kunduchi	New	1		2.8		
5		FZ-3 Line	Ubungo - FZ-3	New	1	8.6			
6		Kariakoo Line	Ilala - Kariakoo	New	1		1.6	0.5	
7		Mbagala Line	Kurasini - Mbagala	New	1		8.5		
8		Tabata Line	Branch from Ubungo-FZ-3 Line	New	1		0.2		0.1 + 0.1 = 0.2km
9	2000	Temeke Line	Yombo - Temeke	New	1		5.0		
10		Mburahati Line	Branch from Ubungo-Ilala	New	1		0.5		
11		Kitunda Line	Yombo - Kitunda	New	1		6.5		
12		Yombo Line	FZ-3 - Yombo	New	1	5.0			
13		Oysterbay Line	Ubungo - Oysterbay	New	1	7.0			
14	2002	Kurasini Line	Yombo - Kurasini	New	1	8.0			
15	2004	Mbezi Line	Zanzibar Line - Mbezi	New	1	3.5			
16		City Center Line	Ilala - City Center	New	1	3.5			
17		Upanga Line	City Center - Upanga	New	1		2.0		
18	2006	Mbagala Line	Yombo - Mbagala	New	1	5.8			
			Total Length			48.4	34.3	0.5	

5.3.2 Short-term Plan of Transmission Line

Execution plan of transmission line expansion program in Dar Es Salaam area in the long-term plan is shown in Table 5.3-2.

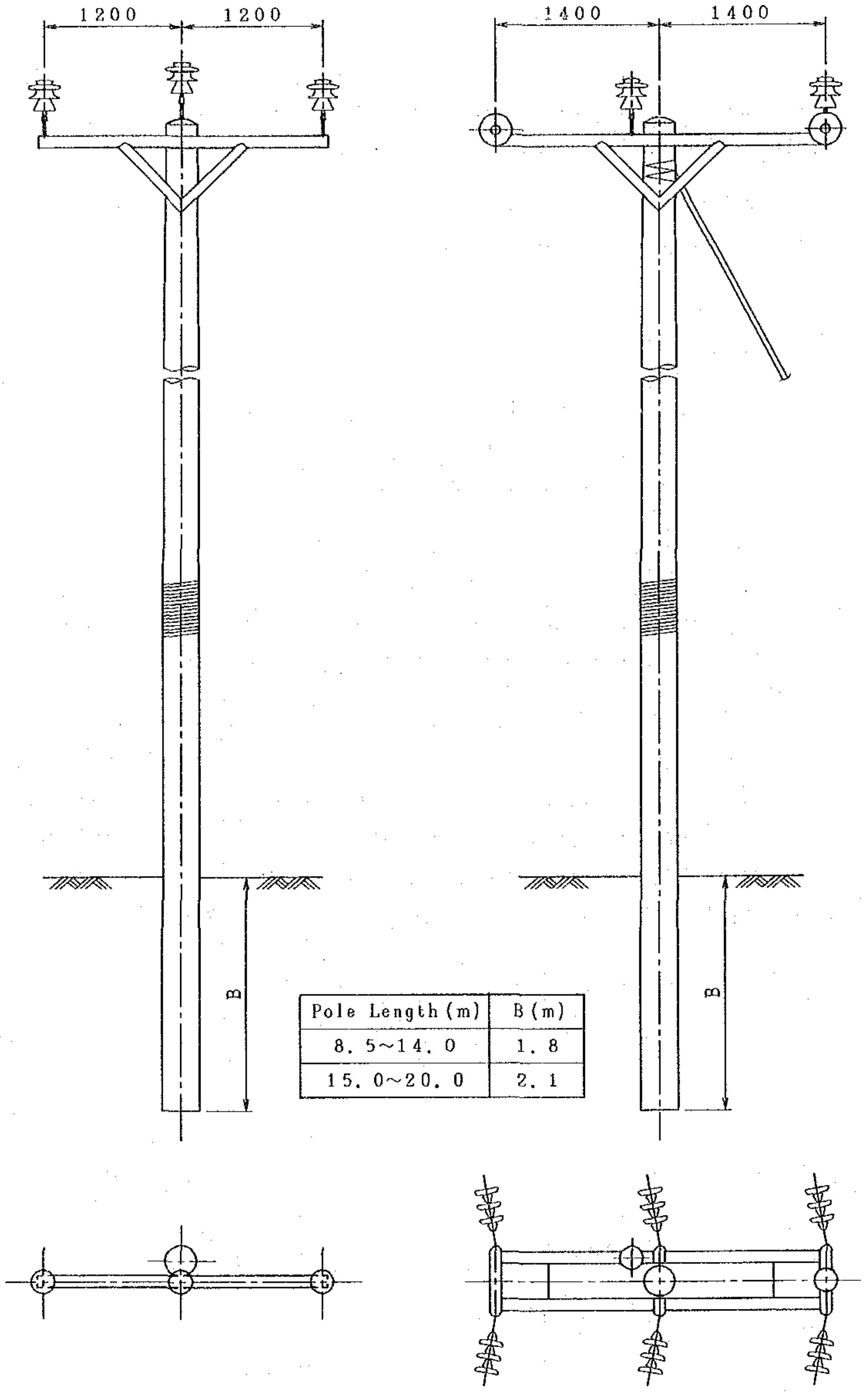
On the other hand, the short-term plan is a part of the long-term plan including construction projects in the first 5 years.

The routes of transmission lines constructed in the short-term plan are shown in Fig. 5.3-13.

Fig. 5.3-14 shows typical examples of pole assemblies used on existing 33 kV transmission lines, while Fig. 5.3-15 shows the types of towers used on existing 132 kV transmission lines.

In this plan, self-supporting towers shown in Fig. 5.3-16 will be employed as supports for 132 kV transmission lines. On the other hand, wooden poles, concrete poles and self-supporting towers will be employed as supports for 33 kV transmission lines.

And, wooden poles used for 33 kV transmission lines and distribution lines are manufactgured by TANESCO and the eucalyptus trees used as the materials are planted and grown by TANESCO. About 25,000 poles are produced every year, contributing to the growth of domestic industries. The short-time plan of transmission line will be studied further in detail based on the results of the second field survey.



Pole Length (m)	B (m)
8. 5~14. 0	1. 8
15. 0~20. 0	2. 1

Fig. 5. 3-14 SUPPORT OF EXISTING 33kV TRANSMISSION LINE

Fig. 5. 3-15 SUPPORT OF EXISTING 132kV TRANSMISSION LINE

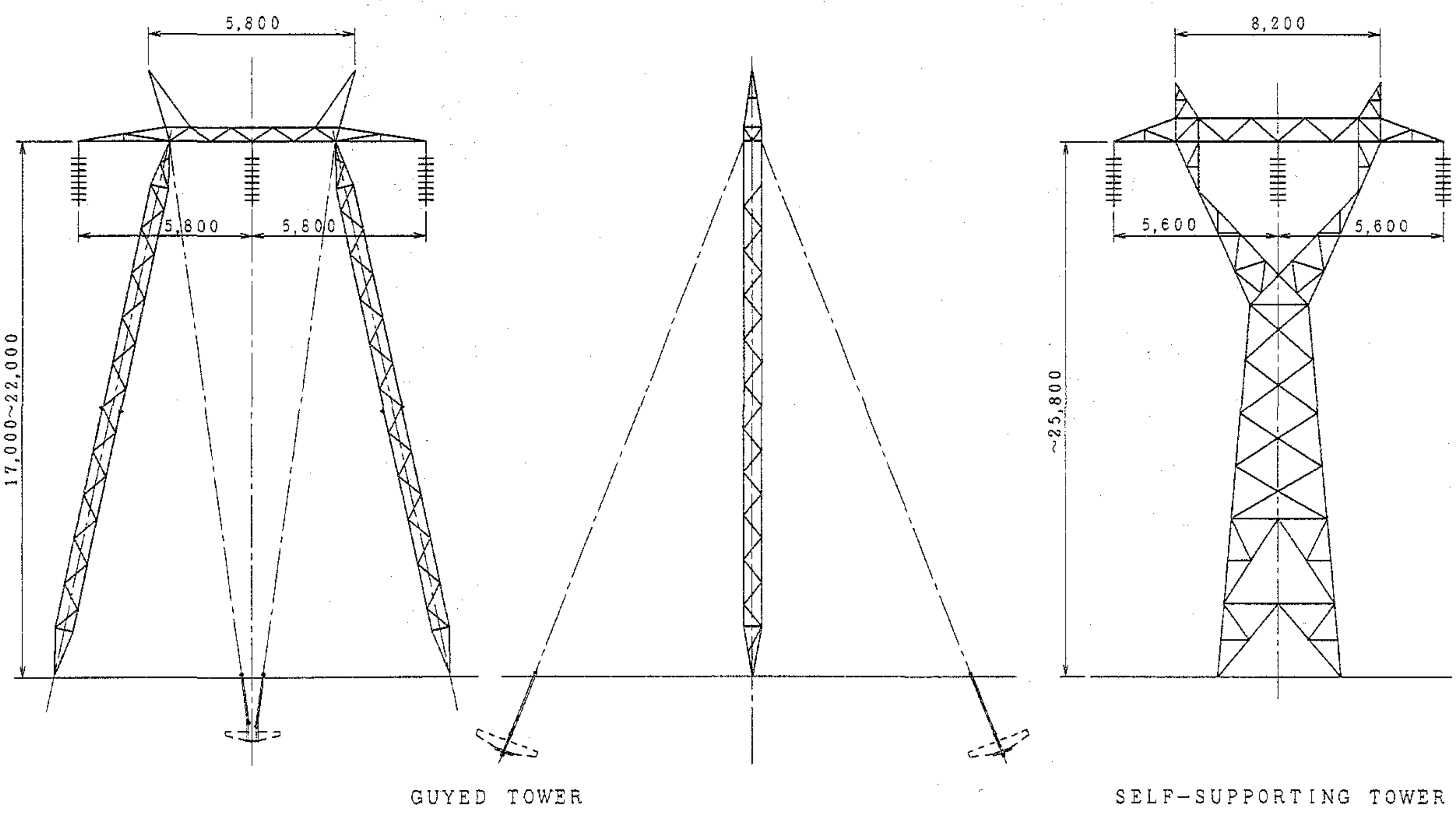
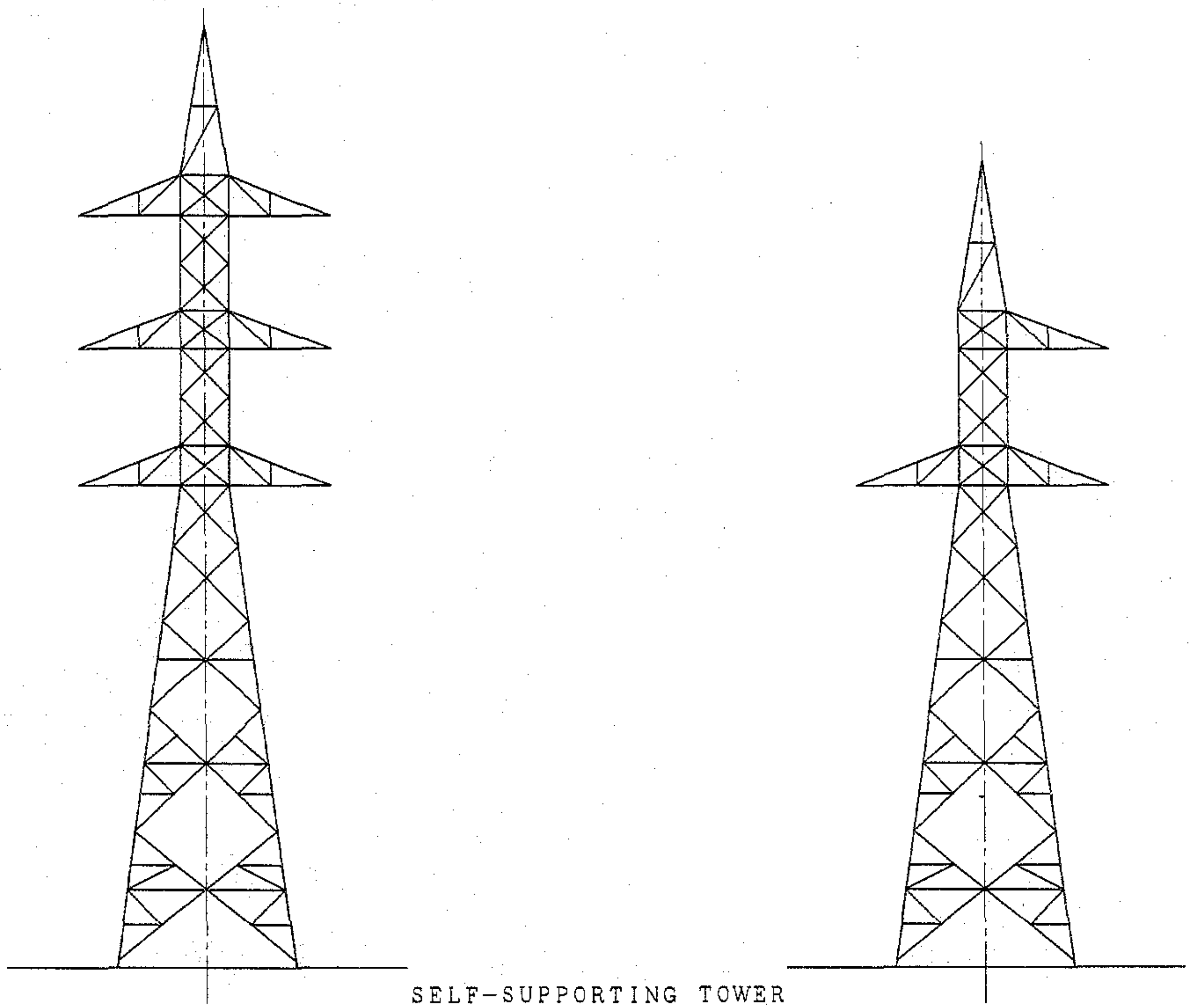


Fig5. 3-16 PROPOSED SUPPORT FOR 132kV TRANSMISSIOIN LINE



SELF-SUPPORTING TOWER