SECTION 3

EXISTING POWER FACILITIES IN KATHMANDU VALLEY

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3.1 General

As stated in 2.3.1 (a), there are three zones in the central region; Bagmati, Narayani and Janakpur. Bagmati and Narayani zones covering Kathmandu valley and Hetauda-Birganj corridor are the largest load centers accounting for 74% of the energy consumption in the whole of Nepal in 1975/76.

The power network covering these two regions is locally called as Central Nepal Power System (CNPS).

The power systems in Bharatpur area and Janakpur zone are now independently operated, being isolated from the CNPS, but Bharatpur will soon be interconnected with CNPS by a new 132 kV transmission line currently under construction between Gandaki and Hetauda.

This section describes the existing power facilities in the CNPS, most of which are for energy supply to the city of Kathmandu and its surrounding area.

3.2 Generating Facilities

The present generating facilities in the CNPS totalling 48,910 kW consist of hydro power plants of 34,620 kW, diesel power plants of 12,690 kW and steam power plants of 1,600 kW as of 1976/77. They are discussed as follows.

(1) Hydro Power Plants

Plant	Owner	Installation
Trisuli	NEC	21,000 kW (7 x 3,000 kW)
Panauti	NEC	2,400 kW (3 x 800 kW)
Sunkosi	NEC	10,050 kW (3 x 3,350 kW)
Sundarijal	NEC	640 kW (2 x 320 kW)
Pharping	NEC	500 kW (2 x 250 kW)
Godawari	ED	30 kW (x 30 kW)
Total		34,620 kW

Hydro power plants at Trisuli, Panauti and Sunkosi are of run-off-river type with small pondages. Plants at Sundarijal, Pharping and Godawari are provided with storage reservoirs.

Trisuli power station is the biggest power station in Nepal at present having its headrace canal capacity of 31.1 m^3/sec from the intake barrage to the daily pondage and of 45.3 m^3/sec from the pondage to the power house. This power station is suffering from deposit of silt in the canal and pondage, which should be protected against for the effective operation of the station.

Panauti power station is now operated as a peaking power station, utilizing its daily pondage. Sunkosi power station is located on Sunkosi river basin which provides a very small pondage.

The discharge water of Sundarijal power station is used for drinking water of Kathmandu city. Therefore, output of this power station is restricted by requirement for city water supply.

The total peak power generating capacities of these power plants are given as below.

Plant	Installation (kW)	Seasonal Peak Capacity (kW)	
		Dry	Wet
Trisuli	21,000	18,000	18,000
Panauti	2,400	1,500	2,400
Sunkosi	10,050	6,000	10,050
Sundarijal	640	640	640
Pharping	500	400	500
Godawari	30	-	30
Total	34,620	26,540	31,620

In addition to the above existing power stations, the Devighat, Gandaki and Kulekhani No.1 hydro-power plants are now under construction with the installed capacity of 14,400 kW (3x4,800kW), 15,000 kW (3x5,000kW) and 60,000 kW (2x30,000kW), respectively.

(2) Diesel Power Plants

Mahendra	(NEC)	1,696 kW	(4 x 424 kW)
Patan	(NEC)	1,490 kW	(1 x 1,490 kW)
Hetauda	(NEC)	4,470 kW	(3 x 1,490 kW)
Janakpur	(HMG)	832 kW	(2 x 284 kW & 1 x 264 kW)
Bharatpur	(NEC)	528 kW	
Janakpur Cigarette Factory		1,060 kW	
Birganj Sugar Mill		800 kW	
Other private plants		1,814.55 kW	
Total		12,690.55 kW	

The operation of the diesel power plants connected with the CNPS are limited and they are used only to meet unexpected excessive peak demand, or for emergency use for saving fuel, both of which have to be imported.

(3) Steam Power Plant

There is one steam power plant of 1,600 kW owned by Birganj sugar mill for its sugar production.

Monthly energy production and typical load curves in the CNPS are illustrated in Fig. 4.1 to 4.3.

3.3 Transmission system

A 66 kV double circuit transmission line connects the Trisuli power station with Kathmandu at the Balaju substation and extends therefrom to the Birganj substation near the Indian border via the Hetauda substation. Another 66 kV single-circuit line connects the Sunkosi power station with Kathmandu at the Patan substation. (usually refered to as Sunkosi substation).

A 33 kV single circuit line transmits power from the Panauti power station of Kathmandu through the Bhaktapur substation located in the suburbs of Kathmandu.

The 132 kV single circuit line under construction will link Gandaki power station with the CNPS at the existing Hetauda substation via the Bharatpur substation currently under construction. By this 132 kV line, the Western grid will be interconnected with the central power system.

The existing transmission system is illustrated in Fig. 3.1.

Particulars of the existing transmission system of the CNPS in 1976/77 are summarized below:

(1) Transmission Lines

66 kV double circuit	:	Trisuli-Balaju	32 km
	:	Balaju - Birganj	122 km
66 kV single circuit	:	Sunkosi-Patan(SUNKOSI S/S)	57 km
33 kV single circuit	:	Panauti-Bhaktapur	20 km
11 kV single circuit	:	Sundarijal - Bhaktapur	10 km
Total			241 km

(2) Main Substations

(a) Kathmandu valley

Balaju substation	66/11 kV, 2 x 11.25 MVA
Patan substation	" , 2 x 6 MVA
Bhaktapur substation	33/11 kV, 2 x 1.55 MVA
Total	37.6 MVA

(b) Other areas

Hetauda substation	66/11 kV, 3 MVA
Amlekhganj substation	" , 1.5 MVA
Simra substation	" , 1.5 MVA
Parwanipur substation	" , 3 MVA
Birganj substation	" , 3 MVA
Total	12 MVA

3.4 Distribution System

The 11 kV double circuit ring lines of 0.2 sq.inch ACSR link the 11 kV sides of the above main substations in the Kathmandu valley. In addition to the above substations, five substations at Teku, Maharajgunj, Chabel, Kathmandu and Thimi are provided for power distribution in the area.

The distribution feeders connected with these eight substations are the 11 kV feeders directly from the 11 kV buses and 3.3 kV feeders through 11/3.3 kV step-down transformers.

Conversion from the 3.3 kV system to a 11 kV system is now being done by NEC to improve the power sending capacity and voltage regulation.

The connection diagrams of the ring line system and eight substations are illustrated in Fig. 3.1 to 3.7.

Summary of the distribution system is mentioned hereunder:

(1) Distribution Lines

11 kV ring line	36 km
11 kV feeder (25 feeders)	330 km
3.3 kV feeder	64 km
400/230 V, 3 ϕ 4-wire network	-

(2) Distribution transformers in Kathmandu valley total 42.6 MVA

Note: Some of distribution lines are underground lines and the existing overhead lines in densely housed areas are planned to be placed underground.

Some particulars of the distribution system are mentioned hereunder:

a) Primary voltage

11,000 volt, 3-phase, 3-wire system and single phase, 2-wire system.

3,300 volt, 3-phase, 3-wire system and single phase, 2-wire system.

b) Secondary voltage

400-230 volt, 3-phase, 4-wire system and 230 volt, single phase, 2-wire system.

c) Voltage ranges

Voltage range at the service point based on 230 voltage is:

Minimum	218 volts
Maximum	241 volts

d) Grounding system

11 kV system ..... Directly grounded at the neutral of the transformer

3.3 kV system ..... Non-grounded

Secondary system .... Directly grounded at the transformer

Detailed descriptions of the supply areas of the above eight substations are given hereunder.

KATHMANDU (K-2) SUBSTATION AREA

The Kathmandu Substation is located at the center of Kathmandu city and supplies the energy to the residential, institutional and monument zones in the center of the Kathmandu valley.

The energy consumption in the area is estimated at 37.8 GWh with a peak demand of 9.7 MW in 1976/1977, about 30 % of the total energy consumption in the Kathmandu valley.

The existing distribution facilities in this area consist of the following and are illustrated in Fig. 3.2.

Distribution Facilities in
K-2 Service Area

11 kV Primary Lines

Number of feeders	6 feeders
Length of lines	95 km (approx)

3.3 kV Primary Lines

Number of feeders	2 feeders
Length of lines	8 km (approx)

Distribution Transformers

Number of transformers	86 nos.
Total capacity of transformers (11/0.4-0.23 kV)	6,336 kVA
- do - (3.3/0.4-0.23 kV)	3,875 kVA

The existing 11 kV feeders are extended to Kamaladi, Mint and Thapathari, Mahabaudha, Lazimpat, and Bhimsensthan, and the existing 3.3 kV feeders are extended to Jyatha and Kaliastan. The 11 kV Mahabaudha feeder is further extended to Pyaphal, Tengal and Asan, with the 3.3 kV system through the 11/3.3 kV transformers at Mahabaudha.

In addition, the Jyatha, Mahabaudha, Tangal and Mint feeders are connected to the distribution systems of the Balaju S/S, Maharajgunj S/S, Chabel S/S and Teku S/S, respectively. There are normally separated by opening the isolators.

TEKU SUBSTATION AREA

The Teku Substation is located at the extreme southwest part of Kathmandu city and supplies the energy to the residential, institutional and commercial zones in the southwestern area of the Kathmandu Valley and also a part of the center of the Kathmandu valley.

The energy consumption in the area is estimated at 31.9 GWh with a peak demand of 7.2 MW in 1976/1977, about 21 % of the total energy consumption in the Kathmandu city.

The existing distribution facilities in this area consists of the following and are illustrated in Fig. 3.3.

Distribution Facilities in
Teku Service Area

11 kV Primary Lines

Number of feeders	6-feeders
Length of lines	100 km (approx.)

3.3 kV Primary Line

Number of feeders	1-feeder
Length of Lines	8 km (approx.)

Distribution Transformers

Number of transformers		110 nos.
Total capacity transformers	(11/0.4-0.23 kV)	10,350 kVA
- do -	(3.3/0.4-0.23 kV)	1,075 kVA

11 kV existing feeders are extended to Himalayan Heights, Thankot, Teku-Hetauda Ropeway stations, Chobal, Patan and Jhochhen. The Kirtipur feeder and Mint feeder are further extended to Chelachhe and Magar, with the 3.3 kV system through the 11/3.3 kV transformers at Kirtipur and Mint.

In addition, the Tahachal, Pullchok and Mint feeders are connected to the distribution systems of the Baraju S/S, Patan S/S and Kathmandu S/S, respectively. These are normally separated by opening the isolators. The 3.3 kV Kalimati feeder is extended to Damai and Arkonarayan. This feeder is connected to the 11 kV Mint feeder through the 11/3.3 kV transformer at Lagan.

BALAJU SUBSTATION AREA

The Balaju substation is located at the northwest of Kathmandu city and supplies the energy to the residential and industrial zones in the north-western area of the Kathmandu Valley and also a part of the center of the Kathmandu city.

The energy consumption in the area is estimated at 13 GWh with a peak demand of 3.0 MW in 1976/1977, about 8 % of the total energy demand in the Kathmandu valley.

The existing distribution facilities in this area consist of the following and are illustrated in Fig. 3.4.

Distribution Facilities in Balaju Service Area

11 kV Primary Lines

Number of feeders	3 feeders
Length of lines	20 km (approx)

3.3 kV Primary Line

Number of feeders	1 feeder connected to 11 kV line
Length of line	14 km (approx)

Distribution Transformers

Number of transformers		49 nos.
Total capacity of transformers	(11/0.4-0.23 kV)	1985 kVA
- do -	(3.3/0.4-0.23 kV)	1890 kVA

11 kV existing feeders are extended to Dnarmastali, Lainchoor, Nayabazar, Swayambhu and Chhuni. The Lainchoor and Swayambhu feeders are further

extended to Bahadur, Thamel and Natapacho, with the 3.3 kV system through the 11/3.3 kV transformers at Lainchoor, Nayabazar and Swayambhu. The Lainchoor and Swayambhu feeders are connected to the distribution system of the Maharajgunj S/S, K-2 S/S, and Teku S/S respectively. These are normally separated by opening the isolators.

MAHARAJGUNJ SUBSTATION AREA

The Maharajgunj substation is located at the extreme north of Kathmandu city and supplies the energy to the residential and institutional zones in the northern area of the Kathmandu valley and a also part of the center of the Kathmandu city.

The energy consumption in the area is estimated at 8.3 GWh with a maximum demand of 2.0 MW in 1976/1977, about 2% to the total energy consumption in the Kathmandu Valley.

The existing distribution facilities in this area consist of the following and are illustrated in Fig. 3.5.

Distribution Facilities in
Mahajgunj Service Area

11 kV Primary Lines

Number of feeders	2 feeders
Length of lines	18 km (approx)

Distribution Transformers

Number of transformers	26 nos.
Total capacity of transformers (11/0.4-0.23 kV)	2360 kVA

11 kV existing feeders are extended to Sitalniwas, Lamatangin, Bansbari and Budhanilkant. The Balwater feeder is connected to the distribution system of the K-2 S/S and chabel S/S, which are normally separated by opening the isolators.

CHABEL SUBSTATION AREA

The Chabel substation is located at the northeast of Kathmandu city and supplies the energy to the residential, recreational and monument zones in the northeastern area of the Kathmandu valley.

The energy consumption in the area is estimated at 14.6 GWh with a maximum demand of 3.3 MW in 1976/1977, about 11 % of the total energy consumption in the Kathmandu valley.

The existing distribution facilities in this area consist of the following and are illustrated in Fig. 3.6.

Distribution Facilities in Chabel Service Area

11 kV Primary Lines

Number of feeders	2 feeders
Length of lines	38 km (approx)

3.3 kV Primary Line

Number of feeders	2 lines connected to 11 kV feeder
Length of lines	10 km (approx)

Distribution Transformers

Number of transformers (11/0.4-0.23 kV)	59 nos.
Total capacity of transformers (11/0.4-0.23 kV)	4,650 kVA
- do - (3.3/0.4-0.23 kV)	1,300 kVA

11 kV existing Padam and Chabel feeders are extended to Nazal, Airport and Baneswar. In addition, two feeders are further extended to Trolley BUS Baneswar and Ranakraya with Gate the 3.3 kV system through the 11/3.3 kV transformers at Naxal and Baneswar.

The Padam feeder and Chabel feeder are connected to the distribution systems of the Maharanjgunj S/S, K-2 S/S and Thimi S/S, which are normally separated by opening the isolators.

BHAKTAPUR and THIMI SUBSTATION AREAS

The Bhaktapur substation and the Thimi substation are located at Bhaktapur town and Thimi town in the northwest of Kathmandu city and supply the energy to Bahaktapur and Thimi town and its surrounding area.

The energy consumption in these area is estimated at 6.3 GWh in total with a peak demand of 1.7 MW in 1976/1977, about 5 % of the total energy consumption in the Kathmandu valley.

The existing distribution facilities in these areas consist of the following and are illustrated in Fig. 3.7.

Distribution Facilities in Bhaktapur and Thimi Service Area

11 kV Primary Line

Number of feeders	2 feeders (one feeder each)
Length of O.H, lines	16 km (approx)

Distribution transformers

Total capacity of transformers	2,000 kVA (approx)

The existing 11 kV feeder at the Bhaktapur substation is extended to Dadmikot and Bhaktapur towns, branching from the 11 kV connecting line between the Sundarijal power station and Bhaktapur substation.

The existing feeder of the Thimi substation is extended to Thimi town and Bode.

PATAN SUBSTATION AREA

The Patan Substation is located at the south of Kathmandu and supplies the energy to the residential, institutional, industrial and monument zones in the southern area of the Kathmandu valley.

The energy consumption in the area is estimated at 15.9 GWh with a peak demand of 3.7 MW in 1976/1977, about 12 % of the total energy consumption in the Kathmandu valley.

The existing distribution facilities in this area consist of the following and are illustrated in Fig. 3.8.

Distribution Facilities in
Patan Service Area

11 kV Primary Lines

Number of feeders	4 feeders
Length of lines	39 km (approx)

3.3 kV Primary Lines

Number of feeders	2 feeders
Length of lines	5 km (approx)

Distribution Transformers

Number of transformers(11/0.4-0.23 kV)	67 nos.
Total capacity of transformers (11/0.4-0.23 kV)	3,960 kVA
- do - (3.3/0.4-0.23 kV)	680 kVA

The existing 11 kV feeders are extended to Chapagaon, Godawari and Pharping. The Jawalakhel feeder is further extended to Walakhu with the 3.3 kV system through the 11/3.3 kV transformer at Saugal.

The 3.3 kV Patan feeder is extended to Kwalakhu and connected to the 3.3 kV line of the Jawalakhel feeder and to the Teku distribution systems, which are normally separated by opening the isolators.

3.5 Power Tariff Structure and Financial Status of NEC

The current power tariff structures of NEC effective since April 1976 are shown in Table 3.1. The power tariff is classified into the following seven categories.

(1) Domestic
(2) Industry
(3) Commercial
(4) Street light
(5) Irrigation and Water supply
(6) Transportation
(7) Temporary connection

The tariff for unmetered domestic consumers is uncertain. For metered consumers the tariff consists of demand charge for installation and unit charge for energy consumption. The unit charge is free upto certain amounts for the domestic consumers.

Progressive charge system is adopted for domestic energy sales. Separate charges are provided for the irrigation and watersupply and for the transportation business, while no special charges are provided for other governmental or public establishments.

The annual revenue and expenditure of NEC are tabulated in Table 3.2 and summarized below referring to the annual report of NEC for the Year 1975/76.

Year	Net Revenue($\times 10^3$Rs)	Expenditure($\times 10^3$Rs)	Balance($\times 10^3$Rs)
1966/67	4,982	2,846	2,136
67/68	5,699	5,076	623
68/69	6,401	5,247	1,154
69/70	7,811	7,676	135
70/71	8,613	8,138	475
71/72	9,629	8,770	859
72/73	12,130	10,620	1,510
73/74	15,812	14,900	912
74/75	18,610	25,887	-7,277
75/76	23,114	32,233	-9,119

As seen in the above figure, revenue during the past five years from 1970/71 through 1975/76 indicated a large increase at the annual average growth rate of 22 % against sold energy increment of 15 %, and the financial status upto 1973/74 was sound.

The financial return of NEC in 1974/75 and 1975/76 was, however showed a deficit. It seems mainly caused by the consumption of high priced fuel for the operation of diesel power stations necessary to cover the shortage of hydro power supply.

TABLE 3.1 POWER TARIFF OF NEC

	NEC	
	CNPS	Bharatpur
DOMESTIC		
a) upto 25 kWh	25 Paisa/kWh	
b) " 100 "	35 "	
c) " 300 "	42 "	data not available
d) above 300"	50 "	
Minimum charge		
a) upto 15 A meter	6.25 Rs/month, 22 kWh free	
b) 16 to 30 "	15.00 " , 45 "	
c) 31 to 60 "	32.50 " , 90 "	6.00 Rs/month &
d) 61 to 100 "	53.50 " , 135 "	12 kWh free
e) above 100 "	116.50 " , 270 "	
INDUSTRY		
a) upto 100 kW		
demand charge	8.50 Rs/kW/month	5.00 Rs/kW/month
unit charge	25 Paisa/kWh	25 Paisa/kWh
b) above 100 kW		
demand charge	17.15 Rs/kW/month	
unit charge	20 Paisa/kWh	
COMMERCIAL		
demand charge	18.00 Rs/kW/month	18.00 Rs/kW/month
unit charge	20 Paisa/kWh	20 Paisa/kWh
STREET LIGHT		
a) metered	25 Paisa/kWh	25 Paisa/kWh
b) unmetered	10 Paisa/W/month	
- 40 W		3.00 Rs/month
- 60 W		4.50 "
- 100 W		7.50 "
- 125 W		8.00 "
- 200 W		15.00 "
IRRIGATION & WATERSUPPLY		
TRANSPORTATION		
demand charge	18.00 Rs/kW/month	18.00 Rs/kW/month
unit charge	25 Paisa/kWh	25 Paisa/kWh
TEMPORARY CONNECTION		
a) metered	75 Paisa/kWh	75 Paisa/kWh
b) unmetered	35 Paisa/W/month	35 Paisa/W/month

US$1.00 = Rs. 12.55

TABLE 3.2 GROSS REVENUE & EXPENDITURE (NEC)

(x 10^3 Rs)

	TOTAL INCOME							TOTAL EXPENDITURE	BALANCE
	DOMESTIC	INDUSTRIAL	COMMERCIAL	STREET LIGHT	OTHERS	REBATE	TOTAL		
1966/67	3,704	567	477	152	157	-72	4,982	2,846	2,136
67/68	4,304	645	582	95	256	-183	5,699	5,076	623
68/69	5,077	491	549	88	299	-103	6,401	5,247	1,154
69/70	5,672	680	746	77	744	-108	6,811	7,676	-865
70/71	5,963	799	1,000	99	856	-104	8,613	8,138	475
71/72	6,338	942	1,155	97	1,166	-69	9,629	8,770	859
72/73	7,537	1,501	1,384	93	1,694	-79	12,130	10,620	1,510
73/74	9,851	2,706	1,597	134	1,618	-94	15,812	14,900	912
74/75	11,083	3,259	2,089	145	2,137	-182	18,610	25,887	-7,277
75/76	13,455	4,656	2,777	156	2,175	-105	23,114	32,233	-9,119

Source: Annual Report of NEC for the year of 1975/76.

FIG. 3.1 EXISTING TRANSMISSION SYSTEM

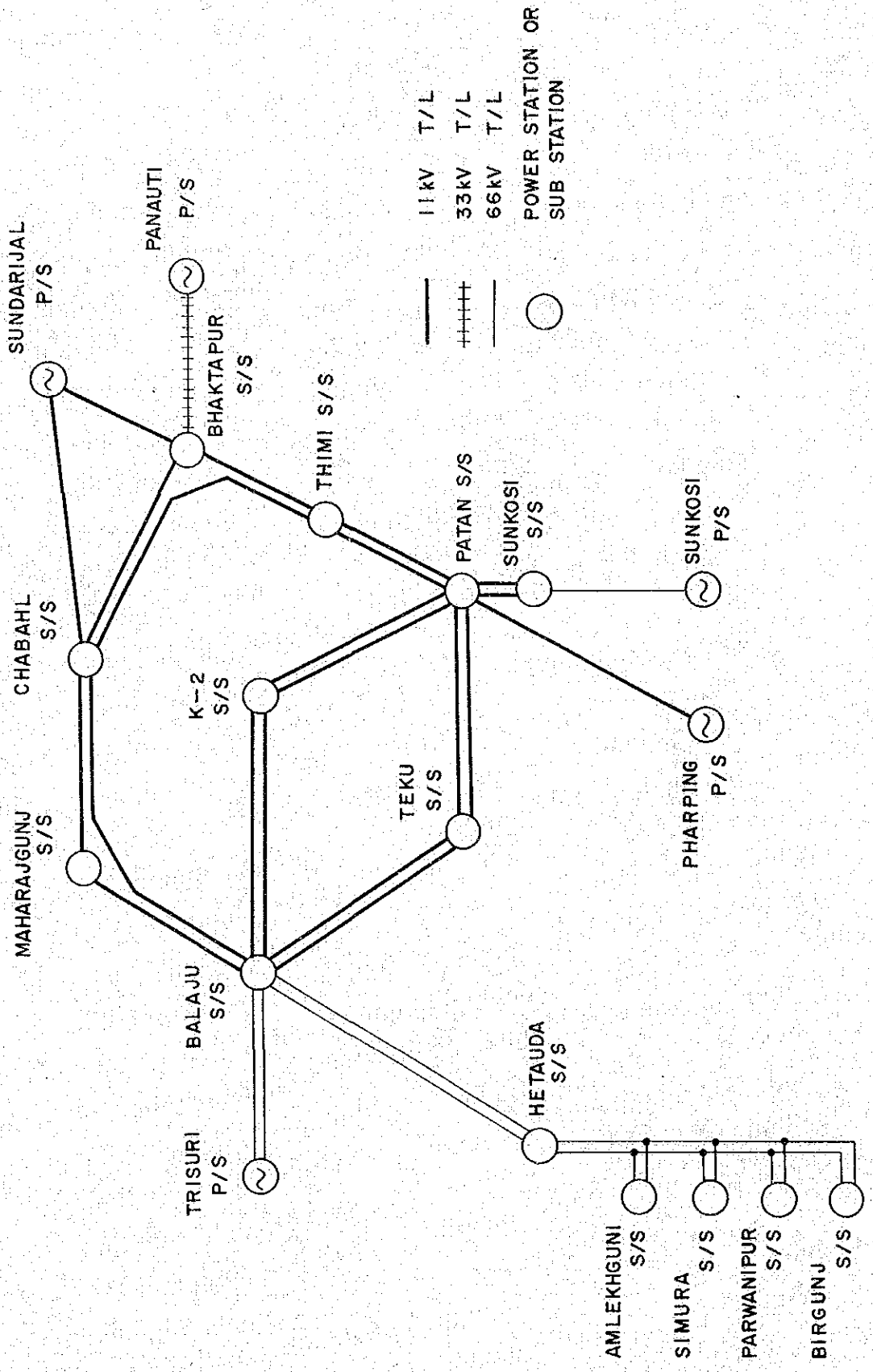


FIG. 3-2 EXISTING D/L SYSTEM OF KATHMANDU S/S

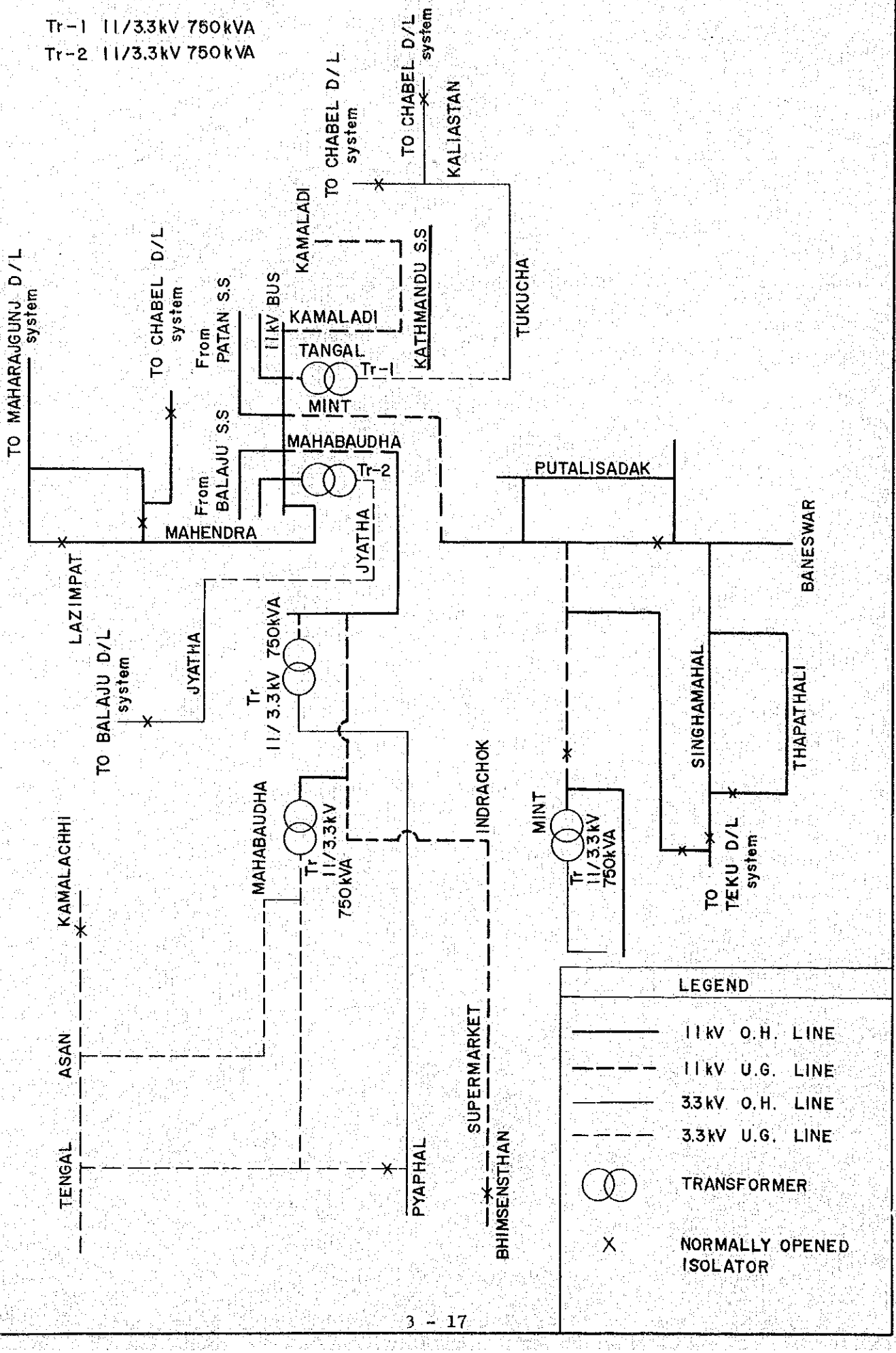


FIG. 3-3 EXISTING D/L SYSTEM OF TEKU S/S

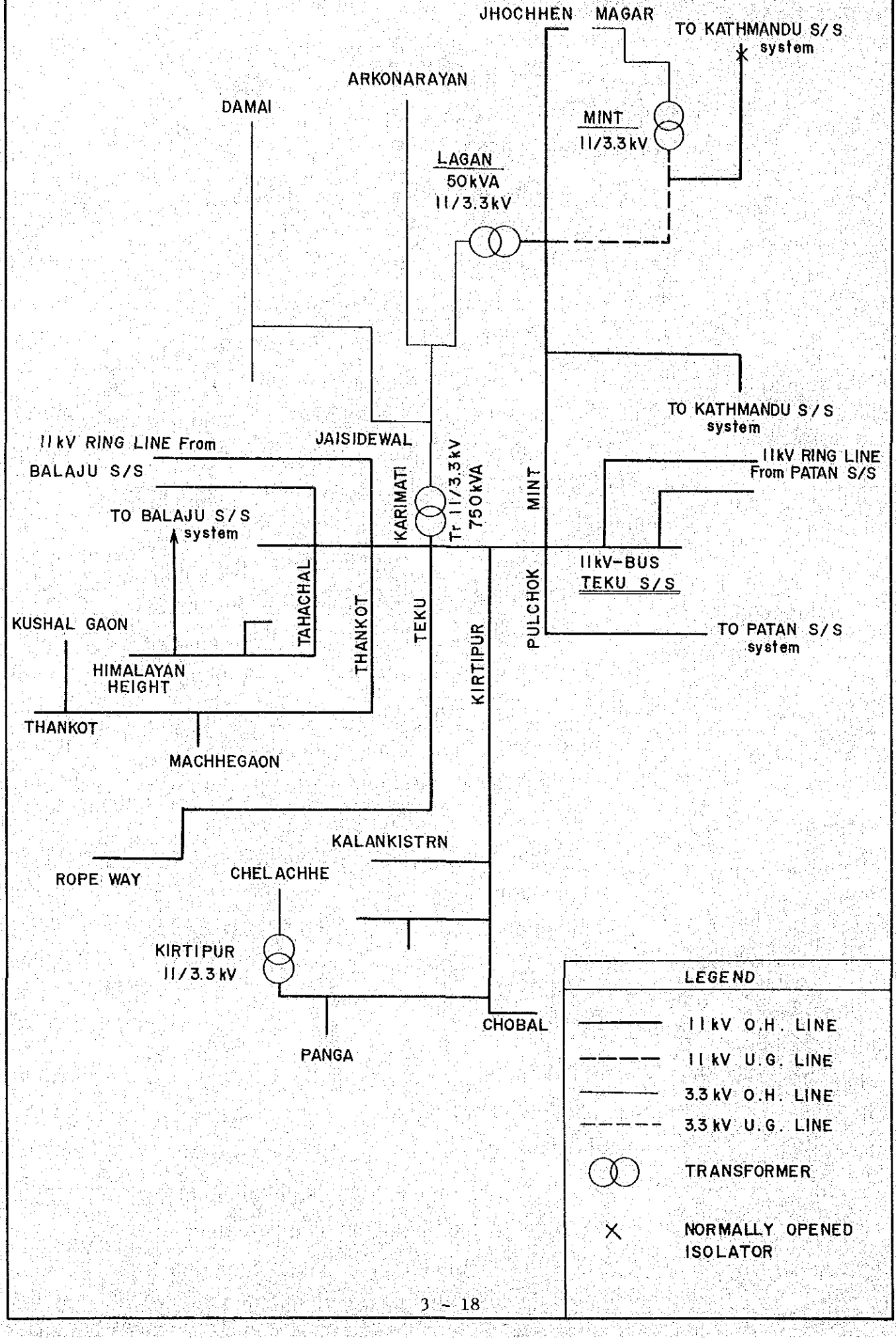


FIG. 3-4 EXISTING D/L SYSTEM OF BALAJU S/S

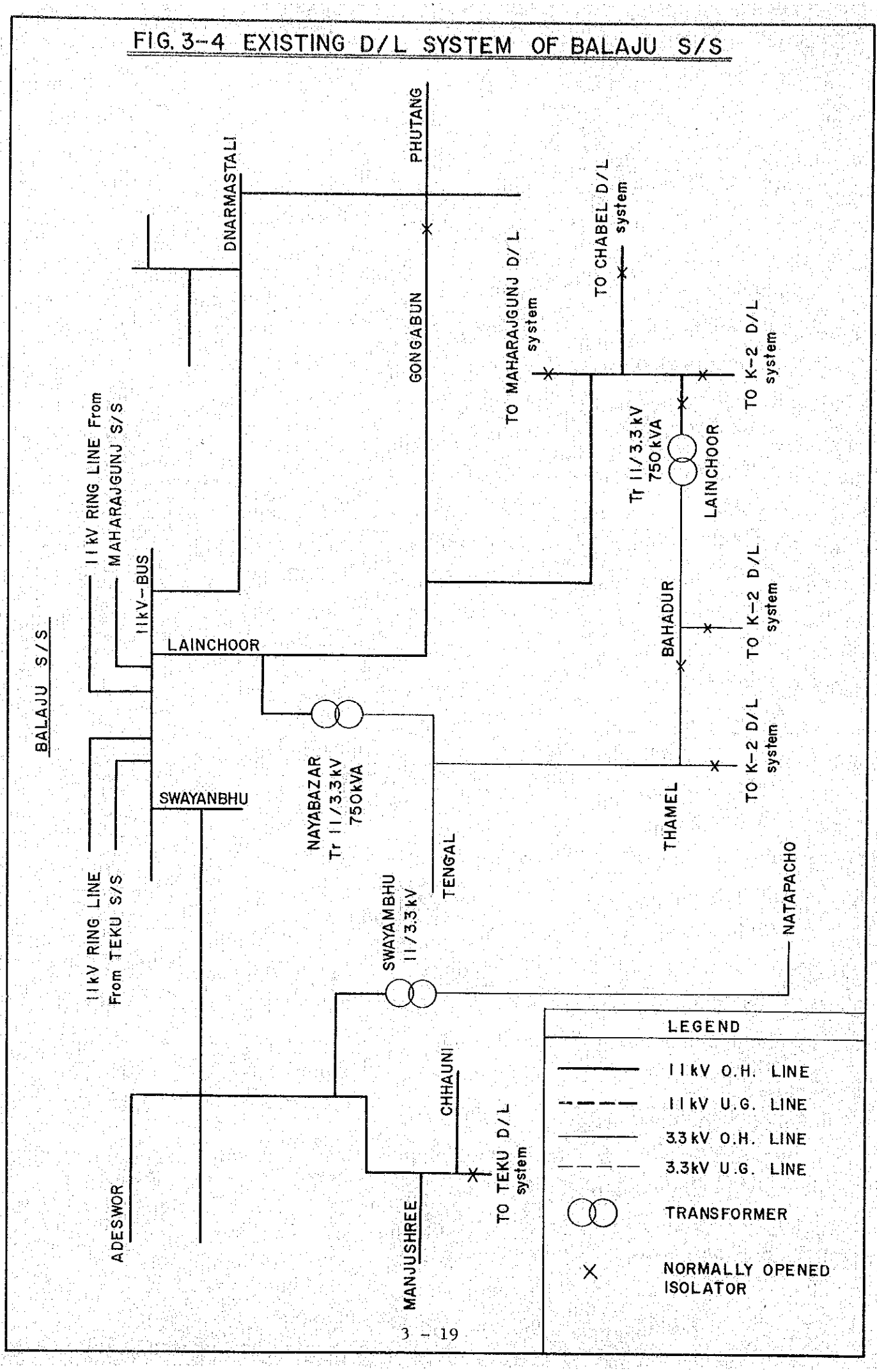


FIG. 3-5 EXISTING D/L SYSTEM OF MAHARAJGUNJ S/S

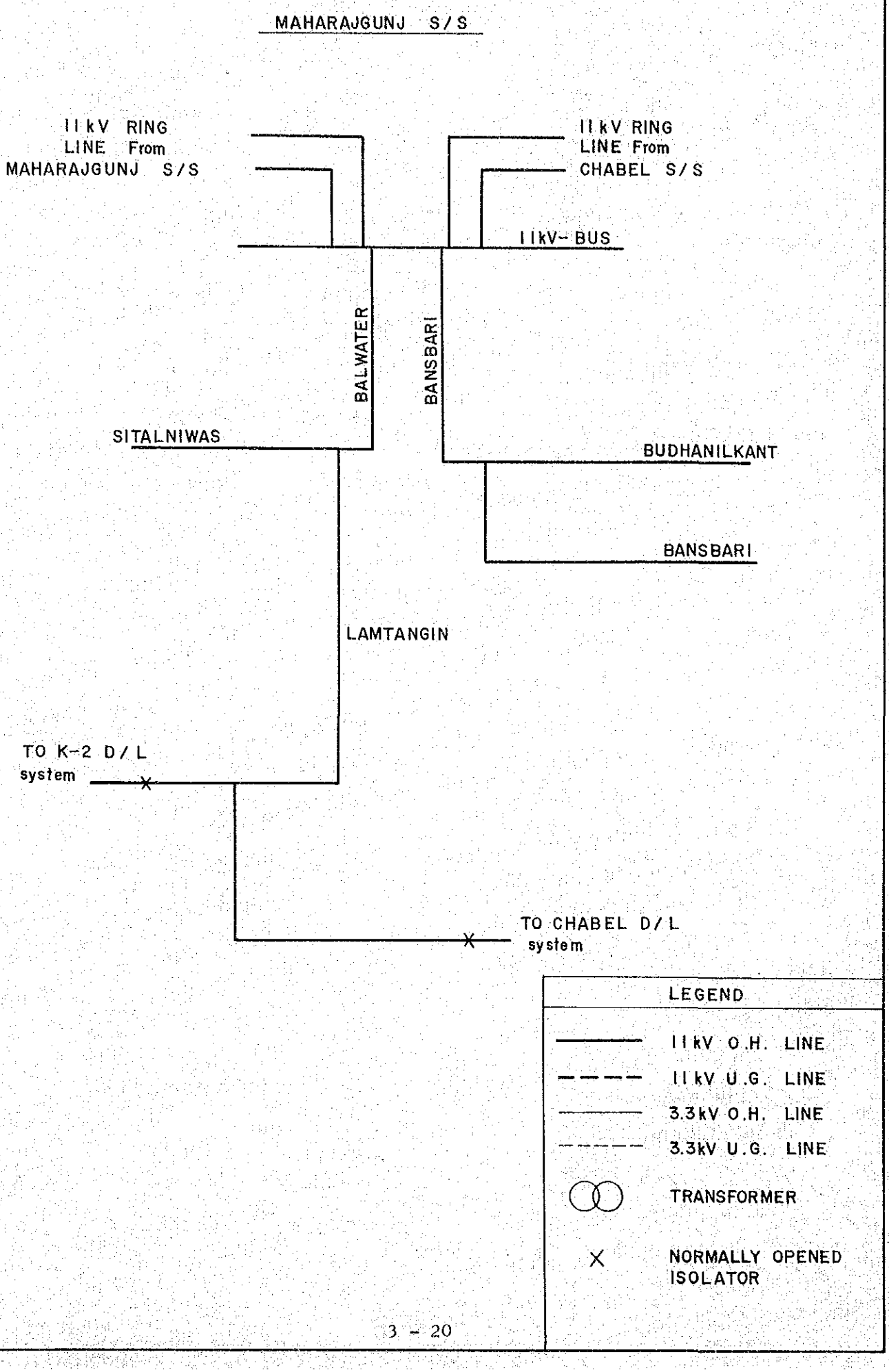


FIG. 3-6 EXISTING D/L SYSTEM OF CHABEL S/S

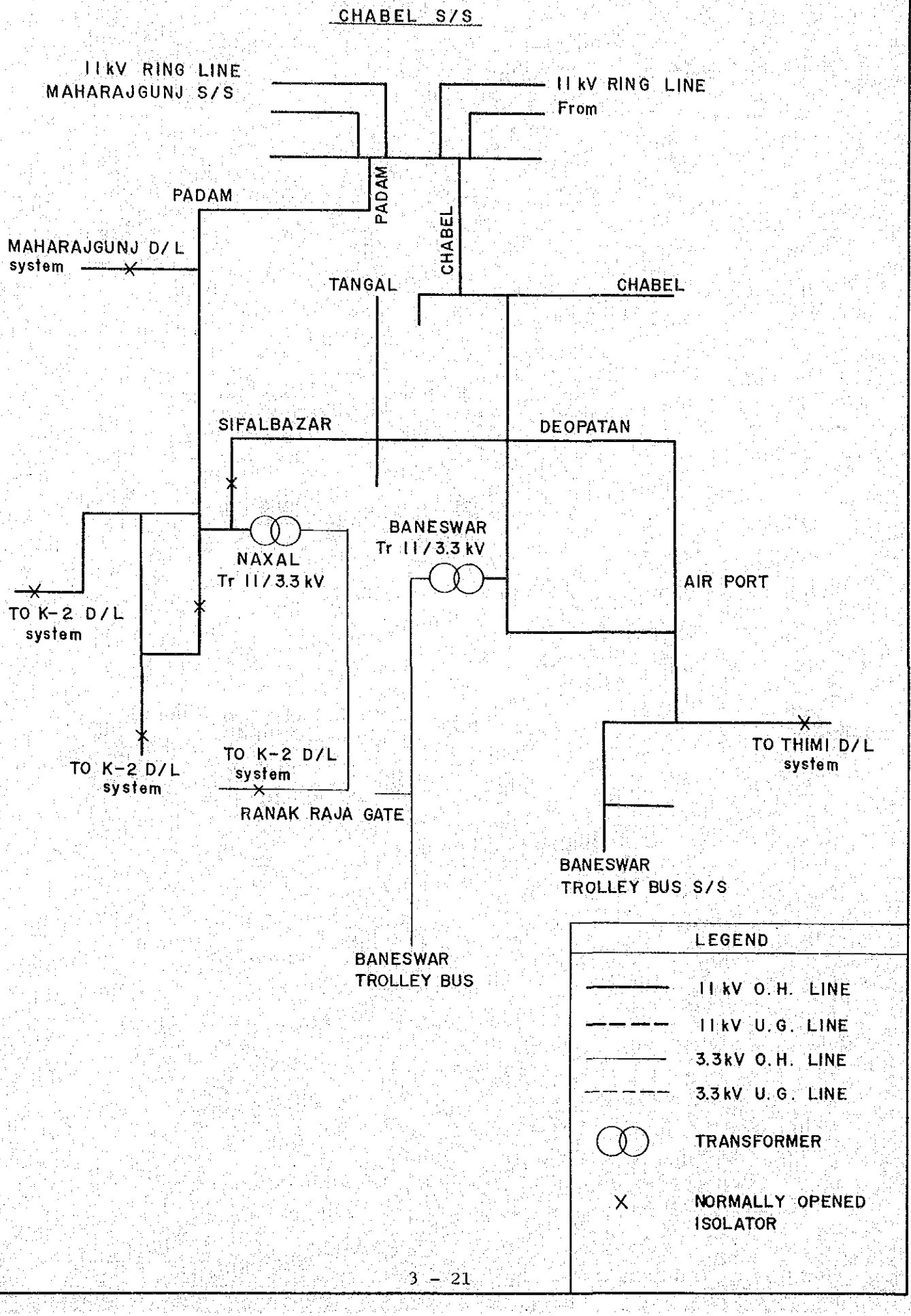


FIG. 3-7 EXISTING D/L SYSTEM OF BHAKTAPUR S/S AND THIMI S/S

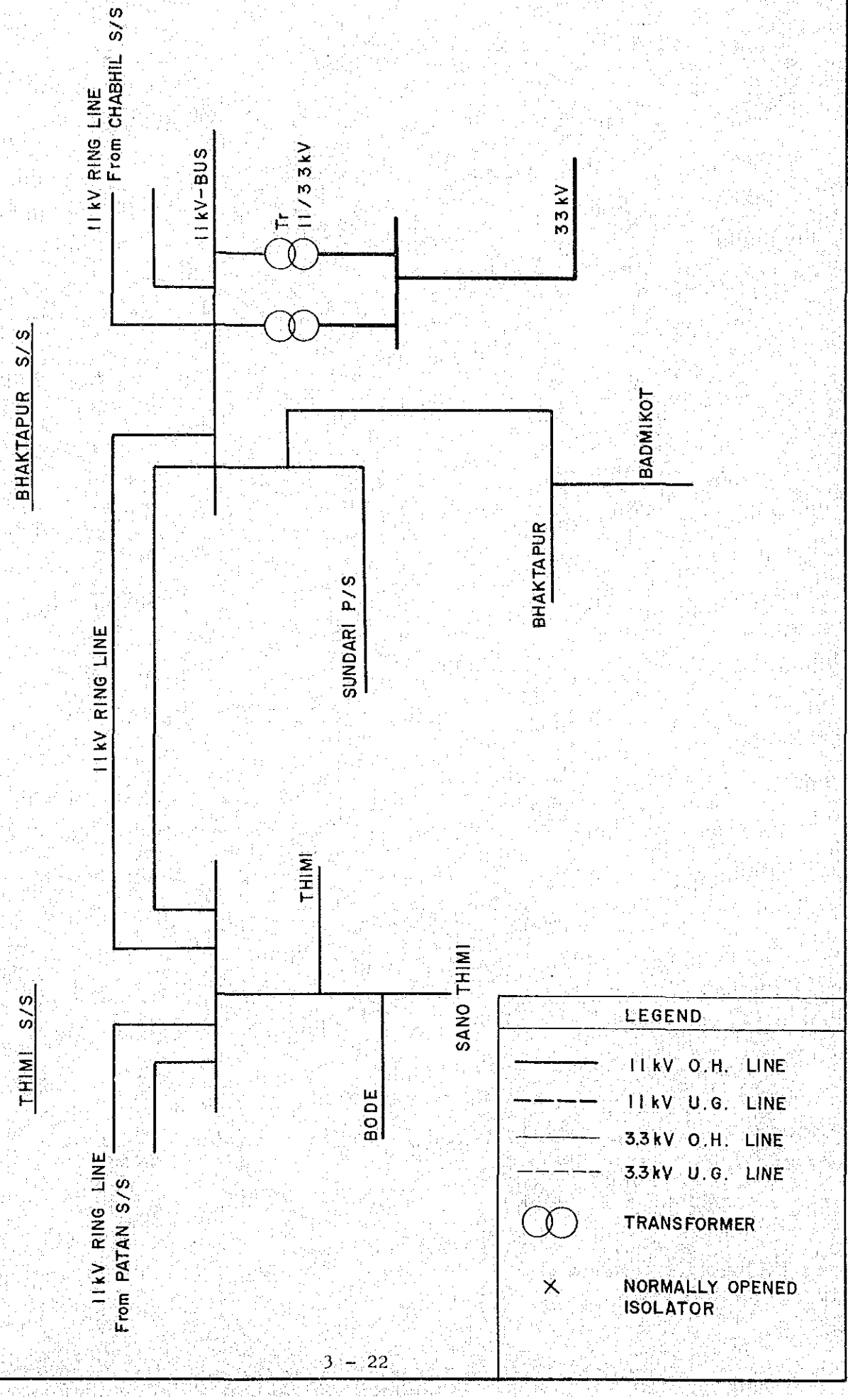
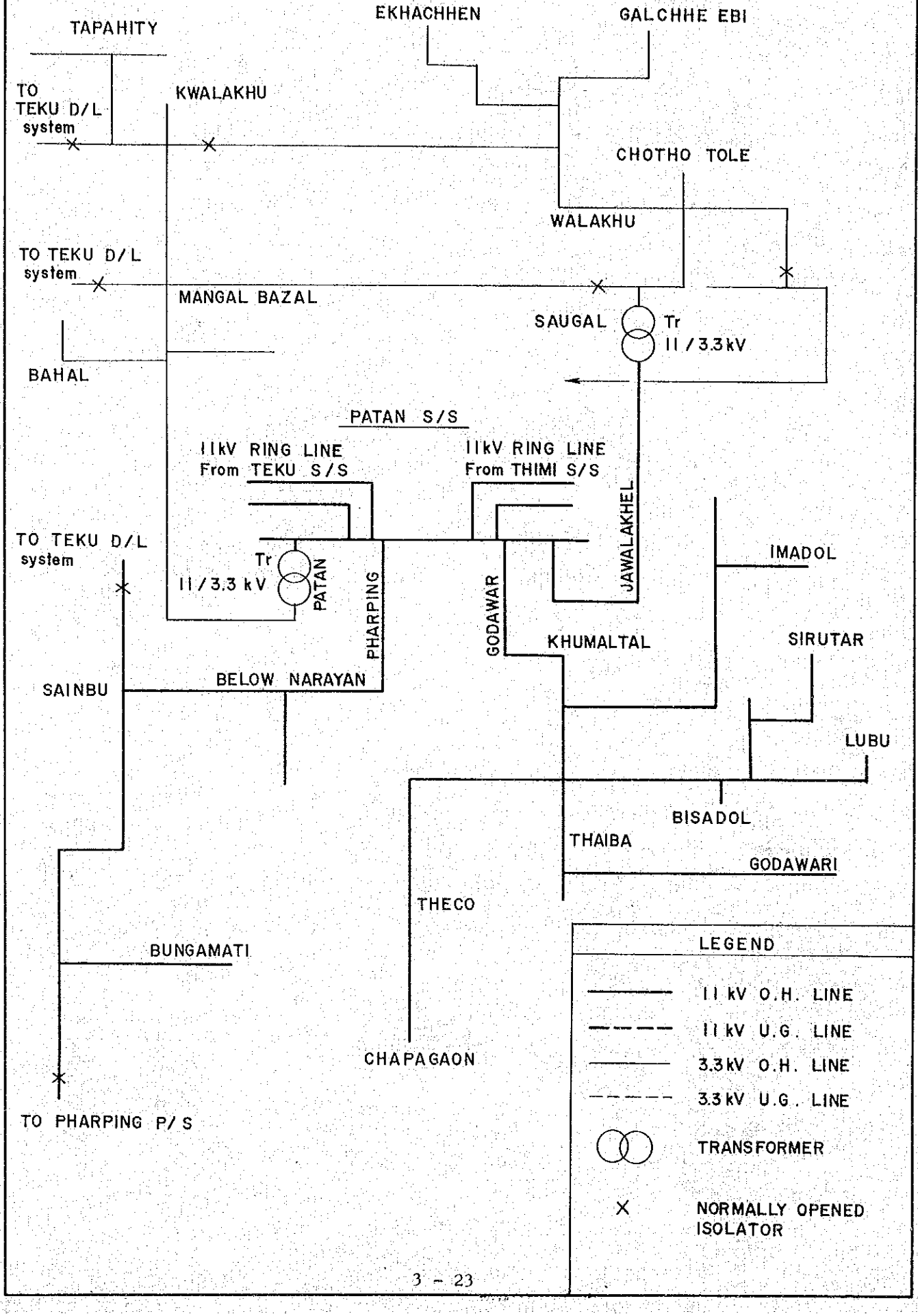


FIG. 3-8 EXISTING D/L SYSTEM OF PATAN S/S



SECTION 4

POWER DEMAND FORECAST OF KATHMANDU VALLEY

SECTION 4

POWER DEMAND FORECAST OF KATHMANDU VALLEY

4.1 Current Power Demand

Recent data of NEC for power generation and consumption in the CNPS are summarized below:

Power Generation and Consumption of the CNPS

YEAR	Energy Generated (MWh)	Peak Demand (kW)	Load Factor (%)	Loss Factor (%)	Energy Sold (MWh)
1963/64	13,740	3,550	44.2	-	6,400
64/65	15,690	3,800	44.8	-	8,040
65/66	19,620	4,800	40.6	-	9,820
66/67	22,520	6,650	44.1	36.9	14,209
67/68	30,360	8,210	42.1	38.6	18,645
68/69	36,120	9,595	41.6	39.6	21,807
69/70	44,870	11,560	44.3	36.6	28,461
70/71	53,650	13,860	44.2	31.5	36,761
71/72	65,950	17,500	43.0	29.4	46,534
72/73	81,269	21,280	43.6	27.3	59,076
73/74	96,205	25,500	43.1	32.7	64,728
74/75	109,550	30,240	41.4	30.8	75,786
75/76	124,849	31,880	44.7	30.0	87,423

During the last ten years from 1966/67 through 1975/76, the energy consumption has increased from 14,200 MWh to 87,400 MWh with an average annual growth rate of 22.4 %, while the peak demand has increased from 6,650 kW to 31,880 kW with an average annual growth rate of 19 %. However, increment of energy consumption and peak demand in the last few years (1973/74 to 1975/76) show the annual growth rates at 16.2 % and 11.8 %. Such recent decay of increment seems to be attributable to insufficient capacities of the power supply system. Application for new connection has been suspended by NEC due to shortage of the power supply capacity.

In addition, energy consumption in 1976/77 was suppressed only to an increase of 5.7 % over the previous year due to the shortage of supply capacity, although the potential demand would have increased at the high rate similar to that of the preceding years.

The monthly energy production, peak demand and the typical daily load curves of the system are illustrated in Figs. 4.1 to 4.3. As seen in the figures, the seasonal variation of power demand is remarkable marking its peak in the winter season from December to February. The daily load factor is about 60 % in the winter season and about 55 % in the summer season as seen in the typical load curves.

The energy consumption records are available for classification in the following five categories:

a) domestic use
b) industrial use
c) commercial use
d) street lighting use and
e) other use

The past records of number of the consumers and power consumption by each category are summarized in Tables 4.1 and 4.2. As seen in the tables, about 60 % of energy consumed in the CNPS is by domestic consumers and about 20 % by industrial used in 1974/75 and 1975/76. Since the energy has been mainly consumed by domestic consumers, the present annual load factor is relatively low at 40 to 45 %. However, the industrial demand shows very rapid increase compared with the domestic demand. Such tendency will continue under the industrization plan of the Government.

Total energy loss of the transmission and distribution systems is worked out as a balance between the generated energy and sold energy at about 30 % of the generated energy. Such high energy loss is supposed to consist of not only physical losses due to small sized conductors and inaccurate metering system but also illegal consumption of energy.

The abovestated power data are for the whole CNPS involving Hetauda and Birganj areas. Though the region for this project is Kathmandu valley,

the detailed information of power data for Kathmandu valley are not available. However, it is obvious that the most of the energy to the CNPS is consumed in the Kathmandu valley. In this report, it is assumed that the valley occupies 85 % of the total energy consumption of the CNPS in 1975/76.

Typical loading and voltage variation of the substations on the ring lines are shown on Table 4.3 and illustrated in Fig. 4.4. to Fig. 4.14.

4.2 Power Demand Forecast

4.2.1 Forecasting Method of Power Demand

At first the past trend of energy consumption was studied in detail. Appropriate growth rates were assumed referring to the past trend taking account of such relevant factors as population, level of energy consumption, developing plans, etc.

Since the power consumption in the CNPS was recorded over the past some ten years being classified into domestic, industrial, commercial and other demands, different growth rate for each category is analysed and applied for the forecast.

The distribution system planned in this report is ready for connection of new consumers with the following schedule:

Starting connection	1980/81
Up to 40,000 connections	1982/83
Up to 50,000 connections	1985/86

The total demand in the forecast is obtained by summing up the growing demand of each category and adding energy loss consumed in the system. The energy loss of the system was recorded at more than 30 % and it is assumed to continue by 1980/81 until the improvement of the distribution network is expected to start and then gradually to decrease ultimately to 15 % on completion of the planned distribution system.

4.2.2 Domestic Demand

The growth rate of domestic demand during the past few years from 1973/74 through 1975/76 was 12 % per annum on the average against 25 % for the previous years from 1966/67 through 1973/74 as seen in Table 4.2. The declined growth rate seems to be caused by the restriction of power supply attributable to lack of distribution capacity of the system. Accordingly, such decline is assumed to continue up to 1980/81 until completion of the Kulekhani No.1 power station and the improvement and expansion of the distribution network can be expected to be implemented.

According to the census, the population of Kathmandu valley in 1971 was 618,911 and the number of persons in a household was 5.57 in average (refer to Rural Development Plan for Kathmandu Valley). The growth rate of population in the Kathmandu valley between the census in 1961 and 1971 was 3.5 % per annum in average. This growth rate is applied for estimating the future population.

As mentioned in Clause 4.1, there will be only few new connections before the implementation of the planned distribution system due to shortage of power supply capacity of the existing distribution system, however, the potential power demand is assumed to grow at a conservative rate. Such increase of potential connections of the domestic consumers will be met by the implementation of the first stage development of the distribution system and the number of new connections is assumed to grow rapidly for several years on completion of the planned distribution system. The electrification ratio in 1990/91 will be about 77 %.

The average energy consumption per one consumer was 859 kWh in 1975/76. This value is comparatively low and is assumed to increase at the average rate of about 8 % per annum, while the initial power consumption of the newly connected consumers is assumed as 800 kWh per annum in average.

The forecast of the domestic power consumption up to 1990/91 is given hereunder:

Year	Population *1	No. of Household *2	Consumers Number	Consumers Increase (%)	Consumption per Consumer (kWh)	Total Consumption (MWh)
1971/72	618,911	111,115	-	-	-	-
75/76	640,573	115,036	51,480	4.89	859	44,210
76/77	662,993	119,029	54,050	5	922	49,830
77/78	686,198	123,195	55,130	2	992	55,130
78/79	710,215	127,507	55,680	1	1,068	59,520
79/80	735,072	131,970	55,680	0	1,155	64,310
80/81	760,800	136,589	55,680	0	1,247	69,430
81/82	787,428	141,369	57,350	3	1,331	76,330
82/83	814,988	146,317	65,950	15	1,354	89,300
83/84	843,512	151,438	75,840	15	1,376	104,360
84/85	873,035	156,839	87,220	15	1,397	121,850
85/86	903,951	162,289	100,300	15	1,416	142,020
86/87	935,217	167,903	112,340	12	1,451	163,010
87/88	967,950	173,779	123,570	10	1,497	184,980
88/89	1,001,828	179,861	133,460	8	1,556	207,660
89/90	1,036,892	186,157	141,460	6	1,631	230,720
90/91	1,073,183	192,672	148,540	5	1,716	254,890

Note: *1. Growth rate of population for Kathmandu valley is assumed as 3.5 % per annum.

*2. Number of person per household is assumed as 5.57 persons in average.

As seen in the above table the annual power consumption is estimated to increase from 49,830 MWh in 1976/77 to 254,890 in 1990/91.

4.2.3 Industrial Demand

As seen in Tables 4.1 and 4.2, annual average increase of number of industrial consumers and their annual energy consumption in the CNPS were 13 % and 38 % respectively during the period from 1970/71 through 1975/76. The annual average growth rate of energy consumption during the past few years from 1973/74 through 1975/76 declined, however, to 31 %. It is not expected that such rapid growth would further continue.

The major industrial and irrigation demands currently under planning are shown in Table 4.4. As seen in the Table, most of industrialization plans are located in Hetauda-Birganj Corridor.

In the demand forecast, the annual growth rate of the potential industrial demand was assumed to be 20 % up to 1979/80 gradually decreasing to 15 % thereafter, considering steady industrialization of the area. The forecast for the industrial demand under such assumption is summarized below.

Year	Energy Consumption (MWh)	Increase Rate (%)
1976/77	19,350	-
77/78	23,220	20
78/79	27,860	20
79/80	33,440	20
80/81	39,460	18
81/82	46,160	17
82/83	53,550	16
83/84	61,580	15
84/85	70,820	15
85/86	81,440	15
86/87	93,660	15
87/88	107,700	15
88/89	123,860	15
89/90	142,440	15
90/91	163,800	15

Energy consumption is forecasted to increase from 19,350 MWh in 1976/77 to 163,800 MWh in 1990/91.

4.2.4 Commercial Demand

The annual growth rate of energy consumption of the commercial category was 14 % on the average varying from 8.2 % to 32.1 % during a period of 1970/71 through 1975/76.

It is noted that the energy consumed in this category was proportional to the number of the tourists according to the information from NEC. The relation between number of tourists visited and energy consumption of commercial category is shown in Fig. 4.15.

Growth of commercial demand is much influenced by the number of visiting tourists to this area. Growth rate of tourists was 19 % on the average during a period of 1967/68 to 76/77. However, the records of the last several years show the annual growth rate of 8 % against growth rate of energy consumption of 18 % during the same period.

The anticipated loads of the hotels currently under planning are shown in Table 4.4. It is supposed that the above loads are consumed with some time lag. Taking the such factors into consideration it is assumed that the bulk load of 3,000 MWh per annum is added in 1979/80.

Demand forecast for the commercial category is worked out under the assumption of annual growth rate at 13 % to 10 % as shown below.

Year	Energy Consumption (MWh)	Addition of Bulk Load (MWh)	Growth Rate (%)
1976/77	8,590	-	-
77/78	9,710	-	13
78/79	10,970	-	13
79/80	15,390	3,000	13
80/81	17,400	-	13
81/82	19,660	-	13
82/83	22,210	-	13
83/84	25,100	-	13
84/85	28,360	-	13
85/86	31,770	-	12
86/87	35,260	-	11
87/88	38,790	-	10
88/89	42,670	-	10
89/90	46,930	-	10
90/91	51,630	-	10

The energy consumption of this category is forecasted to increase from 8,590 MWh in 1976/77 to 51,630 MWh in 1990/91.

4.2.5 Other Demands

(a) Street Lights

Demand of street lights is assumed at 1.2 % of the sum of domestic, industrial and commercial demands referring to the past records.

(b) Others

Energy consumption of this category includes NEC's own use and bulk supply and is assumed as 10% to 5% of the sum of domestic, industrial, commercial and street lights demand referring to the past records.

4.2.6 Total Demand

The total energy consumption is obtained as the sum of the energy consumption for each category.

The current high rate of energy loss slightly exceeding 30% is assumed to be improved with the gradual implementation of the planned distribution system and to reach the ultimate value of 15% upon completion of the project.

The current annual load factor of 44 % is assumed to increase gradually with improvement of the living standard and power consumption level and increase of day time load, ultimately to 53 %.

The forecasted energy consumption, energy supply and peak load are shown in Table 4.5 and summarized hereunder:

Year	Energy Consumption (MWh)	Energy Supplied (MWh)	Peak Load (kW)
1976/77	86,570	123,670	31,370
78/79	108,530	155,040	38,480
80/81	138,670	198,100	47,110
82/83	179,570	239,430	54,660
84/85	239,340	295,480	64,870
86/87	313,160	368,420	79,350
88/89	399,480	469,980	101,230
90/91	499,760	587,950	126,640

TABLE 4.1 - NUMBER OF REGISTERED CONSUMERS ( ): % INCREASE OVER PREVIOUS YEAR

Nepal's Year	2019/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29	29/30	30/31	31/32	32/33
AD	1962/63	63/64	64/65	65/66	66/67	67/68	68/69	69/70	70/71	71/72	72/73	73/74	74/75	75/76
DOMESTIC	10,206	21,606	31,162	14,869	16,385	19,986	26,420	32,259	38,274	44,251	52,225	56,103	57,744	60,565
	(-)	(23.52)	(4.41)	(12.97)	(10.20)	(21.98)	(32.19)	(22.10)	(18.65)	(15.55)	(18.02)	(7.43)	(2.92)	(4.89)
H.M. GOVERN.	252	262	268	280	324	354	373	390	408	439	450	519	552	571
	(-)	(4.00)	(2.29)	(4.48)	(15.71)	(9.26)	(5.36)	(4.56)	(4.62)	(7.60)	(2.51)	(15.33)	(6.36)	(3.44)
INDUSTRIAL	169	216	225	257	328	383	427	478	523	599	823	939	879	973
	(-)	(27.81)	(4.17)	(14.22)	(27.63)	(16.77)	(11.49)	(11.94)	(9.41)	(14.53)	(37.40)	(14.09)	(-6.39)	(10.69)
COMMERCIAL	-	-	-	-	2	3	7	20	14	18	19	26	55	58
					(-)	(50.00)	(133.33)	(185.71)	(-30.00)	(28.57)	(5.56)	(36.84)	(111.54)	(5.45)
TOTAL	10,627	13,084	13,655	15,406	17,039	20,726	27,227	33,147	39,219	45,307	53,517	57,587	59,230	62,167
% INCREASE OVER PREVIOUS YEAR	-	23.12	4.36	12.82	10.60	21.64	31.37	21.74	18.32	15.52	18.12	7.61	2.85	4.95

TABLE 4.2 - ENERGY SOLD (CLASSIFIED) x 10^6 kWh

Nepal's Year	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29	29/30	30/31	31/32	32/33
AD	62/63	63/64	64/65	65/66	66/67	67/68	68/69	69/70	70/71	71/72	72/73	73/74	74/75	75/76
DOMESTIC	3.87	5.32	5.83	7.46	8.89	11.61	13.66	15.54	21.15	28.14	32.63	41.688	46.869	52.017
(INC. GOVERN.)	(-)	(37.47)	(9.59)	(27.96)	(19.17)	(30.60)	(17.66)	(13.76)	(36.10)	(33.05)	(15.96)	(27.76)	(12.49)	(10.98)
INDUSTRIAL	0.62	0.87	1.55	1.70	1.62	1.86	2.77	3.08	3.60	4.32	6.709	10.565	13.813	18.212
	(-)	(40.32)	(78.16)	(9.68)	(-4.71)	(14.81)	(48.92)	(11.19)	(16.88)	(20.0)	(55.30)	(57.48)	(30.74)	(31.85)
COMMERCIAL	-	-	-	-	1.51	2.09	2.62	3.52	4.65	5.09	5.91	6.394	7.778	8.951
					(-)	(38.41)	(25.36)	(34.35)	(32.10)	(9.46)	(16.11)	(8.19)	(21.65)	(15.08)
STREET LIGHTS	-	0.21	0.66	0.66	0.65	0.70	0.92	0.57	0.71	0.69	0.739	0.871	0.884	0.893
				(-)	(-1.52)	(7.69)	(31.43)	(-38.04)	(24.56)	(-2.82)	(7.10)	(17.86)	(1.49)	(1.01)
NEC	-	-	-	-	1.531	1.821	1.31	1.341	1.436	1.415	1.412	1.510	1.82	1.439
					(-)	(18.94)	(-28.06)	(2.37)	(7.08)	(-1.46)	(-)	(6.94)	(20.53)	(-20.93)
BULK SUPPLY	-	-	-	-	-	0.56	1.12	4.41	5.22	6.88	9.525	3.702	4.621	5.94
						(-)	(100.0)	(293.75)	(18.37)	(31.8)	(38.44)	(-61.11)	(24.82)	(28.54)
TOTAL	4.49	6.40	8.04	9.82	14.209	18.645	21.807	28.461	36.761	46.534	59.076	64.728	75.786	87.423
	(-)	(42.5)	(25.6)	(22.14)	(29.1)	(31.2)	(16.9)	(30.5)	(29.1)	(26.5)	(26.9)	(9.5)	(17.0)	(15.3)

TABLE 4.3 LOADING OF S/S ON RING LINE

Average of Jan. 1, 2 & 3, 1977 (Amp.)

Time	Balaju	Mahad -rajgunj	Chab- ahil	Bhakt -pur	Thimi	Patan	Teku	K2	Total
1	56	44	10	31	13	64	149	42	409
2	50	44	10	31	13	59	161	27	395
3	51	44	10	32	14	61	175	28	415
4	55	44	10	34	15	64	191	53	466
5	65	51	10	37	17	78	212	74	544
6	93	62	27	43	20	106	234	76	661
7	126	73	37	52	21	144	270	121	844
8	133	74	43	52	21	144	286	164	917
9	122	79	40	47	19	119	259	159	844
10	87	71	37	37	17	78	224	156	707
11	83	68	27	32	14	66	210	136	636
12	70	66	20	28	14	69	191	179	637
13	64	59	10	28	15	66	186	177	605
14	62	58	10	29	15	69	175	163	581
15	76	60	10	32	16	81	179	161	615
16	82	54	10	33	17	87	190	133	606
17	107	67	27	34	20	101	257	139	752
18	176	97	70	70	31	173	382	216	1,215
19	173	105	63	70	31	169	389	227	1,227
20	162	87	53	60	25	148	375	200	1,110
21	132	78	47	57	21	118	330	183	966
22	105	69	37	46	19	101	262	134	773
23	77	57	27	41	17	89	207	81	596
24	59	48	13	31	14	85	160	40	450

Average of Jul. 19, 20 & 21, 1976 (Amp.)

Time	Balaju	Mahad -rajgunj	Chab- ahil	Bhakt -pur	Thimi	Patan	Teku	K2	Total
1	36	23	-	25	14	54	91	37	280
2	35	21	-	25	14	49	88	33	265
3	35	19	-	25	14	49	88	31	261
4	37	20	-	25	14	49	88	31	264
5	46	26	-	31	14	63	102	34	316
6	59	31	10	29	15	78	126	39	387
7	76	39	10	34	16	88	136	48	437
8	85	37	10	34	17	82	172	57	494
9	70	37	10	28	15	57	158	64	439
10	60	38	10	24	12	40	150	59	393
11	63	46	-	15	13	36	143	59	375
12	52	40	10	15	13	38	110	60	338
13	45	32	-	16	13	43	143	59	351
14	56	38	-	16	12	47	138	58	365
15	56	39	-	18	12	48	136	58	367
16	59	36	-	20	12	49	132	60	368
17	57	34	-	24	12	54	135	60	376
18	63	32	-	25	17	74	162	64	437
19	126	58	10	37	22	125	252	86	716
20	144	60	27	58	25	150	273	106	843
21	123	55	40	47	21	133	217	91	727
22	85	42	28	33	17	98	170	61	534
23	65	40	10	25	15	74	141	49	419
24	48	29	-	25	14	65	100	37	318

TABLE 4.4 - CNPS Major Industrial, Irrigation, Water Supply and Hotel Loads Planned

(Source: Data supplied by Industrial Service Center, Ministry of Industries, Nepal Electricity Corporation and World Bank: Electrowatt's Report table 5.1)

1976	Cement Factory	1,620 kW
	British Gurka Transit Camp	250 "
	Geti Bakery	300 "
	Krishna Loaf	500 "
	Trolley Bus Project	900 "
	Biscuit Factory	640 "
	Glass Plant (Hetauda)	75 "
	Flour Mill (")	300 "
1977	Dairy Extension	150 "
	Agricultural Lime (Hetauda)	160 "
1978	Mill (Hetauda)	80 "
	Cotton Textiles (")	750 "
	Plywood Industry (")	500 "
	Vegetable Ghee Industry (")	800 "
	Brick Industry Bhaktapur	350 "
	Leather Factory (Hetauda)	80 "
	Water Supply (Pharping, Kurtipur, Airport Boreholes, Miscellaneous)	1,670 "
1979	Utensil Industry	67 "
	Slate Factory	100 "
	Small Industry	45 "
	Marida Mill (Balaju)	80 "
	Cement Factory (Narayani)	1,125 "
1980	Cement Factory (Narayani)	1,125 "
	Chitwan Valley (ground water irrigation)	5,000 "
	Rautahat (ground water irrigation)	500 "
	Bara/Parsa (ground water irrigation)	1,500 kW

1982	Water Supply (Lalitpur, Bhartapur, Borehole)	895 kW
1985	Fused Magnesium Phosphate (Hetauda)	3,000 "
	Refractory Brick Plant (Birganj)	420 "
	Rolling Mill (Hetauda)	450 "
	Iron Works (")	1,800 "
	Magnesite (Kharidhunga/Lamosangu)	1,830 "
Total		27,062 kW

Hotel

1976	Tourist Village Bandha	180 kW
	Hotel Malla (Thamel)	375 "
	Hotel Yellow Pagoda	113 "
	Hotel Shanker	113 "
	Hotel Narayani	115 "
	Hotel Manaslu	140 "
1977	Hotel Kathmandu	500 "
	Hotel Annapurna (extension)	800 "
	Hotel Tripura	300 "
1978	Hotel Everest International	500 "
	Hotel Yak and Yeti	800 "
	Hotel Soaltee Oberoi (extension)	300 "
1979	Hotel Soaltee Oberoi (")	300 "
Total		4,536 kW

TABLE 4.5 DEMAND FORECAST OF KATHMANDU VALLEY

Year	Energy Consumption (MWh)						Energy Loss Factor (%)	Energy Supply (MWh)	Ann. load Factor (%)	Peak Load (kW)
	Domestic	Industrial	Commercial	Street Lights	Others	Total				
1976/77	49,830	19,350	8,590	930	7,870	86,570	30	123,670	45	31,370
77/78	55,130	23,220	9,710	1,060	8,900	98,020	30	140,030	45	35,520
78/79	59,520	27,860	10,970	1,180	9,000	108,530	30	155,040	46	38,480
79/80	64,310	33,440	15,390	1,360	10,300	124,800	30	178,290	47	43,300
80/81	69,430	39,460	17,400	1,520	10,860	138,670	30	198,100	48	47,110
81/82	76,330	46,160	19,660	1,710	11,510	155,370	28	215,790	49	50,270
82/83	89,300	53,550	22,210	1,980	12,530	179,570	25	239,430	50	54,660
83/84	104,360	61,580	25,100	2,290	13,530	206,860	22	265,210	51	59,360
84/85	121,850	70,820	28,360	2,650	15,660	239,340	19	295,480	52	64,870
85/86	142,020	81,440	31,770	3,060	16,790	275,080	16	327,480	53	70,540
86/87	163,010	93,660	35,260	3,500	17,730	313,160	15	368,420	53	79,350
87/88	184,980	107,700	38,790	3,980	18,450	353,900	15	416,350	53	89,680
88/89	207,660	123,860	42,670	4,490	20,800	399,480	15	469,980	53	101,230
89/90	230,720	142,440	46,930	5,040	21,260	446,390	15	525,160	53	113,110
90/91	254,890	163,800	51,630	5,640	23,800	499,760	15	587,950	53	126,640

TABLE 4.6 PEAK DEMAND FORECAST OF EACH SUBSTATION IN THE KATHMANDU VALLEY

(kW)

Station	YEAR														
	76/77	77/78	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91
1. K-2	9,700	11,010	11,650	13,010	13,800	14,130	15,560	16,860	18,490	19,130	21,270	23,690	26,370	29,210	32,280
2. TEKU	7,190	8,220	9,080	10,590	11,630	12,040	13,090	14,190	15,550	17,250	19,420	21,910	24,700	27,700	31,000
3. PATAN	3,710	4,010	4,310	4,800	5,170	6,030	6,550	7,110	7,790	8,640	9,970	11,550	13,352	15,280	17,520
4. BALAJU	3,010	3,540	3,820	4,110	4,630	4,810	5,230	5,670	6,210	6,890	7,780	8,820	9,980	11,140	12,480
5. MAHARAJGUNJ	1,980	2,270	2,480	2,790	3,020	3,140	3,410	3,990	4,370	4,980	5,730	6,650	7,690	8,740	9,990
6. CHABEL	3,320	3,850	4,220	4,750	5,140	5,480	5,950	6,450	7,070	7,850	8,890	10,120	11,500	12,910	14,530
7. BHAKTAPUR	1,040	1,140	1,210	1,350	1,460	1,510	1,640	1,780	1,950	2,170	2,450	2,830	3,230	3,540	3,970
8. THIMI	620	680	720	800	860	900	980	1,060	1,160	1,290	1,460	1,710	1,970	2,130	2,380
9. TRISURI	300	300	400	500	600	980	990	990	1,010	1,030	1,050	1,060	1,080	1,090	1,100
10. SUNKOSI	200	200	200	200	400	400	400	400	400	410	420	420	430	430	430
11. PANAUTI	300	300	400	400	400	850	860	960	870	900	910	920	930	940	960
Total	31,370	35,520	38,480	43,300	47,110	50,270	54,660	59,360	64,870	70,540	79,350	89,680	101,230	113,110	126,640

FIG. 4.1 MONTHLY ENERGY PRODUCTION (CNPS)

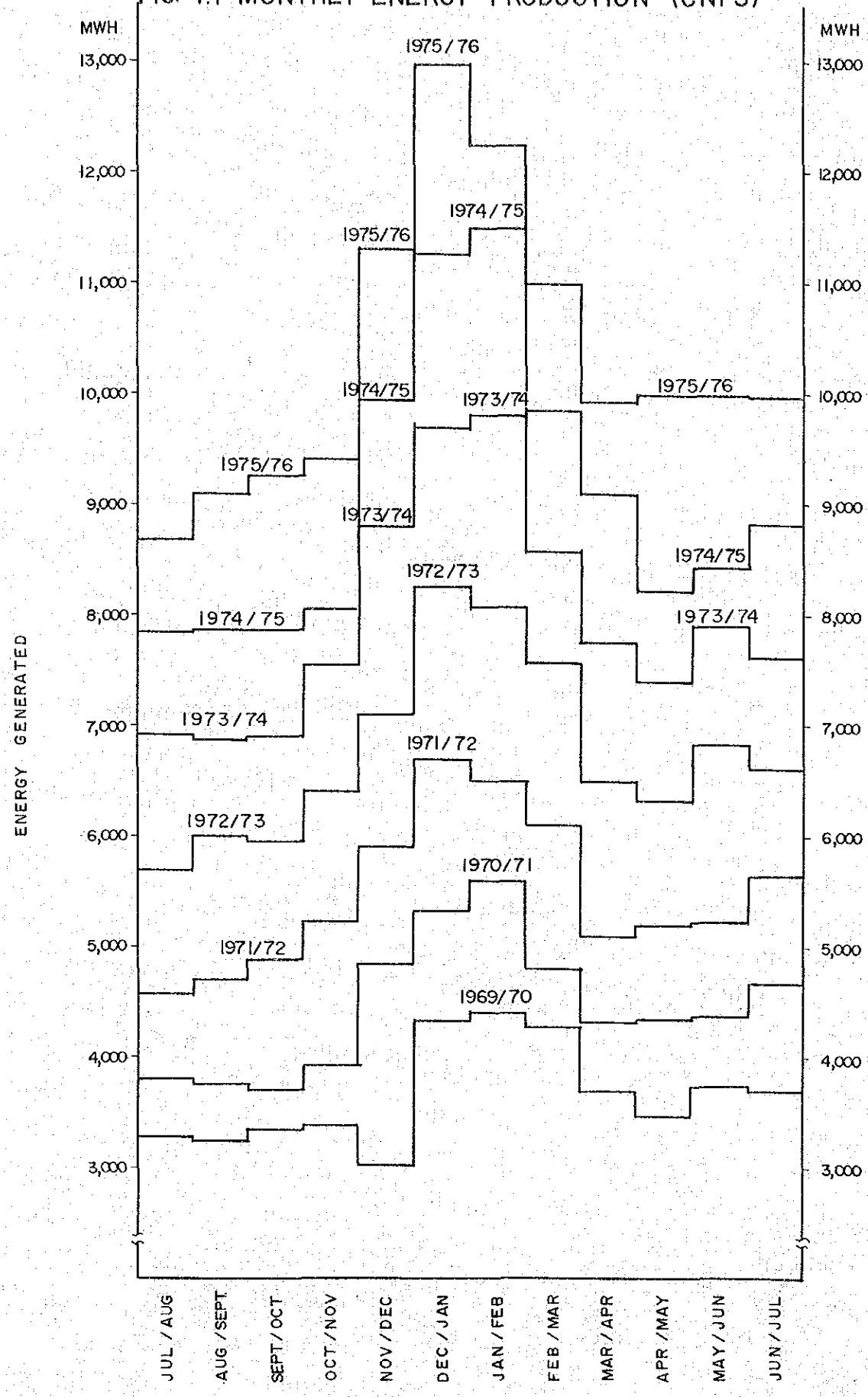
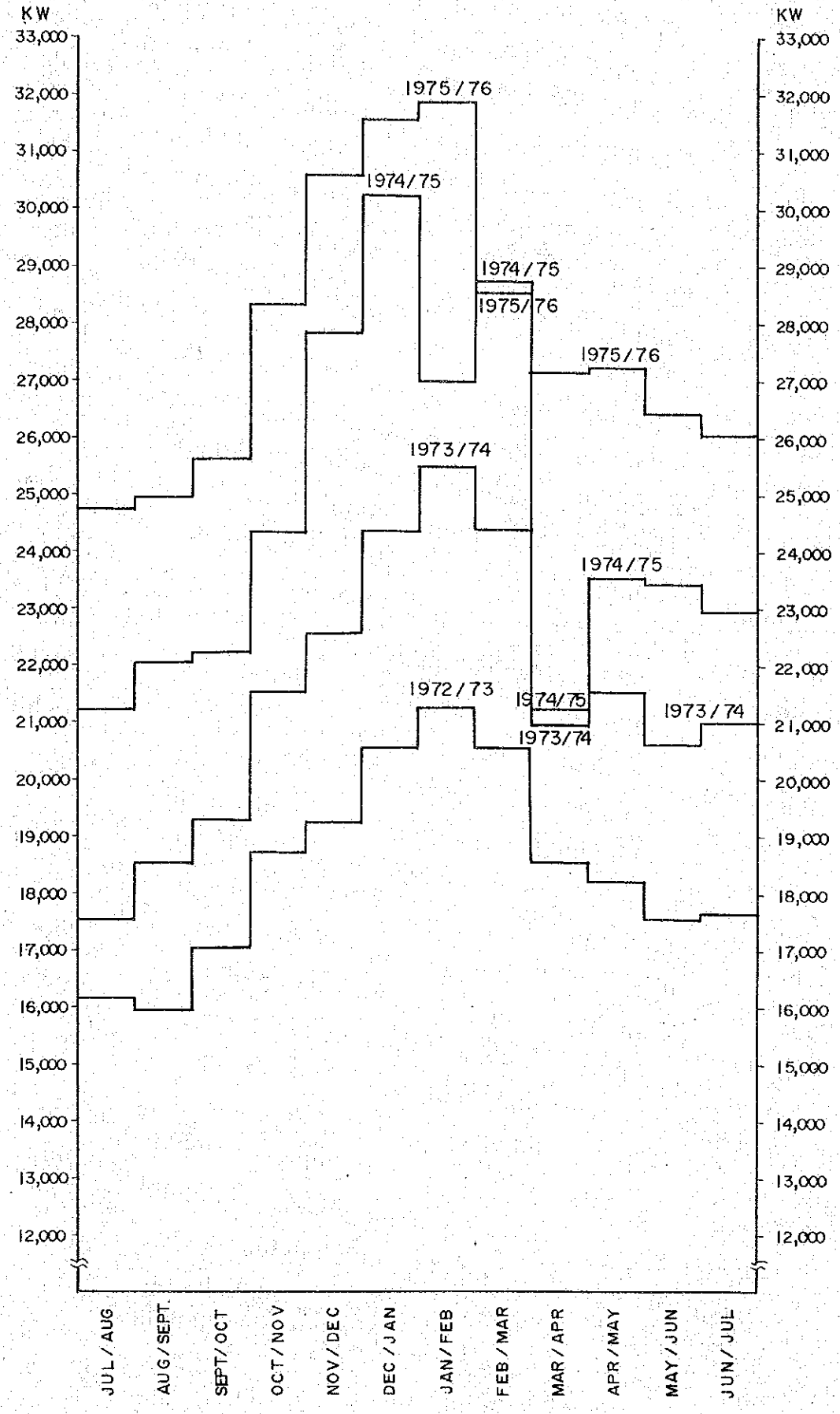


FIG. 4.2 MONTHLY PEAKDEMAND (CNPS)



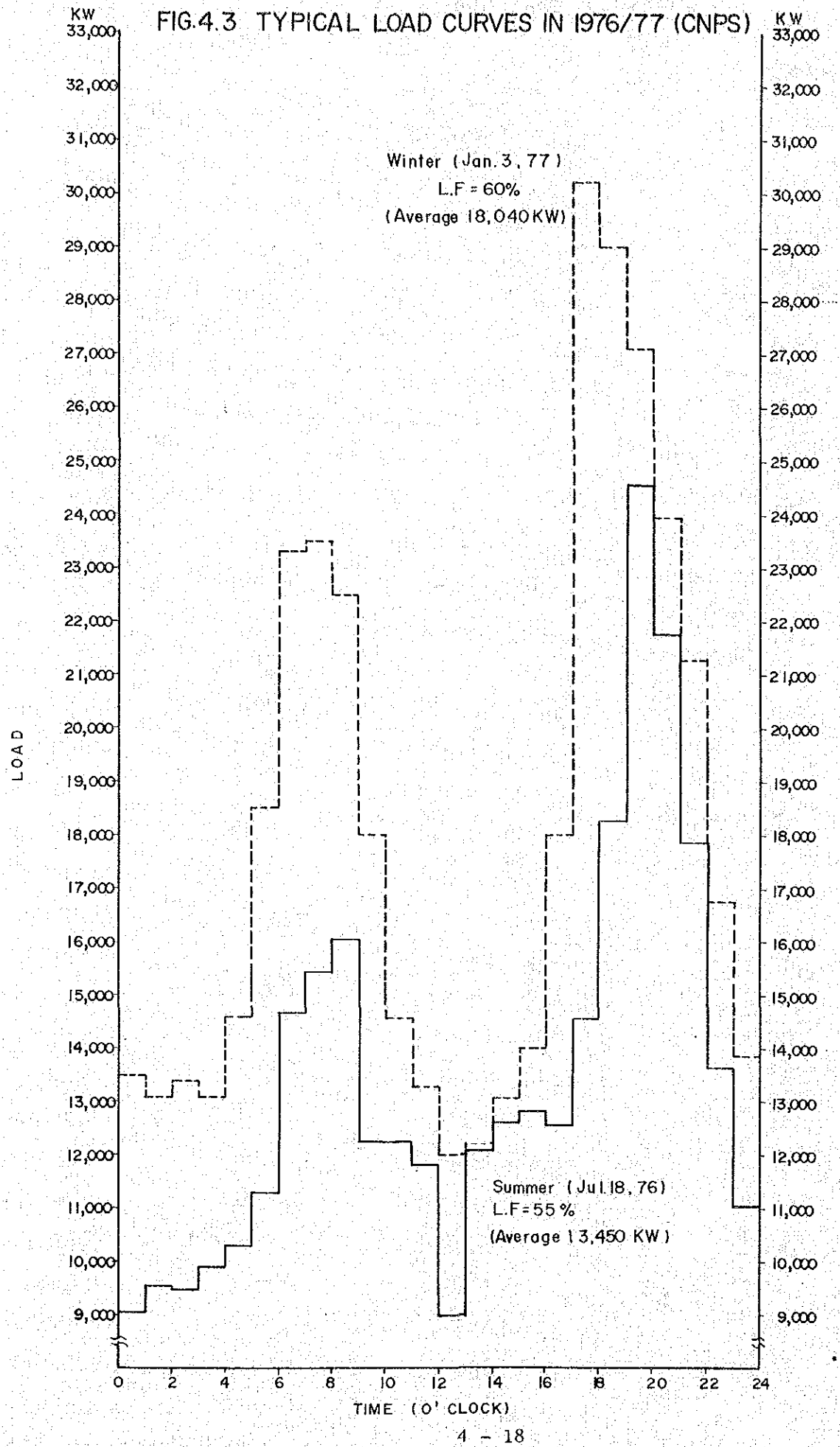


FIG.4.3 TYPICAL LOAD CURVES IN 1976/77 (CNPS)
KW
33,000
32,000
31,000
30,000
29,000
28,000
27,000
26,000
25,000
24,000
23,000
22,000
21,000
20,000
19,000
18,000
17,000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9,000
LOAD
Winter (Jan. 3, 77)
L.F = 60%
(Average 18,040 KW)
Summer (Jul 18, 76)
L.F = 55 %
(Average 13,450 KW)
0
2
4
6
8
10
12
14
16
18
20
22
24
TIME (O' CLOCK)

FIG. 4.4 VOLTAGE VARIATION (WINTER) AT 11 KV BUS

JAN. 2, 1977

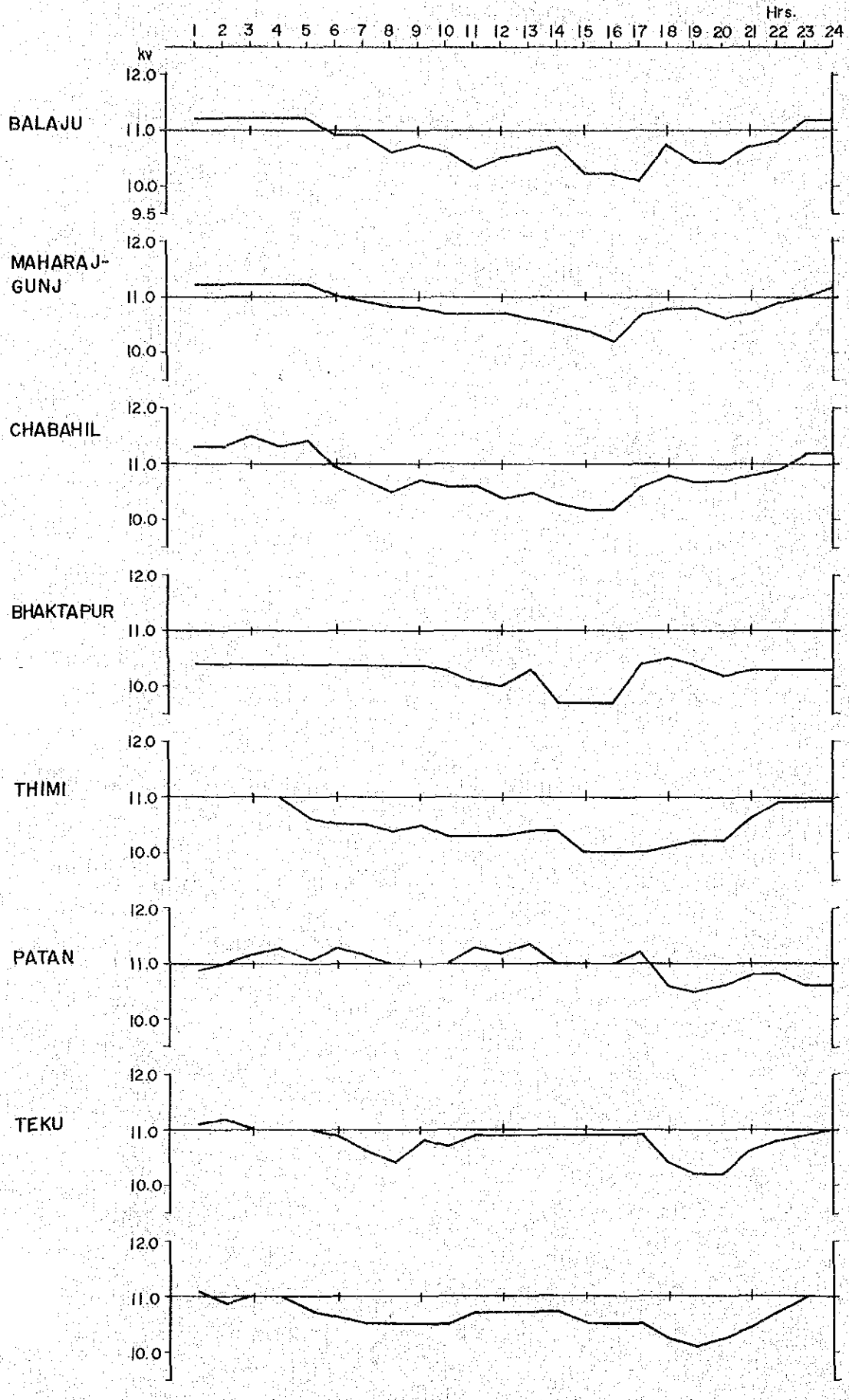


FIG. 4.5 VOLTAGE VARIATION (SUMMER) AT 11KV BUS

JUL. 20, 1976

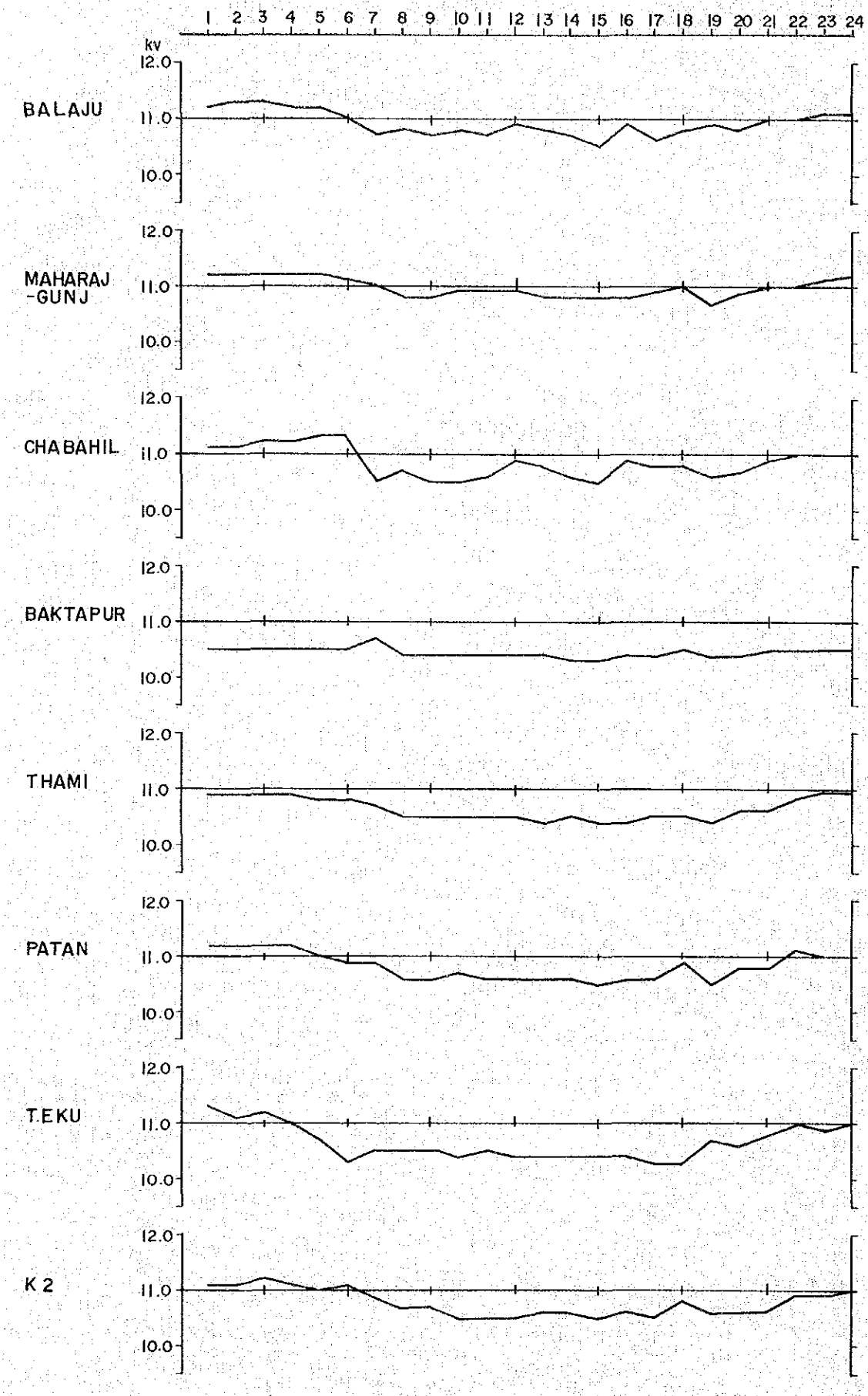


FIG. 4.6 TOTAL LOAD OF S/S ON RING LINE

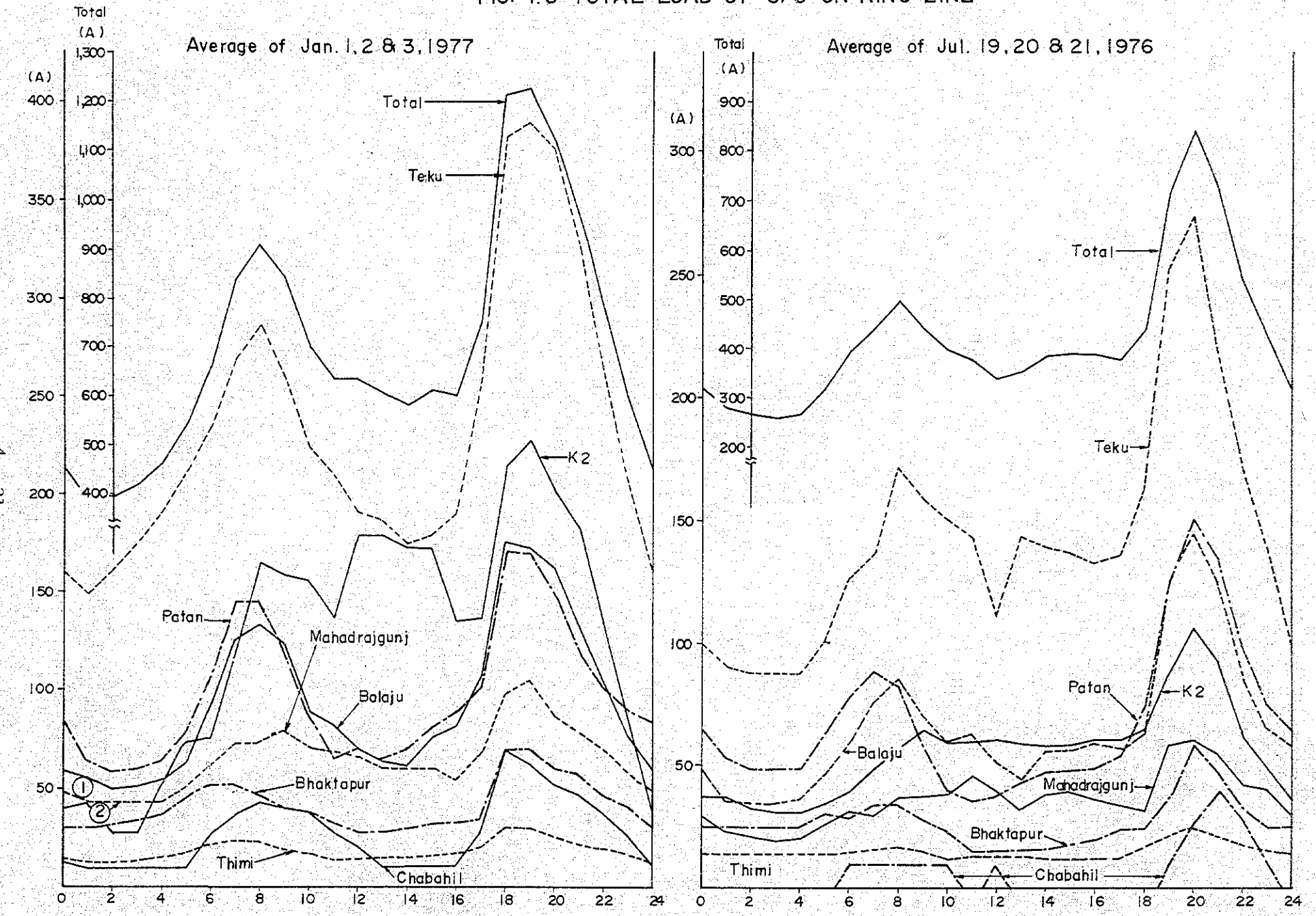


FIG. 4.7 LOAD OF BALAJU S/S

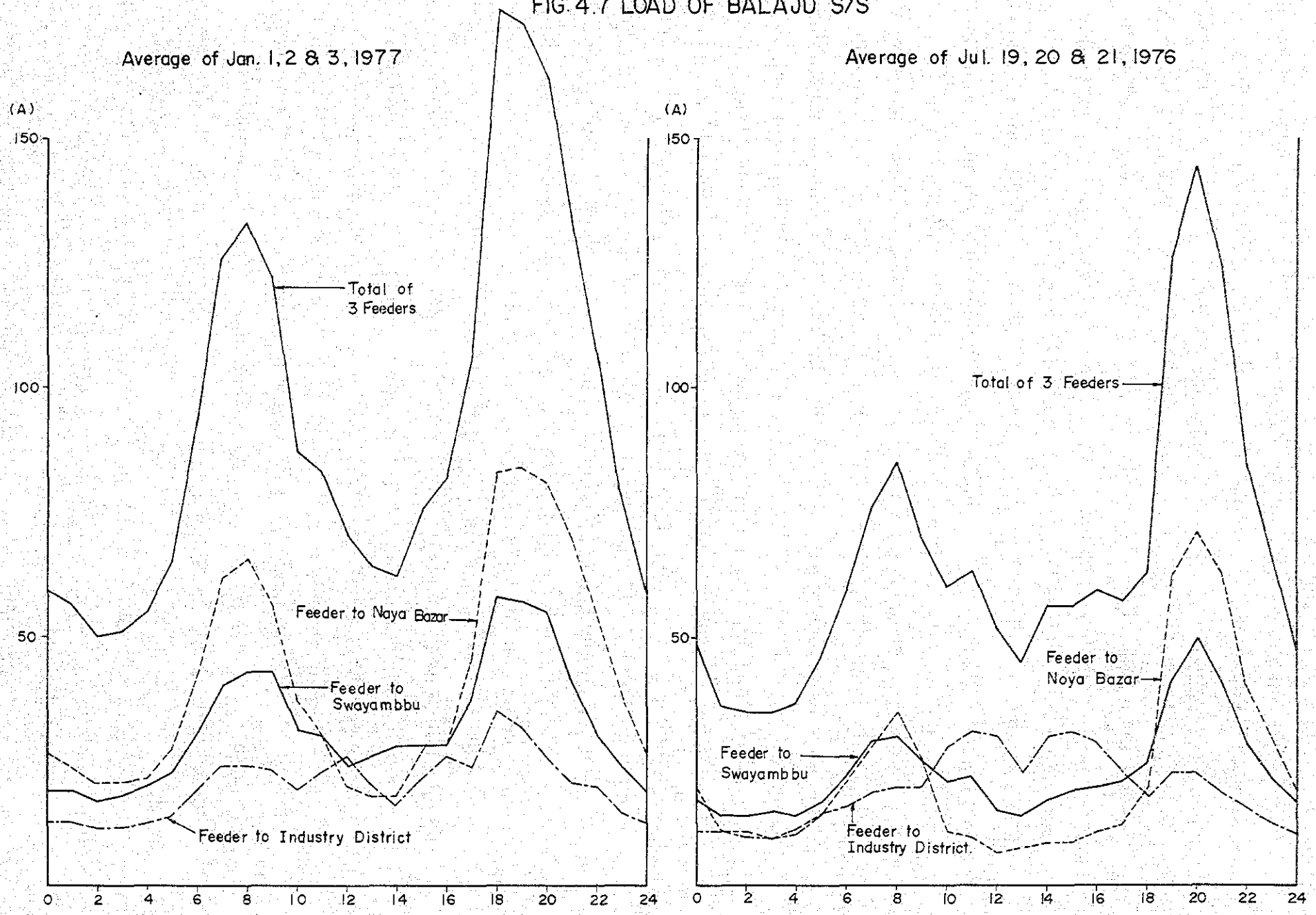


FIG. 4.8 LOAD OF MAHARAJGUNJ S/S

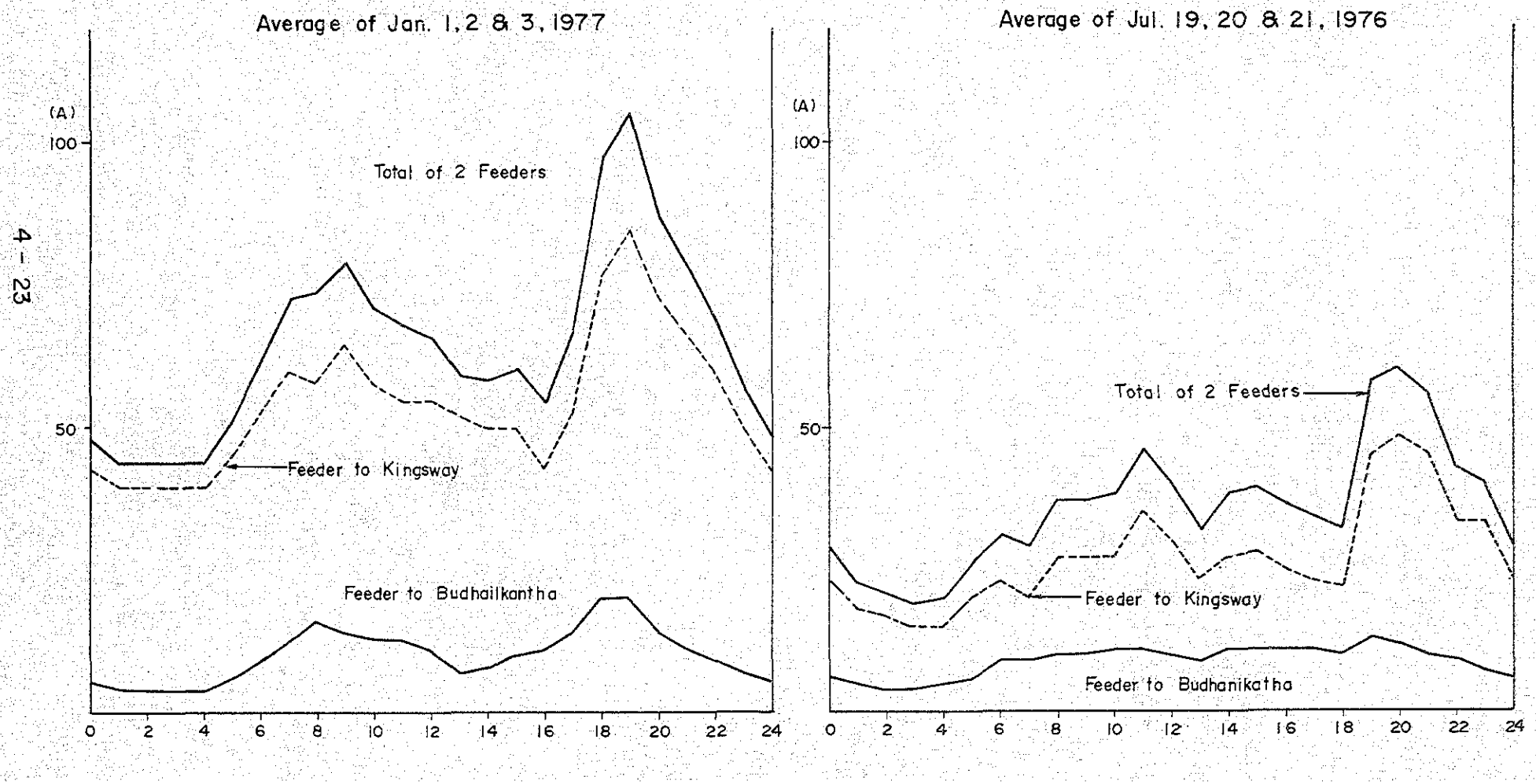


FIG. 4.9 LOAD OF CHABAHIL S/S