4.4.5 Load current of each feeder

The load current of each feeder recorded during the field survey is shown in Tables 4-4-3 - 4-4-6 and the load current of the 33 kV City Centre Line and Factory Zone I Line and the receiving power in both substations are shown in Table 4-4-7.

From these tables, it has been made clear that the load of the 06 feeder of Oysterbay S.S. is the highest at about 4,500 kVA and that the C2 (3,400 kVA) of the City Centre S.S. and D9 (3,200 KVA) of the Ilala S.S. are in that order. Generally, the load sharing differs greatly from feeder to feeder. From the current capacity viewpoint, there are many feeders with light loads allowing a relatively extra capacity.

4.4.6 Protection of 11 kV feeder

The protection against a short-circuit is provided by the overcurrent relay. Against the line-to-ground fault, the overcurrent ground relay is installed in the residual circuit of CT and the operating current value is set to about 10 - 20% of the operating current value of the overcurrent relay.

4.4.7 Characteristics of each feeder

The characteristics of each feeder are shown in Tables 4-4-8 - 4-4-9.

Table 4-4-3

Load current on 11 kV feeders - Oysterbay S.S.

Load Reading (AMPS)

Date	Feeder	Morning			Noon			Evening			Max. Load (kVA)
		R	Y	B	R	Y	B	R	Y	B	
28/6/84											
Thu	02	50	50	50	35	45	40	65	75	75	1,365
"	03	16	25	25	18	30	25	27	40	45	711
"	04	38	44	42	34	40	36	72	82	76	1,461
"	05	35	35	35	30	30	35	35	42	40	743
"	06	140	140	140	140	140	140	180	180	180	3,429
Total		279	294	292	257	285	276	379	419	416	(7,709)
29/6/84											
Fri	02	48	50	55	35	45	40	83	95	95	1,734
"	03	18	30	30	16	30	30	32	55	60	933
"	04	40	46	44	40	44	40	84	100	90	1,740
"	05	33	35	35	35	40	35	45	57	55	997
"	06	140	140	140	140	140	140	230	240	230	4,445
Total		279	301	304	266	299	285	474	547	530	(9,849)
30/6/84											
Sat	02	35	40	40	30	40	35	35	40	40	730
"	03	16	30	30	14	30	25	18	30	30	495
"	04	36	40	40	30	36	34	38	42	40	762
"	05	32	35	38	30	30	35	35	40	40	730
"	06	145	145	145	140	140	140	180	180	180	3,429
Total		264	290	293	244	276	269	306	332	330	(6,147)

Table 4-4-4

Load current on 11 kV feeders - City Center S.S.

Load Reading (AMPS)

Date	Feeder	Morning			Noon			Evening			Max. Load (kVA)
		R	Y	B	R	Y	B	R	Y	B	
28/6/84											
Thu	C2	165	165	162	175	175	180	180	175	180	3,397
"	C3	85	85	90	95	95	95	55	55	55	1,810
"	C4	45	50	50	145	155	150	75	81	80	2,858
"	C8	80	82	82	90	90	90	50	50	50	1,715
Total		375	382	384	505	515	360	360	361	365	(8,763)
29/6/84											
Fri	C2	160	165	162	175	175	175	175	175	175	3,341
"	C3	90	90	90	95	95	95	50	50	50	1,810
"	C4	140	145	150	145	155	150	65	70	70	2,858
"	C8	90	90	90	100	100	100	65	65	65	1,905
Total		480	490	492	515	525	520	355	360	360	(9,906)
30/6/84											
Sat	C2	145	170	165	132	150	150	150	152	150	3,048
"	C3	50	50	50	55	55	55	50	50	50	1,049
"	C4	55	50	55	62	65	64	65	65	65	1,238
"	C8	40	40	40	55	55	55	40	40	40	1,048
Total		290	310	310	304	325	324	305	307	305	(6,052)
1/7/84											
Sun	C2	160	158	160	135	150	150	155	152	152	3,035
"	C3	50	50	50	55	55	55	50	50	50	1,049
"	C4	52	58	58	65	65	64	60	65	62	1,232
"	C8	40	40	40	55	56	56	40	40	40	1,060
Total		302	306	306	310	326	325	305	307	304	(6,102)

Table 4-4-5

Load current on 11 kV feeders - Ilala S.S.

Load Reading (AMPS)

Date	Feeder	Morning			Noon			Evening			Max. Load (kVA)
		R	Y	B	R	Y	B	R	Y	B	
13/7/84											
Fri	D0	40	60	50	60	55	60	50	65	65	1,143
"	D1	5	5	5	5	5	5	5	5	5	95
"	D2	60	180	140	135	155	105	85	82	82	2,508
"	D9	135	165	150	160	170	170	170	145	145	3,175
"	D10	45	70	45	45	40	45	90	100	115	1,937
Total		285	480	390	405	425	385	400	397	412	(7,715)
14/7/84											
Sat	D0	65	70	85	80	75	65	55	45	40	1,397
"	D1	5	5	5	5	5	5	5	5	5	95
"	D2	65	135	150	78	80	75	90	95	90	2,223
"	D9	130	140	165	135	175	185	180	170	160	3,239
"	D10	45	60	40	40	45	40	100	115	115	2,096
Total		310	401	445	338	380	370	430	430	410	(8,065)
15/7/84											
Sun	D0	40	45	65	60	50	25	50	50	50	953
"	D1	5	5	5	5	5	5	5	5	5	95
"	D2	70	75	90	75	75	67	67	90	90	1,568
"	D9	120	120	120	125	120	115	115	115	115	2,286
"	D10	68	58	48	40	40	40	50	100	115	1,683
Total		303	303	328	305	290	252	287	360	375	(6,490)

Table 4-4-6

Load current on 11 kV feeders - Factory Zone I S.S.

Load Reading (AMPS)

Date	Feeder	Morning			Noon			Evening			Max. Load (kVA)
		R	Y	B	R	Y	B	R	Y	B	
28/6/84											
Thu	F2	110	105	100	100	100	100	65	65	65	2,000
"	F3	50	50	50	60	60	60	20	20	20	
"	F4	115	110	115	130	120	130	70	70	75	2,413
"	F5	140	145	145	130	125	125	95	90	85	2,731
Total		415	410	410	420	305	415	250	245	245	(7,842)
29/6/84											
Fri	F2	110	105	100	100	100	100	40	40	40	2,000
"	F3	50	50	50	60	60	60	15	15	15	1,143
"	F4	115	110	115	130	120	130	55	55	55	2,413
"	F5	145	145	145	130	120	125	90	95	90	2,763
Total		420	410	410	420	400	415	200	205	200	(7,874)
30/6/84											
Sat	F2	25	25	25	25	25	20	20	25	20	476
"	F3	0	0	0	0	0	0	0	0	0	0
"	F4	50	50	50	50	50	50	40	35	40	953
"	F5	75	80	80	80	80	80	65	70	65	1,524
Total		150	155	155	155	155	150	125	130	125	(2,921)

Table 4-4-7 Load current and receiving power on 33 kV feeders

(Recorded at Ilala Control)

Date	Morning		Noon		Evening		Remarks
	AMPS	MW	AMPS	MW	AMPS	MW	
City Center S.S.							
13/7/84 (Fri)	180	9.0	160	8.0	120	6.0	PF=0.87
14/7/84 (Sat)	160	8.0	112	5.6	120	6.0	
15/7/84 (Sun)	100	5.0	104	5.2	120	6.0	
Factory Zone I S.S.							
13/7/84 (Fri)	236	11.8	200	10.0	140	7.0	
14/7/84 (Sat)	200	10.0	124	6.2	120	6.0	
15/7/84 (Sun)	100	5.0	128	6.4	120	6.0	

Table 4-4-8 Characteristics of each feeder (1)

Feeder	Line Length (km)	Max. Load (kW)	Description
Oysterbay S.S.			
02	11.3	1,734	- 33 kV double circuit pole assembling along Old Bagamoyo Road - Pole: wood - Conductor: ACSR 100 sq.mm
03	8.8	933	- Feeding to Mikocheni Area - Pole: wood, steel - Conductor: ACSR 100 sq.mm, HDCC 25 sq.mm
04	7.6	1,740	- Connected to D10 feeder - Pole: wood, steel - Conductor: ACSR 100 sq.mm, HDCC 25 sq.mm
05	3.4	997	- Feeding up to Selander Bridge - Pole: steel - Conductor: HDCC 35 sq.mm
06	20.0	4,445	- Feeding to Msasani Area - Pole: wood, steel - Conductor: ACSR 100 sq.mm, HDCC 25 sq.mm
City Center S.S.			
C2	7.6	3,397	- Feeding to Upanga Area - Pole: wood, steel - Conductor: HDCC 35, 25 sq.mm
C3	2.4	1,810	- Feeding to City Center Area - Pole: steel - Conductor: ACSR 100 sq.mm
C4	1.9	2,858	- Feeding to City Center Area - Pole: steel - Conductor: ACSR 100 sq.mm
C5	0.9	0	- Underground Line - Out of operation
C6	1.5	0	- Underground Line Out of operation
C8	2.3	1,905	- Feeding to Ocean Road - Pole: steel - Conductor: HDCC 25 sq.mm

Table 4-4-9 Characteristics of each feeder (2)

Feeder	Line Length (km)	Max. Load (kW)	Description
Ilala S.S.			
D0	0.3	1,397	- Feeding to Brewery only
D1	2.5	95	- Pole: steel - Conductor: HDCC 35 sq.mm
D2	4.3	2,508	- Connected to C4 feeder - Pole: steel - Conductor: HDCC 35 sq.mm
D3	-	-	- Out of operation
D8	7.0	-	- Under repairs - Pole: steel - Conductor: HDCC 25 sq.mm
D9	2.0	3,239	- Feeding to Kariakoo Area - Pole: steel - Conductor: HDCC 50, 25 sq.mm
D10	7.6	2,026	- Connected to 04 feeder - Pole: steel - Conductor: ACSR 100 sq.mm
Factory Zone I S.S.			
F2	6.6	2,000	- Feeding mainly to factories - Pole: steel, wood - Conductor: HDCC 25 sq.mm
F3	5.8	1,143	- Feeding mainly to factories - Underground and Overhead Line - Pole: wood, steel - Overhead conductor: HDCC 25, 70 sq.mm
F4	9.3	2,413	- Feeding mainly to factories - Pole: steel, wood - Conductor: HDCC 25 sq.mm
F5	4.9	2,731	- Connected to D8 feeder - Pole: steel, wood - Conductor: HDCC 25 sq.mm

4.4.8 Overhead distribution lines

(1) Supporting materials and poles assembling

In the urban area or center of a city such as the City Centre and the Ilala area, the steel poles of 36 ft (10.8 m) and 40 ft (12 m) are mainly used. In the new residential area and suburbs such as Oysterbay area and the Factory Zone I area, the wooden poles are also used.

For the typical poles assembling, the wish-bone type is adopted for the steel poles and a single arm horizontal arrangement for the wooden poles. In some parts of the urban area (C3, C4, D1, D2, D9 and D10), a 2-circuit 3-stage arm system is also found. In a special case, like the 02 feeder in Oysterbay, one side of the 33 kV 2-circuit assembling is used as a 11 kV feeder.

(2) Insulator and electric wire

On the straight line poles, pin insulators are mostly used, and at the termination and section, porcelain or glass disk insulators are used in pairs.

The electric wire of ACSR 100 mm^2, 50 mm^2, and HDCC 70 mm^2, 35 mm^2 and 25 mm^2 are being used, but these wires which are found many connecting points are considerably superannuated with the strand breakages.

(3) Other

The number of section switches provided is too small; only 1 switch or less per feeder. The automatic voltage regulators for distribution lines, capacitor for improving power factor and arrestor to prevent a lightning stroke are not installed in the distribution lines. But for the ground wire, almost all the lines are provided with them.

4.4.9 Underground lines

(1) Type of cable and laying method

For the trunk line portion, a 3C x 185 mm^2 paper-insulated steel-wire armored cable is used, and for the branch line portion, a 3C x 70 mm^2 paper-insulated steel-wire armored cable is also used.

The laying method is the direct burying method and at the road crossing area the cable is protected by a conduit line against the load.

(2) Used places of cable

For the outgoing line from a substation, C5 and C6 in the City Centre and F3 in the Factory Zone I, mostly the underground cable of 3C x 185 mm^2 is used. At each branching point to the load in the trunk line portion, such as C5, C6, and F3, the ring main units which the main circuit side has a performance of load-break switch and the branch line side is protected by a fuse are provided at each branched place. However, C5 is not used because the cable has become deteriorated.

The underground cable of 3C x 70 mm^2 is used for branching at places where the overhead branching to the loads is difficult.

(3) Terminal processing of cable

For the terminal of the cable, a cast-iron type and a plastic type cable heads and a terminating material of a heat-shrinkable type are used.

4.5 LOW VOLTAGE DISTRIBUTION LINES

(1) Distribution transformer

(i) Capacity and number of units

The distribution transformer has a large capacity ranging from 25 kVA to 1,000 kVA, but mainly large capacity types of 200 kVA to 500 kVA are used.

The number of transformers installed is about 285 units in the important areas of the 4 substations. Table 4-4-10 shows the number of transformers classified by feeder.

(ii) Protection method for the transformer

It is protected by the open fuse cutout on the primary side against the short-circuit accident under the transformer winding and by the low voltage cutout fuse against the overload or short-circuit under the low voltage line. But for the secondary side of some large capacity transformers, the distribution pillar is provided for protection.

(iii) Installation method of the transformer

Relatively small capacity transformers of about 200 kVA or less are installed on H-framing poles and for 300 kVA or higher, the cable box type transformers are used and they are installed on the ground in many cases.

(iv) Load current of the transformer

Table 4-4-11 shows the load current of transformers actually measured during the survey. For the actually measured 22 transformers in this table, the load current at the time of the survey was less than 60% of the rated current in most cases and no overload was found, but in some cases, such as in the demand value of the No. 15 transformer, the rated current was exceeded by as much as about 14% at the past peak time.

As a result of measuring the current for the earthing wires of 18 transformers the earthing current of about 0.5 - 26A was recognized for 13 transformers.

(v) Electric wire connection on the primary and the secondary sides of the transformer

For the wrapping connection, insufficient number of wraps and imperfect tightening were often found both on the primary and the secondary side and especially the secondary side is left in a bad condition.

Table 4-4-10 Number of transformers/feeders

Feeder	Number of transformers (units)												Total Capacity (kVA)
	KVA 25	50	100	150	200	300	315	400	500	750	1000	Total	
Oysterbay S.S.												(81)	(18,905)
O2		1	5	1	10	2	2			1		22	4,680
O3		1	1	1	3	3						9	1,800
O4		1	5		4	1						11	1,650
O5		1			5	1			1			8	1,850
O6	1	1	1		11	11			5	1		31	8,925
City Center S.S.												(64)	(27,880)
C2					5	8	2		7			22	7,530
C3		1				4		1	10	2	1	19	9,150
C4						1			5	3		9	5,050
C5												0	-
C6												0	-
C8			2		2	1			7	1	1	14	6,150
Ilala S.S.												(67)	(20,790)
D0											2	2	2,000
D1						2						2	600
D2					5	3			11			19	7,400
D8		4	1	6	4	3			2			20	3,900
D9		1			5	1	1		3	3		14	5,415
D10	1	2	1	3	1	2						10	1,475
Sub-total	2	13	16	11	55	43	5	1	51	11	4	(212)	(67,575)
F.Z. I S.S. I												(73)	(21,200)
F2			5	3	4	5			10		1	29	9,650
F3			1	1	1	1		1	2			6	1,750
F4					8	8						16	(4,000)
F5					10	11			1			22	(5,800)
Total	2	13	22	15	78	68	5	2	64	11	5	285	88,775

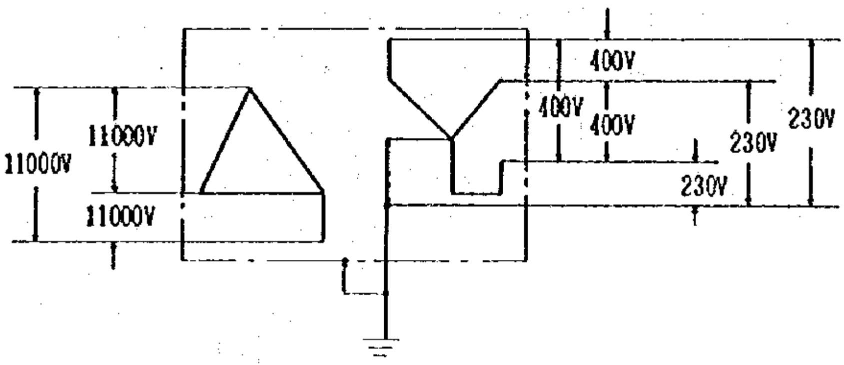
Table 4-4-11 Details of transformers measured

No.	Date	Feeder	Capacity of Tr. (kVA)	Current measured (A)					Pole Assembling	Remarks
				R	Y	B	N	Earth		
1	6/29 A.M.	02	150	110	85	80	25	-	Wood pole H	Rated Current 217A
2	"	04	150	85	65	77	25	-	"	
3	"	"	300	220	250	200	30	-	Steel pole H	Rated Current 433A Distribution Pillar
4	"	"	200	53	28	105	48	-	"	Rated Current 289A
5	6/29 P.M.	06	200	43	40	15	70	0.5	"	
6	"	"	750	88	78	77	24	14	Ground	Rated Current 1083A
7	"	"	200	125	75	110	34	0.5	Wood pole H	
8	"	"	500	105 (350)	150 (420)	75 (250)	50	4		Rated Current 722A Distribution Pillar
9	6/30 A.M.	"	200	4	2	0	2.5	0	Wood/steel pole	Arc horn on 11 kV bushings
10	"	"	100	42	24	30	22	0	Steel pole	Rated Current 144A
11	"	03	150	11	12	10	0	0		
12	7/2 A.M.	C2	200	9.3	3.5	24	23	0	Steel pole	
13	"	"	500	335	255	230	149	2	Ground	
14	"	"	500	90	110	100	9	0.1	"	Muhimbili Hospital
15	"	"	500	350 (560)	400 (820)	330 (775)	-	0.2		Distribution Pillar
16	"	"	50	24	24	70	8	3	Steel pole	Rated Current 72A
17	7/2 P.M.	C3	750	171	235	175	74	7	Ground	TANESCO Head Office
18	7/3 A.M.	C4	750	(480)	(520)	(470)	-	-	Ground	Distribution Pillar
19	"	D2	300	180	230	220	34	26		
20	"	D10	300	42	65	40	18	1.5	Wood pole H	
21	7/5 A.M.	F5	500 500	240 240	210 210	230 240	18 15	0.5 5		
22	7/7 A.M.	D10	315	290	280	230	45	0		Rated Current 455A

(2) Distributing method and distribution voltage

For the distributing method, Y 3-phase 4-wire system and neutral earthing system are adopted as illustrated. The working voltage is a single-phase 2-wire 230V for the single-phase load and a 3-phase 3-wire 400V for the 3-phase load.

Generally, a 3-phase 4-wire system is used for the trunk line portion and a 3-phase 4-wire system or a single-phase 2-wire system for the branch line portion, and the tree branches system is adopted.

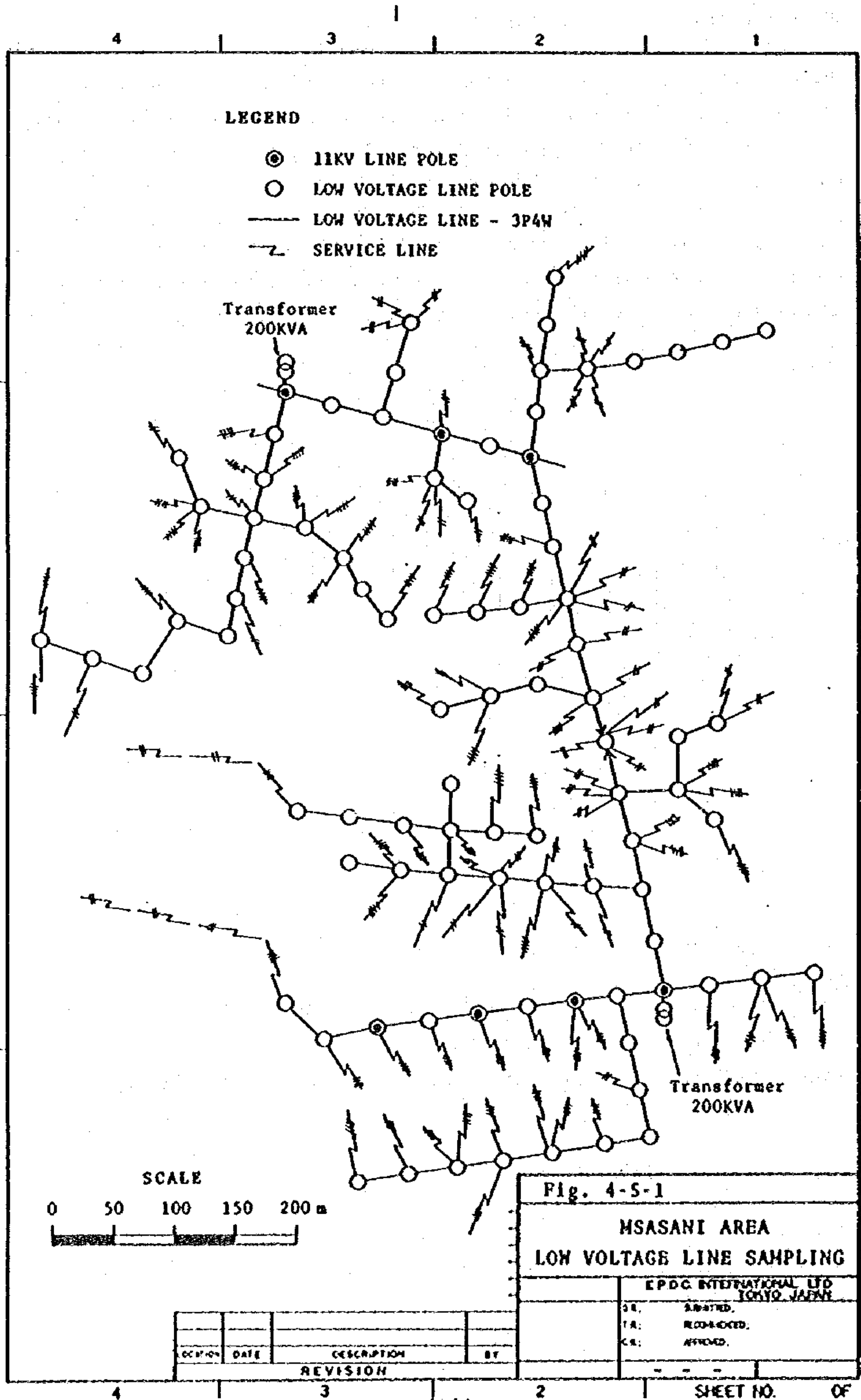


(3) Low voltage line per transformer bank

For the 200 kVA transformers in the surveyed Msasani and Kariakoo areas, the number of spans is 41 - 47 and the total distance is about 1.6 - 1.9 km. Figs. 4-5-1 and 4-5-2 show the field survey diagram of the low voltage line.

(4) Supporting materials and assembling poles

The steel poles of 28 ft (8.4 m) are mainly used in the urban area and wooden poles in the suburbs, and for the assembling, the vertical wiring system is adopted in most cases.



LEGEND
11KV LINE POLE
LOW VOLTAGE LINE POLE
LOW VOLTAGE LINE - 3P4W
SERVICE LINE
Transformer 200KVA
Transformer 200KVA
SCALE
0 50 100 150 200 m
Fig. 4-5-1
MSASANI AREA
LOW VOLTAGE LINE SAMPLING
EPDC INTERNATIONAL LTD
TOKYO JAPAN
DATE
DESCRIPTION
BY
REVISION
SHEET NO.
OF

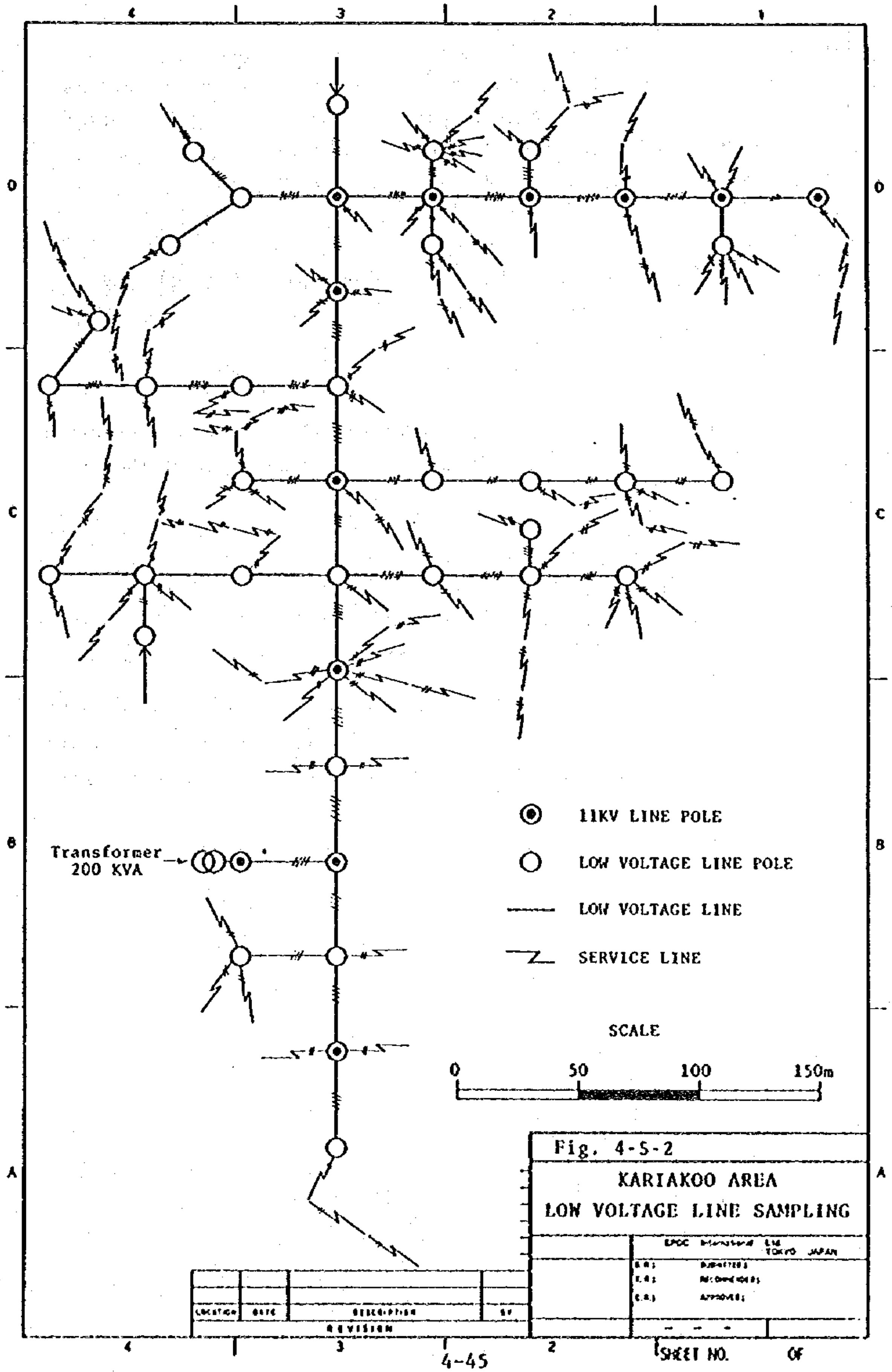


Fig. 4-5-2
KARIAKOO AREA
LOW VOLTAGE LINE SAMPLING

(5) Electric wire and wire connection

Relatively new wires (HAℓ 100 mm^2) are found in some places, but in most cases HAℓ 50 mm^2, Cu 35 mm^2 and Cu 25 mm^2 wires and Cu 3.2 mm and 2.6 mm solid wires are used, and most of them are bare and have many connection points and considerably deteriorated. Insulated wires are also used in some places, but the insulating performance is lost in many cases due to time ageing.

The wire connected parts are also deteriorated due to ageing and many of them are corroded causing accidents.

(6) Service wire

Mostly the bare wires are used, and the insulated wires used in some places are in the same situation as stated in the above (5) and many of them are deteriorated.

(7) Voltage fluctuation situation in general consumers

Figs. 4-5-3 and 4-5-4 show the situation of voltage fluctuation in general consumers actually measured during the survey.

In the circuits of rated voltage 230V, the voltage fluctuation range is big at the range of +45V and -30V. The main reason is that the length and wire size of the low voltage distribution line often do not conform to the load current.

Fig. 4-5-3 RECORD OF VOLTAGE FLUCTUATION AT DOMESTIC CONSUMER

(Recorded in Msasani Area - 06 Feeder)

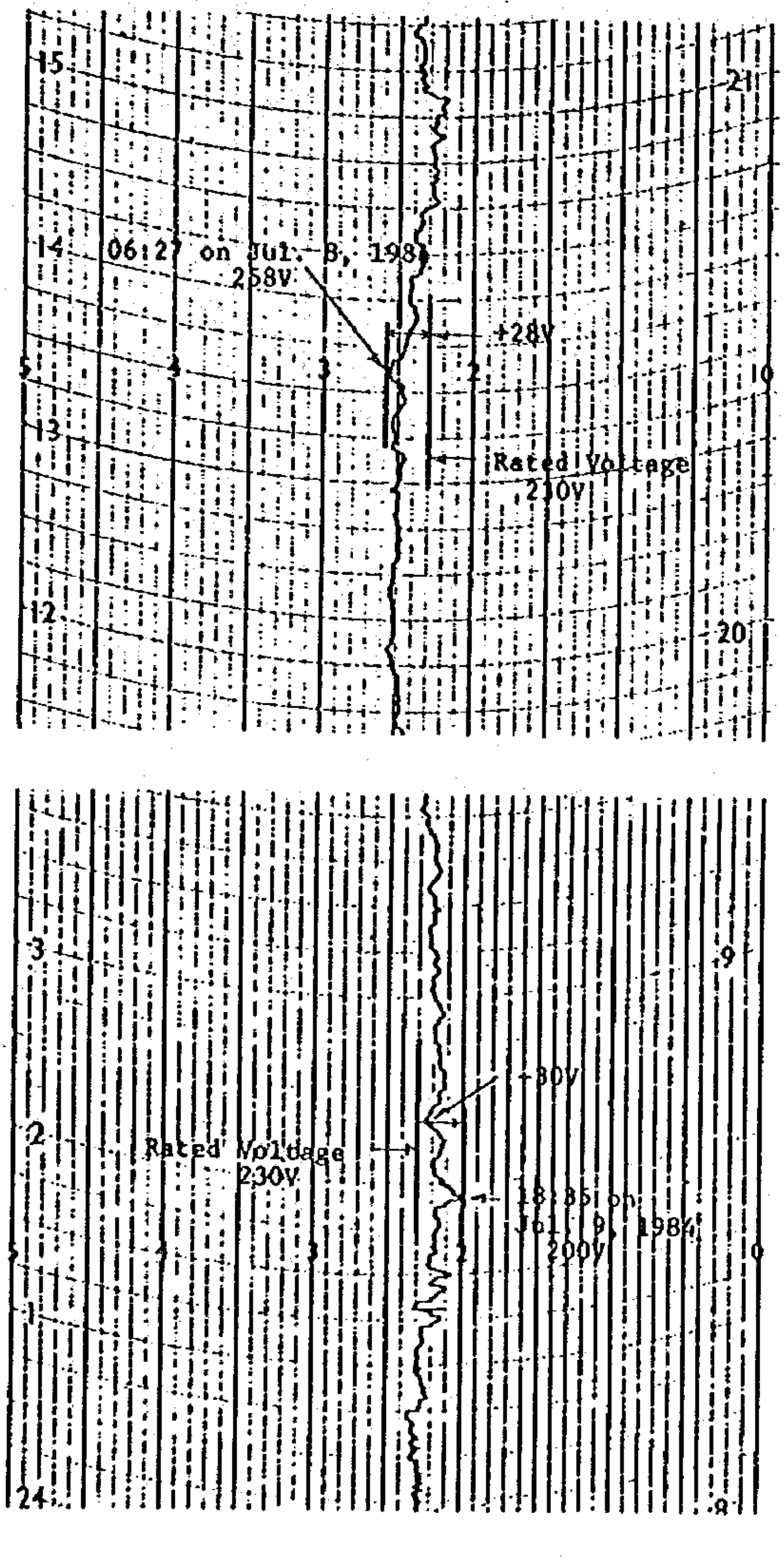
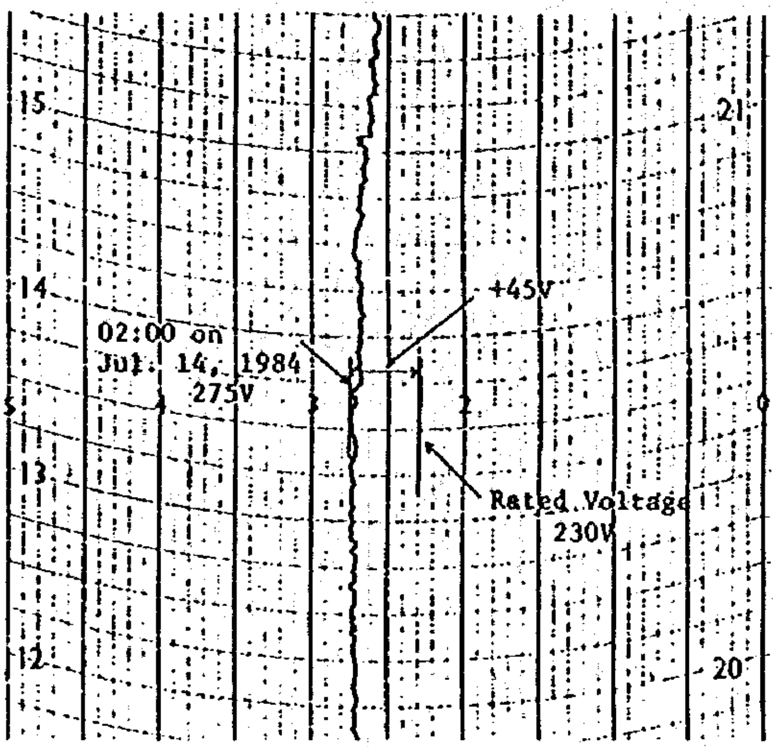
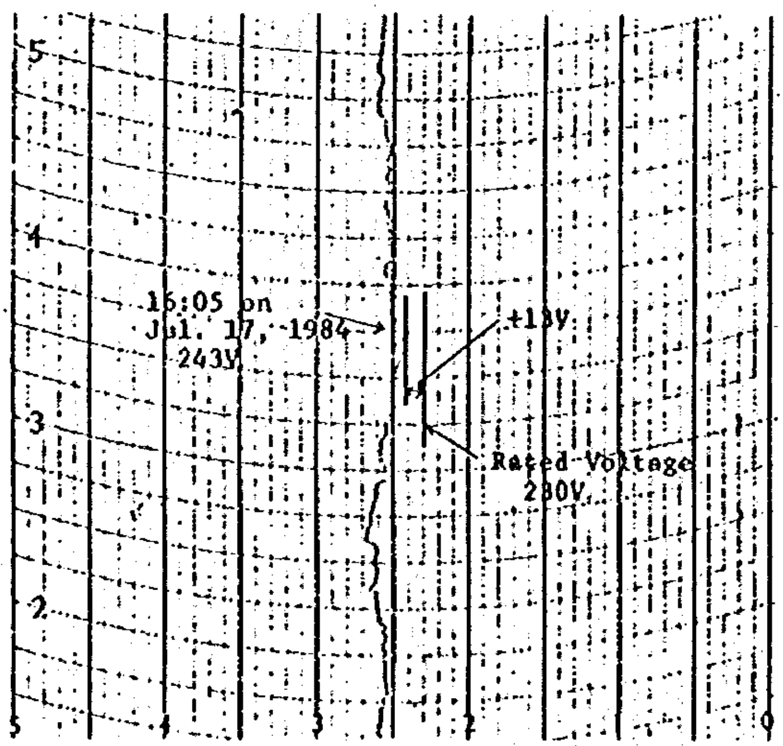


Fig. 4-5-4 RECORD OF VOLTAGE FLUCTUATION AT DOMESTIC CONSUMER

(Recorded in Msasani Area - 06 Feeder)





4.6 PROBLEMS IN THE EXISTING SYSTEM

4.6.1 Substations

(1) Capacity of substation facilities

(i) Ubungo S.S. is equipped with two 132 kV/33 kV 50 MVA transformers. These transformers have a considerable oil leakage but can not be repaired owing to the heavy load and a shortage of materials. TANESCO has intention to upgrade the capacity by installing two 100 MVA transformers or an additional unit of 50 MVA transformer to have three 50 MVA transformers in total.

(ii) 132 kV transmission line between Ubungo - Ilala is not efficiently utilized due to a shortage of capacity in two 132 kV/ 33 kV 10 MVA transformers at Ilala, and relatively high internal impedance of the transformers make operation with two 33 kV transmission lines (jointly used) difficult, to unable load tap converters to be automatically operated.

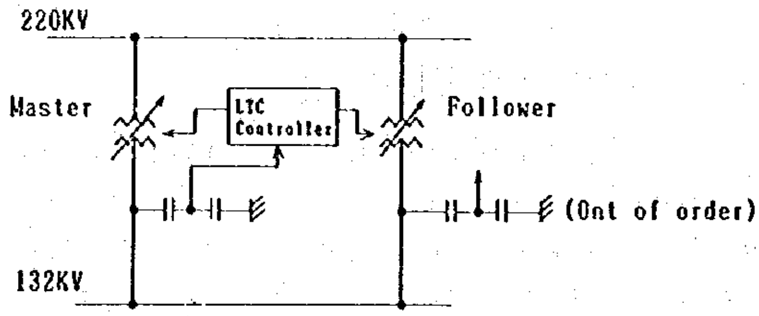
(2) Present condition of facility maintenance

The substation area is not particularly under good maintenance condition, although better than the maintenance of distribution lines. Such poor maintenance conditions are found in unremoved materials, poor cleaning, lack of inspection on moisture absorbent agent, water leakage in building, untidy condition around cubicles, absence of or error in equipment labels, indication of measuring manification and feeder name plates.

In addition, the following equipment has troubles:

(i) One of two voltage detecting devices on 132 kV side to control 220 kV/132 kV 150 MVA transformer LTC at Ubungo S.S., as shown in the figure, has been removed due to trouble.

At present, two LTCs are automatically operated by a voltage detecting device in working order. Should this one fail, LTC has to be manually operated to cause larger voltage fluctuations in 11 kV bus at each distributing substation. Thus, prompt restoration to normal condition is desirable.



(ii) The following transformers have load tap changer (LTC) in trouble:

- Ubungo S.S. 132/33 kV 50 MVA L.T.C. control panel
- Ilala S.S. 33/11 kV 7.5 MVA L.T.C. main unit resistor
- Factory Zone I 33/11 kV 5 MVA L.T.C. driving motor

See item (3) "Present State of Facilities Operation" for details.

(iii) At Ilala S.S., a winding dial thermometer for a 132/33 kV 10 MVA transformer does not work properly, and only a dial thermometer for measuring oil temperature is used.

(iv) At Ilala S.S., overhead ground wires are only connected to a top of steel structures without rising ground lines, to depend its earthing on foot of the steel structures. Should the overhead ground wires be struck by lightning, reverse internal short circuit will occur. Thus, the overhead ground wires are preferably connected to ground network directly by cables.

(v) 132 kV lightning rods at Ilala S.S. have low reliability in performance since they appear to have been used for more than 20 years. According to the field survey, lightning has occurred several times/year, and actuation of arresters, 5 - 10 times, was recorded in counter at distributing substations including Ilala S.S.

Several lightning damages have occurred to two 33/11 kV transformers at Ruvu S.S. and other transmission and distribution facilities.

(vi) The most of transformers at each substation have oil leakage, and packings should be replaced at the earliest time.

(vii) DC power source equipment at Oysterbay S.S., City Centre S.S. and Factory Zone I S.S. are significantly deteriorated and should be replaced.

(viii) 33 kV Line Switch (Ilala S.S. line) at Oysterbay S.S. cannot be operated, due to out of order.

(3) Present state of facilities operation

(i) Voltage fluctuation

At present, load tap changer (LTC) for 220/132 kV transformers at Ubungo S.S. and 33/11 kV transformers at Kurasini S.S. are automatically operated. On the other hand, LTCs for other transformers are manually operated (See 4-2-3(3)), not contributing to voltage regulation.

These manually operated LTCs have the following problems if they are automatically operated:

(a) 132/33 kV transformers at Ubungo S.S. and Ilala S.S. have to be fixed all the time to maintain power flow balance in 132 kV and 33 kV continuous transmission lines, and are manually operated when 33 kV bus voltages are high (low).

(b) A LTC tap control panel for 132 kV/33 kV transformers at Ubungo S.S. has been damaged because of its heating, and top location can not be identified. LTCs have oil leakage.

(c) At Ilala S.S., 33/11 kV 7.5 MVA transformers can not be operated manually, due to the failure of resistors in LTCs.

(d) LTCs for 33 kV/11 kV transformers at Oysterbay S.S., City Centre S.S. and Factory Zone I S.S. can not be monitored from manned Ilala S.S. due to the failure of communication lines between them, and thus can not be automatically operated.

(e) A LTC driving motor (No.1) for 33/11 kV transformers at Factory Zone I S.S. is not operated due to failure. Two other units are operated normally.

33 kV bus voltage at Ilala S.S. is considered to fluctuate in a range of 6% (2% for voltage fluctuation in 132 kV transformers at Ubungo S.S. and 4% for voltage drop in 132 kV/33 kV transformers and transmission lines), both in light and heavy loads, and further fluctuation is expected in 11 kV bus voltage at distribution substations.

(ii) Unbalanced state of feeders

A considerable degree of unbalance in load current at 11 kV feeders of substations is observed, balanced operation is preferable to a possible extent. Also, there are some Circuit Breakers switched off despite of feeders installed partly because of a shortage of equipment and materials available, and appropriate measures are desirable.

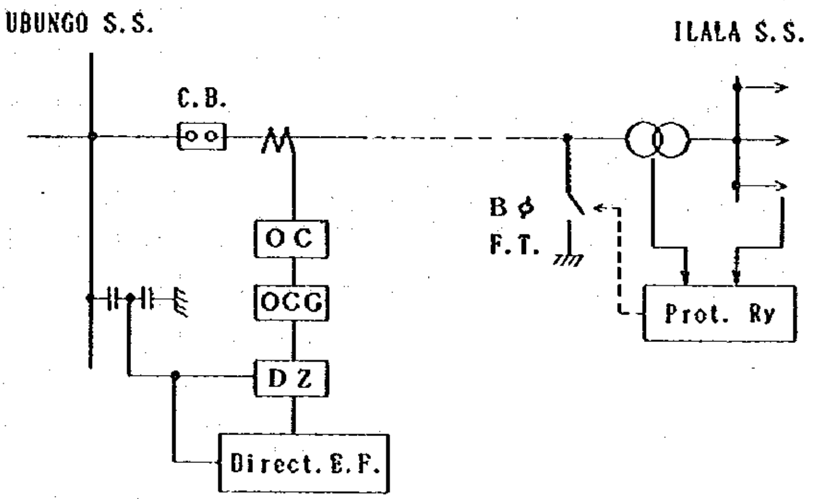
(iii) Operation of division bus

Although 11 kV buses at Ilala S.S. and City Centre S.S. are designed as divisible ones, they are operated as a single bus. They should be operated giving due consideration to advantages and disadvantages, i.e., magnitude and type of load, measures against short circuit current and extent of reduction in power failure.

(4) Protection relay system

Since Circuit Breakers are not installed on Ilala S.S. side in Ubungo S.S. - Ilala S.S. 132 kV transmission lines, Circuit Breakers at Ubungo S.S. are designed to trip at the time of trouble in Ilala S.S. side (including transformers) by grounding a line of F.T. of B phase to switch to "close" position and detecting the grounded current through direction earth fault relay at Ubungo S.S. Similarly, Oysterbay S.S., Factory Zone I S.S., Factory Zone II S.S. and Mbezi S.S. are not installed with receiving Circuit Breakers, and use same protection system using F.T.

The system has disadvantages in increasing accident current and taking seconds for restoration. Also, it has a risk of burning transformers at the time of short circuit at transformer's secondary side, and other various dangers against system stability and protection of equipment connected in series. It is particularly desirable to provide direct ground system with high speed circuit opening.



(5) Voltage fluctuation at Ruvu S.S.

Power for Lower Ruvu pump station which supplies water to Dar es Salaam, is sent from Ubungo S.S. through 33 kV transmission line (Nordic Line) extending over 80 km. At the pump station, three units of cage type induction motors (3,300 V 1,900 HP, usually one or two motors are operated) are used for pumping. However, they have high start current and tend to trip as a result of voltage drop, so that operated motors must be started additionally as no load in each time to start a motor.

4.6.2 33 kV Sub-transmission lines

(1) Ilala to City Center Line

This line covers main loads arising from shops, governmental officer, schools, etc. in the control parts of Dar es Salaam, and it is already overloaded as easily seen from Tables 4-3-1, 4-6-2-1 and 4-6-6-2.

Since the power demand in this area has greatly been on increase and power supply failure, if any, will greatly influence, it is believed that urgent countermeasures be taken as soon as possible.

(2) Ilala to Oysterbay Line

This line was completed 21 years ago, but it can still be usable for the time being. However, the size of electrical wire is only ACSR 50 mm^2. This line is presently out of use, and the power supply to Oysterbay is mainly being done by means of one line of ACSR 100 mm^2 between Ubungo and Oysterbay, which was completed in 1976. The Ilala to Oysterbay line is being used as a spare line in case of emergency. However, the supply line from Ubungo will be overloaded in 1988. In the event that power supply via the Ugungo-Oysterbay line should be stopped, this line will be substituted for it. The present power supply capability of this line is only 70%, and reinforcement thereof should be made in due time.

(3) Ubungo to Kurasini Line

Power supply to Kurasini should be primarily done from Ilala. Nevertheless load control problems in 132-kV and 33-kV connection lines between Ubungo and Ilala, has caused power to be supplied directly from Ubungo via Textile II line not through the Ilala bus bar for reducing the 33-kV load. In the portion between Ubungo and Ilala, conductors of four (4) different sizes are used; i.e., i) ACSR 50 mm^2 between Ugungo and Ilala, ii) ACSR 150 mm^2 between Ilala and Old P.S., iii) ACSR 100 mm^2 between Old P.S. and Kurasini, and iv) two Cu 90 mm^2 underground cables at Pug road crossings between Ilala and Old P.S. The portion of ACSR 50 mm^2 between Ubungo and Ilala is observed to be weak in respect of power supply to Kurasini, although it will be possible to meet the demand up to 1987. In 1987 and subsequent years, however, the 50 mm^2 line transmission capacity will become insufficient to satisfy required power line transmission capacity will become insufficient to satisfy required power some measures should be taken beforehand.

(4) Ugungo to Ruvu (NORDIC) Line

This line supplies power to the Lower Ruvu Pump Station which is a water supply source located 60 km north of Dar-es-Salaam, and also supplies power to several villages scattered along it including Kibaha up to Bagamoyo located 30 km east of Ruvu.

The Ubungo Substation is operating at a somewhat higher transmitting terminal voltage in order to make up for voltage reduction at the reception terminal. Therefore, consumers near Ubungo are complaining that the voltage is too high. In addition, in the pump station there is a problem of tripping when starting the pump. Further, maintenance services have come to be deteriorated due to the shortage of materials and equipment in addition to the obsoleteness of such facilities.

However, it seems difficult to solve the problem of voltage fluctuations under the existing system, and it might be the best policy to change the power transmission system by newly building a 132/33-kV Rubu substation which is stated later (8.6 (2)) in detail. Hence, no reinforcement of the trasmission line is to be made under the framework of this Project.

(5) Ilala to Factory Zone I Line

This line was completed 19 years ago, but it still can be usable. Since power demand in this area is increasing at a comparatively rapid tempo, it is considered that the line become overloaded around 1989. However, the increased demand of the Factory Zone I will be covered by the newly built Factory Zone III which will be mentioned later (8.1.3 (3)) in this report. Reinforcement of the existing lines will not be carried out.

(6) Ilala to Factory Zone II Line

This line was completed 16 years ago, and it employs conductors of ACSR 50 mm^2. In this line, a breaker at the side of Ilala is made open due to power flow control at the Ilala substation. Power supply to the Factory Zone II is done via a branch line from the Ubungo-TAZARA line.

The increase in demand for power supply to the Factory Zone II is not so large, and the operation of this facility can sufficiently be used in the case of accidents and/or failure on the TAZARA line.

(7) 132-kV Transmission Line between Ugungo and Ilala

The power supply to Ilala is being done by means of one circuit 132-kV line and two circuit 33-kV lines. The power transmission capacity of the 132-kV is 96 MVA, and that of the 33-kV lines is 48 MVA. The present system, however, has a problem in that it is rather difficult to place loads on the 132-kV side due to the high internal impedance of the 132/33-kV transformer in Ilala. Consequently, the load to be burdened by the 132-kV line is supplied all the way to the distribution substations and large consumers through distant sub-transmission lines. The efficiency of the facility utilization, however, is in a very low level. Repair of Ilala Substation will be of an urgent necessity for fully utilizing the 132-kV line.

Table 4-6-2-1 Transmission capacity of 33 kV line

Conductor	Ampacity (A)	Approximate Capacity (MW)			Remark
		cosθ=1	cosθ=0.9	cosθ=0.85	
Existing					
ACSR 50 sq mm	213	12.1	10.9	10.3	Rabbit
" 100 "	333	19.0	17.1	16.1	Dog
" 150 "	420	24.0	21.6	20.4	Wolf
Cu 90 sp mm x 2	460	26.2	23.6	22.3	Underground Cable
Proposed					
ACSR 120 sq mm	388	22.1	19.9	18.8	
" 160 "	454	25.9	23.3	22.0	
" 240 "	593	33.8	30.5	28.8	

Table. 4 − 6 − 2 − 2 Lord Forecast at Distribution Substations

(Unit : MW)

Substation/Consumer	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
	(Actual)	(Actual)										
Ilala	13.4	13.0	13.2	14.2	14.3	14.8	16.5	16.6	17.2	18.0	19.0	20.3
City Center	15.8	17.5	17.8	19.2	19.5	21.7	21.8	22.0	23.2	23.3	24.7	26.2
Oysterbay	12.0	12.2	12.4	13.3	13.9	14.8	16.6	17.1	17.2	18.0	19.0	20.3
Factory Zone I	12.0	12.6	12.6	12.6	12.3	12.9	14.7	18.9	22.2	23.1	24.9	26.7
Ubungo	3.7	2.8	2.9	3.1	8.5	4.5	4.5	4.5	5.0	5.3	5.7	6.1
Mbezi	3.0	2.1	2.2	2.4	2.6	2.8	3.8	2.8	4.8	5.1	5.5	8.9
Kurasini	4.0	8.1	8.1	8.1	8.7	9.5	10.7	12.5	13.1	14.0	15.0	16.1
Factory Zone II	3.6	3.6	3.6	3.6	3.7	3.9	3.9	4.0	4.0	4.0	4.0	4.0
ALAF	9.6	9.0	9.0	9.0	9.1	9.2	9.3	9.4	9.5	9.8	10.2	10.5
TAZARA	1.5	0.9	1.0	1.0	1.2	1.2	1.2	1.2	1.3	1.3	1.4	1.4
NORDIC	4.4	5.8	5.8	5.8	6.4	6.8	6.9	6.9	7.0	7.1	7.3	7.5
WAZO Hill	11.8	8.9	8.9	9.2	9.5	9.6	9.7	9.8	9.9	10.0	10.3	10.6
Texitile	3.4	3.0	3.0	3.0	3.2	3.3	3.3	3.3	3.3	3.4	3.5	3.6
Aggrigated Total	95.8	99.5	100.5	104.5	108.4	115.0	126.9	129.0	136.6	142.4	150.5	159.2

4.6.3 11 kV distribution lines

(1) Insufficient maintenance control and operation

(a) Because the line ledger necessary for the maintenance and control is not well prepared, the line length per feeder, type and number of supporting structures, installation places, capacity and quantity of transformers, etc. cannot be clearly grasped, and therefore, rational maintenance control cannot be performed.

(b) The scheduled repair works have hardly been conducted for several years due to the lack of maintenance materials and tools and because they are too busy in coping with the troubles which are occurring daily.

(2) Problems in system configuration

The feeders are interconnected at about 10 places via usually open section switches, but because the usually closed section switches are not properly installed and the wire size is not uniform, the effective load accommodation is not achieved.

It is necessary to improve the interconnection of the system and to install the section switches properly.

(3) Electric wire and wire connection

The deteriorated wires with many strand breakages and/or many connections points cause the breaking down accident of wire. The loose wire connection also causes the fusing troubles. Replacement of the deteriorated wires and the small size wires and repairing of the connection parts are urgently required.

Especially for the wire connection work, the connecting materials suitable for the wire and correct method must be used.

(4) Countermeasures against salt and thunder

In the case that the salt contamination is relatively small even in the coastal area, it is probably because of the rain washing effect of the rainfall occurring in a certain cycle. Therefore, it is judged that special salt contamination countermeasures will not be required.

The occurrence of the lightning in the coastal area is not very much, but since thunder is sometimes heard, some arresters should be installed to protect important equipment.

(5) <u>11 kV underground distribution line</u>

The C6 feeder, for which the underground line is laid because the area is an overcrowded area where it is difficult to construct overhead line, is hardly in service now because of insulation deterioration. The C6 area is adjacent to the City Centre S.S. and it has a high density of demand because of central part of city. This C6 area is presently feeded from the Ilala S.S., but since the City Centre S.S. was changed in capacity to 30 MVA last year and the extra capacity is available, it is considered reasonable to rehabilitate the C6 feeder by replacing the cables and accessory equipment.

(6) <u>Supply reliability</u>

TANESCO is not yet in a position to perform the statistical management for supply reliability, and therefore, it will be difficult to conduct the numerical control on the service level immediately. But it is a good policy to take this opportunity to establish a fundamental indexes for the service level.

(i) Supply voltage

Concerning the allowable limit of supply voltage, it is necessary to reduce the voltage fluctuation to such a range that all the consumers will not have trouble in using the lighting fittings and other household appliances. In reality, however, the actual situation of the distribution facilities and voltage regulating capability of the upper system must be taken into consideration, and therefore, it is recommendable to fix a feasible target that most of the consumers can be included within the allowable range and to endeavor to achieve that target.

The allowable voltage fluctuation range in the UK and Japan is about $\pm 6\%$ against the specified voltage and the fulfilment rate in Japan is 99.6% (1982). As a result of detailed investigation, it is considered reasonable that the allowable voltage fluctuation range for the surveyed area is ±7% (230 ± 16V) and the fulfilment target is appropriate to be about 95%.

(ii) Service interruption caused by faults

Table 4-6-3-1 shows the summary of service interruption caused by faults which occurred in 1983 for the 4 substations located in the important areas.

If the approximate number of service interruptions caused by faults per consumer is analyzed on the 11 kV feeder CB trip, transformer fuse blowing and low voltage line jumper wire fusing, Oysterbay area is the worst at 19.9 (11.4 + 8.5) times/year, City Centre at 15.3 times/year, Ilala area at 11.2 times/year, and Factory Zone I area is relatively good at 6.6 times/year. The actual values will be worse because the troubles of the upper system will be involved.

In Japan, for example, the frequency of service interruptions by faults per consumer is 0.44 times/year (1982). As aforementioned, the actual situation in Dar-es-Salaam is really bad, but it is considered possible to reduce the frequency of service interruptions per user to about 3.0 times/year through proper rehabilitation work and the scheduled maintenance and control.

Table 4-6-3-1 Summary of service interruption caused by faults

Substation	Number of Feeders in Service (A)	Number of CB Trip of 11 kV Feeders (B)	(B)/(A)	Fuse Blowing Primary Side of Tr. (C)	Fuse Blowing on Secondary Side of Tr. (D)	Jumper Wire Breakage (E)	Number of Transformers (F)	$\frac{(C)+(D)+(E)}{(F)}$
Oysterbay	5	57	11.4	108	557	20	81	8.5
City Centre	4	45	11.3	25	223	7	64	4.0
Ilala	5	45	9.0	12	126	6	67	2.2
F.Z. I	4	22	5.5	24	53	0	73	1.1
Total	18	169	9.4	169	957	33	285	4.1

Note) 1. (B)/(A): Average number of service interruptions per consumer caused by 11 kV feeder CB trip

2. [(C)+(D)+(E)]/(F): Average number of service interruptions per consumer caused by transformer fuse blowing or jumper wire breakage

4.6.4 Low voltage lines

(1) Distribution transformer

(i) Improvement of primary and secondary sides of the transformer

In many cases, the protective cutouts on both primary and secondary sides are broken or useless. The connected situation of the wires are really bad, and especially at the connections on the secondary side many traces of overheating are found. The rating of fuses in the protective devices should also be checked for all the banks. Since the defective parts of the transformer protecting devices require an urgent repairing work, TANESCO itself must endeavor to promote the repairing work as much as possible to prevent burning of transformers and to protect the low voltage lines.

Of these materials and tools, the most urgently required items are included in the Emergency Materials Aid Program.

(ii) Load sharing and countermeasures against new demand

In order to share the load from the viewpoint of overload or voltage drop or to cope with the potential and new demands, it is necessary to provide the minimum necessary number of transformers.

(iii) Appropriate tap of transformer and voltage/current control

One of the most important subjects is to minimize the voltage fluctuation and stabilize the service voltage.

It is necessary to grasp the actual situation of the voltage fluctuation by checking the voltage right under the transformer and at the end consumer for both light load and heavy load and to select the optimum tap of the transformer. This is an effective means to maintain a proper voltage.

Also required is the scheduled measurement of load current in order to cope with the overload of the transformers and reduce the unbalanced current. The measuring instrument necessary for controlling the voltage and current are also included in the Emergency Materials Aid Program.

(iv) Current of transformer earthing conductor

When the transformer load current was measured during the field survey, the current of about 100s mA to 20-odd A was found running to the transformer earthing line in many transformers. It has not been made clear but it is supposed that a leak current because the bare wire of the low voltage line is in contact with a tree, etc. and/or through household appliances or house wiring system, or influence of three-phase unbalanced current.

It is the problem for safety, the cause must be found by carefully investigating the effect of the tree contact and the indoor wiring system, and the irrational current must be eliminated including the improvement of the indoor wiring system.

(v) Maintenance of transformer

The transformers are not sufficiently maintained. The transformer is one of the important distribution facilities. In most of the transformers, the breather silica gel is left in the moisture absorbed condition. It is common sense that the moisture absorption causes the insulation deterioration.

It is an important item to be coped with in the daily maintenance operational work such as shortening the inspection and maintenance cycle.

(2) Low voltage line

(i) Voltage fluctuation

For the voltage fluctuation problem, the effect of the upper system including the 11 kV feeder cannot be ignored, but the voltage fluctuation is mainly caused by the correlation among the low voltage line length, wire size and load current. Since these are not well coordinated in the present low voltage lines in many cases, the maximum value of the voltage fluctuation range is big (+45V, -30V) as the actual measurement record shows.

In order to solve this problem, the allowable fluctuation range against the specified voltage should be set and a design standard should be fixed so that most of the low voltage lines will come within the allowable fluctuation range, and the improvement work should be promoted in accordance with the standard.

(ii) Electric wire

Many of the electric wires now in service are super-annuated and include many straight connecting points. Also the connectors are considerably deteriorated. Such situation causes that many transformer fuse blowing problems and loose jumper wire troubles. The only way to improve such deteriorated low voltage lines is to replace the defective parts.

In order to maximize the effect of the aforementioned voltage improvements for the consumers, it is necessary to establish a promoting organization system for strong promotion so that the surveyed proposal of the existing facilities and the rational designing may be actualized. All the deteriorated wires should be replaced with the insulated wires which are also effective for preventing the salt contamination and all the connecting points should be entirely insulated. From a designing viewpoint, it is rational that the electric wires are standardized to HAL-OW 125 mm^2 for the low voltage trunk line portion and HAL-OW 55 mm^2 for the branch line portion.

(iii) Problems in the stringing of low voltage lines

Probably because the vertically wired bare low voltage lines have the unbalanced load current, unevenness in the sag is found in some cases. If such a situation is left as it is, the intermediate line is shorted to the lower low voltage line, and therefore, in some cases a piece of insulated wire is used starting with the upper low voltage line with a relatively small sag and the intermediate line is suspended in the middle of the span, but this is really an eyesore. If the insulation of such suspension wire is deteriorated, naturally a short-circuit accident will be caused and therefore, it should not be left as it is. This problem is caused by improper sag and vertical space of the low voltage line and unbalanced load current. During the low voltage line re-conductoring work is carried out with the emergency materials, the standard design should be fixed and the gradual improvement should be made.

(iv) Service line and watt-hour meter

Most of the service lines are bare wires and many of them are superannuated. The deteriorated service lines should be replaced with insulated wires (DV wires) from the viewpoint of safety and salt contamination prevention.

In many cases the 3-phase 4-wire type watt-hour meter is used even for the single-phase load consumers. For the general consumers with the single-phase load only, the single-phase 2-wire type is considered rational because the load current can easily be balanced, and gradual replacement should be carried out.

It is recommendable that the watt-hour meters now installed indoors in most cases should be changed to install outside to make the power transaction fairer and to facilitate the meter reading work, at any construction occasion.

(v) Tree trimming and safety assurance

The contact between the electric wire and a tree causes breakage of the line and may lead to a serious safety problem such as an electric shock to the public. It is a social responsibility of an electric utility industry to secure the safety of the power facilities. The contact or proximity between the electric wire and tree is found in many places including the 11 kV line. In the future, when the re-conductoring work will be executed, a systematic and large-scale tree trimming will be required, but as a part of the scheduled maintenance and repair work in the routine operation, TANESCO should carry out the tree trimming at the tree-contact places as early as possible.

Also, the contact or proximity places between the electric wire and building or other structure cannot be allowed to remain from the viewpoint of safety, and they should be urgently eliminated in the course of the routine operation.

4.6.5 Communication and supervisory system

Communication facilities at Ilala S.S. and unmanned distributing substations are shown in Table 4-6-5-1.

However, these communication lines are disconnected at several points in all sections except Ilala S.S. - City Centre S.S. section.

Those disconnection is left unrepaired partly because of less need for doing so and partly because of a shortage of materials. To automatically operate L.T.C. at unmanned substations, operating status of L.T.C. has to be monitored, and reclosing condition of distribution lines is preferably known.

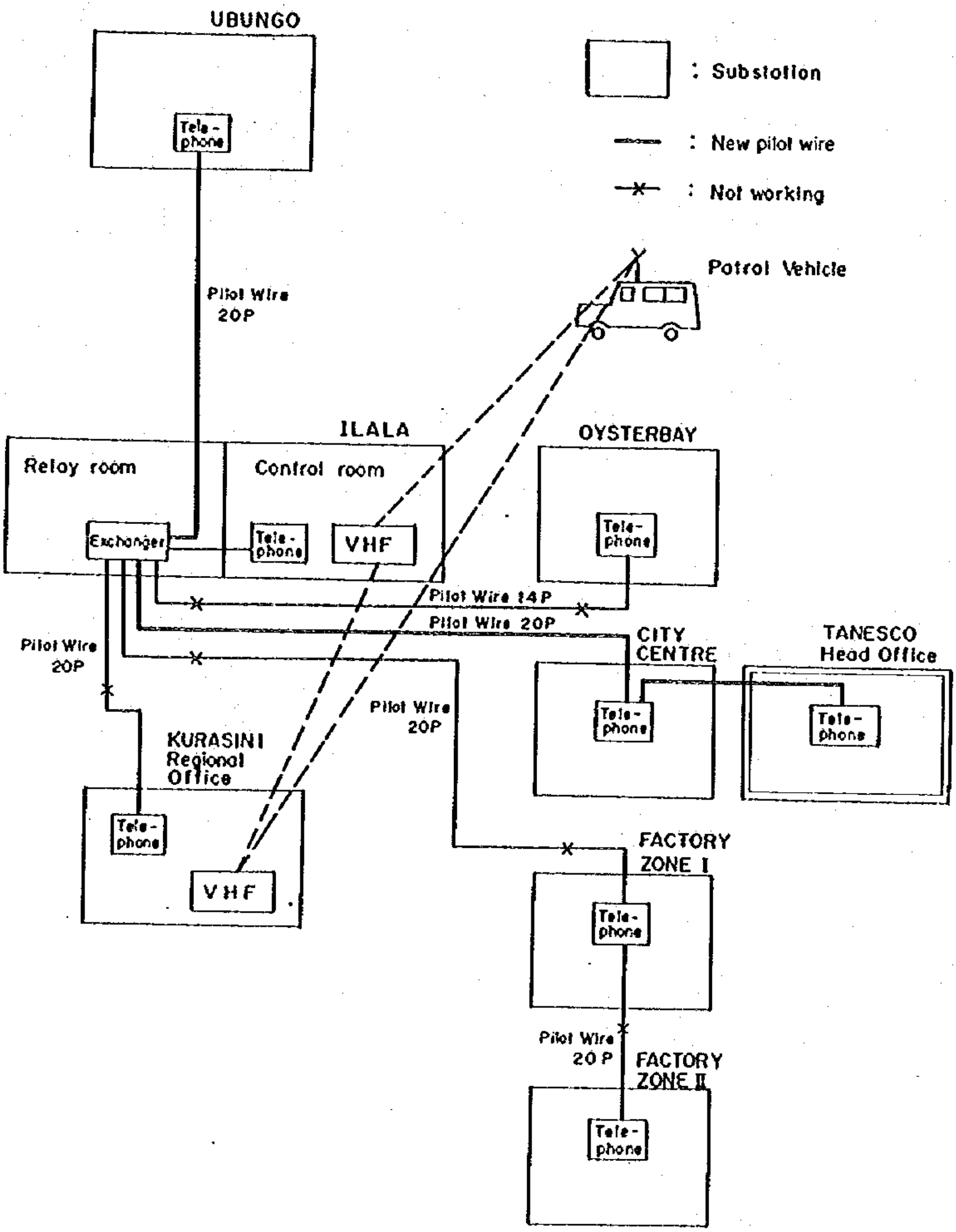


Fig. 4-6-5-1

COMMUNICATION SYSTEM IN DAL ES SALAAM

SHEET NO. OF

CHAPTER 5

EMERGENCY MEASURES TO BE TAKEN FOR SYSTEM DETERIORATION

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As described in 4.6, the power distribution system in Dar es Salaam is in a devastated state, much more than we estimated, and the current situation is really catastrophic with supply failure occurring very frequently and home electric appliances burning out because of extremely large voltage fluctuation, all of which are just inconceivable in advanced countries. People have endless complaints and renovation of the facilities at as an early date as possible is essential. We conclude that measures must be taken urgently based on the following thoughts.

(1) First of all, TANESCO by itself immediately repairs some facilities which are in a dangerous state.

(2) The next step is, on the materials and equipment that TANESCO is making requests, the necessary materials and equipment are calculated on only important areas because of the limit on the amount of available fund, especially aiming at the renovation of low voltage distribution lines and elimination of heavily loaded feeders in the areas, and the necessary renovation is given as soon as the emergency materials and equipment are received.

(3) Because of the limit on the available fund, all measures on the substation facilities, related arrangement of the subtransmission lines, and renovation of the distribution lines in areas other than the aforementioned special areas are set aside of the urgent measures.

The emergency measures based on the above thoughts are outlined in the following:

5.1 EMERGENCY MEASURES TO BE TAKEN BY TANESCO

Although it is not easy, TANESCO must immediately conduct the following through its own effort and out of its own fund without waiting for arrival of emergency materials and equipment, since they are dangerous unless something is done immediately.

(1) Protection of distribution transformers

An overcurrent protection device (fuse) is broken on both of the primary and secondary sides of transformers, and on most transformers no fuse is used but lines are directly connected. This is extremely dangerous. The state of connection at the secondary side line is extremely loose and a trace of overheating is observable on almost all secondary conductors of transformers on which the fuse has blown. TANESCO must immediately arrange fuses so as not to permanently destruct the precious facilities and complete the transformer protection measures on at least the primary side lines.

On the connection at the secondary side lines, all connections must be made tighter immediately.

(2) Elimination of grounded objects contacting with overhead lines

We have noticed that the overhead line was contacting trees at many places and that the overhead line was not installed in a proper spacing with a guy wire at many places. These points must be checked carefully along the whole transmission lines and the problems must be eliminated completely as quickly as possible.

We have also noticed that the grounding wire of many distribution transformers had an abnormally large current, and this proves that various phase wires are contacting objects on the grounds, causing the power leakage to the ground.

(3) Improvement of loose wire connection

In addition to the transformer secondary side, the wires are not tightly connected at many places, for example, in the midst of an overhead line or at a connecting point with a service line. If there is no stock of materials, there is no need of using special materials at such connecting points, and all these loose connections must be corrected immediately by applying a correct joint method.

(4) Optimum tap selection for distribution transformers

We have noticed that in some areas the distribution voltage was abnormally high. The transformer taps must be investigated and if possible, these taps must be changed to optimum ones.

TANESCO must take immediate steps to correct these four points without waiting for arrival of the emergency materials and equipment. If these improvements are done completely, the current serious conditions will be fairly improved and we strongly recommend that no time is wasted in making these improvements.

5.2 MEASURES TO BE TAKEN UPON RECEIVING EMERGENCY MATERIALS

Modifying the details of emergency materials and equipment that TANESCO has requested, we have established a concrete plan based on the premise that these details are not to be drastically changed principally and that the emergency materials and equipment are to be used on parts that require the renovation mostly urgently in the current Dar es Salaam power distribution system. This plan is explained in the following.

5.2.1 Priority areas

Although the existing facilities are old and they must be renovated in all areas, a priority is given to the Msasani district. This is a suburban area, about 8 km north from Dar es Salaam city centre, stretching into the Msasani Peninsula. Its size is approximately 10 km^2 and the area has been developed as a residential area rapidly in recent years. Most of diplomats, offices and residences are located in this area and the scales of private houses are much larger than any in other areas, and the area can be said a high-class residential area.

The Construction of the infrastructure that supports the rapid development of this area is delayed. It happened that the national economy of the United Republic of Tanzania was much depressed in recent years, and the power distribution system, which were expanded in succession but tentatively, must be used as a permanent system.

The problems of supply failure and voltage rise are especially serious in this area. The area has only one 11 kV feeder and the load applied to it is the greatest among the loads to all feeders in the city.

We have taken up this Msasani district as the top priority district, and the renovation plan using the emergency materials and equipment is established as follows:

However, as mentioned in the beginning of this chapter, since there is a limit in the fund for this emergency measures, the renovation must be limited to that of giving a priority to low voltage circuits at the consumers end. The renovation measures to be taken on substations which bear many basic problems are described in a different chapter and the measures described in this chapter by no means complete all the renovation of the Msasani district.

5.2.2 Details of measures

(1) Complete renovation of low voltage circuit in Msasani district

The wires used for the low voltage circuit are extremely poor in the quality. Most of them are reused wires or inadequate wires are used for emergency only, and practically the whole wiring must be redone.

The rewiring is planned on the existing routes and utilizing the current supporting structures (posts) in the majority part, but the protection equipment is to be replaced with new ones on both of the primary and secondary sides, and the improper cable connection will also be corrected.

On any parts of new wiring, a HAL-OW 125 mm^2 insulated wire will be used for the trunk line and HAL-OW 55 mm^2 insulated wire will be used for the branch lines as the standard. The drop wires for consumers will be replaced with new ones substantially.

(2) Measures to reduce the load to 11 kV feeder in Msasani district

As the 11 kV feeder for the Msasani district, two routes of two lines (06 and 03) are drawn from Oysterbay Substation, but the majority of the consumption in the district is dependent on 06. Accordingly, the load applied to the feeder is extremely large (the largest in the whole Dar es Salaam distribution network) and this really is a problem.

If small scale new wiring for 11 kV is installed to connect the 03 and 06 lines, thereby changing the system to supply a fair part by the 03 line constantly, the problem of overload on 06 can be solved refer to Fig. 5-1).

For this reason, an 11 kV distribution line will be installed anew for about 2 km and 11 kV sectionalized switch will be newly installed at five places.

(3) Measures to reduce the load of 11 kV feeder to Upanga district

The main feeder to the Upanga district, which is located between the central part of Dar es Salaam City and the Msasari district is the C2 from City Centre Substation. This C2 is always heavily loaded and measures must be taken to reduce the load.

On the other hand, the 05 feeder from Oysterbay Substation reaches the opposite side of Salander Bridge. This feeder is not too heavily loaded and the supporting structures that exist between the 05 and 02 feeders can be used. Therefore we plan to reduce the load on the C2 feeder by extending the 05 feeder into the Upanga district and having it share a part of the load to 02.

Naturally, in order to appropriately divide the load, an 11 kV sectionalized switch will be newly installed at an appropriate location (refer to Fig. 5-2).

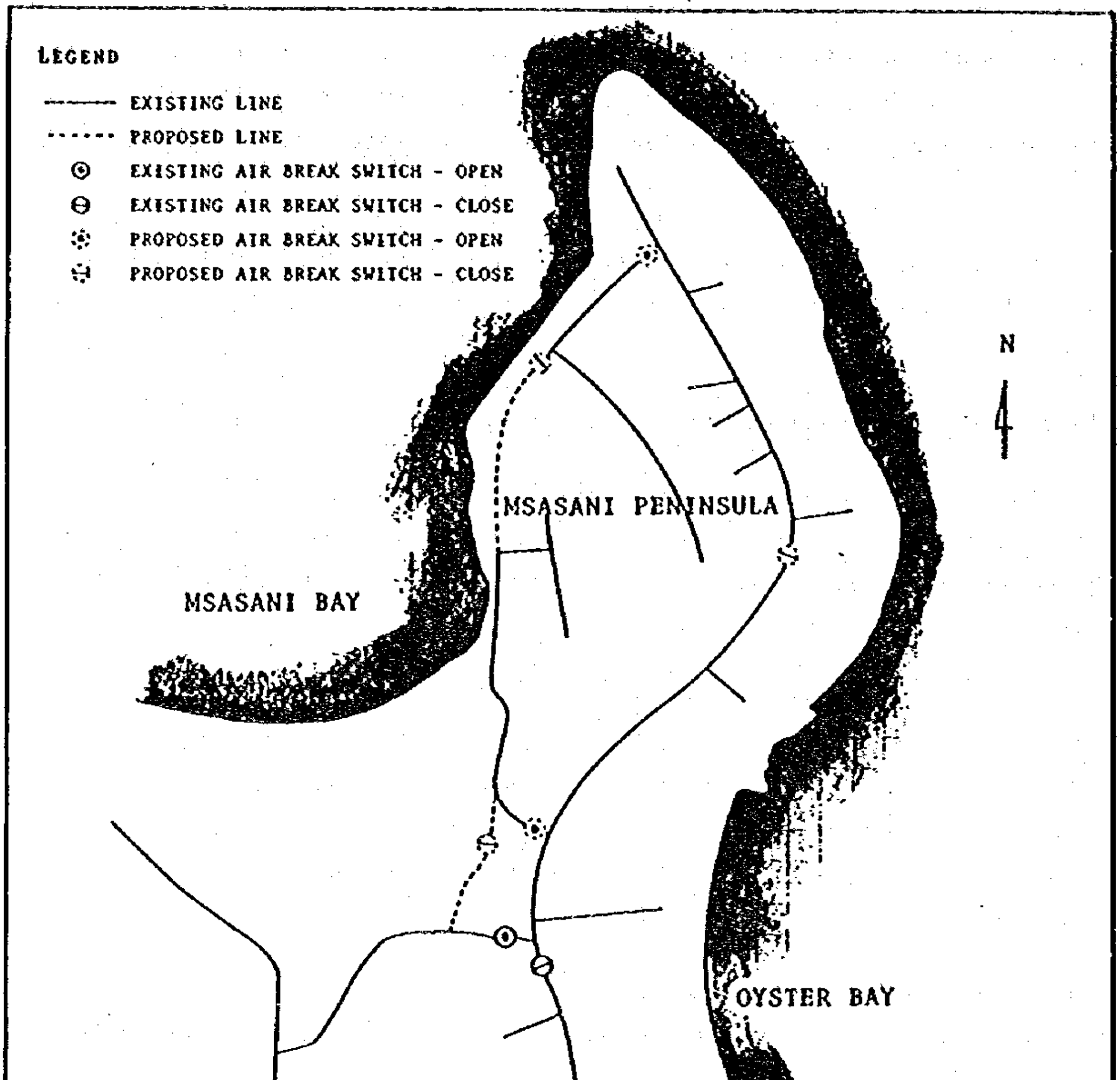

Fig. 5-1

MSASANI AREA

11kV DISTRIBUTION NETWORK

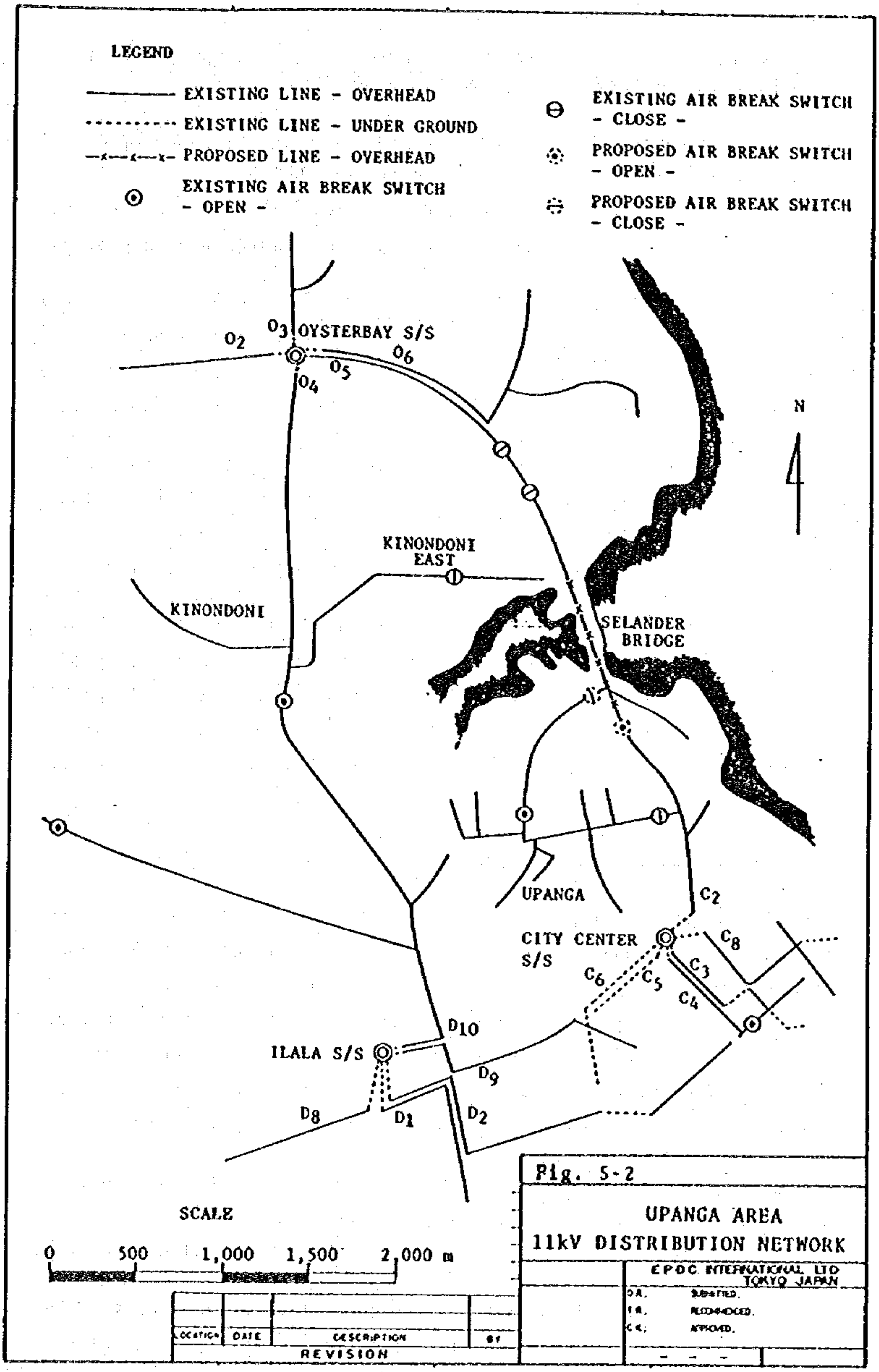

Fig. 5-2 UPANGA AREA 11kV DISTRIBUTION NETWORK

(4) Additional installation of 33 kV transmission line between Ilala Substation and City Centre Substation

At present, the power to City Centre Substation is transmitted by one line of ACSR 100 mm^2 overhead line that comes out of the 33 kV bus of Ilala Substation. This system is already close to an overloaded state because of the capacity of transmission line and emergnecy measures are necessary.

At the City Centre Substation, the main transformers were changed from 15 MVA (5 MVA x 3 units) to 30 MVA (15 MVA x 2 units) and the substation capacity was increased to a double size last year, but the transmission line of aforementioned 100 mm^2 (transmission capacity 19 MVA) remains unchanged.

Since the City Centre Substation is the largest and most important substation among all secondary substations in the Dar es Salaam distribution system, it cannot be stopped for too long hours, and installation of a new line is planned to solve the shortage on the transmission capacity.

The new transmission line will be built for 33 kV in a total length of 2.8 km with a wire size that is capable of supplying the whole quantity of 30 MVA of the City Centre Substation. The overhead portion is designed with ACSR 240 mm^2 and the cable portion with 300 mm^2. Since this part is not in the urban central area, the supporting structures will be made of wood to save the cost.

(5) Materials and equipment to be stocked for recovery and repair

In addition to the materials which are necessary for the above-mentioned measures, we have adjusted and determined the quantities of 11 kV cable, cable end materials and guy wires within the types and quantities of the request list as materials and equipment to be used for repair of the primary and secondary side protective devices of distribution transformers, for recovery from troubles with the existing facilities that occur very frequently at present, and as maintenance materials for the network.

When the scale of Dar es Salaam distribution network is taken into consideration, the determined types and quantities are by no means sufficient, but these represent the types and quantities that are required urgently.

On the aluminum wires and insulators, the quantities were determined by giving 25% allowance to the necessary quantities at the specific places mentioned in Items (1) through (4) in the above, and we believe that non-specific small scale repair can be given in the whole city for the time being.

5.2.3 Repair of street lights

Since the request list contained street illumination equipment, we roughly investigated the situation of street lights along the investigation of distribution facilities.

As in the case of distribution facilities, the street illumination system is rather old, besides, since there is almost no stock of spare lamps and other equipment, the number of lighting street lamps is extremely (not greater than 30%) except on some newly built roads. Therefore, these materials and equipment must be included in the request list and the street illumination system is repaired as quickly as possible. This is extremely important for the safety of traffic and security of the society.

Although the quantities of requested items for each road are adequate, the trouble is that the current illumination system varies in the type for each road and the types of supporting structures are quite varied. Principally, street lights should be selected to fit to the character of each street, but in consideration of the current Tanzanian situation, we consider that standardized, practical and uniform type lamps should be provided by placing the importance on the economy and compatibility.

For these reasons, we determined to provide 1,000 lamps, as requested, in the types of high voltage mercury lamp and high voltage natrium lamp having an arm that can be mounted to the existing illumination post, thus realizing the standardization of the street illumination system.

However, on the Pugu Road (between the city and airport), Port Road and others were comparatively new highway type street lights are equipped, repairs must be made based on the current system, and spare lamps and others (ballasts, fuses, etc.) should be supplied in quantities that would be necessary for the immediate repair work.

5.2.4 Vehicles for renovation work

At present, TANESCO has some 5-ton class tucks as main vehicles for renovation work, but a good part of them are broken and the number of trucks is not enough, making the work efficiency very low.

Also, since it has no small vehicles, large vehicles must be used for patrol even in the city area, and quick and close work is unobtainable, resulting in inefficient work performance.

In order to eliminate these problems, the following vehicles as listed in the request are the minimum requirements.

Vehicle types	Quantity	Use
6-ton truck (with transceiver)	4	For working teams and supply teams
4WD wagon car (with transceiver)	6	For patrol, design team and PR team
Pickup truck (with transceiver)	2	For recovery work team
Auto-bicycle	10	For meter reading

5.2.5 Tools and measuring equipment

The working teams and recovery work teams of TANESCO are not equipped with adequate tools at all. This is creating improper work which is the largest cause for troubles on the distribution system, as well as lowering the morale of workers. In consideration that the lack of proper tools and equipment is causing lower morale to the exact and safe work, we have determined the items and quantities as shown in Clause 5.3 after carefully studying the request list, conferring with TANESCO management and picking up various items such as standard tool set for electrical work, tools and equipment for tree cutting, compressing and bonding tools, general measurement instruments and maintenance equipment.

In order to clarify the current situation, we are describing the results of sampling investigation conducted at the site with regard to the tools actually equipped by the working teams, as follows:

(1) Object of investigation: working team (members 15)

(2) Tools equipped by the team:

Shovel	6	Pliers	1
Tensioning hoist	2	Hammer	1
Pickax	1	Compressor	1
Spanner	2	Ladder	1
Wrench	3		

(3) Tools conditions

Extremely old and we assumed that these had only 50% performance of the initial state.

As is clear from the above investigation results, they do not have enough number of even pliers, screwdriver, spanner which should be carried by everyone and the tools that are used are about the degrees of causing difficulties in the regular patrol. Furthermore, they have no equipment that is essential to work safely, for example, rubber gloves, detector, etc. Accordingly, we consider that the items shown in the request list are the minimum requirements.

5.3 EMERGENCY MATERIALS AND EQUIPMENT LIST

5.3.1 Outline of list contents

We have reviewed the request list submitted by TANESCO in detail with TANESCO with regard to the use purpose, necessary quantity and objective district on each item, and prepared a final list consisting of four categories of A through D. The following are the details of these categories.

A. Materials and equipment for transmission and distribution lines
B. Vehicles and accessories
C. Street lights
D. Tools and measuring equipment

Some numbers are missing in this list. The missing numbers represent items that were eliminated as a result of the conference with TANESCO, and they are as follows:

No.	Item	Reason
A.5	MI seal termination kit	Substituted by Item A.2.
D.1	Pull lift	Substituted by Item D.2.
D.12	Portable A. meters	Item D.13 has the same function.
E	Technical service	Separately planned.

In addition to the elimination of above items, some changes were made on the quantity and specifications and these details are shown below.

(1) A.1 11 kV CVTAZV (Iron armored CV cable)

The original list requested paper-insulated cable, but in consideration that the terminal handling is difficult and the possibility of trouble caused by moisture absorption, CVTAZV is adopted. The paper-insulated cable is hardly used in Japan at present.

(2) A.4 L/T cable lugs

The original request was for 20,000 pcs. for 70 mm^2 and 10,000 pcs. for 300 mm^2. These were changed to 1,500 pcs. for 70 mm^2 and 600 pcs for 300 mm^2, and 1,500 pcs. for 100 mm^2, 1,500 pcs. for 185 mm^2 and 1,500 pcs. for 200 mm^2 are newly added. The reasons for these changes are that the 300 mm^2 cable is not used much in the objective area and the majority is 185 mm^2 cable, the size of A.4 was changed, and the quantity requested was too large compared with the number of transformers used.

(3) A.6 600V CVTAZV (Copper belt armor CV cable)

Since 70 mm^2 and 185 mm^2 in the request list are not large enough on the current capacity, they are changed to 100 mm^2 and 200 mm^2, and 16 mm^2 for the street light is changed to 14 mm^2.

(4) A.7 overhead line conductors

ACSR 100 mm^2 for high voltage line is changed to ACSR 95 mm^2 of JIS (Japanese Industrial Standard) and the requested quantity for 200 km is reduced to that for 60 km only that is necessary for renovation of the Msasani and Upanga districts, excluding the portion for the Nordic line which is outside of the objective area. On the wires for low voltage line, the whole quantity of AA 25 mm^2 and AA 100 mm^2 was eliminated. Instead, the specifications for PVC AA 25 mm^2 and PVC AA 100 mm^2 are changed to HAL-OW 55 mm^2 and HAL-OW 125 mm^2 are changed to HAL-OW 55 mm^2 and HAL-OW 125 mm^2, respectively and the quantities are increased to 100 km and 200 km, respectively. This change was given to realize insulation of the low voltage line and in consideration of the current capacity of the wires.

(5) A.10 11 kV open fuse cutout

Since the number of transformers used in the objective area is about 285, the number of open fuse cutouts was set to 250 instead of the requested 500 sets.

(6) A.11 33 kV open fuse cutout

Since there is no 33 kV distribution line in the objective area, we thought there was basically no need of this open fuse cut. However, transformers are used partially on the 33 kV line that provides the power for the Oysterbay Substation, we determined to include 75 sets in the sense of power source protection although this is outside of the objective area.

The TANESCO request was 200 sets, but 75 sets are enough.

(7) A.12 400A fuse holder

The request was made for 2,000 although the number of objective transformers is 285, and since this is too large, we reduced it to 1,200.

As described in 5.2.1, the area and contents to which the priority of renovation should be given based on the emergency materials and equipment provided this time were set upon conferring with TANESCO would not be sufficient, we added more materials and equipment for the low voltage lines consisting of items in categories 100's through 400's. The contents of these categories are as follows:

100 Electric wires, cables and accessories

200 Fuses and insulators

300 Metal and miscellaneous pieces used on posts

400 Supporting structures

The materials and equipment that are needed for expansion of the 33 kV transmission line, described in 5.2.2 (4), are given Category No. of 500's.

5.3.2 Details and quantities of items to be provided

(1) Revised list of requested items

No.	Item	Unit	Q'ty
A.1.1	11 kV CVTAZV 70 sq.mm x 3	m	2,000
A.1.2	11 kV CVTAZV 300 sq.mm x 1	m	1,000
A.2.1	11 kV Cable Termination 70 sq.mm x 3	set	400
A.2.2	11 kV Cable Termination 185 sq.mm x 3	set	400
A.2.3	11 kV Cable Termination 300 sq.mm x 1	set	120
A.3	Cable Compound	kg	5,000
A.4.1	L/T Cable Lugs 70 sq.mm	pcs	1,500
A.4.2	L/T Cable Lugs 100 sq.mm	pcs	1,500
A.4.3	L/T Cable Lugs 185 sq.mm	pcs	1,500
A.4.4	L/T Cable Lugs 200 sq.mm	pcs	1,500
A.4.5	L/T Cable Lugs 300 sq.mm	pcs	600
A.6.1	600V CV AZV 14 sq.mm x 4	m	20,000
A.6.2	600V CV AZV 100 sq.mm x 4	m	4,000
A.6.3	600V CV AZV 200 sq.mm x 4	m	2,000
A.7.1	ACSR 120 sq.mm	km	60
A.7.2	HAL-OW 55 sq.mm	km	100
A.7.3	HAL-OW 125 sq.mm	km	200
A.8.1	11 kV Fuse 3A	pcs	500
A.8.2	11 kV Fuse 5A	pcs	600
A.8.3	11 kV Fuse 8A	pcs	2,000
A.8.4	11 kV Fuse 25A	pcs	5,000
A.8.5	11 kV Fuse 30A	pcs	2,000
A.8.6	11 kV Fuse 40A	pcs	2,000
A.8.7	11 kV Fuse 50A	pcs	500
A.9.1	33 kV Fuse 2A	pcs	500
A.9.2	33 kV Fuse 5.5A	pcs	2,000
A.9.3	33 kV Fuse 8A	pcs	2,000
A.9.4	33 kV Fuse 10A	pcs	2,000
A.9.5	33 kV Fuse 20A	pcs	1,000
A.9.6	33 kV Fuse 25A	pcs	1,000
A.10	11 kV Open Fuse Cutout	set	250
A.11	33 kV Fuse Cutout	set	75

No.	Item	Unit	Q'ty
A.12	400A Fuse Holder	pcs	1,200
A.13.1	415V HRC Fuse Link 200A	pcs	400
A.13.2	415V HRC Fuse Link 300A	pcs	1,000
A.13.3	415V HRC Fuse Link 400A	pcs	5,000
A.14	Iron Clad neutral Link	pcs	500
A.15.1	11 kV Pin Insulator	pcs	600
A.15.2	33 kV Pin Insulator	pcs	200
A.15.3	250 mm Disc Insulator	pcs	600
A.15.4	L/T Shackle Insulator	pcs	10,000
A.15.5	L/T Bobbin Insulator	pcs	10,000
A.16.1	Meter Seal	pack	500
A.16.2	Seal Wire	roll	100
A.17.1	Guy Wire 22 sq.mm	m	5,000
A.17.2	Guy Wire 30 sq.mm	m	5,000
A.18.1	33 kV Disconnecting Switch	set	5
A.18.2	33 kV Discon. Switch with Earth	set	5
A.19	33 kV Cable Termination	set	10
A.20	Spares & Sandries Items	lot	1
A.21	11 kV Load Interrupter Switch	set	20
A.22.1	Distribution Pillar - 500 kVA	set	20
A.22.2	Distribution Pillar - 75 kVA	set	1
B.1	Cargo Truck 6 ton	unit	4
B.2	4WD Wagon c/W Carrier	unit	6
B.3	Pickup Truck	unit	2
B.4	VHF Transceiver	set	12
B.5	Motor-bike	unit	10
C.1.1	Street Light-Mercury	set	700
C.1.2	Street Light-Sodium	set	300
C.1.3	Spares for C.1.1 & C.1.2	lot	1
C.1.4	Spares for Existing	lot	1
D.2.1	Tensioning Hoist 1 ton	set	30
D.2.2	Tensioning Hoist 1.5 ton	set	30
D.2.3	Tensioning Hoist 2 ton	set	20
D.3	Tirfor 3.0 ton	set	50

No.	Item	Unit	Q'ty
D.4	Compressor c/w Kinematichammer	set	2
D.5	Extension Ladder 11 m	set	30
D.6	Extension Ladder 9 m	set	50
D.7	L/T Safety Glove	pair	500
D.8	Safety Belt	set	100
D.9.1	33 kV Earthing Gear	set	15
D.9.2	11 kV Earthing Gear	set	15
D.10	33/11 kV Switch Stick 6 m	pcs	30
D.11	Binocular	pcs	10
D.13	Tong Tester	set	20
D.14	Recording Volt Meter	set	10
D.15	Loop Impedance Tester	set	5
D.16.1	Earth Tester	set	5
D.16.2	Insulation Tester 500V 1000 Mohm	set	5
D.16.3	Insulation Tester 1000V 2000 Mohm	set	5
D.17	L/T Phase Sequence Meter	set	10
D.18	L/T Current Tester	set	10
D.19	33 kV Phasing Equipment	set	5
D.20	11 kV Phasing Equipment	set	5
D.21.1	Cable Fault Locator	set	2
D.21.2	33/11 kV Voltage Detector	set	5
D.22	First Aid Kit	set	40
D.23	Circuit Tester	set	10
D.24	Tool Box c/w Standard Tools	set	100
D.25	General Work Tool	lot	1
D.26	Measuring Apparatus	lot	1
D.27	Security Goods	lot	1
D.28.1	Compression Tool Y35	set	10
D.28.2	Compression Tool Y40TG-2TG	set	5

(2) List of added items

No.	Item	Unit	Q'ty
101	PDC 22 sq.mm	m	372
102	CVTAZV 60 x 4	m	40
103	DV Wire 3.2 x 2	km	30

No.	Item	Unit	Q'ty
104	DV Wire 3.2 x 4	km	24
105	DV Wire 22 x 4	km	7
106	DV Wire 22 x 4	km	12
107	Comp. Connect. Al 125-Cu 100	pcs	153
108	Comp. Connect. Al 125-Cu 60	pcs	9
109	Comp. Connect. Al 125-Cu 125	pcs	480
110	Comp. Connect. Al 125-Cu 55	pcs	960
111	Comp. Connect. Al 55-Cu 60	pcs	3
112	Comp. Connect. Al 55-Cu 55	pcs	124
113	Comp. Connect. ACSR 120-ACSR 120	pcs	71
114	Sleev-Al 125	pcs	480
115	Sleev-Al 55	pcs	248
116	Sleev-ACSR 120	pcs	66
117	Bolt Connecter PG3	pcs	14,292
118	Bolt Connecter PG5	pcs	36
119	Comp. Terminal Cu 60	pcs	12
120	Insulated Al Bind 3.2 mm	m	7,440
121	Bare Al Bind Wire 4.0 mm	m	1,095
122	Aluminium Tape	m	1,095
123	Bare Cu Bind Wire 2.0 mm	m	4,344
201	11 kV Fuse 2A	pcs	3
202	11 kV Fuse 6A	pcs	6
203	11 kV Fuse 12A	pcs	30
204	11 kV Fuse 20A	pcs	33
205	Stay Insulator	pcs	88
301	Crossarm 2100	pcs	57
302	Crossarm Beace 780	pcs	124
303	Aluminium Clamp	pcs	84
304	Stay Anchor 2t	set	354
305	Stay Anchor 3t	set	44
306	Twist Strap	pcs	168
307	Dead End Clevis	pcs	28
308	D-Iron	pcs	372

No.	Item	Unit	Q'ty
309	Bands for D-Iron	pcs	372
310	Strain Plate	pcs	398
311	Bolt & Nut M16 120 mm	pcs	580
312	Bolt & Nut M16 250 mm	pcs	57
313	Bolt & Nut M16 320 mm	pcs	57
314	Bolt & Nut M16 400 mm	pcs	14
315	Square Washer	pcs	708
316	Pole Cap	pcs	150
317	Pole Number Plate	pcs	2,000
318	Danger Plate		100
319	Polyvinyl Tape	roll	465
320	Barbed Wire	kg	40
321	Iron Wire 4.0 mm	kg	121
322	Iron Wire 1.2 mm	kg	20
323	Round Wire Nail	kg	25
324	Paint	can	40
325	Brush for Painting	pcs	40
401	Wood Pole 8m	pcs	93
402	Wood Pole 11m	pcs	57
403	Kicking block	pcs	150
500	ACSR 240 sq.mm	m	6,000
501	Midspan Joint for ACSR 240	set	3
502	Compression Connector	pcs	30
503	33 kV Pin Insulator	pcs	95
504	250 mm Disc Insulator	pcs	200
505	Stay Rod	pcs	20
506	Stay Wire 30 sq.mm	m	280
507	Wedge Type Aluminium Clamp	pcs	60
508	Crossarm C-2800	pcs	35
509	Crossarm L-2800	pcs	10
510	Crossarm Brace 780	pcs	90
511	Pole Cap	pcs	45
512	Bolt & Nut M20 40 mm	pcs	90
513	Bolt & Nut M20 140 mm	pcs	20

No.	Item	Unit	Q'ty
514	Bolt & Nut M20 240 mm	pcs	75
515	Bolt & Nut M20 280 mm	pcs	45
516	Square Washer	pcs	50
517	Miscellaneous	lot	1
518	Wood Pole 13 m	pcs	45
519	CVTAZV 300 sq.mm x 3	m	800
520	Straight Joint for CVTAZV 300	set	2
521	Cable Termination	set	2

5.4 IMPLEMENTATION METHOD

5.4.1 Work method

While it is determined that the work for this project is directly conducted by TANESCO, it is considered that guidance of Japanese engineers is needed in the initial stage. The work to realize the plan described in 5.2 can roughly be divided by the work procedures as shown below.

- Receiving and management of emergency materials and equipment
- Renovation of low voltage distribution line in the Msasani district
- Installation of 11 kV distribution line connecting the Msasani and Upanga districts
- Change of degraded 11 kV distribution line to new line in the Msasani district
- Renovation of the transformer primary and secondary sides in the Upanga district
- Renovation of transformer protective devices in other districts
- Expansion of the 33 kV transmission line between the Ilala and City Centre substations

In order to firmly implement these renovation and new installation, the work system, shown in Fig. 5.3 must be established.

Fig. 5-3 Work organization

Manager

Japanese engineers

Team	Duties
Design team (about 8 persons)	Conducts detailed designing upon investigating all sites and notifies the results to the working teams, supply team, tree cutting team and liaison team.
Tree cutting team (about 8 persons)	Cuts disturbing trees based on the design drawings.
Supply team (about 8 persons)	Arranges and transport renovation materials according to the design documents.
Liaison team (about 4 persons)	Engages in the negotiation of tree cutting, acquisition of permit to entering premises, and public relation work on the scheduled power supply suspension, according to the design documents.
Working teams (4 teams, each consisting of about 15 persons)	Works on renovation according to the design documents

5.4.2 Technical assistance

Japanese engineers shall render appropriate guidance on the correct working method, maintenance, correct use and handling methods of tools mainly on the work in the Msasani district, thereby aiming at training of leaders among the TANESCO working teams and recovery team.

Although the work scale in the Msasani district is small, since it involves all work related to distribution lines ranging from high voltage handling and low voltage dropping, we consider that the district provides an ideal site for the training.

The major points of technical assistance by Japanese engineers are as follows:

(1) Sure method of wire connection

(2) Design and work to obtain the strength of supporting structures

(3) Most effective and safe work procedures

(4) Correct use method, check and repairing of tools and measuring instruments

(5) Assurance of public safety

(6) Management of maintenance of low voltage distribution lines

(7) Dividing of load

(8) Points and meausres on daily patrol

(9) Work schedule management

(10) Saving of materials

(11) Method of high voltage wire repairing by sectionalized supply suspension and system operation

(12) Preparation of line drawings

5.4.3 Work schedule

As described earlier, the renovation of this project must be started as quickly as possible and exact work in as short a period as possible is strongly desired. Therefore, we have prepared a work schedule, shown in Table 5-1, in which the actual amount of work and easiness of work are taken into consideration fully.

Table 5-1 Work schedule

Work type \ Period (Month)	1	2	3	4	5	6
Receiving materials and preparation for work	━━━					
Renovation of low voltage line in Msasani district		━	━━━	━━━	━━━	━━
New installation of 11 kV connecting line in Msasani district		━				
New installation of 11 kV connecting line in Upanga district		━				
Replacement of degraded high voltage line in Msasani district			━━━	━━━		
Renovation of protective device in Upanga district	━━━	━				
Renovation of protective device in other districts		━	━━━	━━━	━━━	━━━
New installation of 33 kV transmission line					━━━	━━━

5.5 COST ESTIMATE

The expenses to procure the emergency materials and equipment shown in the list of 5.3.2 are as follows. The conditions for calculating these expenses are CIF Dar es Salaam based on 1985 prices.

(1) Costs of materials and equipment

Item	Articles	Amount
A	Materials and equipment for lines	
B	Vehicles and accessories	
C	Street illumination	
D	Tools and measuring instruments	
100-400	Added items (1)	
500	Added items (2)	
Sub-total		

(2) Consultant fee

(3) Total

5.6 EFFECT OF PROJECT

The following effects can be expected from completion of the renovation and new installation using the emergency materials and equipment.

(1) Improvement of voltage stability and reliability of power supply

(i) When the aforementioned work completes in the Msasani district, the voltage fluctuation will be maintained within about 50V even in summertime as opposed to about 60V (in winter) and about 100V (in summer) that are measured at present.

(ii) Since no cause other than propagation influence of internal trouble on the 11 kV consumers is conceivable for the power supply failure after the project implementation in the Msasani district, we believe that the number of power supply failures in the district will be substantially decreased.

(2) Elimination of heavily loaded feeder

The heavy load applied to the 06 and C2 feeders at present will be eliminated.

(3) Less power loss

After the completion of the project, the loss on the line and voltage stability will be greatly improved.

(4) Since sectionalized switches will be additionally installed, the range of suspending the power supply during repair work will be reduced and the load allocation to feeders can be easily established.

(5) Since all renovation and installation will be completely done using adequate materials, the security to the public can be guaranteed.

(6) Due to the supply of emergency materials and equipment, the renovation of protective devices, which are the most serious points at present, can be prompted on a scheduled basis.

(7) Due to the supply of vehicles and tools, the maintenance and repair can be conducted quickly and exactly.

(8) Through the work in the Msasani district under technical guidance of Japanese engineers, the methods and techniques of all work can be standardized to some extent and grading up of the technical level of TANESCO staff can be expected.

(9) Increase of the energy sale can be expected to some extent as a result of stabilized power supply.

(10) The improved street illumination system will bring the effects of preventing crimes and traffic accidents.

(11) When the 33 kV transmission line is completed between the Ilala and City Centre substations, the City Centre Substation can receive more power, and switching of the 11 kV feeder can be made smoothly when a trouble occurred.

CHAPTER 6

LOAD FORECAST

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6.1 GENERAL CONSIDERATION

In general, a load forecast made on a community basis (micro-economic framework) through field survey is considered most appropriate for short-term planning. However, this method can be adopted only when systematic and accurate data and information on the categorical consumers and projects on-going or under planning are available, otherwise, this method may lead to misdirected load forecast. In any way, it is only limited cases in which such a microscopic method is usable.

It is well known that there is a close correlation between growth of power generation and that of national economy represented by GDP. In this connection it is to be noted that the ratio of energy sent out in Dar-es-Salaam to the total power generation of the country was constantly around 50% from 1973 up to present, as shown in Table 3-2 in Chapter 3. This fact means that it is possible to deduce a load forecast for Dar-es-Salaam from the country's power generation in the future to be forecasted based on the above correlation between power generation and GDP.

In the load forecast for a given area, its particular conditions must be taken into account. In the case of Dar-es-Salaam, these are potential power demand of the waiting consumers, component ratios of the existing categorical consumers and their demand growth in the past, etc.

6.2 METHODOLOGY

In general, the demand function for a given commodity consists of price and income, and is specified as follows:

$$Di = f(Pi, Pw, Y)$$

Where: Di : Demand for the i th commodity

Pi : Price of the i th commodity

Pw : Prices of other commodities represented by general prices index

Y : Income of the consumer

Since the response of demand function for income and prices is almost the same, the above equation can be rewritten as follows:

$$Di = f(Pi/Pw, Y/Pw)$$

This means that the demand function for the i th commodity is dependent upon the relative price of commodity and real income of the consumer. The demand function for electricity will take the same form.

From the above theory, the demand function for electricity (y) can be expressed by the following multiple regression equation:

$$y = a + b_1x_1 + b_2x_2$$

Where: x_1 : GDP

x_2 : Average rate per unit (kWh) sold

b_1 : Regression coefficient for income

b_2 : Regression coefficient for price

In case there are more than three kinds of samples which each has a total number of n as follows:

$$(y_1, x_{11}, x_{21}), (y_2, x_{12}, x_{22}), \ldots\ldots (y_n, x_{1n}, x_{2n})$$

the regression coefficients b_1 and b_2 can be obtained by the following simultaneous equations, using the least square method:

$$S_{11}b_1 + S_{12}b_2 = S_{1y}$$

$$S_{12}b_1 + S_{22}b_2 = S_{2y}$$

Where:

$$S_{11} = \sum_{i=1}^{n} (x_{1i} - \overline{x}_1)^2 \qquad \overline{x}_1 = 1/n\sum x_{1i}$$

$$S_{22} = \sum_{i=1}^{n} (x_{2i} - \overline{x}_2)^2 \qquad \overline{x}_2 = 1/n\sum x_{2i}$$

$$S_{12} = \sum_{i=1}^{n} (x_{1i} - \overline{x}_1)(y_{2i} - \overline{x}_2)$$

$$S_{1y} = \sum_{i=1}^{n} (x_{1i} - \overline{x}_1)(y_i - \overline{y})$$

$$S_{2Y} = \sum_{i=1}^{n} (x_{2i} - \overline{x}_2)(y_i - \overline{y})$$

When obtaining regression coefficients b_1 and b_2, the demand function (y) can be obtained by the following equation:

$$y = \overline{y} + b_1(x_1 - \overline{x}_1) + b_2(x_2 - \overline{x}_2)$$

The degree of conformity of the obtained multiple regression equation is measured by the following multiple correlation coefficent:

$$R^2 = \frac{b_1S_{1y} + b_2S_{2y}}{Syy}$$

Where: $S_{yy} = \sum_{i=1}^{n} (y_i - \overline{y})^2$

The degree of deviation of the actual energy generation (y') from energy generation (y) obtained by the above equation is measured by the following standard error of regression:

$$s = \sqrt{1/n\sum(y-y')^2}$$

6.3 REGRESSION EQUATION

Annual energy generation, GDP adjusted by deflator and average rate per unit sold of electricity for the period from 1973 to 1982 are shown in Table 6-1. Based on the above equations and values given in this table, the following multiple regression equation can be obtained:

Regression coefficents: $b_1 = 0.089009$

$b_2 = -9.1182$

From Table 6-1, $\bar{y} = 672.4$ (GWh)

$\bar{x}_1 = 10,677$ (Million Shs)

$\bar{x}_2 = 18.67$ (Cents/kWh)

Therefore,

$$y = \bar{y} + b_1(x_1 - \bar{x}_1) + b_2(x_2 - \bar{x}_2)$$

$$= -107.7 + 0.089009\ x_1 - 9.1182\ x_2$$

Multiple regression coefficient $R^2 = 0.90$

Standard error of regression $s = 38.3$ (GWh)

From the above, the extent of deviation is:

38.3 GWh/672.4 GWh = 5.7 %

6.4 CONDITIONS ADOPTED FOR LOAD FORECASTING

In order to forecast power demand by means of the above-mentioned equation, it is necessary for some conditions to be assumed for the future. These conditions are growth rate of GDP, price rise of electricity and consumer price index (CPI), etc. Furthermore, since the power demand obtained by this equation is expressed in terms of energy generation (kWh), a probable load factor should be estimated in order to obtain peak load. Conditions adopted in this study are the following:

6.4.1 Growth rate of GDP in real terms

As shown in Table 2-3 in Chapter 2, GDP at market prices has grown from T.Shs 11,490 million in 1973 to T.Shs 42,190 million in 1982 at an average rate of 15.5% per annum, while GDP at 1966 constant prices has grown from T.Shs 8,800 million in 1973 to T.Shs 11,435 million in 1982 at an average rate of 3.0% per annum, same as the growth rate of population.

Although the 4th 5-year Plan has a target of growing GDP at an average rate of 6% per annum, this target is considered difficult to be achieved.

In fact, the same table shows that GDP has been declining from Shs 12,014 million in 1980 to Shs 11,812 million in 1981 and Shs 11,435 million in 1982.

However, it is not appropriate to prepare load forecast based on a perspective of GDP growth rate lower than the growth rate of population. As for growth rate of population, the Government forecasts that the population will grow at an annual rate of 3.3% from 1982 to 1990, as shown in Table 2-2 in Chapter 2.

Taking into consideration the past trend and present economic situation, the following perspective was adopted for GDP growth rate:

Period	Lower Limit	Upper Limit
1983-1985	3.3%	3.3%
1986-1993	3.3%	6.0%

6.4.2 Price rise of electricity

The average rate per unit sold was 64.47 cents/kWh in 1981 and 70.94 cents/kWh in 1982, but thereafter the tariff of electricity was raised two times, the first time in January 1983 and the second time in January 1984. According to analysis made by JICA study team, the average rate per unit sold for 1983 and 1984 is estimated at 88 cents/kWh and 105 cents/kWh, respectively.

Therefore, the price rise of electricity at market price from 1973 to 1984 is estimated to be around 13.5% per annum as shown below:

Year	Average rate (cents/kWh)
1973	16.13
1978	48.14
1980	65.05
1984	105.00

Annual increase rate:

1973-1984	13.5%
1978-1984	13.8%

Based on the above data, an average price rise of 13.5% per annum was estimated for electricity tariff for the period from 1985 to 1993.

6.4.3 Inflation rate

Table 2-5 in Chapter 2 shows that the National Consumer Prices Index (CPI) rose from 100 in 1970 to 369.4 in 1980 and 551.8 in 1982. Therefore, the annual average inflation rate during this period was as follows:

Period	Annual inflation rate
1970-1980	14.0%
1980-1982	22.2%
1970-1982	15.3%

As shown above, the price hike has been very high from 1980 to 1982 and thereafter, but it is not çonceivable that such a high-paced price hike still continue for a long time. Taking into consideration the long-term trend from 1970 to 1982, an annual average inflation rate of 15.5% was adopted in this study.

6.4.4 Ratio of energy sent-out in Dar-es-Salaam to the total energy generation of the country

As shown in Table 3-2 in Chapter 3, the ratio of energy sent-out in Dar-es-Salaam to the total energy generation of the country was constantly around 50% during the period from 1973 through 1983.

Considering that the economic balance between Dar-es-Salaam and the remaining part of the country in the future will be almost the same as it was, this ratio for Dar-es-Salaam was assumed to continue for the coming years.

6.4.5 Load factor in Dar-es-Salaam

As shown in Table 3-1, the load factor in Dar-es-Salaam declined from around 66% in 1979 and 1980 to 63.2% in 1982 and 1983. This is due to sluggish activities of industries, but it is clear that the load factor will rise again when restoring from such a sluggish condition. Taking this into account, the following load factor was estimated in this study:

Period	Load factor
1983-1985	63.2%
1986-1990	65.0%
1990-1993	66.0%

6.5 RESULTS OF MACROSCOPIC LOAD FORECAST

When inputting the above conditions in the obtained multiple regression equation, the load forecasts for the country as a whole and for Dar-es-Salaam can be obtained as shown in Table 6-2 and Table 6-3, respectively.

According to Table 6-3, the energy sent-out and peak load in Dar-es-Salaam are summarized as follows:

	Energy sent-out (GWh)			Peak load (MW)		
Year	High	Median	Low	High	Median	Low
1982	-	406.4	-	-	73.4	-
1985	-	443.3	-	-	80.1	-
1990	638.2	592.8	574.3	112.1	104.1	96.1
1993	784.7	701.4	618.0	135.7	121.3	106.9
Annual growth rate:						
1982-1990	5.8%	4.8%	3.8%	5.4%	4.5%	3.4%
1990-1993	7.1%	5.8%	4.1%	6.6%	5.2%	3.6%

For the "median" load forecast, the annual average growth rate of GDP for the priod from 1986 to 1993 is calculated at 4.7%, slightly higher than that (4.6%) recorded during the peirod from 1973 to 1980.

Table 6-1 Economic parameters for load forecast

Year	Energy generation (GWh)	GDP (T.Shs million)			Average rate per unit sold (Cents/kWh)		
		Market prices	Deflator (1966=100)	GDP at 1966 prices	Market prices	CPI (1970=100)	Deflated unit price
1973	515.1	14.490	130.5	8,800	26.13	124.5	20.98
1974	536.0	14.010	155.3	9,020	30.72	148.4	20.70
1975	557.6	16.988	177.8	9,553	31.82	187.9	16.95
1976	590.9	20,648	203.0	10,169	40.34	200.6	20.10
1977	619.1	26,569	240.2	11,061	48.23	223.8	21.55
1978	680.3	29,557	262.6	11.253	48.14	249.3	19.31
1979	752.0	32,579	279.5	11,657	46.09	283.6	16.25
1980	799.6	36,176	301.1	12,014	65.05	269.4	24.12
1981	843.4	39,822	337.01	11,812	64.47	464.1	13.89
1982	829.5	42,190	369.0	11,435	70.94	551.8	12.86
Total	6,723.5			106,774			186.71
Median	$\overline{y}$ = 672.4			$\overline{x}_1$ = 10,677			$\overline{x}_2$ = 18.67

Sources:
- Energy generation and average rate per unit sold were taken from TANESCO Annual Report.
- Gross Domestic Product (GDP) was taken from Statistical Abstract 1982.
- Consumer Price Index (CPI) was taken from "Economic and Operations Report (June 1982) of the Bank of Tanzania.

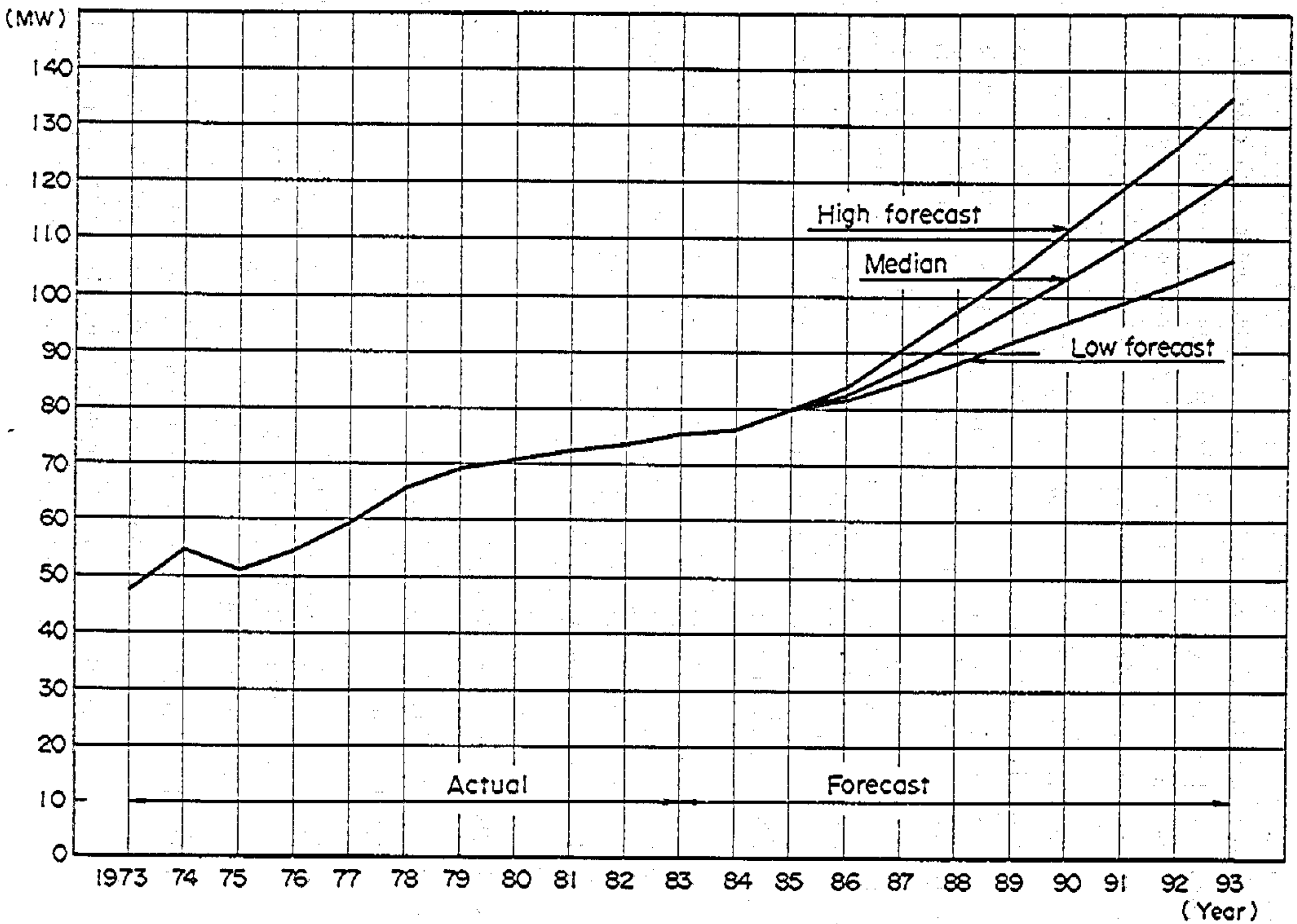
Table 6-2 Power demand forecast for the country as a whole

Year	CDP at 1966 prices (T.Shs million)		Average rate per unit sold (Cents/kWh)			Power demand (GWh)		
	High	Low	Market prices	CPI (1970=100)	Deflated Price	High	Median	Low
1982	11,435		70.94	551.8	12.86		829.5	
1983	11,812		88	637	13.81		817.8	
1984	12,202		105	736	14.27		848.3	
1985	12,605		119	850	14.00		886.6	
1986	13,361	13,021	135	982	13.75	956.1	941.0	925.9
1987	14,163	13,450	154	1,134	13.58	1,029,1	997.4	965.7
1988	15,013	13,894	174	1,310	13.28	1,107.5	1,057.7	1,007.9
1989	15,914	14,352	198	1,513	13.09	1,189.4	1,104.9	1,050.4
1990	16,868	14,826	225	1,748	12.87	1,276.3	1.185.4	1,094.5
1991	17,880	15,316	255	2,018	12.64	1,368.5	1.254.4	1,140.3
1992	18,953	15,821	289	2,331	12.40	1,466.2	1,326.8	1,187.4
1983	20,090	16,343	328	2,692	12.18	1,569.4	1,402.7	1,235.9
Annual growth rate:								
1982-1990						5.5%	4.6%	3.5%
1990-1993						7.1%	5.8%	4.1%

Table 6-3 Power demand forecast for Dar-es-Salaam

Year	Energy sent-out (GWh)			Peak load (MW)		
	High	Median	Low	High	Median	Low
1982		406.4			73.4	
1983		408.9			75.8	
1984		424.2			76.6	
1985		443.3			80.1	
1986	478.1	470.6	463.0	84.0	82.6	81.3
1987	514.6	498.8	482.9	90.4	87.6	84.8
1988	553.8	528.9	504.0	97.3	92.9	88.5
1989	594.7	560.0	525.2	104.4	98.3	92.2
1990	638.2	592.8	547.3	112.1	104.1	96.1
1991	684.3	627.3	570.2	118.4	103.5	98.6
1992	733.1	663.4	593.7	126.8	114.7	102.7
1993	784.7	701.4	618.0	135.7	121.3	106.9
Annual growth rate:						
1982-1990	5.8%	4.8%	3.8%	5.4%	4.5%	3.4%
1990-1993	7.1%	5.8%	4.1%	6.6%	5.2%	3.6%

Fig. 6-1 Load Forecast (Dar-es-Salaam)



6.6 LOAD FORECAST BY SUBSTATION

6.6.1 Forecast to be adopted in the distribution network rehabilitation programme

In paragraph 6-5 two kinds of load forecasts, i.e. high and low load forecasts were obtained, corresponding to the high-paced growth rate (6.0% per annum) and low-paced growth rate (3.3% per annum) of GDP for the period from 1986 to 1993. The annual average growth rate of GDP for the "median" load forecast was calculated to be 4.7%.

Of these three forecasts, the high load forecast seems almost unreal when considering the past trend of economic growth in Tanzania (annual average growth rate of GDP of 4.6% for the period from 1973 to 1980, -2.4% for the period from 1980 to 1982 and 3.0% for the period from 1973 to 1982).

Even the median load forecast can be realized only when economic development plan in the future will be executed fairly satisfactorily. Therefore, this load forecast seems also a little over-estimated as far as the present economic situation is taken as the basis.

However, the power distribution network is an important infrastructure for the national economy, and its rehabilitation takes a long time. Taking these conditions into account, the median load forecast was adopted as the basis for the distribution network rehabilitation programme.

6.6.2 Manner of load allocation

The load allocation to each substation in Dar-es-Salaam was conducted in the following manner:

(i) The first step is to allocate at the most probable timing the potential power demand of the waiting consumers to each corresponding substation.

(ii) The second step is to estimate the aggregated maximum power demand for the period from 1983 to 1993 based on the peak load and diversity factor. When deducting the potential power demand of the waiting consumers from the aggregated maximum power demand, the growth in power demand of the existing consumers can be obtained. From this, the annual growth rate of power demand of the existing consumers for the periods of 1983-85, 1985-90 and 1990-93 can be obtained.

(iii) The third step is to classify the above growth rate of power demand of the existing consumers into two categories of domestic-commercial and industrial, taking into account the annual growth rates of power demand of these categorical consumers for the period from 1973 to 1980 when national economy developed normally, as well as, the component ratios of power demand of these categorical consumers in 1982, 1985 and 1990. As the results of analysis, the annual average growth rates of power demand of the existing consumers for the above three periods were abtained as follows:

Existing consumers	1983-85	1985-90	1990-93
Domestic-commercial	4.7%	1.4%	5.7%
Industrial	1.7%	0.5%	2.5%
Total	3.14%	0.95%	4.55%

(iv) The above growth rate of domestic-commercial power demand is applied to the existing consumers of Ilala, City Center, Oysterbay, Ubungo and Mbezi substations, and that of industrial power demand is applied to the existing consumers of other substations.

6.6.3 Potential power demand of the waiting consumers

(1) Power demand by substation

Capital works orders

As described in paragraph 3-4-4 in Chapter 3, the waiting consumers of the total power demand of 29.5 MW (25.5 MW of the "Capital works orders" and 4.0 MW of the "Service lines works orders") are anticipated to be connected in accordance with progress of the distribution network rehabilitation grogramme.

The applicated contracted power of the waiting consumers of the "Capital works orders" is shown in Table 6-4, and their maximum power demand by substation is estimated as follows:

(MW)

Substation	Domestic	Commercial	Industrial	Total
Ilala	-	0.3	1.6	1.9
City Center	-	2.0	-	2.0
Factory Zone I	0.1	-	11.3	11.4
Oysterbay	0.1	0.3	1.3	1.7
Ubungo	0.4	0.9	-	1.3
Factory Zone II	0.1	0.2	-	0.3
Kurasini	0.1	0.3	3.3	3.7
Nbezi	0.2	0.1	2.0	2.3
NORDIC	0.5	0.4	-	0.9
Total	1.5	4.5	19.5	25.5

Service lines works orders

The waiting consumers of the "Service lines works orders" consist of domestic and commercial consumers. The potential power demand of these consumers by substation is estimated as follows:

Substation	Power demand (MW)
Oysterbay	1.6
Kurasini	1.6
Ilala	0.8
Ubungo	0.8
Total	4.0

(2) Time-schedule of connection

The time-schedule of connection of the waiting consumers was estimated as follows:

Capitasl works orders

Domestic : Full demand (1.5 MW) will be fed from 1986.

Commercial : Full demand (4.5 MW) will be fed from 1987.

Industrial :

- Large-scale factories of the applicated contract power of more than 1,000 kVA:
  - J.V. Synthetic Textile of Factory Zone I and Glass Factory of Kurasini will be fed in the following manner:

    50% of the maximum demand in 1989
    70% of the maximum demand in 1990
    Full demand from 1993

  - Light Source and Rajan Oil Industry of Factory Zone I and Low Loader Factory and Kawe Meat Plant of Mbezi will be fully supplied with power from 1990.

- The other waiting consumers will be fully supplied with power from 1988.

Service lines works orders

The connection of the waiting consumers of the "Service lines works orders" was estimated to be started in 1986 and completed in 1990 at the following time-schedule:

Oysterbay	From 1986 to 1989
Kurasini	From 1986 to 1989
Ilala	In 1990
Ubungo	In 1990

6.6.4 Results of load forecast by substation

The results of load forecast by substation are shown in Table 6-5 and Table 6-6, and summarized as follows:

(MW)

Substation	1983	1985	1990	1993
Ilala	13.0	14.2	17.2	20.3
City Center	17.5	19.2	22.2	26.2
Oysterbay	12.2	13.3	17.2	20.3
Factory Zone I	12.6	12.6	22.2	26.7
Ubungo	2.8	3.1	5.0	6.1
Mbezi	2.1	2.4	4.8	5.9
Kurasini	8.1	8.1	13.1	16.1
Factory Zone II	3.6	3.6	4.1	4.5
ALAF	9.0	9.0	9.4	10.0
NORDIC	5.8	5.8	7.0	7.5
TAZARA	0.9	1.0	1.3	1.4
WAZO Hill	8.9	9.2	9.8	10.6
Friendship Textile	3.0	3.0	3.3	3.6
Aggregated maximum demand	99.5	104.5	136.6	159.2
Diversity factor	1.312	"	"	"
System peak load	75.8	80.1	101.4	121.3

Table 6-4 Potential power demand of waiting consumers

(kVA)

Substation	Domestic	Commercial	Industrial	Total	Note
Ilala	-	500	2,500	3,000	(1)
City Center	-	3,150	-	3,150	(2)
Factory Zone I	100	-	17,800	17,900	(3)
Oysterbay	150	500	2,100	2,750	(4)
Ubungo	600	1,450	-	2,050	(5)
Factory Zone II	225	300	50	575	
Kurasini	90	600	5,315	6,005	(6)
Mbezi	295	150	3,200	3,645	(7)
NORDIC	840	525	50	1,415	
Total	2,300	7,175	31,015	40,490	

Note :

(1) Ilala (kVA)

Simba Plastic	1,000
Tanzania Breweries	1,500

(2) City Center

NPF Head Office extension	300
New Africa Hotel phase III	300
Office accomodation Azikiwe street	500
NASACO Headquarter	300
SUKARI House	500
NIC accomodation scheme	300
Danish Embassy building	200

(3) Factory Zone I

J.V. Synthetic Textile	12,500
Light Source	1,600
Rajan Oil Industry	1,000
New Airport	1,500
AISCO Complex	500
TRAMA GARMENT W/shop	200

(4) Oysterbay

ACHE MWEDA	500
Coir and Fibre	100
SMUZA Pumping station	750
KARMAL Stove factory	500
KAYS Textile	200

(5) Ubungo (kVA)

NDF Office accomodation	300
University extension	500
TPTC Housing scheme	500

(6) Kurasini

Glass Factory	4,000
Land Rover Factory	500
BP Extension	500

(7) Mbezi

Low Loader Factory	1,600
Kawe Meat Plant	1,500

Table 6-5 Summary of load forecast by substation

(MW)

Substation	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
	(Actual)											
Ilala	13.0	13.0	13.2	14.2	14.3	14.8	16.5	16.6	17.2	18.0	19.0	20.3
City Center	15.8	17.5	17.8	19.2	19.5	21.7	21.8	22.0	22.2	23.3	24.7	26.2
Oysterbay	12.0	12.2	12.4	13.3	13.9	14.8	16.6	17.1	17.2	18.0	19.0	20.3
Factory Zone I	12.0	12.6	12.6	12.6	12.8	12.9	14.7	18.9	22.2	23.1	24.9	26.7
Ubungo	2.7	2.8	2.9	3.1	3.5	4.5	4.5	4.5	5.0	5.3	5.7	6.1
Mbezi	2.0	2.1	2.2	2.4	2.6	2.8	2.8	2.8	4.8	5.1	5.5	5.9
Kurasini	4.0	8.1	8.1	8.1	8.7	9.5	10.7	12.5	13.1	14.0	15.0	16.1
Factory Zone II	3.6	3.6	3.6	3.6	3.7	3.9	4.0	4.0	4.1	4.2	4.4	4.5
ALAF	9.6	9.0	9.0	9.0	9.1	9.2	9.2	9.4	9.4	9.6	9.8	10.0
NORDIC	4.4	5.8	5.8	5.8	6.4	6.8	6.9	6.9	7.0	7.1	7.3	7.5
TAZARA	1.5	0.9	1.0	1.0	1.2	1.2	1.2	1.2	1.3	1.3	1.4	1.4
WAZO Hill	11.8	8.9	8.9	9.2	9.5	9.6	9.7	9.8	9.8	10.0	10.3	10.6
Friendship Textile	3.4	3.0	3.0	3.0	3.2	3.3	3.3	3.3	3.3	3.4	3.5	3.6
Aggregated maximum power demand	95.8	99.5	100.5	104.5	108.4	115.0	121.9	129.0	136.6	142.4	150.5	159.2
Diversity factor	1.305	1.312	"	"	"	"	"	"	"	"	"	"
System peak load	73.4	75.8	76.6	80.1	82.6	87.6	92.9	98.3	104.1	108.5	114.7	121.3

Table 6-6 (1) Detail of load forecast by substation

(MW)

Substation	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
	(Actual)											
Ilala												
Existing	13.0	13.0	13.2	14.2	14.3	14.5	14.6	14.7	14.9			
CW - D/C						0.3	0.3	0.3	0.3			
SL - D/C									0.4			
CW - IND							1.6	1.6	1.6			
Total	13.0	13.0	13.2	14.2	14.3	14.8	16.5	16.6	17.2	18.0	19.0	20.3
City Center												
Existing	15.8	17.5	17.8	19.2	19.5	19.7	19.8	20.0	20.2			
CW - D/C						2.0	2.0	2.0	2.0			
Total	15.8	17.5	17.8	19.2	19.5	21.7	21.8	22.0	22.2	23.3	24.7	26.2
Oysterbay												
Existing	12.0	12.2	12.4	13.3	13.4	13.6	13.7	13.8	13.9			
CW - D/C					0.1	0.4	0.4	0.4	0.4			
SL - D/C					0.4	0.8	1.2	1.6	1.6			
CW - IND							1.3	1.3	1.3			
Total	12.0	12.2	12.4	13.3	13.9	14.8	16.6	17.1	17.2	18.0	19.0	20.3
Factory Zone I												
Existing	12.0	12.6	12.6	12.6	12.7	12.8	12.9	13.1	13.2	13.8	14.6	15.4
CW - D/C					0.1	0.1	0.1	0.1	0.1			
CW - IND							1.7	5.7	8.9	9.3	10.3	11.3
Total	12.0	12.6	12.6	12.6	12.8	12.9	14.7	18.9	22.2	23.1	24.9	26.7

Table 6-6 (2) Detail of load forecast by substation

(MW)

Substation	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
	(Actual)											
Ubungo												
Existing	2.7	2.8	2.9	3.1	3.1	3.2	3.2	3.2	3.3			
CW - D/C					0.4	1.3	1.3	1.3	1.3			
SL - D/C									0.4			
Total	2.7	2.8	2.9	3.1	3.5	4.5	4.5	4.5	5.0	5.3	5.7	6.1
Mbezi												
Existing	2.0	2.1	2.2	2.4	2.4	2.5	2.5	2.5	2.5			
CW - D/C					0.2	0.3	0.3	0.3	0.3			
CW - IND							-	-	2.0			
Total	2.0	2.1	2.2	2.4	2.6	2.8	2.8	2.8	4.8	5.1	5.5	5.9
Kurasini												
Existing	4.0	8.1	8.1	8.1	8.2	8.3	8.3	8.4	8.5			
CW - D/C					0.1	0.4	0.4	0.4	0.4	11.2	12.0	12.8
SL - D/C					0.4	0.8	1.2	1.6	1.6			
CW - IND							0.8	2.1	2.6	2.8	3.0	3.3
Total	4.0	8.1	8.1	8.1	8.7	9.5	10.7	12.5	13.1	14.0	15.0	16.1
Factory Zone II												
Existing	3.6	3.6	3.6	3.6	3.6	3.6	3.7	3.7	3.8			
CW - D/C					0.1	0.3	0.3	0.3	0.3			
CW - IND							-	-	-			
Total	3.6	3.6	3.6	3.6	3.7	3.9	4.0	4.0	4.1	4.2	4.4	4.5

Table 6-6 (3) Detail of load forecast by substation

(MW)

Substation	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
	(Actual)											
NORDIC												
Existing	4.4	5.8	5.8	5.8	5.9	5.9	6.0	6.0	6.1			
CW - D/C					0.5	0.9	0.9	0.9	0.9			
CW - IND							-	-	-			
Total	4.4	5.8	5.8	5.8	6.4	6.8	6.9	6.9	7.0	7.1	7.3	7.5
ALAF	9.6	9.0	9.0	9.0	9.1	9.2	9.2	9.4	9.4	9.6	9.8	10.0
TAZARA	1.5	0.9	1.0	1.0	1.2	1.2	1.2	1.2	1.3	1.3	1.4	1.4
WAZO Hill	11.8	8.9	8.9	9.2	9.5	9.6	9.7	9.8	9.8	10.0	10.3	10.6
Friendship Textile	3.4	3.0	3.0	3.0	3.2	3.3	3.3	3.3	3.3	3.4	3.5	3.6
Aggregated maximum power demand	95.8	99.5	100.5	104.5	108.4	115.0	121.9	129.0	136.6	142.4	150.5	159.2
Diversity factor	1.305	1.312	"	"	"	"	"	"	"	"	"	"
System peak load	73.4	75.8	76.6	80.1	82.6	87.6	92.9	98.3	104.1	108.5	114.7	121.3

Note: CW - D/C ..... Domestic and commercial waiting consumers of the "Capital works orders".
CW - IND ..... Industrial waiting consumers of the "Capital works orders".
SL - D/G ..... Domestic and commercial waiting consumers of the "Service lines works orders".

CHAPTER 7

SYSTEM ANALYSIS

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7.1 OUTLINE OF SYSTEM CONFIGURATION

Tanzania electric power system is comprised of a 220 kV, a 132 kV and a 33 kV in the order from a higher voltage. Dar es Salaam, capital of the United Republic of Tanzania, receives an electric power from the Kidatu P.S. which is located about 300 km west away from Dar es Salaam. Transmission line between the Kidatu P.S. and the Morogoro S.S. is connected by one 220 kV line, and transmission lines between the Morogo S.S. and the Ubungo S.S. (located in Dar es Salaam) are connected by one 220 kV line and one 132 kV line.

There are a scattering of small-sized hydroelectric power stations in the northern part of Tanzania. They are connected with the Dar es Salaam network by a 132 kV transmission line. The electric power demand of the northern part exceeds its power supply from these hydroelectric power stations. Therefore, at the peak demand period, this area receives the electric power from the Kidatu P.S. The transmission system in Dar es Salaam is composed mostly of 33 kV lines except one 132 kV line between Ubungo S.S. and Ilala S.S.

7.2 SYSTEM CALCULATIONS

The system calculations have been made for main trunk line and distribution network in Dar es Salaam after completion of the distribution rehabilitation program.

7.2.1 Contents of the system calculations

The system calculations have been made for the following items:

- Power flow and voltage calculation
- System stability calculation
- Short-circuit current calculation

7.2.2 Conditions for calculation

The following conditions have been settled prior to the actual calculation.

(1) Scope of the systems concerned

The calculating scope of the systems concerned is limited to 1) 220 kV transmission lines spreading over the western area, 2) 132 kV and 66 kV transmission lines spreading over the northern area, and 3) the Dar es Salaam transmission line which consists of a 132 kV and a 33 kV lines. Fig. 7-1 shows the scope of these lines.

(2) Year to be calculated and load scale

The systems in 1990 are to be calculated and their load scale to be settled as follows based on the demand estimation explained in the previous Chapter 6.

	Peak Load	Off-peak Load
Dar es Salaam System	104.1	65.6
Western and Northern Connected Systems	162.6	102.6
Total	266.7 MW	168.2 MW

(Note)

Off peak load value = Peak load value x load ratio (0.63)

(3) Power flow and voltage calculation

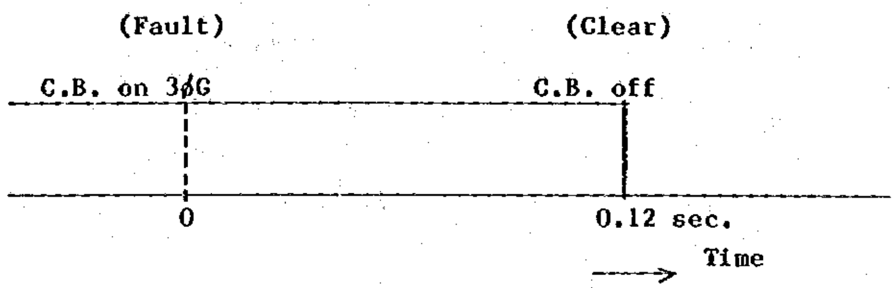
The operational conditions for the system equipment are decided as follows in order to keep up the system voltage.

- Operational range of bus voltage : 95 - 108%
- Operational voltage of generator : 100 ± 5%
- Tap ratio of transformer : 1.00 - 0.85 P.U.
- Power factor of load : 0.90 (lagging)

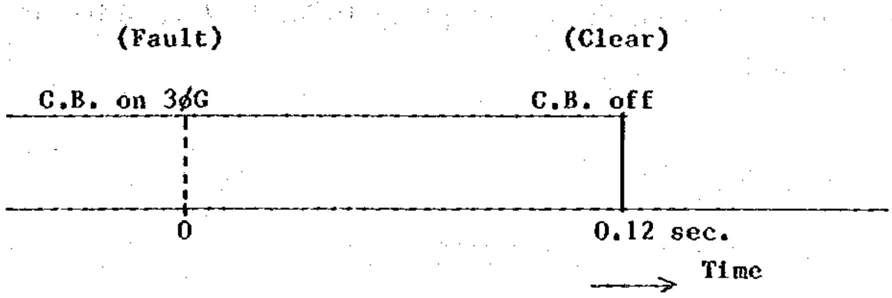
(4) <u>System stability calculation</u>

The system stability calculation should be carried out in accordance with the reliability standard of the system and settle the fault situation of a transmission line. However, in this case, a three-phase-ground-fault (3ϕG) has been adopted. The class of the transmission voltage and its accident sequence are shown below.

i) 66 kV and 132 kV transmission lines



ii) 220 kV transmission line



(5) Short-circuit current calculation

The generator reactance and operating generators which have been used for short-circuit current calculation are shown below.

Generator reactance: Transient reactance (xd')

Tap ratio of transformer: 1.00 P.U.

Operating generators:

Ubungo P.S.	5.50	MVA x 3
	7.66	MVA x 3
	10.10	MVA x 2
	18.60	MVA x 1
Hale P.S.	12.35	MVA x 2
Pangani Falls P.S.	3.125	MVA x 3
	6.25	MVA x 2
Nyumba ya Mungu P.S.	4.70	MVA x 2
Arusha P.S.	1.19	MVA x 4
	0.448	MVA x 2
Kidatu P.S.	60.0	MVA x 4
Mtera P.S.	40.0	MVA x 2
Total	459.911	MVA

(6) Technical data

Impedances of the transmission lines and the transformers are shown in Fig. 7-1 and generator characteristics are given in Table 7-1, which are used for the system analysis.

7.3 RESULTS OF CALCULATION

7.3.1 Power flow and voltage calculation

Dar es Salaam, the biggest power consuming city, receives the electric power by 220 kV line from the Kidatu P.S. located about 300 km far from Dar es Salaam. It is now planned that 220 kV lines spreading over the western area will be expanded to 1,200 km or more in/around 1990. The voltage of these 220 kV transmission lines in the western area from Kidatu P.S. is risen by the ferranti phenomena due to its long distance and a light power flow.

On the other hand, the voltage drop of the line in the area between Kidatu and Dar es Salaam is increased suddenly due to its heavy power flow. Accordingly, the control of a voltage rise and compensation of a voltage drop must be carried out simultaneously in the different areas. Especially, the operation of a shunt reactor is necessary in order to control the voltage rise during the light load time.

(1) Peak load time

The power flow of the system at the peak load time is shown in Fig. 7-2.

(i) The Dar es Salaam network

In the Dar es Salaam network, unless the generator of Ubungo P.S. is operated, there is no equipment to supply reactive power and to keep up the system voltage. The voltage control must be executed only by the tap control of the transformers.

Until 1990, each substation will be able to keep up the voltage of a secondary side at 90% or more by the tap control of the transformers.

However, at the Ruvu S.S. located about 60 km away from the Ubungo S.S., a voltage drop is increased and a condenser (4.5 MVA) for voltage compensation must be provided. The reactive power consumed in Dar es Salaam should be supplied through the 220 kV network and Kidatu P.S. Therefore, the voltage between the Kidatu P.S. and the Ubungo S.S. remarkably drops.

(a) Dar es Salaam network without a condenser

In case that the condenser for voltage compensation is not provided at the Ubungo S.S. or the Ilala S.S., the 220 kV bus voltage of the Ubungo S.S. drops to 90% or less level. This means 18% decrease in comparison with the voltage at Kidatu P.S. (Fig. 7-2). However, the voltage of 33 kV distribution network can be kept up at 90% or more level by the tap controlling of transformers, that is, the transformers of 220/132 kV and 132/33 kV at Ubungo S.S. and the transformer of 132/33 kV at Ilala S.S.

(b) Dar es Salaam network with condenser

In case that a 10 MVA condenser for voltage compensation is provided at the Ubungo S.S., the 220 kV bus voltage of Ubungo S.S. rises 6.6% in comparison with no condenser (Fig. 7-3). As a result, the system voltage rises and the transmission loss decreases. A condenser for voltage compensation should be provided at the terminal of consumer because of its economical importance. The condenser should therefore be provided at the consumers' sides in accordance with the increase of power demand.

(ii) The western and northern networks

For 220 kV network spreading in the western area, the reactor should be provided at the following two substations in order to control the voltage rising.

Mbeya S.S. .... 13.5 MVA
Singida S.S. .... 4.5 MVA

For the northern network, a condenser (3.3 MVA), which compensates for a voltage drop corresponding to the demand increase, should be provided at the Arusha S.S.

(2) Off-peak load time

The power flow of the system at the off-peak load time is shown in Fig. 7-4.

During the off-peak load time, in order to control the voltage rising of 220 kV network caused by the ferranti phenomena, the shunt reactor should be provided at the following substations and power station.

Iringa S.S. .... 6.5 MVA
Mbeya S.S. .... 17.5 MVA
Mtera P.S. .... 46.9 MVA
Singida S.S. .... 4.8 MVA

However, at the Ruvu S.S. which belongs to the Dar es Salaam network, the voltage drop is about 8.0% even in the off-peak load time because its transmission line is long. To compensate for this, the condenser (0.9 MVA) should be operated.

(3) Shunt reactor of Ubungo S.S.

At present, shunt reactors are directly connected to Ubungo S.S. side of a 132 kV cable between Ubungo S.S. and Zanzibar S.S. to absorb leading reactive power generated by the cable. They should be separated from the power system at a peak load time expected around 1990.

This is because more reactive power will be consumed in Dar es Salaam system at the peak load time, and it is no need to absorb reactive power by the shunt reactors.

The required capacity of shunt reactor at an off-peak load time is around 30 MVA, which is equivalent to the capacity of a shunt reactor installed on the tertiary side of 220/132 kV transformers at Ubungo S.S. Thus, the shunt reactor is considered to provide sufficient capacity for closing/opening to regulate the system voltage at peak load and off-peak load times.

7.3.2 System stability calculation

The system stability calculation has been carried out in the following four cases, applying three-phase-ground-fault (3∅ G) on the 132 kV and 66 kV transmission lines for the generators of the northern area.

Case-1:	Hale P.S.	- Tanga S.S.	132 kV line
Case-2:	Kiyungi S.S.	- Arusha P.S.	66 kV line
Case-3:	Kiyungi S.S.	- Arusha P.S.	132 kV line
Case-4:	Morogoro S.S.	- Chalinze S.S.	132 kV line

Fig. 7-5 shows the applied fault points.

The generator's swing curve of each calculated case is shown in Fig. 7-6 (1) - (4), and the voltage perturbation curve is shown in Fig. 7-7. In each case, all generators are under a stable condition. In Case-4, since the power flow of the faulted transmission line is large, the fluctuation to the generators of the northern network is large as compared with the other cases. The system voltage is stable in each case.

7.3.3 Short-circuit current calculation

Fig. 7-8 shows the results of short-circuit current calculations.

The maximum current of the bus at each voltage class is shown below.

220 kV bus	Kidatu P.S.	1.93 kA (= 735 MVA)
132 kV bus	Ubungo S.S.	1.45 kA (= 332 MVA)
33 kV bus	Ubungo S.S.	5.51 kA (= 315 MVA)
11 kV bus	Ubungo S.S.	11.70 kA (= 222 MVA)

Interrupting capacity of each circuit breaker operated on the Dar es Salaam network satisfies this short-circuit current.

7.4 STUDY OF REPLACEMENT OF TRANSFORMERS OF ILALA S.S.

7.4.1 Problems of the present facilities

(1) Carrying capacity to Ilala S.S.

At present, the power transmission from the Ubungo S.S. to the Ilala S.S. is conducted in parallel of one 132 kV line and two 33 kV lines. Out of these transmission lines, while the transmission capacity of 132 kV line is 96 MVA, the actual power flow is limited to 20 MVA. This is only because that the capacity of 132/33 kV transformer of the Ilala S.S. is 20 MVA. On the other hand, the 33 kV transmission line has a carrying capacity of 48 MVA. Operating the 132 kV and 33 kV transmission lines in parallel, the power flow of these lines is in unbalanced state to their carrying capacities, and the efficiency of equipment use is extremely poor.

(2) System configuration of Dar es Salaam

Since the carrying capacity of the 132 kV line from the Ubungo S.S. to the Ilala S.S. is small, although the Ilala S.S. is a better to supply the power to 33/11 kV substations from the viewpoint of system configuration, the Ubungo S.S. is supplying the power instead. In other words, the Ubungo S.S. is sharing the demand of the Ilala S.S. As a result of this, large voltage drop and the transmission loss of the 33 kV lines outgoing from the Ubungo S.S. increase.

7.4.2 Improvement program

(1) Replacement of transformers of Ilala S.S.

The carrying capacity from the Ubungo S.S. to the Ilala S.S. can be increased by replacing the 132/33 kV transformers (10 MVA x 2) with transformers of 90 MVA (45 MVA x 2) to be equivalent to the carrying capacity of 132 kV line. Also, the receiving power from the 132 kV side to the 33 kV side of the Ubungo S.S. increases at the same time. As a result, the power supply to Dar es Salaam increases.

(2) Change of connection of 33 kV lines

The substations in the neighborhood of Ilala S.S., namely, Kurasini and Oysterbay substations, which are being supplied by the Ubungo S.S., is changed to have the Ilala S.S. supply them, for which the connection of 33 kV line is changed (Fig. 7-9).

This brings about the following advantages:

- The use efficiency of 132 kV line increases.
- The voltage drop of the 33 kV line can be improved.
- The transmission loss can be decreased.

(3) Comparison of carrying capacity

Table 7-2 shows the increased carrying capacity compared the present equipment with the improved project of replacing the Ilala S.S. transformers and changing the connection of 33 kV lines.

(i) Parallel operation of 132 kV and 33 kV lines

When all facilities are normal, the total carrying capacity from the 132 kV bus of Ubungo S.S. to the Ubungo S.S. 33 kV side and the Ilala S.S. is 113 MVA at present, and 190 MVA after the renovation, or an increase of 77 MVA (Fig. 7-10, 7-11).

When one bank of either of the 132/33 kV transformers (50 MVA x 2) of Ubungo S.S. or the 132/33 kV transformers (10 MVA x 2 at present and 45 MVA x 2 after replacement) of Ilala S.S. stops, the total carrying capacity decreases to 69 MVA on the existing system and to 116 MVA after the renovation, but there is a 47 MVA increase of the carrying capacity brought by the renovation.

For this review, the ratio of demand between the Ubungo S.S. and Ilala S.S. is set to the peak load of 1990, and the same rate of demand increase is used for both substations after 1990.

(4) Voltage regulation

When the power flow around 1990 is used as an example, the 220 kV bus voltage of Ubungo S.S. is 85.8% of the rated voltage at a peak time and 101.5% at an off-peak time, and a fluctuation width reaches to above 15% (compared Fig. 7-2 with Fig. 7-4). In order to regulate the voltage fluctuation of the 33 kV network caused by the said 220 kV bus voltage fluctuation, the taps of 220/132 kV transformers and 132/33 kV transformers of the Ubungo S.S. and 132/33 kV transformers of the Ilala S.S. must be controlled.

The approximate values of tap ratios of transformers selected at peak time and off-peak time are as follows, and it is able to cope with voltage regulation by the tap-specifications of the existing and the projected transformers.

Transformer	Peak time	Off-peak time
Ubungo 220/132 kV Tr.	220 kV Tap 0.900 P.U.	220 kV Tap 1.00 P.U.
Ubungo 132/ 33 kV Tr.	132 kV Tap 0.875 P.U.	132 kV Tap 0.90 P.U.
Ilala 132/ 33 kV Tr.	132 kV Tap 0.875 P.U.	132 kV Tap 0.90 P.U.
Total tap-range		
Ubu.220 kV-Ubu.33 kV	0.225 P.U.	0.10 P.U.
Ubu.220 kV-Ubu.33 kV	0.225 P.U.	0.10 P.U.

When selecting tap ratios of these transformers, the tap ratio of Ubungo S.S. 132/33 kV transformer and that of Ilala S.S. 132/33 kV transformer must be the same. If the tap ratios of these two transformers vary largely, a cross current flows between the 132 kV line and 33 kV lines, and the power flow balance on both lines.