JAPAN INTERNATIONAL COOPERATION AGENCY
NEPAL ELECTRICITY AUTHORITY
HIS MAJESTY'S GOVERNMENT OF NEPAL

BASIC DESIGN STUDY REPORT ON EXTENSION AND REINFORCEMENT OF POWER TRANSMISSION AND DISTRIBUTION SYSTEM IN KATHMANDU VALLEY (PHASE-II) IN HIS MAJESTY'S GOVERNMENT OF NEPAL

APRIL 1994

NIPPON KOEI CO., LTD.

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PREFACE

In response to a request from His Majesty's Government of the Kingdom of Nepal, the Government of Japan decided to conduct a basic design study on Extension and Reinforcement of Power Transmission and Distribution System in the Kathmandu Valley (Phase II) and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Nepal a study team headed by Mr. Hidetoshi Ishioka, First Basic Design Study Division, Grant Aid Study and Design Department, JICA and constituted by members of Nippon Koei Co., Ltd. from November 19 to December 18, 1993.

The team held discussions with the officials concerned of the Government of the Kingdom of Nepal, and conducted a field survey at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Nepal in order to discuss a draft report, 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 His Majesty's Government of the Kingdom of Nepal for their close cooperation extended to the teams.

April, 1994

Kensuke Yanagiya
President
Japan International Cooperation Agency

April, 1994

Mr. Kensuke Yanagiya
President
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

We are pleased to submit to you the basic design study report on Extension and Reinforcement of Power Transmission and Distribution System in the Kathmandu Valley (Phase II) in the Kingdom of Nepal.

This study was conducted by Nippon Koei Co., Ltd. under a contract to JICA, during the period November 10, 1993 to April 20, 1994. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Nepal and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

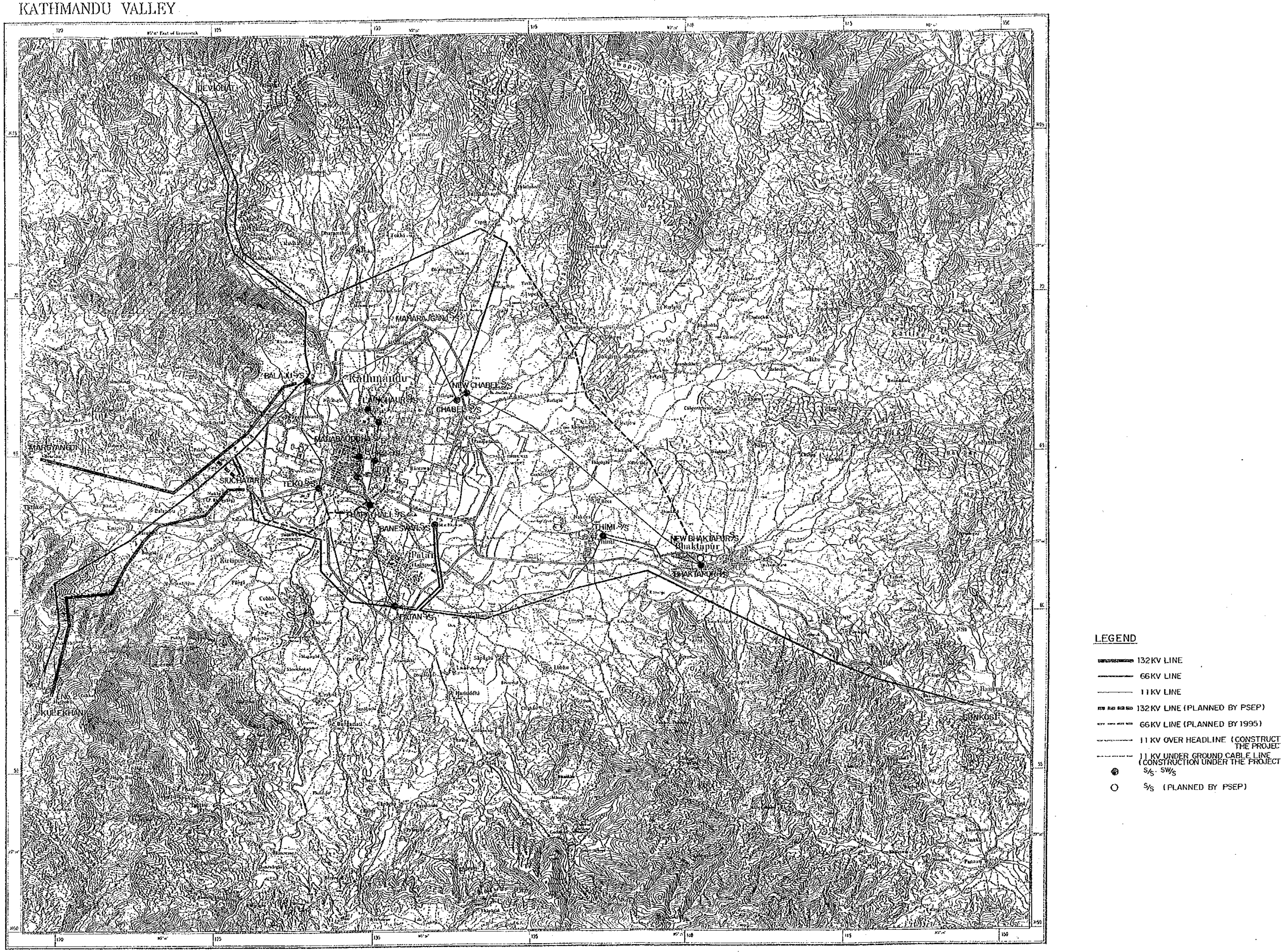
We wish to take this opportunity to express our sincere gratitude to the officials concerned of JICA, the Ministry of Foreign Affairs, the Ministry of International Trade and Industry, and the Nepalese Embassy in Tokyo. We would also like to express our deep gratitude to the officials concerned of the Ministry of Water Resources of Nepal, the Nepal Electricity Authority, JICA Kathmandu Office, and the Japanese Embassy in Kathmandu for their close cooperation and assistance throughout our field survey.

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

Very truly yours,

Y. Sunagawa
Project Manager
Basic Design Study Team on
Extension and Reinforcement of
Power Transmission and Distribution
System in Kathmandu Valley (Phase II)
Nippon Koei Co., Ltd.
Tokyo, Japan

KATHMANDU VALLEY



SUMMARY

SUMMARY

The Kingdom of Nepal is a landlocked country surrounded by Tibet to the north across the Himalayan Mountains and India to the east, west, and south. The area of the country is approximately 147,200 km^2 and its population is, according to the 1991 census, about 18.5 million. Statistics of the Nepal Electricity Authority (NEA) reveal the electrification rate of the whole country to be 9.1% against 68.5% in the Kathmandu Valley where is the objective area of this Project.

Four hydroelectric power stations as the Kuleh Khani No.1, Kuleh Khani No.2, Devigat and Marsyangdi have been developed in the country under the financial assistance of the World Bank, Japan, India, Germany, and others in 1980s. In addition, three projects for reinforcement and improvement of the power transmission and distribution system in the Kathmandu Valley were implemented under Japan's Grant Aid in the same decade. As a result of the implementation of the projects, power supply in the area has improved remarkably and become more reliable and stable. The power supply system in the valley, however, will face some problems, like overloading, shortage of transformer capacity, excessive voltage drop on the distribution system, deterioration of power supply reliability, etc., since the power demand is growing at a higher rate than was forecast in the past.

Under such circumstances, His Majesty's Government of Nepal requested that the Government of Japan conduct a Master Plan Study and Feasibility Study on the reinforcement and improvement of the power transmission and distribution system in the valley in 1990. The master plan study was conducted from October 1990 to March 1991 by the Japan International Cooperation Agency (JICA). Further, JICA proceeded to the Feasibility Study from June 1991 to December 1991 to the facilities identified in the master plan for the urgent rehabilitation and extension. The feasibility study team recommended the stage-wise project implementation program of Phase-I and Phase-II.

The Government of Nepal requested to the Government of Japan to extend the Japan's Grant Aid for the project. The requested are given in Table-1 below.

On the basis of these studies' results, the Government of Nepal submitted a request for Japan's Grant Aid for the Project for extension and reinforcement of the power transmission and distribution system in the Kathmandu Valley.

In response to the request, the Government of Japan decided to conduct a Basic Design Study for the Project, and JICA dispatched a Basic Design Study Team to Nepal in January 1992.

From the results of the Study, the Project was formulated in the phase wise implementation and the components of the Project, Phase-I and Phase-II requested by the Government of Nepal are given in Table-1 below.

Table-1 Project Components Requested by the Government of Nepal

	Components	Phase
1.	Augmentation of 11 kV cubicles at the Royal Palace, Old Patan, and Old Chabel switching stations	Phase-I
2.	Construction of 11 kV underground cable laying between the Lainchaur substation and K2 switching station	Phase-I
3.	Reinforcement and improvement of the main 11 kV feeders	Phase-I
4.	Augmentation of a 132/66 kV transformer at the Siuchatar substation	Phase-II
5.	Construction of a new K3 substation	Phase-II
6.	Extension and reinforcement of the 11 kV and low-tension distribution line	Phase-II
7.	Provision of tools, instruments, and vehicles for the operation and maintenance works	Phase-I & II

JICA on behalf of the Government of Japan dispatched a Basic design Study team for the Phase-I project and the team formulated the implementation program over two years (Stage-1 and Stage-2). On the basis of the program, the Government of Japan decided to extend the Grant Aid for the Phase-I project, and the Notes for the Grant Aid to the project were exchanged between both Governments on July 16, 1993. The phase-I project is now in progress.

Succeedingly, upon the request from the Government of Nepal, the Government of Japan decided to conduct the basic design study for the Phase-II project. JICA dispatched a Basic Design Study Team for the project to Nepal for 30 days from November 19 to December 18, 1993.

Through the discussions with the NEA and the field investigation of the team, a part of the original scheme was modified. The studied components of the whole project including the Phase-I and Phase-II projects are summarized in Table-2 below:

Table-2 Outline of the Project

Components requested by the Government of Nepal		Components amended for implementation		
		Phase-I	Phase-II	Total
1. Reinforcement and improvement of 11 kV feeders and low tension lines				
11 kV Lines	113.83 km	60.75 km	62.68 km*1	123.43 km
400-230 V Lines	106.56 km	39.20 km	63.10 km	102.30 km
Transformers	25,925 kVA	8,050 kVA	17,900 kVA	25,950 kVA

*1 Including an additional request for the construction of a new feeder of Kingsway

	Components requested by the Government of Nepal		Project Phase
2.	Augmentation of a 132/66 kV *transformer at the Siuchatar substation*		Phase-II
3.	Construction of a K3 substation		defered
4.	Procurement of tools, instruments and vehicles for the O/M works	including an additional request for increasing the number of vehicles & tools	Phase-I & II
5.	Replacement of the 11 kV switching facilities at the Maharajgunj switching station	additional request	Phase-II
6.	Procurement of spare parts	additional request	Phase-II
7.	Construction of 11 kV underground cables between the Lainchaur substation *and the K2 switching station*		Phase-I (in progress)
8.	Replacement of the 11 kV switching facilities at Royal Palace, Old Patan, and Old Chabel switching stations		Phase-I (in progress)

Judging from the amount of work for and construction period of the facilities, two construction periods are recommended for the Project (Phase-II), Stage-1 for eight months and Stage-2 for eight and half months.

Stage-I	(a)	Replacement of the 11 kV switching facilities at the Maharajgunj switching station
	(b)	Reinforcement and improvement of the 11 kV feeders and low tension lines
	(c)	Procurement of maintenance tools and vehicles
	(d)	Procurement of spare parts
Stage-II	(a)	Augmentation of a 132/66 kV transformer at the Siuchatar substation
	(b)	Reinforcement and improvement of the remaining 11 kV feeder and low-tension lines

It is estimated from the power record in 1992 that the maximum possible output of the existing generating facilities in the Nepal central power system is 216 MW. The present power demand in the system exceeds the maximum supply capacity. NEA copes with the supply shortage by enforcement of the scheduled region-wise load shedding at the peak load time in the Kathmandu Valley.

The Government of Nepal has the development program of Kali Gandaki hydropower project, Arun III hydropower project and others. However, commissioning of all the projects is anticipated after 1999/2000.

For more serious shortage of power supply after 1996, NEA plans to install new diesel-generator sets of 60MW in total and to import electricity from India during 1996 to 1998. However, the fundamental solution of the issue of power supply shortage will not be solved until completion of the Kali Gandaki hydropower project.

Under such situation, reduction of the present energy losses amounting 23% of the production is to give effects on solution of shortage of the power source.

The following improvements to the power distribution system are expected by implementing the Project:

- To increase power supply capacity and stabilize the operation of the system by replacement of the outdated facilities at the Maharajgunj switching station and installing an additional transformer at the Siuchatar substation.

- To increase power supply reliability with the separation of the service area by the addition of new feeders.

- To reduce voltage drop and improve voltage regulation at the consumers' end, and reduce energy losses by installing additional distribution transformers and upgrading of conductor size.

- To reduce frequent trips of feeders by the adoption of insulated overhead cables and underground cables. The cabling will also ensure the safety of inhabitants in the densely populated areas and reduce energy pilferage.

- To develop the activities of the NEA's staff and engineers for the operation, maintenance, and erection works of the power system through the Project.

Upon conclusion of the E/N on the project between two Governments, a Japanese consulting firm shall immediately conclude a contract with NEA for the Engineering Services on preparation of tender documents, evaluation of tenders, assistance to negotiation of NEA with a successful tender for the contract and construction supervision of the entire works. While, NEA, as the executing agency of the project will be responsible for negotiation of contract with a Japanese consultant firm and contractor, for obtaining all the necessary permission, negotiation with residents, and all other works necessary for the execution of the project.

Although the population in the Kathmandu Valley in 1991 was approximately 1.1 million, which was about 6% of the total population in Nepal, 47% of the total electric energy was consumed in this area. Therefore, the development of a distribution line in the Kathmandu area will have a large effect on the whole country. Moreover, the completion of the Project will significantly contribute to upgrading the livelihood of the residents in the Kathmandu Valley as well as developing tourism, industry, and the economic conditions in the country, etc. The experienced staff of NEA, developed during the previous three projects in the 1980s, will be a great help in making the Project successful.

To secure the safety and proper operation of the power distribution system, it is recommended to make the frequent inspection of the distribution lines and the following maintenance works periodically.

- Restoration and reinforcement of the inclined distribution line poles with stay wires, for maintaining the specified clearance and tension of the conductors.

- Adjustment of the sag of conductors, for maintaining the specified clearance an tension of the conductors.

- Adoption of the service wires of adequate size against the consumers' power demand, for improvement of the voltage regulation at the consumers' end and reduction of the energy losses of the distribution network.

- Exclusion of the illegal use of electricity from the low-tension lines, for reduction of the energy losses of the distribution network.

- Adoption of the adequate connectors for connection of the service wires, for improvement of the voltage regulation at the consumers' end and reduction of the energy losses of the distribution network.

- Cutting and trimming the trees dangerous to the distribution lines.

- Replacement of the damaged insulators for lines conductors and stay wires.

- Restoration of the slackening stay wires.

The works mentioned above are an essential works of maintenance of the distribution lines.

BASIC DESIGN REPORT

CONTENTS

LIST OF TABLES

LIST OF FIGURES

<u>LIST OF APPENDICES</u>

CHAPTER 1

INTRODUCTION

CHAPTER 1
INTRODUCTION

Electric power supply in the country was established in 1911 when the small Pharping hydropower station commenced operation. Although the power supply system had been expanded by construction of new power stations and power transmission and distribution facilities, power supply in the country in the late 1970s to the early 1980s was in a very poor condition. In order to improve the situation, hydropower development projects, such as Devighat, Kulekhani I, Kulekhani II, and Marsyangdi were implemented under the financial assistance of the International Development Agency (IDA) and foreign countries, such as India, Japan, and Germany. Besides the hydropower development, reinforcement of the existing transmission and distribution system was also conducted under three grant aid projects of the Government of Japan in the 1980s. As a result of such development and reinforcement, power supply in the country has improved remarkably and become more reliable and stable. The power supply system in the valley, however, will face some problems soon, like overloading, shortage of transformer capacity, excessive voltage drop on the distribution system, deterioration of power supply reliability, etc., since the system demand is growing at a higher rate than forecast in the past.

Under such circumstances, His Majesty's Government of Nepal requested that the Government of Japan conduct a Master Plan Study and Feasibility Study on the reinforcement and improvement of the power transmission and distribution system in the valley in 1990. The studies were conducted in two stages from September 1990 to March 1991 for the Master Plan Study, and from June 1991 to December 1991 for the Feasibility Study on the urgently required transmission and distribution facilities identified in the Master Plan, by the Japan International Cooperation Agency (JICA).

On the basis of the study results, the Government of Nepal requested Grant Aid from the Government of Japan for extension and reinforcement of the power transmission and distribution system in the valley.

In response to the official request of the Government of Nepal, the Government of Japan decided to conduct a Basic Design Study to examine the viability of the Project. JICA sent a Basic Design Study Team in January 1992, to study and examine the following objectives of the Project requested by the Government of Nepal:

(1) Augmentation of switchgear equipment at the Royal Palace, Old Patan, and Old Chabel switching stations.

(2) Construction of 11kV underground cables between the existing Lainchaur substation and K2 switching station.

(3) Reinforcement and improvement of the 11kV main feeders in the Kathmandu Valley.

(4) Augmentation of a 132/66 kV transformer at the Siuchatar substation.

(5) Construction of a K3 substation in the center of Kathmandu.

(6) Reinforcement and improvement of the other 11kV feeders and low tension lines.

(7) Supply of tools and vehicles for maintenance works.

From the results of the Study, the Project was formulated in the phase wise implementation by order of priority. The Project Items: (1) Augmentation of a switching station, (2) Construction of 11kV underground cables, (3) Reinforcement and Improvement of 11kV main feeders, and supply of a part of item (7) Tools and vehicles, were implemented in 1993 and 1994 under the Grant Aid from the Government of Japan, as the Project, Phase-I.

Besides, the Government of Nepal requested to the Government of Japan for the Grant Aid for implementation of the Project, Phase-II for the Items: (4) Augmentation of a 132/66 kV transformer at the Siuchatar substation, (5) Construction of a K3 substation in the center of Kathmandu, (6) Reinforcement and improvement of the other 11kV feeders and low tension lines, and (7) Supply of tools and vehicles for maintenance works.

In response to the official request, JICA dispatched a Basic Design Study Team to Nepal headed by Mr. H. Ishioka, JICA for 30 days from November 19 to December 18, 1993. The Team surveyed the Project area, collected relevant data and information for reviewing the Basic Design, and discussed technical aspects of the Project with the officials of NEA, the executing agency of the Project.

A list of the survey team members, survey schedule, parties concerned in the recipient country, and minutes of discussions are given in Appendices 1-1, 1-2, 1-3, 1-4, and 1-5.

The Report includes 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, Phase-II.

CHAPTER 2

BACKGROUND TO THE PROJECT

CHAPTER 2
BACKGROUND TO THE PROJECT

2.1 Outline of Nepal

The Kingdom of Nepal is a landlocked country surrounded by Tibet to the north across the Himalayan Mountains and India to the east, west, and south. The area of the country is about 147,200 km^2.

Nepal is located between 26°22' and 30°27' north latitudes and between 80°04' and 80°12' east longitudes. The latitudes of Nepal are similar to those of the Okinawa islands of Japan. Nepal lags 3 hours 15 minutes behind Japan.

The latest population census was performed by the Central Bureau of Statistics from May to July of 1991, and the total population was 18,462,081 (Growth rate: 2.08% p.a in the last decade).

The Gross Domestic Product (GDP) of Nepal in 1991/92 was estimated to be 130.7 billion Nepalese Rupees (NRs.) at the current price levels, which increased by an annual growth rate of about 4% during the years 1974/75 to 1991/92. In 1990/1991, per capita GDP was estimated to be NRs. 5,704 at the current price levels and NRs. 6,933 in 1991/92.

The Gross National Product (GNP) in 1989/90 was NRs. 92.7 billion at the current price levels and the figure for 1990/91 was estimated to be NRs. 107.4 billion. Thus, it was estimated that the country's GNP increased by 18.5% in 1990/91 compared to the previous year 1989/90. The GDP grew at a rate of 7.2% per annum during the years 1974/75 to 1979/80 and this rate increased to 13.9% during the years 1979/80 to 1990/91.

Nepal is an agricultural country. The share of the agricultural sector was about 53% of the country's GDP in 1990/91 at the current price levels, and about 90% of the total population was engaged in the sector. However, agricultural production is still mainly dependent on weather conditions. There is a great potential for increased agricultural production if the dependence on the weather factor can be reduced through the better use of technology suitable soil conditions which are acceptable to farmers, fertilization, and use of fertilizers. The total amount of food grain production during the previous year was 5.9 million metric tons while during 1990/91 the grain production was estimated to be 5.45 million metric tons due to the adverse weather conditions.

Nepal is one of the most attractive countries for tourism in the world. It has beautiful natural resources, such as snow peaks like Mt. Everest, green forests, lakes, and rivers. In addition to the natural landscape, Nepal has historical monuments and a variety of ethnic religions and cultures which are also important tourism resources. The number of tourist arrivals amounted to 293,000 in 1991, approximately 60% for pleasure and 5% for business. The total foreign exchange earning from the tourism sector amounted to about NRs. 2.9 billion in 1991.

The total government expenditure in 1990/91 was NRs. 23.5 billion, an increase of 19.7% over that of the previous year. The total revenue amounted to NRs. 9.1 billion which was an increase 21.8% over the amount of the previous year. In 1979/80, the expenditure was NRs. 3.5 billion and revenue was 2.7 billion expenditure increased 6.7 times and revenue 3.4 times. The expenditure exceeds the revenue every year, and the financial deficit inevitably increased 18 times from NRs. 0.8 billion in 1979/80 to NRs. 14.4 billion in 1990/91. The greater part of the financial deficit was covered by foreign loans. The loan amount had reached NRs. 5.7 billion in 1990/91.

2.2 Outline of the Power Sector

(1) Energy Consumption in Nepal

The major sources of energy in Nepal are forests, organic matter, petroleum products, hydroelectricity, and coal. Wind and solar power are also being used on a small scale.

During 1989/90, energy consumption in Nepal was equivalent to 8.877 million metric tons of coal, which increased to 9.148 million metric tons in 1990/91. Thus, the energy consumption in 1990/91 showed an annual consumption increase of 3.06% over that of the previous year. The annual per capita energy consumption for the country as a whole was estimated as equivalent to 505 kilograms of coal. 94.7% of the total energy consumption was generated by traditional energy resources, like fuelwood, agricultural residue, animal dung, and other biomass, and 5.3% was supplied by the commercial sector.

Although no oil, gas, and coal resources have been confirmed, Nepal is one of the richest countries in the world in respect to hydropower generation potential. The country has a hydropower potential of 83,000 MW of which only 238 MW were harnessed or 0.28% of the hydropower potential was utilized by the end of 1992.

(2) Outline of NEA

The electricity industry in Nepal is managed by NEA, administratively organized under the Ministry of Water Resources (MWR). NEA was established on August 15, 1985. NEA is responsible for the planning, construction, operation, and maintenance of all generation, transmission, and distribution facilities in Nepal's interconnected power system and principal isolated systems. The NEA's board presently consists of 8 members, the Minister of Water Resources is the chairman and the Managing Director of NEA is the member secretary. NEA has 8 directorates: Finance and Administration, Planning, Engineering, Construction, Operation and Maintenance, Rural Electrification, Arun-III Hydroelectric Project, and Distribution & Consumer Service.

The Distribution & Consumer Service Directorate (DCS) of NEA will be responsible for executing the Project for extension and reinforcement of the power transmission and distribution in the Kathmandu Valley.

Power Generating Facilities

The power generating facilities of NEA consist of hydro-, diesel, and solar power plants, but it is basically a hydro dominant system. The total installed capacity of the power generating facilities in the country is 286.7 MW, of which 79.8% (228.7 MW) is generated by hydropower plants as summarized below:

Type of Power Plant	No. of Stations	Installed Capacity
Major Hydropower	9-stations	228,650 kW (79.8%)
Small Hydropower	36-stations	10,513 kW (3.7%)
Diesel Power	9-stations	47,378 kW (16.5%)
Solar Power	3-stations	130 kW (- %)
Total	57-stations	286,671 kW

The solar power plants have a capacity of 130 kW (3 sites) and are located in remote mountainous areas. Most of the diesel power plants are not in operation due to the lack of spare parts and outdated machines, only six power plants, including the Morang multifuel power station which was completed in 1991, are presently operating (36.4 MW).

In addition to the above existing power generating facilities, small and mini-hydropower plants with an installed capacity of 14.6 MW in total are under construction. The details of the existing facilities and facilities under construction are given in Table 2.1.

Power Transmission Facilities

The present transmission line voltages employed in the country are 132 kV, 66 kV, and 33 kV for the transmission lines, 11 kV and 3.3 kV for the high-tension lines, and 400-230V for the low-tension lines of the distribution system.

With the completion of the Nepalgunj - Mahendranagar 132 kV transmission line project in 1992, the transmission line from the eastern to the far western area of Nepal was connected to the Central Nepal Power System via 132 kV transmission lines. The total length of the transmission lines and capacity of the substations are summarized below:

Transmission Line Length			Capacity of Substations	
Voltage	Length	Circuit	Voltage	Capacity
132 kV	1,191 km	single circuit	132/11 kV	28.5 MVA
66 kV	158 km	double circuit	132/33 kV	145.0 MVA
66 kV	64 km	single circuit	132/66 kV	102.8 MVA
33 kV	1,196 km	single/double circuit	66/11 kV	193.3 MVA
			66/33 kV	12.5 MVA
			132/33/11 kV	10.0 MVA

(3) Power Market

Power Supply and Demand

The historical records for generation, peak demand, sold energy, and line losses of the interconnected system over the last 13 years are summarized below:

Power Supply and Demand of Nepal

	Generation	Peak Demand	Sold Energy	Losses	
	(GWh)	(MW)	(GWh)	(GWh)	(%)
1980/81	235.4	59.5	164.4	71.0	30.2
1981/82	275.2	75.1	186.4	88.8	32.3
1982/83	347.0	83.7	235.6	111.4	32.1
1983/84	382.4	96.8	252.3	130.1	34.0
1984/85	420.8	104.5	293.0	127.8	30.4
1985/86	488.5	113.7	341.4	147.1	30.1
1986/87	571.0	123.0	402.6	168.4	29.5
1987/88	628.5	135.2	465.2	163.3	26.0
1988/89	672.3	149.5	496.2	176.1	26.2
1989/90	771.8	176.2	547.5	222.8	28.9
1990/91	902.3	204.0	664.6	237.7	26.3
1991/92	981.1	216.0	737.4	243.7	24.8
1992/93	963.3	214.0	733.8	229.5	22.8
Average Increase (%)					
80/81 - 85/86	15.7	13.8	15.7	15.7	
85/86 - 90/91	13.1	12.4	14.3	10.1	
80/81 - 90/91	14.4	13.1	15.0	12.8	

Note: (1) Generation includes imports from other power systems
(2) Sold energy includes exports to India
(3) Losses = (Generation - Sold Energy)/(Generation)

Sold Energy

The sold energy by consumer according to the tariff system is summarized below:

Sold Energy by Consumer

(GWh)

	1987/88	1988/89	1989/90	1990/91	1991/92	Growth (%)
Domestic	185.7	193.3	231.4	261.4	275.2	10.5
Noncommercial	52.4	48.1	47.4	46.2	46.7	-2.9
Commercial	25.4	30.8	33.7	36.7	45.2	15.7
Industrial	161.6	175.2	178.3	206.9	246.4	11.3
Others	24.0	31.1	34.0	37.6	38.5	12.9
Export to India	16.1	17.6	23.3	80.6	85.4	70.0
Total	465.2	496.1	548.0	669.4	737.4	12.4

Electrification Ratio

The electrification ratios by area as of June 1991 based on the 1991 census are as follows:

Electrification Ratio by Area

(Unit: 1000)

	Household	Customer	Elect. Ratio
Nepal	3,345.1	304.9	9.1%
Eastern	825.8	27.2	3.3%
Central	1,123.0	211.3	18.8%
(Bagmati)	417.9	162.6	38.9%
Western	691.8	42.7	6.2%
Mid-Western	417.2	10.2	2.4%
Far-Western	287.2	6.9	2.4%

Load Curve

The daily load curve of the interconnected system on the second Wednesday of January and August in the past three years is illustrated in Figure 2.2 together with the generation by major power stations. As shown in the figure, there are two peak times; the highest peak from 6:00 to 7:00 pm and a low peak around 8:00 am.

A notable feature of power demand in Nepal is that the highest annual demand is recorded in the winter when heating is required, and the summer peak demand is about 70% to 80% of the winter peak demand. In the winter, the output of hydropower stations, especially run-of-river type hydropower stations, decreases because of the low discharge from rivers.

(4) Demand Forecast

There are two power demand forecasts which were recently produced by foreign consultants. One was produced by a French consultant under the Ten-Year Transmission and Distribution Master Plan of IDA in 1989 and the other was produced by JICA for the Master Plan Study on Extension and Reinforcement of the Power Transmission and Distribution System in the Kathmandu Valley in 1990. An outline of the demand forecasts are given below:

Power Demand Forecast

	EDF Forecast		JICA Forecast		Actual	
	GWh	MW	GWh	MW	GWh	MW
1987/88	611	141			629	141
1988/89	656	150			672	150
1989/90	691	160	747	172	774	176
1990/91	739	169	798	182	906	204
1991/92	811	186	881	200	981	216
1992/93	890	204	969	219	963	214
1995/96	1,176	269	1,319	293		
2000/01	1,910	436	2,134	462		
2005/06	2,822	632	3,207	681		

(5) Supply Forecast

Total possible output of the existing generating facilities in the country is 216 MW against the total installed capacity of 287 MW.

As outlined in subsection 2.3, HMGN and NEA have development programs of several power schemes for increasing power generation of the country. Following is the expected annual output in the country, taking account of those new power sources.

Year	Project	Possible Output (MW)	Total Output (MW)
1993/94	–	216.0	216.0
1994/95	Renovation of Trisuli Hydroelectric Project	3.0	219.0
1995/96	New Jhimurk Hydroelectric Project	12.5	231.5
	Import from India	50.0	281.5
1996/97	New diesel power stations	30.0	311.5
1997/98	New diesel power stations	30.0	341.5
1998/99	–	–	341.5
1999/00	Kali Gandaki 'A' Hydroelectric Project	140.0	481.5
2000/01	Khimti Khola Hydroelectric Project	60.0	541.5
2001/02	–	–	541.5
2002/03	Arun III Hydropower Project	201.0	742.5
2003/04	–	–	742.5
2004/05	–	–	742.5

It is noted that the Modi Khola hydroelectric power project is also programmed to be developed, but the commissioning year is unknown at the present.

(6) Demand and Supply Balance

Following is the present and future power balance in the whole country obtained from the demand forecast and supply balance discussed in the foregoing clauses.

HMGN and NEA program to develop various power schemes. However, as seen in the table, such imbalance is forecasted not to solve till 1998/99 when the Kali Gandaki power project would be commissioned. At the present, NEA is obliged to enforce the scheduled load shedding in the Kathmandu Valley for the shortage of power sources.

Year	Forecasted Demand (MW)	New Project (MW)	Possible Output (MW)	Power Balance (MW)	Percentage Shortage (%)
1993/94	240.47	–	216.0	-24.47	11
1994/95	264.74	3.0MW: Renovation of Trisuli	219.0	-45.74	21
1995/96	292.85	12.5MW: Jhimurk HEP			
		50.0MW: Import from India		-11.35	4
1996/97	320.86	30.0MW: New diesel	311.5	-9.36	3
1997/98	351.54	30.0MW: New diesel	341.5	-10.04	3
1998/99	385.15	–	341.5	-43.65	13
1999/00	421.96	140MW: Kali Gandaki-A HEP	481.5	59.54	
2000/01	462.31	60.0MW: Khimti Khola HEP	541.5	79.19	
2001/02	494.87	–	541.5	46.63	
2002/03	536.15	201MW: Arun III HEP	742.5	206.35	
2003/04	580.77	–	742.5	161.73	
2004/05	629.00	–	742.5	113.50	

Table-2.2 illustrates the above power balance.

(7) Power System Operation

The interconnected power system is controlled by the Load Dispatching Center (LDC) in Kathmandu which was established in 1987 under the grant aid of Japan.

Control of the Power Supply

The hydropower stations which satisfy the most energy demand in the interconnected power system are summarized in Table 2.1. Among these hydropower stations, only the Kulekhani power station has a substantial storage capacity and all the others are of the run-off-river type with only a pond capable of daily and/or hourly regulation.

A detailed operation schedule for each power station has been established. The power supply is controlled by LDC. To meet the variable energy demand, LDC adjusts the outputs of the Kulekhani and Marsyangdi power stations, while other power stations run under maximum operation in proportion to the inflow of water available to each station.

Control of the System Voltage

The system voltage is managed to maintain the voltage of the 11 kV buses of the substations and switching stations in the Kathmandu Valley within a range of 10.5 kV in peak times to 11.5 kV in off-peak times.

The system voltage is controlled by the manual operation of tap-changers on the main transformers (132/66 kV and 66/11 kV) at each substation under the instruction of LDC.

Switching Operation

The following are the principal operation rules for switching:

(a) The switches on the 66 kV and 132 kV systems and on-off function of the static capacitors and shunt reactors are operated under the instruction of LDC.

(b) Switches for 11 kV or lower voltages are operated by the substation operations.

(c) If load shedding is required or faults occur, the complete operation of the switches is carried out under the instruction of LDC.

Reporting

The following reports are periodically completed:

(a) Supply data

A report is prepared daily by LDC and submitted to all the directors of NEA.

(b) Maximum power

Maximum demand and the time on every feeder in each substation and switching station are reported weekly to LDC by the respective stations.

(c) Tripping

All tripping faults at substations and switching stations are reported to LDC daily, and a summary is submitted monthly by the stations.

2.3 Outline of the Related Development Scheme

A new government was established after free elections among plural political parties. The Eighth Five-Year Development Plan was started in 1992 under the new government, which is mainly based on: (i) development of the stable economy, (ii) reduction of poverty, and (iii) equalization of regional differences.

The development of power sources are formulated for the power sector in Jhimurk hydroelectric power project (HEP) (12.5MW), Kali Gandaki A HEP (140MW), and Arun III HEP (201MW) at the public sector. Besides, the Khimti Khola HEP (60MW) and Modi Khola HEP (14MW) are planned for development at the private sector.

On the other hand, the plan intends construction of a total of 405 km of transmission line and reinforcement of distribution facilities, reduction of power and energy losses, improvement of load management, electrification of 1,200 villages, and development of mini-hydro sites (5 sites with 3,260kW of capacity in total).

In the Kathmandu Valley the following projects have been implemented or are currently being implemented under the assistance of IDA:

(1) Power Sector Efficiency Project (PSEP)

IDA conducted the Power Sector Review (PSR) in 1987. According to the recommendations of the review, the following studies (Cr. 1902-NEP) were accomplished:

(a) Long-Run Marginal Cost and Tariff Study

(b) Update of the Least Cost Generation Expansion Plan

(c) Ten-Year Transmission and Distribution Master Plan

(d) Rural Electrification Ten-Year Master Plan

(e) Feasibility Study for Upgrading and Refurbishing the 35MW Trisuli-Devigat Complex

To resolve issues raised by the above-mentioned studies and to find adequate measures to cover the shortage of power before completion of the Arum III HEP, the Power Sector Efficiency Project was formulated.

(2) Loss Reduction Program

The major purpose of the PSEP is to develop the following plans formulated in the PSR.

(a) Repair and improvement with the supply of spare parts and maintenance facilities for Trisuli, Devigat, and other hydroelectric power stations and diesel-engine power stations.

(b) Reinforcement and improvement of the transmission and distribution line facilities in the Kathmandu Valley.

(c) Provision of technical assistance and consulting services for improvement of system management, personnel training, and collection of electricity charges of NEA.

(d) Supply of necessary equipment to the NEA's headquarters and training center.

(e) Implementation of the Marsyangdi Catchment Management Pilot Project.

(f) Energy management of the major industries.

The total annual system energy loss from 1985/86 to 1989/90 reached 32% of the gross generation. Such a high system loss has been a critical factor affecting the NEA's operational and financial performance. The technical and nontechnical losses account for 50% each of the total loss. The technical loss is mainly caused by the overloading of transformers, overextended distribution lines, inadequate service drop wires to customers, low load factor, and improper plan for the distribution network. While, improper billing, illegal connections, and incorrect metering are the primary causes of the nontechnical loss.

Under such circumstances, IDA provided finance for the Loss Reduction Program (LRP), and conducted the Phase-1 study for loss reduction in the Kathmandu Valley in 1986. The study recommended the stepwise implementation program for loss reduction over a 5-year period. Under the same assistance of IDA (Phase-2), the first 2-year program for the LRP was implemented and completed at the beginning of 1992.

The Phase-3 program has been formulated to continue the same implementation of the Phase-2 program and extend the program over the whole country. Although the Phase-3 program was to be conducted within the framework of the PSEP, its purpose was not agreed on in the negotiations held in Washington from April 29 to May 3, 1991. Finally, the Phase-3 program is now implemented under the fund balance of the Marsyangdi hydroelectric power project.

2.4 Outline of the Request

(1) Background to the Request

Such major hydropower plans as Devigat, Kulekhani I, Kulekhani II and Marsyangdi were constructed in the 1980s under the financial assistance received from Germany, IDA, India, and Japan, and besides these developments, the reinforcement of the power transmission and distribution system in the Kathmandu Valley was also implemented under three Grant Aids from the government of Japan. The reinforcement program of the transmission and distribution system resulted in remarkable improvement of the system. The power demand in the valley is still growing at a higher rate than the previous demand forecast, which will soon lead to a shortage of transformer capacities as well as remarkable declination of the system voltage regulation and stable power supply. In response to the official request of HMGN, the government of Japan formulated, in 1990, the Master Plan for the extension and reinforcement of the power transmission and distribution system in the valley and conducted the Feasibility Study for the Project in 1991. In the studies, the following project components were recommended to develop through two phase implementation:

(a) Reinforcement of 11kV switching station,

(b) Augmentation of 11kV underground cable lines,

(c) Reinforcement of 11kV trunk lines,

(d) Augmentation of a 66kV substation,

(e) Reinforcement of 132kV transformers, and

(f) Reinforcement of 11kV and low-tension lines.

On the basis of the recommendation, HMGN requested in December 1991 that GOJ implement the components ranked as high priority in the studies. In response to the official request, GOJ through JICA conducted the Basic Design Study on the extension and reinforcement of the facilities for Phase-I formulated in the above-mentioned study, and implemented the Project in 1992 and 1993.

GOJ dispatched a study team to Nepal for 30 days from November 19 to December 18, 1993 for the basic design of the Project formulated as Phase-II. The Study Team conducted an investigation of the present situation, survey of the sites of the substation/switchyard/distribution line routes concerned, examination of NEA's maintenance and management of facilities, study on issues of the system after implementation of Phase-I, collection of necessary materials for planning Phase-II, and held discussions with NEA.

(2) Executing Agency

The executing agency of the Project is NEA. DCS of NEA is responsible for the successful execution of the Project. For this purpose, a separate "Project Office" will be established under the Directorate in order to carry out the necessary measures for smooth implementation of the Project.

(3) Administration of the Project

For executing the Project, NEA intends to employ a consultant for the following works:

- Detailed design of the facilities;
- Preparation of tender documents;
- Evaluation of tenders;
- Checking and approval of the contractor's design, surveys, specifications, and drawings;
- Factory inspection before shipment;
- Assisting NEA in managing the implementation of the Project;
- Construction supervision;
- Other supervisory work for implementing the Project;
- Commissioning test and preparation of various reports for the Project

(4) Expected Benefit of the Project

(a) Population that will benefit directly from the Project

A population of around 956,000 living in the Kathmandu, Lalitpur, and Bhaktapur areas, which is equivalent to 5% of the National population, will directly benefit from the implementation of the Project, owing to the qualified power supply and further electrification.

(b) Population that will benefit indirectly from the Project

The reduction of energy losses in the valley system, which consumes 46% of the total energy in the country, will contribute to the NEA revenue earning and power supply situation outside the valley. The effective utilization of energy to be improved under the Project will cause a reduction in the consumption of fuelwoods leading to conservation of the natural environment. The indirect population which will benefit from the Project will be, in this respect, the total national population.

(c) Area that will benefit from the Project

The anticipated area is about 900 km^2 covering Kathmandu, Lalitpur, and Bhaktapur districts.

(d) Economic and social effects of the Project

(a) Effective utilization of generated energy due to the qualified energy and reduction of energy losses,

(b) Acceleration of industrialization due to the reinforced and improved networks,

(c) Satisfaction of customers' requirement for a qualified energy supply and increase of energy consumption,

(d) Saving of fuelwoods and imported energy due to the utilization of energy saved from the reduction of electric energy losses,

(e) Reduction of the NEA's O/M costs due to reinforced and renovated facilities,

(f) Improvement of the NEA's financial state due to the reduction of energy losses and O/M costs, and

(g) Increase in the standard of living of people's owing to the improvement of the quality of supply.

Table 2.1 Existing Generating Equipment

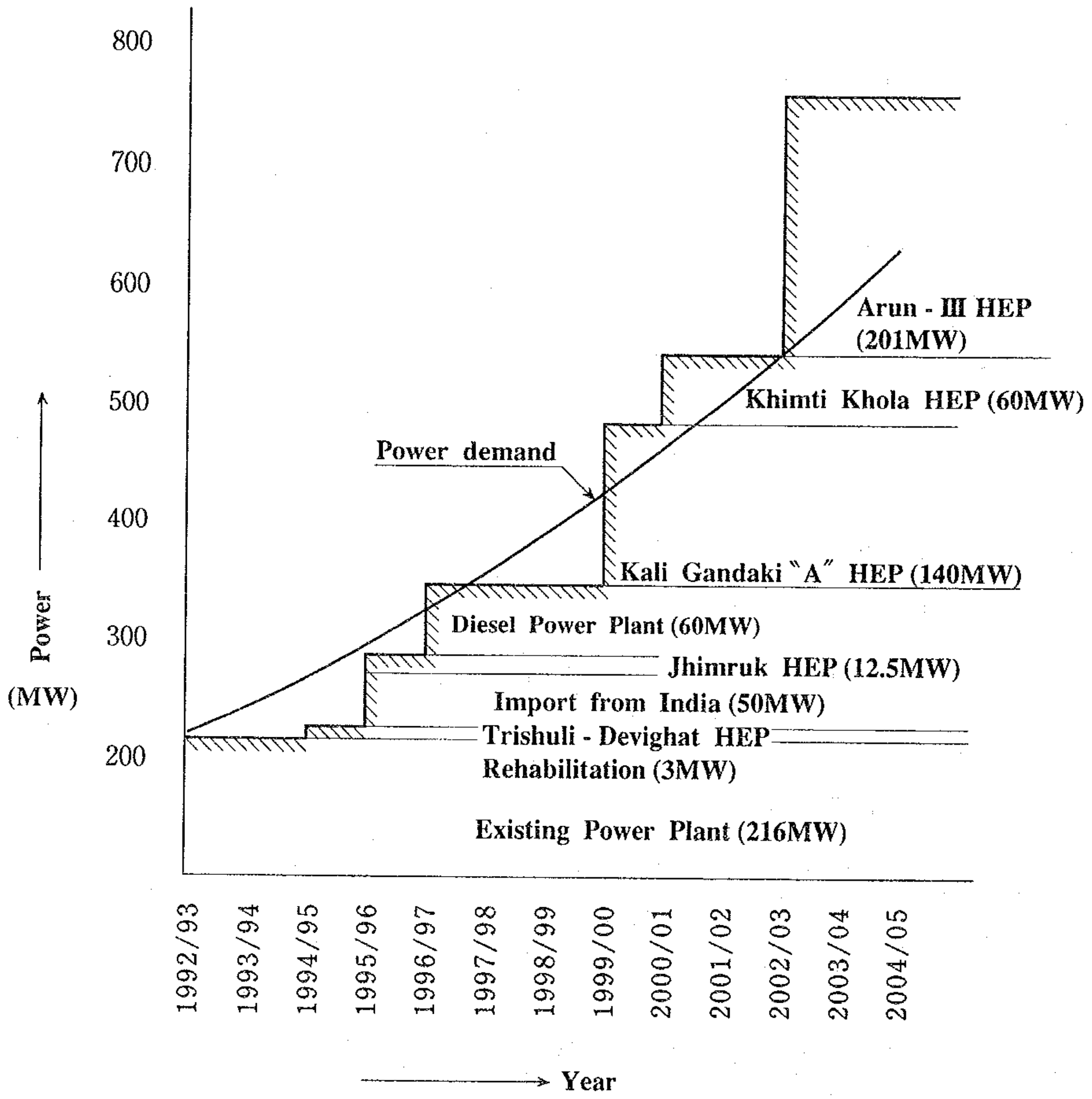
(As of end/1993)

	Power Plant	Unit Nos.	Unit Capacity (kW)	Installed Capacity (kW)	Date in Service	Region	Remarks
A.	Major Hydropower Plants						
1)	Existing Plants						
	1. Panauti	3	800	2,400	1963/64	Central	
	2. Trisuli	7	3,000	21,000	1962/70	Central	Only 6-units operating
	3. Sunkosi	3	3,350	10,050	1973	Central	
	4. Gandak	3	5,000	15,000	1979	Western	
	5. Kulekhani No.1	2	30000	60,000	1982	Central	
	6. Devighat	3	4,700	14,100	1984	Central	In tandem with Trisuli
	7. Kulekhani No.2	2	16,000	32,000	1986	Central	In tandem with Kl-1
	8. Marsyangdi	3	23,000	69,000	1990	Western	
	9. Andhi Khola	2	2,550	5,100	91/06/02	Western	
	Total	28		228,650			
2)	Under Construction						
	1. Jhimruk Piuthan	3	4,000	12,000	(1994)	Western	
B.	Integrated Small Hydropower Plants						
1)	Existing Plants						
	1. Sundarijal	2	320	640		Central	
	2. Phewa (Pokhara)	4	272	1,088	66/69	Western	
	3. Seti	3	500	1,500	1985	Western	
	4. Butwal (Tinau)	3		1,024	1974	Western	
	5. Surkhet	1	345	345			
	Total	13		4,597			
C.	Isolated Small Hydropower Plants						
1)	Existing			10,513			36 stations
2)	Under Construction			4,725			7 stations
D.	Diesel Plants						
	1. Hetauda	-		14,450		Central	
	2. Morang(B.nagar)	4	6,500	26,000	1991	Eastern	
	3. Others	-		6,928			
	Total	4		47,378			
E.	Solar Power Plants			130			3 sites

Remark : *Kulekhani No.1 and No.2 share a common hydraulic system and can only be operated in tandem* as a (30+16) = 46 MW unit. Similarly, unit outage at Trisuli requires reduction at Devighat.

Sources : NEA's information and 1992/93 Annual Report

Table 2.2 Future Power Balance



CHAPTER 3

OUTLINE OF THE PROJECT SITE

CHAPTER 3
OUTLINE OF THE PROJECT SITE

3.1 Location and Socioeconomic Situation of the Project Area

The project area, in the Kathmandu Valley extendeds slightly to the east from the center of the country and lies at the north latitude 27°42' and east longitude 150°18', and is surrounded by the Himalayan Mountains. Kathmandu, the capital of the country is situated between the Bagmati and Bisnumati rivers in the valley. The valley covering 899 km^2 is administratively divided into 3 areas, Kathmandu, Lalitpur, and Bhaktapur. Lalitpur and Bhaktapur are situated to the south and east of Kathmandu town, respectively. The population of the valley is approximately 1.1 million, about 6% of the total population of the country according to the results of the national census in 1991.

Kathmandu is the biggest town in the country and has prospered as the center of politics, administration, economy, finance, culture, etc. since the medieval times. The king's palace is located in the center of the town, wherefrom radial roads extend. Kathmandu has an international airport and regular air services connect Thailand, Singapore, Hong Kong, Bangladesh, India, and Germany. Commercial activity in Kathmandu is in the form of shops, hotels, and lodges for tourists.

About 75% of the total population in the valley is engaged in the agricultural sector, and the populations engaged in the industrial and commercial sectors in the area are 17.3% and 18.8%, respectively, of that in the whole country.

3.2 Natural Conditions

The climate of the country varies from region to region. However, the Kathmandu Valley situated at an altitude of 1,300 m has a very pleasant and moderate climate. The air temperature in the valley varied between -3.5°C and 34°C over the last 11 years (1976 - 1986), and the mean annual air temperature was 17.4°C to 18.5°C during that period. The minimum air temperature is usually recorded during January and the maximum during June.

The temperatures recorded at the observatory station at Kathmandu airport from 1976 to 1986 and in 1992 are summarized below:

		1976 - 1986	1992
Maximum air temperature		34.0°C	33.0°C
Minimum air temperature		-3.5°C	-2.0°C
Mean monthly air temperature	highest	24.4°C	24.0°C
	average	18.0°C	17.0°C
	lowest	11.7°C	10.0°C

The humidity in the valley is not very high and relative humidity varies from about 40% in April to about 85% in August. The records (1976 to 1986) of the station show that the average annual rainfall is 1,420 mm and 80% to 90% of the rainfall is concentrated in the period from May to September.

3.3 Social Environment

The urban areas of Kathmandu and Lalitpur districts are surrounded by an asphalt-paved highway called the "Ring Road". Main roads in the urban areas are wide and asphalted, but other roads are rather narrow and graveled. A trolley-bus system constructed under assistance from China is used as the main traffic system in the town, besides buses and taxies.

Overseas telephone communications and facsimile services in Kathmandu have direct dialing access. The water supply system in the Kathmandu area has deteriorated and its function has been lowered, but the system is now being rehabilitated and extended under the grant aid of Japan.

People in the valley enjoy one government television program and programs from India and Hong Kong through a satellite station.

3.4 Power Sector in the Project Area

3.4.1 Power Supply System in Kathmandu Valley

Power is supplied to the Kathmandu Valley from the Marsyandi and Kulekhani power stations through 132 kV transmission lines and from the Kulekhani I, Trisuli, Devigat, and Sunkosi power stations through 66 kV transmission lines. The power delivered through the 132 kV transmission lines is stepped down to 66 kV at the Suichatar and Balaju substations, and therefrom delivered to distribution substations in the town by 66 kV transmission lines.

The following 6 distribution substations (66/11 kV) are operated in the Kathmandu area. All the other substations other than the New Patan substation are located in Kathmandu town.

(a)	Balaju substation	20.0 MVA	(2 x 10 MVA)
(b)	Lainchaur substation	20.0 MVA	(2 x 10 MVA)
(c)	New Chabel substation	18.9 MVA	(3 x 6.3 MVA)
(d)	Suichatar substation	36.0 MVA	(2 x 18 MVA)
(e)	New Patan substation	36.0 MVA	(2 x 18 MVA)
(f)	Baneswar substation	18.0 MVA	(1 x 18 MVA)

The Lainchaur and Balaju substations are provided with the latest Gas Insulated Switchgear (GIS), while the other substations have conventional outdoor switchgear. The Sunkosi feeder from the New Patan substation has very old-fashioned switchgear.

3.4.2 Distribution Facilities

The power stepped-down to the distribution line voltage of 11 kV at the above-mentioned substations is delivered to the end customers through the Ring Main system - switching stations - 11 kV distribution lines - pole transformers - low-tension distribution lines.

(1) Ring Main system

The Ring Main system has delivered reliable power to Kathmandu city center since the 1960s. The system consists of 11 kV double circuits of Aluminium Conductor Steel Reinforced (ACSR) 200 mm^2 lines and several switching stations. From these switching stations in the system and distribution substations, 11 kV primary distribution lines are extended for power supply to consumers on low-tension lines through 11 kV/400-230V pole mounted transformers. The power supply system in the Kathmandu Valley involving the Ring Main is illustrated in Figure 3.1, and details of the 11 kV Ring Main lines are summarized in Table 3.1.

(2) Switching stations

There are 9 switching stations in the Kathmandu Valley as shown in Figure 3.1. The details of the 11 kV switchgear installed in the substations and switching stations are given in Table 3.2.

(3) 11 kV distribution lines

The existing distribution lines consist of overhead lines and underground cable lines. Such various types of supports as wooden poles, steel tubes, concrete poles, or rails are used for supporting various kinds of conductors on the overhead lines. Most of the underground cables have been used for over 15 years, and the old oil-filled paper power cables are operated in a seriously deteriorated condition and should be urgently replaced. The existing 11 kV lines extend on 58 feeders over 603 km in total. The following table shows the region wise line length, capacity of the pole-mounted transformers and low-tension lines in the Kathmandu Valley as of 1992.

Distribution Facilities in the Valley

	KTM Center	KTM West	KTM East	Lalitpur	Bhaktapur	Total
(a) 11 kV Line						
- Overhead (km)	41.8	158.8	128.7	139.7	100.2	569.2
- Underground (km)	14.4	3.6	6.9	6.4	2.5	33.8
Total (km)	56.2	162.4	135.6	146.1	102.7	603.0
(b) Transformers (11/0.4 - 0.23 kV)						
- No. of units	453	324	225	306	184	1,492
- Capacity (MVA)	82.0	42.8	30.8	43.3	27.1	226.0
(c) Low-tension Line						
- Overhead (km)	272.0	414.7	278.8	534.3	226.1	1,713.8
- Underground (km)	n.a.	4.2	24.1	2.0	-	29.0
Total (km)	272.0	418.9	302.9	536.3	226.1	1,742.8

Source: NEA

The 11 kV distribution lines are networked in radial form. Most of the lines are of the 3-phase, 3-wire type. The distribution lines into high load-density areas are connected with plural substations or switching stations. The Power is normally supplied from a particular substation or switching station under the off-condition of switches on the lines. Under non-supply conditions form one source, power is to be supplied by another source due to the switch operation on the lines.

The city center where overhead lines are not located due to the extremely narrow space is supplied with power by underground cables. The switching-over of the power supply of the underground cable system is generally performed by the bus arrangement on supports for pole mounted transformers, but oil switches were also partially introduced in the underground cable system for this purpose.

The average feeder length in the urban areas is several kilometers, while that in the suburbs reaches dozens of kilometers.

(4) Distribution transformers

The distribution transformers (11 kV/400 - 230V) installed in the valley as of 1993 numbered 1,492 units with a 226 MVA capacity. The unit capacity of the transformers ranges from 5 kVA to 1,000 kVA, and the majority are 250 kVA in the urban areas, 100 kVA in the city areas, and 50 kVA in the rural areas. All the larger transformers are of the three-phase type, but some transformers installed in the remote rural areas are of the small capacity single-phase type for supply of the lighting load only.

The primary side of distribution transformers is generally protected by switches with fuses. The power is delivered form pole-mounted transformers to low-tension lines through distribution circuit breakers, while such delivery in some areas is conducted without any breakers. The Bhaktapur area is a center of tourism for many historical temples and buildings, but the natural environment is maintained by the installation of distribution transformers enclosed in the ground-cubicles and underground cables.

(5) Low-tension distribution network

The low-tension distribution network from the distribution transformers supplies power to low-tension customers through a 400/230V, three-phase, four-wire system of overhead lines in the radial network. In urban areas, most of the distribution lines have wires for street lighting on the same supports.

ACSR conductors of various sizes are used for trunk lines. Insulated wires and aerial bundled cables also use supports and/or are attached to the walls of buildings in some areas of the city center that are densely populated and congested with houses and buildings along narrow roads.

3.5 Power Demand in the Kathmandu Valley

The number of customers and electric energy sold in 1991/92 by area and demand sector are given below:

Customers and Sold Energy in the Kathmandu Valley

	Nepal	Kathmandu				
		Kathmandu	Lalitpur	Bhaktapur	Total	
Number of Customers						
- Residential	369,931	96,913	33,713	23,273	153,899	(42%)
- Commecial & Non-Commercial	8,023	1,198	263	166	1,627	(20%)
- Industrial	9,935	1,895	620	467	2,982	(30%)
- Others	1,637	188	17	23	218	(13%)
Total	389,526	100,184	34,613	23,929	158,726	(41%)
Sold Energy (MWh)						
- Residential	259,833	115,094	25,671	9,123	149,888	(58%)
- Commecial & Non-Commercial	94,701	52,249	7,244	1,780	61,273	(65%)
- Industrial	273,752	41,401	13,576	5,569	60,546	(22%)
- Others	81,099	10,437	625	1,720	12,782	(16%)
Total	709,385	219,181	47,116	18,192	284,489	(40%)

Remarks: (1) "Nepal" excludes export to India
(2) Percent in ( ) shows the ratio against "Nepal"

3.6 Power Demand Forecast

A demand forecast worked out in the master plan study for the extension and reinforcement of the power transmission and distribution in the Kathmandu Valley by JICA in 1990 is the only current demand forecast available for the area. The results are as follows:

Demand Forecast of the Kathmandu Valley

Area	1989/90		1995/96		2000/01	
	GWh	MW	GWh	MW	GWh	MW
Kathmandu Central	118.2	39.8	173.4	52.7	248.9	69.8
Kathmandu Western	33.4	11.2	71.6	21.7	133.1	37.4
Kathmandu Eastern	41.8	14.1	87.8	26.7	161.2	45.3
Lalitpur	42.0	14.1	73.2	22.2	119.4	43.4
Bhaktapur	14.7	4.9	30.4	9.2	66.7	15.6
Total	250.1	84.1	436.4	132.5	718.3	211.5

3.7 Operation and Maintenance of the Power Facilities in Valley

(1) Generating/transmission line/substation facilities

The O/M bureau of NEA has 4 divisions: generation, system operation, transmission network, and engineering.

The transmission network division has a further 3 regional offices: Bagmati, eastern, and western regional offices. Each office is responsible for O/M of the transmission lines and substations in the respective regions.

(2) Distribution facilities

The distribution facilities and services bureau in the Kathmandu Valley are managed by Kathmandu and Lalitpur/Bhaktapur/Kavre divisions. Each division controls the following branch offices:

(a) Kathmandu division office

- (i) Kathmandu eastern branch office
- (ii) Kathmandu central branch office
- (iii) Kathmandu western branch office
- (iv) Rasuwa/Nuwakot branch office

(b) Lalitpur and Bhaktapur/Kavre division office

- (i) Lalitpur branch office
- (ii) Bhaktapur branch office
- (iii) Kavre branch office
- (iv) Sindhu/Dolakha branch office

Upon completion of construction, the distribution facilities are transferred to the regional offices and maintained by the branch offices and/or units. The branch offices used to manage large scale maintenance and rehabilitation and the installation of service drop wires to customers. The construction of small-scale distribution lines and maintenance of the distribution facilities in the area are managed by each branch office. The units used to be responsible for only metering and the collection of revenue.

Table 3.1 Existing 11 kV Ring Main System

No.	11kV Line (From)	(To)	Circuit	Voltage (kv)	Length (km)	Conductor Size
1	Balaju	Maharajgunj	SC	11	4.5	0.2 sq. in
2	Balaju	Old Chabel	SC	11	9.0	0.2 sq. in
3	Teku	Thapathali	DC (UGC)	11	1.7	200 sq. mm
4	Balaju	Teku	DC	11	3.8	0.2 sq. in
5	Teku	Siuchatar	DC	11	2.5	0.2 sq. in
6	Teku	N. Patan	DC	11	4.5	0.2 sq. in
7	New Patan	K-2	DC	11	4.8	0.2 sq. in
8	K-2	R. Palace	SC (UGC)	11	1.0	240 sq. mm
9	K-2	Lainchaur	SC (UGC)	11	1.7	240 sq. mm
10	Lainchaur	R. Palace	SC (UGC)	11	0.7	240 sq. mm
11	Maharajgunj	Old Chabel	SC	11	2.7	0.2 sq. in
12	Old Chabel	N. Chabel	DC	11	1.0	0.2 sq. in
13	N. Chabel	Bhaktapur	DC	11	9.6	0.2 sq. in
14	Bhaktapur	Thimi	DC	11	3.2	0.2 sq. in
15	Thimi	New Patan	DC	11	7.9	0.2 sq. in
16	Old Patan	N. Patan	DC (Cable)	11	0.05	0.1 sq. in

Source : NEA
Remarks : UGC = Underground power cables
SC = Single circuit
DC = Double circuit

Table 3.2 11kV Switching Equipment in the Kathmandu Valley

Station	Number of Panels						S. Circuit Current (kA)	Type of Circuit Breaker	Manufacturer	Remarks (No. of C.B /Outage)
	Trans. 2ndry	Ring Main	Feeder	St. Trans.	Bus Coupler	Total				
Substation										
1) Siuchatar	2	2	7	-	1	12	26.30	Min. Oil	Indian Manuf.	1
2) Balaju	2	2	10	1	1	16	20.00	Min. Oil	AEG (Germany)	3
3) New Patan	2	6	2	-	1	11	26.30	Min. Oil	Indian Manuf.	1
4) New Chabel	3	2	5	2	2	14	18.40	Bulk Oil	Indian Manuf.	1
5) Baneswar	1	2	6	-	1	10	25.00	Vacuum	Meiden (Japan)	-
6) Lainchaur	2	2	10	1	1	16	20.00	Vacuum	AEG (Germany)	-
Switching Station										
1) Teku	-	4	7	-	-	11	7.88	Bulk Oil	English Elec.(UK)	1
	-	4	2	-	-	6	20.00	Bulk Oil	Yorkshire(UK)	2
2) Royal Palace	-	2	1	2	-	5	7.88	To be replaced under the Project (Phase-I)		
3) Maharajgunj	-	2	3	-	-	5	7.88	Bulk Oil	English Elec.(UK)	1
4) K-2	-	4	11	-	3	18	25.00	Vacuum	Meiden (Japan)	2
5) Old Patan	2	4	6	-	-	12	7.88	To be replaced under the Project (Phase-I)		
6) Old Chabel	-	4	6	-	-	10	7.88	To be replaced under the Project (Phase-I)		
7) Thapathali	-	2	6	-	-	8	40.00	Min. Oil	Meiden (Japan)	-
8) Thimi	-	4	2	-	-	6	7.88	Bulk Oil	English Elec.(UK)	1
9) Bhaktapur	-	4	6	-	1	11	20.00	Bulk Oil	Yorkshire(UK)	2

CHAPTER 4

OUTLINE OF THE PROJECT

CHAPTER 4
OUTLINE OF THE PROJECT

4.1 Project Objectives

Kathmandu is the capital of the country and almost 46% of the total generated energy in the country was sold in the Kathmandu Valley. Thus, most of the demand and electricity in the country are concentrated in the valley. The power demand in the valley is growing at a higher rate than was forecast in the past, therefore, the power supply system will face problems, such as over-loading, excessive voltage drop and high energy losses on the distribution system, deterioration of power supply reliability, etc.

The Project has the following short-, medium-, and long-term objectives:

(1) Short-term objectives

(a) Increase of the system capacity to meet the current demands and growing demands in the valley power system.

(b) Replacement of the deteriorated facilities to increase power supply.

(c) Improvement of the voltage regulation of 11 kV feeders and low-tension lines to supply standard quality energy to customers.

(d) Reduction of the current energy losses for saving valuable indigenous energy and effective utilization of the existing power facilities.

(2) Medium and long-term objectives

(a) Maintaining of the power supply reliability of the facilities implemented under the Project without further reinforcement in the near future.

(b) Provision of sufficient capacity for the new facilities purchased under the Project for the growing demands.

(c) Keeping the feeders and lines augmented with adequate facilities, under the Project, to lower energy losses.

(d) Excellent maintenance works of the system facilities by the NEA's staff trained under the Project.

The Project aims not only to support the economic activities of Kathmandu, but also to contribute to the betterment of living standards and the increase in employment opportunities in the industrial sector through stable and reliable power supply. It will also improve cost efficiency by reducing system losses and O/M costs by reinforcement of the power transmission and distribution facilities which need urgent countermeasures.

4.2 Examination of the Request

4.2.1 Necessity and Appropriateness of the Project

The following current issues pointed out in the Master Plan Study in 1992 were re-examined and confirmed by the Basic Design Study Team.

(a) Urgent rehabilitation of the existing power facilities, in particular, generating facilities in order to meet the growing demand.

(b) Construction of generating facilities together with transmission lines and substation facilities in order to meet the growing demand.

(c) Improvement of the electrification ratio in the rural region.

(d) Reduction of the energy losses of the distribution networks.

(e) Improvement of the power supply reliability.

Improvement and reinforcement of some of the issues of items (a), (b), and (c) are under planning and/or implementation under the assistance of IDA and ADB (refer to Subsection 4.2.2).

While, the JICA Project aims mainly to cover the issues of the above items (d) and (e).

The necessity and appropriateness of the Project have been examined and confirmed in this study stage by the team in detail through a series of discussions with officials of the Government of Nepal and NEA, detailed site investigation, and analysis in Japan. The findings are as follows:

(a) Most of the 11 kV feeders cover commonly both the urban and rural areas. However, consumers in rural areas are facing excessive voltage drops due to long lines. Those in urban areas are facing frequent power supply outages due to line faults caused in the rural areas. An effective countermeasure is to separate the power supply into urban and rural areas by adding another new line feeder, as planned in the Project.

Construction of exclusive-use feeders to the rural consumers will improve the excessive voltage drops at the consumers' end in the rural areas because of less load current of the urban consumers. While, other exclusive feeders to the urban consumers will reduce supply outages due to lessened line faults caused by the rural areas.

Thus, additions of new feeders are recommended for improvement of voltage drops and supply outages.

(b) In order to reduce the frequency of circuit breaker tripping, which is the main cause of short circuits and line-to-ground faults when using bare conductors, insulated cables will be adopted for both the 11 kV and low-tension lines under the Project. Short circuit faults are caused by mutual contact of bare conductors, while line-to-ground faults are mostly caused by tree contact to the bare conductors. Accordingly, application of insulated cables to overhead lines will ensure remarkable reduction of short circuits and line-to-ground faults of the lines comparing with bare conductors.

Applications of insulated cables are, thus, an effective measure to improve the present supply reliability. Insulated cables are also effective in lengthening the life of circuit breakers and minimizing the maintenance cost of clearing a right-of-way.

(c) At the end of 1993, the main transformer at the Siuchatar substation was loading about 78% of the rated capacity under the condition of load shedding in the peak power demand time. If the transformer operates under the normal supply condition, it is supposed to overload. Besides, from the power flow analysis on the power system in the Kathmandu Valley, the estimated load on the transformer will exceed the rated transformer capacity in 1995/96.

In order to avoid the overloading of the transformer, an additional transformer is necessary to be installed for proper operation of electrical equipment in the substation.

(d) The power demand of the service area of the Maharajgunj 11 kV switching station has been rapidly growing in recent years. However, the facilities at the switching station have never been renovated or expanded since its commissioning in 1969. The existing facilities have been superannuated beyond their service lives. At present, genuine spare parts for repair of the facilities are not available because the facilities consist of old models.

Unless improvement would be done, the function of the substation will shortly be suspended, and also stable supply of power to the customers will not be continued.

The facilities in the switching station should therefore be replaced with new facilities for proper operation of the station, and additional feeders should be provided in order to meet the growing demand and produce stable operation of the system.

(e) Reliable contractors for erection of the power transmission and distribution system are not easily found in Nepal, and most daily extension and rehabilitation works on the system are carried out by NEA. Therefore, it is recommended that both the supply and erection of the facilities to be implemented under the Project would be carried out by a Japanese Contractor.

(f) About 68% of the total population, 1.1 million, in the Kathmandu Valley enjoys electricity supply, including many government offices, banks, foreign agencies, hotels, etc. It is expected that a greater percentage of the population will enjoy electricity supply if the Project is executed. Implementation of the Project will have a great effect on the economic stability in the whole country.

4.2.2 Related Similar Projects

The following projects for the reinforcement and upgrading of the existing power transmission and distribution system in the Kathmandu Valley are in progress with financial assistance from international organizations and foreign governments:

(1) Power Sector Efficiency Project (PSEP)

The project aims to increase the NEA's effective power supply capacity by improving the technical and operational efficiency, upgrading the existing generation capacity, and improving the system load factor. The project is composed of several components, some of the major ones are described below:

(a) Rehabilitation of the Trisuli - Devighat Hydropower Stations

The project aims essentially to refurbish the civil and electromechanical aspects of the Trisuli hydropower station, established 26 years ago, and Devighat hydropower stations, established 11 years ago, with current capacities of 18 MW and 14.1 MW, respectively.

By increasing the spillway height by 12m, adding one aqueduct on the Trisuli river, and enhancing the capacity of the channel, the project aims to raise the channel discharge from the present 31 m^3 to 45 m^3 to facilitate the generation of an additional 95.3 GWH of energy to aid the current energy deficit in the power system. In addition, the life of the generating facilities is expected to increase by another 30 years.

(b) Kathmandu Valley High Voltage Reinforcement Project

The Kathmandu Valley High Voltage Reinforcement Project, under the IDA credit was estimated to cost NRs. 768.6 million and aims to reinforce the 132 kV and 66 kV systems in the valley. The following works are involved in this project;

- Reinforcement of ten existing substations.
- Construction of a 132 kV transmission line for connecting the Marsyangdi-Balaju line to the Siuchatar substation.
- Upgrading the capacity of the Teku switching station to 66 kV, 36 MVA and construction of a related 66 kV transmission line.
- Augmentation of transformers at the Baneswar and Lainchaur substations.
- Construction of a 66 kV, 20 MVA substation in the Bhaktapur area and a transmission line (132 kV design) between the substation and Bulhanilkanth and the incoming line from the Sunkosi - Patan line.

The supply and erection contracts for this project were completed with an Indian contractor for the transmission line works and a Chinese contractor for the substation works in November 1993.

(c) The Duhabi - Bhantabari 132 kV Transmission like project

This project aims to ease the current energy crisis by importing power from India under the Nepal - India power exchange agreement. Undertaken with loan assistance from IDA and having an estimated cost of NRs. 86.43 million, the completion of the project is scheduled by the end of 1994/95.

(2) Restoration of 66 kV and 11 kV switching equipment at the Lainchaur substation.

All 66 kV and 11 kV switching equipment at the Lainchaur substation was destroyed by a fire in an 11 kV cubicle in July 1990. The restoration of the switching equipment was implemented under KfW financing and completed in May 1993.

(3) Additional stringing of the second circuit conductors on the existing 66 kV double circuit transmission line between the Siuchatar and Patan substations.

This work aimed to improve the unreliable power supply to the Patan, Baneswar, and Baktapur areas and was completed in July 1993 with NEA financing. The necessary 66 kV switching equipment at both substations is included in the PSEP.

(4) Loss Reduction Project (LRP)

Phase II of LRP is in progress and Phase III will begin with reallocation of the remaining loan for the Marsyangdi Hydroelectric Power Project. Phase III of LRP includes improving the connections of the low-tension distribution lines and service wires for the consumers and replacement of improper energy meters in a part of and outside the Kathmandu Valley.

(5) Computerized Billing Project

The computerized billing project is being undertaken with a US$ 1.761 million loan from ADB. The project seeks to computerize the billing and accounting system in the 28 different branches of NEA in a phase wise manner.

4.2.3 Components of the Project

The components of the Project, Phase-I and Phase-II requested by the Government of Napal and the phase wise execution of the project components are summarized below:

	Components requested by the Government of Nepal	Components of the Project, Phase-I & II
1.	Augmentation of 11 kV cubicles at the Royal Palace, Old Patan, and Old Chabel	Phase-I
2.	Construction 11 kV underground cable laying between the Lainchaur substation and K2 switching station	Phase-I
3.	Reinforcement and improvement of the main 11 kV feeders	Phase-I
4.	Augmentation of a 132/66 kV transformer at the Siuchatar substation	Phase-II
5.	Construction of a K3 substation	Phase-II
6.	Extension and reinforcement of the 11 kV and low-tension distribution line	Phase-II
7.	Procurement of tools, instruments, and vehicles for the O/M works	Phase-II

The components requested by The Government of Napel were examined on the basis of the Feasibility Study carried out by JICA in 1991.

The details of the components of the Project, Phase-I, which have been implemented in 1993 and 1994 are shown in the attached Appendix 2-1.

The following are the components of the Project, Phase-II requested by The Government of Napel:

1. Augmentation of a 132/66 kV transformer at the Siuchatar substation
2. Construction of a K3 substation
3. Extension and reinforcement of 11 kV feeders and low-tension lines
4. Procurement of tools and vehicles

The results of the discussions and examination with NEA on the Basic Design Study for the Project, Phase-II are shown in the attached Appendix "Minutes of Meeting". The above 4 project components mentioned above have a high priority in the Feasibility Study report and are examined in the Phase-II Basic Dasign Study as follows:

(1) Augmentation of a 132/66 kV transformer at the Siuchatar substation

As a result of the system analysis, the estimated load on the existing 132/66 kV, 37.8 MVA transformer at the Siuchatar substation will exceed the rated transformer capacity in 1995/96.

In 1993, the load on this transformer was laden with 78% of the rated capacity under load shedding conditions at the peak load time. It will exceed the rated transformer capacity under normal supply conditions. In order to rectify the over-loading of the transformer, an additional transformer with the same capacity and ratings is supposed to be installed.

(2) Construction of a K3 substation

To meet the growing demand in the center of the Kathmandu valley and to reduce the excessive voltage drop of 11 kV buses at the K2, Royal Palace, and Lainchaur stations, a K3 substation is to be constructed at the center of Kathmandu along the Tukucha river. Power for the K3 substation will be supplied from the Siuchatar substation through a 66 kV double circuit line which will be tapped from a new 66 kV double circuit line to be constructed under PSEP between the Siuchatar and Teku substations.

In the Feasibility Study, construction of a K3 substation was recommended to meet the growing power demand in the center of the Kathmandu Valley. However, the power demand in the Kathmandu Valley has been restrained due to the shortage of power supply capacity in the country. Besides, the implementation of power development plans, such as the Kali Gandaki "A" and Arun-III Hydroelectric Projects has been delayed. Through discussions for the Phase-II Basic Design Study, the Nepalese side and Japanese side have agreed to defer the construction of a K3 substation from the Project, Phase-II.

(3) Extension and reinforcement of 11 kV and low-tension distribution lines

Urgent extension and reinforcement of the following 11 kV feeder lines and low tension lines were requested:

(a) Center of Kathmandu town

(b) Extension of Dharmasthali feeder

(c) Baralgau - Gokarneswar feeder

(d) Connection of the Nayabazar and Budhanilakantha feeder to the ring road

(e) Renovation of the Nagarkot - Bramhakhel feeder

(f) Rerouting of the Thimi feeder

(g) Other feeders in the Kathmandu Central branch

(h) Other feeders in the Kathmandu East branch

(i) Other feeders in the Kathmandu West branch

(j) Other feeders in the Kathmandu Lalitpur branch

(k) Other feeders in the Kathmandu Bhaktapur branch

(l) Reinforcement and improvement of low-tension lines in each branch.

The works of Item (f), Rerouting of the Thimi feeder, have been carried out by NEA. Therefore, this work is eliminated from the Project.

(4) Procurement of tools and vehicles

For proper O/M of the power system in the Kathmandu valley, procurement of tools, vehicles, VHF radio equipment, and measuring equipment for NEA was recommended in the Feasibility Study.

The VHF and measuring equipment and some of the tools and vehicles were procured under the Project, Phase-I. The rest of the tools and vehicles will be procured under this Project.

4.2.4 Contents of the Requested Major Facilities

For the implementation of the Project, Phase-II, the major equipment requested by The Government of Napel and its necessity are summarized below:

(1) Augmentation of a 132/66 kV transformer at the Siuchatar substation

In order to rectify the overloading of the transformer, an additional transformer with the same capacity is to be installed and operated in parallel with the existing transformer.

(2) Extension and reinforcement of 11 kV feeders and low-tension distribution lines

Serious issues, like the excessive power loss and voltage drop on the feeders have occurred due to the shortage of capacity of the distribution facilities in relation to the size of the conductors and number of feeders. It is necessary to extend and reinforce such feeders for maintaining a stable and reliable power supply.

(3) Procurement of tools and vehicles

The tools and vehicles are used for the effective execution of O/M of the power facilities.

In addition to the original plans mentioned above, the following requests were made by NEA through discussion and study for the Project, Phase-II.

(4) Replacement of the 11 kV switching facilities at the Maharajgunj switching station

The Maharajgunj switching station, established in 1969 and located in the northern part of Kathmandu, serves electricity to the residentials areas, shopping streets, public hospitals, governmental offices, industries, embassies, and a resort area in the northernmost part of Kathmandu. The power for the water-purifying plant to be constructed under Japan's Grant Aid will also be supplied by this station.

The switching facilities of the two 11 kV feeder cubicles and two ring main circuit cubicles for receiving the power from the Balaju substation are installed in this station. Nevertheless the service area and power demand of this station have sharply expanded in recent years and the switching facilities have never been subjected to renovation and expansion since they were established. The facilities have been superannuated over their life. Besides, the spare parts for maintenance and repair of these facilities are difficult to obtain because these old type facilities are no longer manufactured.

The replacement and installation of the additional cubicles will greatly contribute to reliable power supply to the area and stable power operation in the Kathmandu Valley.

(5) Construction of new Kingsway feeder

Power demand in the Maharajgunj area was supplied by two (2) feeders, the Baluwater (11 kV overhead line) and Kingsway (11 kV underground) feeders, from the Maharajgunj switching station. This area involves embassies, hospitals, hotels, residences, commercial center, governmental offices, and public facilities, and is an important zone for daily life of people in Kathmandu city. Demand density in this area is so high as 1,000 to 4,000 kVA/km^2. An underground cable of the Kingsway feeder had a grounded fault very recently, but the cable is impossible to be restored because of superannuation of more than 20 years old. On the other hand, the switching facilities of more than 20 years old for the feeder at the Maharajgunj switching station remain not repaired due to unavailable spare parts.

Under the situation, the area is supplied power by only the Baluwater feeder for the switching station. The feeder is now loaded with 4,950 kVA against its distribution capacity, and operated at its critical capacity without allowance for increasing demand. Since only one feeder is operated and its supply area is wide, supply outages by line faults or line maintenance are once to cover all the consumers in the area.

To increase distribution capacity and enhancement of supply reliability to the area, construction of a new Kingsway feeder was proposed by NEA in related to the additional reinforcement and extension of the Maharajgunj switching station.

The purpose of the new Kingsway feeder is to bear a portion of load on the present Baluwater feeder. With the additional feeder, the Kingsway feeder is to bear 2,100 kVA of the present total demand in this area and 2,850 kVA to the existing Baluwater feeder. Those loads are respectively equivalent to 38% and 52% of the distribution capacity of 5,500 kVA, and accordingly both feeders have sufficient allowance for the future demand increase. Besides the reduction of load sharing of the feeder, area covered by a feeder is to be lessened for improvement of supply reliability.

Judging from those merits, the additional proposal is considered to be appropriate for the Project.

(6) *Additional tools for maintenance*

NEA additionally proposed tensioners, tension meters, and light trucks for the distribution line maintenance works. The Team had examined NEA's explanation on the reasons for the necessity of those items and the present conditions of the same with NEA's stock.

The Team judged that the present stocks of those items have been superannuated for the further use, and those items should be replaced with new goods for the proper maintenance. Accordingly, the Team recommends to provide the items under the Project.

(7) Procurement of spare parts

Some feeders have been operated without protection facilities for the system, such as lightning arresters for distribution transformers and 11 kV line facilities, dropout switches for distribution transformers, molded case circuit breakers for low-tension lines, and sectionalizing switches for 11 kV lines due to the lack of spare parts for repair and replacement of the damaged facilities.

In order to ensure the safe operation of the system and reliable power supply, spare parts for these facilities will be procured.

The components of the whole Project are summarized in Table-2 below, as an end result of the Study.

Table-2 Outline of the Project

Components requested by The Government of Napel		Phase-I	Phase-II	Total of Phase I & II
1. Reinforcement and improvement of 11kV feeders and low-tension lines				
11 kV Lines	113.83 km	60.75 km	62.68 km*1	123.43 km
400-230 V Lines	106.56 km	39.20 km	63.10 km	102.30 km
Transformers	25,925 kVA	8,050 kVA	17,900 kVA	25,950 kVA

*1 Including an additional request for the construction of a new feeder of Kingsway

	Components requested by The Government of Napel		Project Phase
2.	Augmentation of a 132/66 kV transformer at the Siuchatar substation		Phase-II
3.	Construction of a K3 substation		defered
4.	Procurement of tools, instruments, and vehicles for the O/M works	including an additional request for increasing the number of vehicles & tools	Phase-I & II
5.	Replacement of the 11 kV switching facilities at the Maharajgunj switching station	additional request	Phase-II
6.	Procurement of spare parts	additional request	Phase-II
7.	Construction of 11 kV underground cables between the Lainchaur substation and the K2 switching station		Phase-I
8.	Augmentation of Royal Palace, Old Patan, and Old Chabel 11 kV switching stations		Phase-I

4.2.5 Necessity of Technical Assistance

As previously stated, the network reinforcement projects were implemented under Japan's Grant Aid in the 1980s. The core members of the technical staff of NEA for O/M of the distribution system were trained by the engineers of the contractor through on-the-job training under these projects.

Under this Project, the NEA staff training for O/M will be conducted by the engineers of the contractor through on-the-job training as explained in Subsection 4.1.4. Therefore, experts will not need to be engaged for technical assistance.

4.2.6 Basic Consideration on Assistance for the Project

As mentioned in the preceding sections, the effect, viability, and capability for implementation of the Project have been confirmed. Likewise, the appropriateness of the implementation of the Project under Japan's Grant Aid has been confirmed, since the effect of the Project accords with the scheme of Japan's Grant Aid.

The basic design will be conducted by considering the outline of the Project and the assumption of Japan's Grant Aid. However, part of the project components requested by The Government of Napel should be modified as aforementioned.

4.3 Outline of the Project

4.3.1 Organization for Maintaining the Distribution Facilities

O/M of the distribution system in the country is managed under the responsibility of DCS of NEA. The distribution facilities to be extended and reinforced under the Project, therefore, are maintained by both the Kathmandu and Lalitpur / Bhaktapur divisional offices and their branch offices in the valley under the control of the Bagmati regional office of DCS.

The number of staff in these divisional and branch offices as of November 1993 is given below, and the staff list of DCS is given in Table 4.1:

Offices	Technical	Administrative	Total
1) Kathmandu Area			
a) Divisional office	8	7	15
b) KTM eastern branch office	68	58	126
c) KTM central branch office	199	181	380
d) KTM western branch office	138	101	239
2) Lalitpur-Bhaktapur Area			
a) Divisional office	4	14	18
b) Lalitpur branch office	182	136	318
c) Bhaktapur branch office	124	99	223

Note: Kavre/Sindhu/Dolakha branch offices, outside Kathmandu, are also under the management the of Lalitpur-Bhaktapur divisional office. But the Rasuwa/Nuwakot branch offices are directly under the Kathmandu divisional office.

4.3.2 Location and Conditions of the Project

The locations of the switching stations, substations and distribution lines in each plan are shown in Figure 4.1.

(1) Replacement of the cubicles of 11 kV switching stations

The existing Maharajgunj switching station is located in the northern part of Kathmandu, at the crossing point of the ring road and the Kingsway road passing through the center of Kathmandu.

The station covers a wide space and there is easy access from the ring road. The cubicles for replacement and those to be added will be installed in the existing building under the Project. The space in the existing building for installation of the new cubicles will be insufficient and it is to be expanded by NEA.

(2) Augmentation of a 132/66 kV transformer at the Siuchatar substation

The existing Siuchatar substation is located in the western part of Kathmandu, outside the ring road.

The substation covers a sufficient site for the project works and there is easy access from the ring road. The additional transformer and related switchgear equipment will be installed in the existing outdoor transformer bay and switchgear bay. The control facilities will be installed in the existing control room in the substation building.

(3) Extension and reinforcement of 11 kV feeders and low-tension lines

The 11 kV feeders and low-tension lines selected for the Project, except the lines in the city center, extend from the 11 kV ring main lines to the suburbs of Kathmandu. The land along the route of the lines is undulating plain.

4.3.3 Outline of the Facilities

From the results of the basic design survey, some modifications to the contents of the Project were requested by The Government of Napel and were explained in Subsections 4.2.3 and 4.2.4. An outline of each component of the Project which meets the scheme of Japan's Grant Aid is given below:

(1) Replacement of 11 kV cubicles

The major facilities for replacement of the 11 kV cubicles at the Maharajgunj switching station are summarized below:

(a)	11 kV Ring Main Feeder Cubicle	4 circuits
(b)	11 kV Feeder Cubicle	8 circuits
(c)	11 kV Bus Coupler Cubicle	1 circuit
(d)	St. Transformer Cubicle	1 circuit
(e)	DC Cubicle	1 circuit

(2) Augmentation of a 132/66 kV transformer at the Siuchatar substation

The major facilities for the addition of a 132/66 kV transformer at the Siuchatar substation are summarized below:

(a)	Single phase transformer, 132/66 kV, 12.6 MVA	3 units
(b)	132 kV transformer bay equipment	1 lot
(c)	66 kV transformer bay equipment	1 lot
(d)	Control equipment	1 lot

(3) 11 kV feeders and low-tension lines

The line length and major materials for each feeder to be reinforced are summarized below:

	Feeders	11 kV Feeder		Low-tension Line		Transformer	
		O/H Line	U/G Line	O/H Line	U/G Line	Nos.	(kVA)
(a)	Center of Kathmandu town	-	7.36	-	2.40	3	600
(b)	Extension of the Dhamasthali feeder	1.60	1.20	1.00	-	2	300
(c)	Baralgau-Gokameswar feeder	1.23	-	2.50	-	5	500
(d)	Connection of the Nayabazar and Budhanilakantha feeder	2.36	0.33	2.00	-	4	400
(e)	Renovation of the Nagarkot -Bramhakhel feeder	2.07	-	1.00	-	2	200
(f)	Kathmandu Central branch	4.81	3.36	4.00	2.40	11	2,200
(g)	Kathmandu eastern branch	13.41	8.81	26.00	-	51	8,000
(h)	Kathmandu western branch	1.71	-	10.00	-	20	2,500
(i)	Lalitpur branch	4.67	1.29	6.00	1.60	13	2,000
(j)	Bhaktapur branch	6.77	1.70	1.00	3.20	6	1,200
	Total	38.63	24.05	53.50	9.60	117	17,900

The materials and equipment required for the implementation of the above mentioned 11 kV feeders and low-tension lines are summarized below:

11 kV insulated conductors	114 km
11 kV aerial cable	3 km
11 kV underground cables	24 km
400 V insulated conductors	453 km
400 V underground cables	10 km
Poles for the 11 kV distribution lines	955 nos.

Poles for the low-tension lines	1,368 nos.
Distribution transformers	117 units (17,900 kVA)

(4) Procurement of maintenance tools and vehicles

(a) Tools:

(a-1)	Hydraulic compressor for conductor joints	2 sets
(a-2)	Snatch block : 100 mm dia.	15 nos.
(a-3)	Wire tensioner : 1.5 ton	5 nos.
(a-4)	Wire tensioner : 5 ton	2 nos.
(a-5)	Tension meter : 1 ton	5 sets
(a-6)	Tension meter : 5 ton	1 set
(a-7)	Aluminum pulley : 300 mm dia.	50 pcs
(a-8)	Aluminum pulley : 120 mm dia.	50 pcs

(b) Vehicles:

(b-1)	4 WD working truck with an insulated elevator bucket	3 nos.
(b-2)	3 ton pick-up truck	3 nos.
(b-3)	Light maintenance vehicle	3 nos.

(5) Procurement of spare parts

1) Sectionalizing switches	15 nos.
2) Drop out fuse switches for the primary circuit of the transformers	375 nos.
3) Lightning arresters	375 nos.
4) Molded case circuit breakers for the distribution boxes	625 nos.

4.4 Scope of Work

This Project is to be implemented through close cooperation between the Government of Japan and The Government of Napel within the framework of Japan's Grant Aid. It is reasonable for the Governments of the two counties to share the Project between them as follows:

(1) The work to be done by the Government of Japan

(a) Facilities

- To procure and erect the facilities for replacement of the 11 kV cubicles at the Maharajgunj switching station described in Subsection 4.3.3.(1).

- To procure and erect the facilities for addition of a 132/66 kV transformer at the Siuchatar substation described in Subsection 4.3.3.(2).

- To procure and erect the facilities for extension and reinforcement of 11 kV feeders and low-tension lines described in Subsection 4.3.3.(3).

(b) Equipment

- To procure the maintenance tools described in Subsection 4.3.3.(4).

- To procure the vehicles described in Subsection 4.3.3.(4).

- To procure the spare parts described in Subsection 4.3.3.(5).

(c) Others related to the above work

- To transport the facilities and equipment from Japan to Nepal.

- To transport the imported facilities, equipment, and materials from the port of disembarkation to the project site.

(2) The work to be done by The Government of Napel

(a) Site structure

- To secure the right of way for the overhead and underground distribution lines

- To clear level land and reclaim the site of the Maharajgunj switching station and Siuchatar substation

- To construct an access road to the sites of the distribution lines, switching station and substation

(b) Infrastructure

- To provide the facilities for city water distribution to the site

(c) Preparatory work

- To expand the building for the 11 kV switching station at Maharajgunj.

- To construct a multi-circuit switching house.

(d) Procedural work and expenses borne by the Nepalese side

- To request Indian authority for smooth clearance of the equipment and materials at the disembarkation port and for inland transportation in India.
- To obtain necessary permits for import into Nepal and bear the license fee for such permits.
- To get permission from the other authorities concerned for the construction work.
- Banking arrangement expenses.
- 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.
- To exempt Japanese nationals from custom duties, internal taxes, and other fiscal levies which may be imposed in the recipient country with respect to the supply of the products and services under the contract.
- To accord Japanese nationals, whose services may be required in connection with the supply of the products and services under the contract, such facilities as may be necessary for their entry into the recipient country and stay therein for the performance of their work.
- To construct service wire connection to the consumers.
- To coordinate with the inhabitants of the project areas on matters which may arise during the implementation of the Project.
- To carry out necessary power shutdown according to the construction schedule.
- To maintain and use properly and effectively the facilities constructed and equipment provided under the Grant.

(3) Expenses to be borne by The Government of Napel

- Expansion and construction cost of the building at Maharajgunj switching station and Mint multi-circuit switching house — NRs.3,000,000
- Banking arrangement fee — 0.1% of the amount set forth in the E/N

It will also be necessary to include the fees that cover the import duties, tax for the various subjects, and all other expenses for the implementation of the Project.

It is desirable that The Government of Napel provides enough 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 will be utilized effectively.

CAPTER 5

BASIC DESIGN

CHAPTER 5
BASIC DESIGN

5.1 Basic Concepts for Design

The basic concepts for the design of the power transmission/distribution system are; i) to ensure high reliability and safety, ii) to apply similar design to the existing facilities for easy O/M, iii) to build the system with flexibility for future expansion, and iv) to consider the technical level of NEA. The design will be formulated under the following criteria:

5.1.1 Natural Conditions for Design

The natural conditions, such as ambient temperature, wind velocity, humidity, rainfall, earthquakes, and thunderstorm activity in the project area are very important factors for the design of the facilities. The basic design criteria were worked out from historical climatic records for the eleven years from 1976 to 1986 and for 1992, and the present design standard of NEA.

5.1.2 Special Site Conditions for Erection

The site erection works for the project facilities will be carried out in accordance with the standards and/or practice of NEA. However, it was noted that in Nepal the finishing works, including the paving and asphalting of public roads and footpaths which are excavated and back-filled for the construction of the project facilities, shall be performed by the Road Department at the prevailing cost which will be borne by the contractor.

The prevailing costs of the finishing works of the roads and footpaths are as follows, but are subject to change at the time of construction of the Project:

Costs of the Finishing Works

Kind of pavement	NRs/m^2
Asphalt paved road	522.94
Concrete paved road	500.00
Stone laid road	168.44
Brick laid footpath	500.00

Note: effective to the end of June 1994

The contractor is requested to submit its construction plan with necessary illustrations and drawings, deposit money for the finishing works, and get permission for the erections from the Road Department prior to the commencement of the erection works.

5.1.3 Procurement of Local Materials and Equipment

All equipment and materials to be provided under the Project will be imported from Japan. However, raw materials, such as cement, aggregate, timber, brick, steel bars, etc. will be procured in Nepal.

5.1.4 Operation and Maintenance Capability of NEA

Through the past three Japanese grant aid projects implemented in the 1980s and the Project, Phase-1 in 1993 for the reinforcement and improvement of the power distribution system, the capability of NEA for O/M of the system has been proven. The training for management techniques of operation was conducted under the LRP.

For standardization of the line works, the draft of the safety regulation and construction engineering standards for the distribution line works at 400 V and 11 kV lines was completed by DCS of NEA in 1993, and are expected to be come effective in the near future. Besides, a computer and digitizer program for drawing up plans of the distribution lines has been provided to conduct easy and effective planning, operation, and maintenance of the power distribution system.

The management orientation training, seminar, and workshop for high and middle-level managers of NEA was arranged by the Human Resource Department in 1993. A similar skill orientation program was conducted for the supervisory level administrative and account staff. These programmes were conducted with the affiliation of the Nepal Administrative Staff College and financing from the World Bank. The NEA Training Center contributed its regular training programmes for the technical staff of NEA in meter reading, generation, distribution, and computer applications.

The transfer of technical knowledge to the core technical staff of NEA for O/M of the power distribution system was conducted by on-the-job training through the site erection works of the Project, Phase-I and their technical knowledge has been much improved. Moreover, their activities will be more developed through the site erection works of the Project, Phase-II.

5.1.5 Facilities for the Project

The facilities of the distribution lines, switching stations, and substations to be provided under the Project will be designed and chosen by avoiding the adoption of high technology and taking into account the easy O/M of the system, compatibility with the existing facilities, and present technical level of NEA. Besides, the maximum safety of the workers engaged in O/M and inhabitants shall be ensured.

5.1.6 Construction Schedule

The Project will be implemented in two stages as shown in Table 5.1, in accordance with the total work volume of the Project, the necessary period for the manufacturing of the equipment and materials, transportation via India, and erection.

In this Study, the necessary period for the manufacturing of each component is estimated below:

(1) Distribution line facilities

– Manufacturing of supports and fittings	2 to 4 months
– Manufacturing of conductors, cables and fittings	2 to 4 months
– Manufacturing of transformers and switches	3 to 5 months

(2) Substation and switching station facilities

– Manufacturing of outdoor switchgear equipment	3 to 5 months
– Manufacturing of indoor control panels and cubicles	2 to 4 months
– Manufacturing of 132/66 kV transformers	6 months
– Manufacturing of 11 kV feeder cubicles	3 to 5 months

(3) Transportation from Japan to the site via India — 2 months

5.2 Design Conditions

5.2.1 Climatic Conditions

There are two seasons i.e. the dry season (October to April) and rainy season (May to September).

The maximum air temperature and minimum air temperature recorded in the Kathmandu area were 32.3°C and -3.5°C, respectively. For safety, the same conditions that were applied to the Project, Phase-I in the Kathmandu Valley Distribution Network will be applied to the design of the Project. They are listed briefly as follows:

– Minimum ambient temperature	-5°C
– Maximum ambient temperature	40°C
– Average ambient temperature	20°C

–	Mean annual rainfall	1,420 mm
–	Relative humidity - Max.	85%
	- Min.	40%
–	Altitude	1,300 m

The maximum wind velocity applied to the Project is 25 m/s, since the highest wind velocity recorded at Kathmandu International Airport was 52 knots (equivalent to 26.75 m/s) and 25 m/s was applied to the past 3 projects and the Project, Phase-I without any trouble.

5.2.2 Design Criteria

(1) Design wind pressures on structures

The wind pressures worked out from the abovementioned wind velocity were applied to the projected area of each structure as follows:

(a)	Conductors and wires	: 35 kg/m^2
(b)	Lattice structures	: 130 kg/m^2
(c)	Tubular structures (poles, etc.)	: 31 kg/m^2
(d)	Insulators and hardware	: 55 kg/m^2
(e)	Equipment (transformers, etc.)	: 100 kg/m^2

(2) Sag computation

The sags of overhead conductors will be computed on the basis of the following assumptions.

(a) Maximum conductor temperature is 60°C taking into account temperature rise due to current flow.

(b) Minimum conductor temperature is 0°C. Although the minimum ambient temperature is minus 5°C, the likelihood of such a case, that is, maximum wind velocity at minimum air temperature, is very rare.

(c) Every Day Stress (EDS) is calculated under the ambient temperature of 20°C in still air.

(d) Minimum factor of safety of conductor stress at maximum wind pressure and 0°C is 2.5 and for EDS 4 against the ultimate tensile strength of conductors.

(e) The maximum sag of conductors is calculated under the conditions of maximum conductor temperature in still air.

(3) Minimum factors of safety

(a) Structures, tubular poles, and other kinds of supports under maximum working loads against their ultimate strength 2.5

(b) Conductors under the maximum working tension against their ultimate tensile strength 2.5

(c) Insulator sets under the maximum loading condition against their mechanical breaking strength.. 2.5

(d) Foundations of structures and supports under the simultaneous maximum loads against the ultimate ground bearing capacity and uplift resistance.. 2.5

(4) Required minimum clearances of distribution lines

The following minimum clearances from conductors will be applied:

(a) Lowest point of conductors above ground

	132 kV Line	66 kV Line	11 kV Line	L/T Line
Road crossing	-	-	6 m	6 m
Along the road	-	-	5 m	5 m
General train	7 m	6 m	5 m	4 m

(b) Space between 11 kV insulated conductor and LT insulated conductor .... 0.6 m
(c) Phase space of 11 kV insulated conductors .... 0.5 m
(d) Vertical space of 11 kV insulated conductors .... 0.6 m
(e) LT phase space of insulated conductors.................................. 0.2 m
(f) Space between 11 kV bare conductor and LT bare conductor .... 1.0 m
(g) Space between 11 kV bare conductor and LT insulated conductor.. 0.8 m
(h) Phase space of 11 kV bare conductors.................................. 0.8 m
(i) Vertical space of 11 kV bare conductors................................ 1.0 m
(j) Phase space of 11 kV cables .... 0.4 m
(k) Phase space of LT bare conductors .... 0.3 m

(5) Electrical requirement

In the design of the system and facilities to be formed under the Project, the following requirements will be taken into account:

(a) System connection:

- 132 kV : 3-phase, 3-wire, way-connected, neutral point of transformer is solidly grounded.

- 66 kV : 3-phase, 3-wire, way-connected system with effectively grounded neutral.

- 11 kV : 3-phase, 3-wire, way-connected system with effectively grounded neutral.

- 400/230 V : 3-phase, 4-wire, way-connected system with effectively grounded neutral.

- 110 V D.C. : Midpoint will be grounded through on earth fault detector.

(b) System frequency:

Rated frequency shall be 50 Hz.

(c) System parameter:

	132 kV	66 kV	11 kV
- Nominal system voltage (kV)	132	66	11
- Maximum system voltage (kV)	145	72	12
- Lighting impulse withstand voltage, 1.2 x 50 micro-sec (kV peak)	650	350	75
- Power frequency withstand voltage (kV r.m.s.)	550	300	90
- Nominal 3-phase symmetrical interrupting capacity (kA r.m.s.)	25	25	25

(6) Standards applied

The materials and equipment will be designed, manufactured, and tested in accordance with the requirements of the JIS, JEC, IEC, BS, or other international standards.

5.3 Basic Design

5.3.1 Extension and Reinforcement Plan

The extension and reinforcement plan of the Maharajgunj 11 kV switching station, Siuchatar substation, and distribution lines under the Project, Phase-II are as follows:

(1) 11 kV switching stations

The existing cubicles at the Maharajgunj switching station will be replaced and new cubicles will be added.

The existing cubicles for the two ring main line circuits and two feeder circuits are to be replaced with new cubicles: one station service transformer cubicle, one bus coupler cubicle, one battery and charger cubicle, eight 11 kV feeder cubicles including one spare cubicle, and four ring main cubicles. All these cubicles will be installed in the existing switching station.

Extension of the station building will be executed by NEA.

The connection diagram, cubicle layout plan, and routes of the feeder cables are given in Figures 5.1, 5.2, and 5.3.

(2) Augmentation of transformers at the Siuchatar substation

Three single phase transformers, 12.6 MVA, 132/66 kV with related facilities, such as 132 kV and 66 kV switchgear equipment and control facilities, will be installed at the existing Siuchatar substation. The additional transformers will have the same capacity and will be operated in parallel with the existing transformer.

The existing spare, single phase transformer, will be placed as the common spare for the existing and newly installed transformers.

The transformer augmentation plan is as follows:

(a) Three single phase transformers,

- three bushing current transformers on the primary side,
- three bushing current transformers on the secondary side, and
- one current transformer on the neutral terminal of the secondary circuit,

will be installed on the concrete foundation in the bay adjoining the existing transformer bay.

(b) A 132 kV switchgear bay equipped with,

- one circuit breaker,
- one disconnecting switch,
- three current transformers, and
- three lightning arresters,

will be installed in the existing outdoor 132 kV switchgear bay.

(c) A 66 kV switchgear bay equipped with,

- one circuit breaker,
- two disconnecting switches,
- one single phase potential device, and
- three lightning arresters,

will be installed in the existing outdoor 66 kV switchgear bay.

(d) Control and protection relay boards equipped with one lot of meters, control switches, lamps, and protection relays for the transformer will be installed in the existing control room. The control equipment will be provided with transducers for sending signals to the load dispatching center in the same way as the existing transformer circuit.

The concrete foundation and steel support works of the outdoor switchgear equipment, bus bar conductors, and grounding system will be included in the Project, Phase-II.

The single line connection diagram and outdoor switchyard layout plan are given in Figures 5.4, 5.5, and 5.6.

(3) 11 kV distribution lines

The following measures will be principally carried out for the reinforcement and improvement plans of 11 kV and low-tension lines:

- Feeders will be reinforced by such measures as upgrading their existing conductor size, diversion of load flow to other feeders, addition of new feeders, replacement of the existing distribution transformers, or addition of distribution transformers.

- In order to reduce the frequent trips of feeders, particular points of specific feeders will be altered from the existing bare overhead conductors to insulated conductors or underground cables. The insulated conductors will also ensure the safety of inhabitants in the densely populated areas and reduce energy pilferage.

- In the congested areas or narrow streets, the support of the one-shoulder conductor arrangement type or aerial bundle cable will be employed for saving necessary insulation distance to houses or other objects.

- New feeders or lines will be constructed with additional transformers to meet the growing demands of the newly developed industries or developing areas under the city plan for improvement of the present unreliable power supply.

Based on these principles, concrete plans for reinforcement and improvement of the feeder and low-tension lines will be established.

(a) Center of Kathmandu town

The central part of the town is densely crowded with buildings and houses not only along main roads but also in the interior areas. The branch roads from the main roads into the interior areas are so narrow that they are not accessible to vehicles and the 11 kV overhead lines are not aligned. A number of low voltage lines extend over long distances along mazes in the areas, with cables being hung on the walls of buildings and houses, accordingly. Such long low voltage lines without distribution transformers serve customers with power that experiences excessive voltage drops, such as 170 V to 180 V against the rated voltage of 230 V and also cause frequent failures of the power supply.

It seems that town reconstruction to improve such crowded areas is impossible under the present situation, therefore, the way to supply reliable and stable power to the customers in the congested areas is to extend the 11 kV system by underground cables from the existing 11 kV network. The overhead lines to be added in the narrow spaces should be of the aerial cable type. The underground cable lines plan is shown in Figure 5.7.

It is noted that the works to be carried out in such crowded areas are not easy because of the necessity of traffic interruption, excavation of narrow mazes in the densely populated areas, etc. Close cooperation and smooth communication with the local inhabitants are always required.

(b) Extension of the Dharmasthali feeder

The existing Balaju Industry District (BID) feeder is supplying power from the Balaju substation to not only BID but also to public consumers therein. The existing feeder should be upgraded with ACSR Dog for increasing the current capacity. Another new feeder will be required in this area before the District further expands on an industrial scale. However, upgrading and reinforcement of the feeder over 1 km will be implemented by NEA in cooperation and by negotiation with the District, since all electrical facilities on the premises are operated, maintained, and managed by the District which is fully responsible for them.

On the other hand, in order to increase the reliability of the power supply to BID, public consumers will be completely disconnected from the BID feeder so that the existing BID feeder will function exclusively for the industrial district. For this purpose, the interconnection to the Dharmasthali feeder will be disconnected from the BID feeder, and a new extension of the Dharmasthali feeder will be completed to connect with a branch line of the Swayambhu feeder, to supply power to the public consumers around BID.

(c) Baralgau-Gokarneswar feeder

New industries have developed along the road between Baralgau and Gokarneswar. The extension of lines from the existing branch lines to the industrialized area is difficult due to the topographic conditions.

The Division Office has proposed a new line from Baralgau town to Gokarneswar (3 km), branching the newly reinforced Boudha-Jorpati line planned along the road. The proposal seems reasonable.

The poles for the plan will be of the one-shoulder conductor arrangement type for the safety of the line and the public in the narrow spaces.

(d) Connection of the Nayabazar and Budhanilakantha feeders on the ring road

Areas on both sides of the ring road around Maharajgunj are being developed as residential and industrial zones. Power demand is rapidly growing due to the development.

The Nayabazar feeder from the Lainchaur substation and the Budhanilakantha feeder from the Maharajgunj switching station run around the areas. However, both feeders are not interconnected at present. The plan is to link both lines to increase the supply reliability and prevent excessive voltage drop anticipated to occur in the near future in the areas.

(e) Renovation of the Nagarkot-Bramhakhel feeder

A section, between Cangunariyan and Bramhakhel villages, of the Nagarkot feeder is at present unused because of such incomplete facilities as a one phase conductor. After completion of the new Bhaktapur substation under the PSEP of IDA, it is anticipated that the Nagarkot feeder will also supply power from the substation towards Boudha-Jorpati. Accordingly, the section will be restored under the Project with a single circuit of ACSR Dog on new supports over 2 km.

(f) Reinforcement and improvement of the other 11 kV feeders and low-tension lines under each DCS branch office.

The other 11 kV feeders and low-tension lines proposed by each DCS branch office will be reinforced and improved under the Project.

The materials and equipment required for the Project works of the distribution line are listed in Table 5.2.

(4) Maintenance tools and equipment

The following tools and vehicles will be procured under the Project, Phase-II, for proper O/M:

(a) Tools

(a-1)	Hydraulic compressor for conductor joints	2 sets
(a-2)	Snatch block, 100 mm dia.	15 sets
(a-3)	Wire tensioner, 1.5 ton	5 nos.
(a-4)	Wire tensioner, 5 ton	2 nos.
(a-5)	Tension meter, 1 ton	5 nos.
(a-6)	Tension meter, 5 ton	1 no.
(a-7)	Aluminum pulley, 300 mm dia.	50 pcs.
(a-8)	Aluminum pulley, 120 mm dia.	50 pcs.

(b) Vehicles

(b-1)	4 WD hoist truck with an insulated working bucket	3 nos.
(b-2)	3 ton pick-up truck	3 nos.

(b-3) Light maintenance vehicle 3 nos.

(5) Procurement of spare parts

For replacement and repair of the existing damaged line facilities, the following spare parts will be procured under the Project:

(a) Sectionalizing switches,
(b) Drop out fuse switches for the primary circuit of the transformers,
(c) Lightning arresters, and
(d) Molded case circuit breakers for the distribution boxes

5.3.2 Project Facilities

(1) 11 kV switching station

The new cubicles for the incoming lines, ring main circuits, feeder circuits, bus bar couplers, station service transformers, and batteries and battery chargers will be of the self-supporting indoor, metal enclosed type. Each 11 kV cubicle will be equipped with the devices shown below:

	Ring Main Line	Outgoing Feeder	Bus Coupler
1) Copper bus	1	1	1
2) Circuit breaker 12 kV, 25 kA	1,200 A	800 A	1200 A
3) Disconnecting switch 12 kV, 600 A	-	-	2
4) Current transformer single phase	3 x 1200/600 - 300/5	3 x 600 - 300/5	3 x 1200/5
5) Over current relays	3	3	3
6) Over current ground relay	1	1	-
7) Reclosing relays	-	1	-
8) Ammeter with selector switch	1	1	-
9) Watt meter	1	1	-
10) Watt hour meter	2	1	-
11) Var meter	1	1	-
12) Power factor meter	1	1	-
13) Feeder cables	1 lot	1 lot	

In addition to the above, the following devices will be provided on each bus bar and mounted in each cubicle:

- Three lightning arresters
- Three single phase potential transformers
- One under voltage relay

- One voltmeter with selector switch
- One frequency meter

The station service transformer cubicle will be equipped with the following devices:

- One draw-out type disconnecting fuse switch, 11 kV, 20 VAF, 6 AT
- Three single phase potential transformers
- Ten molded circuit breakers
- One station service transformer, 3-P 75 kVA, 11 kV/400-230 V
- Three current transformers, 100/5 A
- Three over current relays
- One under voltage relay
- One ammeter with selector switch
- One voltmeter with selector switch
- One lot of control switches

The batteries and battery chargers:

- One battery of 50 ampere-hours
- One battery charger
- Two DC ammeters with selector switch
- One DC voltmeter with selector switch
- One 3-pole molded circuit breaker 600 V, 100 AF
- Eight 2-pole molded circuit breakers 600 V, 100 AF
- One lot of control switches, lamps, and other necessary instruments and devices

Major equipment in the cubicles

An outline of the equipment to be mounted in the new cubicles is given below.

The 11 kV main bus will be rated at 2,000A of continuous current and 25 kA/one second of withstand current.

The circuit breaker will be of the indoor, draw-out vacuum type rated at 12 kV, 1200A for the ring main line circuits and 800A for the outgoing feeder lines, and 25 kA of interrupting current.

The station service transformer in the 11 kV cubicle together with the disconnecting power fuse switch on its primary side will be of the three phase, 11 kV/400-230V, 75 kVA, dry epoxy-resin molded, self-cooled type, as it has maintenance free operation and needs a high reliability against faults.

The 11 kV current transformers and potential transformers will be of the molded type.

AC power is to be supplied from the station service transformer. The station service transformer cubicles will be equipped with 600V molded case circuit breakers on the front panel.

Batteries for the DC power source will be of the high grade, Nickel-Cadmium alkaline enclosed seal, 110 volt, 50 ampere-hours type and contained in a cubicle with the battery charger of thyristor design for continuous use.

The control switches, meters, fault indicators, and protection relays, etc. will be mounted on the front panel of the cubicles.

(2) Augmentation of a transformer at the Siuchatar substation

As a result of system analysis, the estimated load on the existing 132/66 kV, 37.8 MVA transformer at the Siuchatar substation will exceed the rated transformer capacity in 1995/1996. In order to rectify the overloading of the transformer, an additional transformer with the same capacity is to be installed and operated in parallel with the existing one.

The features of the transformer augmentation plan are as follows:

(a) Three single phase transformers, 12.6 MVA, 132/66 kV, equipped with

Three bushing current transformers on the primary side, 200/5A, 40 VA
Three bushing current transformers on the secondary side, 400/5A, 40 VA, and
One current transformer on the neutral terminal of the secondary circuit, 100/5A, 40 VA

(b) 132 kV transformer bay equipped with:

One circuit breaker, 145 kV, 800A, 25 kA
One disconnecting switch, 145 kV, 800A, 25 kA
Three single phase current transformers, 200/5A, 40 VA and
Three lightning arresters, 120 kV, 10 kA

(c) 66 kV transformer bay equipped with

One circuit breaker, 72 kV, 600A, 20 kA
Two disconnecting switches, 72 kV, 600A

One single phase potential device, $\frac{66}{\sqrt{3}}$ kV/110V, and

Three lightning arresters, 75 kV, 10 kA

(d) Control and protection relay board equipped with

One lot of meters, control switches, lamps, and necessary accessories, and
One lot of protection relays for the transformer

Facilities

The following outline the main equipment to be installed at the Siuchatar substation:

(a) Transformer

The new transformer at the Siuchatar substation will be of the outdoor, single phase, 12.6 MVA, oil immersed, force-air cooled, 132/66 kV type, with on-load-tap-changers (132 kV, 10%). The transformer will be operative at 8.667 MVA output without operation of the cooling fans.

The connection of the windings is star-star with delta connected tertiary stabilizer windings. Busing current transformers will be provided on the primary and secondary sides and neutral of the secondary side.

(b) 132 kV switchgear equipment

The circuit breaker will be of the outdoor, SF6 gas filled type rated at 145 kV, 800A, and 25 kA of interrupting current. It will be provided with a control mechanism capable of both remote electrical and local manual operation, and will be driven by compressed oil.

The disconnecting switch will be of the three-pole, single throw gang-operated, remote controlled, mechanically hand operated, horizontal center break rotating insulator type.

Three sets of single phase current transformers, of the outdoor, oil filled, and hermetically sealed type will be provided for measurement.

The lightning arresters will be of the outdoor, explosion-proof, gapless, and heavy duty type designed for a rated discharge current of 10 kA.

(c) 66 kV switchgear equipment

The circuit breaker will be of the outdoor SF6 gas filled type rated at 72 kV, 600A, and 20 kA of interrupting current. It will be provided with a control mechanism capable of both remote electrical and local manual operation, and will be driven by compressed oil.

The disconnecting switch will be of the three-pole, single throw gang-operated, remote controlled, mechanically hand operated, horizontal break type rated at 72 kV, 600A.

One single phase voltage transformer rated at $\frac{66}{\sqrt{3}}$ kV/110V, 200 VA, of the outdoor, oil filled, and hermetically sealed type will be installed.

The lightning arresters will be of the outdoor, explosion-proof, gapless, and heavy duty type designed for a rated discharge current of 10 kA.

(d) Control boards

The control boards will be of a construction similar to the existing boards of the indoor duplex panel type, equipped with control switches, meters, fault indicators, etc. on the front panels and protection relays on the rear panels.

(3) Distribution line facilities

(a) Supports

The supports for the 11 kV and low-tension lines will be of the jointable steel tubular type and 11.2 m and 9 m long, taking into account the common use of the pole assembling materials and future expansion of the distribution system. The poles will be set with a sole plate, an under brace of steel made to increase the strength, and guy wires with steel anchors of the driven type, which will also be used wherever conductor tension is unbalanced, at dead ends and angle points. The general layout of the supports is given in Figures 5.8 to 5.14.

The supports for the distribution lines are classified as follows:

(i) Supports for the 11 kV one circuit line of triangular formation

Type 100A-1 Single pole to be applied at a straight line section and light angle point of up to 5 degrees, provided with pin type insulators.

Type 100B-1 Single pole to be applied at an angle point of up to 15 degrees, provided with pin type insulators and a guy wire assembly.

Type 100C-1 Single pole to be applied at an angle point of more than 15 degrees, provided with tension insulator sets and clamps on double cross arms, pin type insulators for jumper wires, and a guy wire assembly.

Type 100D-1 Single pole to be applied at line dead ends, provided with tension insulator sets on double cross arms and a guy wire assembly.

Type 100Br-1 Single pole to be applied at line branch points, provided with pin type insulators on single cross arms, tension insulator sets with clamps on double cross arms, jumper wires, and a guy wire assembly.

(ii) Supports for the 11 kV one circuit line of shoulder formation

Type 100A-E Single pole to be applied at a straight line section and light angle point of up to 5 degrees, provided with pin type insulators.

Type 100BC-E Single pole to be applied at a straight line section and light angle point of up to 5 degrees, provided with pin type insulators.

(iii) Supports for the 11 kV two circuit lines

Type 100A-2 Single pole to be applied at a straight line section and light angle point of up to 5 degrees, provided with pin type insulators.

Type 100BC0-2 Single pole to be applied at an angle point of more than 5 degrees, provided with tension insulator sets on double cross arms, pin type insulators for jumper wires, and two guy wire assemblies.

(iv) Supports for the low-tension lines

Type 95A-L	Single pole to be applied at a straight line section and light angle point of up to 5 degrees, provided with spool type insulators.
Type 95B-L	Single pole to be applied at an angle point of up to 15 degrees, provided with spool type insulators and a guy wire assembly.
Type 95C-L	Single pole to be applied at an angle point of more than 60 degrees, provided with spool type insulators and tension clamps, and guy wire assemblies.
Type 95D-L	Single pole to be applied at line dead ends, provided with spool type insulators and tension clamps, and a guy wire assembly.

(v) Supports for the transformers and line switches

Type 100S-1	Single pole to be applied for loading a line switch with three lightning arresters on two cross arms fixed to the pole type 100A-1, and a guy wire assembly.
Type 100T-1	Double poles to be applied for loading a distribution transformer with three cutout switches and three lightning arresters on the primary side and a distribution switch box on the secondary side, and two guy wire assemblies.

(b) Conductors and cables

The tripping frequency of the circuit breakers on the distribution lines due to short-circuit faults from line to line contact and earth faults from tree to line contact is very high. To reduce the frequent trips of feeders, insulation covered HAL conductors (OC) will be used for the 11 kV overhead line and 600 V fully insulated wire (OW) for the low-tension line.

In the densely populated and residencial areas, underground cable and/or aerial bundle cables for the 11 kV and low-tension lines will be considered for the Project.

(c) Insulators

The pin and disk type insulators of porcelain and glazed brown specified in the JIS standard are to be used for supporting the 11 kV line conductors and spool insulators for the low-tension line conductors. The conductors will be fixed to the insulators by preformed grips.

(d) Arms

The conductors of the 11 kV lines will be arranged in triangular formation on the top of the poles and will have a box type cross arm of 1.2 m long which will be fixed to the poles with a through bolt and arm ties. For the low-tension lines, the conductors will be arranged in vertical formation on the spool insulators and supported with secondary distribution racks. The secondary distribution racks will be fixed to the poles with steel bands.

(e) Distribution transformers

The distribution transformers will be of the outdoor, three-phase, oil immersed type with a voltage ratio of 11 kV/400-230V. The ratings of the distribution transformers will be classified into two different capacities of 100 kVA and 200 kVA.

(f) Fuse cut-out switches

For protection of the transformers from overloading, fuse cut-out switches will be installed on the primary side of the transformers. The cut-out switches will be of the 14.4 kV, 10A, drop out type. The cartridge fuses for the cut-out switches will be 25A and 12A for each transformer capacity.

(g) Lightning arresters

The lightning arrester will be of the 14 kV, 5 kA non-linear or gapless type and will be mounted on the end of the lines, primary side of the distribution transformers, secondary side of the line switches, and at the intersection of the underground cables and overhead lines.

(h) Line switches

The line switches will be 11 kV, 200A for the branch lines, 400A for the main line and of the three pole, manually gang operated, pole mounted, air break switch type. The line switches will be installed at the branch points of the main lines and on the long distance lines, to isolate the trouble line and section and/or a section of the line for maintenance works.

(i) Distribution switch boxes

Most of the existing low-tension feeders are directly connected to the distribution transformers without distribution switch boxes. Such connection causes unsafe O/M works of the lines and transformers. In order to increase the supply reliability and safe operation/ maintenance of the system, distribution switch boxes will be installed at the secondary side of the distribution transformers. The switch boxes will be of the molded case circuit breaker type (MCCB) with a specified trip current enclosed by a galvanized metal box.

(j) Grounding

The lightning arresters, cases of the line switches, transformer tanks, secondary neutrals, and other metal parts required for safe operation will be grounded by a grounding rod. A copper coated steel rod will be used for grounding.

5.4 Construction Plan

5.4.1 Construction Works

To maintain high reliability of the system operation, the following essential points have been taken into account for the construction of the facilities to be provided under the Project:

i) The distribution lines will be constructed and rehabilitated with insulated conductors/wires and/or aerial bundle cables for both the 11 kV and low-tension distribution lines. The erection method of these conductors/wires/ cables is much different from that for the bare conductors used on the existing lines. NEA has less experience in the erection of these conductors/ wires/cables.

ii) The underground cables for the works of the distribution lines, switching stations, and substations are to be laid by the optimum means to meet the specifics of the cable.

iii) Shorter power shutdowns and safety measures are demanded for the replacement works of the 11 kV cubicles at the Maharajgunj switching station and additional 132/66 kV transformer works at the Siuchatar substation.

In addition to the above, reliable local contractors for the construction of the power transmission/distribution system are not easily in Nepal and the daily maintenance, repair, and construction works are carried out by NEA. Therefore, all the construction works for the facilities under the Project will be executed exclusively by the local contractors under the guidance of the Japanese Contractor, except peculiar works, such as the commissioning test, joining of cable, termination of the cable head, installation of the 132/66 kV transformer and switchgear equipment, and other key works for the system which will be carried out by the Japanese specialists.

NEA is capable of implementing the Project, but does not possess sufficient numbers of engineers for planning, designing, and supervising the wide range of activities. These works will be undertaken by the Japanese Consultant.

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

(1) Works to be undertaken by the Consultant

(a) Home works

- To prepare the detail design of the switching stations, substations, and distribution lines.
- To prepare the tender documents for procurement and erection of the materials and equipment.
- To approve and comment on the design, specifications, and drawings provided by the Contractor(s).
- To attend the pre-shipment inspections and tests for the materials and equipment at the manufacturers' factories.
- To report and explain to JICA.

(b) Site works

- To prepare the working drawings of the facilities under the Project
- To adjust and check the construction schedule.
- To assist NEA in construction supervision.

- To approve the schedule of the commissioning tests submitted by the Contractor(s).

- To attend the commissioning tests.

- To prepare the monthly reports on the construction.

- To prepare the completion report of the Project.

(2) Works to be undertaken by the Contractor

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

As discussed with NEA, arrangement of the necessary permission of the concerned authorities for execution of the Project and dismantling and reconnecting of service wires to the consumers will be undertaken by NEA.

As explained in Subsection 5.1.2, for getting the permission of the Road Department, the Contractor is required to submit applications with work plans and to pay a deposit for the finishing work on excavated roads prior to the commencement of excavation and restoration of public roads as required under the Project.

(3) Works to be undertaken by the NEA

- To request Indian authority for smooth clearance of the equipment and materials at the disembarkation port and for inland transportation in India.

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

- To get the permission of the other authorities concerned for the construction works, when needed.

- To coordinate with the inhabitants in the Project area on matters that may arise during the implementation of the Project.

- To dismantle and reconnect service wires to the consumers.

- To make the necessary arrangements for power shutdown according to the construction schedule.

- To provide a stockyard for imported materials and equipment.

- 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.

5.4.2 Conditions for the Site Construction Works

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

(a) Since acquisition of private and arable lands for the Project is difficult, new lines will be constructed along the roads or on the existing lines routes.

(b) Power shall be shutdown during the execution of the works for the distribution lines, replacement of cubicles at the switching stations, and augmentation of a 132/66 kV transformer at the Siuchatar substation. The power supply shall be resumed toward evening and special attention shall be paid to the work schedule and pre-information to the customers for the shutdown.

(c) For construction of the underground cables, prior applications will be required to get the necessary permission from the Road Department. The finishing works, including paving and asphalting of roads, will be carried out by the Road Department itself at the expense of the Contractor.

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

5.4.3 Construction Supervision Plan

NEA normally forms an individual project team for execution of the projects to be implemented under the financial assistance of foreign countries. The DCS of NEA which assisted in the Master Plan, Basic Design Study of the Project, and execution of the Project, Phase-I will establish a project office for execution of this Project.

The project office will administer the design and construction supervision of the Project under the assistance of the Consultant. The works to be carried out by NEA, such as the dismantling and reconnecting of the service wires, dismantling work of the existing lines, and storage of the dismantled materials and equipment will also be managed by the project office. Besides, the project office will be responsible for the execution of the works mentioned in Subsection 5.4.1 (3) Works to be undertaken by NEA.

5.4.4 Procurement Plan of the Materials and Equipment

The supply and erection of the materials and equipment for the Project will be executed by the Japanese Contractor(s).

All the materials and equipment will be transported from Japan to Kathmandu by the following route:

Japan - transport by sea - India (Calcutta) - transport by land - Nepal (Kathmandu)

The customs procedures for the materials and equipment will be conducted at Bilgunj near the border of Nepal and India.

5.4.5 Implementation Schedule

The Project will be implemented in two stages and the components for each stage are given below:

Stage-I Project

(a) Replacement of the 11 kV cubicles at the Maharajgunj switching station

(b) Extension and reinforcement of the 11 kV feeders and low tension lines

(b-1)	11 kV overhead lines	18.7 km
(b-2)	11 kV underground cable lines	10.8 km
(b-3)	Low-tension overhead lines	30.0 km
(b-4)	Low-tension underground lines	- km

(c) Procurement of maintenance tools and vehicles

(d) Procurement of spare parts

Stage-II Project

(a) Augmentation of 132/66 kV transformer at the Siuchatar substation

(b) Extension and reinforcement of the 11 kV feeders and low tension lines

(b-1)	11 kV overhead lines	19.4 km
(b-2)	11 kV underground cable lines	12.5 km

(b-3) Low-tension overhead lines 23.5 km

(b-4) Low-tension underground lines 9.6 km

Facilities in each stage are selected in order of the priority in the system which is ranked on the basis of urgency of neccessity in consideration of superannuation of facilities or incapability of facilities to meet the growing power demand.

The following are the grounds for implementation of the facilities:

Stage-I Project

(1) The power requirement in the Maharajgunj area has rapidly grown beyond the forecast. The area is supplied with power through 2 x 11 kV feeders from the Maharajgunj switching station. To meet the growing demand in the area, expand the supply area, and reduce the voltage drop and energy loss in the central division, the number of feeders at the station should be increased from the present 2 to 8. Expansion of the supply area contributes to maintaining stable power supply in other areas in the division.

For this purpose, 8 new 11 kV cubicles will be installed at the Maharajgunj switching station, including 6 cubicles for new feeders and 2 cubicles for replacement of the existing old and incapable cubicles.

(2) 8 of 11 kV feeders, over about 4 km, will be used in relation to reinforcement of the upgraded Maharajgunj switching station.
7 of 11 kV lines, over about 14 km, will act as mainly trunk lines in the western and eastern divisions to supply new housing and heavy demand areas to urgently improve voltage regulation and upgrade the distribution capacity of the existing lines.

(3) A total of 11.5 km of low-tension lines will be used for extension to new customers and to upgrade the existing lines for the growing demand in relation to the above-mentioned 11 kV lines.

(4) The maintenance tools, vehicles, and spare parts will be used for the quick and efficient restoration of equipment at the stations and distribution lines. Those previously supplied under the Japan's grant aid projects have deteriorated and are running short. These are the most important items for O/M of the power system.

Stage-II Project

(1) To meet the growing demand in the valley, augmentation of the Siuchatar substation is required by the addition of 3 units of 132/66kV, 12.6 MVA transformers and related equipment. The substation is now receiving power from the Kulekhani No.2 hydropower station, and is programmed to be connected with the Marsyandi hydropower station. The 132 kV transmission facilities from the Marsyandi power station are to be provided under the PSEP.

Augmentation of the substation under this Project mentioned above will be implemented after the repair of the major roads from India and bridges on the roads which were seriously damaged by storms and flooding in July 1993, in similar time as completion of the 132 kV transmission line facilities.

(2) The 11 kV feeders and their related low-tension lines to be extended and reinforced in this stage are sublines tapped from the trunk feeders.

Table 5.1 Implementation Schedule

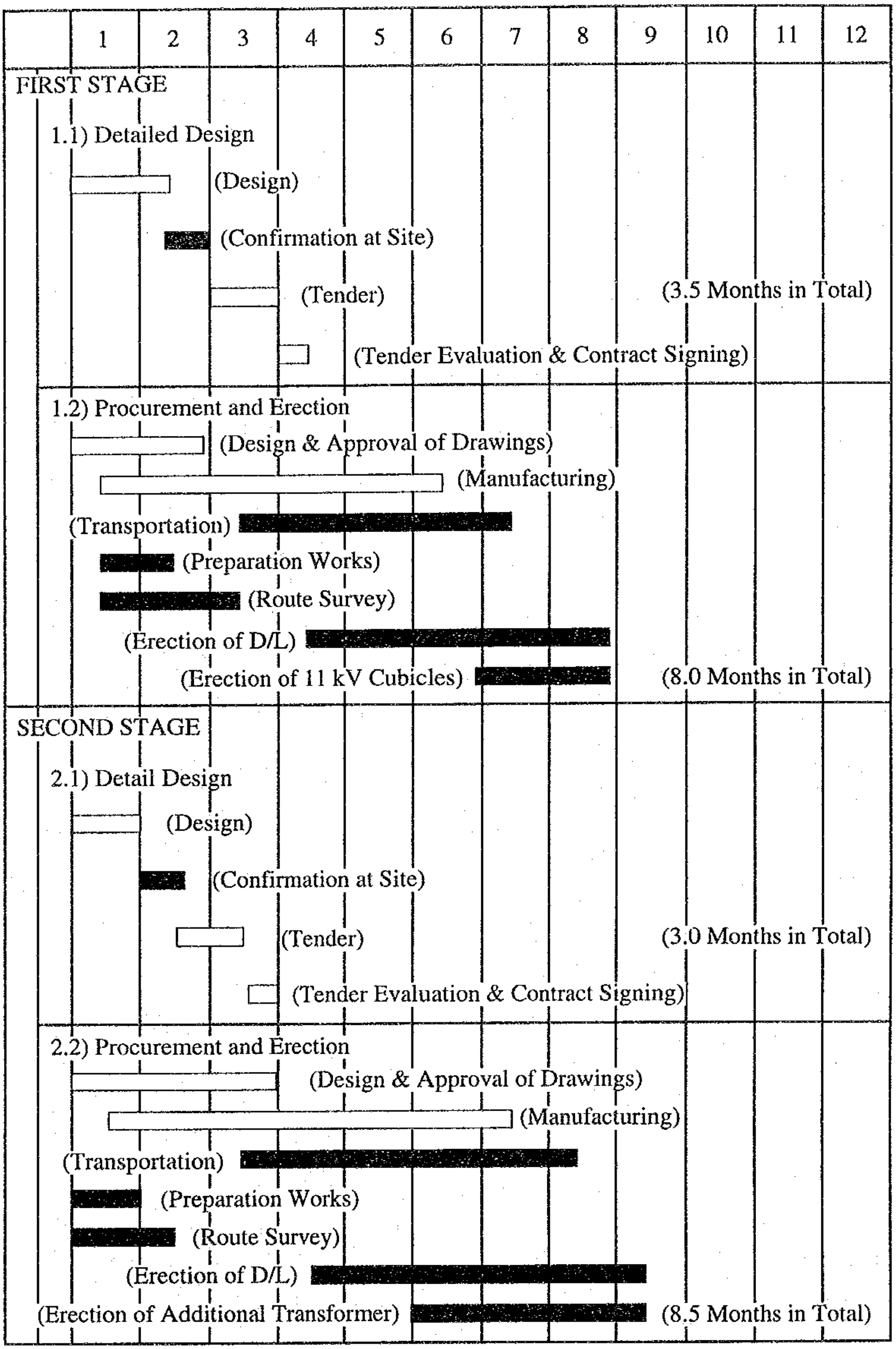


Table 5.2 Major Materials and Equipment to be Provided (1/2)
(First Stage)

Description			Unit	Quantity
A)	Distribution Facilities			
a)	Steel Poles for 11 kV Lines			
	a-1)	1CCCT Triangular Configuration	Sets	341
	a-2)	1CCCT Triangular Configuration for Transformers	Sets	60
	a-3)	1CCCT Triangular Configuration for Sectionalizers	Sets	0
	a-4)	1CCCT Vertical Configuration	Sets	0
	a-5)	2CCCT Horizontal Configuration	Sets	0
	a-6)	Aerial Cable Configurations	Sets	70
b)	Steel Poles for Low-Tension Line		Sets	720
c)	11 kV HAL Insulated Wires			
	c-1)	200 mm²	m	0
	c-2)	100 mm²	m	45,840
d)	600 V AL Insulated Wires			
	d-1)	95 sq.mm	m	134,250
	d-2)	55 sq.mm	m	44,750
	d-3)	30 sq.mm	m	44,750
e)	11 kV Aerial Cable			
	e-1)	11 kV CVT-SS 3x100 sq.mm (Cu)	m	2,920
f)	11 kV Power Cable			
	f-1)	11 kV CVT 3x240 sq.mm (Cu)	m	9,890
	f-2)	11 kV CVTAZV 3x240 sq.mm (Cu)	m	0
	f-3)	11 kV CVTAZV 3x240 sq.mm (Al)	m	0
	f-4)	11 kV CVTAZV 3x200 sq.mm (Al)	m	1,680
	f-5)	11 kV CVTAZV 3x100 sq.mm (Al)	m	0
g)	600 V Power Cable			
	g-1)	600 V CVQTAZV 200 sq.mm (Al)	m	0
	g-2)	600 V CVQTAZV 60 sq.mm (Al)	m	0
h)	Distribution Transformers with Cut-out Switch			
	h-1)	100 kVA (pole mounted type)	Sets	29
	h-2)	200 kVA (pole mounted type)	Sets	31
i)	11 kV Sectionalizers		Sets	28
j)	600 V Service Drop Wires			
	j-1)	DV 4C x 38 mm²	km	2.0
	j-2)	DV 2C x 25 mm²	km	7.7
	j-3)	DV 2C x 6 mm²	km	18.7
B)	11 kV Switching Station Facilities			
a)	Marajgunj Switching Station			
	a-1)	11 kV Ring Main Circuit	Circuits	4
	a-2)	11 kV Feeder Circuit	Circuits	8
	a-3)	11 kV Bus Coupler	Panel	1
	a-4)	Station Service Low Tension Panel	Panel	1
	a-5)	Battery and Charger	Set	1
b)	Baneswar Substation			
	b-1)	11 kV Feeder Circuit	Circuits	4
C)	Maintenance Tools and Vehicles			
a)	Maintenance Tools			
	a-1)	Hydraulic compressor for conductor joints	Sets	2
	a-2)	Snatch block: 100 mm dia.	Nos.	15
	a-3)	Wire tensioner: 1.5 ton	Nos.	5
	a-4)	Wire tensioner: 5 ton	Nos.	2
	a-5)	Tension meter: 1 ton	Sets	5
	a-6)	Tension meter: 5 ton	Set	1
	a-7)	Aluminum pulley: 300 mm dia.	Pcs.	50
	a-8)	Aluminum pulley: 120 mm dia.	Pcs.	50
b)	Vehicles			
	b-1)	4 WD working truck with on insulated elevator bucket	Nos.	3
	b-2)	3 ton pick up truck	Nos.	3
	b-3)	Light maintenance vehicle	Nos.	3
D)	Spare Parts			
	d-1)	Sectionalizing Switches	Nos.	15
	d-2)	Drop Out Fuse Switches on the primary circuit of transformers	Nos.	375
	d-3)	Lightning Arresters	Nos.	375
	d-4)	Molded Case Circuit Breakers for the distribution boxes	Nos.	625

Table 5.2 Major Materials and Equipment to be Provided (2/2)
(second Stage)

			Description	Unit	Quantity
A)	Distribution Facilities				
	a)	Steel Poles for 11 kV Lines			
		a-1)	1CCCT Triangular Configuration	Sets	429
		a-2)	1CCCT Triangular Configuration for Transformers	Sets	47
		a-3)	1CCCT Triangular Configuration for Sectionalizers	Sets	10
		a-4)	1CCCT Vertical Configuration	Sets	3
		a-5)	2CCCT Horizontal Configuration	Sets	0
		a-6)	Aerial Cable Configuration	Sets	0
	b)	Steel Poles for Low-Tension Lines		Sets	648
	c)	11 kV HAL Insulated Wires			
		c-1)	200 sq.mm	m	0
		c-2)	100 sq.mm	m	68,280
	d)	600 V AL Insulated Wires			
		d-1)	95 sq.mm	m	137,280
		d-2)	55 sq.mm	m	45,760
		d-3)	30 sq.mm	m	45,760
	e)	11 kV Aerial Cable			
		e-1)	11 kV CVT-SS 3x100 sq.mm (Cu)	m	0
	f)	11 kV Power Cable			
		f-1)	11 kV CVT 3x240 sq.mm (Cu)	m	o
		f-2)	11 kV CVTAZV 3x240 sq.mm (Cu)	m	1,540
		f-3)	11 kV CVTAZV 3x240 sq.mm (Al)	m	3,880
		f-4)	11 kV CVTAZV 3x200 sq.mm (Al)	m	1,550
		f-5)	11 kV CVTAZV 3x100 sq.mm (Al)	m	5,510
	g)	600 V Power Cable			
		g-1)	600 V CVQTAZV 200 sq.mm (Al)	m	4,800
		g-2)	600 V CVQTAZV 60 sq.mm (Al)	m	4,800
	h)	Distribution Transformers with Cut-out Switch			
		h-1)	100 kVA (pole mounted type)	Sets	26
		h-2)	200 kVA (pole mounted type)	Sets	20
		h-3)	200 KVA (cubicle type)	Sets	11
	i)	11 kV Sectionalizers		Sets	16
	j)	Multi-circuit switches		Sets	3
B)	11 kV Switching Station Facilities				
	a)	Thapathali Switching Station			
		a-1)	11 kV Feeder Circuit	Circuit	1
C)	Substation Facilities				
	a)	Single phase transformers, 12.6 MVA 132/66 kV		Units	3
	b)	132 kV transformer bay equipment			
		b-1)	Circuit breaker, 145 kV, 800A, 25 kA	Set	1
		b-2)	Disconnecting switch, 145 kV, 800 A	Set	1
		b-3)	Single phase current transformers, 200/5 A	Sets	3
		B-4)	Lightning arresters, 120 kV, 10 kA	Sets	3
	c)	66 kV transformer bay equipment			
		c-1)	Circuit breaker, 72 kV, 600A, 20 kA	Set	1
		c-2)	Disconnecting switch, 72 kV, 600 A	Sets	2
		c-3)	Single phase potenial transformers, 66/3kV/110V	Set	1
		c-4)	Lightning arresters, 75 kV, 10 kA	Sets	3
	d)	Control facilities		Lot	1