ELECTRICITE DU CAMBODGE
THE KINGDOM OF CAMBODIA

BASIC DESIGN STUDY REPORT

ON

THE PROJECT FOR REHABILITATION AND UPGRADING OF ELECTRICITY SUPPLY FACILITIES IN PHNOM PENH, PHASE II

IN

THE KINGDOM OF CAMBODIA

MARCH 1998

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD. TOKYO

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PREFACE

In response to a request from the Government of the Kingdom of Cambodia, the Government of Japan decided to conduct a basic design study on the Project for Rehabilitation and Upgrading of Electricity Supply Facilities in Phnom Penh, Phase II and entrusted the study to the Japan International Cooperation Agency (JICA).

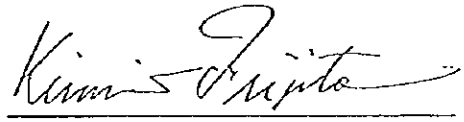
JICA sent to Cambodia a study team from April 2 to May 1, 1997.

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

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

I wish to express my sincere appreciation to the officials concerned of the Government of the Kingdom of Cambodia for their close cooperation extended to the teams.

March 1998



Kimio Fujita

President

Japan International Cooperation Agency

March 1998

Letter of Transmittal

We are pleased to submit to you the basic design study report on the Project for Rehabilitation and Upgrading of Electricity Supply Facilities in Phnom Penh, Phase II in the Kingdom of Cambodia.

This study was conducted by Nippon Koei Co., Ltd., under a contract to JICA, during the period from March 17, 1997 to March 27, 1998. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Cambodia and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

Finally, we hope that this report will contribute to further promotion of the project.

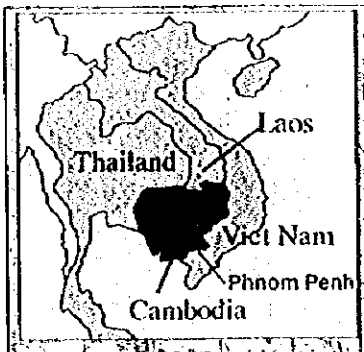
Very truly yours,

Yoshikazu Sunagawa

Project manager,

Basic design study team on
The Project for Rehabilitation and
Upgrading of Electricity Supply
Facilities in Phnom Penh, Phase II

Nippon Koei Co., Ltd.



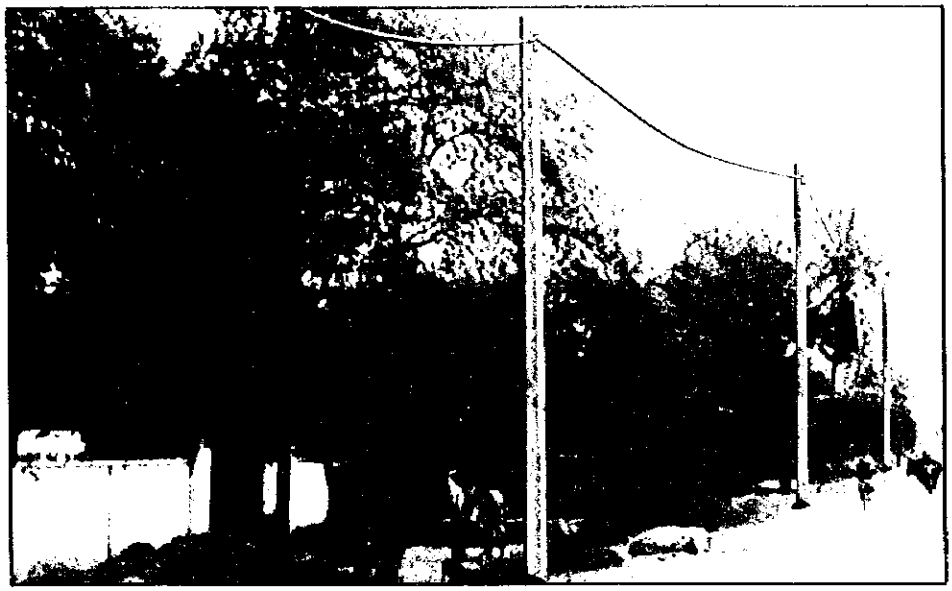
Chroy Chang War Area

Russey Kao Area

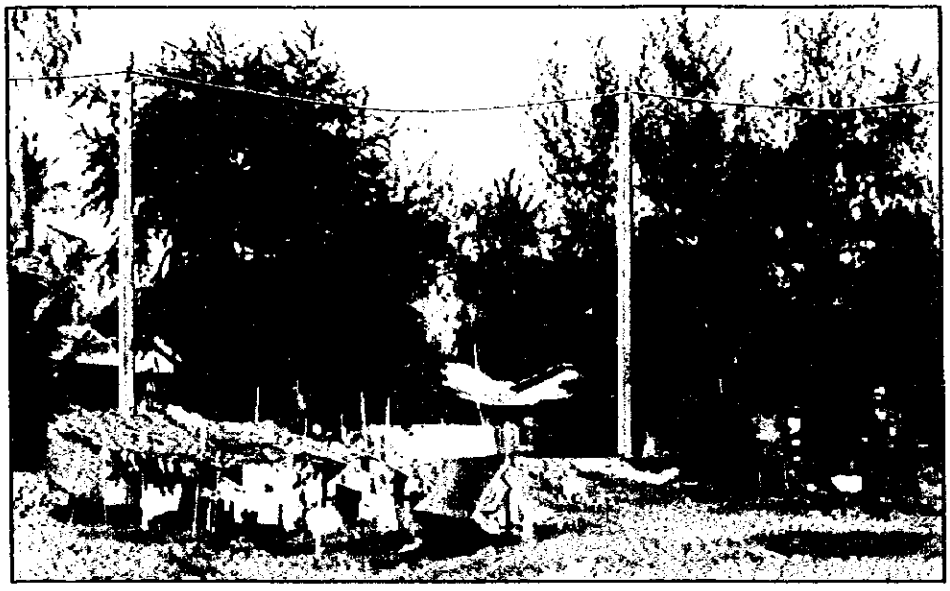
Pochengtong Area

Takmau Area

Location Map / Pictures



Takmau Area



Chroy Chang War Area

Envisaged Pictures

Pochengtong Area

Russey Keo Area

Envisaged Pictures

Abbreviations

Organizations

ADB	: Asian Development Bank
EdC	: Electricite du Cambodge
IEC	: International Electrotechnical Commission
ISO	: International Organization for Standardization
JCS	: Japanese Cable Standards
JEC	: Japanese Electro Technical Committee Standards
JICA	: Japan International Cooperation Agency
JIS	: Japan Industrial Standards
MIME	: Ministry of Industry Mines and Energy
NK	: Nippon Koei Company Limited
WB	: World Bank

Terms

AC	: Alternating Current
B/A	: Banking Arrangement
CT	: Current Transformer
DL	: Distribution Line
EDS	: Every Day Stress
E/N	: Exchange Note
FY	: Fiscal Year
HT	: High Tension
IPP	: Independent Power Producer
LDC	: Load Dispatching Center
LV	: Low Voltage
MCCB	: Modeled Compact Circuit Breaker
MV	: Medium Voltage
O&M	: Operation and Maintenance
OH	: Overhead
PS	: Power Station
SS	: Substation
TL	: Transmission Line
UTS	: Ultimate Tensile Stress

Units

mm	: millimeter	
cm	: centimeter	
m	: meter	
km	: kilometer	
mm^2	: square millimeter	
cm^2	: square centimeter	
m^2	: square meter	
km^2	: square kilometer	
m^3	: cubic meter	
km/hr	: kilometer per hour	
kg	: kilogram	
kg/m^2	: kilogram per square meter	
t	: metric ton	
°C	: degree(s) centigrade	
A	: ampere	
kA	: kiloampere	
V	: volt	
kV	: kilovolt	
kW	: kilowatt	
MW	: megawatt	$= 10^3$ kW
GW	: gigawatt	$= 10^3$ MW
kVA	: kilo voltampere	
MVA	: mega voltampere	$= 10^3$ kVA
GVA	: giga voltampere	$= 10^3$ MVA
kVAR	: kilovar	
kWh	: kilowatt hour	
MWh	: megawatt hour	$= 10^3$ kWh
GWh	: gigawatt hour	$= 10^3$ MWh
W/m^2	: watt per square meter	
Hz	: hertz (cycles per second)	

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CHAPTER 1

BACKGROUND OF THE PROJECT

CHAPTER 1 BACKGROUND OF THE PROJECT

1.1 Background of the Request

Since the civil war broke out in 1970, the political unrest and instability in the country had extend over a long period of time. After the Paris Accord was concluded in 1991, it is ascertained to be given support internationally to reconstruction of the country. At the time, the power systems in Phnom Penh are in very poor conditions due to the serious shortage of spare parts, aged equipment, and facilities destroyed through the civil war.

In 1994, the total possible output of the generating facilities in the Phnom Penh power system is 28.7 MW, which is only 40.3 % of the total installed capacity (71.2 MW) and 40.7 % for the required power demand on the system forecasted by Electricite du Cambodge (EdC).

Since 1993, various donors and international financial institutions including Japan have extended their technical and financial assistance in the projects for rehabilitation and reconstruction of the Phnom Penh power system. Thus the power system is remarkably improved on its generating and distribution capacity through projects.

Besides, the Government of Cambodia had implemented an Independent Power Producer (IPP) program in generation (Executor: Leader Universal Holding, Delcom Service Cambodia Utilities Private Ltd.) in order to meet the growing power demand. The available generating capacity of the Phnom Penh power system has reached 85.6 MW in total at the end of April 1997. And also, it is recorded to be the unprecedented power demand of 49.9 MW on March 30, 1997. Moreover, EdC made a new contract for IPP with installed capacity of 60 MW (Executor: Becon Hill Association, US) in March 1996, in order to cope with the growing demand in near future.

At present, the rehabilitation and expansion projects of the Phnom Penh power system are being implemented under the finance of Asian Development Bank (ADB), World Bank (WB), and various donor countries and will be anticipated to be completed by the beginning of 1999. With completion of those projects, the rehabilitation and expansion works of distribution system in the whole of urban area of Phnom Penh will be over.

However, all projects are concentrated on the power system in the urban areas of the capital as an urgent countermeasure for the restoration plan of postwar, and are making an exception for

the areas of Pochengtong, Russey Keo, Chroy Chang War, and Takmau which are adjoining Phnom Penh.

These areas are functioning as form a part of Phnom Penh in the social structures and economic activities for their daily life. As the social environments in the areas are being gradually restored, the power demand in the areas is also growing in the sectors of residence, industries, commercials, and services. However, the aged existing distribution facilities are unable to cope with even the present power demand in distribution capacity, besides power supply reliability and voltage regulation are in a very poor state at the consumers end.

Under such circumstances, the Government of Cambodia requested grant aid from the Government of Japan to implementation of the Project for rehabilitation and expansion of the distribution facilities in the areas.

Outline of the Request

i) Objective areas of the Project

- Takmau district
- Pochengtong district
- Russey Keo district
- Chroy Chang War district

ii) Project components requested by the Government of Cambodia

- Middle voltage distribution lines	83	km
- Low voltage distribution lines	210	km
- New construction of distribution substations	11	stations
- Expansion of existing distribution substations	63	stations
- New construction of pole mount transformers	16	transformers
- New Installation of watthour meter	18,500	nos.

In response to the official request, the Japan International Cooperation Agency (JICA) dispatched a Basic Design Study Team to Cambodia for 30 days from April 2 to May 1, 1997 and 15 days from January 31 to February 14, 1998. The team surveyed the Project areas, collected relevant data and information for the Basic Design study, and discussed technical aspect of the Project with the official of EdC, the executing agency of the Project and concerned departments of the Government.

A list of the survey team members, survey schedule, parties concerned in the recipient country, and minutes of discussions are given in Appendices.

The Report includes the conclusions and recommendations, a project evaluation, and an implementation program based on the analysis of the results from the site investigation and technical requirement of the Project.

1-2 Outline of Cambodia and Project Areas

(1) Land

Cambodia is an agricultural country blessed with fertile lands and water resources of the Mekong river basin. It is a compact situated in the southwestern part of the Indochina peninsula (longitude 102°-108° East, latitude 10°-15° North). It is divided into 21 provinces and special cities (Phnom Penh, etc.).

Cambodia has 181,035 km^2 in land area, a little over a half size of Viet Nam, about one third of Thailand, or slightly less than half of Japan. It is bounded by Viet Nam to the east and southeast, by Thailand to the west, by Laos and Thailand to the north, and by the Gulf of Thailand to the south and southwest.

The country consists mainly of low plains crossed by many rivers. About 70 % of the country are forested, while 16 % of the country is mountainous. There are low mountain ranges along the northern border with Thailand and in the southwest, while the northeast part is a forested plateau, which has a higher elevation than the central plain.

During the monsoon flood season between June and October, the overflow from the Mekong is diverted up the Tonle Sap River into the Great Lake, reversing Tonle Sap's flow, expanding the area of the Lake to many times its normal size (normal area 2,600 km^2, maximum expanded area 25,000 km^2) silting and fertilizing the rice plains, and providing a large supply of fresh water fish. As the Mekong begins to recede, the Tonle Sap resumes its normal flow from mid-October.

(2) Climate

The climate in Cambodia is tropical monsoon. In summer, the southwest monsoon is drawn landward from the Indian Ocean, and during the winter, the Northeast monsoon sends back dry

air. The southwest monsoon brings the rainy season from mid-May to early October and the northeast monsoon's flow of drier and cooler air lasts from early November to March. The average annual rainfall is between 1,000 and 1,500 mm, with the heaviest fall in the southwest and southeast coastal areas (over 3,000 mm annually). Rainfall from April to September in the Tonle Sap Basin-Mekong lowlands area averages 1,300 to 1,900 mm annually, with the lowest rainfall found in the rain shadow region of the Elephant and Cardamom Mountains.

Temperatures are fairly uniform throughout the Central Basin area, with small variations from the annual mean of 25°C. The maximum mean is about 28°C; the minimum about 22°C. Maximum temperatures of higher than 32°C, however, are common and, just before the start of the rainy season, maximum temperatures may rise to more than 38°C. Minimum temperatures rarely fall below 10°C. January is the coldest month, and April is the warmest. Typhoons (tropical cyclone), which often devastate coastal Viet Nam, rarely cause damage in Cambodia. In Phnom Penh and the Project areas, the average annual rainfall is 1,375 mm, and the average annual temperature is 27.5°C. January is the coldest month, and April is the warmest.

(3) Demography

The total population in Cambodia was estimated at 10.25 million in 1996 with an average annual growth rate of 3.0 % (estimation of WB). According to the WB and ADB reports, the overall life expectancy is estimated to be 48 years. The birthrate is roughly 38 per thousand and the infant mortality rate at 85 per thousand. Nearly half of population in under 19 years of age and the economically active population is estimated to be around 5.9 million.

About 90 % of population live in the rural areas. The average population density is approximately 50 persons per km^2 for the whole country.

Cambodia is almost ethnically homogeneous with Khmers accounting for 5/6 of the population. The rest of the population is made up of over 30 minority ethnic groups. Buddhism is the religion of 95 % of the population.

(4) Outline of the Project areas

The Project areas are composed of four districts; Pochengtong district, Takmau district, Russey Keo district, and Chroy Chang War district.

Phnom Penh and the Project areas are in the Kandal state. Takmau is the capital of state and located in the suburb on the south of Phnom Penh. Pochengtong district and Russey Keo

district are located on the west and the north of Phnom Penh. Chroy Chang War district is located on the opposite bank of the Tunle Sap in the northeast of Phnom Penh.

Population, number of household and density of population of each district are given below.

Table 1.1 Outline of the Areas

Districts	Population	Families	Area (km^2)	Density (person/km^2)
Takmau	55,000	9,800	42	1,309
Pochengtong	75,000	13,400	63	1,190
Russey Keo	94,000	16,700	54	1,566
Chroy Chang War	47,000	8,400	79	594
Total	271,000	48,300		

(a) Takmau District

Takmau district is located at an important point of traffic of which the national routes No.3 and No.2 is crossing, and developed throughout the ages with the economical activities in the sectors of agriculture, gardening, commerce and small-scale industry.

Power to Takmau district is being sent from No.2 power station through a two-circuit 15 kV MV distribution line. There is a large number of warehouses and middle and small sized factories (cigarette, sugar, ironwork, repair shop, sawmill, woodworking shop, tire, and sewing) between the power station and Takmau, and power to these factories are fed from the above mentioned distribution line. Therefore, the distribution capacity is remarkably insufficient for the demand of Takmau city.

Receiving voltage at consumer's end in this district is only 148 V as explained in Clause 2-3-3 (3). From this fact, it is confirmed that the existing distribution line is beyond its capacity for present demand. Some residence areas in this district are still not electrified.

As regional development plan, the area along the Basac river in the southeast and in the south of Takmau city are programmed to be developed for industrial zone and for residential area, respectively.

(b) Pochengtong District

The surrounding of the Pochengtong International Airport and the fields between the airport and Phnom Penh city are the objective area of the Project in Pochengtong district.

Power to the Project area is being sent from No.5 power station through a circuit of 15 kV MV distribution line. The line feeds the power to the international airport, a large number of domestic consumers, factories of various categories (mobile repair, ironworks, sewing, food industry, concrete products, agricultural machines, construction machinery center, container station, GI sheet, TV assembling), hospital, TV broadcasting, and military camp.

This distribution line was restored as urgent countermeasure of postwar under the situation of a shortage of line materials.

Therefore, the line conductors are jointed with a numbers of conductors in different small size as well as the distribution facilities are in condition of superannuated. Thus, it causes excessive voltage drop of 40 % at the consumers' end and low reliability of power supply. It is certainly that the existing distribution system is being unable to cope with the present demand in its distribution capacity.
The area along the national road in the surrounding of the airport has being developed as a site for the light industrials of large-scale and residential quarters. Besides, there is an extensive field between the airport and the city and being developed for industrial and residential zones. At present, there is no connection with EdC system in this area.

(c) Russey Keo District

The area along the national route No.5 in the west bank of the Sap River as well as the southeastern parts of the district adjacent to Phnom Penh are the objective areas of the Project in Russey Keo District.

There are a large number of residences and factories (oil storage, sawmill, sewing, concrete products) of small scale along the national route No.5. Power to this area is being sent from No.1 power station through a circuit of 15 kV MV distribution line. The conditions of distribution facilities and power supply are same as other districts.

The southeastern parts of the district are to be developed as residential and industrial zone by the Phnom Penh Municipality. New by-pass road from Phnom Penh to national route No.5 through this area has already completed. At present, there is no connection with EdC system in this area.

(d) Chroy Chang War District

The Project area in Chroy Chang War District is located on the opposite bank of the Sap river in the northeastern part of Phnom Penh. Chroy Chang War District and Phnom Penh are connected through the Chroy Chang War bridge and the National Route No.6

The bridge and the route No.6 were reconstructed under the grant aid program of the Government of Japan. A means of transportation between Phnom Penh and the district has much improved, a larger number of restaurant now run along the route NO.6 in this area as well as residential zone and industrials of small scale are being developed.

The study of the water supply project, utilize the water of the Mekong River for Phnom Penh's water supply, are being carried out under the financial assistance of WB in this area.

At present, this district is partially electrified, and necessary power is supplied by private generators. There is no connection with EdC system.

CHAPTER 2

CONTENTS OF THE PROJECT

CHAPTER 2 CONTENTS OF THE PROJECT

2-1 Objective of the Project

Since 1993, various donors and International Financial Institution including Japan are assisting Cambodia in the projects for rehabilitation and reconstruction of the Phnom Penh power system. Besides, the Government of Cambodia has implemented IPP program in generation, the power system in Phnom Penh is having adequate power generating capacity for the suppressed demand and load growth to be developed as a result of the rehabilitation and expansion of the distribution network.

At present, the rehabilitation and expansion projects of the Phnom Penh distribution network are being implemented under the finance of the ADB and the WB. All the projects are concentrated in the urban area of the capital as an urgent countermeasure for the restoration plan of postwar, and are making an exception for the areas of Pochengtong, Russey Keo, Chroy Chang War, and Takmau adjoining Phnom Penh.

These areas are functioning as form a part of Phnom Penh City in the social structures and economic activities, and the power demand in the areas are growing in the sectors of residence, industry and services for their rehabilitation and reformation. However, some regions in the areas are still not electrified and also the aged existing distribution facilities in the areas are unable to cope with the growing demand in distribution capacity. The power supply reliability and voltage regulation are in a very poor conditions.

Under this situation, the Government of Cambodia requested Grant Aid from the Government of Japan to implementation of the Project for rehabilitation and expansion of the distribution facilities in the areas.

The Project aims not only to support the political and economical activity of the areas, but also to contribute to betterment of living standards and increase the employment opportunities in the industrial sector through stable and reliable power supply. It will also improve the cost efficiency by reducing system losses and operation and maintenance cost by reinforcement of the power distribution facilities which need countermeasures urgently.

2-2 Basic Concept of the Project

In this clause, the basic ideas and frameworks of the Project are described based on the results of site investigation and subsequent home analysis in Subclauses (1) through (7), and outline of the selected plans is explained in Subclause (8).

(1) Balance of Demand and Supply

Generating facilities must be timely expanded and reinforced to meet growing future power demand. This condition is essential to justify the execution of this Project.

The available generation capacity of Phnom Penh city was 81 MW at the end of April 1997. In No. 2 power station, a 35 MW diesel power station is under construction as an IPP program. Five diesel generators of 5 MW capacity have already been put into operation and the remaining two units of 5 MW are scheduled to be completed by May of 1997. By completion of this power station, the available generation capacity of Phnom Penh will become 91 MW. In addition, as to the 60 MW IPP generating plant that is planned in No. 4 power station, the construction contract has already been concluded and generating units are scheduled to be commissioned one by one by 1999. If these projects progress as scheduled, the 1999 available generating capacity will reach 145.4 MW after taking into account retirement of some old units. Two hydroelectric power projects, Kirirom (11 MW) and Kamchay (128 MW), are planned for development after 2000. The generation capability will further be reinforced if these projects show good progress.

Recently, the future demands of Phnom Penh have been forecast by EdC and donor organizations. The forecast peak demands of EdC, the JICA Master plan and the WB are tabulated below in comparison with the planned available generating capacity.

Table 2.1 Comparison of Power Demand Forecasts in MW

		1997	1998	1999	2000	2001	2002	2003
(1)	EdC's demand forecast	82.8	94.3	106.1	117.0	127.6	137.4	147.4
(2)	JICA's demand forecast	69.0	76.0	83.0	88.0	--	--	--
(3)	WB's demand forecast	63.4	67.0	78.6	90.2	101.3	110.7	117.1
(4)	Available generation capacity	91.1	90.1	145.4	145.4	145.4	145.4	145.4
Allowance (4) - (3)		27.7	23.1	66.8	55.2	44.1	35.3	28.3

Among the above forecasts, the forecast of WB is the latest one. When compared with the actual peak demand of 30th March 1997, 49.9 MW, the difference of the WB forecast with the actual record is smallest among the three forecasts. Against the WB's forecast, the planned generating capacity has 28 MW margin in 2003.

Guessing from the above investigation results, it is expected that the demand-supply situation of Phnom Penh will not cause supply shortage though the planned Project is implemented.

(2) Capability of Existing Distribution Facilities of Each District

The current situations of distribution facilities in each plan district are summarized below.

Takmau District

Power to Takmau District is being sent from No. 2 power station through a two-circuit 15 kV Middle Voltage (MV) distribution line. The conductor size of this line is copper 74 mm^2 and its transferring capacity is 18,000 kVA, about 9,000 kVA per circuit. 23 substations and 18 pole-mounted transformers are connected to this distribution line. The sum of capacities of these substations and transformers is 8,115 kVA.

Chroy Chang War District

At present this district is partly electrified, and necessary power is being supplied by private generators. There is no connection with EdC system.

Pochengtong District

Power to Pochengtong District is being sent from No. 5 power station through a two-circuit 15 kV MV distribution line. The conductor size is same as the above and power transferring capacity is 18,000 kVA. 19 substations and 21 pole-mounted transformers are connected to this distribution line. The sum of capacities of these substations and transformers is 8,418 kVA.

Russey Keo District

Power to Russey Keo District is being sent from No. 1 power station through a one-circuit 15 kV MV distribution line. The conductor size is same as the above and power transferring capacity is 9,000 kVA. 18 substations and 16 pole-mounted transformers are connected to this distribution line. The sum of capacities of these substations and transformers is 9,380 kVA.

The capacities of existing distribution facilities for each district are summarized below.

Table 2.2 Capacities of Existing Distribution Facilities in Each District

Name of District	No. of DL Circuits (circuits)	Transferring Cap. (kVA) *	Trans. Capacity (kVA)
Takmau	2	18,000	8,115
Chroy Chang War	0	0	0
Pochengtong	2	18,000	8,418
Russey Keo	1	9,000	9,380

* : The current capacity of 74 mm^2 bare copper conductor is 342 A, then sending power is about 9,000 kVA under line voltage of 15 kV.

For the above three districts electrified by EdC, enough information about Low Voltage (LV) distribution line routes, number of circuits, conductor sizes, etc. was not available. However, as explained in Subclause 1-2-(5), the voltage drops in LV lines at the consumer ends of Takmau, Pochengtong and Russey Keo districts are 32 %, 35 % and 39 % respectively. Majority of these voltage drops are accrued in the LV systems. From these facts, it is clear that the LV systems are not properly composed. It is evident that lengths of LV feeders are excessively long.

(3) Demand Forecast of Each District

Concerning demand forecast of each district, EdC prepared load forecast of the existing 15 kV and planned 22 kV distribution lines for each district.

The procedure of forecasting demand of each district is as mentioned below.

(a) Consumers are classified into the following categories, and count number of consumers of each category in each district through field investigation.

Class 1: Houses without air conditioner

Category A: Small residences and shop houses of wooden construction

Category B: Medium size residences and shop houses, and concrete residences

Category C: Large residences of concrete construction

Class 2: Houses with air conditioner

Category A: Small residences and shop houses of wooden construction

Category B: Medium size residences and shop houses, and concrete residences

Category C: Large residences of concrete construction

(b) For each of categories, the following average per consumer peak demands and annual energy consumption are assumed as given below.

Table 2.3 Peak Demand and Energy Consumption of Each Category of Consumer

Class and Category	Peak Demand (kW)	Annual Energy (kWh)
Class 1: Houses w/o air conditioner:		
Category A	0.6	600
Category B	2.0	2,000
Category C	3.0	3,000
Class 2: Houses with air conditioners:		
Category A	2.0	4,000
Category B	4.0	8,000
Category C	7.0	14,000

Note: For large consumers, peak power and annual energy are estimated individually.

(c) Based on the above assumed peak powers and confirmed number of consumers of each category, the present peak power of each district can be calculated.

(d) The calculated peak power is allocated to the existing and planned substations, and the peak power of each substation is obtained by adding the estimated distribution loss. Then, the future demands of each area are forecast by applying the following growth rates for each substation and large consumer.

Table 2.4 Assumed Annual Growth Rates of Demand (%)

Location	Substations	Large Consumers
Phnom Penh City	10	4
Outside Phnom Penh	15	6

(e) The feeder loads are obtained by allocating loads of substations and large consumers to each feeder. The sum of feeder loads in each plan district corresponds to the demand of the district.

The peak demand of each district forecast by the above procedure is tabulated below.

Table 2.5 Peak Demand Forecast of Each District (kVA)

District Name (Year)	1997	2002	2007	2012
Takmau	11,601	15,801	19,967	25,264
Chroy Chang War	1,500	2,082	2,657	3,391
Pochengtong	14,788	18,891	23,018	28,172
Russey Keo	12,323	15,974	19,633	24,225

To confirm consistency of the calculated demand of each district with the demand of whole Phnom Penh, a comparative study was carried out as shown in the following table. In the table, the forecast feeder demand is the sum of all feeder loads in each plan district.

Table 2.6 Consistency of Demand Forecasts of Whole Phnom Penh and Sum of Feeder Loads

(Year)	1997	2002	2007
(1) Peak demand of whole Phnom Penh (kW) (WB forecast)	63,435	110,650	144,011
(2) Sum of all feeder peak loads (kW) (EdC forecast) *1	97,369	129,494	143,733
(3) Diversity factor, (2)/(1) *2	1.53	1.17	1.00

*1: The peak load of each feeder is expressed in kVA, and the kW values are obtained by assuming power factor of 0.89 that is applied in the WB's forecast.

*2: $\text{Diversity factor} = \frac{\text{Sum of peak feeder loads of each district}}{\text{Maximum demand of whole area}}$

(4) Necessity for Upgrading Distribution Voltage to 22 kV

At present, in the MV distribution systems of Phnom Penh there are three applied voltages of 4.3 kV, 6.6 kV and 15 kV that differs district by district according to time and country of origin. To attain simplicity of operation and maintenance, EdC is intending to standardize distribution

voltage and as well as distribution facilities. In the distribution network reinforcement and extension projects of ADB and WB, MV lines are designed with 22 kV insulation and transformers are specified with double ratings of 15 and 22 kV. Thus, the MV distribution voltage of Phnom Penh city will become standardized to 22 kV by 1999 when the two projects are completed.

To justify economic superiority of 22 kV distribution, comparison of 22 kV and 15 kV distribution for the case of 4000 kW transfer over 15 km distance is tabulated below.

Table 2.7 Trial Calculation for Comparison of 22 kV and 15 kV Distribution

Subject	Unit	Distribution Voltage		Comparison Result
		15 kV	22 kV	(Superiority of 22 kV)
Loss power	(kW)	261	113	decrease to 43 %
Annual loss energy	(kWh)	1,098	476	decrease to 43 %
Annual loss value *	(US$ 1000)	165	71	decrease to 43 %
Voltage drop at end	(%)	9.66	4.34	decrease to 45 %
Transfer capacity	(kW)	4,200	6,200	about 50 % increase

* : Evaluated with energy cost of US¢ 15 per kWh.

From the above comparison, superiority of the 22 kV distribution over the 15 kV is very clear in view of loss power, voltage drop and transfer capacity.

Taking into account the above comparison, the 22 kV design is in principle adopted for MV distribution facilities of this Project.

(5) Appropriate Quality of Electric Power Supply to Consumers

The quality of electric power supply to consumers is expressed based on the following three criteria of services.

- Degree of continuity of power supply
- Degree of maintaining supply voltage in a specified range
- Degree of maintaining system frequency in a specified range

Among the above service levels, the system frequency is determined by the balance of generated power and consuming power and out of control of a distribution system. Therefore,

the factors that can be affected by a distribution system are continuity of power supply and supply voltage.

(a) Voltage Stability

According to the design criteria of EdC, the voltage drop must be within 4 % in MV distribution lines and 5 % in LV distribution lines. These voltage drops are within ranges that can be compensated by adjusting taps on distribution transformers, and are said to be suitable as the target service levels for consumer supply. Therefore, these voltage variations were adopted as the standards for plan formulation.

According to the results of analysis of the measured voltages, the voltage drops in MV and LV distribution lines in the planned district are as given below.

Table 2.8 Voltage Drops in MV and LV Distribution Lines

Name of District	PS send out volt. (kV)	SS end volt. (kV)	MV line V-drop (%)	Tr. end volt. (V)	Consumer volt. (V)	LV line V-drop (%)	Measure date (1997)
Takmau	14.0	13.1	6.4	218	148	32.1	19:00 Apr. 22
Pochengtong	14.8	13.5	8.8	212	137	35.4	20:00 Apr.24
Russey Keo	14.6	13.6	6.8	221	136	38.5	19:00 Apr.21

From the above table, it is confirmed that actual voltage drops in the MV and LV distribution lines are larger than the above target values. Especially, the voltage drops in LV lines are extraordinary large. The major causes of such voltage drop are (i) length of LV lines is too long, (ii) conductor sizes are too small against load and (iii) lack of reactive power compensation on the load side. Therefore, this excessive voltage drop problem can be solved by applying the most common methods of distribution system improvement, i.e. increasing number of distribution transformers, grading up of conductor and cable sizes and installing power factor improving capacitors.

(b) Reliability of Power Supply

The degree of continuity of power supply is defined as the supply reliability, and assessed by the duration of supply interruption in a year (hours per year). In a

developed country, the average duration of supply interruption in a year is in a range of a few to several hours, and in developing countries the average duration usually goes up exceeding 10 hours. To understand the current situation of supply reliability in Phnom Penh, the numbers of supply interruption and total duration of supply interruption of the existing 15 kV feeders in each district in one month period of May 1996 are given below:

Table 2.9 Number and Total Duration of Supply Interruption

District	Number of Interruptions	Duration (Hours-Minutes)
Takmau	7	32 - 32
Pochengtong	17	42 - 48
Russey Keo	22	86 - 55

From these records, it is understood that the reliability level is considerably low. Many consumers have their own generating sets as the EdC supply is not reliable causing frequent interruption. However, the above listed interruptions include other factors not attributable to the distribution facilities, such as faults of generating facilities and load shedding to attain balance of demand and supply. In May 1996, enough generating capacity to meet the demand was available and the most of supply interruptions was derived from the distribution system.

Conceived countermeasures to improve supply reliability on the distribution system and expected merits of measures are enumerated below:

Table 2.10 Countermeasures for Improvement of Supply Reliability

Countermeasures to be Taken	Estimated Improvements
1. Tree cutting along OH line routes	Avoiding short-circuit/ground faults
2. Use of insulated wires and OH cables	Avoiding short-circuit/ground faults
3. Reinforce lightning protection design	Reducing lightning faults
4. Networking of distribution lines	Avoiding spread of faults
5. Sectionalizing by HT section switches	Avoiding spread of faults

In this project, the most appropriate countermeasures will be selected from the above and applied based on site properties to promote supply reliability.

In Japan, the management level of supply reliability is assessed from statistically obtained (i) average number of supply interruptions and (ii) average total duration of supply interruption in a year at the consumer ends. To properly evaluate the reliability, the past fault records need to be processed and analyzed. In case of EdC, properly-arranged records are not available and therefore it is not possible to properly assess the present situation.

Under such circumstance, the supply reliability criteria for the planned project was set up referring to the Security of Supply; 1978 of the United Kingdom as mentioned below:

Control Level of Supply Reliability

In each plan district, the power supply must be able to be resumed even under continuation of a fault of a MV line by changingover operations of section switches, and the planned system must meet demand for the period of five years.

(c) Number of MV Distribution Line Circuits and Capacity of Transformers

The conductor sizes of MV distribution lines were selected based on the EdC standard, and the required number of circuits was determined based on the above supply reliability criteria for each plan district.

As distribution transformers can be easily added later, the required capacity of each plan district was determined so as to avoid excessive installation, taking into account the demand of five years in future. It was assumed that in future the power supply quality problem will be taken care of by the own arrangement of EdC.

(6) Rehabilitation Plans for Power Supply Facilities by Other Donors

In Phnom Penh city, several distribution network reinforcement projects are in progress using financial assistance from WB, ADB, France, Ireland and Belgium. (Reference to Fig. 1.1)

Among these projects, the Project under consideration by JICA must be planned taking into account consistency with the WB project and the IPP power plant that is under construction in No. 2 power station. The connecting stations of MV distribution lines for the plan districts are given in the table below together with scheduled completion times.

Table 2.11 List of Ongoing Substation Projects

District	Connected Source	Completion Date	Present Progress
Takmau	Cubicles for IPP generating plant in No. 2 PS	Completed	--
Chroy Chang War	No. 1 Project grid SS of WB Project	Jan. 1999	Contract signed on 13 Mar. 97
Pochengtong	No. 3 grid SS &	SS: Jan. 1999	Contract signed on 13 Mar. 97
	DL of WB Project	DL: May 1999	Tender on 28 Apr. 97
Russey Keo	No. 1 grid SS of WB, Project	Jan. 1999	Contract signed on 13 Mar. 97

The execution schedule of this Project must be prepared taking into account the progress of the related projects. However, there is possibility of delay in completion of the WB projects. The following substitute points were selected as connecting points of the feeders under the Project for the case that the WB projects are not completed as scheduled through discussion with EdC officials. It was confirmed that power sources for feeder connection can be secured though the WB projects may not be completed by the time.

Table 2.12 Alternative Connecting Points

District	Connecting points if WB projects delay
Chroy Chang War	15 kV cubicle in No. 4 or No. 5 PS
Pochengtong	15 kV interconnector constructed under Grant Aid from Japan
Russey Keo	Existing 15 kV Russey Keo line or interconnector under Grant Aid from Japan

(7) Selection of Types of Distribution Lines

The types of distribution lines to be constructed under the Project are planned to be classified as given below.

<u>22 kV MV distribution lines</u>

Overhead line with insulated conductors

Overhead cable line

Underground cable line

LV distribution lines

Overhead cable line

Underground cable line

Concerning conductors of overhead MV lines, insulated wires and cables were selected instead of bare conductors to prevent grounding and short-circuit faults due to trees touching conductors and to improve reliability of power supply. There is difference in insulation strength between insulated wires and cables. The insulation of outdoor use insulated wires is called semi-insulation and has not enough insulation to withstand the line voltage, and though the insulation can withstand momentary tree touching with considerable resistance it does not allow continual contact of trees. Therefore, the line conductors must be installed with the same clearances as bare wires from trees and structures. On the other hand, cables are fully insulated, and the line can be operated though trees or structures touch the cables. As the cost of cables is higher than that of insulated wires, the overhead cables are planned to be installed only where street trees are thick or enough separation from structures can not be secured, and insulated wires are planned to be installed in open air.

According to the EdC's practice, underground cables are buried for distribution lines in the city center area. Though the installation cost of underground cables is much higher than that of overhead lines, the underground cables have merits in view of aesthetics of scenery in city area and installation safety. Therefore, the installation of underground cables is planned in the city center area and parts of urban areas.

For LV lines, installation of cables was planned according to a regulation of EdC.

(8) Outline of the Project

As the result of studies mentioned above, the basic frameworks of this Project were determined. In the four plan districts, improvement and reinforcement of distribution facilities are planned as mentioned below to improve the present situations of power supply and to meet the forecast growth of demand in future.

The number of MV distribution lines and the total capacity of transformers in each plan district were determined based on the forecast future demands of the district and appropriate supply quality levels stated in Subclauses (3) and (5). The planned number of MV distribution lines and total capacity of transformers for each district are given in Table 2.13 together with forecast demands.

Table 2.13 Forecast Peak Demand and Planned Distribution Capacity in Each District

District Name	Forecast Peak Demand				Planned MV Distribution Facilities			
	1997	2002	2007	2012	No. of cct.	Line Transfer Capacity *1		Transformer Total Capacity (kVA)
						Max. Value (kVA)	Reliable (kVA)	
	(kVA)	(kVA)	(kVA)	(kVA)	(circuits)			
Takmau	11,601	15,801	19,967	25,264	2	29,000	14,500	13,655 *3
					2 + (1) *2	43,500	29,000	
Cheroy Chang War	1,500	2,082	2,657	3,391	2	29,000	14,500	4,375
Pochengtong	14,788	18,891	23,018	28,172	3	43,500	29,000	21,595
Russey Keo	12,323	15,974	19,633	24,225	2	29,000	14,500	16,240

*1: Maximum capacity is based on the line current capacity and reliable capacity shows the transfer capacity under separation of one circuit.

*2: " + (1)" means use of the existing 15 kV distribution line after raising the operating voltage to 22 kV.

*3: A 2500 kVA transformer for the tire factory is planned to be provided, and the total transformer capacity becomes 16,155 kVA if this capacity is added.

Takmau District

The planned routes and system diagram of new MV distribution lines are shown in Figure 2.2. Two 22 kV feeders will be connected to the cubicles of the IPP power plant in No. 2 power station, and run to the Takmau urban area along National Route No. 2 on the opposite side of the existing distribution line. As the existing line is of overhead construction, an underground cable line was selected from the aesthetic view point avoiding parallel run of overhead lines along a road. Underground cable lines were selected in the city center area according to the regulation of EdC. Overhead lines are planned for extension from there, and installation of overhead cables was also planned to avoid grounding and short circuit faults to minimize cutting of trees.

The new MV lines of two circuits do not have enough transmission capacity to satisfy the forecast demand of five years in future if the supply reliability shown in Table 2.13 is taken into account. The existing lines will be used to solve this problem. The existing line between No. 2 power station and the road branch near No. 349 Substation will be graded up from 15 kV to 22 kV, and this line will be connected to the new cable line. As the conductor size of the existing line is small, two circuits of the existing line is utilized as one circuit of the new line.

The works of the voltage upgrading of the existing overhead lines and connection to the cable lines will be carried out by EdC themselves inclusive of the procurement necessary materials. The cable lines are to be constructed under the Project.

Chroy Chang War District

The planned routes and system diagram of MV new distribution lines are shown in Figure 2.3. Two feeders will be connected to No. 1 grid substation to be constructed under the WB project.

Though there is no power supply to this district at present by EdC, this district is partly electrified with private generators. There are many large restaurants along National Road No. 6 and the tip portion of the peninsula is a residential area. As clear from Table 2.13, the amount of latent demand will not be so large, but the construction of two feeders is planned to secure high supply reliability.

In the tip portion of peninsula there are many trees, and installation of overhead cables is adopted from considerations to erection works and prevention of faults due to tree

touching. Along National Road No. 6, there are telephone cables on concrete poles on the other side of the road. For erection of an overhead line, the borrow filled road is narrow and enough space to ensure security of poles is not available on the road shoulder, and the both side pole installation along a narrow road is not preferable from aesthetic view point. From such considerations, the underground cable line was selected for MV line along National Road No. 6.

Pochengtong District

The planned routes and system diagram of new MV distribution lines are shown in Figure 2.4. Three feeders will be connected to the MV distribution lines to be constructed under the WB project. Three feeders are required not only satisfying requirements of supply reliability but also supplying power to widely dispersed loads in the district that covers a very wide area.

The underground cable line will be adopted for the new line aligned along National Road No. 4 near to the airport from the aesthetic view point taking into consideration that this area constitutes the gateway of Cambodia. The overhead cables are installed on parts of the lines with many street trees.

Russey Keo District

The planned routes and system diagram of new MV distribution lines are shown in Figure 2.5. Two feeders will be connected to No. 1 grid substation to be constructed under the WB project.

One circuit of MV distribution line will be constructed along National Road No. 5, as loads of this district are concentrated in the area along this road. The underground cable line will be constructed for the section between the grid substation and No. 114 Substation based on the EdC's policy, as this area is an urban area. Along the most of line route between this point and the line end of No. 117 Substation many street trees are planted, and there are also many houses near the road. Overhead cables are planned to be installed due not only to approaching trees but also difficulty of securing necessary clearance from houses.

Another feeder will pass the western part of the district and connected to No. 386 Substation, supplying power to loads of the area from there to No. 117 Substation. Various future development projects are envisaged along the planned route of the feeder,

and this feeder will supply power also to these loads.

According to Table 2.13, the supply capacity of these two new feeders will not be sufficient to meet the demand of five years in future if supply reliability is taken into account. Regarding this point, enough supply is expected by the voltage upgrading of the existing 15 kV system to 22 kV.

The locations of substations and capacities of transformers in each plan district were determined taking into account the load density and easiness of land acquisition. Static capacitors necessary to avoid excessive voltage drop and to improve system power factor will be installed at large capacity substations with large reactive loads like manufacturing factories, etc.

To improve reliability of power supply, the remote controlling devices are provided to some circuit breakers of outgoing feeders.

LV distribution line routes were selected taking into account of present distribution of consumers and sizes of loads.

2-3 Basic Design

2-3-1 Design Concept

The design policy for the system is to ensure high reliability and safety, to be compatible with the existing facilities for easy operation and maintenance, and to be flexible for future expansion considering the current technical level of EdC. The design will be formulated under the following criteria :

(1) Applied Standards

All materials and equipment will be designed, manufactured and tested in accordance with the following standards :

Japanese Industrial Standards (JIS),
Japanese Electro Technical Committee Standards (JEC),
Japanese Cables Standard (JCS),
International Electrotechnical Commission (IEC),
International Organization for Standardization (ISO), and
Other International Standards.

The site erection works for the Project facilities shall be carried out in accordance with the regulations and/or practices of EdC. And also the Project shall be executed taking into account all necessary safety measures to the public and workers at the erection sites.

(2) Voltage Levels

As discussed in Subclause 1-2-(4) of this Chapter, the 22 kV three-phase three-wire system design is adopted for the MV distribution facilities. The distribution transformers will be designed with dual windings of 15 kV and 22 kV.

Therefore, three phase voltage levels in Phnom Penh power system are as follows

Table 2.14 System Voltage

Voltage level		System
Medium voltage distribution system	:	22 kV three-phase, three -wire
Low voltage distribution system	:	400/230 V three-phase, four -wire

(3) Climatic Conditions

The Project areas are located on the banks of the Sap, the Bassac and the Mekong rivers , at an elevation of about 10 m above sea level. The climate is tropical with the wet season during the months of May to November.

With reference to the climatic data for the past ten years in Phnom Penh and the present design standards of EdC, the design conditions for the facilities to be provided under the Project will be adopted as follows :

Table 2.15 Climatic Conditions

Climatic Parameter		Climatic Design Value
Altitude sea level	:	less than 1,000 meters
Climate	:	Tropical
Ambient air temperatures		
average	:	27.5 ℃
minimum	:	13.3 ℃
maximum	:	40.5 ℃
Annual rainfall average	:	1,290 mm
Relative humidity	:	65 - 100 %
Wind speed average	:	37 km/hr
maximum	:	72 km/hr

The design wind pressures are worked out from the above mentioned wind velocity, and the sag and tension of overhead conductors are computed on the basis of the following assumptions.

Table 2.16 Design Conditions

Design Parameter			Design Value
Design wind pressures	conductors	:	36 kg/m^2
	poles	:	45 kg/m^2
	other equipment	:	36 kg/m^2
Ground temperature	maximum	:	+ 25℃
Sag and tension	maximum sag occurs at	:	75℃, still air
	maximum stress occurs at	:	13℃, maximum wind
	every day stress (EDS) occurs at	:	27℃, still air
	factor of safety at maximum stress	:	2.5 against UTS
	factor of safety at EDS	:	4.0 against UTS
Solar constants	maximum solar radiation	:	1,000 W/ m^2
	solar emissivity	:	0.8
	solar absorption	:	0.7

(4) Ground Conditions

A geological survey, using cone-penetration tester, was carried out in order to confirm the ground bearing capacity at the locations of new substations and the distribution line routes.

Form analysis of the survey results, the ground conditions are sufficient to support the facilities to be constructed under the Project. Then, the special design of the foundations for the Project facilities are not required.

(5) Electrical Design Parameters

The following electrical design parameters will be adopted for the MV and LV distribution systems:

(a) MV Distribution System

Table 2.17 MV Electrical Design Parameter

Distribution system	: Three-phase, three-wire system	
Nominal system voltage	:	22/15 kV
Maximum system voltage	:	24 kV
Rated impulse voltage withstand (peak)	:	125 kV
Rated power-frequency withstand voltage (1 min, rms.)	:	50 kV
Rated short-time current (1 sec rms.)	:	20 kA
Rated peak short-circuit current (peak value)	:	50 kA
Rated frequency	:	50 Hz

(b) LV Distribution System

Table 2.18 LV Electrical Design Parameter

Distribution system	: Three phase, four wire system	
Nominal system voltage	:	400/230 V
Maximum system voltage	:	440/254 V
Rated power-frequency withstand voltage (1 mint, rms.)	:	2000 V
Rated impulse voltage withstand (peak)	:	6000 V
Rated frequency	:	50 Hz

(6) Earthing System

The earthing for the MV and LV distribution system are as follows.

Table 2.19 Grounding System

a)	MV distribution system	:	Non-grounding system, (resistor grounding system at generator side)
b)	LV distribution system	:	Solid grounding system

The low voltage neutral terminal of the all distribution transformer which to be installed under the project shall be adopted solidly grounding system.

(7) Clearance

(a) Overhead distribution lines

The following minimum clearance for conductors will be adopted.

Table 2.20 Minimum Clearance

Particular		Minimum Clearance (meters)
Clearance above ground - 22 kV		
along or across road	:	6.5
off road	:	5.5
Clearance above ground - LV		
along or across road	:	5.5
off road	:	5.0
Clearance above ground - Service		
along or across road	:	5.5
in place liable to be used by vehicles	:	3.5
elsewhere	:	2.7
Separation - 22 kV		
between phases horizontal	:	0.7
between phases vertical	:	0.6
to LV lines	:	1.2
to telephone lines	:	1.8
Separation - LV Bundled to telephone	:	0.6

(b) Safe working clearance

In the interests of personnel safety, the following safe working clearance will be adopted.

Table 2.21 Safe Working Clearance

Particular		Minimum Clearance (meters)
22 kV	:	0.460
LV bare	:	0.150

(8) Voltage Variation

The following voltage variation will be kept to ensure a quality supply at end the of distribution line and/or the customer's switchboard:

Table 2.22 Voltage Variation

Voltage Level			Voltage Variation
MV network	22 kV	:	± 5%
LV network	400/230 V	:	+ 5%, - 6 %

2-3-2 Basic Design

(1) Project Area and Project Facilities

(a) Project area

The Project is comprised of the following districts as shown in Fig.1.6.

- Takmau district
- Chroy Chang War district
- Pochengtong district
- Russey Keo district

The above is listed in order of importance district for execution of the Project as requested by EdC.

(b) Project facilities

The facilities to be provided under the Project are as shown in Table 2.23.

Table 2.23 Project Facilities

Description	unit	Takmau	Pochentong	Russey Keo	Chroy Changwar	Total
1 22 kV Distribution Lines						
Overhead lines	km	8.0	14.7	16.7	8.8	48.2
Underground lines	km	9.6	10.3	7.2	6.0	33.1
2 LV Distribution Lines						
Overhead lines	km	46.5	59.3	42.2	16.3	164.3
Underground lines	km	8.0	7.5	5.7	6.0	27.2
3 Distribution Substations						
Indoor Type Substations						
New construction, 400 kVA	units	3	3	7	2	15
630 kVA	units	1	1	2	2	6
1000 kVA	units	-	7	3	-	10
Upgrading, 400 kVA	units	6	8	3	4	21
630 kVA	units	4	3	5	-	12
1000 kVA	units	4	4	3	-	11
Outdoor Cubicle Substations						
New construction, 400 kVA	units	-	3	1	-	4
630 kVA	units	-	1	-	-	1
Pole Mount Type Substations						
New construction, 100 kVA	units	1	5	4	-	10
200 kVA	units	3	2	2	2	9
315 kVA	units	1	3	2	1	7
Remote Control Devices	sets	5	6	6	2	19
4 Watt-hour Meters						
Single Phase, 5 - 20 A	sets	7,274	6,617	6,829	2,454	23,174
10 - 30 A	sets	54	20	9	67	150
15 - 60 A	sets	36	24	12	6	78
Three phase, 10 - 30 A	sets	1	7	6	1	15
20 - 60 A	sets	8	5	4	4	21
30 - 90 A	sets	8	7	6	6	27
Three phase with CT	sets	22	16	20	5	63
5 Static Capacitor						
200 kVAR	sets	8	8	11	3	30
300 kVAR	sets	6	10	14	-	30
6 Service Wires	km	9.9	7.0	8.4	2.6	27.9
7 Maintenance Vehicles						
Auger Crane	nos.	-	-	-	-	1
Bucket Crane	nos.	-	-	-	-	1
Excavators	nos.	-	-	-	-	2
8 Maintenance Tools and Equipment						
Mobile Cubicle Type Substation	nos.	-	-	-	-	4
Compactors	nos.	-	-	-	-	2
Concrete Cutters	nos.	-	-	-	-	2
Meters and Instruments	lot	-	-	-	-	1

(2) Distribution Substation

The distribution substation to be provided under the Project will be designed for the following three types:

- Indoor type substation,
- Outdoor cubicle type substation, and
- Pole mount type substation.

The major features of the above substations are as follows:

(a) Indoor Type Substation

The substation facilities are installed in the station building of the brick and concrete structure as follows:

- 22 kV incoming and outgoing feeder cubicles,
- Transformer primary circuit cubicle,
- Transformer,
- LV distribution panel, current transformers and watt-hour meter,
- LV capacitors, and
- Remote control devise for load break switch and earth fault detector for outgoing feeder cables (for specified station only).

The Project is also including new construction of the station buildings and rehabilitation and expansion of the existing buildings. The substations are classified into the three sizes with transformer capacity of 400 kVA, 630 kVA and 1000 kVA. The transformers will provide dual windings for 15 kV and 22 kV.

The load break switches to be installed in the feeder cubicles at specified substations will also be operated through radio control device from Load Dispatching Center (LDC). At the same substations, the cable fault detectors will also be equipped on the outgoing feeder cables to transmit the fault warning signal to LDC.

Figure 2.7 shows layout of station building and arrangement of equipment for the indoor type substations.

The specifications of the major equipment are given below.

(i) Transformer

a)	Type	:	three-phase, oil immersed indoor type no-voltage tap changer (±5%, 5-steps)
b)	Capacity	:	400 kVA, 630 kVA, 1,000 kVA
c)	Voltage ratio,		
	Primary side	:	15/22 kV, 3-phase 3-wire system
	Secondary side	:	400-230 V, 3-phase 4-wire system
c)	Vector group	:	Dyn 11
d)	Cooling system	:	ONAN

(ii) 22 kV Switchgear Cubicle

The 22 kV feeder cubicles and transformer primary circuit cubicles will be of self-supporting, metal-enclosed indoor type.

The switches for the feeder circuit cubicles will be of load break switch type and will provide a motor driven device for remote control at the specified substation.

The transformer primary circuit cubicle will provide a load break switch and power fuses.

All cubicles will be designed taking account of future expansion of the switchgear in the both sides of cubicles. The specifications of the major equipment are as follows:

a)	22 kV load break switch		
-	Rated voltage	:	24 kV, 50 Hz
-	Switch	:	load break switch
-	Rated current	:	630 A (for feeder circuit)
			200A with fuse (for transformer circuit)
-	Short circuit current	:	16 kA (1.0 second)
b)	Potential transformer		
-	Rated voltage	:	3-phase, 24 kV / 110 V
c)	Current transformer		
-	Rated voltage	:	24 kV
-	Rated current ratio	:	20 / 5 A (for 400 kVA transformer)
		:	30 / 5 A (for 630 kVA transformer)

: 50 / 5 A (for 1000 kVA transformer)

(iii) Low Voltage distribution board

LV distribution board will be of wall mounted, metal-clad indoor type. The board will provide a molded compact circuit breaker (MCCB) for the main switch of LV circuit and cartridge type fuses for the feeder circuits.

a)	Service voltage	:	400-230 V, three phase four wires system
b)	Switch	:	1600 A(for main circuits)
		:	400 A(for feeder circuits)
c)	short circuit current		32 kA(1.0 second)
d)	Feeder circuit	:	8 circuits

(iv) Control and Protection Equipment

a)	Control mode	:	Manual operation at local
		:	Remote operation at LDC (for specified station)
b)	Protection mode	:	Auto off by power fuse for transformer circuit Indication and warning for feeder circuit (for specified station)

(v) Remote control system

The load break switches for outgoing feeder circuits at the specified substations will be operated through radio control device from LDC. The on-off status of breakers will be indicated on the supervising panel in LDC.

The cable fault detectors will be equipped on outgoing feeder cables at the specified substations. In case of cable fault occurs, the warning signal will be transmitted through radio control device to LDC and the fault section of the feeder cables will be indicated on the supervising panel. The warning lamp mounted on the wall of station building is blinking simultaneously.

The remote control system at the specified substations will be composed of the followings:

- Cable fault detector
- Motor drive device of load break switch
- Remote control relay panel
- Radio control device

The devices and facilities for the remote control system at LDC will be provided by other project.

(vi) LV capacitor

The LV capacitor banks will be provided with automatic controller to improve the power factor and voltage regulation on the distribution system. The LV capacitor banks are installed at the indoor type substation with over 400 kVA transformer capacity and large industry consumers.

a)	Type	:	Three-phase, oil immersed, indoor use
b)	Service voltage	:	Three-phase, 400 V
c)	Rated frequency	:	50 Hz
d)	Rated capacity	:	200 kVAR, 300 kVAR.
e)	Control equipment	:	automatic control, 12-steps.

(b) Outdoor Cubicle Type Substation

The cubicle type substation will be of metal housing, thermal insulation and water-proof, outdoor type. The metal housing will be installed on the concrete foundation.
All equipment for the 22 kV feeder circuits, transformer primary circuit, transformer and LV distribution board will be installed in the metal housing. This substations will be classified in the capacity of 400 kVA and 630 kVA.

During the period of rehabilitation and upgrading works of the existing indoor type substation, this substation will be utilized for temporally substation.

The specifications of major equipment are as follows :

(i) Transformer

a)	Type	:	three-phase, oil immersed indoor type with no-

voltage tap changer (±5%, 5-steps)

b) Voltage ratio :
   Primary side : 15/22 kV, 3-phase 3-wire system
   Secondary side : 400-230 V, 3-phase 4-wire system
c) Vector group : Dyn 11
d) Cooling system : ONAN

(ii) 22 kV switchgear :

a) Rated voltage : 24 kV, 50 Hz
b) Switch : load break switch
c) Rated current : 630 A (for feeder circuit)
   200 A with power fuse (for transformer primary circuit)
d) Short circuit current : 16 kA (1.0 second)

(iii) Low voltage distribution board :

a) Type : Distribution board, in the cubicle
b) Service voltage : 400-230 V, three-phase, four-wire
c) Switch : 1,600 A (for main circuit)
   400 A (for feeder circuit)
d) Feeder circuit : 8-circuit

(c) Pole Mounted Distribution Substation

The pole mounted distribution substation will be classified into three size with transformer capacity of 100 kVA, 200 kVA, and 315 kVA.

The transformer, disconnecting switch with fuses, lighting aresters and LV distribution board will be installed on the H-type concrete poles.

The specifications of the major equipment are as follows:

(i) Transformer

a) Type : three-phase, oil immersed indoor type with no-voltage tap changer (±5%, 5-steps)

b) Voltage ratio

Primary side	:	15/22 kV, 3-phase 3-wire system
Secondary side	:	400-230 V, 3-phase 4-wire system

c) Vector group : Dyn 11

d) Cooling system : ONAN

(ii) 22 kV fuse switch :

a) Type : Pole mounted, hand operated type

b) Rated voltage : 24 kV

c) Rated current : 100 A frame

d) Rated breaking current : 10 kA

(iii) 22 kV Lighting arrester :

a) Type : non-linear zinc oxide resistor (ZnO), pole mounted type

b) Rated voltage : 24 kV, 50 Hz

c) Nominal discharge current : 5 kA

d) Max. residual voltage at normal current : 79.9 kV

(iv) Low voltage switchgear

The major equipment are as follows :

a) LV load break switch :

Type	:	Pole mounted, Manual operate, 2-feeder circuits,
Service voltage	:	400-230 V, 3-phase 4-wires system, 50 Hz
Nominal current	:	165 A

b) LV panel :

Type	:	Outdoor use, cabinet type, 4 feeders,
Service voltage	:	400-230V, 3-phase 4-wires system, 50 Hz
Nominal current	:	800 A
Rated short circuit current	:	25 kV (1.0 second)

(d) Utilization of the Existing Facilities

There are the existing indoor type substations of 44 stations in the Project area. The quality of substation equipment have been deteriorating through the long operation period more than twenty five years and the capacity are also insufficient for the current power demand.

To meet the requirements of the Project design, all of the existing equipment will be replaced with new equipment having adequate supply capacity and voltage level under the Project. The existing buildings will be repaired for leaking of rainwater in the roof, damaging door and ventilation, crumbling mortar wall, and peeling off paint under the Project.

EdC has an intention to utilize the removal existing equipment for purpose of rehabilitation of the power system in the rural areas.

(3) Distribution Line Facilities

The distribution line facilities to be provided under the Project are shown in Table 2.23.

(a) Overhead distribution facilities

(i) Overhead line support

Supports for overhead liens are to be of steel reinforced concrete pole, with 12 m long for MV distribution lines and 9 m for LV lines. The poles will be set in the concrete foundations. Stay wire is set with drive type steel anchors to increase the strength of angle type and dead-end type supports. The pole assembly of the distribution lines is shown in Figure 2.8.

The height of poles was decided as follows:

Table 2.24 Height of Pole

	MV Line (m)	LV Line (m)
Span	50.00	30.00
Distance from lower crossarm to the top of pole	2.26	0.25
Maximum sag of conductor	1.76	0.77
Minimum height of conductor above ground	5.50	5.50
Clearance	0.48	0.98
Depth of pole	2.00	1.50
Total (necessary pole height)	12.00	9.00

(ii) Insulators

Pin and disk insulators are to be used for supporting the 22 kV line conductors. The conductors will be fixed to the insulators by insulated annealed aluminum bind wires.

(iii) Conductors

The tripping frequency of feeder circuit breakers are considerable high, arising from the short circuit faults due to contact the line to line or earth faults due to contact the line to tree of the existing bare line conductors.

Taking account of the above, hard aluminum insulated conductors will be used instead of the existing bare conductors as follows:

a) MV overhead line conductors

- Insulated wire : 150 sq.mm x 1-core aluminum conductors, polyethylene insulated wire.
- Aerial bundle cable : 150 sq.mm x 3-cores aluminum conductors, cross linked polyethylene insulated cable with messenger-wire.

b) MV underground cable

- Underground cable : 240 sq.mm x 3-cores aluminum conductors, vinyl sheathed, cross linked polyethylene insulated.

c) LV overhead line conductor

- Aerial bundle Cable : 150 sq.mm × 3-core + 75 sq.mm × 1-core aluminum conductors, vinyl insulated cable.

d) Service wires : Aluminum conductors, vinyl insulated wires. 3.5 sq.mm × 2-wires twisting, 8 sq.mm × 2-wires twisting, and 8 sq.mm × 4-wires twisting,

(iv) Arms

The conductors of the MV overhead distribution lines will be arranged in triangular-formation for a circuit on the straight pole. The arm are to be fixed to the pole with two through bolts. The conductors on the angle and end poles will be arranged in horizontal formation with a cross arm which is to be fixed to the pole with a through bolt and two arm ties as shown in Figure 2.8

(v) Fuse cutout switches

Fuse cutout switch with cartridge fuses for the transformer protection will be adopted 24 kV, 100 A, drop-out type, and the fuse rating will be used 10 A, 15 A and 20 A.

(vi) Lightning arresters

Lightning arresters will be of 24 kV, 5 kA non-linear resistor type and mounted on the end of lines, at the joint of underground cables and overhead lines, at the line switches, and distribution transformer stations.

(vii) Grounding

The transformer, lightning arrester, switch case and other metal parts required for safe operation will be grounded by means of a grounding rod. Copper coated steel rods will be used for grounding.

(viii) Watt-hour meters

Watt-hour meters will be of AC single and three-phase, outdoor use and cyclometer register type.

The single phase watt-hour meters will be used for domestic consumers, and three phase watt-hour meters and CT's meter arrangement for metering of the large consumers.

The major electrical features of the watt-hour meter are as follows :

Table 2.25 Watt-hour Meter

		Single-phase	Three-phase	Three-phase with CT
Rated voltage	(V)	230	230/400	230/400
Frequency	(Hz)	50	50	50
Rated current	(A)	5 - 20	10 - 30	5
	(A)	15 - 60	30 - 90	-
Power factor		0.7 - 0.98	0.7 - 0.98	0.7 - 0.98
Class		2	2	2
Number of Figure		6	6	7

Aggregate meter boxes will be made from plastics for out door use. The size of boxes will be for mounting three (3) or five (5) single phase watt-hour meters or one (1) three phase watt-hour meter with necessary accessories and fittings such as terminal blocks, miniature circuit breakers and fuses etc. The boxes will be mounted on an existing distribution line pole or building wall near the grouped consumers.

(b) Underground cable line

Underground cables will be of 24 kV, 240 sq.mm × 3-cores aluminum conductors, vinyl sheathed, cross linked polyethylene insulated steel armored cable.

The cable ends will be of premould stress cone type and the straight through joint of the cables will be installed in concrete pits for their protection. The cables at the routes along roads and at the footpath will be laid in the direct-burried system as shown in Figure 2.9.

The cables at the crossing portion of main roads will be laid in super vinyl pipes and/or in concrete ducts.

The power cables to be installed on the Chroy Changwar Bridge will be laid with cable racks inside of the bridge girder as shown in Figure 2.10.

(4) Civil and Building Works for Substations

The required civil and building works for new substations and renovation of the existing substations under the Project are as follows:

- Land formation works
- Construction of substation buildings
- Renovation and enlargement works of existing buildings
- Grounding works for all equipment

(a) Land Formation Works

Land formation works are necessary for the indoor type substations and outdoor cubicle type substations. The existing substation buildings will be renovated and/or enlarged under the Project. The numbers of stations for the above works are as follows:

Table 2.26 Substations for Land Formation Works

Project Area	Package type substation	Indoor substation	
		New	Existing
Takmau	0	4	2
Chroy Chang War	0	4	0
Pochengtong	4	8	1
Russey Keo	1	11	0
Total	5	27	3

The total volumes of land formation works for new construction and for enlargement of the existing substations are to be 1,393 sq.m.

Land acquisition for the above must be carried out by EdC.

(b) Construction of New Substation Buildings

New station buildings will be of concrete and brick structure providing with a steel door, lighting apparatus, ventilation and door flame. The building works are also including concrete foundations for the transformers and cubicles, floor concrete, and cable ducts.

The areas of station buildings are given below.

Table 2.27 Area of Substation Building

Dimensions (m) (w) × (d) × (h)	Number of substations
4.0 × 3.8 × 4.8	25
7.0 × 3.8 × 4.8	1
7.8 × 5.0 × 4.8	1

(c) Renovation and Enlargement Works for Existing Buildings

(i) Enlargement works

For indoor type substations, all substation facilities to be provided under the Project will be installed in the existing buildings with their renovation and/or enlargement works.

The details of required enlargement works are as follows:

Table 2.28 Area of Enlargement of Buildings

District	No. of building	Building Dimensions (W) × (L) × (H), (m)	
		Existing	Enlarged
Pochnegtong	1	3.8 × 3.8 × 4.94	7.3 × 3.8 × 4.94
Takmau	1	7.4 × 5.8 × 4.97	11.4 × 5.8 × 4.97
	1	2.8 × 2.8 × 4.71	4.0 × 3.8 × 4.71

(ii) Renovation works for existing building

a) Repair works of building

The steel door and ventilation for the existing substation buildings are necessary to repair. The details of the repair works are as follows:

Table 2.29 Repair Works of Buildings

District	Repair	
	Door	Ventilation
Takmau	3	4
Chroy Chang War	2	3
Pochengtong	1	5
Russey Keo	3	7
Total	9	19

b) Water proof works

The required water proof works in roof of the existing buildings are as follows:

Table 2.30 Water Proof Works

District	No. of building	Roof space (m^2)
Takmau	4	96
Chroy Chang War	4	55
Pochengtong	2	36
Russey Keo	3	58
Total	13	245

c) Floor raising works

The required floor raising works to protect from the flood water for the existing substation building are as follows :

Table 2.31 Floor Raising Works

Project Area	No. of building	Floor	
		Raising height (mm)	Floor space (m^2)
Takmau	3	200	70.9
Chroy Chang War	1	300	12.5
	1	100	15.6
Pochengtong	1	200	16.0
	1	300	14.5
	1	500	15.3
Russey Keo	1	200	22.8
Total	9	-	167.6

d) Wall repair works

The mortar walls have crumbled at the some existing substation buildings. Furthermore, the wall will be given some damages by the works of remove and installation of the substation equipment. Those walls will be repaired under the Project

g) Painting works of the substation buildings

The painting are peeling off the existing substation buildings. The painting works will be carried out under the project as follow :

Table 2.32 Painting Works

District	No. of building	Coating surface (m^2)
Takmau	14	3,106
Chroy Chang War	4	674
Pochengtong	0	0
Russey Keo	10	2,000
Total	13	5,780

(d) Grounding Works

All distribution substation equipment and other metal parts required for safe operation will be grounded by means of a 35 mm^2 copper cable and ground rods. Cooper coated steel rods will be used for grounding. The grounding resistance for neutral terminal of distribution transformers shall be of less than 10 ohm.

CHAPTER 3

IMPLEMENTATION PLAN

CHAPTER 3 INPLEMENTATION PLAN

3-1 Implementation Plan

3-1-1 Implementation Concept

This Project is to be implemented through close cooperation between the Government of Japan and the Government of Cambodia within the framework of grant aid from the Government of Japan.

The Ministry of Industry Mines and Energy (MIME) is responsible for the management of the Project on the Cambodia side and the implementing Agency is EdC.

The distribution line facilities consist of various kinds of materials and equipment such as support, insulators, conductors, cables, and transformers, etc. Each material and equipment has its own mechanical and electrical strength in different configuration and specific. To maintain high reliability of the system operation, the following essential points should be taken into account for the design and construction of the facilities to be provided under the Project.

(a) Facilities are to be designed and constructed in accordance with the specific actions of the materials and equipment.

(b) Shorter power shutdowns and safety measures are demanded from the reconstruction of distribution lines and distribution substations

In addition to the above, local contractors have been trained for construction works of the power distribution facilities through implementation of the distribution projects. However, reliable local contractors in Cambodia are still in short supply. Therefore, all construction works under the Project will be executed by local contractors under guidance of the Japanese contractor(s), except for special works such as commissioning test, jointing of cables, terminating of cable heads, and other key works, which will be done by the Japanese specialist.

Although EdC has capability for implementing the Project, it is insufficient in number of experienced engineers. Therefore, planning, designing, and supervising the Project works will be undertaken by the Japanese Consultant.

The works to be undertaken by the Consultant, Contractor, and EdC are mentioned below:

(1) **Works to be undertaken by the Consultant**

(a) Home Works

- To prepare the detailed design of the distribution lines and distribution substations.
- To prepare the tender document for procurement and erection of materials and equipment.
- To execute tendering and evaluation works
- To assist EdC in contract negotiation and conclusion of the Contract
- To approve and comment on the design, specifications and drawings provided by Contractor(s).
- To attend the pre-shipment inspection and test on the materials and equipment at the manufacturer's factories.
- To prepare inspection certificate.
- To report and explain to JICA.

(b) Site Works

- To prepare the working drawings for civil and building works for the distribution substations.
- To adjust and check the construction schedule.
- To prepare route map and assembly drawings for distribution lines.
- To assist EdC in construction supervision including quality control and safety measure.
- To approve the commissioning tests schedule submitted by the Contractor(s).

- To attend the commissioning test.

- To transfer technical knowledge

- To prepare the monthly reports on construction.

- To prepare progress payment certificates.

- To prepare the completion report for the Project.

(2) Works to be undertaken by the Contractor

The works to be undertaken by the Contractor are include designing, manufacturing, testing, painting, transportation, and erection of the materials and equipment to be supplied under the Project.

As discussed with EdC, obtaining the necessary permission from the concerned authorities for execution of the project, and dismantling and reconnecting of service wires to the consumers' will be undertaken by the Cambodia side.

As explained in section 2-1-2, in order to obtain permission from the Road Department, the contractor is required to submit applications with work plans prior to the commencement of installation of power cables on the Chroy Changwar bridge, and excavation and restoration of public roads as required under the project.

(3) Works to be undertaken by EdC

- To make banking arrangements.

- To obtain necessary permits for imports into Cambodia and to bear the license fee.

- To secure the right of free entrance to the Project sites.

- To get permission from the authorities concerned for the construction works when needed.

- To coordinate with the residents in the Project area on matters that may arise

during the implementation of the Project.

- To dismantle and reconnection of the service wires.
- To remove the existing distribution lines.
- To secure the right of way for the Project.
- To make the necessary arrangements for power shutdown according to the construction schedule.
- To secure a stockyard for materials and equipment to be granted.
- To bear all the expenses, other than those to be borne by the Grant, necessary for construction of the facilities as well as for the transportation and installation of the equipment.

3-1-2 Implementation Conditions

The matters to be attended for the site construction works are described below:

(1) Though acquisition of private and arable lands for the Project is easy, the lands are swampy. Therefore, new lines will be constructed along the road or on the existing line routes.

(2) Power shall be shutdown during the execution of construction and reinforcement for distribution lines and reconstruction of the distribution substations. Power supply shall resumed toward evening. Special attention shall be paid to the work schedule and pre-information to the customers for the shutdowns.

(3) For construction of underground cables, prior applications will be required in order to get the necessary permission from the Road Department. The finishing works, including paving and asphalting of the roads, will be done by the contractor according to the regulation of the Road Department.

(4) For tree felling and trimming for distribution line works including exploration of the line route, prior applications for permission from the concerned authorities are required.

(5) The Power cable for crossing over the Sap river will be installed on the Chroy Changwar bridge, prior applications will be required in order to get the necessary permission from the Road Department.

(6) The overhead distribution lines in the airport area shall be constructed in accordance with the regulation for international airport to maintain the height and distance of the lines.

3-1-3 Scope of Works

The component of the distribution facilities are illustrated as follow;

MV. Distribution Lines	(Overhead line, Underground cable lines)
↓	
Distribution Substation	(House type, Cubicle type, Pole mount type)
↓	
LV. Distribution Lines	(Overhead lines)
↓	
Watt-hour Meters	(Single phase meter, Three phase meter)
↓	
Service Wires	
↓	
Consumers	

The works in other projects are including supply and erection for all necessary materials and equipment to complete the system except election of service wires for consumers. The erection of service wires have been done by EdC.

Accordingly, the following materials and equipment to complete the planned distribution system in the Project areas will be supplied and constructed within the framework of the Japan's grant aid schem, except erection of service wires which is to be done by EdC.

(1) Supply and installation of the facilities for 22 kV overhead and underground distribution lines.

(2) Supply and installation of the facilities for 22-15 kV/400-230 V distribution substations.

(3) Supply and installation of the watt-hour metering facilities.

(4) Supply of the service wire facilities.

(5) Supply of maintenance tools, instruments, vehicles and spare parts .

(6) Other related works to the above such as transportation of facilities and equipment, civil and building works for distribution substations, and on-the-job training.

3-1-4 Consultant Supervision

In execution of a Japan's Grant Aid Project, the appropriateness of the Project is at first confirmed by the Japanese Government. Then, an Exchange Note (EN) is to be prepared between the concerned two governments, and then implementation of the Project is started. In executing detailed design and project supervision, a project executing organization must be established paying due attention to the followings.

(i) To understand background of project execution

(ii) To understand contents of the Basic Design Study

(iii) To understand framework of the grant aid assistance from Japan

(iv) To understand contents of the Exchange Note agreed between the two governments

(v) To fully take into account site working conditions

Taking into account the above understanding, the contents of consulting services, member of consultants and a necessary organization for execution are explained hereunder.

(1) Consultant Services

(a) Detailed Design and Preparation of Tender documents

(i) Detailed design

Taking into account the results of the Basic Design Study, the construction cost is

estimated and the portions of works to be carried out by the Cambodian side shall be clarified through site investigation and discussion with Cambodian officials.

(ii) Preparation of tender documents

The tender documents for competitive tendering are prepared based on the results of basic design study, construction plan and regulation for grant aid assistance from Japan.

(b) Construction supervision

(i) Tendering process

The consultant services in this stage include tender invitation, questionnaires and replies, official tender opening, evaluation of submitted tenders, negotiation with contractors and concluding contract.

(ii) Construction stage

The consultant services in this sage include attendance to a meeting among concerned parties prior to commencing project construction, review and approval of design documents, factory inspection before delivery, construction supervision during site erection, preparation of progress reports during site erection period, issue of interim reports for site erection and attendance to the completion test. From special features of site erection, management of power interruption plans associated with changeover from the existing facilities to the new installations will be an important task.

(iii) Project completion

The consultant services in this stage include issue of the completion certificate, procedure for takingover completed project, preparation of final report and procedure necessary for completion of the services.

(2) Member of Consultant Services

To smoothly execute necessary services itemized in (1) above, it is required that a senior engineer with ample experience to similar kinds of services and enough understandings to the contents of the Project will be nominated as the Project Manager and an effective organization for execution consisting of staffs for detailed design, tendering procedures, review and

approval of design, factory inspection, and site supervision shall be established.

(a) Project Manager

Based on full understanding of the background and purpose of the Project, the Project manager shall manage overall execution of the Project. He shall review and understand progress of the Project and current problems, and control progress of the works and provide advice to constitute members.

(b) Detailed design

Taking into account the established basic criteria, the consultant shall carry out decision of specifications of equipment and materials necessary for the Project, layout designing, detailed designing, preparation of the construction plan taking into account supply interruption planning, and estimation of project cost.

(c) Tendering process

The consultant shall review the tender documents and carry out tender invitation, tender acceptance, evaluation of submitted tenders, negotiation and conclusion of contract.

(d) Review of design and factory inspection

In the home office, the consultant shall review drawings, specifications, instruction books, etc., decide approval or not and inform to contractors, and carry out factory inspection prior to delivery.

(e) Site erection supervision (Overhead line-1, Overhead line-2, Underground line and Substation as resident supervising engineers)

Three engineers shall station at the work site and supervise the Project execution during the entire period from starting site erection till completion.

3-1-5 Procurement Plan

The materials available in the local market such as cement, gravel, plywood, bricks, and structural steel will be procured in Cambodia. A modern concrete pole factory has recently

been established in Phnom Penh. The Study Team had an inspection for the factory facilities and it is found that the quality of product and production capacity of the factory meet the requirements of the Project. Therefore, the concrete poles for supports of MV and LV distribution lines will be procured in Phnom Penh.

The procurement plan of the materials and equipment for the Project shall be made paying due attention to the following:

i) To provide experienced facilities for EdC in operation and maintenance.

ii) To able to procure and repair in reasonable price in the country.

iii) To coordinate with facilities to be constructed under other projects.

From the above understanding, the procurement plan is presented as shown below.

Table 3.1 Procurement Plan

Description			Country
Supports	MV Lines	Concrete Pole	Cambodia
	LV Lines	Concrete Pole	Cambodia
Supports' Accessories		Arms, Bolt, Nut, Grounding rot, and Others	Japan
Guy Wires		Guy wire, Insulator, Band, Anchor	Japan
Conductors	MV Lines	Insulated wire	Japan
		Aerial bundled cable	Sweden
		Underground cable	Sweden
	LV Lines	Aerial bundled cable	Norway
		Underground cable	Norway
	Service Lines	Insulated service wire	Japan
	Others	Grounding wire and others	Japan
Conductors' Accessories		Connectors, Joint box, Cablehead, Cable protection pipe	Sweden/Norway/ Japan
Insulators	MV Lines	Pin type, Tension type	Japan
	LV Lines	Spool type	
Line Equipment		Line switches	France
		Arrestor	Japan
Transformers		100, 200, 315, 400, 630, 1,000 kVA	Thailand/Indonesia
Cubicles		MV cubicles	France
		LV switching board	Singapore
Capacitor		200, 300 kVAR	France
Watt-hour Meters		Single phase, three phase, CT's meter	Indonesia/Germany
Aggregate Meter Boxes		For 3 and 5 meters	France/Malaysia

3-1-6 Implementation Schedule

The Project will be implemented in two stages and the sub-projects for each stage are divided as follows;

Stage-I Project

Project areas: Takmau and Chroy Chang War areas

Table 3.2 Projects of Takmau and Chroy Chang War areas

	Description	Unit	Q'ty
(a)	22 kV overhead distribution lines	km	16.8
(b)	22 kV underground distribution lines	km	15.6
(c)	LV distribution lines	km	76.8
(d)	Indoor type substations	units	26
(e)	Cubicle type substation	units	-
(f)	Pole-mounted transformer stations	units	8
(g)	Watt-hour meters	pcs	9,946
(h)	LV capacitor	kVA	4,000
(i)	Maintenance tools and equipment	lot	1
(j)	Vehicles for maintenance works	lot	1
(k)	Spare parts	lot	1

Stage-II Project

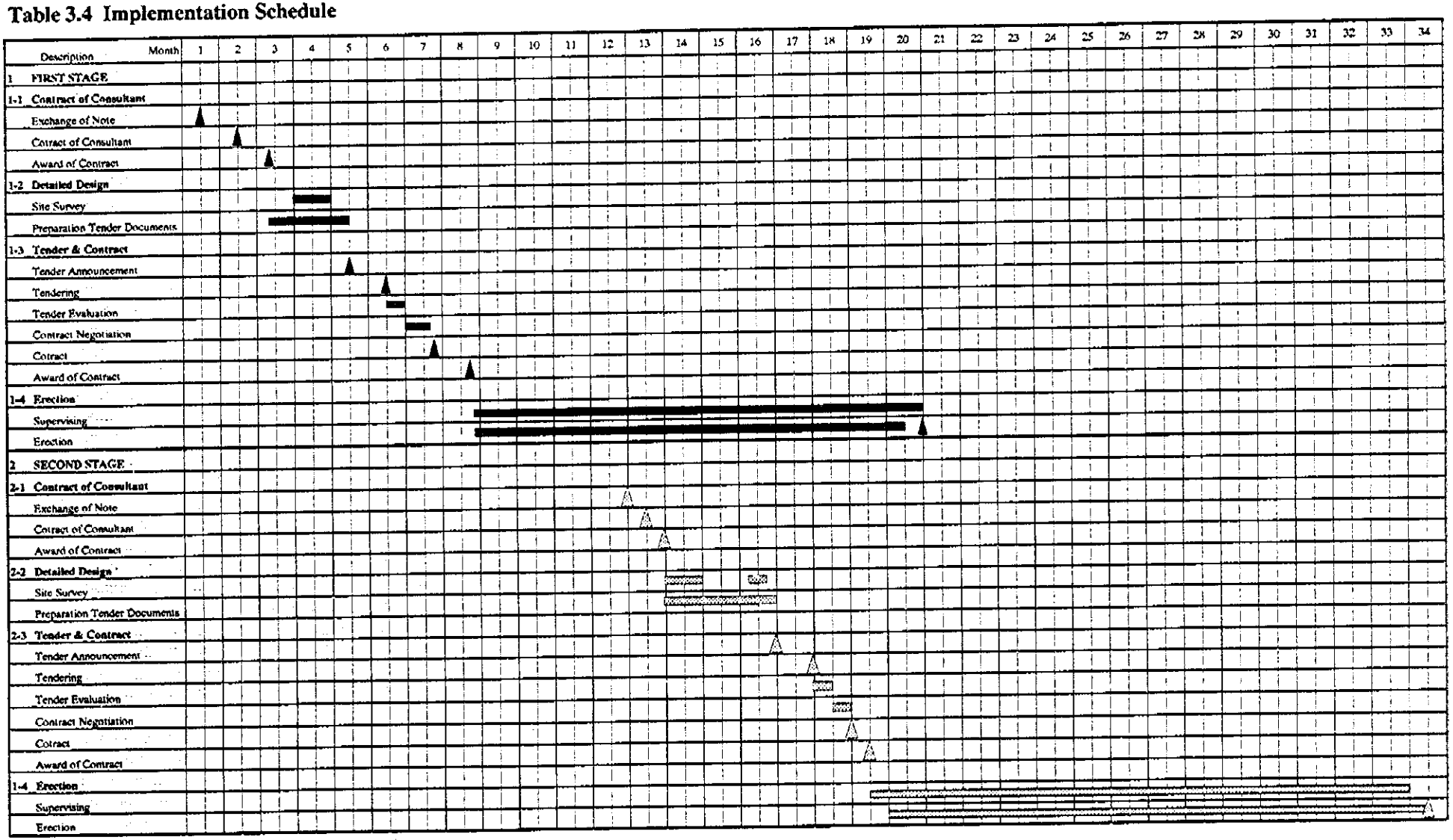
Project areas: Pochengtong and Russey Keo areas

Table 3.3 Projects of Pochengtong and Russey Keo areas

	Description	Unit	Q'ty
(a)	22 kV overhead distribution lines	km	31.4
(b)	22 kV underground distribution lines	km	17.5
(c)	LV distribution lines	km	114.7
(e)	Indoor type substations	units	45
(f)	Cubicle type substation	units	5
(g)	Pole-mounted transformer stations	units	18
(h)	Watt-hour meters	pcs	13,582
(i)	LV capacitor	kVA	11,000
(m)	Spare parts	lot	1

The implementation schedule is as shown in Table 3.4.

Table 3.4 Implementation Schedule



3-1-7 Obligations of Recipient Country

In the implementation of the Grant Aid Project, the recipient country is required to undertake such necessary measures as the following:

(1) to secure land necessary for the sites of the Project and to clear, level and reclaim the land prior to commencement of the construction.

(2) to provide facilities for the distribution of electricity, water supply and drainage and other incidental facilities in and around the sites.

(3) to secure buildings prior to the procurement in case the installation of the equipment.

(4) to ensure all the expenses and prompt execution for unloading, customs clearance at the port of disembarkation and internal transportation of the products purchased under the Grant Aid.

(5) to exempt Japanese nationals from customs duties, internal taxes and other fiscal levies which will be imposed in the recipient country with respect to the supply of the products and services under the Verified Contracts.

(6) to accord Japanese nationals whose services may be required in connection with the supply of the products and services under the Verified contracts, such facilities as may be necessary for their entry into the recipient country and stay therein for the performance of their work.

(7) "Proper Use"

The recipient country is required to maintain and use the facilities constructed and equipment under the Grant Aid properly and effectively and to assign staff necessary for this operation and maintenance as well as to bear all the expenses other than those covered by the Grant Aid.

(8) "Re-export"

The products purchased under the Grant Aid should not be re-exported from the recipient country.

(9) Banking Arrangement (B/A)

(a) The Government of the recipient country or its designated authority should open an account in the name of the government of the recipient country in an authorized foreign exchange bank in Japan (hereinafter referred to as "the Bank"). The Government of Japan will execute the Grant Aid by making payments in Japanese Yen to cover the obligations incurred by the government of the recipient country or its designated authority under the Verified Contracts.

(b) The payments will be made when payment requests are presented by the Bank to the Government of Japan under an authorization to pay issued by the Government of the recipient country or its designated authority.

3-2 Operation & Maintenance Plan

It is desirable that Government of Cambodia provides a budget for the Project and conducts the works on schedule so that the entire Project will be implemented smoothly and the facilities to be constructed under the Project are utilized effectively.

The cost for the Project to be owned by Cambodia are estimated at about US$270,000. The major part of the cost is for land acquisition for new substations and connection work of service drop wire to customers. The breakdown of the estimation is shown in Appendix 5.

It will also be necessary to include in the above that banking arrangement fee, authorization to pay, the fees covering the import duties, tax for the various subjects, and all other expenses for implementation of the Project.

The implementing agency is EdC. EdC will also be responsible for operation of all power facilities in Phnom Penh after completion of the Project. The existing Phnom Penh distribution system are being managed and operated by Distribution Department, Commercial Department and Inspection Office of EdC. The individual duties and responsibilities of those departments are defined as follows:

Table 3.5 Duties and Responsibilities of each Department

Distribution Dept. (number of staff: 306)	Commercial Dept. (number of staff: 213)	Inspection Office (number of staff: 22)
- Operation & Maintenance	- Meter leading	- Facilities inspection
- Load dispatching	- Charge collection	- Complaint procedure
- Meter calibration	- Supply contract	- Surveillance illegal use

The actual operation and maintenance of the distribution facilities are directly undertaken by the staff of 272 persons of Distribution Department. After completion of the projects under assistance of WB and ADB including this Project, total length of the distribution lines is expected to reach about 920 km, for the medium and low voltage. It means that the field of activity for each person in Distribution Department is less 4 km in length, for operation and maintenance of distribution lines. Therefore, it is not necessary to increase the number of staff for Distribution Department at present.

At present, the energy is supplied to customers from EdC directly or through wholesalers. The wholesalers purchase energy from EdC and they are licensed to sell energy in a given area. EdC is currently taking over the direct control of energy sales in the area which the distribution system is renovated by the projects. The collection system of electricity charge in direct control is being reviewed and studied by the Consultant under assistance of WB, and their report will be submitted by the end of 1997.

A transition for EdC budget and O&M cost of Phnom Penh distribution system in the past three years is as shown below.

Table 3.6 EdC Budget and O&M Cost (unit: Million Riel)

	1994	1995	1996
Total budget of EdC	34,789	40,162	69,956
D/L operation & maintenance cost	417	512	842
Rate of O&M cost in EdC budget	1.2 %	1.3 %	1.2 %

The total budget of EdC in FY 1996 is an increase of Riel 35,167 Million (101 percent) from FY 1994. Although the rate of O&M cost in the total budget is almost constant through the past three years, the amount in FY 1996 is Riel 842 million which is an increase of twice from FY 1994.

For operation and maintenance of the distribution facilities , expenditures for insulation oil, insulators, arresters, personnel, etc., is required. The budget for operation and maintenance shall be provided timely and yearly.

An estimation of the annual budget for operation and maintenance of the facilities to be constructed under the Project is as follows.

(1) Material cost

Table 3.7 Material cost

Description	Unit	Quantity	Unit rate	Price
			(US$)	(US$)
Pin insulators	pcs	50	60	3,000
Tension insulators	pcs	50	200	10,000
Cable terminations	sets	2	500	1,000
Arresters	sets	10	2,500	25,000
Insulation oil	litter	360	12	4,320
Fuse and others	lot	1	3,000	3,000
Watt-hour meters	set	30	60	1,800
Sub-total				48,120

(2) Personnel expenses

For operation and maintenance of the distribution system, it is sufficient with the present number of staff of Distribution Department as discussed in above. Therefore, the personnel expenses are not considered for this purpose.

The estimate annual budget is to be US$ 44,120, for operation and maintenance of the facilities to be constructed under this Project.

CHAPTER 4

PROJECT EVALUATION AND RECOMMENDATION

Chapter 4 Project Evaluation and Recommendation

4-1 Project Effect

Although the projects of rehabilitation and reconstruction of the Phnom Penh Power System have being extended under the technical and financial assistance of the various donor countries and international financial institutions since 1992, the objective areas of the Project, Pochengtong, Russey Keo, Chroy Chang War and Takmau districts, have been left from those projects. These districts are functioning in the form a part of Phnom Penh in the social structures and economic activities for their daily life.

As the social environments in the areas are being gradually restored, the power demand in the areas is also growing in the sectors of residence, industries, commercials, and services. However, the aged existing distribution facilities are unable to cope with even the present power demand in distribution capacity, besides power supply reliability and voltage regulation are in a very poor state at the consumers end. And also, there is still no power supply to Chroy Chang War district and some areas in other districts at present by EdC.

The Project Works are including the rehabilitation and expansion of the existing power distribution facilities in Pochengtong, Russey Keo, and Takmau districts and new construction of the distribution facilities in Chroy Chang War district.

The current issues on the existing distribution system and the countermeasures to be enforced under the Project are shown below.

Issues	Countermeasures
1 **Excessive voltage drops and energy losses** - Excessive voltage drops, which is caused by insufficient capacity of the conductors. - Large amount energy losses more than 30% of generated energy, which is mostly caused in the low-tension network. - Insufficient distribution and transformer capacity, it will not able to cater for the growing demand.	Upgrading the conductor size, increasing transformer capacity, and installation of capacitors. The existing low-tension line will be renewed with conductors of proper size.

Issues	Countermeasures
2 Low reliability of power supply - Large supply area of the existing feeders, which causes expansion of power failure area. - Aged and deterioration distribution facilities, which will cause more faults. - Frequent occurrence line faults, which is caused by contact with the bare line conductors and trees.	Installation of line switches at the transformer station, renewal of the aged facilities and adoption of insulated wire for line conductors.
3 Improper metering - Improper metering of energy consumed by customers, metered amount include energy losses on the low-tension lines, because customers' meters are installed not at the customers ends but at the aggregate meter houses in the distribution substations.	Aggregate meter boxes will be installed at the close by consumers' group
4 Complicated low-tension line conductors - Low-tension line conductors are stretched like cobwebs in long distance with improper size from distribution transformer station to the consumers' end.	Low-tension feeder cables having sufficient capacity will be constructed from the transformer stations to the aggregate meter boxes to be installed at the close places of consumer's groups. The consumers will be connected by service drop wires with the shortest distance from the aggregate meter boxes.
5 Illegal practice of electricity charge - Electricity charge of high rate of 500-900 Riel/kW against the regular charge of 350 Riel/kW. is corrected by the wholesalers,	The contract with wholesalers will be cancelled in the areas, upon completion of rehabilitation works of distribution system.
6 Shortage of maintenance materials and spare parts - The proper maintenance and repair works are hindered due to shortage of maintenance materials and spare parts. - Facilities repaired in an improper way and temporary expedient, it will accelerate the decline in their reliability and safety.	For proper maintenance and repair works, the maintenance materials and spare parts will be supplied under the Project.

Following are the expected major effects on the completion of the Project.

- To secure the high power supply reliability for the customers.
- To increase activities of the local industrial and agricultural production.
- To release the present customers from restraint of increase of receiving power.
- To upgrade the living standard and welfare of people in the area.
- To improve the energy loss and voltage regulation on the distribution system.
- To make easy operation and maintenance of the power system and common use of the spare parts and maintenance materials in the formulation of the system voltage.
- To produce satisfactory results for application of the reasonable price of electricity.
- To improve the technical level of the operation and maintenance staffs.
- To improve the scenery in the areas due to the rehabilitation of the existing low-tension lines stretched like cobwebs

The project is not only the improvement of the very poor quality in the service level of power supply and meet the needs of electricity of the hidden consumers but also upgrade the infrastructure and economic activities and welfare of peoples in the areas. Besides, the energy losses on the distribution system will much reduced. The power demand in the Project area is forecasted about 220 GWh in 2002, it is means that the revenue of electricity will increase with US$ 18 million comparing with the current revenue as shown in Table 4.1. These will improve great the financial ability of EdC

There are no power supply to the Chroy Chang War district and some areas in other districts at present by EdC, this district and areas are partly electrified with innumerable private generators in small capacity driven by the inefficient engine. If the district and areas are electrified by the EdC power system, it will contribute to reduce the demand for import energy.

The Study Team, therefore, has determined that cooperation in the form of grant aid would be appropriate for the Project.

Table 4.1 Comparison of Income of Electricity Charge

From the power operation records in February 1998 and the electric energy forecasted for year of 2002, the income of power rates are computed for each year of 1998 and 2002 as follow:

	1998			2002		
	Peak Demand (kW)	Electric Energy (MWh)	Income of Power Rate (US$)	Peak Demand (kW)	Electric Energy (MWh)	Income of Power Rate (US$)
Takmau	2,000	9,373	911,283	14,063	65,907	6,407,639
Chroy Chang War	0	0	0	1,853	8,684	844,295
Pochengtong	2,500	11,717	1,139,104	16,813	78,796	7,660,699
Russey Keo	1,600	7,499	729,027	14,217	66,629	6,477,794
Total of Income			2,779,414			21,390,426

The income of increase in 2002 : 21,390,426(in 2002) – 2,779,414(in 1998) = US$ 18,611,012(increase)

Note
1) Electric energy for a year was computed from the peak demand and the load factor of 0.535
2) Load factor was computed from generated electric energy (MWh) and max. generated power(MW) during the period from January 1997 to March 1997.
3) Power rate 350 Riel/kWh
4) Exchange rate 2600 Riel/US$

4-2 Recommendations

On the occasion of implementation of the Projects, the following are recommended to effects operation of the Phnom Penh Power System.

Coordination with other similar projects

The following projects are being implemented to rehabilitation and expansion of the power system in the urban area of Phnom Pen.

a) Phnom Penh Power Rehabilitation Project (WB)
b) Power Rehabilitation Project (ADB)
c) Distribution Network Replacement Project in Phnom Penh (Ireland)
d) Rehabilitation Electric System in Phnom Penh (France)
e) Rehabilitation and Improvement Distribution Facilities in Phnom Penh (Belgium)
f) IPP-I Project, C2 Power Station
g) IPP-II Project, C4 Power Station

The facilities and system to be provided under the Project must be formulated with the technical coordination in design policy of above projects, to ensure the high reliability and qualified power supply to consumers from the power system.

Preparation of data list of facilities

Data list of facilities should provide to grasp the condition of facilities and equipment, all data of each facilities and equipment are recorded historically in the Data List the following their characteristics.

- Type, ratings and capacity
- Manufacturing year
- Installed location and year
- Operation conditions
- Historical record of maintenance and repair

The list must be revised in compliance with the modification of the facilities. The list will be served the operation and maintenance purpose

Mapping of Distribution Networks

It is recommended to provide the map of distribution networks with the scale of 1/2000 indicated the following notations:

- Route of HV and LV underground cable lines and location of the cable markers
- Type, size and number of the cables

- Route of HV and LV overhead lines
- Location and type of the supports, and distance between the supports
- Size, type and number of the conductors

- Location, type and capacity of distribution transformer stations

- Location of the aggregate meter boxes and number of meters in the box
- Route, type and size of service drop wires
- Location of the consumers

These maps and above data list will be combined to be essential for planning and execution of the works of operation/maintenance, new construction, expansion, and discontinuance of the distribution system.

Periodical inspection

To secure the safety and reliability of the facilities, the inspection and operation test of the distribution lines and substation facilities should be carried out in periodical with an inspection/check list.

Calibration of Watt-hour Meters

Watt-hour meters provided at the consumers' end should be inspected periodically with a proper calibration facility. As the need arises, the meters shall be adjusted in accordance with the instruction manuals of the manufacturers and sealed with a steel wire and metal tag.

Personnel Training

EdC's persons occupied in the works of the operation and maintenance are still insufficient in

their technical effort for the latest equipment and materials, it will be the prime cause of the troubles and accidents of the system and of accelerate the deterioration of the facilities.

To train the staff for operation and maintenance shall be a prerequisite for stable electricity supply. The most appropriate method would be on-the-job training from the assisting instruction, providing practical experience in operation and maintenance through the execution of the Project.

Management of the Voltage Regulation

To manage the voltage regulation, the system voltage should be recorded periodically at the feeding terminals in power stations, primary and secondary terminals of distribution transformers, and consumers' end, with the voltage recorders to verify the service levels in the voltage on the power system. As the need arises, transforms' tap and/or the capacity of capacitors will be adjusted to maintain the proper service level.

FIGURES

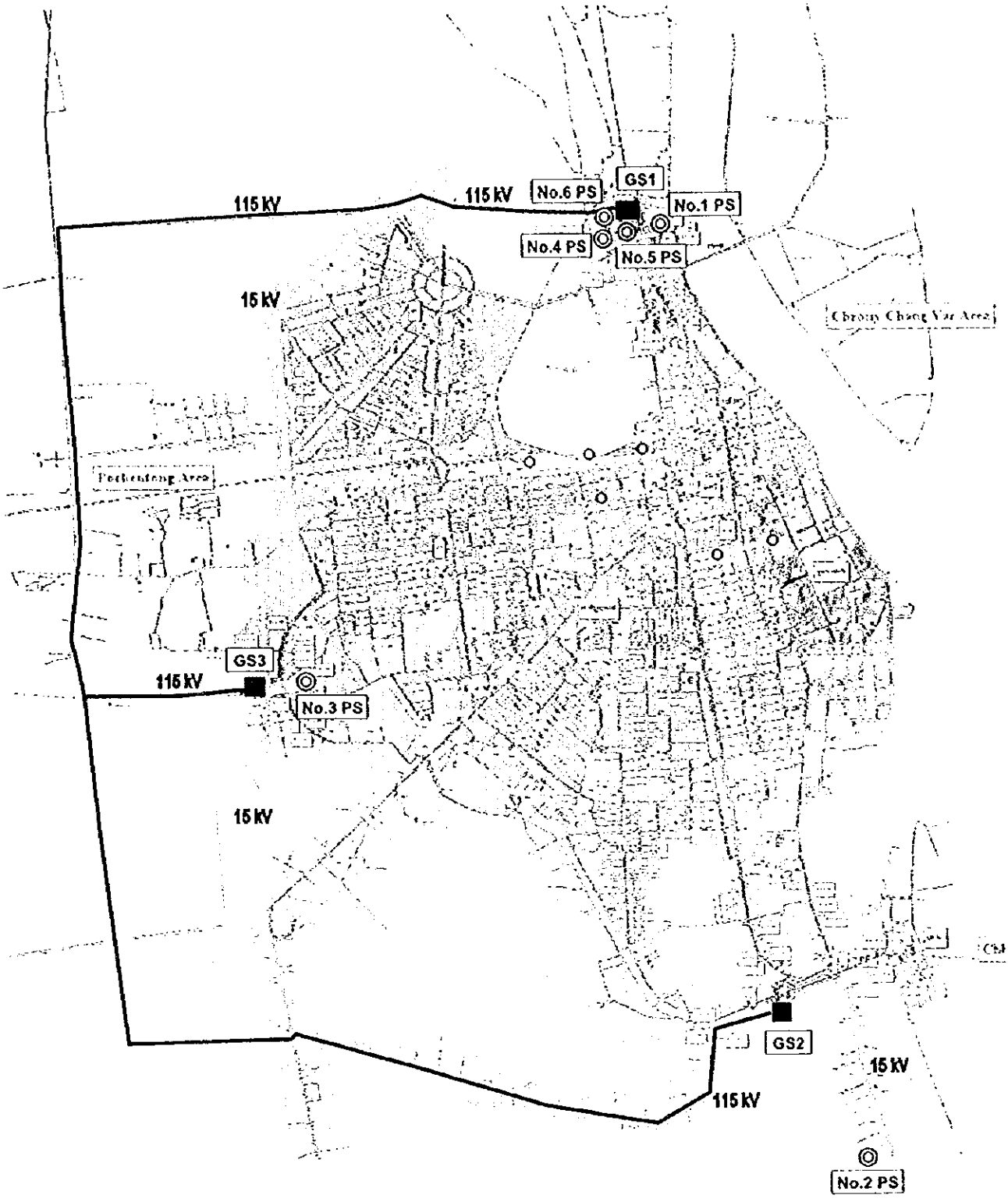


Figure 2.1 Rehabilitation Plans of Phnom Penh Power System by Other Donors

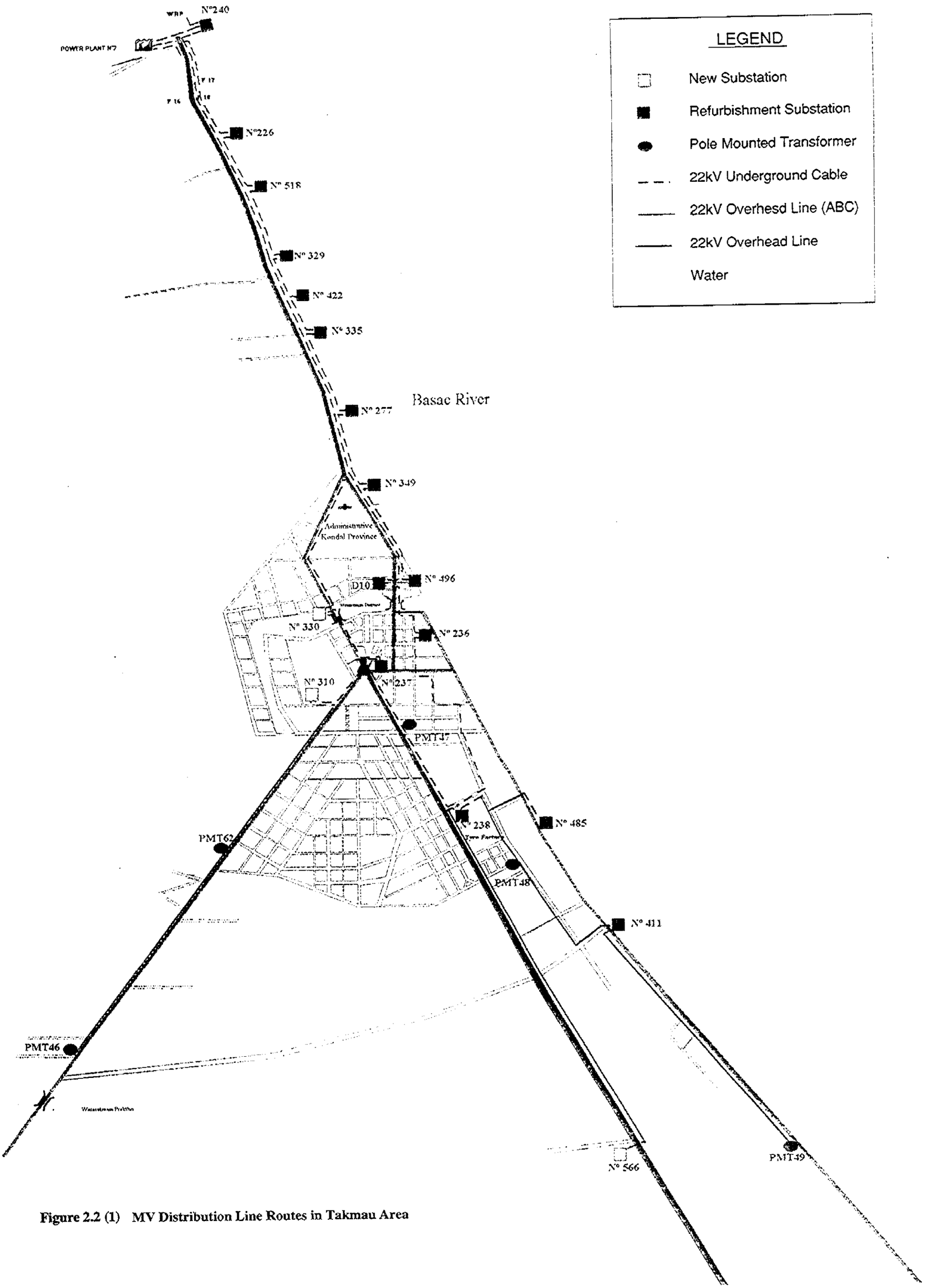


Figure 2.2 (1) MV Distribution Line Routes in Takmau Area

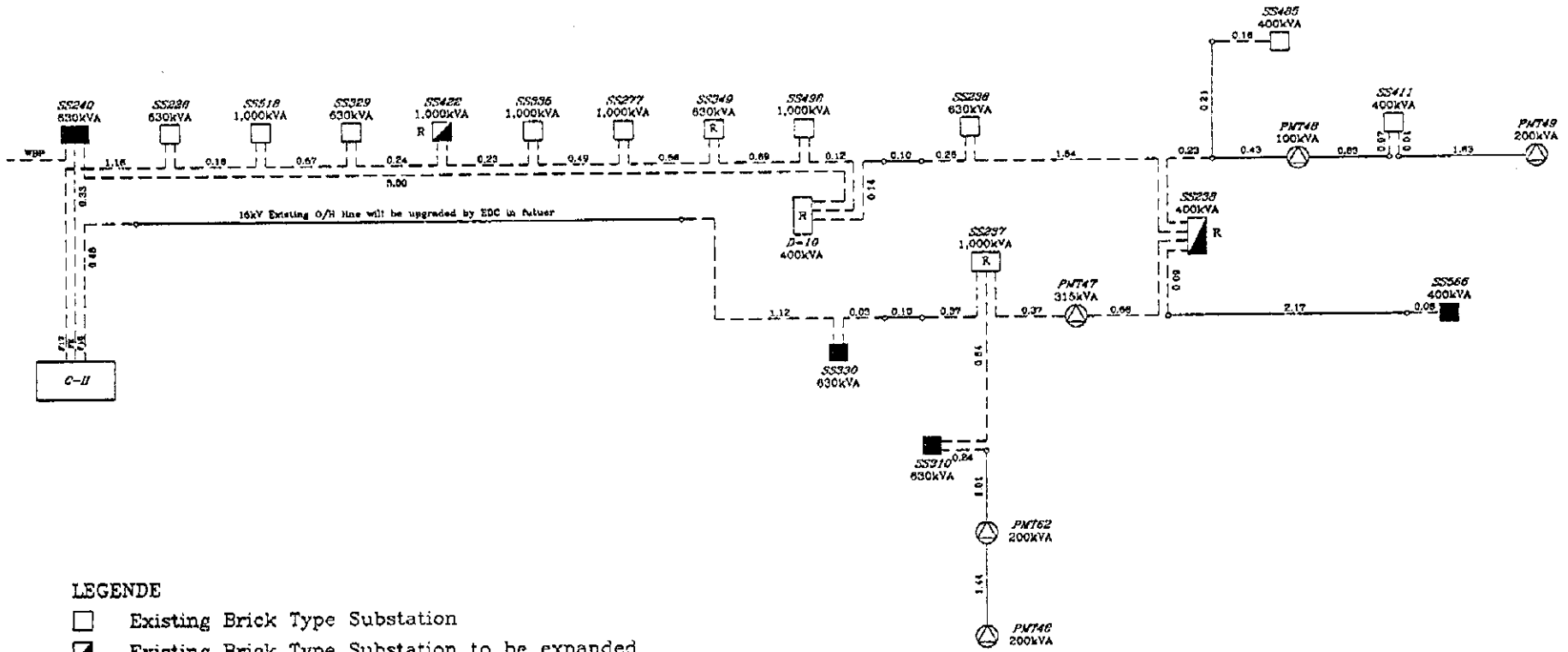


Figure 2.2 (2) MV Distribution System Diagram in Takmau Area

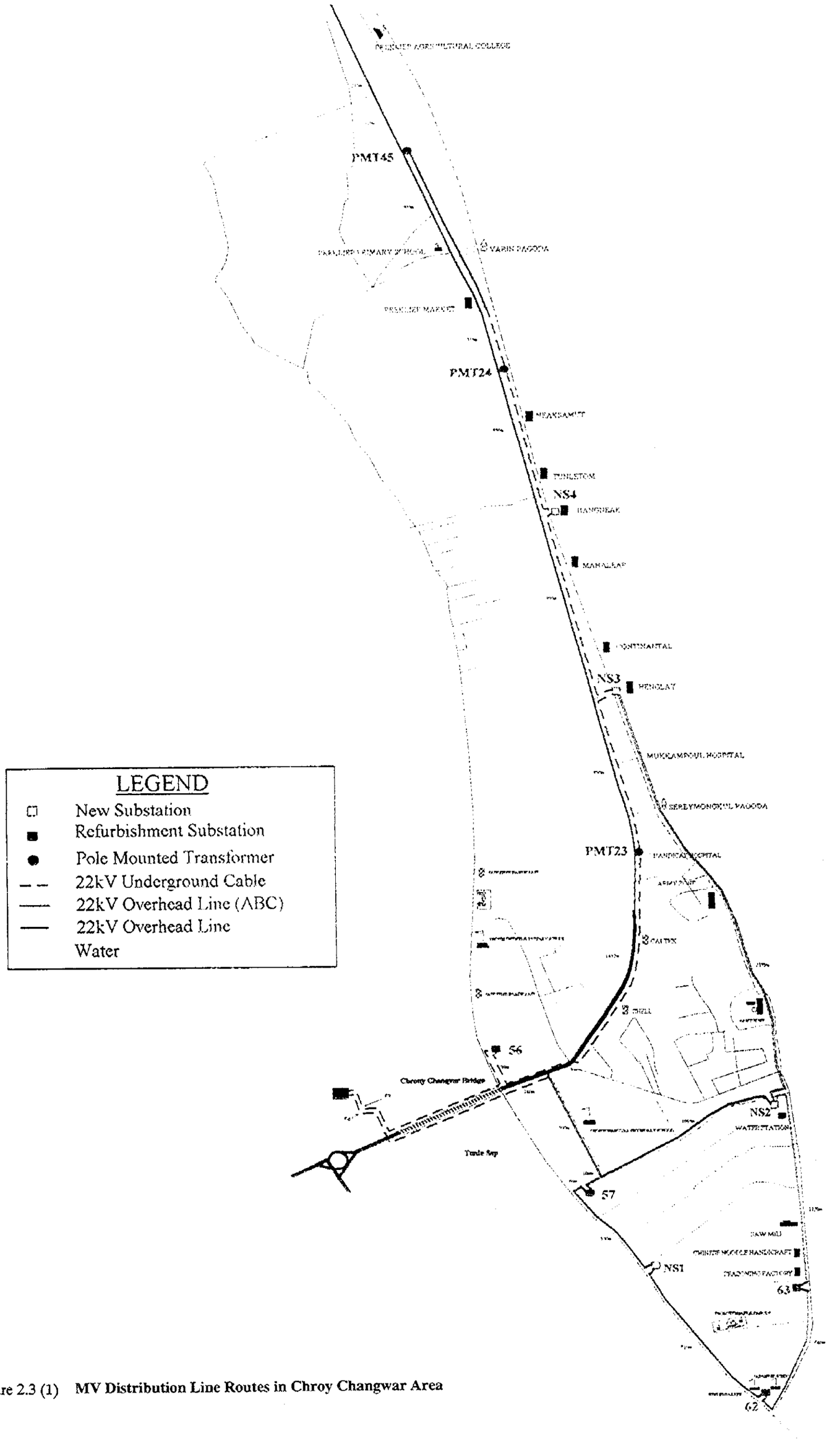
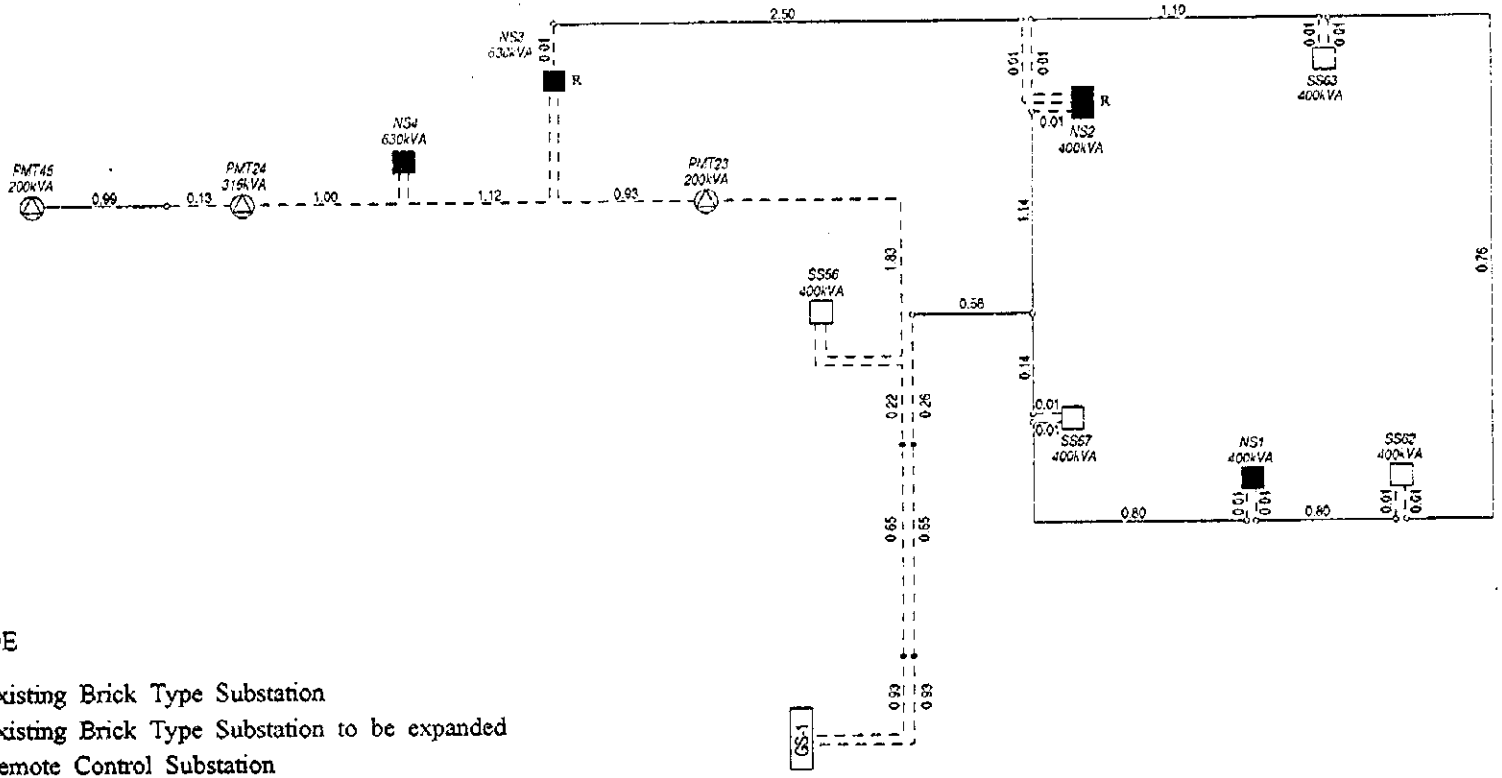


Figure 2.3 (1) **MV Distribution Line Routes in Chroy Changwar Area**



LEGENDE

- Existing Brick Type Substation
- Existing Brick Type Substation to be expanded
- Remote Control Substation
- New Brick Type Substation
- Pole Mounted Transformer
- Underground Cable Line
- New Overhead Line
- Aerial Bundled Cable Line

Figure 2.3 (2) MV Distribution System Diagram in Chroy Changwar Area

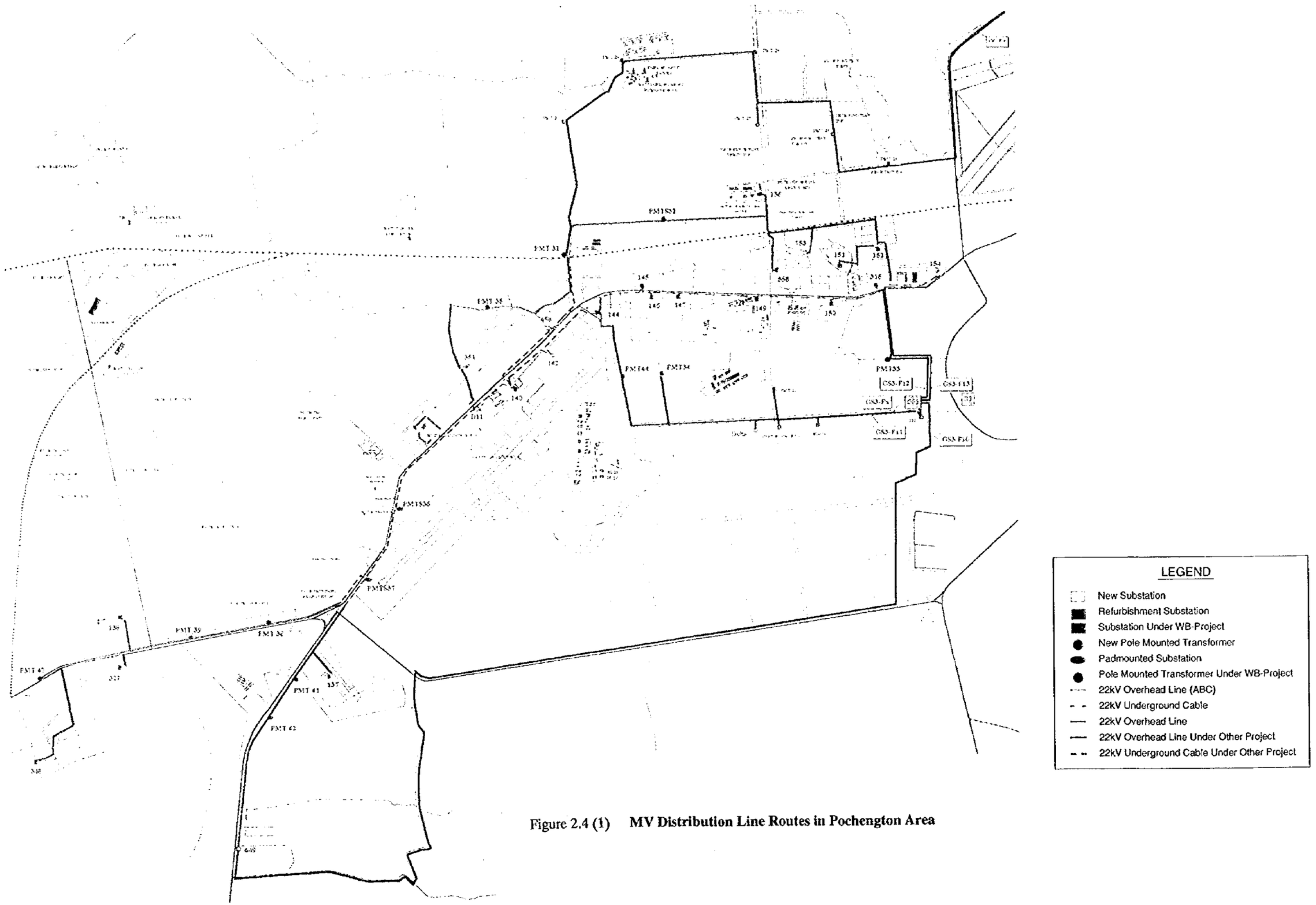
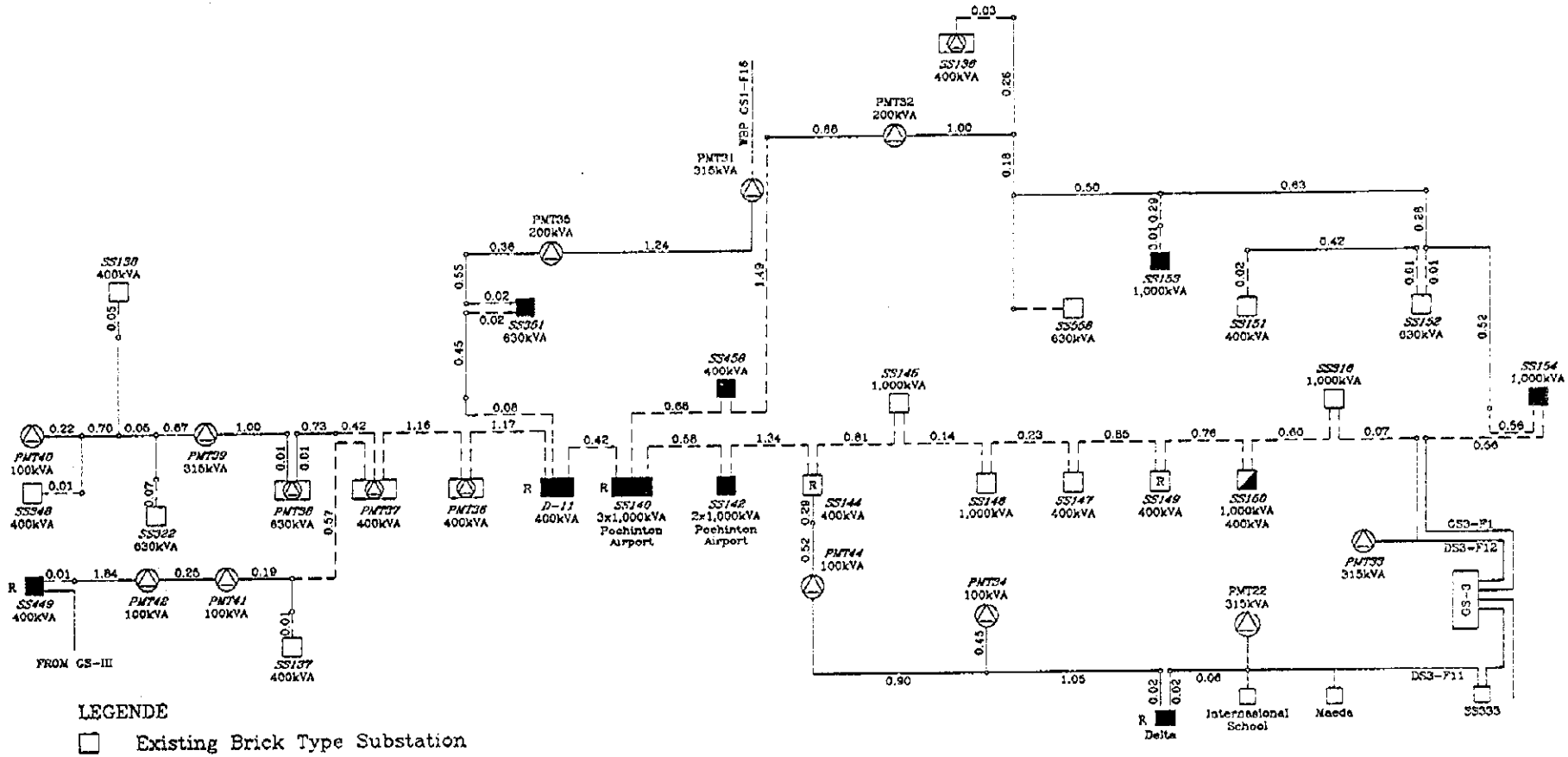


Figure 2.4 (1) **MV Distribution Line Routes in Pochengton Area**



LEGENDE

- Existing Brick Type Substation
- Existing Brick Type Substation to be expanded
- Remote Control Substation
- New Brick Type Substation
- Pole Mounted Transformer
- Underground Cable Line
- New Overhead Line
- Aerial Bundled Cable Line
- Upgrading of Line Voltage
- Under the World Bank Project

Figure 2.4 (2) MV Distribution System Diagram in Pochengtong Area

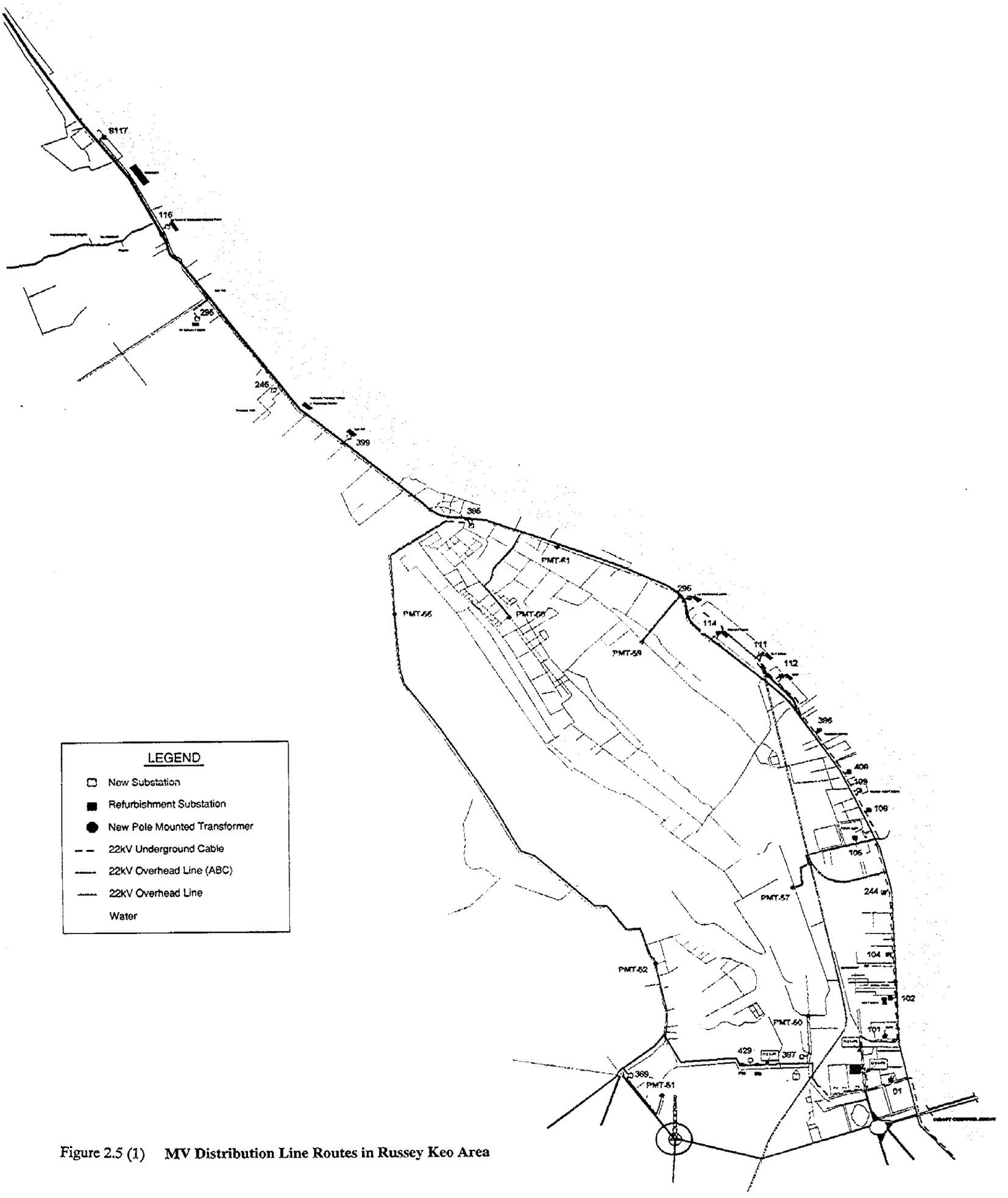
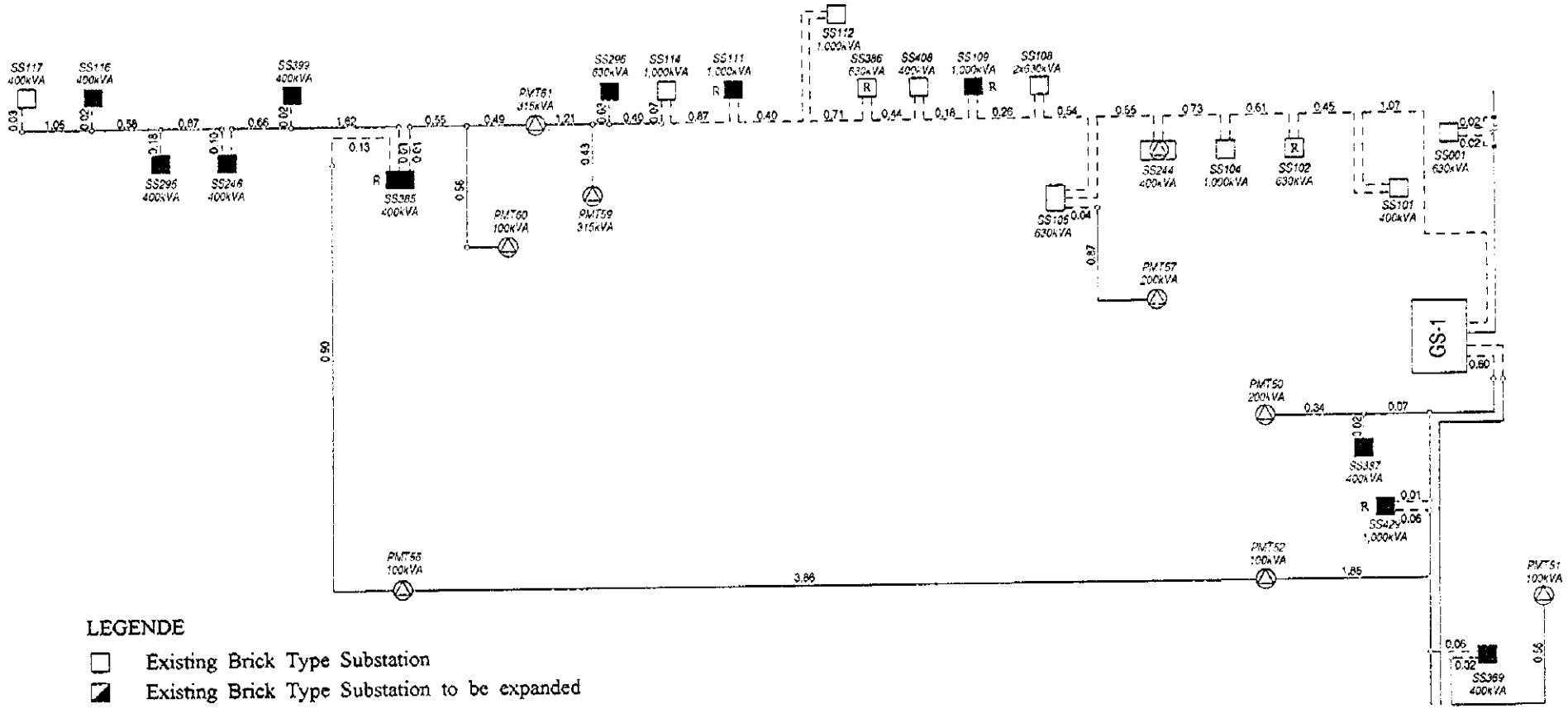


Figure 2.5 (1) **MV Distribution Line Routes in Russey Keo Area**



LEGENDE

- Existing Brick Type Substation
- Existing Brick Type Substation to be expanded
- Remote Control Substation
- New Brick Type Substation
- Pole Mounted Transformer
- Underground Cable Line
- New Overhead Line
- Aerial Bundled Cable Line
- Upgrading of Line Voltage
- 22kV Existing Line

Figure 2.5 (2) MV Distribution System Diagram in Russey Keo Area

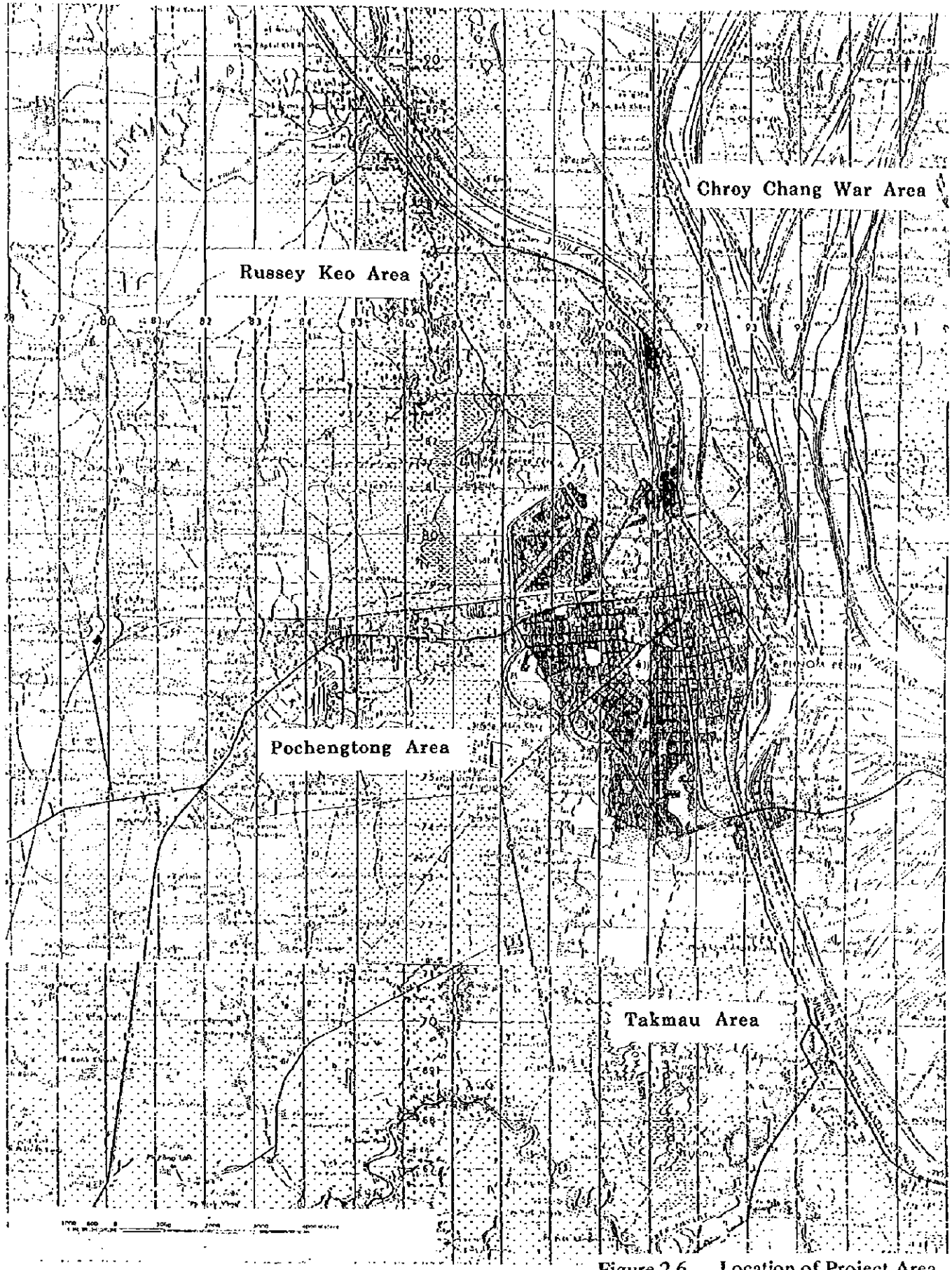


Figure 2.6 Location of Project Area

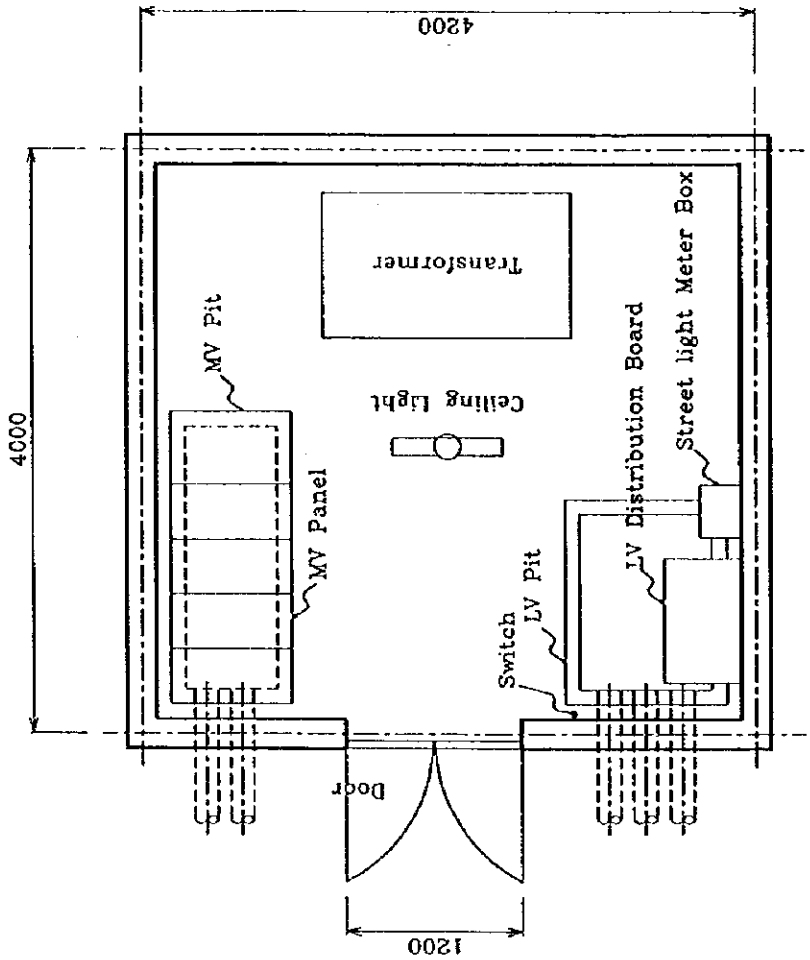


Figure 2.7 (1) Indoor Type Substation, Arrangement of Equipment

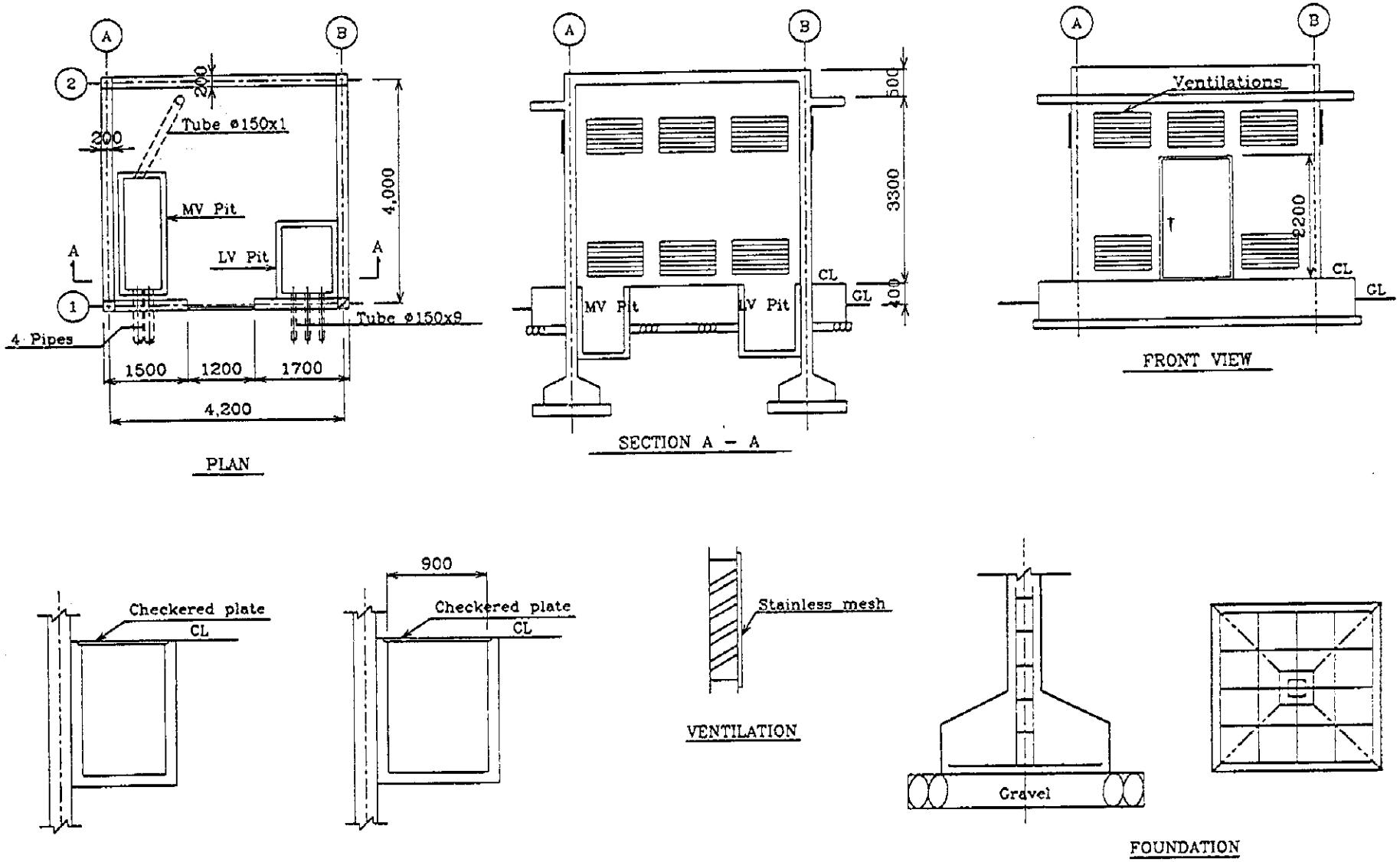


Figure 2.7 (2) Indoor Type Substation Building

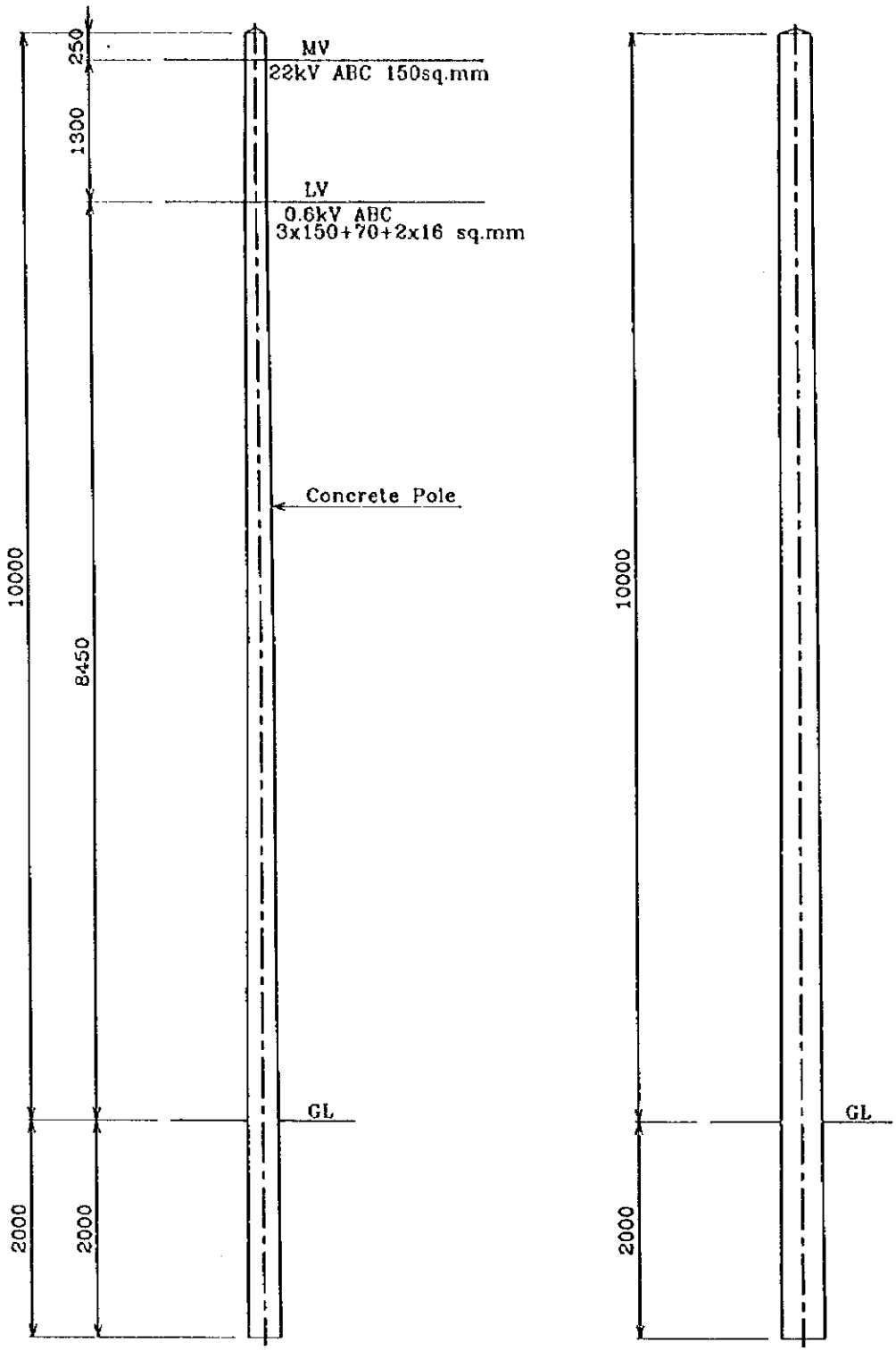


Figure 2.8 (1) MV and LV Aerial Bundle Cables Arrangement on Pole

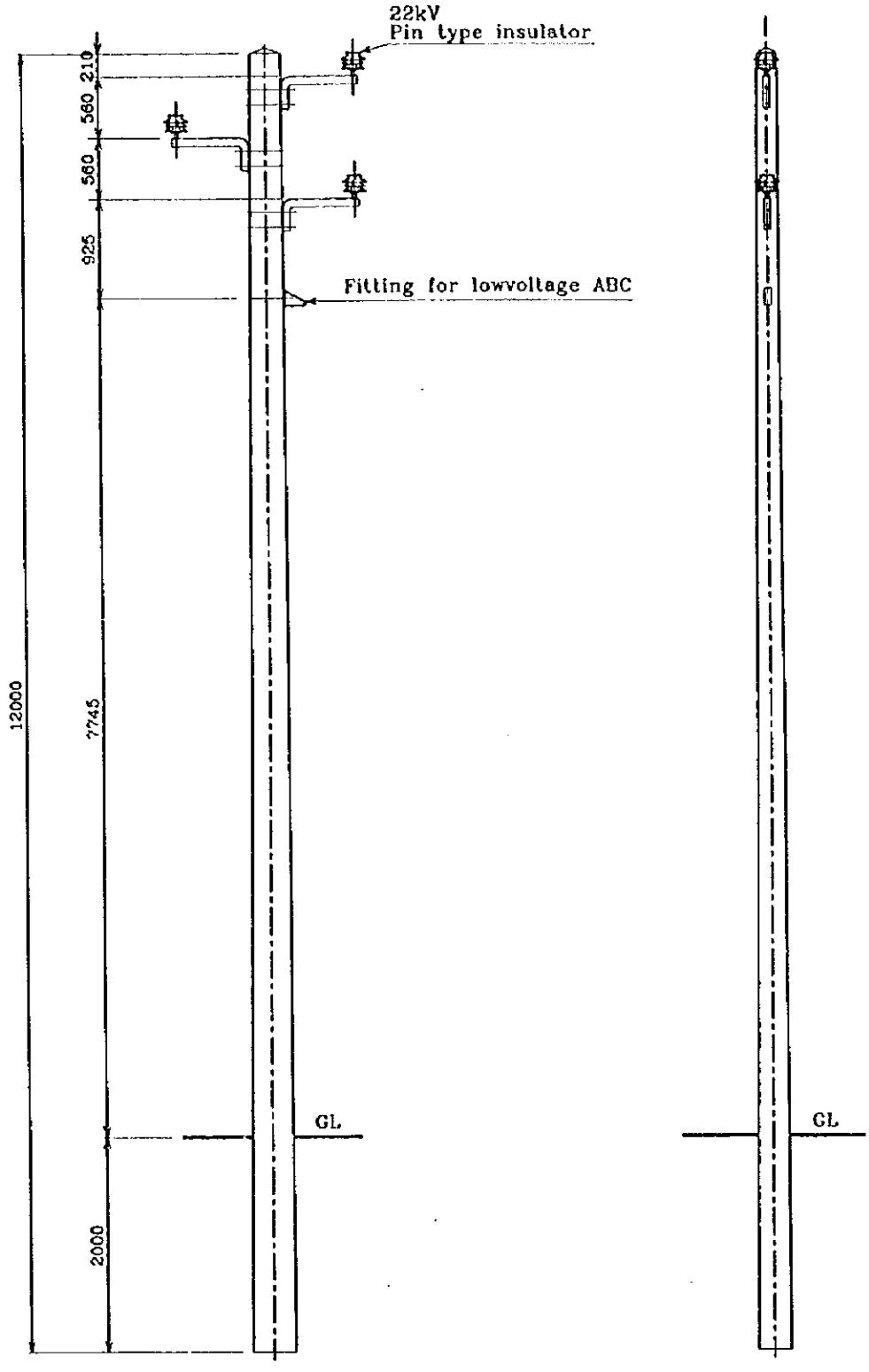


Figure 2.8 (2) MV Insulated Wires Arrangement on Straight Pole

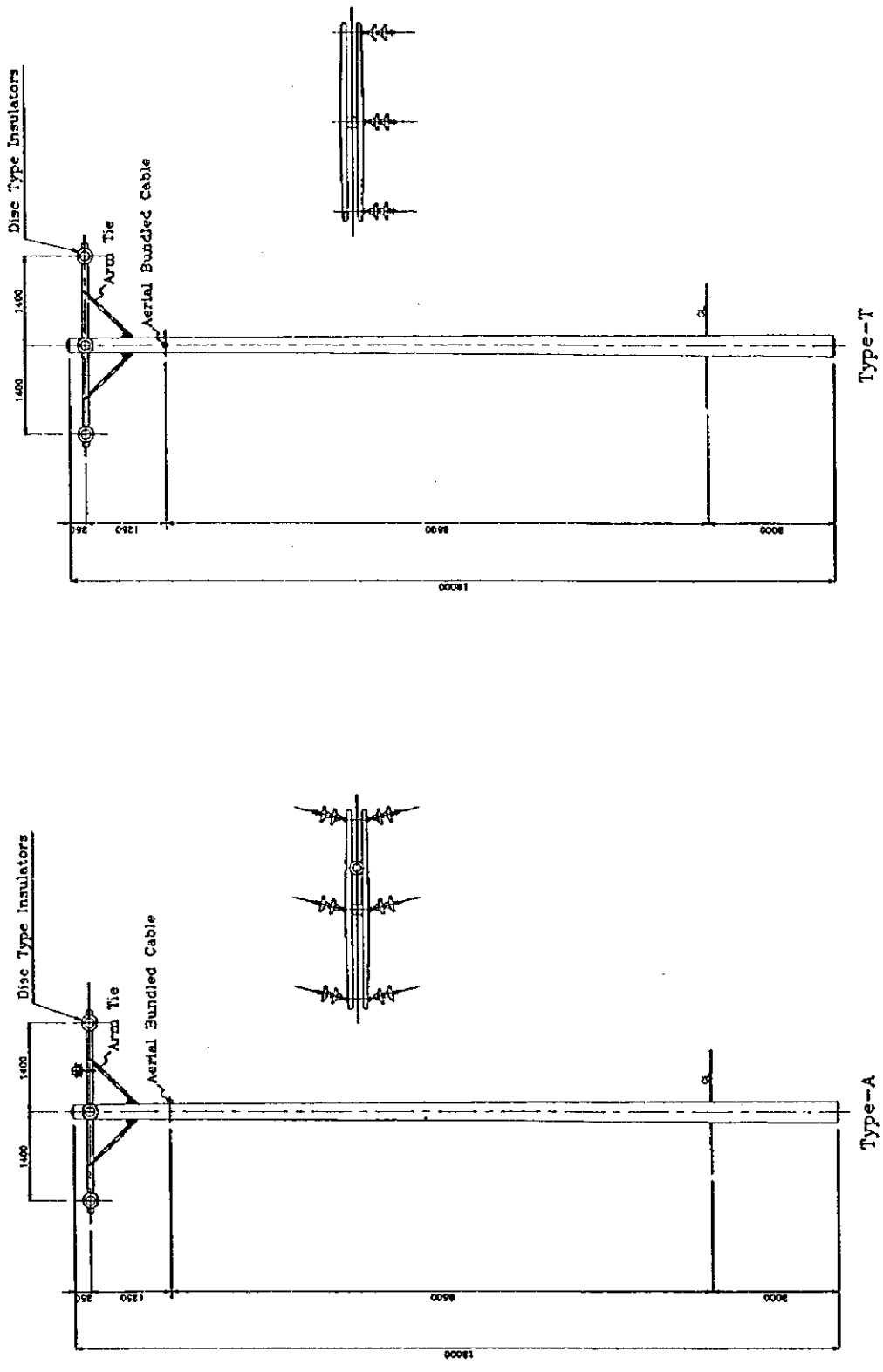


Figure 2.8 (3) MV Insulated Wires Arrangement on Angle and End Pole

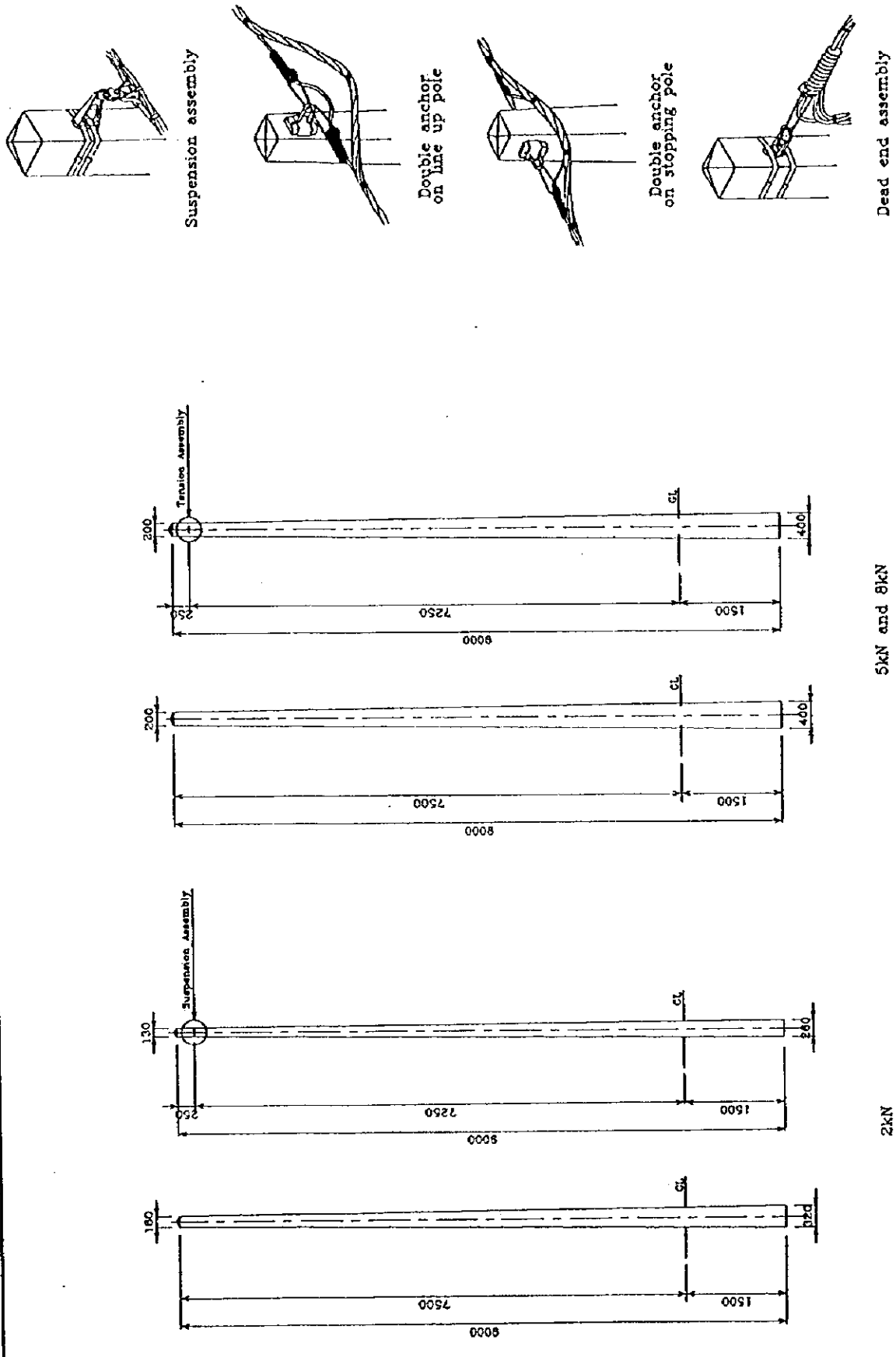


Figure 2.8 (4) LV Pole Arrangement

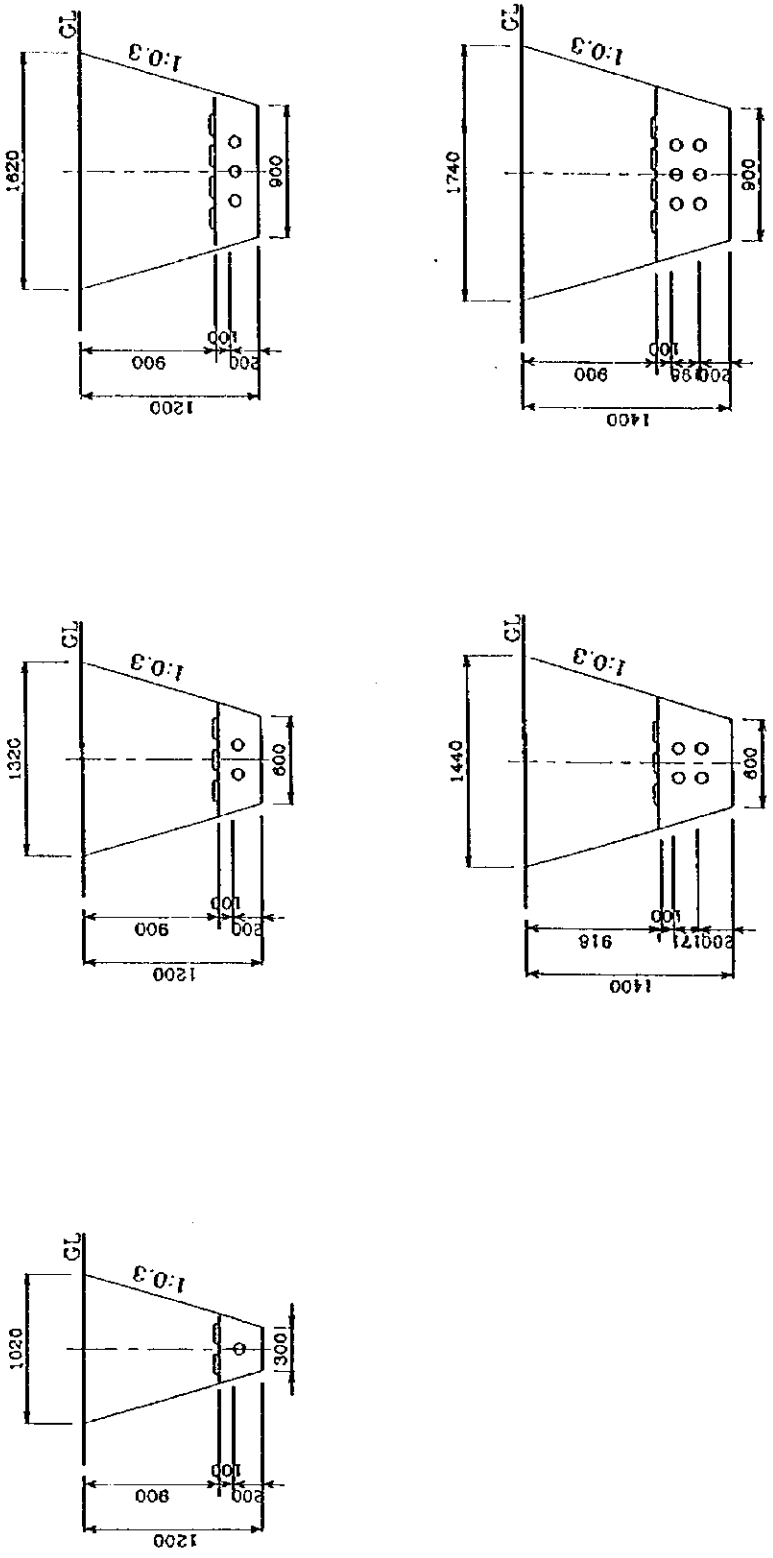
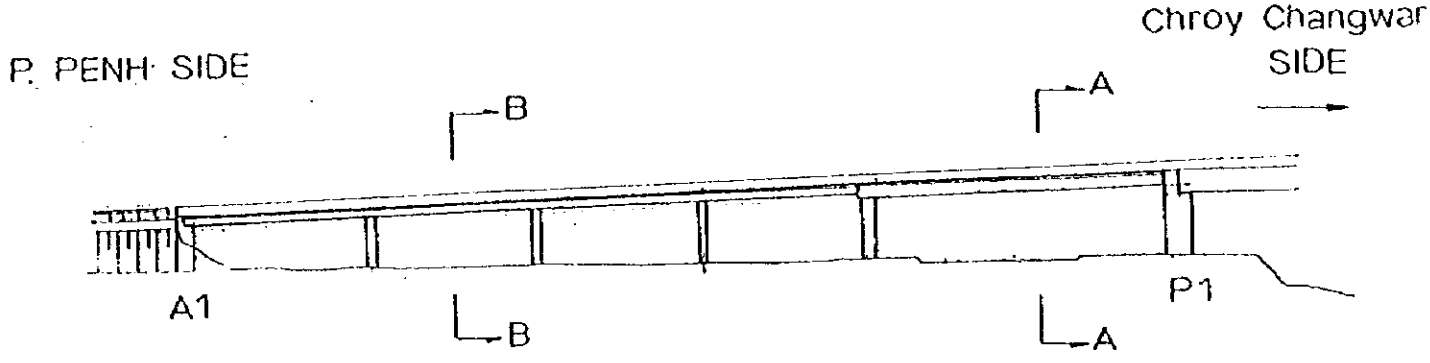
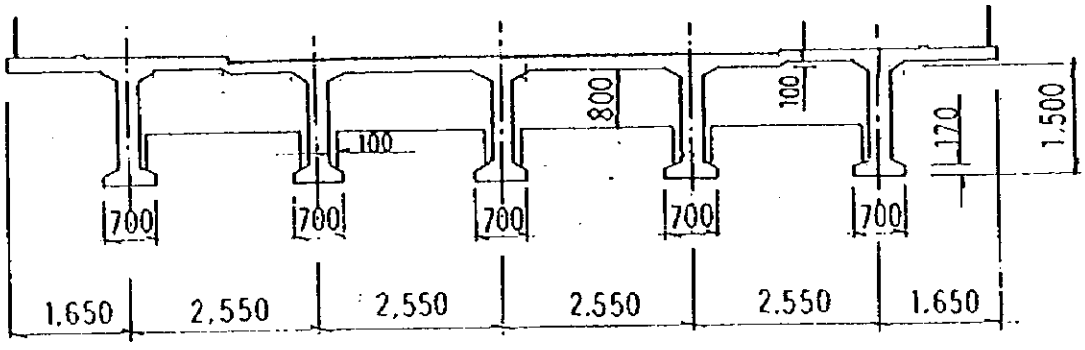


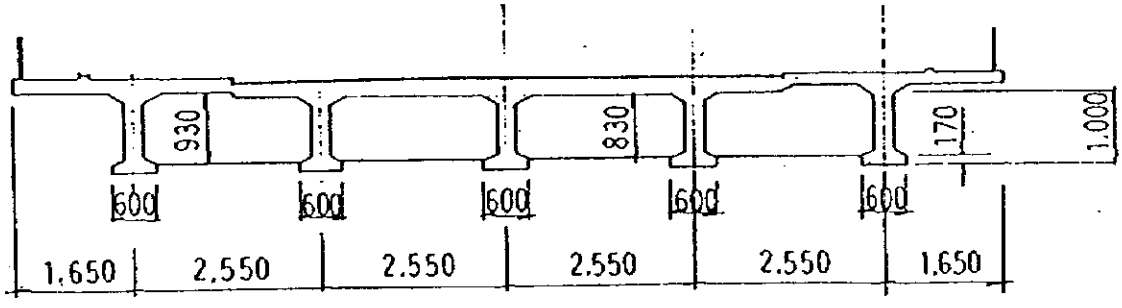
Figure 2.9 Installation of Underground Cable



PROFILE

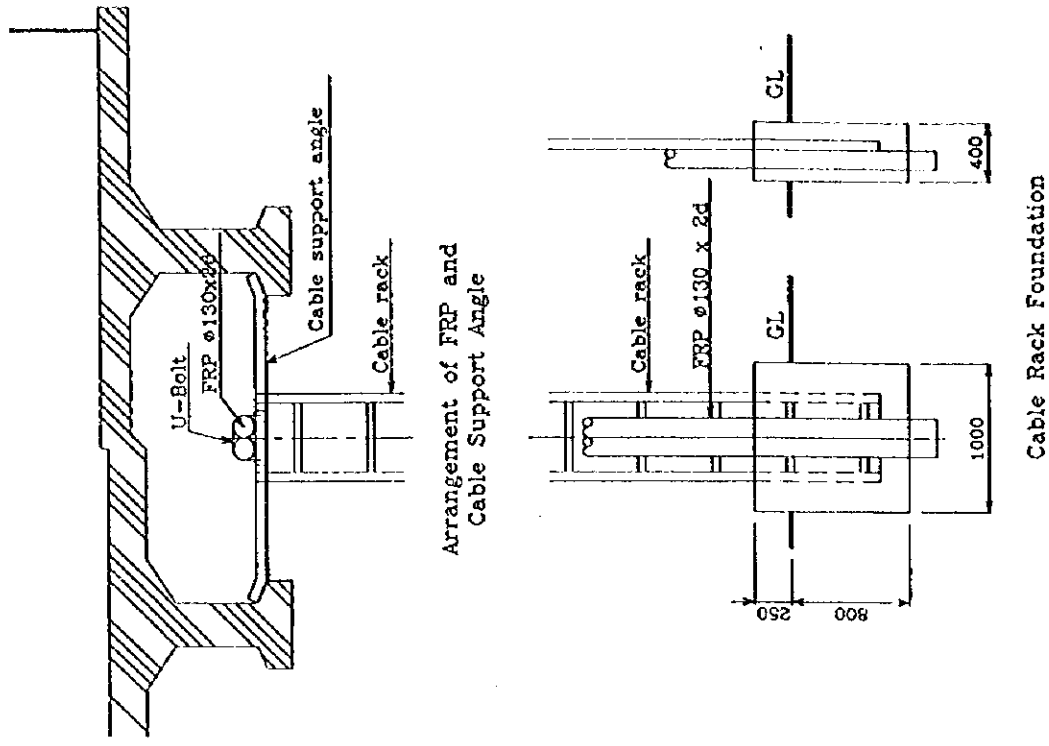


SECTION A-A
S = 1/100



SECTION B-B
S = 1/100

Figure 2.10 (1) Installation of Power Cable on Chroy Changwar Bridge



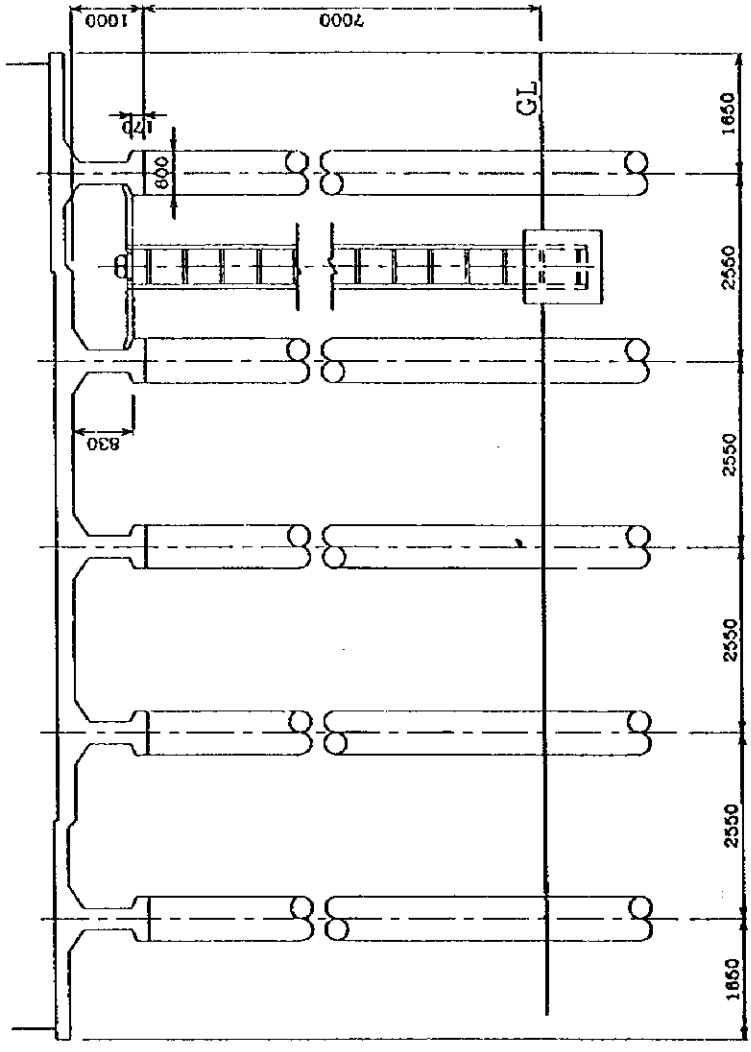


Figure 2.10 (2) Installation of Power Cable on Chroy Changwar Bridge

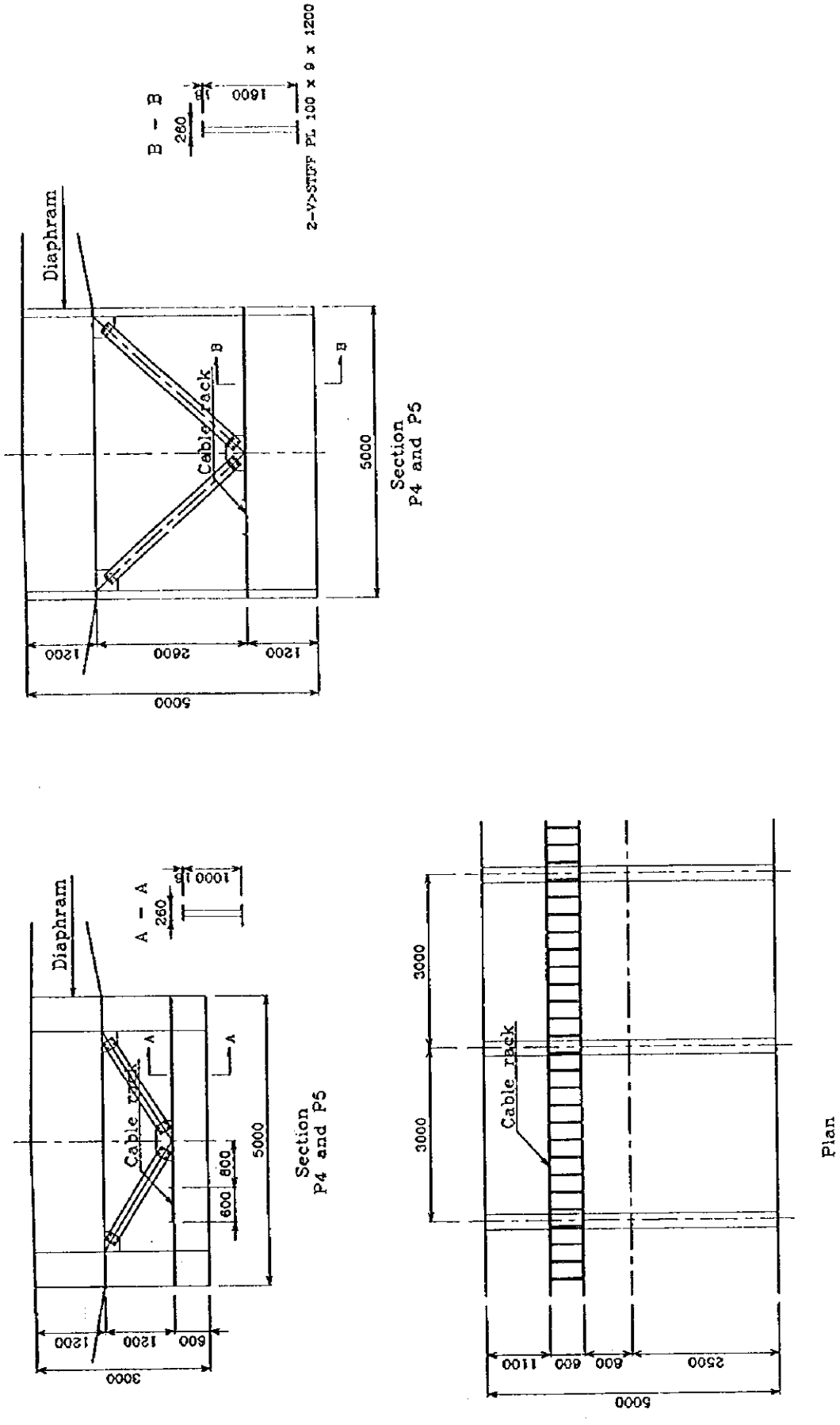


Figure 2.10 (3) Installation of Power Cable on Chroy Changwar Bridge

APPENDICES

Appendix 1 Member List of Survey Team

The First Survey

1. Leader	Mr. Hayao ADACHI	Development Specialist, Japan International Cooperation Agency (JICA)
2. Technical Adviser	Mr. Jun SUZUKI	Electrical Appliance Safety Office, Public Utilities Dept., Agency of Natural Resources and Energy, Ministry of International Trade and Industry (M.I.T.I)
3. Chief Consultant / Power Supply Planner	Mr. Yoshikazu SUNAGAWA	Nippon Koei Co., Ltd.
4. Facility Planner	Mr. Kazuhiko KATO	Nippon Koei Co., Ltd.
5. Power Distribution Planner I	Mr. Tomoyasu FUKUCHI	Nippon Koei Co., Ltd.
6. Power Distribution Planner II	Mr. Toshiyuki ARITA	Nippon Koei Co., Ltd.
7. Cost Estimator / Procurement Planner	Mr. Tsutomu MORI	Nippon Koei Co., Ltd.

The Second Survey

1. Leader	Mr. Hayao ADACHI	Development Specialist, Japan International Cooperation Agency (JICA)
2. Project Coordinator	Mr.Tsutomu TANAKA	First Project Study Division, Grand Aid Project Study Depatment, Japan International Cooperation Agency (JICA)
3. Chief Consultant / Power Supply Planner	Mr. Yoshikazu SUNAGAWA	Nippon Koei Co., Ltd.
4. Facility Planner	Mr. Masato OKUDA	Nippon Koei Co., Ltd.
5. Power Distribution Planner	Mr. Tomoyasu FUKUCHI	Nippon Koei Co., Ltd.

Appendix 2 Survey Schedule

1. Schedule of the First Survey

No.	Date	Day	Place of Stay	Contents of Survey
1	4 / 2	Wed	BKK	Transfer ; NRT - BKK (except Mr. Kato)
2	4 / 3	Thu	P/ P	Transfer ; BKK -- P/P (except Mr. Kato), Courtesy Call on JICA
3	4 / 4	Fri	P/ P	Courtesy Call on Embassy of Japan, Discussion with EDC
4	4 / 5	Sat	P/ P	Site Visit ; Project Sites
5	4 / 6	Sun	P/ P	Data Collection
6	4 / 7	Mon	P/ P	Discussion with EDC, Discussion with MIME
7	4 / 8	Tue	P/ P	Site Visit ; Power Stations, Data Collection
8	4 / 9	Wed	P/ P	Preparation of Minute of Discussions (M/D), Discussion with EDC
9	4 /10	Thu	P/ P	Site Visit ; Concrete Pole Factory, Preparation of M/D
10	4 / 11	Fri	P/ P	Report to Japanese Embassy & JICA, Internal Meeting
11	4 / 12	Sat	P/ P	Survey of the D/L Route
				Transfer ;P/P - BKK (Mr. Adachi and Mr. Suzuki)
12	4 / 13	Sun	P/ P	Data Collection
				Transfer ; BKK - NRT (Mr. Adachi and Mr. Suzuki)
13	4 / 14	Mon	P/ P	Survey of the D/L Route, Data Collection
14	4 / 15	Tue	P/ P	Survey of the D/L Route, Data Collection
15	4 / 16	Wed	P/ P	Survey of the D/L Route, Data Collection
16	4 / 17	Thu	P/ P	Site Visit with Surveyor
				Transfer ; NRT - BKK (Mr. Kato)
17	4 / 18	Fri	P/ P	Discussion with EDC, Site Survey
				Transfer ; BKK -- P/P (Mr. Kato)
18	4 / 19	Sat	P/ P	Discussion with EDC, Site Survey
19	4 / 20	Sun	P/ P	Data Collection
20	4 / 21	Mon	P/ P	Data Collection, Site Survey
20	4 / 21	Mon	P/ P	Data Collection, Site Survey
21	4 / 22	Tue	P/ P	Data Collection, Site Survey
22	4 / 23	Wed	P/ P	Preparation of the Report and Technical Minutes
23	4 / 24	Thu	P/ P	Discussion with Kandal Province, Preparation of the Report and Technical Minutes
24	4 / 25	Fri	P/ P	Discussion with Municipality of P/P, Discussion with EDC
25	4 / 26	Sat	P/ P	Preparation of the Report and Technical Minutes
26	4 / 27	Sun	P/ P	Data Collection
27	4 / 28	Mon	P/ P	Preparation of the Report and Technical Minutes
28	4 / 29	Tue	P/ P	Signing of Technical Minutes, Report to EOJ & JICA
29	4 / 30	Wed		Transfer ; P/P - BKK
30	5 / 1	Thu		Transfer ; BKK - NRT

Notes) P/P: Phnom Penh BKK : Bangkok NRT : Narita EOJ : Embassy of Japan

2. Schedule of the Second Survey

No.	Date	Day	Place of Stay	Contents of Survey
1	1 / 31	Sat	BKK	Transfer ; NRT - BKK
2	2 / 1	Sun	P/ P	Transfer ; BKK – P/P
3	2 / 2	Mon	P/ P	Courtesy Call on EOJ and JICA, Discussion with MIME and EDC
4	2 / 3	Tue	P/ P	Site Visit ; Project Sites
5	2 / 4	Wed	P/ P	Discussion with EDC, Preparation of Minutes of Discussion
6	2 / 5	Thu	P/ P	Discussion on Minutes
7	2 / 6	Fri	P/ P	Signing of Minutes, Report to EOJ & JICA
8	2 / 7	Sat	P/ P	Data Collection Transfer ; P/P – BKK (Mr. Adachi and Mr. Tanaka)
9	2 / 8	Sun	P/ P	Day Off Transfer ; BKK – NRT (Mr. Adachi and Mr. Tanaka)
10	2 / 9	Mon	P/ P	Discussion with EDC, Site Survey
11	2 / 10	Tue	P/ P	Data Collection, Discussion with EDC
12	2 / 11	Wed	P/ P	Data Collection, Site Survey
13	2 / 12	Thu	P/ P	Data Collection, Report to JICA
14	2 / 13	Fri		Transfer ; P/P - BKK
15	2 / 14	Sat		Transfer ; BKK - NRT

Notes) P/P: Phnom Penh BKK : Bangkok NRT : Narita EOJ : Embassy of Japan

Appendix 3 List of Party Concerned in the Recipient Country

(1) Electricite du Cambodge

1)	Mr. TAN KIM VINN	General Director
2)	Mr. TY NORIN	Executive Director Corporate Planning and Projects
3)	Mr. MEN SARUN	Executive Director Commercial and Customer Services
4)	Mr. NOU SAK KHON	Deputy Director Transmission and Distribution
5)	Mr. VICTOR YOYO	Head of Project Implementation Office
6)	Mr. TIV RAVUTH	Deputy Head of Recovery Office

(2) Ministry of Industry, Mines and Energy

1)	Mr. ITH PRAING	Secretary of State
2)	Mr. NHEK CHROEUNOT	Director of Energy Department
3)	Mr. KHLAUT RANDY	Advisor to the Second Prime Minister
		Chairman of Board of Directors
4)	Mr. TUN LEAN	Deputy Director of Energy Department
5)	Dr. BUN NARITH	Dipl. Engineer Ph. D. Hydropower National Project Manager
6)	Dr. YIT BUNNA	Director

(3) Phnom Penh Water Supply Authority

1)	Mr. EK SONN CHAN	Director

(4) Kandal Province

1)	Mr. CHHUN SIRUN	Governor Deputy
2)	Mr. HAK VANNDY	Chief of Industrial Department
3)	Mr. PEN SOKHAN	Chief of Technical office
4)	Mr. NOU NIM	Deputy Chief of Economic Office

(5) Municipality of Phnom Penh

1)	Mr. CHAP NHALYVOUD	Vice Governor
2)	Miss MOM SANDAP	Director of Planning Department
3)	Mr. EAN NARIY	Deputy Director of DPWT
4)	Mr. PENH SAK HOEUN	Department of Urbanization
5)	Mr. CHHOM NARADY	Department of Urbanization
6)	Mr. CHHUON SEANG LAN	Department of Urbanization
7)	Mr. SO SAUR SVAP	Department of Industry
8)	Mr. KIM SAYSAMA LEN	Deputy Chief of Cabinet
9)	Mr. LIM NORA	International Relation Bureau

Appendix 4 Minutes of Discussion

MINUTES OF DISCUSSIONS
BASIC DESIGN STUDY
ON THE PROJECT FOR REHABILITATION AND UPGRADING OF ELECTRICITY SUPPLY FACILITIES IN PHNOM PENH, PHASE II IN THE KINGDOM OF CAMBODIA
(CONSULTATION ON DRAFT REPORT)

In April 1997, the Japan International Cooperation Agency (JICA) dispatched a Basic Design Study team on the Project for Rehabilitation and Upgrading of Electricity Supply Facilities in Phnom Penh, Phase II (hereinafter referred to as "the Project") to the Kingdom of Cambodia, and through discussions, field survey, and technical examination of the results in Japan, has prepared the draft report of the study.

In order to explain and to consult the Cambodian side on the components of the draft report, JICA sent to Cambodia a study team (hereinafter referred to as "the Team"), which is headed by Mr. Hayao Adachi, Development Specialist, JICA and is scheduled to stay in the country from February 1 to 7, 1998.

In the course of discussions, both parties confirmed the main items described on the attached sheets.

Phnom Penh, February 6, 1998

Mr. Hayao Adachi
Leader
Draft Report Explanation
Team, JICA

Mr. Nhek Chroeung
Director
Energy Department,
Ministry of Industry,
Mines and Energy

Mr. Tan Kim Vinn
General Director
Electricite du Cambodge

ATTACHMENT

1. **Components of Draft Report**

The Government of Cambodia has agreed and accepted in principle the components of the draft report proposed by the Team.

2. **Japan's Grant Aid System**

(1) The Government of Cambodia has understood the system of Japanese Grant Aid explained by the Team. (Annex I)

(2) The Government of Cambodia will take the necessary measures, described in Annex II for smooth implementation of the Project on condition that the Grant Aid assistance by the Government of Japan is extended to the Project.

3. **Further Schedule**

(1) The Team will proceed with the supplementary study in Cambodia until February 13, 1998.

(2) The Team will make the final report in accordance with the confirmed items, and sent it to the Government of Cambodia by the end of March 1998.

4. **Other Relevant Issues**

The following items were confirmed by both parties in case that the Japan's Grant Aid is extended to the Project.

(1) Both parties have agreed that the two areas of Takmau and Chroy Chang War should be firstly proceeded in the scope of the Project.

(2) The Government of Cambodia shall allocate the necessary budget and personnel for implementation of the Project as designated in the Basic Design.

(3) Both parties have agreed that the installation works of the service drop wires from each energy meter box to consumer's house should be carried out by the Cambodian side by utilizing the equipment and materials to be procured under the Grant Aid.

(4) On the basis of the Basic Design, the Cambodian side shall make an arrangement to establish the responsible organization and to secure the budget and manpower for the operation and maintenance for the facilities to be granted by the Project.

(5) The Cambodian side has agreed to take responsibility for its internal procedures with relevant authorities concerned for the implementation of the Project.

(6) The Cambodian side requested some counterpart training in Japan. The Team recommended that the official request should be submitted to the Government of Japan.

Annex I Japan's Grant Aid Scheme

1 Grant Aid Procedures

(1) Japan's Grant Aid Program is executed through the following procedures.

Application	(Request made by a recipient country)
Study	(Basic Design Study conducted by JICA)
Appraisal & Approval	(Appraisal by the Government of Japan and Approval by Cabinet)
Determination of Implementation	(The Note exchanged between the Government of Japan and the recipient country)

(2) Firstly, the application or request for a Grant Aid project submitted by a recipient country is examined by the Government of Japan (the Ministry of Foreign Affairs) to determine whether or not it is eligible for Grant Aid. If the request is deemed appropriate, the Government of Japan assigns JICA (Japan International Cooperation Agency) to conduct a study on the request.

Secondly, JICA conducts the study (Basic Design Study), using (a) Japanese consulting firm(s).

Thirdly, the Government of Japan appraises the project to see whether or not it is suitable for Japan's Grant Aid Program, based on the Basic Design Study report prepared by JICA, and the results are then submitted to the Cabinet for approval.

Fourthly, the project, once approved by the Cabinet, becomes official with the Exchange of Notes signed by the Government of Japan and the recipient country.

Finally, for the implementation of the project, JICA assists the recipient country in such matters as preparing tenders, contract and so on.

2 Basic Design Study

(1) Contents of the Study

The aim of the Basic Design Study (hereinafter referred to as "the Study") conducted by JICA on a requested project (hereinafter referred to as "the Project") is to provide a basic document necessary for the appraisal of the Project by the Japanese Government. The contents of the Study are as follows:

1) Confirmation of the background, objectives, and benefits of the requested Project and also institutional capacity of agencies concerned of the recipient country necessary for the Project's implementation.

2) Evaluation of the appropriateness of the Project to be implemented under the Grant Aid Scheme from a technical, social and economic point of view.

3) Confirmation of items agreed on by both parties concerning the basic concept of the Project.

4) Preparation of a basic design of the Project

5) Estimation of costs of the Project

The contents of the original request are not necessarily approved in their initial form as the contents of the Grant Aid Project. The Basic Design of the Project is confirmed considering the guidelines of Japan's Grant Aid Scheme.

The Government of Japan requests the Government of the recipient country to take whatever measures are necessary to ensure its self-reliance in the implementation of the Project. Such measures must be guaranteed even though they may fall outside of the jurisdiction of the organization in the recipient country actually implementing the Project. Therefore, the implementation of the Project is confirmed by all relevant organization of the recipient country through the Minutes of Discussions.

(2) Selection of Consultants

For smooth implementation of the study, JICA uses (a) registered consultant firm(s). JICA select (a) firms(s) based on proposals submitted by interested

firms. The firm(s) selected carry(ies) out a Basic Design Study and write(s) a report, based upon terms of reference set by JICA.

The consulting firm(s) used for the Study is (are) recommended by JICA to the recipient country to also work on the Project's implementation after the Exchange of Notes, in order to maintain technical consistency and also to avoid any undue delay in implementation should the selection process be repeated.

3 Japan's Grant Aid Scheme

(1) What is Grant Aid?

The Grant Aid Program provide a recipient country with non-reimbursable funds needed to procure the facilities, equipment and services (engineering services and transportation of the products, etc.) for economic and social development of the country under the principles in accordance with the relevant laws and regulations of Japan. Grant Aid is not supplied through the donation of materials as such.

(2) Exchange of Notes (E/N)

Japan's Grant Aid is extended in accordance with the Notes exchanged by the two Governments concerned, in which the objectives of the Project, period of execution, conditions and amount of the Grant, etc., are confirmed.

(3) "The period of the Grant Aid" means the one fiscal year in which the Cabinet approves the Project . Within the fiscal year, all procedures such as exchange of the Notes, concluding contracts with (a) consultant firm(s) and (a) contractor(s) and final payment to them must be completed.

However in case of delays in delivery, installation or construction due to unforeseen factors such as weather, the period of the Grant Aid can be further extended for a maximum of one fiscal year at most by mutual agreement between the two Government.

(4) Under the Grant aid, in principle, Japanese products and services including transport of those of the recipient country are to be purchased.

When both Governments deem it necessary, the Grant Aid may be used for the purchase of the products or services of the third country.

However the prime contractors, namely, consulting constructing and procurement firms, are limited to "Japanese nationals". (The term "Japanese nationals" means persons of Japanese nationality or Japanese corporations controlled by persons of Japanese nationality.)

(5) Necessity of "Verification"

The Government of recipient country or its designated authority will conclude contracts denominated in Japanese Yen with Japanese nationals. Those contracts shall be verified by the Government of Japan. This "Verification" is deemed necessary to secure accountability to Japanese taxpayers.

(6) Undertakings required of the Government of the recipient country

In the implementation of the Grant Aid Project, the recipient country is required to undertake such necessary measures as the following:

1) to secure land necessary for the sites of the Project and to clear, level and reclaim the land prior to commencement of the construction.

2) to provide facilities for the distribution of electricity, water supply and drainage and other incidental facilities in and around the sites.

3) to secure buildings prior to the procurement in case the installation of the equipment.

4) to ensure all the expenses and prompt execution for unloading, customs clearance at the port of disembarkation and internal transportation of the products purchased under the Grant Aid.

5) to exempt Japanese nationals from customs duties, internal taxes and other fiscal levies which will be imposed in the recipient country with respect to the supply of the products and services under the Verified Contracts.

6) to accord Japanese nationals whose services may be required in connection with the supply of the products and services under the Verified contracts, such facilities as may be necessary for their entry into the recipient country and stay therein for the performance of their work.

7) "Proper Use"

The recipient country is required to maintain and use the facilities constructed and equipment under the Grant Aid properly and effectively and to assign staff necessary for this operation and maintenance as well as to bear all the expenses other than those covered by the Grant Aid.

8) "Re-export"

The products purchased under the Grant Aid should not be re-exported from the recipient country.

9) Banking Arrangement (B/A)

a) The Government of the recipient country or its designated authority should open an account in the name of the government of the recipient country in an authorized foreign exchange bank in Japan (hereinafter referred to as "the Bank"). The Government of Japan will execute the Grant Aid by making payments in Japanese Yen to cover the obligations incurred by the government of the recipient country or its designated authority under the Verified Contracts.

b) The payments will be made when payment requests are presented by the Bank to the Government of Japan under an authorization to pay issued by the Government of the recipient country or its designated authority.

ANNEX II

Necessary measures to be taken by the Government of Cambodia in case that Japan's Grant Aid is executed.

1. To secure the site for the Project.
2. To clear, level and reclaim the site prior to commencement of the construction.
3. To undertake incidental outdoor works such as gardening, fencing, gates and exterior lightning in and around the site.
4. To bear commissions to the Japanese foreign exchange bank for the banking services based upon Banking Arrangement.
5. To exempt taxes and to take necessary measures for customs clearance of the materials and equipment brought for the Project at the port of disembarkation.
6. To exempt Japanese Nationals from customs duties, international taxes and other fiscal levies which may be imposed in Cambodia with respect to the supply of the products and services under the verified contracts.
7. To accord Japanese Nationals, whose services may be required in connection with the supply of products and the services under the verified contracts, such facilities as may be necessary for their entry into Cambodia and stay therein for the performance of their work.
8. To use and maintain properly and effectively the facilities constructed and equipment purchased under the Grant.
9. To bear all the expenses, other than those to be borne by the Grant, necessary for construction of the facilities as well as for the transportation and the installation of the equipment.

Appendix 5

Cost Estimation Borne by the Recipient Country

No.	Item	Q'ty	Unit	Unit Price	Budget
1.	Land acquisition cost for S/S	1,393	m^2	US$100/$m^2$	US$139,300
2.	Connection work of service wire to consumers	23,528	nos	Riel 20,000	Riel 470,560,000 (US$130,711)
	Total				US$270,011

Notes) 1 US$ = 3,600 Reil

Appendix 6 Referrences

	Title	Source
1.	Development Objectives, Strategies and Programs	ADB-2, NPRD and SEDP
2.	General Organization Chart	EDC
3.	Royal Decree	EDC
4.	Sub-Decree	EDC
5.	Technical Standards for digging; filling up road and sidewalk and burying underground system	The Phnom Penh Municipality
6.	Project Management Unit	EDC
7.	Specification for digging and back full the trench for underground system	The Phnom Penh Municipality
8.	The power balance between the power demand and available output	EDC
9.	Drawing of concrete pole (ADB Project)	EDC
10.	Catalogue of remote control unit	EDC
11.	Drawing of concrete pole	EDC
12.	Operation Records of Power Stations (No. C1～C6 P/S)	EDC
13.	Contract Document for Phnom Penh Power Rehabilitation Project	EDC
14.	Articles of Information of the Electricity Company of Cambodia	EDC
15.	Draft the electricity act of 1995	EDC
16.	Phnom Penh Power Rehebilitation Project World Bank Project No. KH-PA-4032 ; Bid Documents for Installation and Commissioning of Distribution Equipment and Related Services	EDC
17.	Phnom Penh Distribution Rehabilitation Project World Bank Project ; Bidding Documents for Procurments of Distribution Equipment and Related Services	EDC
18.	Maps ; Project Areas (1/2000)	The Phnom Penh Municipality
19.	Phnom Penh Power Sector ADB Loan No. 1199-CAM (SF) Lot 2 ; Tender for Distribution Facilities	EDC
20.	Phnom Penh Power Rehabilitation Project World Bank Project Variation Order	EDC
21.	Realisation du Bureau Central de Conduite de Phnom Penh Specifications Techniques	EDC, EDF
22.	Phnom Penh Distribution Rehabilitation Project World Bank Project ; Design Report on The Construction of Distribution Facilities	EDC