Collective groups are allowed to charge electricity within the range from 180 Riel/kWh to 220 Riel/kWh. However, there are many collective groups that charge electricity at a rate at a greater than the allowed range. Some of them were found to have charged as much as 350 Riel/kWh. Moreover, EDP does not know the exact number of consumers who receive electricity from respective collective groups. In order to control illegal operation and to promote appropriate operation of collective groups, EDP is planning to form an evaluation committee which will evaluate the operation and management condition of respective collective groups with regard to the following six items:

(a) Whether an appropriate amount of bond is paid or not;

(b) Whether electricity charge is paid, without delays, twice a month;

(c) Whether feeder lines are installed appropriately in accordance with guidelines;

(d) Whether watt-hour meters are installed and maintained in a box fixed to a high place on an electric pole or in a hut;

(e) Whether electricity is charged within the allowed range; and

(f) Whether theft is prevented by employing a night guard.

5.5.3 Installation Situations of Watt-hour Meters

Previously, government and municipality organizations unofficially consumed a considerable portion of electricity generated by EDP. Consequently, the unofficial consumption of electricity was one of the major causes of the very low ratio of sold energy, which is the source of EDP's revenue, to the total electricity production. EDP recently took various countermeasures in order to control the unofficial electricity consumption. Consequently, all government and municipality organizations have installed watt-hour meters. Watt-hour meters are also installed for all other consumers.

Consumers have to purchase their own watt-hour meters. The purchased watt-hour meters are brought to the Meter Office of EDP, inspected, and sealed. As far as the Study Team observed, the watt-hour meters collectively installed in a hut by a collective group

were all sealed. However, a problem observed is that some seals were partially peeled off because the seals were pasted.

Table I.5.1 No. 1 Power Station

(Jan. 1993)

Unit No.	Manufacturer		Type	Year Inst.	Capacity (kW)		Gen. Voltage(V)	rpm	Remarks
	Name	Country			Rated	Available			
1	Sulzer Gramme	France	ST - 36	1926	550	350	4,400	250	
2	Sulzer Alsthom	France	GT - 48	1948	1,380	700	4,400	250	
3	Worthington G E	USA	SW6-1416	1958	3,000	-	4,400	428	Out of order from 1987
4	Worthington G E	USA	SW6-1416	1960	2,860	1,500	4,400	428	
5	Sulzer Oerlikon	France	4Z - 200	1929	1,100	-	4,400	250	Out of order from 1979
6	Sulzer Gramme	France	ST - 48	1937	1,150	600	4,400	250	
7	Worthington G E	USA	SW6-1416	1960	2,860	-	4,400	428	Out of order a/
8	Sulzer Oerlikon	France	10TPF- 48	1955	2,240	-	4,400	250	Out of order from 1987
9	Sulzer Oerlikon	France	10TPF- 48	1957	2,240	-	4,400	250	Out of order from 1992
10	Worthington G E	USA	SW6-1416	1962	3,000	-	4,400	428	Out of order from 1992
11	Sulzer Oerlikon	France	10TPF- 48	1966	3,120	1,500	6,300	250	
	TOTAL				23,500	4,650			

Note: a/ date unknown

Table I.5.2 No. 2 Power Station

(Jan. 1993)

Unit No.	Manufacturer		Type	Year Inst.	Capacity (kW)		Gen. Voltage(V)	rpm	Remarks
	Name	Country			Rated	Available			
Steam									
1	B: CKD-DUKLA T: PRVNI BRNESKA G: SKODA PLZEN	Czecho Czecho Czecho	BRNC-BEZ	1967	6,000	5,000	6,300	3,000	
2	G: SKODA PLZEN	Czecho	BRNC-BEZ	1967	6,000	5,000	6,300	3,000	
3	G: SKODA PLZEN	Czecho	BRNC-BEZ	1967	6,000		6,300	3,000	Under repairing from Nov. 1992 to May 1993
	Sub-Total				18,000	10,000			
Diesel									
1	GM	USA	20-645-B4	1973	2,100	1,500	4,160	750	
2	GM	USA	20-645-B4	1973	2,100	1,500	4,160	750	
3	GM	USA	20-645-B4	1973	2,100	-	4,160	750	Out of order since 1984
4	GM	USA	20-645-B4	1973	2,100	-	4,160	750	Under maintenance from Dec. 1992 to Feb. 1993
5	GM	USA	20-645-B4	1973	(2,100)	-	4,160	750	Out of order since 1979
	Sub-Total				10,400	3,000			
	TOTAL				28,400	13,000			

Table I.5.3 No. 3 Power Station

(Jan. 1993)

Unit No.	Manufacturer		Type	Year Inst.	Capacity (kW)		Gen. Voltage(V)	rpm	Remarks
	Name	Country			Rated	Available			
1	GM	USA	20-645-B4	1973	2,100	-	4,160	750	Out of order since 1991
2	GM	USA	20-645-B4	1973	2,100	-	4,160	750	Out of order since 1992
3	GM	USA	20-645-B4	1973	2,100	1,500	4,160	750	Operating at night only
	TOTAL				6,300	1,500			

Table I.5.4 No. 4 Power Station

(Jan. 1993)

Unit No.	Manufacturer		Type	Year Inst.	Capacity (kW)		Gen. Voltage(V)	rpm	Remarks
	Name	Country			Rated	Available			
1	Russky Diesel	USSR	DG-4000-G5	1984	3,000	2,600	6,300	1,000	
2	Russky Diesel	USSR	DG-4000-G5	1984	3,000	-	6,300	1,000	Out of order since 1990
3	Russky Diesel	USSR	DG-4000-G5	1984	3,000	-	6,300	1,000	Out of order since 1992
4	Russky Diesel	USSR	PG-4000-G7	1986	3,000	-	6,300	1,000	Out of order since 1992
5	Russky Diesel	USSR	PG-4000-G7	1986	3,000	2,600	6,300	1,000	
	TOTAL				15,000	5,200			
	Grand Total				73,300	24,350			
System	Diesel Engine Generator				55,300	14,350			
	Steam Turbine Generator				18,000	10,000			

Table I.5.5
EDP Income Statement

Million Riel

Item		1989	1990	1991	1992 (Jan. - Jun.)
Generation (million kWh)		200.1	182.7	113.7	65.9
Sales (million kWh)		102.0	100.9	46.3	42.4
Sales/generation ratio (%)		51	55	41	64
Average rate (Riel per kWh)	1)	4.0	11.3	126.0	171.8
Gross revenue from sales	2)	406.7	1,139.6	5,833.3	7,284.2
Other income		28.1	40.4	121.6	136.0
Total		434.8	1,180.0	5,954.9	7,420.2
Operating expenses	3)	723.9	1,541.0	6,376.3	4,795.0
1) Fuel		553.0	1,211.1	5,322.0	3,921.0
2) Repair & maintenance		77.8	109.3	342.1	171.1
3) Salaries & wages		7.7	24.0	45.9	48.3
4) Administration		55.3	99.5	358.0	343.4
5) Others		30.1	97.1	308.3	311.2
Operating Income		▲ 289.1	▲ 361.0	▲ 421.4	2,625.2
Amortization		34.2	33.9	183.8	92.0
Interest payment	4)	38.0	27.8	68.9	14.0
Government subsidies	5)	315.7	403.1	419.3	-
Net income		▲ 45.6	▲ 19.6	▲ 254.8	2,519.2
Internally generated cash		▲ 11.4	14.3	▲ 71.0	2,611.2

1) The power rate was raised from 37.0 Riels/kWh to 170 Riels /kWh on Aug. 1, 1991.

2) Sales revenue to be collected. The actually collected revenues were Riel 1,154.9 million (collection ratio = 20%) in 1991 and Riel 3,146.4 million (43%) in Jan. - Jun. 1992.

3) EDP is in debt to many fuel suppliers, etc. The accounts payable amounted to R. 5,958 million at the end of 1991, and R. 5,761 million at the end of June 1992.

4) Interest was paid to the Municipality Bank at the monthly interest rates of 1.0% until May 1991 and 2.4% since June 1991. The interest payments to the External Trade Bank started in July 1992 and is not included here.

5) Actual payment of the government subsidies was deferred. Actual disbursement of the subsidies for three years (1989-91)was:
Riel 225 million in 1989
Riel 913.1 million in 1992

Source : EDP Audit Reports (1989, 1990, and 1991), etc.

Table I.5.6 Inflation Rate and Deflators

Item	1989	1990	1991	1992 (Jan. - Jun.)
Annual Inflation Rate (%)	70.00%	157.00%	121.00%	200.00%
Commodity Price Increase (1989=100)	100	257	568	1,704
Deflators (1989=1)	1.00	2.57	5.68	17.04

Table I.5.7 Average Electricity Rate

Item	1989	1990	1991	1992 (Jan. - Jun.)
Average Electricity Rate (Riel/kWh)	4.00	11.30	126.00	171.80
Deflated Rate (Riel/kWh)	4.00	4.40	22.18	10.08

Table I.5.8 Average Generation Cost

Item	1989	1990	1991	1992 (Jan. - Jun.)
Total Generation (Million kWh)	200.10	182.70	113.70	65.90
Total Operation Expenses (Million Riel)	723.90	1541.00	6376.30	4795.00
Average Generation Cost (Riel/kWh)	3.62	8.43	56.08	72.76
Deflated Cost (Riel/kWh)	3.62	3.28	9.87	4.27

Table I.5.9 Average Sales Cost

Item	1989	1990	1991	1992 (Jan. - Jun.)
Total Sales (Million kWh)	102.00	100.90	46.30	42.40
Total Operation Expenses (Million Riel)	723.90	1541.00	6376.30	4795.00
Average Sales Cost (Riel/kWh)	7.10	15.27	137.72	113.09
Deflated Cost (Riel/kWh)	7.10	5.94	24.25	6.64

Table I.5.10
Balance Sheet

Million Riel

Item		1989	1990	1991	June 92
Assets					
1. Fixed assets 1)	A	835.5	862.0		
	B			2,495.0	2,517.9
2. Total amortization 1)	A	473.0	507.8		
	B			1,664.9	1,754.4
3. Net fixed assets 1)	A	362.5	354.2		
	B			830.1	763.5
4. Unfinished works (A&B) (C-5 station)		126.1	179.8	378.3	419.4
5. Working capital (A&B)		473.1	507.8	157.7	160.7
Total assets (3+4+5)	A	961.7	1,041.8		
	B			1,366.1	1,343.6
Liabilities					
1. Capital & Surplus (A&B) (Gov't capital contribution)		586.3	670.1	736.8	542.4
2. Bank Loans (A&B) 2)					
- Loan beginning of year (a)		227.4	181.6	371.7	629.3
- Borrowing during year (b)		1,059.1	790.3	1,118.3	406.3
- Repayment during year (c)		1,104.9	600.2	860.7	234.4
- Loan end of year (a+b-c)		181.6	371.7	629.3	801.2
3. Other (current liabilities)		193.8	-	-	-
Total liabilities	A	961.7	1,041.8		
	B			1,366.1	1,343.6

A: Assets being valued at cost (book value)

B: Assets being revalued in 1991 by Ministry of Finance Decree.

1) Pursuant to the Decree of Ministry of Finance (issued March 1990) EDP revised fixed assets and total amortization about 3 times in 1991 to reflect price increases and changes in exchange rate.

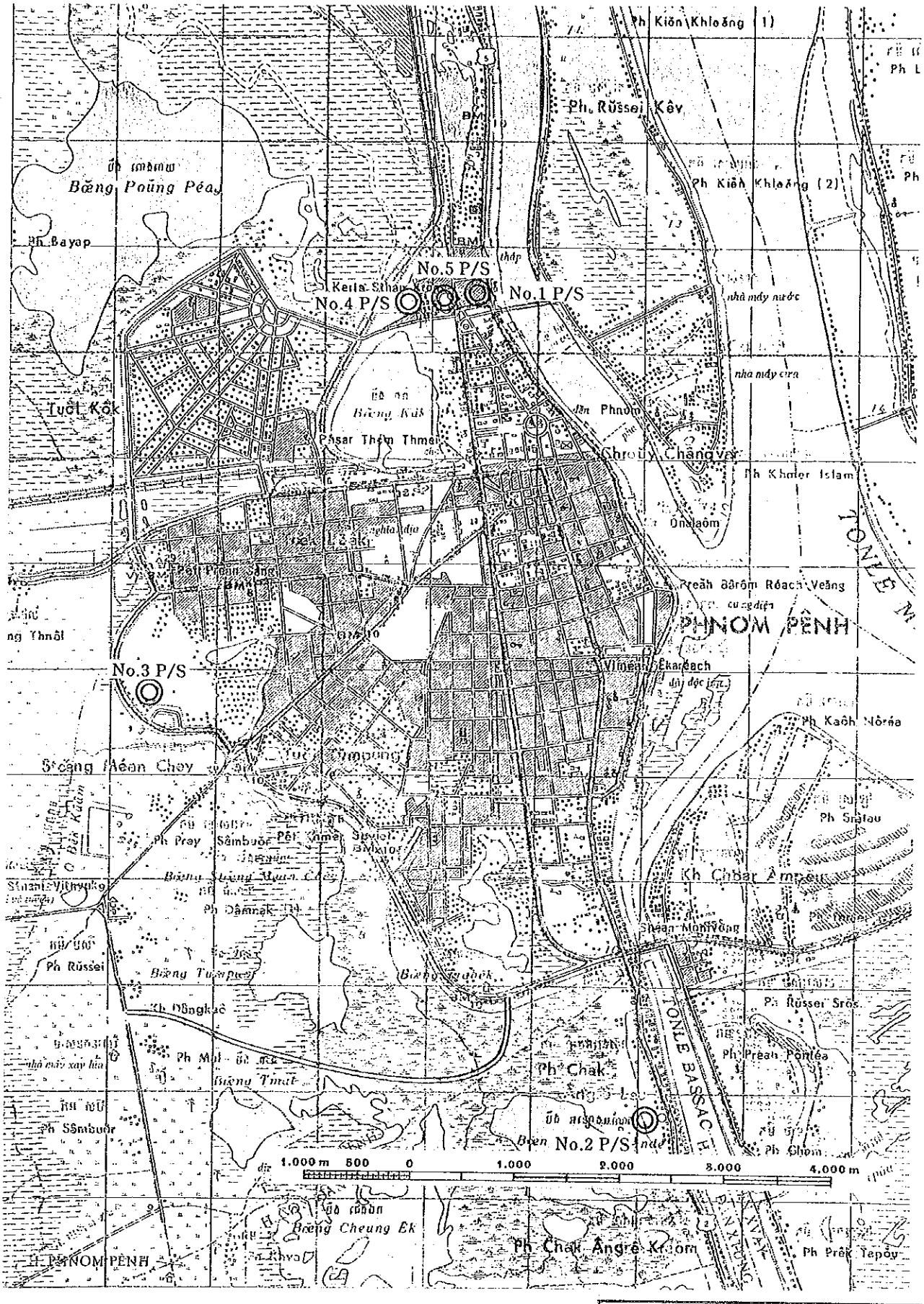
2) Bank loans from the Municipality Bank and External Trade Bank.
The loan balances at the end of June 1992 were:
R.173.8 million for the Municipality Bank
R.627.4 million ($967,600) for the External Trade Bank

Source : EDP Accounting & Finance Bureau

Table I.5.11 Comparison of Diesel Fuel Use between Japan and Cambodia

Unit:litter/kWh

	1965	1970	1975	1980	1985	1986	1987	1988	1989	1990	1991	1992
Japan	0.28931	0.29510	0.27349	0.27453	0.27011		0.26806	0.26789	0.27040	0.26788	0.26921	
Cambodia					0.30984	0.32593	0.32947	0.32815	0.32978	0.32870	0.32710	0.33377



TITLE

Figure I.5.1
MAP OF PROJECT AREA
PHNOM PENH

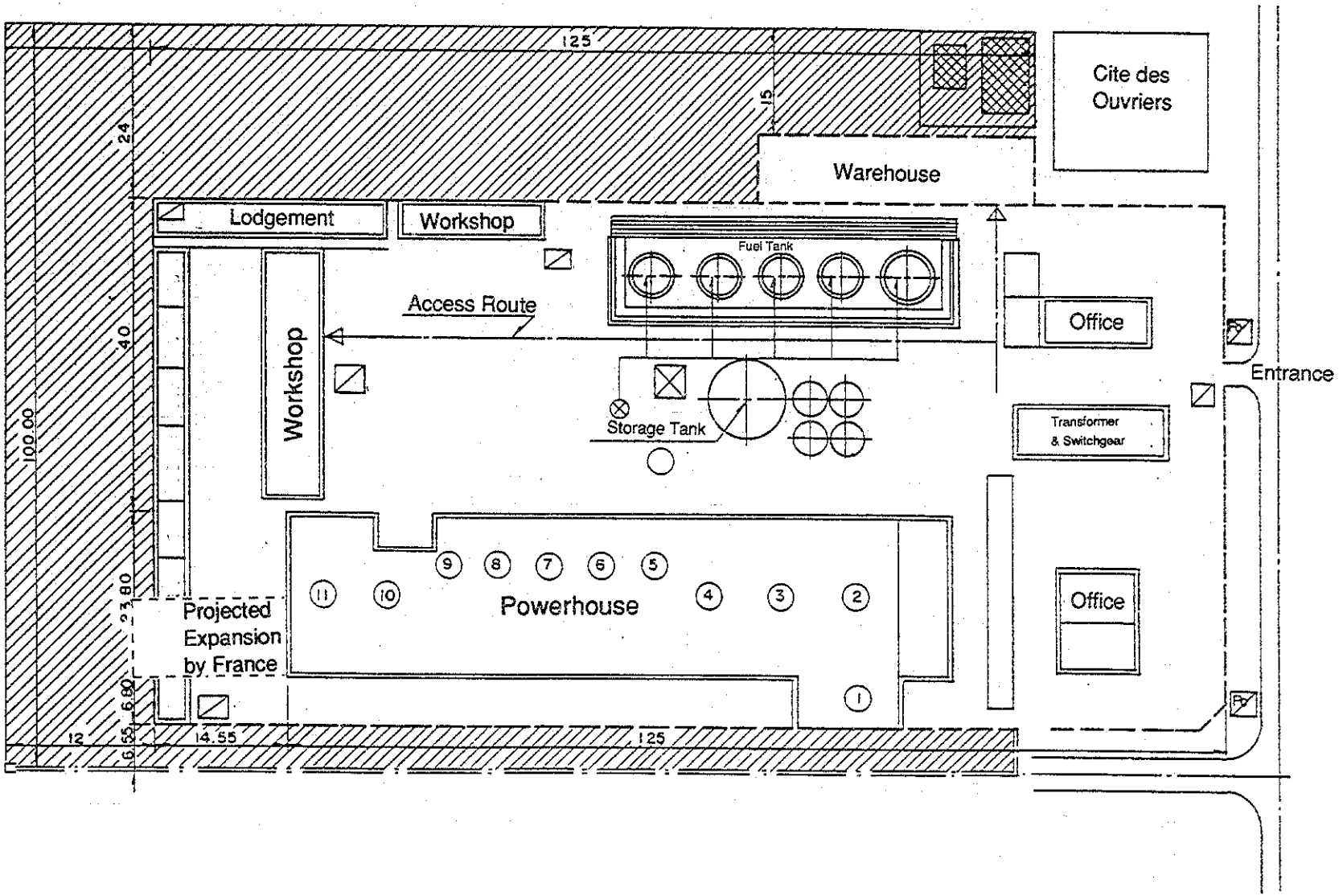


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Figure I.5.2
No.1 POWER STATION

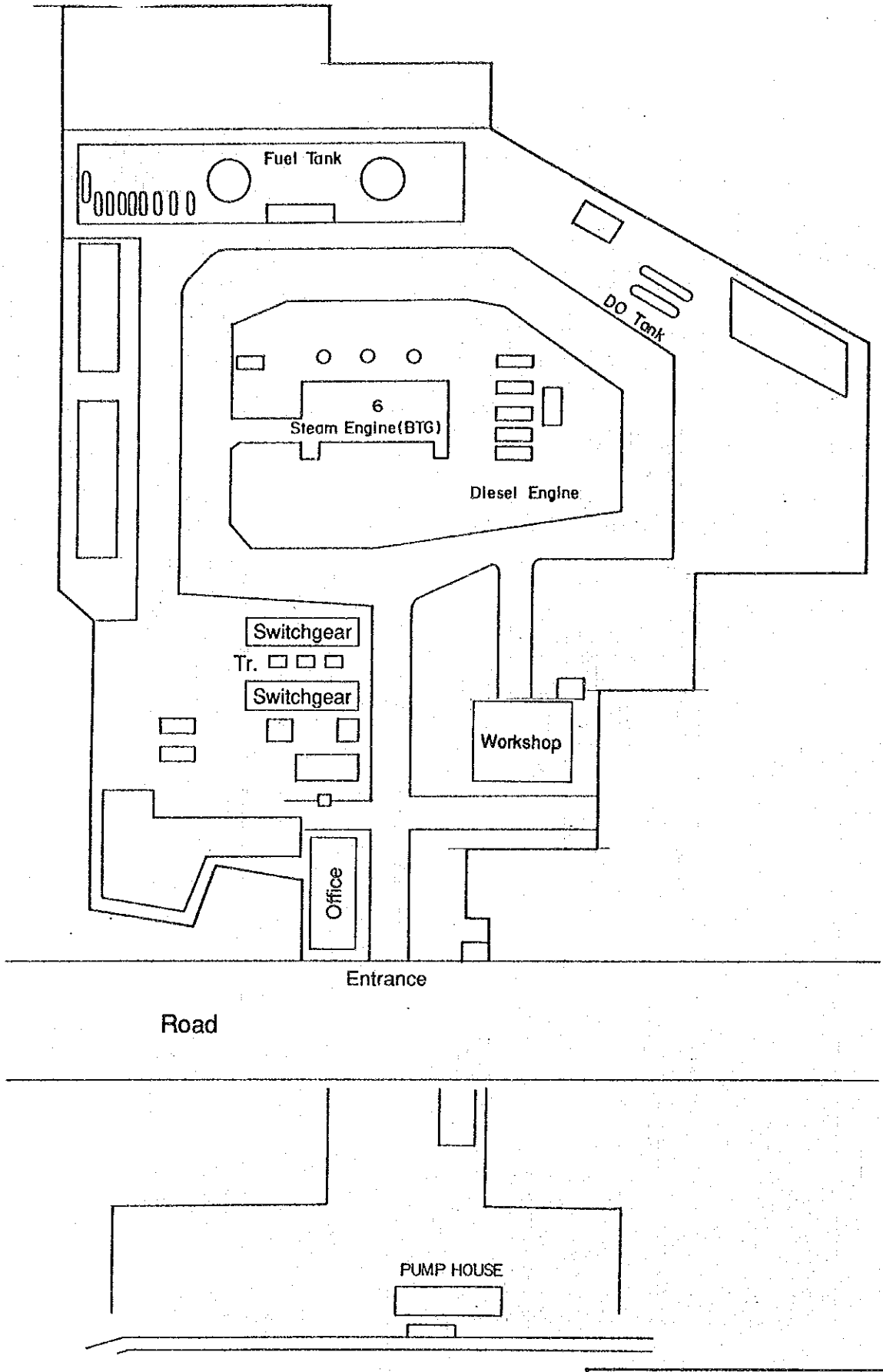

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Figure I.5.3
No.2 POWER STATION

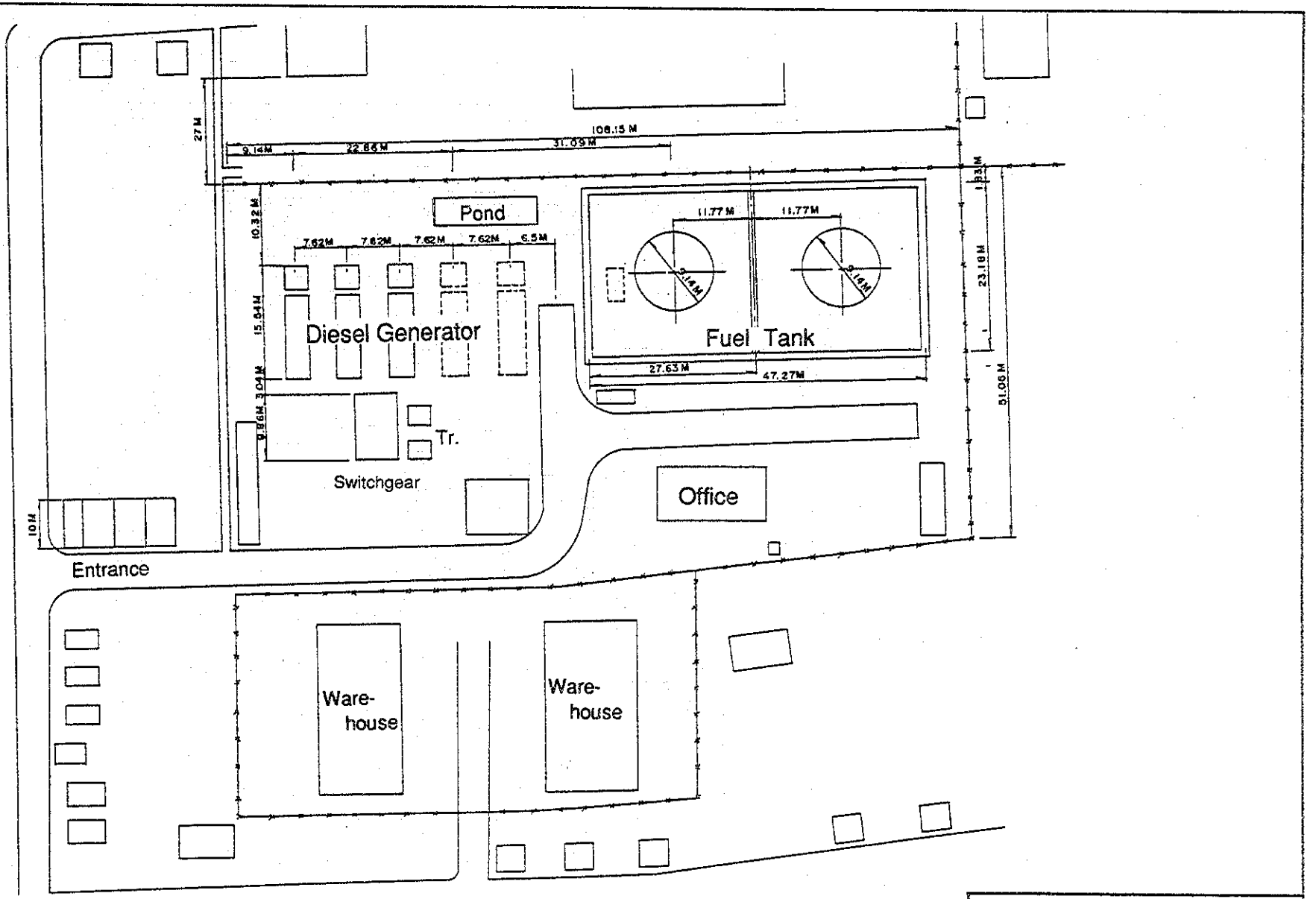

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Figure I.5.4
No.3 POWER STATION

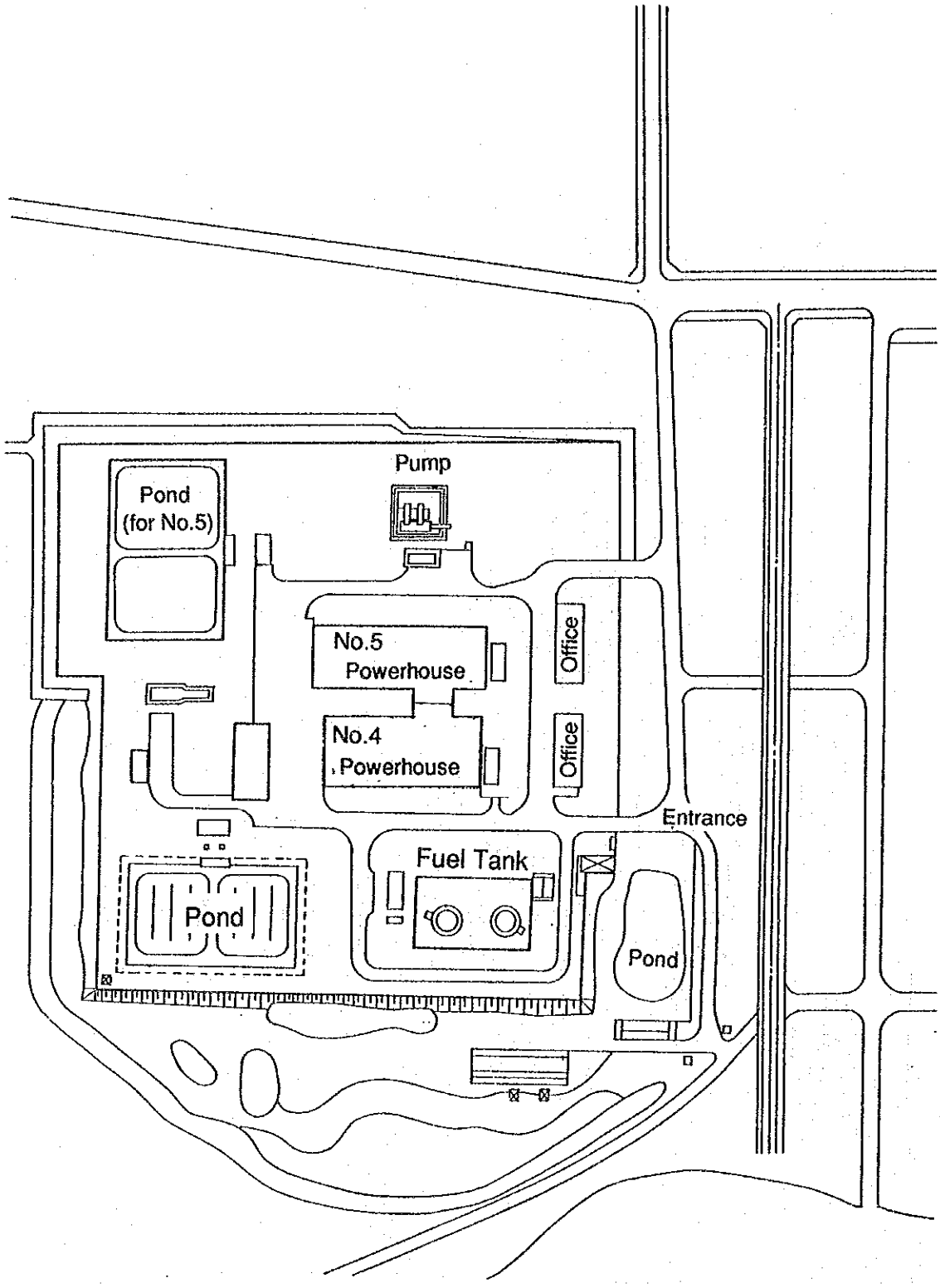

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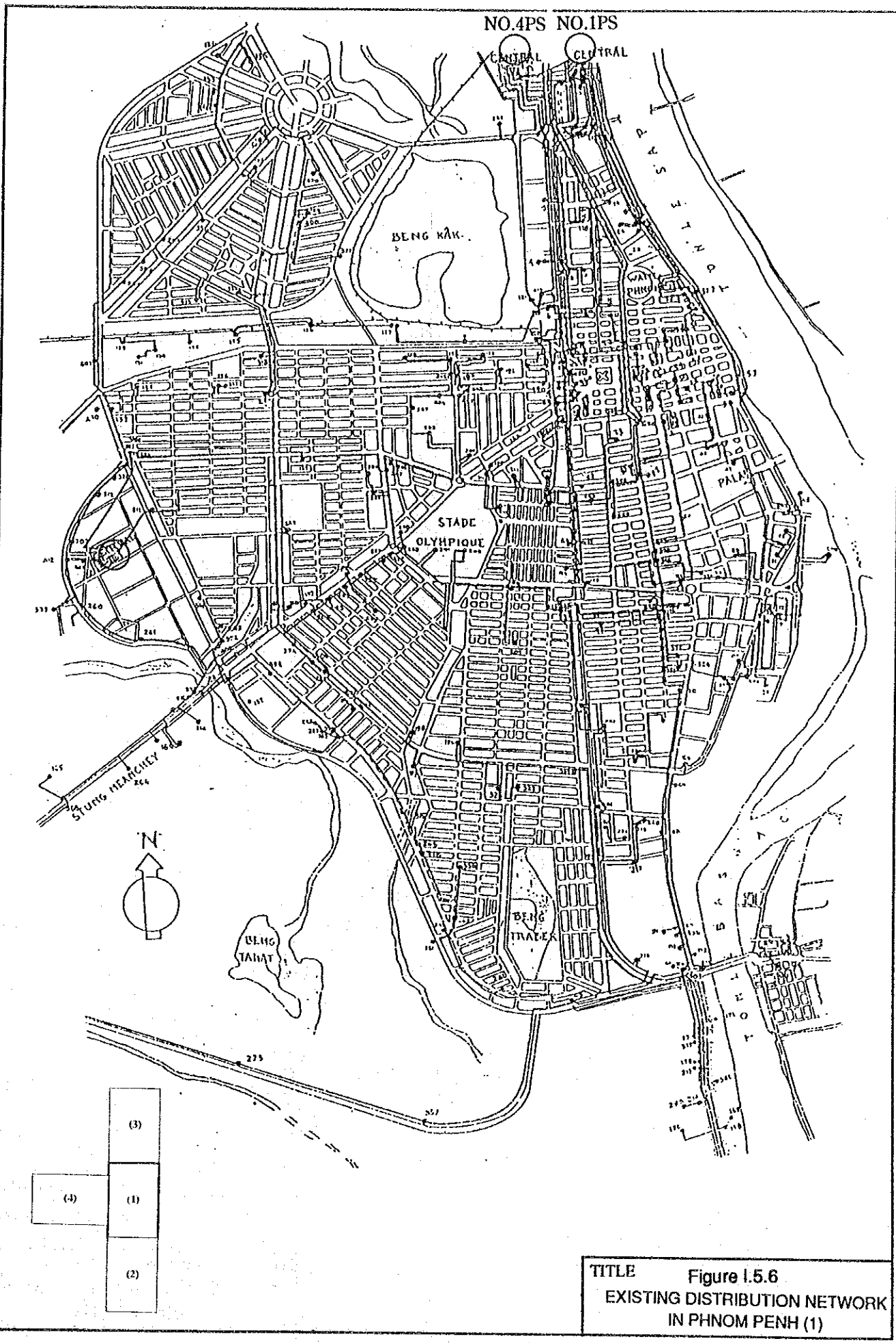
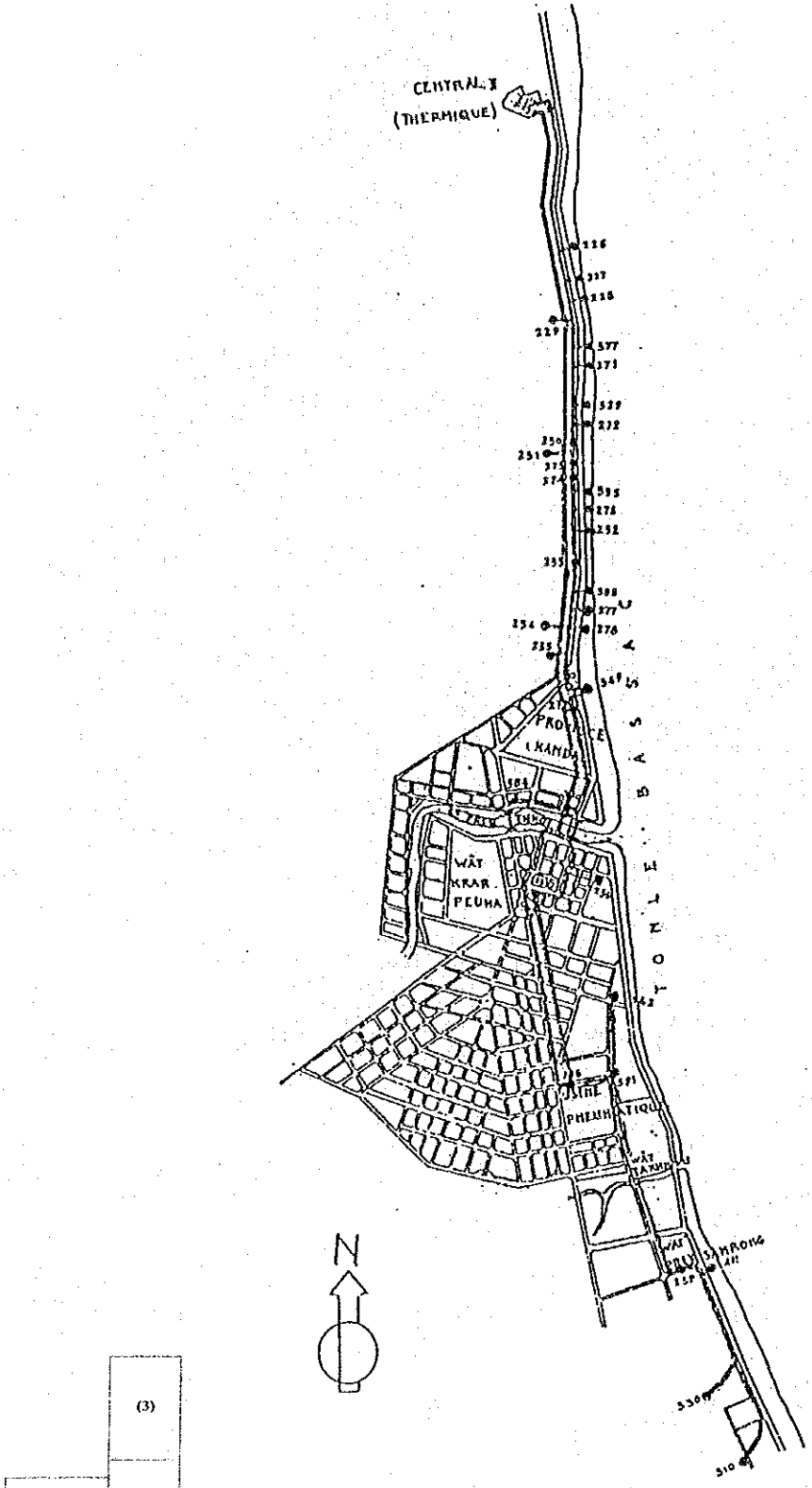
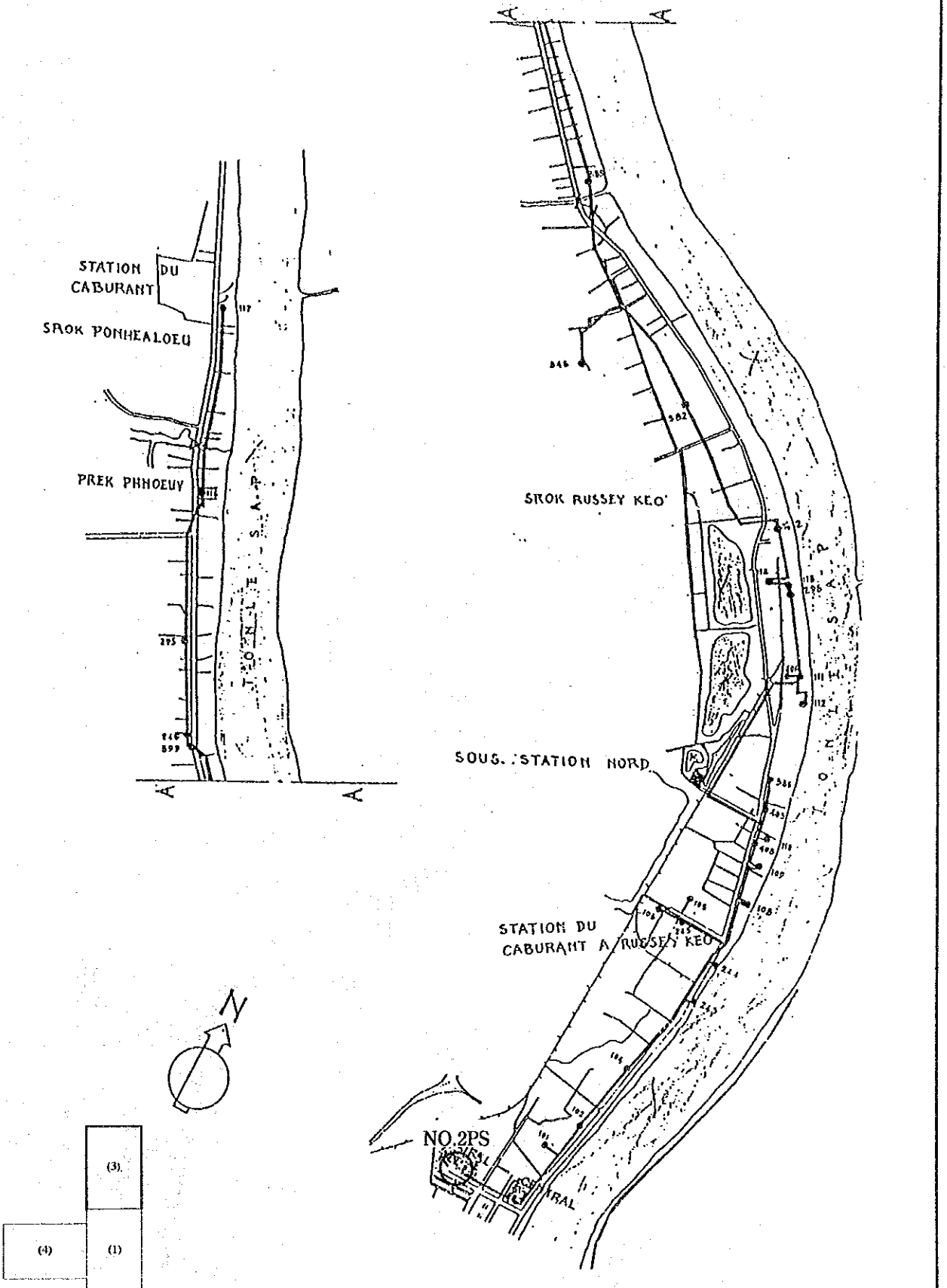
Figure I.5.5
No.4 POWER STATION



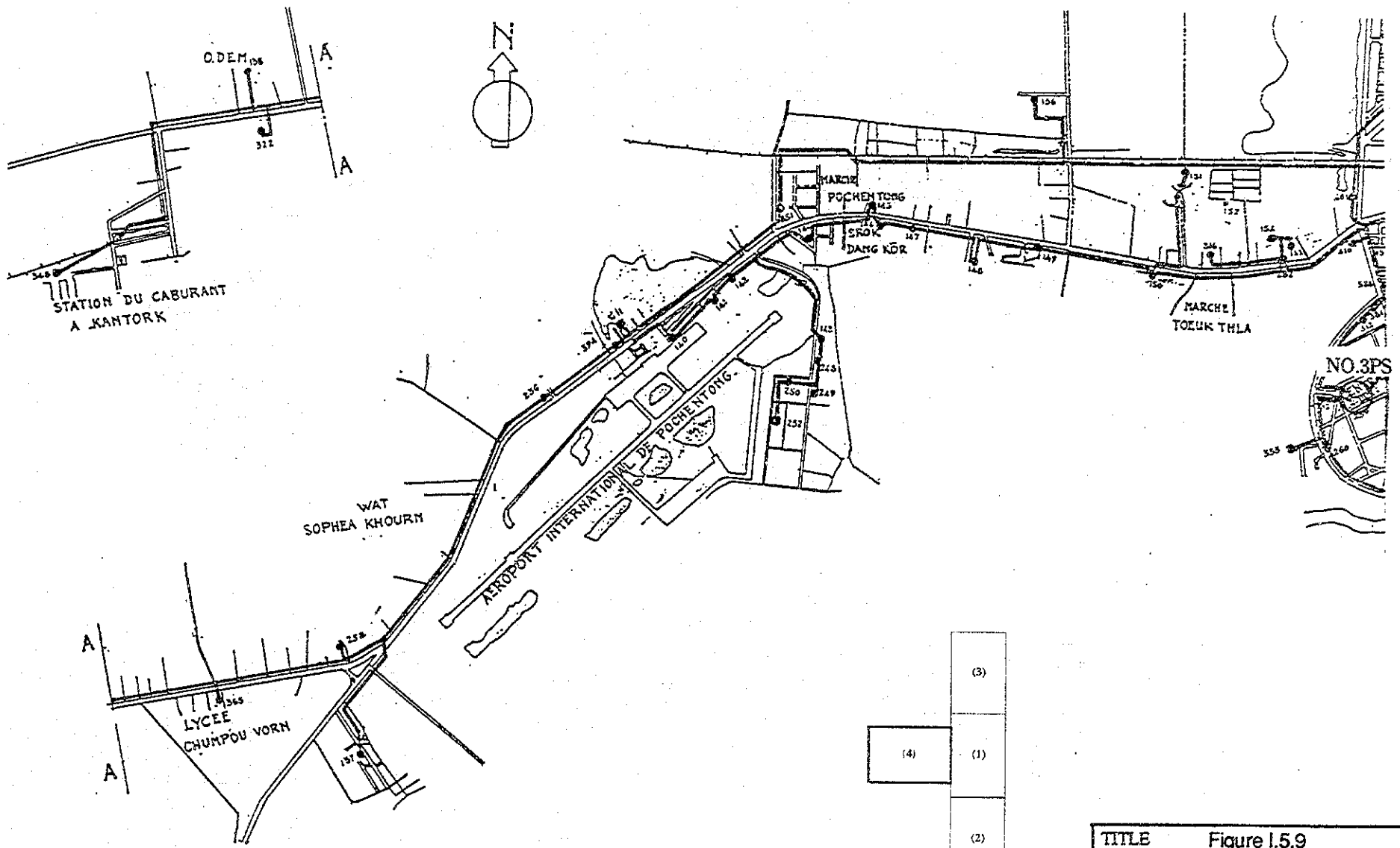
TITLE Figure I.5.6
EXISTING DISTRIBUTION NETWORK
IN PHNOM PENH (1)



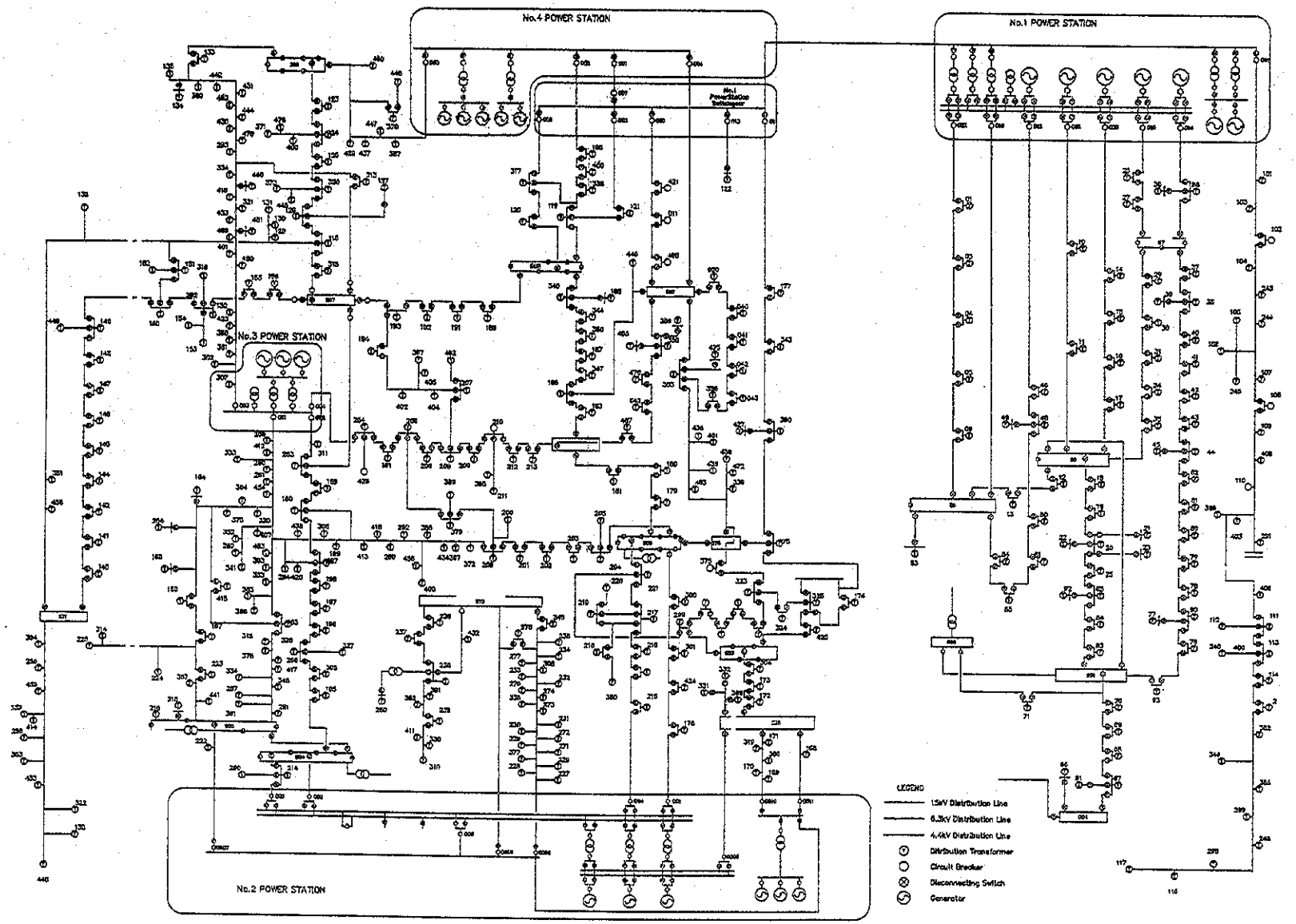
TITLE Figure I.5.7
EXISTING DISTRIBUTION NETWORK
IN PHNOM PENH (2)



TITLE Figure I.5.8.
EXISTING DISTRIBUTION NETWORK IN PHNOM PENH (3)



TITLE Figure I.5.9
EXISTING DISTRIBUTION NETWORK
IN PHNOM PENH (4)



TITLE

Figure I.5.10

SINGLE LINE DIAGRAM OF EXISTING DISTRIBUTION NETWORK

Figure-I.5.11

Overall Organization Structure of EDP

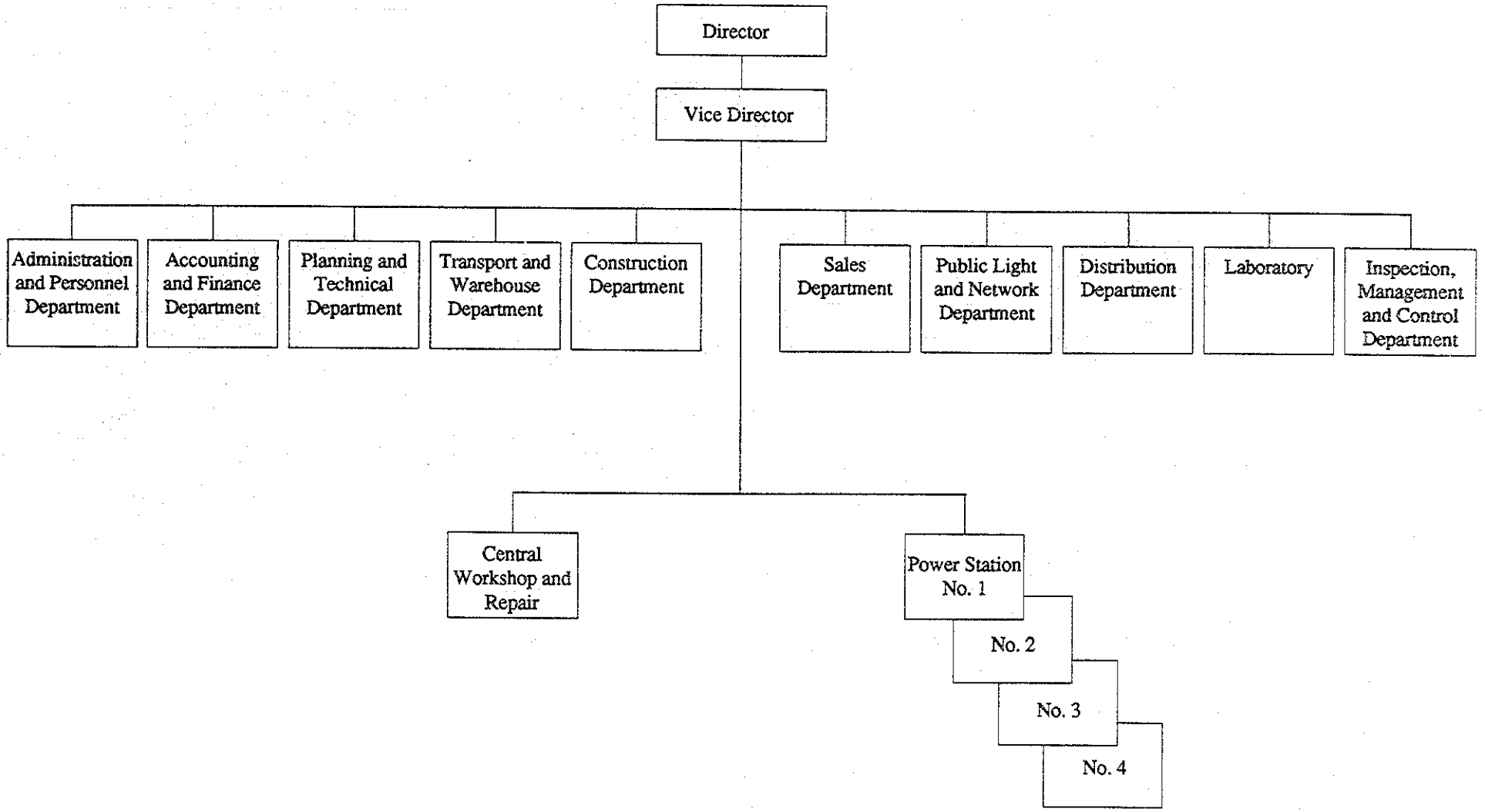


Figure I.5.12 Structures of Administration · Personnel Office and Accounting · Office

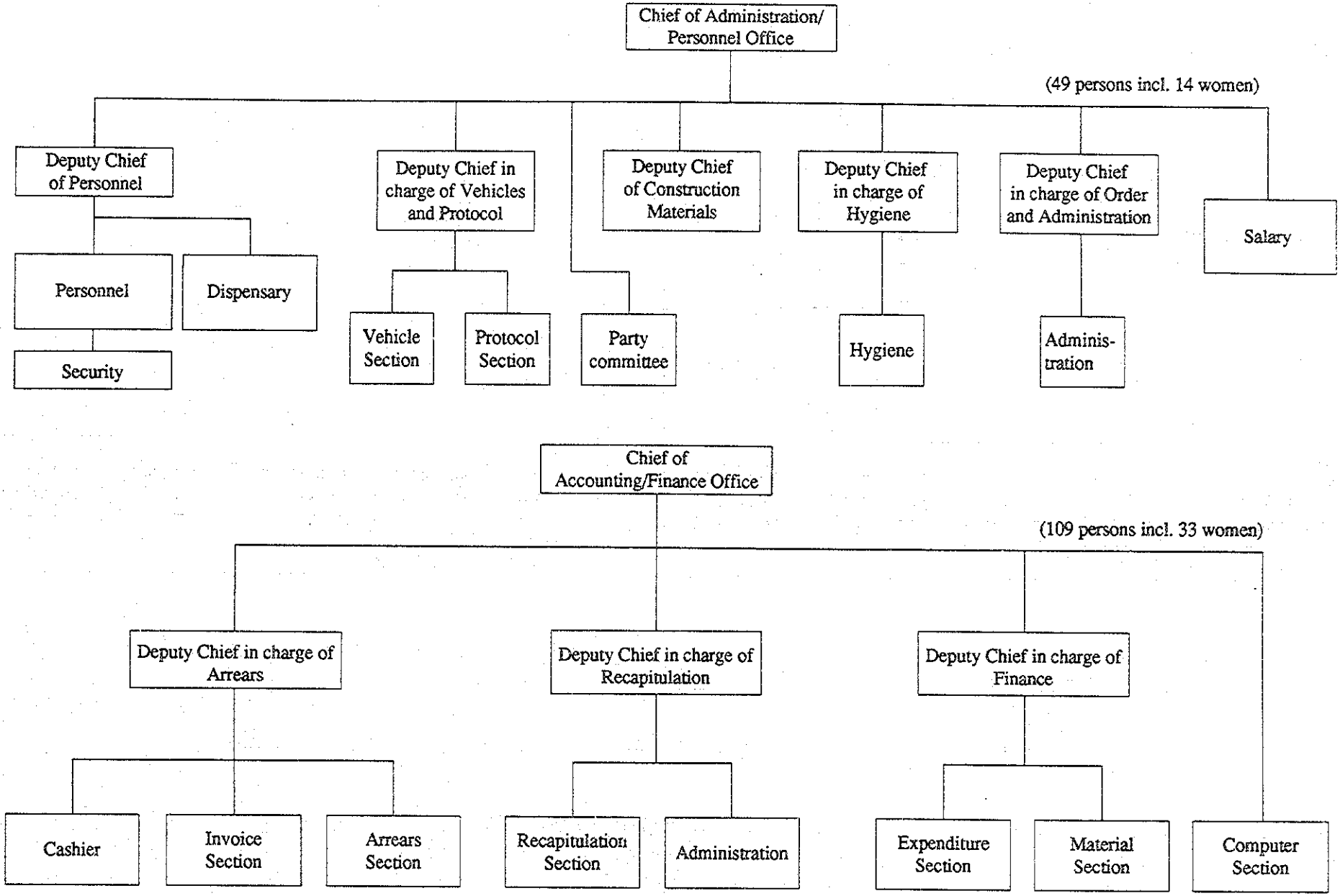


Figure I.5.13 Structures of Technic · Planning and Transport · Warehouse Offices

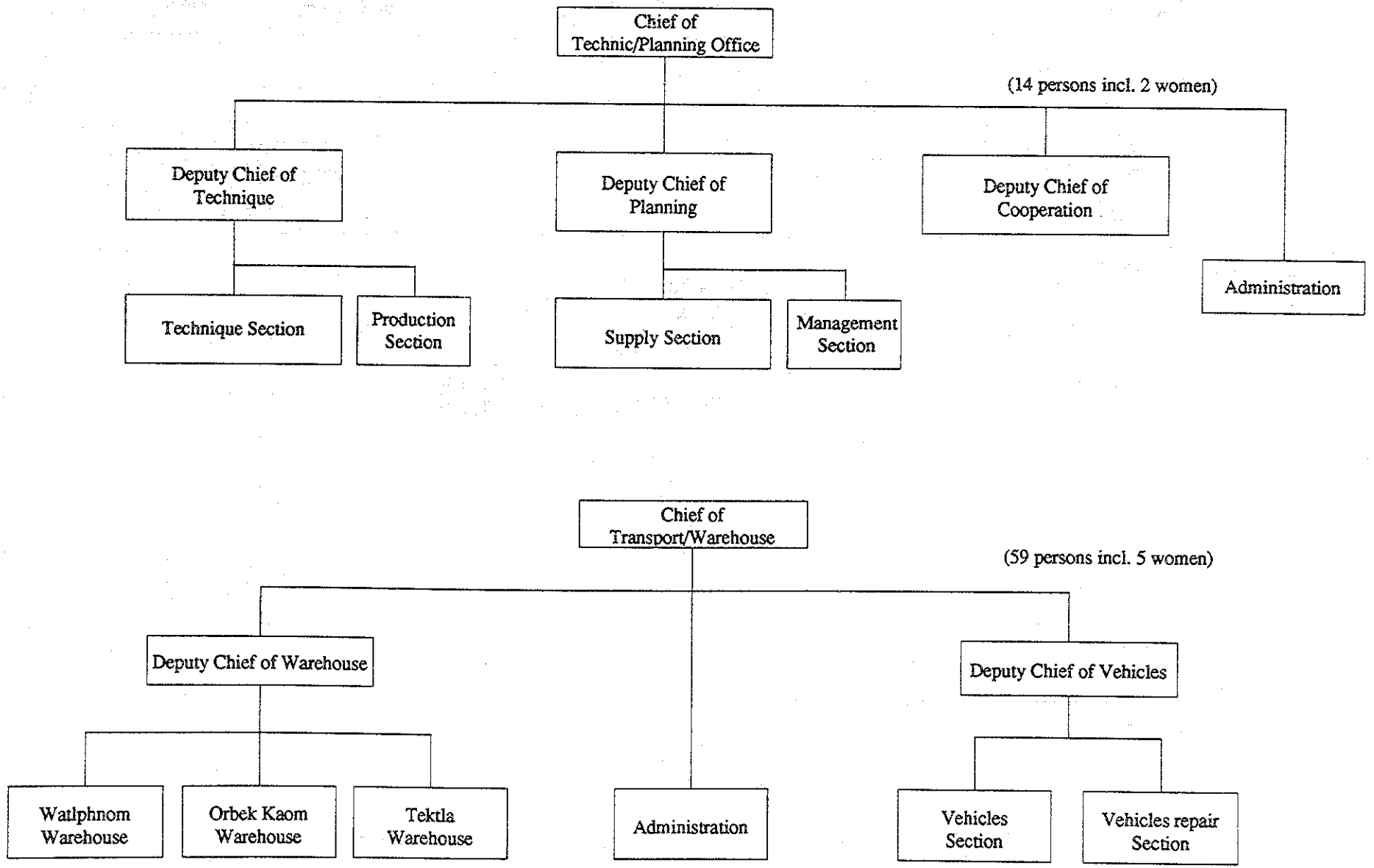


Figure I.5.14 Structures of Construction, Technical Research and Sales Offices

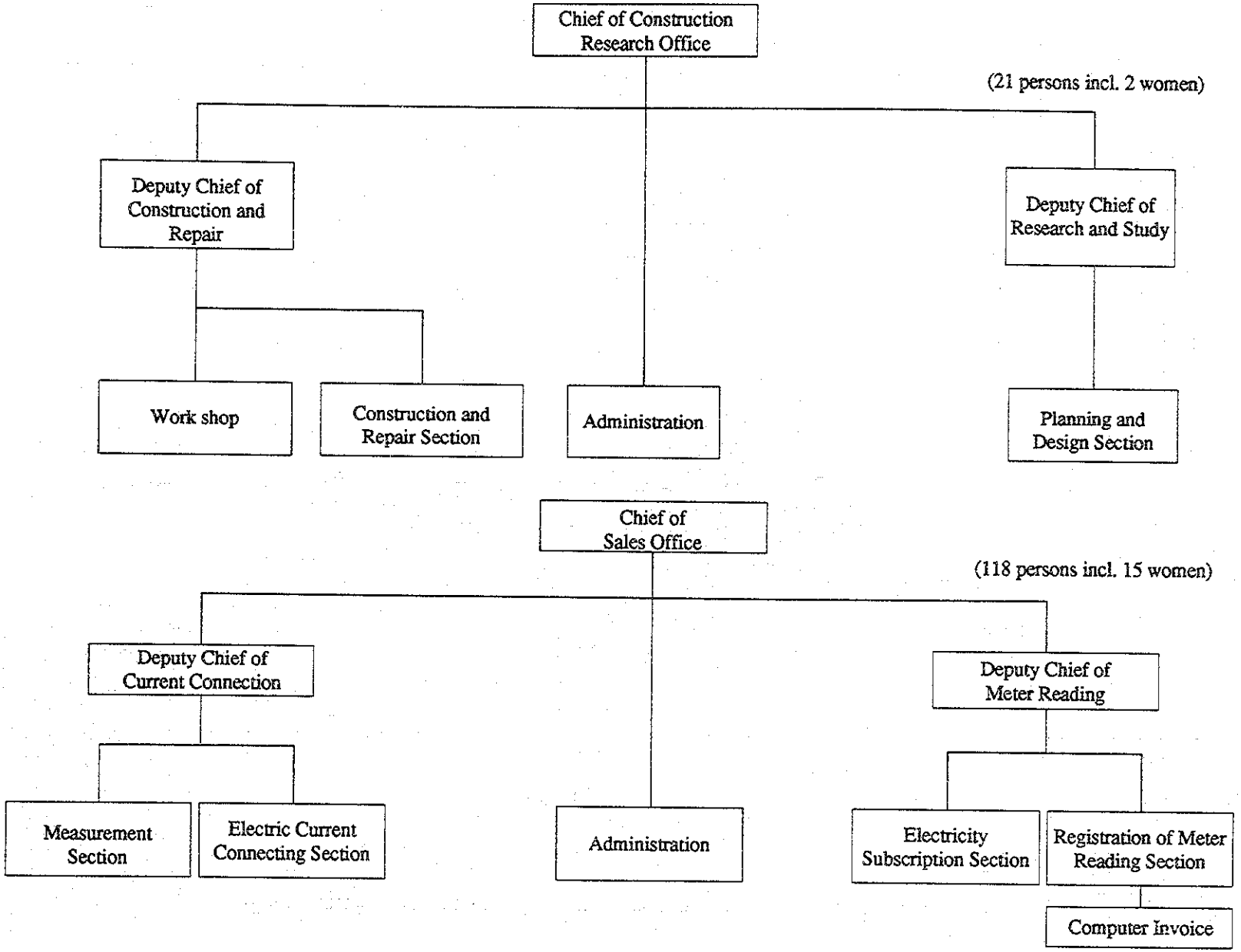
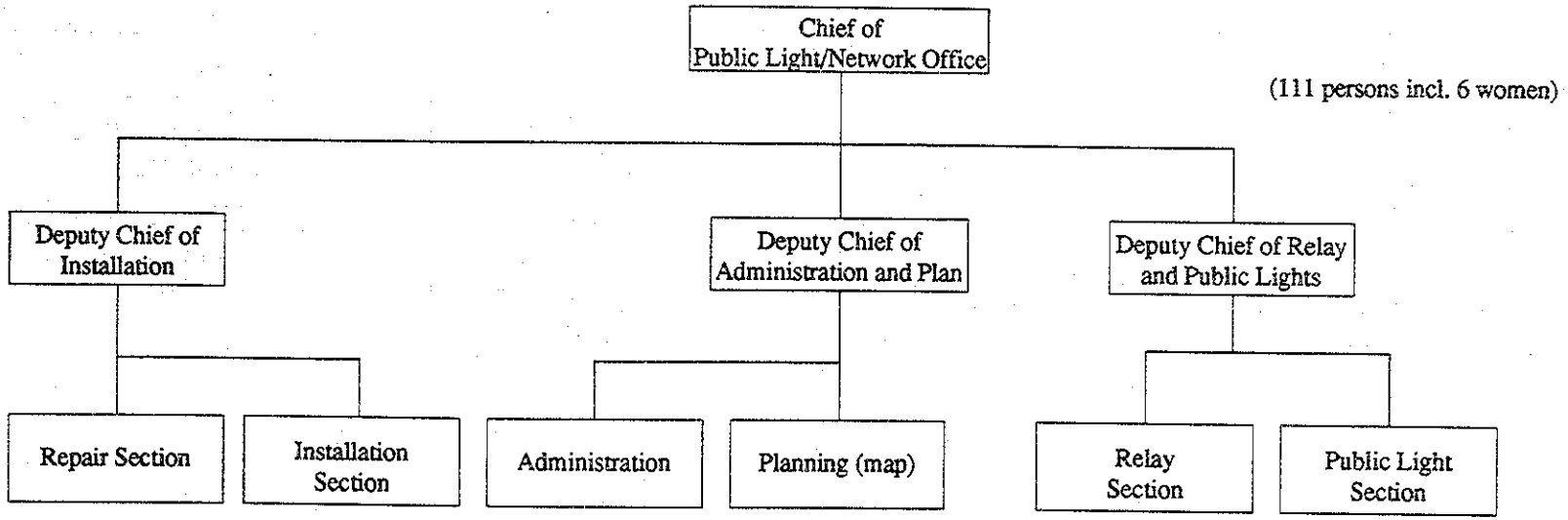


Figure I.5.15 Structures of Public Lighting · Network Office and Laboratory



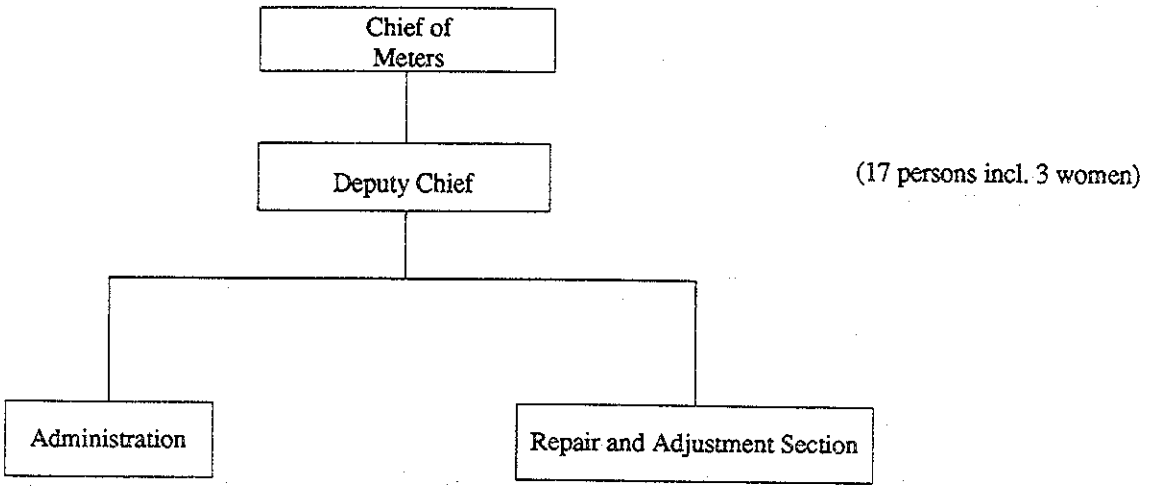
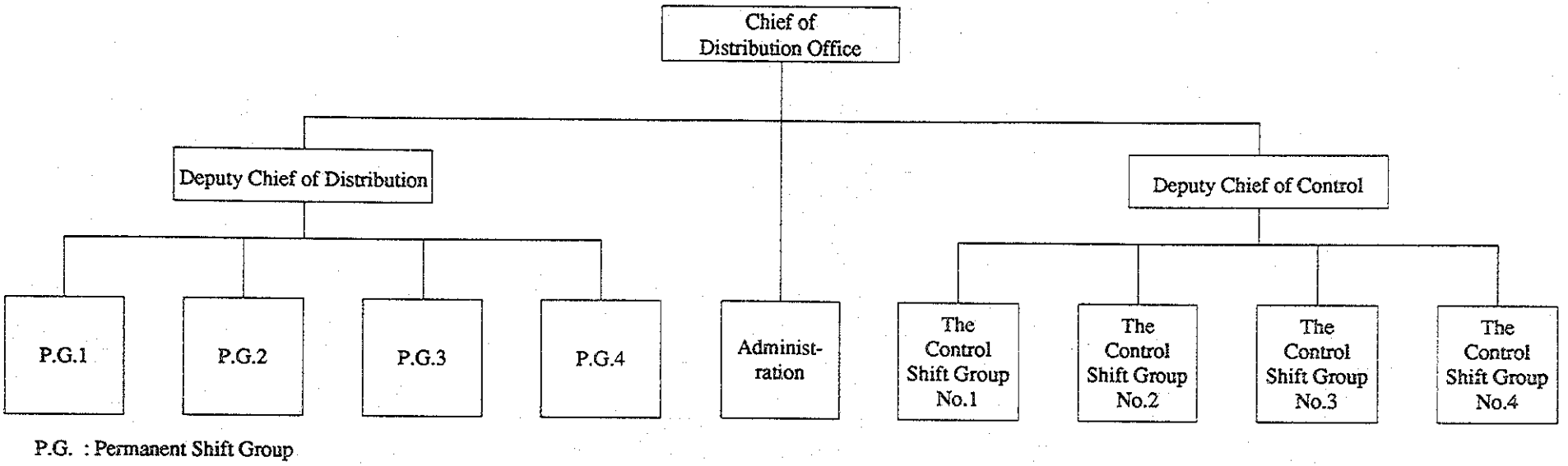


Figure I.5.16 Structures of Distribution, Inspection · Management · Control Offices, Central Workshop and Repair



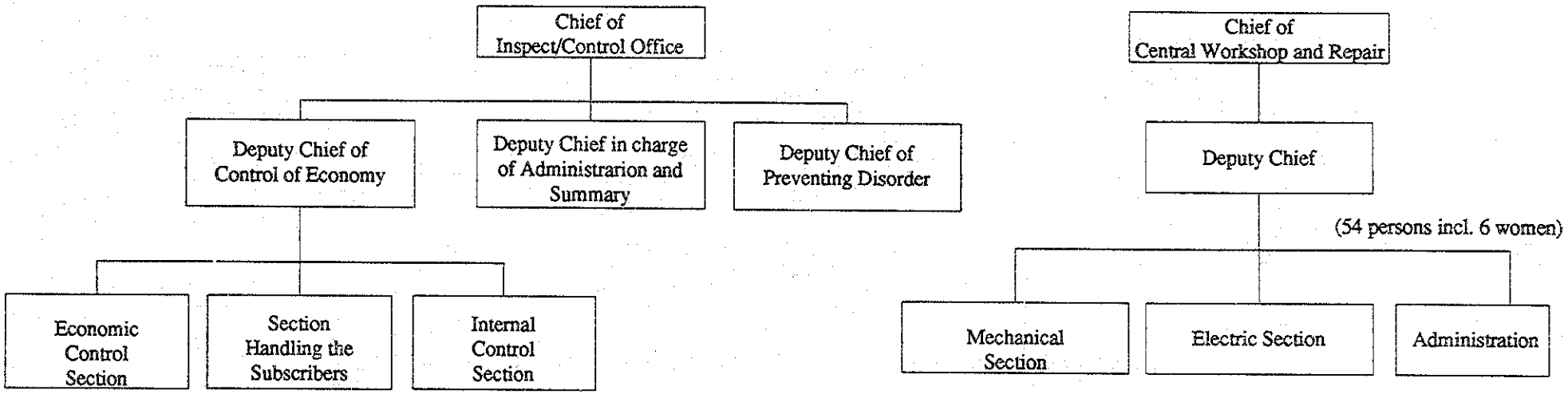


Figure I.5.17 Structure of No. 1 Power Plant (C1)

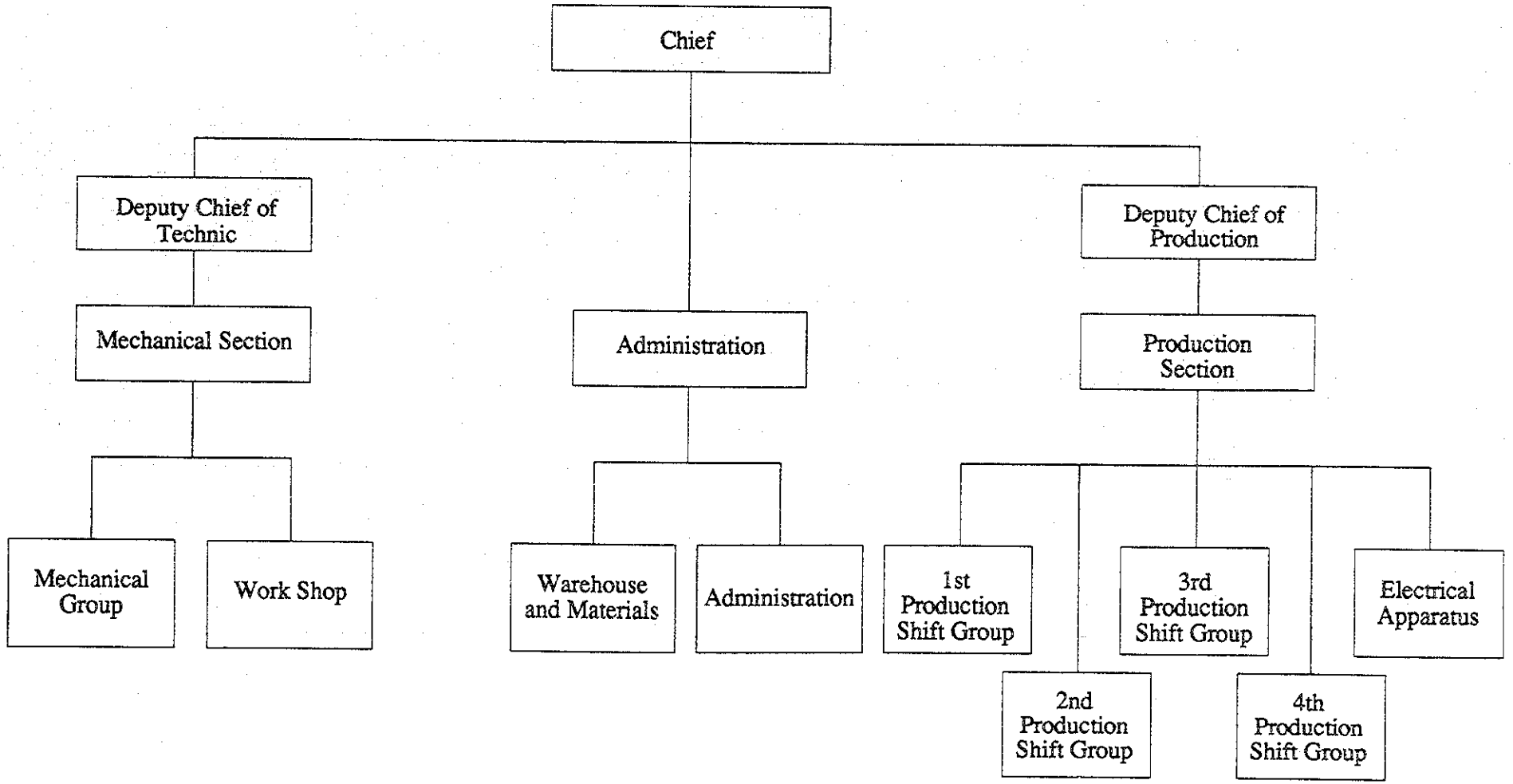


Figure I.5.18 Structure of No. 2 Power Plant (C2)

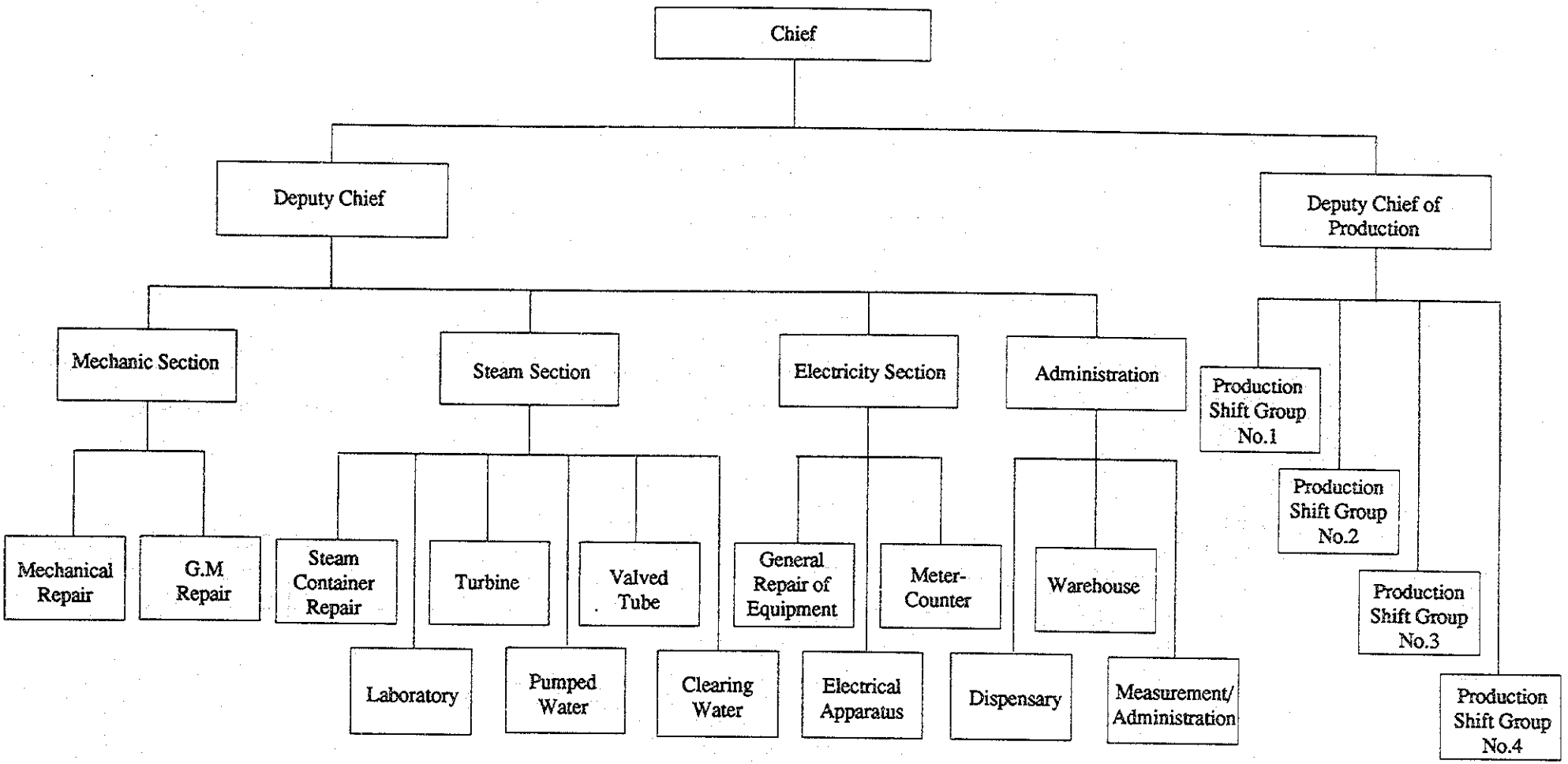
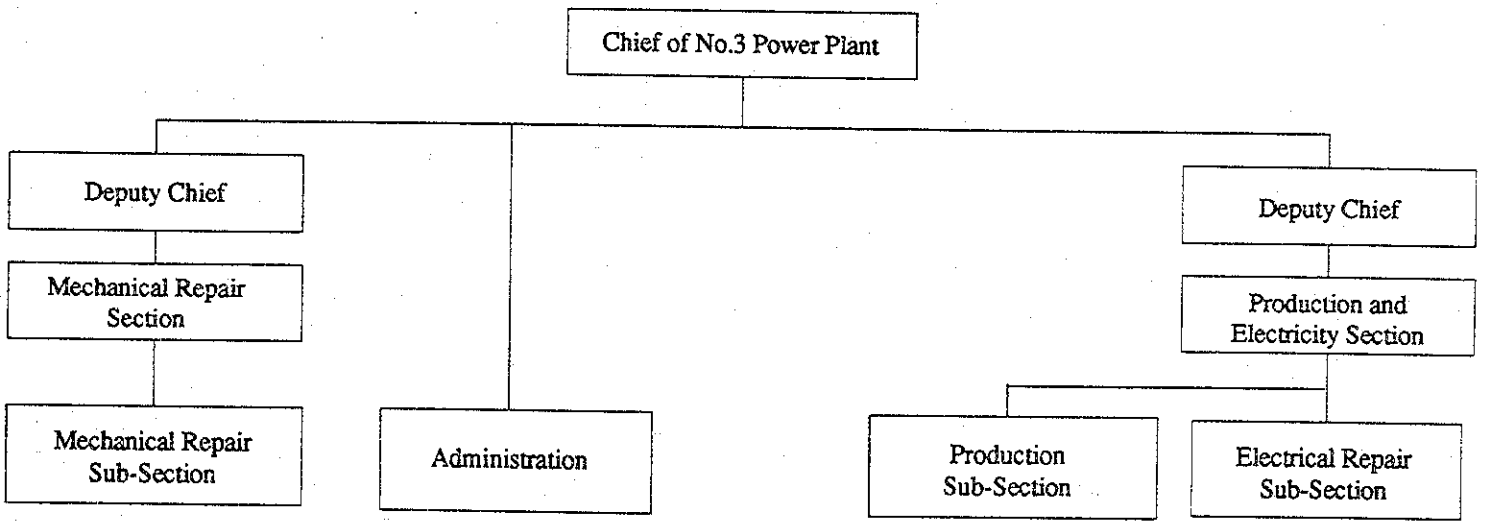


Figure I.5.19 Structures of No. 3 Power Plant (C3) and No. 4 Power Plant (C4)



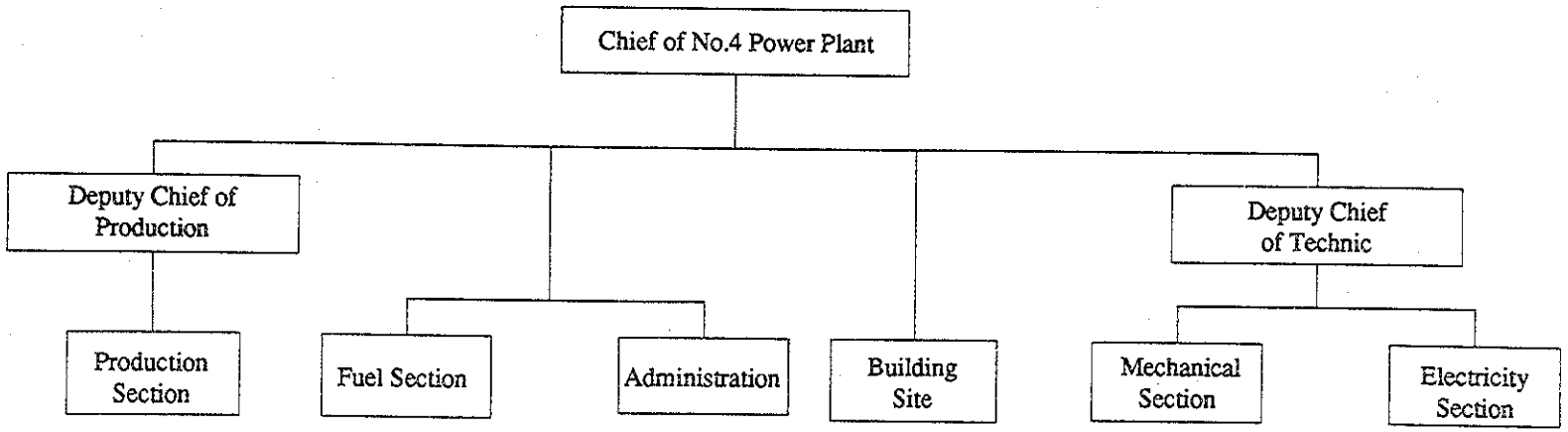
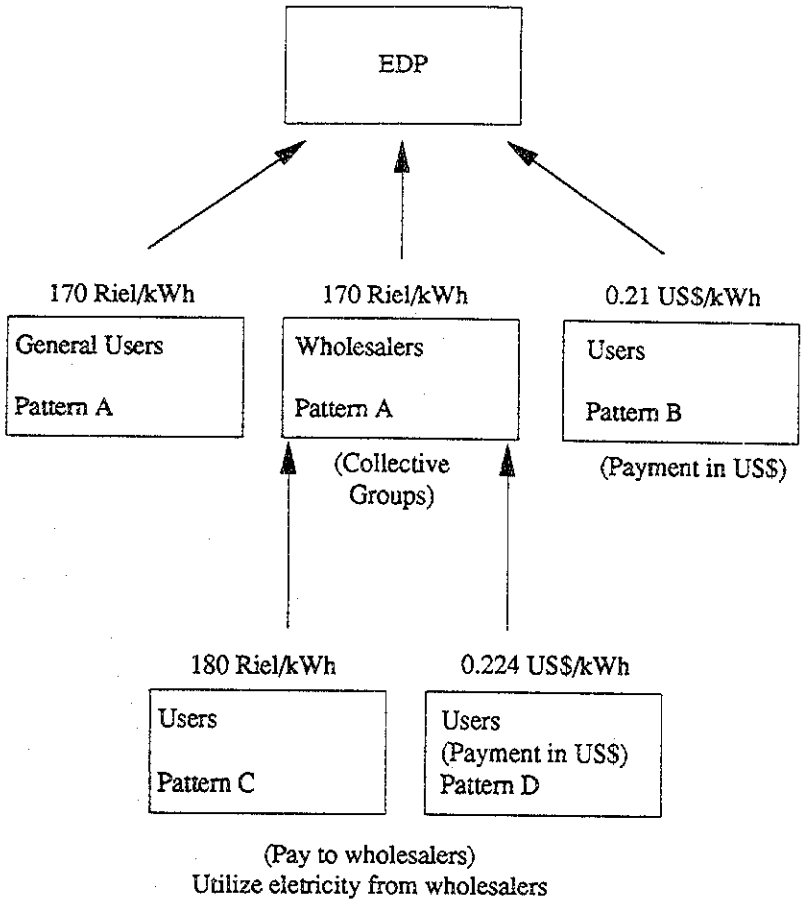


Figure - I.5.20
Tariff Schedule

Effective Date: 1 August 1991



Pattern A, B : Pay to EDP directly

Pattern C : Pay to wholesalers

Pattern D : Pay to wholesalers

Chapter 6

Present Siem Reap Power Sector and Issues

CHAPTER 6 PRESENT SIEM REAP POWER SECTOR AND ISSUES

6.1 Generating Facilities

6.1.1 Existing Facilities

At present, a power station with a total capacity of 2,230 kW operates in Siem Reap City. The station capacity ranks fourth in Cambodia behind Phnom Penh, Bttambang, and Kompong Som as seen in Table I.4.1. The power station was built in 1985 under assistance of the former Soviet Union (named the "Cambodia-U.S.S.R Friendship power station "). The power station is located in the northwest of the city and is operated under the control of the People's Committee.

Facilities of the power station are shown below:

Unit No.	1	2	3	4
Manufacturer	Russky Diesel (USSR)	Russky Diesel (USSR)	Russky Diesel (USSR)	Russky Diesel (USSR)
Model	Diesel G72 300	Diesel G72 300	Diesel DGA 315	Diesel DGA 315
Year	1985	1987	1985	1987
Rated	800 kW	800 kW	315 kW	315 kW
Possible Output (as of Jan. 1993)	550 kW	720 kW	280 kW	-
Generated voltage	6,300 V	6,300 V	400 V	400 V
Speed	375 rpm	375 rpm	500 rpm	500 rpm

The No.4 generating unit which has been left incomplete because of suspension of assistance from the former Soviet Union has been disassembled in order to provide spare parts for the No.3 generating unit. Facilities such as switchgear, oil tank, well, cooling water pond, and warehouse, exist on the premises of the power station. Space for future extension is also available on the site.

There was another power station built in 1960, which is located in the east of the city. The power station had supplied electric power to the city and suburbs before the above-mentioned power station commenced operation. The power station is now functioning as a substation; power generation has ceased. The generating units have partially been disassembled and their parts are being used as spare parts for the above-mentioned power

station. A powerhouse, cooling water pond, etc. are still available subject to repair. An outline of this power station is shown below:

Unit No.	1	2	3	4
Manufacturer	SKODA	SKODA	SKODA	SKODA
Type	6S35PN	6S35PN	6S275	6S275
Rated capacity	640 kW	640 kW	256 kW	256 kW
Generated voltage	6,300 V	6,300 V	400/230 V	400/230 V
Speed	375 rpm	375 rpm	500 rpm	500 rpm

General layouts of both station are illustrated in Figures I.6.1 and I.6.2.

Annual generated electricity from 1980 to 1992 was recorded as follows:

Year	Electricity Generated	Remarks
1980	702,252 kWh	by old power station
1981	354,343 kWh	ditto
1982	234,198 kWh	ditto
1983	450,000 kWh	ditto
1984	177,000 kWh	ditto
1985	436,300 kWh	by new power station
1986	578,081 kWh	ditto
1987	627,517 kWh	ditto
1988	871,316 kW	ditto
1989	930,200 kWh	ditto
1990	989,000 kWh	ditto
1991	1,089,900 kWh	ditto
1992	2,476,500 kWh	ditto

Source: People's Committee of Siem Reap

As mentioned, four (4) generating units have been installed in the new power station, but one unit has been left incomplete and used as a source of spare parts for the other units. Consequently the electric power is supplied by three units, which is resulting in a shortage of electric power supply. Under such circumstances as insufficient installed capacity and also difficulties of procurement of spare parts, the Committee is obliged to force scheduled load shedding to maintain the plants. The power demand in Siem Reap has grown remarkably due to an increase in the number of hotels to accommodate many tourists. Most of the hotels are equipped with their own generating facilities to supplement the electric power.

Present operation of the new power station is outlined below:

Hours	Unit No.	Possible Output	Maximum supplied electric power
0:00 - 9:00	No. 3	280 kW	240 kW
9:00 - 14:00	No. 1	550 kW	500 kW
14:00 - 16:00	No. 3	280 kW	240 kW
16:00 - 18:00	No. 2	720 kW	500 kW
18:00 - 20:30	No. 2 + 3	1,000 kW	900 kW
20:30 - 24:00	No. 2	720 kW	720 kW

Parallel operation with two (2) generating units is carried out in the hours between 18:00 and 20:30 to cope with peak demand. As seen in the above table, the figures of possible output and supplied electric power appear balanced, since the load shedding area is controlled so as to meet the capacity of one or two generating units.

6.1.2 Examination of Generating Facilities

The present condition of each generating unit in the new power station is outlined below:

(1) No.1 generating unit

The generator and exciter are in good order, but the possible output has been reduced to 550 kW from the rated output of 800 kW. This has occurred because the turbo charger was replaced with that for a 640 kW generator from the old power station.

(2) No.2 generating unit

The generator and exciter are in good order, but it is necessary to inspect in detail the present condition of the coil, insulation, and parts, since they might be damaged due to frequent forced parallel operation.

(3) No.3 generating unit

It will be necessary to inspect in detail the present condition of the coil, insulation, and parts.

(4) Parallel operation

Parallel operation among the generating units is conducted under commercial operation, and remedial works to the synchronizers will urgently be required for No.2 and No.3 generating units, because they are not working properly. The synchronizer for No.1 generating unit is functioning well.

(5) High voltage cubicle

Regular maintenance of the protection system including protective relays seems to have not been carried out.

6.1.3 Issues of Generating Facilities and Others

The major problems affecting the generating facilities in Siem Reap are summarized as follows:

(1) Shortage of generating facilities

According to the People's Committee, the maximum power demand at the beginning of February 1993 is expected to reach 1,700 kW excluding latent demands, which is more than the existing possible output of 1,550 kW with the three(3) generating units operating in parallel. The major problem in Siem Reap is how to cope with such a remarkable increase of power demand. Siem Reap is the major tourist spot in Cambodia and foreign currency income from tourists is contributing to the growth of the city. From this point of view, rehabilitation and expansion of the existing generating facilities are required.

(2) Shortage of equipment and materials for maintenance and repair

At present, damaged parts are replaced with the same parts or modified parts either from the old power station or No.4 generating unit. Shortage of equipment and materials for maintenance will cause faster deterioration of the existing generating facilities.

(3) Insufficient technical reference books

Technical documents such as operation manuals, drawings, and reference books are not available. The upgrade of operation and maintenance technique of the station staff is important to maintain the facilities properly.

6.2 Distribution Facilities

6.2.1 Existing Facilities

There are two (2) systems in the Siem Reap network: a 6.3 kV (3-phase) high voltage system and a low voltage system with two voltages: of 380/220V (3-phase) and 220/127V (3-phase). The high voltage lines are radially extended with 3-phase 3-wire cables with overhead and underground, while the low voltage lines in whole area are overhead with 3-phase 4-wire cables. The switching equipment such as circuit breakers and disconnecting switches are installed in only limited transformer houses, and most of the houses are not equipped with switching and protective equipment, which is causing problems in the control of the system.

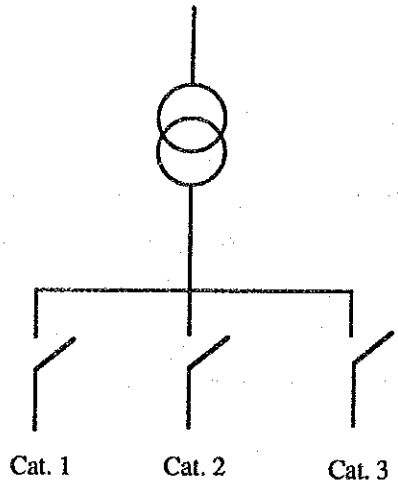
The existing distribution lines in the network are as follows:

(circuit-km)

Distribution line	Underground	Overhead
High voltage	3.5	7.7
Low voltage	-	13.1

The distribution line network in Siem Reap is shown in Figures I.6.3 and I.6.4. The distribution lines for the airport area and for the Angkor complex have been damaged and left. Three (3) phase distribution transformers are installed in transformer houses or on the distribution poles. A total of twenty (20) transformers with unit capacities between 45 kVA and 630 kVA are installed, and the total installed capacity is estimated at 3,745 kVA. As seen in Figure I.6.4, there exist only two (2) 6.3 kV distribution lines from the new power station to cover the power demand in the whole city, one supplies electric power for ice plants having only two (2) transformer units (total capacity 350 kVA), and the other is to cover most of the power demand in the city with eighteen (18) transformer units (total capacity 3,395 kVA). As indicated above the distribution line network is being operated under unbalanced conditions.

Load shedding is routine in Siem Reap, and is well organized (requiring only 4 persons working full-time!). It is also facilitated by the layout of the transformer stations. Each of the 16 substations supplying the city has the following scheme:



Category 1 : Customers supplied with power 24 hours a day
Category 2 : Customers supplied at least 18 hours a day
Category 3 : Customers supplied whenever possible

Three main switches serve to control the electricity supply to customers.

From 12 pm to 9 am and from 2 pm to 4 pm (i.e., when only the small 280 kW set is operating) in all the transformer stations, all Category 3 customers (domestic) are systematically cut off.

During the peak period (7 pm-8 pm), Category 3 customers are still subject to load shedding, but only in several substations (load shedding by rota).

Category 1 customers are never cut off (except for a serious failure).

If required, load shedding occurs in Category 2 on an alternate basis.

6.2.2 Issues of Distribution Facilities

Problems associated with the existing distribution facilities are outlined below:

(1) There exist only two (2) distribution lines in the network. They are subject to unbalanced loads, one line is loaded by two (2) transformer units and the other is loaded by eighteen (18) transformer units. Consequently, in case of power failure in the latter, most of the city is effected.

(2) The distribution lines for the airport and for the Angkor complex are still severely damaged.

(3) Conductor and cable sizes of the existing system are insufficient to meet a growing power demand.

(4) Insufficient quantity and capacity of distribution transformers and also lack of protection devices cause operation problems in the network.

(5) Maintenance materials and equipment especially for cable terminations and straight joints for the underground cables are insufficient.

6.3 Load Dispatching Facilities

6.3.1 Existing Facilities

A load dispatching system is not organized in Siem Reap due to the small-scale power network. Generation scheme and restoration work are undertaken by the power station staff. Communication for operation of switching equipment or restoration work in the distribution system is carried out by means of transceivers mounted on maintenance vehicles.

The existing communication facilities are outlined below:

Transceiver (144 MHz, 2 channels)

(a) Power Station : 1 set

(b) Distribution Network : 2 sets

6.3.2 Issues of Load Dispatching Facilities

(1) No hindrance to radio communications has been observed so far. However, it is feared that communication for the load dispatching works of the power system will be interfered with in future when many similar transceiver sets are used in the town.

(2) No supervisory panels have been installed. Indication of equipment status in the power station and the transformer houses is not available.

6.4 Operation of Electric Power Enterprise

6.4.1 Organization of Siem Reap Electric Power Enterprise

The organization of Electricité de Siem Reap (EDSR) is shown in Figure 6-4-1 which indicates that EDSR is a subordinate organization of the People's Committee of Siem Reap city. The Department of Economy under the City Governor administrates economic activities. This department is divided into four sectors: industry, agriculture, communications, and commerce. The Electric Power Enterprise is classified in the industry sector, which consists of four enterprises: handicraft; electricity; water supply and ice manufacture; and workshop enterprises.

Within the electric power firm's organization, two Deputy Chiefs, in charge of electrical and mechanical equipment, are assigned as assistants to the Chief of the Power Firm. Organized under the Chief of the Power Firm are the Administration Section, Planning Section, Accountancy Section, Sales Section, Network Control Board/ Distribution/Electric Section, and Maintenance/Machine/Generator Section. There is one staff member assigned to the Administration Section, four to the Planning Section, four to the Accountancy Section, thirteen to the Sales Section, fourteen to the Network Control Board/Distribution/Electric Section, and nine to the Maintenance/Machine/ Generator Section .

The organization of this electric power firm in view of administration, operation, planning and construction, and electricity charge collection, which are the general elements constituting an electric power enterprise is examined below.

The Administration Section and Accountancy Section are deemed to form the general management department, the Sales Section belongs to the sales department, while the Network Control Board/Distribution/Electric Section and the Maintenance/Machine/ Generator Section constitute the operation department. Judging from the configuration of the staff members, the Planning Section seems to have dual functions, both planning and administrative. However, it seems that no construction function has been allocated to any department in the power firm. Considering that the electric power supply territories of the SEPE are extremely limited and in view of the historical background of this power station (that is, this power station was built with the assistance from the former Soviet Union commemorating the friendship between Cambodia and the Soviet Union), it was deemed that there was no particular need to have a construction department in the organization of the electric power firm.

6.4.2 Operating Condition of EDSR

(1) Operating condition of the electric power facilities

The profit and loss statements for EDSR is presented in Table I.6.1. Although the installed capacity of the power station has not increased since 1987, electrical energy production has increased since 1991. This is deemed to have been caused by a rapid increase in the electric power demand by hotels, which has resulted from a rapid increase in the number of tourists visiting the historical remains of Angkor Wat. The ratio of the sold electric energy to the total electrical energy production has tended to increase since 1989 and a peak of 49% was recorded in 1992. However, this ratio is substantially lower than envisaged by EDP (64%) in the earlier half of 1992. This very low ratio is assumed to have been caused by distribution losses, theft of electric power, power failure, inefficiency in load dispatching operation in compliance with fluctuations of power load, and others. The considerable increase in the ratio, to as high as 49%, is deemed to have resulted from the increased portion of the electric power demand by hotels out of the overall electrical energy demand. In other words, the ratio is deemed to have been raised because electric power demand from hotels is almost free from theft.

(2) Average sales prices, electrical energy production cost, and sales cost

Presented in Table I.6.2 are the average electrical energy sales prices and the deflated electrical energy sales prices calculated based on the profit and loss statements of EDSR. The average values and deflated values of electrical energy production cost calculated similarly are presented in Table I.6.3; and the average values and deflated values of electrical energy sales cost are presented in Table I.6.4.

As presented in Table I.6.2, the average electricity sales price has been raised rapidly reflecting hyperinflation in Cambodia. In the case of SEPE, the increase rate of the price exceeds that of EDP. When the price is compared using the price deflator in order to take hyperinflation into consideration, the deflated price level in 1989 is considered to be nearly equal to that in 1990. However, the deflated price in 1991 has increased by nearly four times to 25.71 Riel/kWh over previous years. The deflated price in 1992, which was 23.48 Riel/kWh, can be considered to be equal to that in 1991 when the hyperinflation rate of more than 200% is taken into account.

As Table I.6.3 shows, the average electrical energy production cost increased rapidly, which, apparently, reflects hyperinflation. The electrical energy production cost has apparently increased substantially year after year from 3.69 Riel/kWh in 1989 to 11.11 Riel/kWh in 1992. The high increase in the rate of electrical energy production cost is presumed to have resulted from the unavoidable lengthy continuous operation of the inefficient power generation facilities in order to meet the rapid growth of electric power demand since 1991 and a growing shortage of spare parts.

The average sales cost is presented in Table I.6.4. When the values, converted in terms of the 1989 price level using a deflator, are compared, the cost has increased continuously since 1989 until 1991. However, while the electrical energy production cost in 1992 increased, the electrical energy sales cost decreased to 22.85 Riel/kWh in 1992 from 32.28 Riel/kWh in the previous year. The reduction in the sales cost is deemed to be attributable to the improvement in the ratio of sold electrical energy to the total energy production in 1992.

In 1991, deflated electrical energy production costs and sales costs were more than doubled compared with those in the previous year. It has been observed that EDSR has also been substantially affected by the suspension of assistance from the former Soviet Union similarly as in the case of EDP.

(3) Recovering electrical energy sales cost

The electrical energy sales cost represents the expenditure required to sell 1 kWh of electrical energy. By comparing the unit electrical energy sales cost and average electricity price, it is possible to assess to what extent the electrical energy sales cost is recovered by electricity sales. The average sales price and sales cost in 1989 were deflated to 7.00 Riel/kWh and 11.47 Riel/kWh respectively. The deflated sales cost exceeds the deflated sales price, which means that only a portion of the sales cost is recovered. This situation prevailed continuously until 1991. However, in 1992, the deflated average electrical energy sales price and sales cost became 23.48 Riel/kWh and 22.85 Riel/kWh respectively, that is the average sales price exceeded the unit sales cost, which indicates that it is possible to recover the sales cost. However, this electrical energy sales cost included only the fuel and other operation costs but did not include the depreciation cost for power plant equipment and distribution facilities.

In 1992, the deflated average sales price exceeded the deflated sales cost only by 0.63 Riel/kWh. If the depreciation cost is added to the sales cost, then the sales cost is deemed to substantially exceed the average sales price.

(4) Financial conditions

As indicate in the profit and loss statements in Table I.6.1, EDSR had had a deficit every year since 1989 until 1991. A surplus, as a result of a substantial increase in electricity charge was recorded in 1992. However, if the equipment depreciation cost is added to the operation cost described in the profit and loss statements, then the balance is deemed to be a deficit even in 1992.

The organization of SEPE is small in scale and has only one power station. There are no loans from any bank or financial institution. However, the funds for procurement of spare parts, lubricants, fuels, and so forth are not sufficient.

6.4.3 Operation of Generation and Distribution Facilities

(1) Operation and maintenance system for equipment and facilities

As indicated in Figure I.6.3, the operation and maintenance of the power station is undertaken by the Operation and Maintenance (Maintenance/Machine/Generator) Section, while the operation and maintenance of distribution lines is undertaken by the Distribution (Network Control Board/Distribution/Electric) Section. The power station is operated by eight operation staff members based on a double shift work system. Although four operation staff members are engaged in a shift operation for twelve hours, the operation shift team is divided into two consisting of two members to reduce their working hours to six. The distribution lines are maintained by six operation shift members based on the same shift operation system as that of the power station on a twenty-four hour basis.

If power supply failure occurs, the staff members of the Distribution Section will take countermeasures. The countermeasure system is almost entirely the same as that of the power station, except the maintenance staff visits the failure directly from the power station. Since restoration of power supply failure is not carried out on a twenty-four hour basis, same as in the case of EDP, the restoration work from power supply failure during the night will be brought forward to the next day.

Safety control activities have not been promoted and therefore, it is necessary to take measures to improve the safety control system.

(2) Management of spare parts

Since the power plant equipment and components were manufactured by the former Soviet Union, it has become nearly impossible for the power enterprise to procure spare parts.

Even if spare parts are procured their specifications are not compatible with existing equipment. In addition, it is getting impossible to use procured spare parts due to discrepancies which have resulted from frequent improvisations of various other parts.

The spare parts for the power plant equipment and distribution lines are stored in warehouses annexed to the power station. Although some spare parts are stored in warehouses, insulators, transformers, conductors, and other parts are stockpiled outdoors. This arrangement is considered inappropriate, and it is deemed to be a problem in view of inventory control, prevention of theft, and so forth. The absolute shortage of spare parts is considered to be more severe than the problem of unsatisfactory storage conditions. The stock of cable heads and insulators is particularly in short supply and thus, it is getting very difficult to meet the further increases in electric power demand.

6.5 Electric Power Sales System

6.5.1 Electricity Charge

(1) Existing electricity charges

In Siem Reap, electricity charges were not imposed until 1979. According to the existing electricity charges revised in 1992, the charge has been set (stratified) based upon the payment conditions regardless of the category of consumer similarly as in the case of EDP. When paying electricity accounts in hard currency, a rate of US$0.30/kWh is applied mainly to hotels, restaurants, bars, offices of overseas organizations including their staffs' households. When the charge is paid in local currency a rate of 320 Riel/kWh is applied. The electricity charges collected in U.S. dollars are converted into local currency based on the exchange rate of the month and allocated as a revenue for the power firm.

Reflecting the exchange rate of Riel devaluated successively against U.S. dollar, the average electricity charge shown in the profit and loss statement in Table I.6.1 was 400 Riel/kWh in 1992, which is much higher than the electricity charge of 320 Riel/kWh when paid in local currency.

(2) Electricity charge revision policy and process

Although there was no clear explanation of the policy for formulating the electricity charges of the People's Committee of Siem Reap, the existing electricity charges are deemed to have been formulated by accumulating the cost of expenses related to electrical energy production and distribution in detail while taking the profit into consideration. Under the current economic situation in Cambodia prices have escalated rapidly due to hyperinflation, as well as the costs and expenses related to electric power supply. Therefore, the electricity charges are required to be revised from time to time as appropriate. For this purpose, future assistance is desired for establishing the procedures and system in order to formulate the appropriate electricity charges depending on the prevailing economic and social situations in Cambodia.

As SEPE is annexed to the People's Committee of the Siem Reap city, revised electricity charges will be proposed by the People's Committee and finally decided and notified after deliberation.

6.5.2 Electric Power Sales System

(1) Watthour meter installation and number of consumers

As mentioned previously, electricity charge was not collected before 1979 in Siem Reap. When charge collection was initiated thereafter, watthour meters were installed for two hundred of the four hundred consumers at that time. During the period from 1986 to 1987, SEPE positively promoted installation of such instruments. At present, watthour meters have been installed for 95% of the 1,534 consumers. Roughly 25% were installed at the expense of the consumers, while the others were installed by the power enterprise. The 5% of consumers who have not been equipped with a watthour meter pay the electricity charge at a fixed rate. The fixed rate is limited to two lamps, and the electricity charge is calculated based on estimated watthours per month.

Hotels make up more than 60% of the total electric power demand. As the number of hotel rooms is scheduled to be increased to 2,000 in 1995 from roughly 250 at present, the electric power demand by hotels is forecast to undergo rapid growth.

(2) Watthour meter reading and collection of electricity charges

The reading of watthour meters and collection of electricity charges are carried out once a month. Each inspector inspects watthour meters and collects electricity bills for the previous month at the same time. Electricity wholesalers or the so-called "Collective Group" system has not been adopted by SEPE, and, therefore, the thirteen staff members of the Sales Section undertake the task of meter reading and electricity charge collection.

Table I.6.1

Profit and Loss Statement of Siem Reap Electric Power Industry (EDSR)

(Unit: 10^3 Riels)

Item	1989	1990	1991	1992
Generation (1000 kWh)	930.2	989.0	1,089.9	2,476.5
Sales (1000 kWh)	299.3	359.1	369.0	1,204.2
Sales/generation ratio (%)	32	36	34	49
Average rate (Riel per kWh)	7	20	146	400
Gross revenue from sales	2,095	7,181	53,814	482,493
Other income	14	1,297	6,036	6,133
Total	2,109	8,478	59,850	488,626
Operations expenses:				
1) Fuel	2,735	9,808	57,952	431,758
2) Repair & maintenance	23	379	1,213	8,234
3) Salaries & wages	604	2,587	5,071	16,854
4) Administration	54	143	101	713
5) Others	17	75	3,326	11,221
Total	3,433	12,992	67,663	468,780
Operating income	▲ 1,324	▲ 4,514	▲ 7,813	19,846
Provincial government subsidies	1,324	4,514	7,813	-
Net income	0	0	0	19,846

Table I.6.2 Average Electricity Price

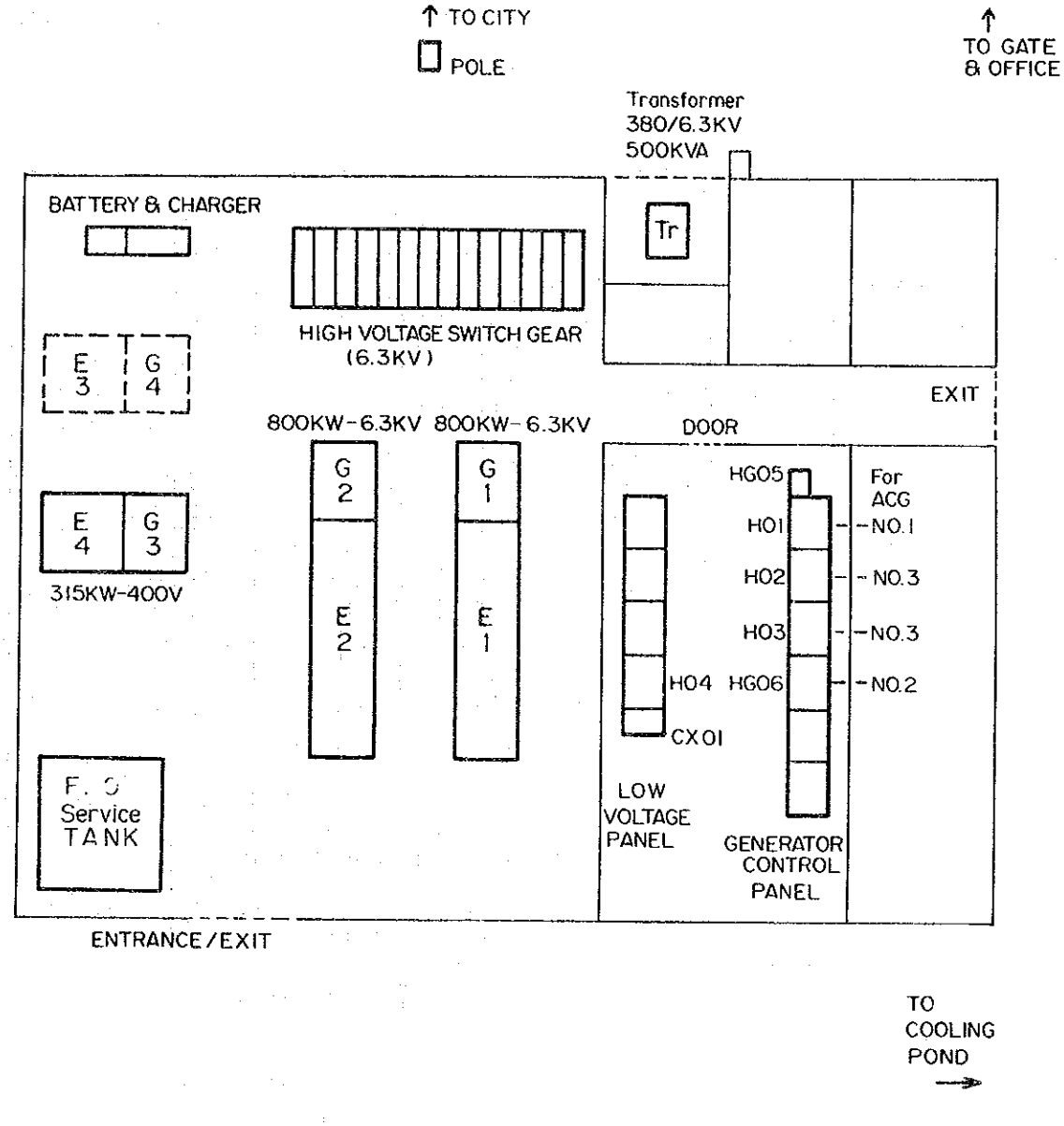
Item		1989	1990	1991	1992
Average electricity rate	(Riel/kWh)	7.00	20.00	146.00	400.00
Deflated rate	(Riel/kWh)	7.00	7.78	25.71	23.48

Table I.6.3 Average Production Cost

Item		1989	1990	1991	1992
Total generation	(Thousand kWh)	932.20	989.00	1,089.90	2,476.50
Total operation expenses	(Thousand Riel)	3,433	12,992	67,663	468,780
Average generation cost	(Riel/kWh)	3.69	13.14	62.08	189.29
Deflated cost	(Riel/kWh)	3.69	5.11	10.93	11.11

Table I.6.4 Average Sales Cost

Item		1989	1990	1991	1992
Total sales	(Thousand kWh)	299.30	359.10	369.00	1,204.20
Total operation expenses	(Thousand Riel)	3,433	12,982	67,663	468,780
Average sales cost	(Riel/kWh)	11.47	36.18	183.37	389.29
Deflated cost	(Riel/kWh)	11.47	14.08	32.28	22.85



TITLE	Figure I.6.1 PLAN OF EXISTING POWER STATION

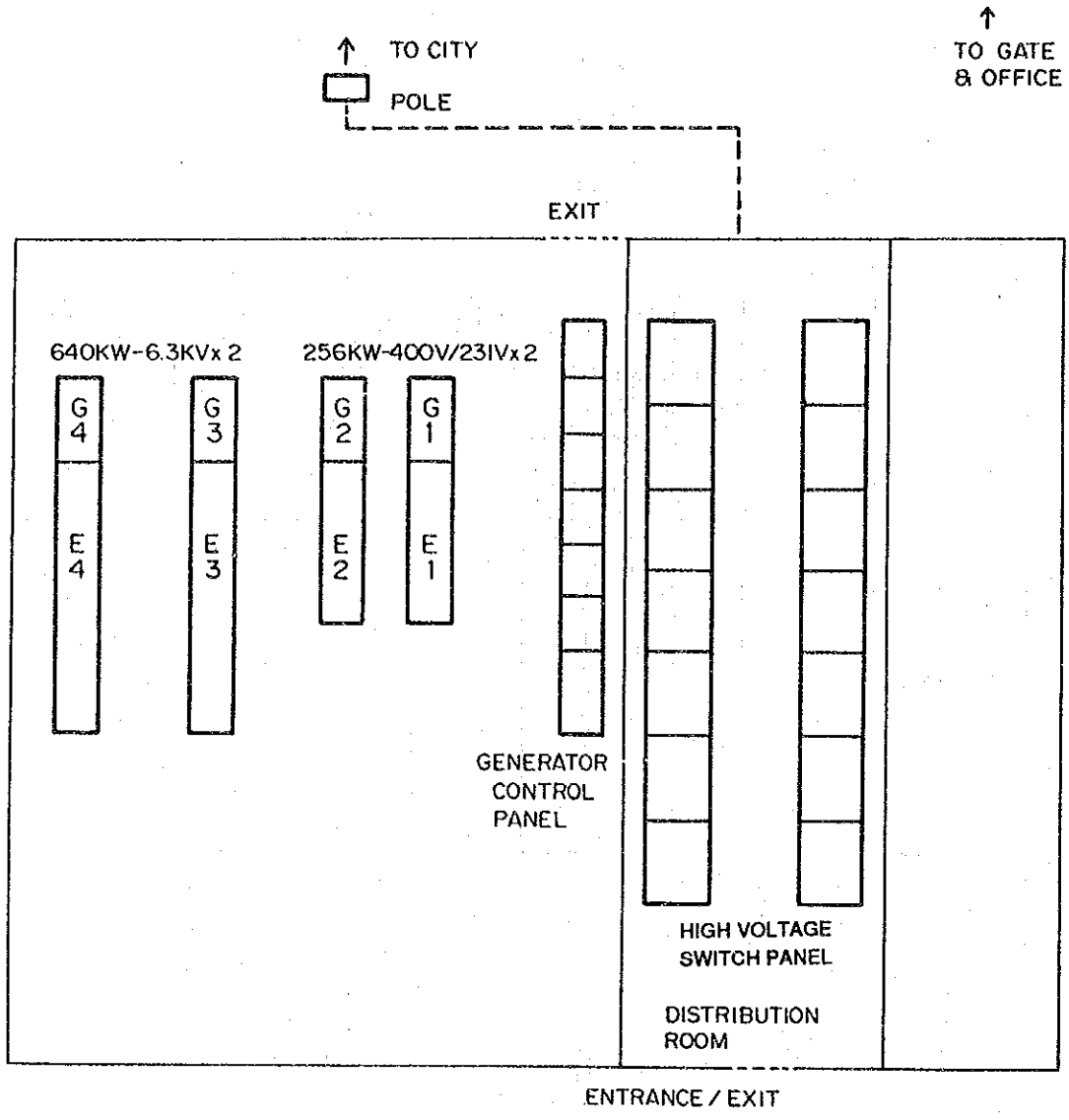


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Figure I.6.2
PLAN OF OLD POWER STATION

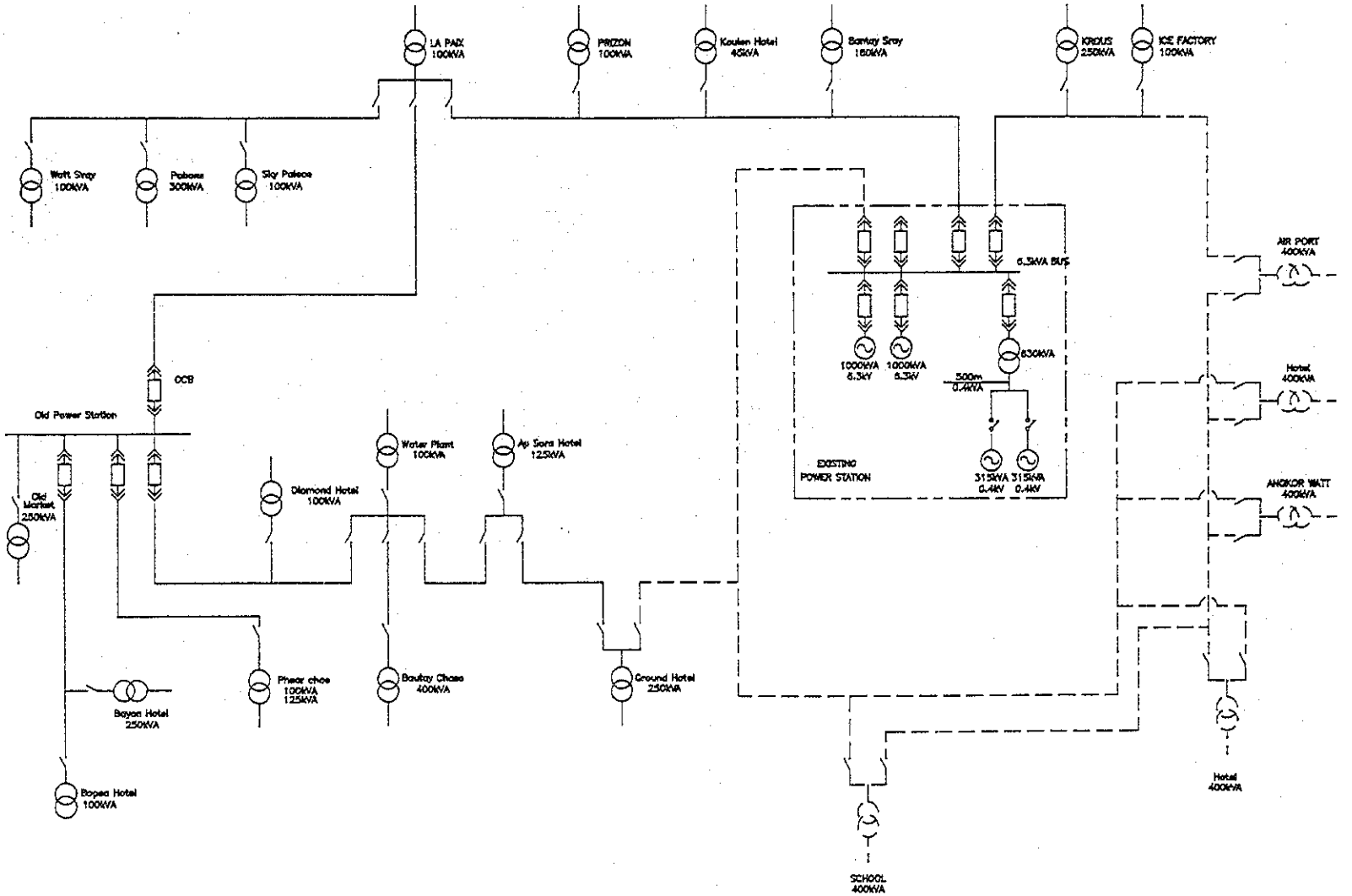

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Figure I.6.3
DISTRIBUTION LINE NETWORK

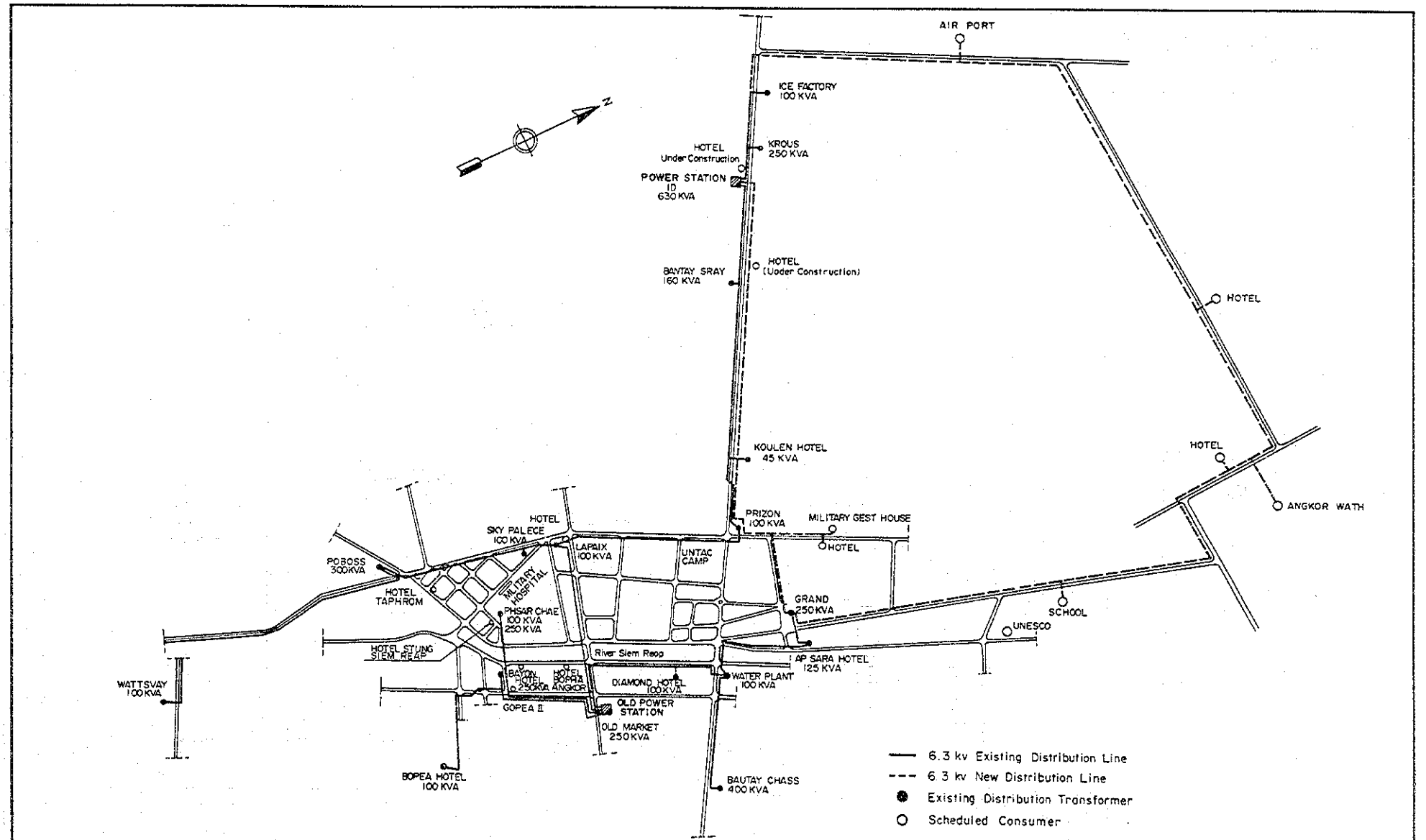

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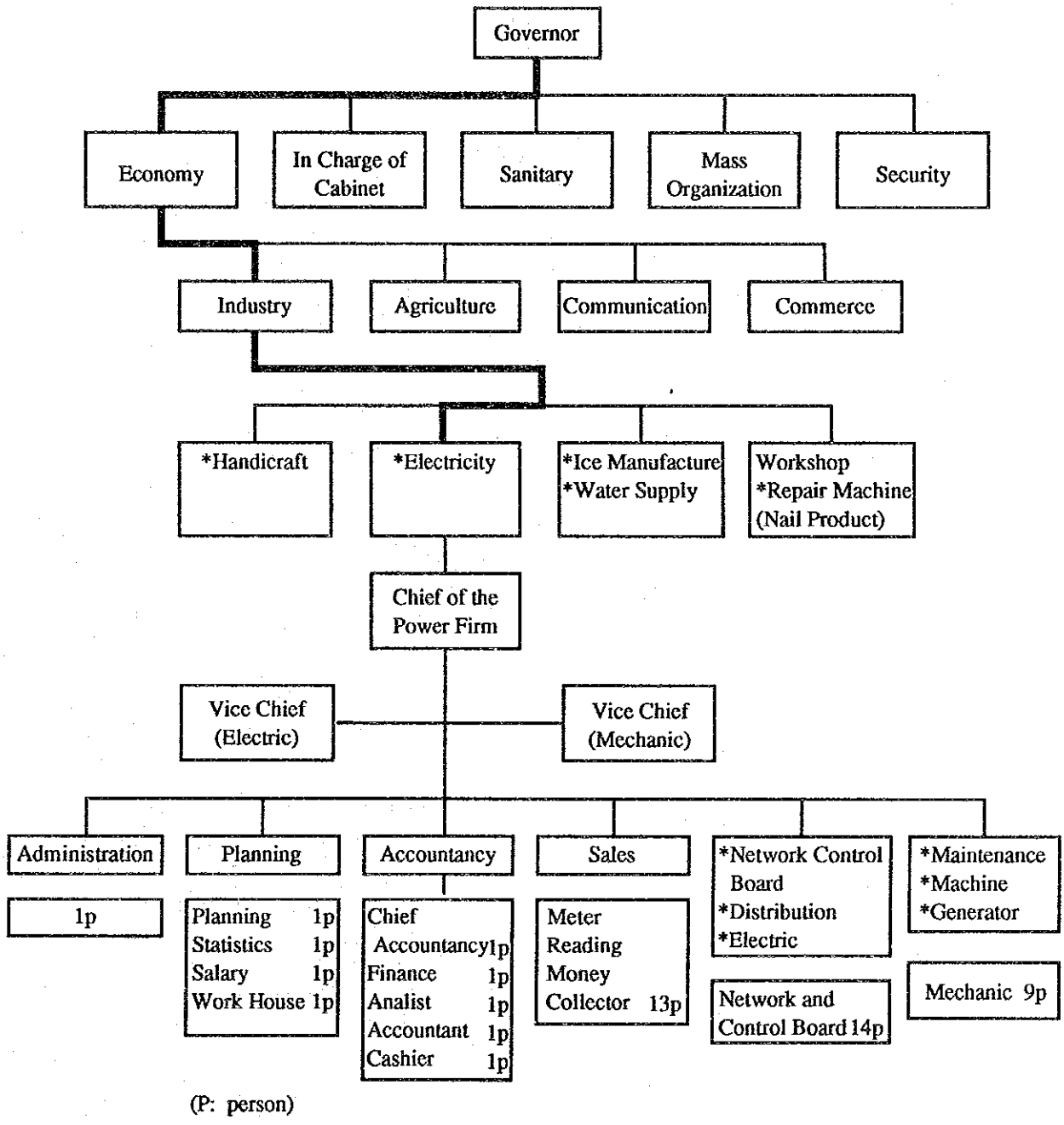
Figure I.6.4

DISTRIBUTION LINE ROUTE MAP

Figure I.6.5
Organization of Siem Reap Electricity Industry



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Chapter 7

Power Demand Forecast

CHAPTER 7 POWER DEMAND FORECAST

7.1 Phnom Penh

7.1.1 General

As discussed in detail in Chapter 5, out of the 26 existing generation units in the 4 power plants, only 12 units were in service as of January 1993 (the others are either worn out and cannot be replaced due to the lack of financing resources, or have broken down and cannot be repaired because no spare parts are available). These 12 units can provide a maximum of 24 MW whereas the total installed capacity is 71 MW.

Consequently, EDP is unable to provide the electric power required by the city and must resort to load shedding every day. The present electricity output is therefore not representative of the demand.

In this context, the real demand of customers is not accurately known. In order to estimate real demand, a load shedding study, which is difficult to conduct with accuracy, is required.

Forecasting the demand will thus be difficult as it will be based on estimated and, therefore, inaccurate present demand.

7.1.2 Sectorial Demand Analysis

Power demand forecast is normally conducted with a sectorial modeling of consumption by distinguishing at least 3 major sectors: domestic, tertiary, and industry. It is obvious that the more accurate the available statistical information is the more reliable the forecast model will be.

In the case of Cambodia, the total absence of reliable sectorial data makes such an approach hazardous. There is neither a recent breakdown of sales showing the domestic, tertiary and industry sectors nor a sectorial analysis of power demand available in the country. Therefore, the present overall demand was estimated on the following:

(a) The maximum power to be generated per year,
(b) The annual energy to be provided, and
(c) The annual/monthly load curves.

Due to a lack of sufficient information, it seems impossible to divide the demand into the recommended sectors, therefore a more simplistic breakdown is recommended, as follows:

- Domestic sector, and
- Non-domestic sector (tertiary, industry, public).

The forecasts were made for potential demand assuming there are no generation or network constraints.

The socio-economic environment in the coming years has been forecasted on the basis of the following elements after careful review:

- Number of inhabitants,
- Number of households,
- Electrification rate,
- Household demand,
- GDP trends,
- Demand of non-domestic customers, and
- Loss rate trends.

7.1.3 Review on Present Market

Since no reliable and detailed historical records are available, power demand is forecasted on the basis of 1992 information. The power demand forecast was based on the following:

(a) Potential demand of domestic customers in 1992, and
(b) Potential demand of non-domestic customers in 1992.

For estimation of those demands, examinations of the following items have been conducted:

(i) Generation
(ii) Sales
(iii) Energy losses
(iv) Load shedding
(v) Private generation

The results of the examinations are as follows:

(1) Power Tariff System

It would be useful to provide some details about the various tariff structures adopted over the last few years. They determine to a fairly considerable extent the statistical results of electricity sales, and therefore define the level of useful information that can be obtained from it for the purpose of performing a sectorial consumption analysis. However, since the present tariff system does not provide appropriate customers' categories, results of the examination will not reflect to the demand forecast.

(2) Generation

(a) Generation Record

Recent statistics on electricity generation are abundant and kept up-to-date by the staff of EDP. However, the generating facilities are in a permanent state of failure, so the output is not representative of demand.

For the past 2 to 3 years, more artificial indicators have also been directly available, such as daily and monthly energy generation or maximum and minimum power per day.

	1985	1986	1987	1988	1989	1990	1991	1992
Generation (GWh)	143	146	165	183	200	183	114	141
Peak Power (MW)	26	26	28	30	34	26	29	25

The annual generation records since 1980 shows a period of growth up to 1989, followed by a fairly sharp drop in 1991. A recovery was observed in 1992.

(b) Seasonal Variation

The examination of seasonal variations of energy consumption for the year 1992 showed that no seasonal movement was recorded because the temperature is extremely stable throughout the year. At present the main use of electricity sensitive to temperature, air conditioning, only concerns hotels/restaurants and large villas where foreigners live, which are supplied

by private generators and, in any case, are air conditioned throughout the year.

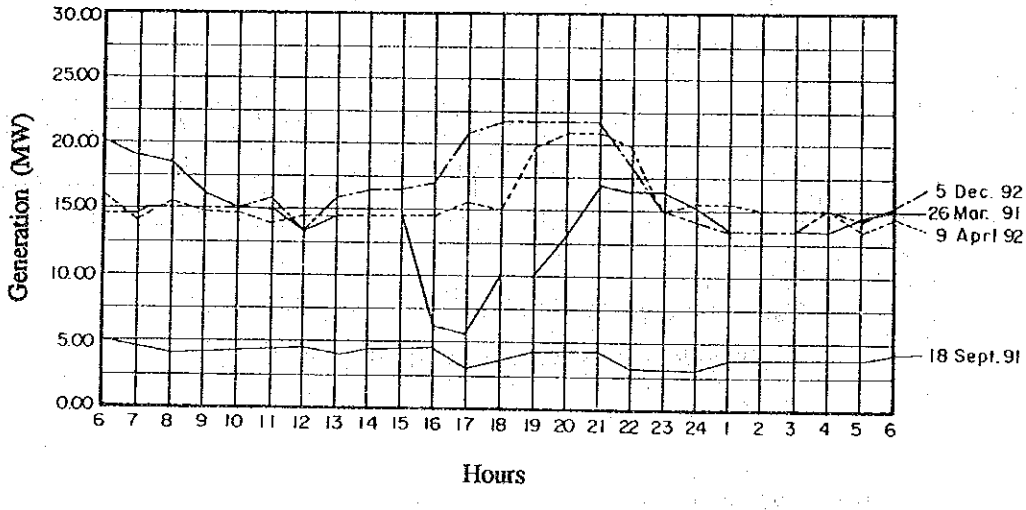
It should be mentioned that the potential demand cannot be met with the existing generating facilities and that consequently, all potential demand fluctuations (weekly, monthly, or even yearly) are leveled out due to the generation constraints.

(c) Load Curves

The following are typical daily load curves of the Phnom Penh power system on (i) 26 March 1991, (ii) 18 September 1991, (iii) 9 April 1992, and (iv) 5 December 1992. The load curve (i) shows the outage of the steam unit in No.2 power plant around 4 pm and (ii) shows a break in fuel oil supply and shut down of all diesel generating sets.

Those curves show loading condition under the scheduled load shedding and therefore are unable to be used for the purpose of demand forecasting.

Daily Generation Curve



(3) Sales

Total sales in the year 1992 was 96.5 GWh, and the breakdown is as follows:

Customers	Share of Sales	No. of Customers
Municipal Services		
- water supply	6.6	8
- public lighting	1.0	55
- others	1.9	73
Government offices	30.6	322
Embassies	4.7	28
EDP direct customers	21.7	801
Wholesalers	28.3	138
Losses	5.2	-
Total	100.0 %	1,425

These sectorial breakdowns are not detailed enough to allow an analysis of sales for the major economic sectors. Thus, the domestic consumption values do not appear clearly in the table above. A major number of the public offices staff and state organizations staff live near their place of work and are connected to the substation supplying their employer. Thus, the employees benefit from free electricity and their consumption is included in that of their employer.

(4) Technical and Non-technical Losses

At present, the losses observed between the energy generated and the energy invoiced are outlined in terms of percentages as follows:

Generation	100.00%
Energy supplied	95.00% (5% for power plant auxiliaries)
Energy to transformers (MV/LV)	90.25% (5% losses on the MV network)
Energy sold	81.22% (10% non-technical loss)
Energy used	71.50% (12% discount to agents)
Energy invoiced	68.00% (5% outstanding payments)

(5) Load Shedding

EDP has to resort to daily load shedding as it is unable to provide the required electric power.

Since September 1992, load shedding has been carried out according to a weekly pre-arranged plan which changes day-to-day.

The load shedding is achieved in two ways. First, a number of substations are switched off, either individual substations or switching points. Second, feeders at the power stations are switched off by circuit-breaker operation. The former are longer interruptions (4 to 5 hours), while the latter are more flexible and of shorter duration (1 to 3 hours).

The state of the system can therefore be analysed during the peak operation, since the following is available for every day:

- Power measurements at each feeder of each power station at 7 pm and
- Details about the switching off of feeders and network sections between 2 substations.

An estimate of the prospective maximum demand without load shedding can be made by proportioning the actual demand over the MVA rating of the substations being supplied up to the MVA rating of all the substations of the system.

The results are as follows:

Total transforming capacity	107 MVA
Sum of maximum demand during the day	22 MW
Sum of maximum demand at night	28 MW

By applying the ratio 28/107 (i.e. 26%) to the transforming capacity interrupted by the local shedding at a given time, an estimation of the interrupted power can be obtained.

These calculations were carried out over a period of several days in December 1992 (Saturday 19, Sunday 20, Monday 21 and Tuesday 22), at 7 pm, and the results indicated that load shedding varying between 5 and 8 MW. Therefore, the maximum potential power demand was estimated between 33 and 36 MW. Such reasoning is however doubly biased:

(a) By adding the maximum demand measured in each of the substations, the total maximum demand is overestimated, since the coincidence factor effect is disregarded (however, one may suppose that it is high during the evening peak).

(b) Allowance is not made for the potential demand of customers (such as some hotels/restaurants) who have their own private generator and supply themselves systematically whether or not load shedding occurs.

(6) Private Generation

Hotels/restaurants, plants, shops, as well as embassies, administrative offices and even villas for foreigners operate their own generating facilities.

The boom in the sale of generating sets took place in 1992. More than 300 sets, either new (mostly Japanese equipment) or used (from Singapore), were sold in the city of Phnom Penh.

It is difficult to estimate the total installed capacity in kVA and still more so the capacity is induced in kW because of the varied utilization behavior:

(a) Some customers, normally supplied by the EDP network, only switch on their sets if there is a voltage interruption,
(b) Some are supplied permanently by their sets, and
(c) Finally, some customers have part of their installation connected to the network and part to their sets: for example: in the evening, a restaurant may supply its kitchens with its sets and use the public network to light the dinning area (and, of course, switch over if needed).

7.1.4 Bases for Demand Forecast

(1) Domestic Demand in 1992

To have a good understanding of domestic consumption, it must be broken down into uses, in other words, in terms of electric appliances.

Since there are major disparities in the standard of living in Phnom Penh, the following 3 categories of households corresponding to 3 salary levels will be assumed:

(a) High level

This category is composed of foreigners (United Nations representatives, NGO members, embassy personnel, etc.) as well as high-ranking Cambodian civil servants and Cambodian businessmen. These people live in large villas and have a western way of life.

(b) Medium level

This category is composed of relatively well-to-do Cambodian families (the country's executives) living in small individual houses or flats.

(c) Low level

Most of the inhabitants of the capital are in this category. They are low-income persons dwelling in three- or four-storey buildings which are a part of the ordinary landscape of the city.

The breakdown per type is assumed to be as follows in 1992:

High level	Medium level	Low level
5%	15%	80%

A detailed analysis of the unit consumption values of electric appliances and of household equipment rates makes it possible to obtain daily consumption and power demand estimations (see Tables I.7-1 and I.7-2).

From the tables, the following results are obtained:

		High level	Medium level	Low level	Average
Daily (kWh)	consumption	52	7	1	4.6
Monthly (kWh)	consumption	1,588	211	35	140
Annual (kWh)	consumption	19,056	2,527	425	1,670
Peak demand (kW)		3.8	0.6	0.2	0.45

In order to confront these theoretical estimations with reality, sales readings of three (3) MV/LV substations (No. 262, No. 375 and No. 189) were analyzed during the first fortnight in January 1993 (reading and invoicing are done fortnightly in Phnom Penh).

Substation No. 262

Located in the urban district of Tul Kok, in the western part of Phnom Penh, this substation is representative of the poorest areas of the capital. Its capacity is 200 kVA. Only a private group is supplied by this substation: there is no direct EDP customer. From 1 to 15 January 1993, the total energy demand was 9,856 kWh.

Substation No. 375

This typical substation, located in the Chamker Mon district, supplies a rather residential quarter where a number of villas for foreigners are situated.

It consists of two transformers:
- One with a capacity of 200 kVA for the services of the Ministry of Education, and
- One with a capacity of 315 kVA for a private group (wholesaler).

For the 1st fortnight of January 1993, the energy sold to the group was 26,000 kWh.

Substation No. 189

This substation, located in the center of town (district 7 Makara), is considered as a "large" substation:

It consists of two transformers:

- One with a capacity of 315 kVA for 5 direct customers and
- One with a capacity of 560 kVA for a private group.

Sales from 1 to 15 January 1993 came to 70,000 kWh.

Besides, the number of customers in the supply areas of the substations is as follows:

Monthly Consumption (kWh)	Substation No. 262 (No.)	Substation No. 375 (No.)	Substation No. 189 (No.)	Total (No.)
below 100	174	151	480	805
100 - 200	22	27	400	449
200 - 400	12	26	98	136
above 400	8	28	23	59
Total	216	232	1,001	1,449

The percents of customers with monthly energy consumption below 200 kWh, 200 to 400 kWh, and above 400 kWh, are 86.5%, 9.4%, and 4.1%, respectively. Those figures are similar to those assumptions mentioned above for low, medium, and high level customers.

Considering the 3 areas, the average monthly consumption of a customer is computed from their half month sales of 146 kWh/customer which was calculated as follows:

$$(9,856+26,000+70,000)x2/(216+232+1,001) = 146 \text{ (kWh/customer)}$$

There is another source of comparison by using the work conducted at the Ecole Technique Supérieure Khmero-soviétique de Phnom Penh. For the past few years, the students of the electricity section have been studying, for practical work, the city's present and future electricity distribution, under the supervision of Professor A. Gremiakov. During the network calculations, which they perform accurately, the Cambodian students consider the average peak demand values in 1995 to be:

- 3 kW for villas
- 1 kW for medium dwellings and

- 0.5 kW for flats.

The consistency between all those values (theoretical estimations, measurements, students' work) deems that domestic demand for the year 1992 in this report are reasonable. The estimations have also been agreed by EDP.

The population of Phnom Penh is estimated by the Municipality at 674,509 inhabitants in mid-1992. This figure corresponds to the number of permanent residents. It includes neither temporary residents nor illegal inhabitants, who are nevertheless also likely to consume electricity. However, the exact number of inhabitants is not really known. According to sources, estimations vary between 600,000 and 1,000,000. The Study Team selected the median value of 800,000 inhabitants in 1992.

The number of persons per household according to the Municipality's statistics is 6, and hence the number of households was estimated at 133,333.

The electrification rate in 1992 for Phnom Penh was estimated by EDP to be 40%; hence 53,330 households are supplied with electricity.

Considering a load coincidence factor of 0.7, the theoretical maximum power demand of domestic customers in 1992 was estimated at a value of:

$$0.45 \times 53{,}330 \times 0.7 = 17 \text{ MW}$$

(2) Non-domestic Demand in 1992

The demand of those customers is estimated after assessing the load shedding effect.

In 1992, the generation peak was 25.2 MW at 9 pm on 14 April. If a technical loss rate of 20% is applied, a total of 20 MW of demand was met by EDP. Domestic consumption at that time, with the priority given in the evening to private individuals, was estimated to be 14 MW, out of the 17 MW of potential domestic demand.

It can therefore be estimated that about 6 MW of non-domestic demand were met by EDP.

The non-domestic demand met by private generators is assessed to be at least 10 - 12 MW. A statistical report available from EDP's Planning Department confirms that these estimates are realistic.

Grouping the customers by activity sector gives the following results:

Sector	kW
Hospitals	1,560
Radio/TV	1,100
Army/Police	2,600
Embassies	1,050
Hotels	3,550
Press	450
State Institutions	1,850
State Factories	12,450
Total	24,610

The sum of the maximum demand values (24.6 MW) is, of course, a majorant of the total maximum demand and, in particular, of the power demand during the peak period (7 pm - 8 pm). A coincidence factor of 50% can be applied to the peak hour and thus the power demand was estimated between 12 and 13 MW. Since 1989, the number of hotels/restaurants has increased significantly. It is feasible that the value of 12 or 13 MW in 1989 had increased to 18 MW in 1992.

(3) Number of Inhabitants

In 1992, the estimated population of Phnom Penh varies between 600,000 and 1,000,000 and, of the whole country, between 8.5 million and 9 million. As previously mentioned in section 7.1.4 (1), the population of the capital was estimated at 800,000.

An essential element in the population that should be taken into consideration is the extreme youth of the population: 50% of Cambodians today are under 20 years of age. The natural population growth rate (defined as: birth rate-mortality rate) was estimated at 2.5% in 1986 whereas the world average is 1.6%.

A slowing down of the population growth rate is not very likely in the near future, due to the fact that birth control is not widely practiced, a new and appreciable drop in mortality rate should occur, and, in view of the young population, there will be many marriages before new trends are seen.

The growth rate of 2.8% per annum is used in most of the studies on Cambodia conducted by international organizations. It is applied to the country as a whole, however, it is advisable to distinguish rural areas form urban areas and, in particular, from the capital. Rural poverty, the irregularity of harvests and, therefore, of income, and the attraction of better living conditions in urban areas encourages thousands of rural people to leave their villages for the large urban centers. Many Cambodians head for Phnom Penh with the hope of easily finding a lucrative job (strong tourist development expected, hence business expansion, etc.). The same situation is envisaged for many demobilized soldiers and Cambodians who took refuge abroad and are now returning to their homeland.

It is justified to expect a population growth rate of +4% per annum in Phnom Penh. This is also the value proposed for the urban population by the Japanese Engineering Consulting Firms Association in its report on the reconstruction and development of Cambodia (1992).

(4) Number of Households

The average traditional Cambodian family has from 4 (in the city) to 6 (in the country) children. The statistics provided by the Municipality of Phnom Penh show 6 as the average number of persons per household in 1992.

The number of households is therefore obtained by dividing the number of inhabitants by 6.

(5) Electrification Rate

The household electrification rates provided by EDP for the last few years are as follows:

1988	22%
1989	28%
1990	33%
1991	36%
1992	40%

With the Government granting priority to private individuals and EDP's financial situation recovering since the setting up of private concessioners, it is hoped that the work to rehabilitate the Low Voltage network (initiated with the assistance of France) will result in real distribution improvement and make it possible to improve the electrification rate.

A 2.5% increase per year of the household electrification rate assumed by EDP is agreeable.

(6) GDP Trends

The growth of professional demand will be indexed to that of industrial GDP. Since Cambodia has been ravaged and disorganized by years of war, it is difficult to come up with reliable estimations of macro-economic performance indicators.

The Cambodian authorities gave the following estimations for industrial GDP growth rate:

1991	+ 8.6%
1992	+ 9.0%
1993	+10.0% (Ministry of Planning forecast)

This growth rate of 10% in 1993 is relatively high, but not unfeasible if it is compared with the average annual growth rates in ASEAN countries provided by the World Bank.

Country	Period	GDP	Breakdown			
			agricult.	industry	manufact.	services
Indonesia	1965-80	7.0	4.3	11.9	12.0	7.3
	1980-90	5.5	3.2	5.6	12.5	3.7
Philippines	1965-80	5.7	3.9	7.7	6.8	5.0
	1980-90	0.9	1.0	-0.8	0.1	2.6
Thailand	1965-80	7.3	4.6	9.5	11.2	7.4
	1980-90	7.6	4.1	9.0	8.9	7.8
Malaysia	1965-80	7.4	-	-	-	-
	1980-90	5.2	3.8	7.1	8.8	4.2

Source: World Development Report 1992, The World Bank

If conditions become favorable again (lasting restoration of civil peace, arrival of foreign capital), Cambodia should experience major economic growth in the coming year, from which Phnom Penh, as the economic, social, political, and administrative capital, should benefit to a considerable extent.

The rebirth of the industrial sector began in the second half of the 1980s. It can be characterized by the re-emergence of small-scale, artisanal, and family-based establishments, and by the reactivation by the Ministry of Industry of medium and large-scale enterprises. These were supplemented by measures promoting private sector development, joint-venture companies, and wholly-owned foreign companies. However, the development of the industrial sector has been slowed by the lack of a reliable power supply.

The tertiary sector should experience a similar increase particularly in the services field. The country's tourism potential (mainly based on the Angkor Hindu and Buddhist temples at Siem Reap) is substantial. Most of the tourists spend at least one night in Phnom Penh, and the capital is expecting positive spin-offs (hotels, restaurants, business, crafts, etc.).

The presence of a considerable number of United Nations representatives in Phnom Penh has given rise to an impressive number of hotels and restaurants. Even if one were to express doubts about the capacity of all of them to survive, it is nevertheless obvious that this sector should become an essential part of the city's activity and largely contribute to electricity demand.

All these considerations lead to select a sustained growth rate for the 1993 - 2000 period as follows:

1992/1993	+10%
1993/1994	+10%
1994/1995	+10%
1995/1996	+ 9%
1996/1997	+ 9%
1997/1998	+ 8%
1998/1999	+ 8%
1999/2000	+ 8%

(7) Loss Rate Trend

Technical losses were estimated to be 20% in 1992. The rehabilitation of the Low Voltage network, theoretically provided for the short term if the required funds are available, should make it possible to gradually lower this rate. Although this improvement was not quantified by EDP, it is realistic to consider a reduction of 0.5% per annum in the technical loss rate.

(8) Load Factor

This value is representative of main domestic consumption. However, the noteworthy restart-up of the tertiary and industrial sectors will be expressed by an initial increase in the load factor. It will increase linearly up to 70% in the year 2000.

7.1.5 Demand Forecast

(1) Assumptions

It is important to emphasize that the forecasts were based on a large number of assumptions (and it is therefore "necessarily" marred by a wide margin or error) which were rather optimistic. The assumption are as follows:

(a) Institution of long-term peace in Cambodia,
(b) +4% population growth per annum in Phnom Penh,
(c) +2.5% increase in the household electrification rate per annum,
(d) Overall rise in the standard of living of households: increased demand per type of household and deformation of the structure of society (more medium-level households),
(e) GDP growth rate between 11% and 8% per annum, and
(f) 0.5% reduction of technical energy losses per annum.

(2) Potential Demand

It should also be mentioned again that these forecasts are forecasts of potential demand, i.e., the demand which would be expressed without any generation or network constraint.

(3) Change of Situation

The possible departure of United Nations forces from Cambodia would result in a significant decrease of electricity demand estimated at -10% as there would be a departure of many persons with a high standard of living, and a drop in the activity of hotels, restaurants, clubs, etc.

(4) Domestic Demand

The power demand of an average household during the peak period is estimated at 450 W in 1992 as discussed in section 7.1.4 (1).

In order to express the expected increase in the standard of living, the domestic customer structure is assumed to develop as follows:

Level	1992	1995	2000
High level	5%	5%	5%
Medium level	15%	20%	25%
Low level	80%	75%	70%

A yearly increase of 2% in individual demand for each type of household will also be assumed. A coincidence factor of 70% will be applied to the sum of individual demands.

(5) Non-domestic Demand

The demand analysis conducted for 1992 revealed an estimation for non-domestic customers of 18 MW. Using this value as a basis, it will be evolved proportionally to industrial GDP (with an elasticity factor of 0.8).

(6) Results of Demand Forecast

Combining all the elements mentioned above gives the following annual generation forecasts in power and energy. Further details are shown in Table I.7.1 and I.7.2.

	1992	1993	1994	1995	1996	1997	1998	1999	2000
Peak Demand (MW)	44	47	53	58	62	69	76	83	89
Generation (GWh)	230	253	291	322	354	401	449	499	548

7.1.6 Comparison with Other Forecasts

(1) Soviet Study of 1989

A study was conducted in 1988 by a Soviet institute "Energosetprojekt". It involved analysing the development of the Cambodian power system from 1990 to 2005. An electricity demand forecast was performed according to a sector-based breakdown:

(a) Industry
(b) Domestic
(c) Administrations
(d) Public lighting

The forecast was carried out for the cities of Phnom Penh and Kompong som. as well as for the various provinces. The estimated values for Phnom Penh are as follows:

	1990	1995	2000	2005
Peak Power (MW)	60	90	165	265
Generation (GWh)	265	400	740	1,250

The assumptions which led to those results are not clearly defined.
The demand growth which emerges seems optimistic and overestimated.

(2) UNDP Study

This study was conducted in 1992 within the scope of a UNDP project on Cambodia "Technical assistance for rehabilitation of the power utilities of Phnom Penh and Sihanoukville".
Peak demand values in the report are given for 1992 to 1995.

Demand (MW)	June 92	Dec. 92	Dec. 93	Dec. 94	Dec. 95
Hypothesis-1	60	63	70	77	84
Hypothesis-2	40	42	46	51	56
Hypothesis-3	35	37	42	47	52

Absolutely no explanation is given in the report on the way these values were obtained. It should simply be stated that the peak demand increase rate varies between +10% and +12% per annum, depending on the scenarios.

(3) EDP Study

As part of a requested by the Municipality of Phnom Penh to the Japanese Government, "Request for Japanese grant aid for rehabilitation of electric sector in Phnom Penh", electricity demand forecasts were made for the period 1991-2010.

The principle of the energy forecast is simple (global extrapolation), but sensible:

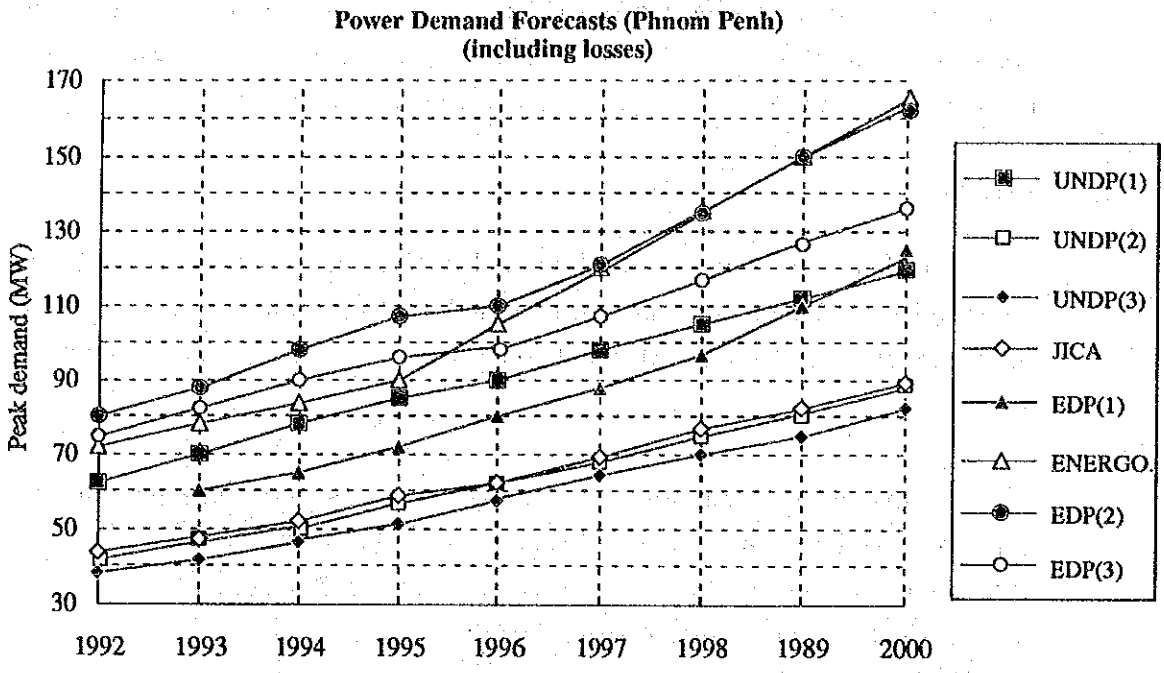
(a) Point of departure: energy sold and losses in 1990.
(b) 2 energy demand growth scenarios +9% and +11% per annum,
(c) Decrease of losses by 1% every 5 years.

Demand forecasts (maximum annual demand) are, traditionally, obtained by applying a load factor to the planned output. The load factor used is 32.6% in 1990 and it is increased 3% every 5 years.

There is another document in circulation at EDP which makes mention of forecasts. The document in question presents in a graphic manner the supply-demand balance in the future. It also shows an annual peak demand curve. It appears that a global annual growth rate of + 11% is applied, starting from a basis of 60 MW in 1993.

(4) Graphical Comparision of Power Demand Forecasts

The above-mentioned forecasts (potential demand including losses) from 1992 to 2000 were graphed on the same chart as follows:



N.B.: UNDP values have been extrapolated from 1996 till 2000.

JICA forecast values are very close to UNDP scenario 2 values. It can be noticed that the curves are mainly distinguishable from each other by their starting points: in 1992, the estimated potential demand varies between 37 MW (UNDP 3) and 79 MW (EDP).

All forecast experts agree that an annual growth rate of about 10% is appropriate.

7.2 Siem Reap

7.2.1 General

Located 310km from Phnom Penh, not far from the Tonle Sap Lake in the north-western part of Cambodia, the city of Siem Reap is known for its proximity to the Angkor site. Siem Reap would be a small provincial town, or even a village, with only a farming vocation and no economic development prospects in the short term, if it were not located near this substantial tourist development potential site.

The town is supplied with electricity from a single power station consisting of 4 diesel generators. Although electricity demand is very low, the limited generating facilities available do not make it possible to meet even this demand and the electricity utility has to resort to load shedding every day.

N.B: Oddly enough, this electricity utility has borne no official name since the breakup of Electricite du Cambodge; for the sake of convenience, it shall be called Electricite de Siem Reap (EDSR) in this report.

7.2.2 Review of Present Market

(1) Tariff Categories

Three (3) categories of consumers in EDSR's system were distinguished according to the continuity of service from which they benefit:

(a) Category 1: Customers supplied with power 24 hours a day

The main customers in this category are the town's large hotels. These customers pay either in local currency: 720 Riels/kWh, or in US$: 0.3$/kWh (1992 tariff)

(b) Category 2: Customers supplied at least 18 hours a day (18 hours guaranteed by contract), in other words, evening, night and several hours during the day.

This Category is composed of shops, small handicrafts, etc. At present, these customers are invoiced at the same rate as customers in Category 1, i.e., 0.3 $/kWh (despite a lower quality of service).

(c) Category 3: Customers supplied whenever possible.

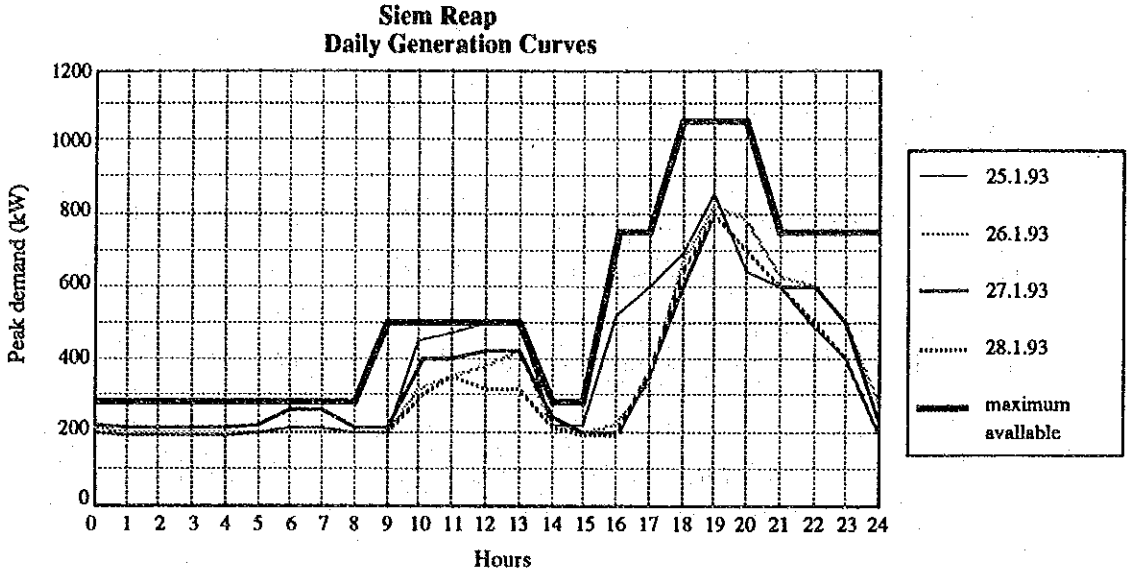
The customers are domestic and pay 320 riels/kWh.

(2) Generation

In Chapter 6 was discussed the generation in the EDSR system in detail. As similar to the Phnom Penh power system, scheduled load shedding is enforced in the town. However, the operating schedule of the sets was determined with good sense and for the purpose of :

- Making careful use of equipment and
- Providing electricity, if possible, when people need it the most, in other words, in the evening.

The same schedule is applied every day, except in case of a breakdown or exceptional event. The maximum daily generation curve is therefore as follows (thick line):



As was the case for Phnom Penh, the generation is not representative of the demand because of load shedding.

	1989	1990	1991	1992
Output (MWh)	930	989	1,090	2,476
Growth Rate	-	+6%	+10%	+127%

The considerable increase in 1992 is due to the arrival of several United Nations peacekeeping units and especially to a significant resumption in tourist activity.

(3) Sales

Meter reading and invoicing take place at the end of each month. Sales statistics show 5 customer categories:

(a) Domestic (payment in Riels),
(b) Houses for foreigners (US$),
(c) Hotels and restaurants (US$),
(d) Administrations (Riels),
(e) Leaders (Riels).

The breakdown of sales for the months of September (wet season) and December (dry season) 1992 are given below:

Month	September			December		
	kWh	%	No. of Customers	kWh	%	No. of Customers
Domestic	27,867	24	1,205	20,682	17	1,321
House for foreigners	13,108	11	59	17,894	15	59
Hotels and restaurants	61,601	53	10	58,318	48	12
Administrations	12,248	10	52	21,433	18	52
Leaders	2,372	2	17	1,973	2	17
Total	117,196	100	1,343	120,300	100	1,461

The past sales and growth rates were as follows:

	1989	1990	1991	1992
Sales (MWh)	299	359	369	1,204
Growth Rate	-	+20%	+3%	+226%

(4) Technical and Non-technical Losses

Past generation and sales figures given above reveals extensive losses:

	1989	1990	1991	1992
Generation (MWh)	930	989	1,090	2,476
Sales (MWh)	299	359	369	1,204
Losses (MWh)	631	630	721	1,272
Losses (%)	68	64	66	51

The fairly marked reduction of the global loss rate observed between 1989 and 1992 can be explained by the installing of meters on the premises of customers who had none. For these customers, the invoices were estimated in a lump sum manner on the basis of declared electric appliances. This process inevitably led to fraud. In December 1992, of 1,461 customers, only twenty or so were still without meters.

EDSR admits its inability to break down the overall losses into technical and non-technical losses. One certainty is that both are substantial:

(a) Non-technical losses because there is generalized fraud and because neither EDSR nor private concessions attempts have curbed it.
(b) Technical losses because the overhead network is outdated and in poor condition.

In any event, it is considered that losses were approximately 50% of production in 1992 of which 25% were technical losses and 25% were non-technical losses.

(5) Load Shedding

Category 1 is never cut off (except for a serious failure). If required, load shedding occurs in Category 2 on an alternate basis. An analysis below provides an idea of the extent of load shedding.

Situation 1992 (source: EDSR)

Number of transformers	19 (including 3 not yet in service)
Total capacity	3,745 kVA
Normal maximum power demand	795 kW
Exceptional maximum power demand	1,415 kW

Maximum power demand means the sum of maximum power demand values read in the transformer houses on days without load shedding. It therefore constitutes a majorant of the real maximum power demand. A look at the prevailing operation diagram (maximum capacity available about 1,000 kW) shows that in "exceptional" cases (holidays, receiving of distinguished visitors, etc.), load shedding may be assessed at 400 kW.

(6) Private Generation

As is the case in Phnom Penh, almost all the professional customers are equipped with private generating sets to cope with load shedding.

Among the hotels, it is curious to note that one of the largest, the "Grand Hotel d'Angkor" is solely supplied by the public network (250 kVA transformer plus a

100 kVA transformer for the neighbouring Apsara Villa); this makes it EDSR's biggest customer.

The provincial authorities wish to control the purchasing of private generators, which amounts to a loss of foreign currency. Any customer desiring to buy such equipment has to request prior authorization from EDSR.
Examples of private generators:

Ice factory	100 KVA
Ta Prohm Hotel	200 kVA
Bayon Hotel	200 kVA
Stung Siem Reap Hotel	100 kVA
Baray Hotel	35 kVA
UNTAC-French Civil Eng. Section	2 x 125 kVA

Apart from the ice factory that mainly uses its own set, the other customers are supplied by the public network, only switching over to their generators in case of voltage interruption. Accordingly, load shedding and private generation may be assimilated.

7.2.3 Bases for Demand Forecast

(1) Domestic Demand in 1992

The standard of living in Siem Reap is much lower than in Phnom Penh. The population makes its living from farming and dwells in straw huts.

The sales statistics show a monthly consumption of about:

20 kWh for an average domestic customer
260 kWh for a villa for foreigners
130 kWh for a leader

These figures are well below the normative values for Phnom Penh.

EDSR even makes mention of households consuming barely 1 kWh per month.

It is true that these customers are supplied for only 12 or so hours per day, but the high cost per kWh combined with their low income, means that, these customers

would be unable to consume much more under the present circumstances in any case. The electricity is used for lighting and ventilation; there are few television sets.

According to the sale statistics, the "basic" domestic customers in Siem Reap, who represent 90 to 95% of the domestic consumers, may be assimilated to "low level" domestic customers in Phnom Penh, while foreigners and high ranking people may be assimilated to "medium level" customers in Phnom Penh. Their consumptions are lower (mainly because customers are supplied only for 10 to 12 hours a day) but their peak demands may be deemed similar.

The average household demand in Siem Rep is therefore estimated to be around (0.9 to 0.95 x 200 + 0.1 to 0.05 x 600) 240 W to 220 W.

To change over from individual domestic demand to total domestic demand, the number of electrified households must be known. The population of Siem Reap in 1992 is estimated at 80,000 inhabitants if the suburbs are included, 30,000 if only the downtown area is considered.

The number of persons per household is 6, hence the number of households comes to 13,333. The electrification rate is very low, about 10% in 1992, i.e., 1,333 electrified households (value consistent with the figure of 1,321 domestic customers which emerges from the sales statistics).

Considering a load coincidence factor of 0.7, the following value of the theoretical maximum demand by domestic customers in 1992 is estimated as follows:

$$0.23 \times 1{,}333 \times 0.7 = 215 \text{ kW}$$

(2) Non-domestic Demand in 1992

(a) The exceptional maximum power demand recorded in 1992 was 1,415 kW, which is a excellent reference to the power system and deemed to be the actual peak demand in the year excluding the potential demand of the UNTAC camp.

(b) The maximum demand of the domestic customers is estimated at 215 kW as above-mentioned.

(c) The total estimated maximum demand of non-domestic customers was 840 kW including hotels, restaurants, and other small industries. From the viewpoint, transformer capacity of the Grand Hotels/Apsara Villa (350 kVA) and private generators of other hotels (535 kVA), the potential demand of hotels is reasonably estimated at 600 kW. Total maximum demand of restaurants and other customers in the system is estimated at 320 kW.

(d) The technical losses in the system were 25% of generation and amount to 280 kW, accordingly.

(3) Number of Inhabitants

The population of the Province is fairly well known thanks to a census conducted in 1991 (with a view to the elections); there is about 555,000 inhabitants, including 80,000 in Siem Reap and suburbs. Reasons similar to those given for Phnom Penh indicate that a population growth rate of +4% per annum is appropriate for Siem Reap.

(4) Number of Households

Six persons per households is used throughout the study.

(5) Electrification Rate

The electrification rate was dramatically low in 1992, 10%, which leaves an enormous electrification potential. Outside the town center, electricity is mainly supplied to dwellings along roads (lack of materials for the construction of new lines, access made difficult by vegetation).

New housing estates are planned (Phoum Themei district), in particular to house those people who used to live in the Angkor area and who had to be resettled when a preservation order was placed on the site. This represents about 2,000 houses that have not been electrified in early 1993.

All households without electricity are potential customers of EDSR. Indeed, not only is electricity expensive, which makes people hesitate, but they must pay about 20,000 Riels (the customer pays for the connection equipment) for the connection. It is estimated that barely one third of the new inhabitants would be able to afford this expense.

It is assumed that the electrification rate will develop rapidly until it reaches 40% in 1995, then more slowly until it comes to 50% in the year 2000.

(6) Loss Rate Trend

Technical losses are estimated to be 25% in 1992. Assuming that the financial resources are made available to increase and rehabilitate the low voltage network, a drop in losses of 0.7% per annum can be considered as a realistic figure.

(7) Changeover from Power to Energy

A load factor of 50% was estimated in 1992 and it is estimated to increase linearly up to 60% by the year 2000.

7.2.4 Demand Forecast

(1) Domestic Demand

The power demand in 1992 during the peak evening period by an average household was estimated at 230W. In order to express the expected rise in the standard of living, it is estimated that this demand will increase by:

5% per annum from 1992 till 1994,
8% per annum from 1995 till 1996, and
10% per annum from 1997 to 2000.

(2) Non-domestic Demand

In 1992, there was almost no large industrial activity in Siem Reap. Apart from the power station and water authority, only an ice factory, a mechanical workshop, a dozen construction equipment factories, rice treatment plants, a few sawmills, and handicraft workshops exist.

On the other hand, hotel activity resumed in 1992 and will develop, if political conditions allow. At the end of 1992, Siem Reap had 8 hotels with a capacity of 300 rooms: 3 hotels are being built which will bring the town's accommodation capacity up to 500 rooms. Siem Reap's Planning Office is expecting 100,000 tourists in 1995 (10 times the 1992 figure).

Nowadays, Siem Reap airport receives around 200 passengers a day, and a hundred or so other tourists come by road. As communication facilities are supposed to develop in the next future and the airport is expected to retrieve its international status (direct flights from Thailand, Vietnam), a doubling of the number of tourists per day is possible. Tourists usually stay in Siem Reap for 2 or 3 days, so that a 2,000-room capacity is not an overestimation.

The predominance of this tourist activity will lead to professional electricity demand such as:

- The demand from hotels and restaurants.
- The demand from other customer categories.

Concerning hotels and restaurants, it was considered that a peak demand of 600 kW occurred in 1992. The demand from hotels of 600 kW will develop proportionally to the number of hotels built.

The demand be potentially much higher, not only during the day, but at night, if, for example, projects for the illumination of the Angkor Wat temple or the lighting of the airport runways are realized.

From 1992 till 1997 demand is considered to increase at a growth of 150 kW per annum, and 100 kW per annum from 1998 to 2000.

(3) Results of Demand Forecast

After combining all the elements mentioned above, the following annual generation forecasts (in energy and power) were obtained. Details are given in Table I.7.3.

	1992	1993	1994	1995	1996	1997	1998	1999	2000
Peak power (MW)	1.4	2.2	3.2	4.4	4.9	5.5	6.1	6.8	7.5
Generation (GWh)	(6.1)	9.8	14.8	20.6	23.6	27.4	31.0	34.9	39.4

It is noted that no other organization has ventured to make such forecasts.

Table I.7.1 Phnom Penh - Domestic Electricity Consumption per End-use (1992)

Appliances	Capacity (a) (W)	Equipment rate (b) (%)			Number of households (c)			Duration (d) (hrs/day)	Average consumption (Wh) (e)=(a)(b)(c)(d)			Number of appliances used during peak periods (f)			Power demand (W) (g)=(a)(b)(f)		
		High	Medium	Low	High	Medium	Low		High	Medium	Low	High	Medium	Low	High	Medium	Low
Lighting	60	100	100	100	50	20	2	6	18,000	3,600	720	20	4	2	1,200	240	120
Fridge	120	100	40	0	1.5	1	0	24	4,320	1,152	0	1.5	1	0	180	48	0
Iron	1,000	100	80	10	1	1	1	0.25	250	200	25						
Vacuum cleaner	500	50	0	0	1	0	0	0.5	125	0	0						
Kettle	600	100	30	0	1	1	0	0.25	150	45	0						
Radio-TV	100	100	70	50	1	1	1	4	400	280	200	1	1	1	100	70	50
Fan	75	100	80	40	4	2	1	7	2,100	840	210	2	2	1	150	120	30
Air condition.	1,200	100	5	0	2	1	0	8	19,200	480	0	1	1	0	1,200	60	0
Hot plate	1,000	60	5	0	2.5	1	0	2	3,000	100	0	1	1	0	600	50	0
Water pump	250	100	50	5	1	1	1	0.5	125	62.5	6.25						
Washing machine	3,000	5	0	0	1	0	0	0.5	75	0	0						
Outdoor lighting	200	90	6	0	2	1	0	12	4,320	144	0	2	1	0	360	12	0
								Daily consumption	52,065	6,904	1,161			Global demand	3,800	600	200

Table I.7.2 Phnom Penh - Power Demand Forecasts

Peak demand 8 pm	1992	1993	1994	1995	1996	1997	1998	1999	2000
(a) Phnom Penh inhabitants	800,000	832,000	865,280	899,891	935,887	973,322	1,012,255	1,052,745	1,094,855
(b) Number of households	133,333	138,667	144,213	149,982	155,981	162,220	168,709	175,457	182,476
(c) Electrification rate (%)	40	42.5	45	47.5	50	52.5	55	57.5	60
(d) Number of electrified households	53,330	58,935	64,900	71,240	78,000	85,165	92,790	100,890	109,490
(e) Individual peak demand (W)	450	463	477	490	504	518	532	546	560
(f) Domestic peak demand (MW)	17	19	22	24	27	31	35	39	43
(g) Industrial GDP (1.00% = 1992)	1	1.10	1.22	1.34	1.46	1.60	1.72	1.86	2.01
(h) Professional peak demand (MW)	18	19	21	23	24	26	28	30	31
(i) Total maximum demand (MW)	35	38	43	47	51	57	63	69	74
(j) Technical losses (%)	20	19.5	19	18.5	18	17.5	17	16.5	16
(k) Peak for generation (MW)	44	47	53	58	62	69	76	83	88
(l) Generation required (GWh)	230	253	291	322	354	401	449	449	548

a = +4% per annum
b= a/6
c = +2.5% per annum
d = b·c
e = upgrade of low level customers
f = d·e·0.7

g = annual growth rate of 11% ~ 8%
h = GDP elasticity 0.8 = (example: 1994) x {(1.22 - 1.00) x 0.8 + 1.00} x 18 = 21.17 (MW)
i = f + h
j = reduction of 0.5% per annum
k = i/(1-j)
l = k x 8760 x (load factor 0.6 ~ 0.7)

Table I.7.3 Siem Reap - Power Demand Forecasts

Peak demand 8 pm	1992	1993	1994	1995	1996	1997	1998	1999	2000
(a)Siem Reap inhabitants	80,000	83,200	86,528	90,000	93,590	97,332	101,226	105,275	109,486
(b) Number of households	13,330	13,867	14,420	15,000	15,600	16,222	16,870	17,546	18,248
(c) Electrification rate (%)	10	20	30	40	42	44	46	48	50
(d) Number of electrified households	1,333	2,773	4,326	6,000	6,552	7,138	7,760	8,422	9,124
(e) Individual peak demand (W)	230	242	254	274	296	325	358	394	433
(f) Domestic peak demand (kW)	215	470	769	1,151	1,358	1,624	1,945	2,323	2,765
(g) Number of hotels and restaurants	8	11	15	20	21	22	23	24	25
(h) Number of rooms	300	500	1,250	2,000	2,100	2,200	2,300	2,400	2,500
(i) Hotels and Restaurants peak demand (kW)	600	825	1,125	1,500	1,575	1,650	1,725	1,800	1,875
(j) Others (kW)	235	385	535	685	385	985	1,085	1,185	1,285
(k) Total maximum demand (kW)	1,050	1,680	2,429	3,336	3,766	4,259	4,755	5,308	5,925
(l)Technical losses (%)	25	24.5	24	23.5	23	22.5	22	21.5	21
(m) Peak for generation (MW)	1.4	2.2	3.2	4.4	4.9	5.5	6.1	6.8	7.5
(n) Generation required (GWh)	(6.1)	9.8	14.8	20.6	23.6	27.4	31.0	34.9	39.4

a = +4% per annum
b = a/6
c = increase up to 40% in 1995 and 50% in 2000
d = b·c.
e = annual growth of 5% upto 1994, 8% upto 1996 and 10% thereafter
f = d·e·o.7

i = (g/8) x 600
j = increase of 150 kW per annum upto 1997 and 100 kW thereafter
k = f + i + j
l = reduction of 0.5% per annum
m = k/(1-1)
n = m x 8760 x (load factor 0.5 ~ 0.6)

Chapter 8

Master Plan for Rehabilitation and Reconstruction of Electricity Supply in Phnom Penh City

CHAPTER 8 MASTER PLAN FOR REHABILITATION AND RECONSTRUCTION OF ELECTRICITY SUPPLY IN PHNOM PENH CITY

8.1 General

8.1.1 Generating Facilities

As discussed in section 5.1, Cambodia's present power facilities are beset with numerous problems. These include superannuated facilities, inappropriate management, and supply capacity far below existing demand. In addition, a tremendous increase in electricity demand is being created by: the development of various social infrastructure facilities, including medical facilities, water mains, and sewers; the recovery of other sectors of Cambodia's economy; and the major inflow of international institutions. This situation requires an urgent solution.

Aside from short term recovery plans, however, there are as yet no medium or long term recovery plans which would provide Cambodia with the necessary electricity to rebuild its national infrastructure and economy. In particular, as Cambodia is heavily dependent on petroleum imports, development of her rich hydro-power resources would be highly desirable. In addition, superannuation and restoration of power facilities is not only a problem of financing, but is also complicated by an acute shortage of engineers, operators, and technicians, as well as maintenance and management personnel. Cambodia also needs assistance from the developed world for its "soft sector"; i.e., improvement of personnel training, organization, and management.

This Chapter provides a rehabilitation and reconstruction plan for Phnom Penh's power facilities, based on the projected demand values discussed in Chapter 7. This Master Plan Study is further divided into a short-term reconstruction project, and an expansion project which extends over the short, medium and long term. The appropriate facilities for which the Government of Japan should provide assistance are recommended for each sub-project herein.

8.1.2 Distribution Facilities

The present condition and problems of the existing distribution network were mentioned in Chapter 5 and the sources of these problems are similar to those for the generating facilities.