JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

NEPAL ELECTRICITY AUTHORITY
THE KINGDOM OF NEPAL

EXTENSION AND REINFORCEMENT OF POWER TRANSMISSION AND DISTRIBUTION SYSTEM IN KATHMANDU VALLEY

BASIC DESIGN REPORT

JULY 1992

NIPPON KOEI CO., LTD., TOKYO

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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 the Extension and Reinforcement of the Power Transmission and Distribution System in the Kathmandu Valley and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Nepal a study team headed by Mr. Toshikazu Nagashima, Director of Study Review and Coordination Division, Grant Aid Study and Design Department, JICA and constituted by members of Nippon Koei Co., Ltd. from February 2 to March 7, 1992.

The team held discussions with the officials concerned of His Majesty's of the Kingdom of Government of Nepal, and conducted field surveys at the study area. After the team returned to Japan, further studies were made. Then, the present report was prepared.

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 team.

July 1992

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

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 the Extension and Reinforcement of the Power Transmission and Distribution System in the Kathmandu Valley in the Kingdom of Nepal.

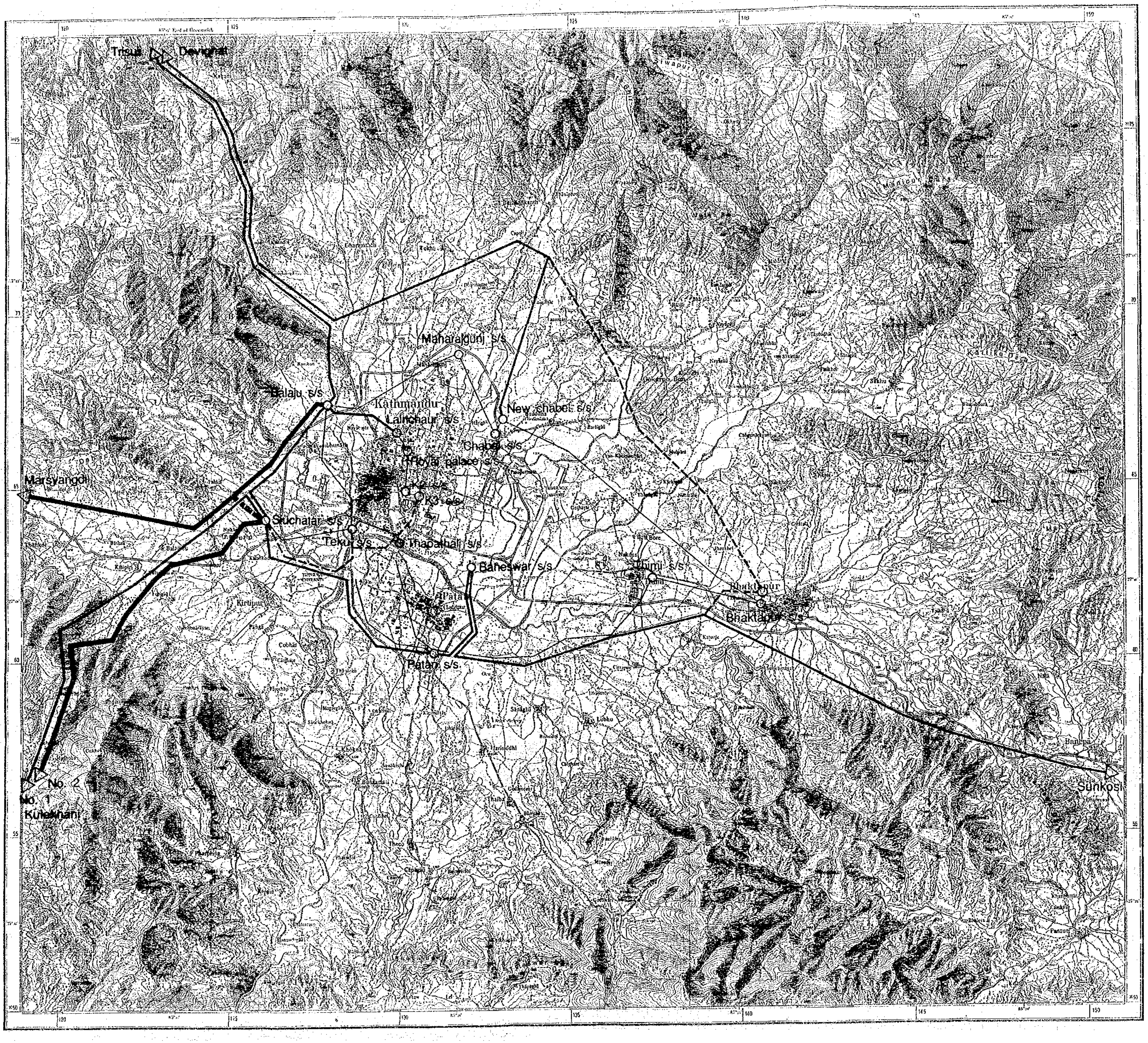
This study has been made by Nippon Koei Co., Ltd. dated from January 31 to July 15, 1992, in accordance with the Contract. Throughout the study, we have taken into full consideration the present situation in Nepal, and have planned the most appropriate project in the framework of Japan's grant aid.

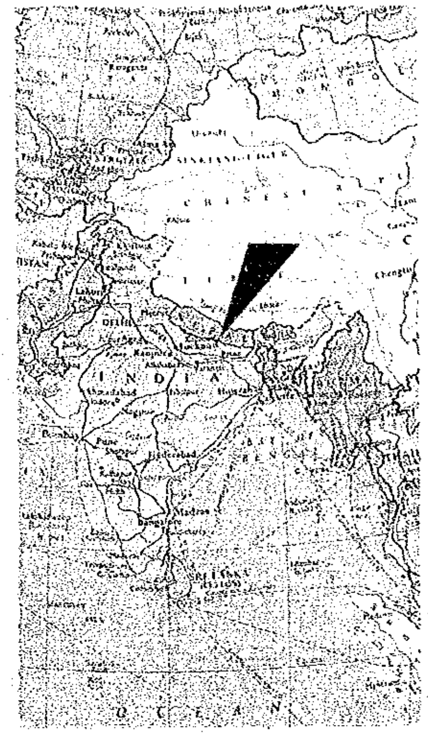
We wish to take this opportunity to express our sincere gratitude to the officials concerned of JICA, the Ministry of Foreign Affairs, the Ministry of International Trade and Industry, and the Nepalese Embassy in Tokyo. We also wish to express our deep gratitude to the officials concerned of the Ministry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

We hope that this report will be useful for the promotion of the Project.

Very truly yours,

Team Leader, Y. Miyagawa
Basic Design Study Team on
Extension and Reinforcement of
Power Transmission and Distribution
System in Kathmandu Valley
Nippon Koei Co., Ltd.
Tokyo, Japan





LEGEND

- 132KV LINE
- 66KV LINE
- 11KV LINE
- 132KV LINE (PLANNED BY 1995)
- 66KV LINE (PLANNED BY 1995)

SCALE

0 — 5km

KATHMANDU VALLEY

SUMMARY

SUMMARY

The Kingdom of Nepal is a landlocked country surrounded by Tibet on its north and by India on its 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 from the Nepal Electricity Authority (NEA) and the 1991 census show an electrification ratio of 9.1% for the entire nation and 68.5% for the area in the Kathmandu Valley. Demand rate for electricity will grow rapidly, because the electrification ratio is low compared with that of other developed countries and the potential for power demand is very high.

Electric power consumption in the Kathmandu Valley is about half that of the entire country and is deemed to increase. As a result of development and reinforcement of the transmission and distribution system under financial assistance from international organizations and foreign governments such as the Government of Japan (GOJ), power supply in the Valley has improved remarkably. The reliability and quality of the power supply have met the rapid demand increase in the area. However, some problems were observed recently such as over-loading, excessive voltage drop on the distribution system, deterioration of power supply reliability, etc., the cause of which was supposed to be from a power demand beyond expectations.

Upon a request of His Majesty's Government of Nepal (HMGN) to GOJ, The Japan International Cooperation Agency (JICA) conducted a master plan study on the reinforcement and improvement of the transmission and distribution systems in the Valley in 1990. A feasibility study was conducted subsequently in 1991 for the urgently required transmission and distribution facilities identified in the master plan, and as a result suggested that several projects should be improved by the end of fiscal year 1995/1996.

On the basis of the study results, HMGN requested grant aid from GOJ for extension and reinforcement of the power transmission and distribution systems in the Valley.

In response to the official request, GOJ decided to conduct a basic design study to examine the viability of the Project and dispatched to Nepal a basic design study team for 35 days from February 2 to March 7, 1992. The team surveyed the project area, collected relevant data and information for reviewing the basic design, and discussed technical aspects of the Project such as site conditions, survey of the switching station, route of the underground and distribution lines, maintenance plan by NEA, problems of the distribution system, etc., with the officials of the Nepal Electricity Authority (NEA) which is the executing agency of the Project.

It is judged from a result of the study that The completion of the Project is a great effective countermeasure for the current issues of excessive voltage drop and system loss, maintaining stable and reliable power supply, in the Kathmandu valley.

As a result of active discussion and examination with NEA, field survey and analysis in Japan, four items out of the requested seven items having high priority were selected for the subject of the basic study and are shown in Table-1 below.

Table-1 Outline of the Project

	Items Requested by HMGN	Scope in Basic Design Study
1.	Augmentation of three 11 kV switching stations	Selected
2.	Construction of 11 kV underground cable lines between the Lainchaur substation and the K2 switching station	Selected
3.	Reinforcement and improvement of the 11 kV main feeders	Selected
4.	Addition of 132/66 kV transformers to the Siuchatar substation	Not selected
5.	Construction of the new K3 substation	Not selected
6.	Reinforcement and improvement of the 11 kV feeders including a low tension line	Not selected
7.	Tools, instruments and vehicles for operation and maintenance of the distribution system	Partially selected

The following points were modified from the original scheme:

(1) Scope of works

As a result of discussions with NEA, items 4, 5, and 6 in Table-1 above are eliminated from the scope of works as they are not urgently required and are deeply related to the reinforcement project financed by the International Development Association (IDA).

(2) Location change of the Royal Palace switching station

Since the Royal Palace switching station is an important station for stable power supply to the downtown area, all accidents should be avoided, especially, in this station. Moreover, power supply outage during replacement of facilities will disturb events in the palace, as this is the only station to supply power to the palace. A switching station was planned to be constructed near the existing station, according to the proposal of

NEA and its detailed review. The new station, which will be constructed by NEA with its own funds, is of great advantage as the outage of power supply to the palace will be minimized during erection.

(3) Replacement of transformer and low tension cubicle of the Royal Palace switching station

Two transformers (1,000 kVA) and one complete set of low tension cubicle in the Royal Palace switching station should be renewed, since these facilities are so overaged that an accident in the facilities may affect the entire distribution system in the Kathmandu area.

(4) Installation of underground cable between Lainchaur and K2

Double circuit underground cable is more advantageous than single circuit for the following three reasons: First, reliability of power supply to the downtown area will improve significantly. Second, a double circuit of 240 mm^2, 3 cores, 2 cables is able to be constructed with small additional cost, compared with a single circuit of 325 mm^2, single core, 4 cables recommended in the feasibility study. Finally, to install one more circuit in the future in addition to the original single circuit is not only costly but also difficult to control traffic when installing the additional circuit.

As a result of the study on the cable route, the cable route has been modified from the original Kanti Path street route to Darbar Marga street route via the Royal Palace. This minimizes the effect on the traffic during installation of the underground cables and the trees which line both sides of the street.

(5) Insulated cable

The line conductor is modified from the original ACSR bare conductors to insulated HAL wires in order to prevent faults from earth and/or short circuit.

Tripping frequency of the circuit breakers in the feeders in the Kathmandu Valley records 29 times per feeder per year in average, which hinders reliable power supply to the Kathmandu Valley. The tripping of circuit breakers is mostly caused by short circuit faults due to line-to-line touch or earth fault due to line-to-earth touch, usually trees. However, recent environmental protection policy makes it difficult to get permission from the concerned authority to trim such trees. The adoption of insulated wires is, hence, not only a proper measure to reduce maintenance costs of trimming trees but also a safe way to reduce the tripping frequency of circuit breakers.

Judging from the amount of works and construction period of the facilities, a two stage construction is recommended for the project in consideration of the construction period for seven and half months for the Stage-1 and eight months for the Stage-2 as shown in Table-2 below.

Table-2

Construction Stage		Facilities
Stage-1	a)	Construction of the 11 kV underground cable lines between the Lainchaur substation and the K2 switching station
	b)	11 kV main feeders *1
	c)	Tools, instruments and vehicles for operation and maintenance of the distribution system
Stage-2	a)	Augmentation of three 11 kV switching stations
	b)	Remaining 11 kV distribution feeders

Remark: *1 - includes Sundarijal, Boudha-Jorpati, Thankot, Baneswar, Nagarkot lines and a part of the lines in the central area

If the Project is implemented under grant aid from GOJ, it is recommended that Japan undertake preparation of tender documents, evaluation of tenders, procurement of equipment and materials, erection of facilities and construction supervision of the entire works, while HMGN assist the project implementation politically and legislatively by getting all the necessary permission, negotiating with residents, and all other works necessary to perform the Project.

HMGN has tried to supply electric power to as many people as possible by developing distribution lines in the country. Developing industries, upgrading livelihood and the high electrification ratio of 68.5% in the Valley are the results of such good effort from HMGN and NEA. However, the latest power demand is still at a very high level.

Although population of the Valley in 1991 was approximately 1.1 million, which was about 6% of the total population in Nepal, 47% of electric energy was consumed in this area. Therefore, the extension and reinforcement of the distribution system in the Kathmandu area will have a large effect on the 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 the tourism industry, stabilizing the political and economic conditions in the country, etc. The experienced staff of NEA, developed during the previous three transmission and distribution line projects in the 1980s, and its financial capacity will be a great help in making the Project successful.

BASIC DESIGN REPORT

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CHAPTER 1

INTRODUCTION

CHAPTER 1
INTRODUCTION

The Kingdom of Nepal is a land-locked country surrounded by Tibet on its north and by India on its east, west and south. The area of the country is about 147,200 km^2 and the population, according to the 1991 census, is about 18,462,000. The electrification ratio of the entire country, based on the 1991 census and the Nepal Electricity Authority (NEA)'s statistic data, is 9.1% and 68.5% in the Kathmandu Valley. Demand is expected to grow at a higher rate in the future, since the electrification ratio is still low and there is a large potential for power demand.

Electric power supply in the Valley was established in 1911 from the Pharping small hydropower station. Although the power supply system had been expanded by construction of new power stations and power transmission and distribution facilities, power supply in the Valley 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 Association (IDA) and foreign countries like India, Japan and German. Besides the hydropower developments, reinforcement of the transmission and distribution system was also conducted under three grant aid projects from the Government of Japan (GOJ) in the 1980s. As a result of such development and reinforcement of the system, power supply in the Valley has improved remarkably and become more reliable and stable. This has met the rapid demand increase in the area. The power supply system in the Valley, however, will face some problems soon like over-loading, 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 that forecasted in the past.

The GOJ conducted, upon a request of His Majesty's Government of Nepal (HMGN), a Master Plan Study on the reinforcement and improvement of the transmission and distribution system in the Valley in 1990 and a Feasibility Study for the urgently required transmission and distribution facilities identified in the Master Plan.

On the basis of the study results, HMGN requested Grant Aid from GOJ for extension and reinforcement of the power transmission and distribution system in the Valley (the Project).

In response to the official request, GOJ decided to conduct a Basic Design Study to examine the viability of the Project. The Japan International Cooperation Agency (JICA) dispatched a

Basic Design Study Team to Nepal headed by Mr. T. Nagashima, JICA, for 35 days from February 2 to March 7, 1992. 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 which is the executing agency of the Project.

A list of the survey team members, survey schedule, concerned parties 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 at the site investigation and technical requirements of the Project.

CHAPTER 2

BACKGROUND OF THE PROJECT

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2.1 Background of the Project

2.1.1 Outline of Power Sector

(1) General

The power generating facilities in the country consist of hydro, diesel and solar power plants but it is basically a hydro dominant system. Total installed capacity of power generating facilities was 293.3 MW, of which 81% (238.2 MW) was generated by hydropower. Solar power plants having a capacity of 130 kW (3 sites) are located in remote mountainous area. Most of the diesel power plants are not in operation due to lack of spare parts, and only six power plants, including the Morang multi-fuel power station which was completed in 1991, are presently operable (36.4 MW).

In addition to the above existing power generating facilities, small and mini-hydropower plants having installed capacity of 14.4 MW in total are under construction. The details of existing facilities and facilities under construction are given in Table 2.1.

In order to deliver the power generated at those power stations to the demands, power transmission and distribution systems are operated, as seen in Figure 2.1.

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

The 132 kV power transmission system has been extended to cover the major load centers over 1,000 circuit km in the country, with financial assistance of foreign countries.

Historical records of generation, peak demand, sold energy and line losses in the interconnected system over the last 10 years are summarized below.

Year	Generation (GWh)	Peak Demand (MW)		Sold Energy (GWh)	Losses (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	114.4	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
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 India
(2) Sold energy includes exports to India
(3) Losses = (Generation - Sold Energy)/(Generation)

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

Demand Forecast of 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	55.7	15.6
Total	250.1	84.1	436.4	132.5	718.3	211.5

2.1.2 Development Schemes

In order to reinforce and improve the existing power system in the country, several development schemes as undermentioned are in progress or under planning at present.

(1) Generating Plants

For development of power generating projects, only the Jhimruk hydropower project having an installed capacity of 12 MW and a few small hydropower plants are under construction. The time schedule for further development projects such as Arun-3 (402 MW), Kali Gandaki-A (90 MW), etc. has not been fixed yet. However, recently there is a new proposal to reduce the installed capacity of the Arun-3 project to 201 MW.

(2) Sub-transmission and distribution lines in the Terai Plain

Under the Asian Development Bank (ADB)'s finance, the Sixth and Seventh projects which are for extension and reinforcement of the sub-transmission (33 kV) and distribution system are presently under way in the Terai Plain.

(3) Power sector efficiency project (PSEP)

As a result of Power Sector Review conducted with the assistance of consultants under the Third Technical Project of IDA (Cr.1902-NEP), the Power Sector Efficiency Project (PSEP) was formulated to address power rehabilitation investment needs and NEA's institutional development as well as to support actions in energy conservation and assist in the implementation of the Marsyangdi Catchment Management Pilot Project (MCMPP).

One of major components of PSEP is the "HV Transmission/Substation Reinforcement Project in the Kathmandu Valley". The project consists of (i) augmentation of transformer capacity, (ii) construction of two 66/11 kV substations, (iii) construction of transmission lines, and (iv) supply of equipment, spare parts, and tools.

(4) Loss reduction program

Annual system losses of the power system averaged around 30% of gross generation. Such high system losses have been a critical factor affecting NEA's operational and financial performance. Technical and non-technical losses are caused primarily by improperly and inadequately planned distribution systems such as overloaded transformers, overextended lines, underrated lines, poor service connections, poor power factors, etc., while improper billing, illegal connections and incorrect metering are the primary causes of the non-technical losses.

Under such circumstances, IDA provided finance for the System Loss Study in 1986 (Phase I) and for loss reduction in the Kathmandu Valley (Phase II) in 1989. Phase III program would continue Phase II works in the Kathmandu Valley and extend the successful elements to the rest of the country financed by the remainder of the loan from the Marsyangdi Hydroelectric Power Project.

2.1.3 Necessity of the Project

In addition to some major hydropower plants like Devighat, Kulekhani I, Kulekhani II and Marsyangdi have been constructed in the 1980s from financial assistance received from India, Japan and IDA, the reinforcement of the power transmission and distribution system in the Kathmandu Valley was also implemented under three Grant Aids from GOJ, aiming at satisfactory operation of the system in the year 1990.

Through such system reinforcement and power development, power supply in the Valley has improved remarkably and become more reliable and stable. However, this system will face over-loading, excessive voltage drops and deterioration of reliability soon, since the system demand is growing at a higher rate than that forecasted in the past.

In fact, such issues as over-loading on transformers, excessive voltage drop of sub-transmission and distribution lines, remarkable decrease of supply reliability, etc. have occurred in the system.

In order to examine the issues inhering in the Valley's power system, the Master Plan and Feasibility Study on extension and reinforcement of power transmission and the distribution system in the Valley were conducted by JICA in 1990 and 1991.

The study recommended to implement (a) addition and replacement of 11 kV cubicles, (b) addition of new 11 kV underground cable line, (c) reinforcement and improvement of 11 kV main lines, (d) addition of 132/66 kV transformer, (e) construction of a new 66 kV substation, (f) reinforcement and improvement of 11 kV distribution lines and low tension lines, and (g) supply of maintenance materials and tools.

The immediate benefit from the completion of the Project will be stable and reliable power supply which is expected not only to improve the functioning of the capital, Kathmandu, but also upgrade the standard of living in the Kathmandu Valley and increase the production of industry including cottage industries. Kathmandu is the center at the Nepalese Society whether it be politics, administration, economics, finance or culture.

It is also expected to decrease the expenditure of HMGN by reducing electric energy loss and to conserve forest resources by the effective use of electric energy.

2.1.4 Executing Agency

The executing agency of the Project is Nepal Electricity Authority (NEA), administratively organized under the Ministry of Water Resources (MWR). 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. NEA's board presently consists of 10 members, the Minister of Water Resources is the chairman. NEA has six (6) directorates, Finance and Personnel Administration, Planning, Engineering, Construction, Operation/Maintenance and Distribution/Consumer Service, as seen in Figure 2.2.

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

In order to take the necessary measures for a smooth implementation of the Project, a separate "Project Office" will be established under the directorate .

2.2 Outline of the Request

In order to reinforce and improve the deteriorating transmission and distribution system in the Kathmandu Valley, HMGN requested GOJ to implement the following facilities:

- (a) Augmentation of three 11 kV switching stations
- (b) Construction of 11 kV underground cable lines between the Lainchaur substation and the K2 switching station (1.9 km)
- (c) Reinforcement and improvement of 11 kV main feeders (about 45 km)
- (d) Addition of 132/66 kV transformers to the Siuchatar substation (3 x 12.6 MVA single phase transformers)
- (e) Construction of a new K3 substation (66/11 kV, 2 x 18 MVA)
- (f) Reinforcement and improvement of the 11 kV feeders including a low tension line (11 kV: 40 km, LV: 150 km)
- (g) Tools, instruments and vehicles for operation and maintenance of the distribution system

It is, however, noted that after discussion between NEA and the Study Team, items (a), (b), (c), and (g) were finally retained, as discussed in Chapter 5 hereinafter.

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 contractor's drawings
- Factory inspection before shipment
- Assist NEA in managing implementation of the Project
- Construction supervision
- Other supervisory work for implementing the Project

2.3 Outline of The Project Area

2.3.1 General

Kathmandu is the capital of Nepal and the biggest city in the country. It has prospered as the center for politics, administration, economics, finance, culture, etc. since the medieval times. The area of the Kathmandu Valley is 899 km^2 and its population in 1991 was about 1.1 million which is 6% of total population in Nepal. The Valley is administratively divided into three areas, Kathmandu, Lalitpur, and Bhaktapur.

The urban areas of Kathmandu and Lalitpur districts are surrounded by an asphalt-paved high-way called the "Ring Road". Inside the Ring Road, most of roads are rather narrow but paved with asphalt. Outside the Ring Roads, roads except for trunk roads, are gravel.

Overseas telephone communication and facsimile services in Kathmandu have direct dialing access. A water supply service system in the town areas of Kathmandu, Lalitpur and Bhaktapur has been in operation since the Ranas dynasty and improvements to the water supply system have been completed successfully. In rural areas, some hamlets have some small-scale water supply systems.

2.3.2 Power Network in the Kathmandu Valley

(1) Power supply to the Kathmandu Valley

Power is supplied to the Kathmandu Valley from the Marsyangdi and Kulekhani power stations through 132 kV transmission lines and from the Kulekhani I, Trisuli, Devighat, and Sunkosi power stations through 66 kV transmission lines. Power delivered through 132 kV transmission lines is stepped down to 66 kV at the

Siuchatar and Balaju substations, and from there delivered to distribution substations in the town by 66 kV transmission lines.

There are six (6) 66/11 kV distribution substations having a transformer capacity of 148.9 MVA in total. The Lainchaur and Balaju substations are provided with the latest Gas Insulated Switchgears (GIS), while the other substations have conventional outdoor switchgears. The Sunkosi feeder from New Patan substation has a very old-fashioned switchgear.

(2) Distribution Facilities

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

Ring Main System and Switching Stations

The so-called Ring Main has served reliable power to the Kathmandu city center area since the 1960s. The Ring Main system consists of 11 kV double circuits of Aluminium Conductor Steel Reinforced (ACSR) 200 sq.mm lines and several switching stations. From those switching stations on the Ring Main and distribution substations, 11 kV primary distribution lines are extended for power supply to consumers on low voltage lines through 11 kV/400-230V pole-mounted transformers. The power supply system in the Kathmandu Valley involving the Ring Main and switching stations are illustrated in Figure 2.3, and details of the 11 kV Ring Main lines as well as 11 kV switchgear installed in the substations and switching station are summarized in Table 2.2 and 2.3.

11 kV Distribution Lines and Distribution Transformers

In order to supply electric power to the customers in the Kathmandu Valley, 11 kV distribution lines having 58 feeders and 590 km in total are extended.

Distribution transformers (11 kV/400-230V) installed in the Valley as of 1991 totaled 1,481 units and 224 MVA in capacity. Unit capacity of the transformers ranged from 5 kVA to 1,000 kVA and the majority are 250 kVA in urban areas, 100 kVA in city areas and 50 kVA in rural areas. Principally, all the larger transformers are three-phase type. The smaller size single-phase transformers are used for light loads in remote areas.

Low-tension Distribution Network

The low-tension distribution network connected to the low-tension side of the distribution transformers supplies electricity to low-tension consumers through a 400/230V, three-phase, four-wire system. Low tension lines are radial feeder type and most of them are overhead lines. In city areas, most of the distribution lines are commonly used for wires for street lighting.

ACSR conductors of various sizes are used for the trunk lines. Insulated wires and aerial cables are also applied on pole supports and/or on the walls of buildings in some areas of the city center which are densely populated and congested with houses and buildings with narrow roads.

2.3.3 Power Demand in the Kathmandu Valley

Number of customers and electric energy sold in 1990/91 by area and demand sector are given below:

Customers and Sold Energy in Kathmandu Valley

	Nepal	Kathmandu				
		Kathmandu	Lalitpur	Bhaktapur	Total	
Number of Customers						
- Residential	304,941	87,972	30,603	20,572	139,147	(46%)
- Commercial & Non-Commercial	7,570	762	269	147	1,178	(16%)
- Industrial	8,324	1,586	521	406	2,513	(30%)
- Others	1,466	100	15	16	131	(9%)
Total	322,301	90,420	31,408	21,141	142,969	(44%)
Sold Energy (MWh)						
- Residential	261,399	121,495	27,517	8,884	157,897	(60%)
- Commercial & Non-Commercial	82,870	44,899	7,169	1,856	53,925	(65%)
- Industrial	206,881	31,278	11,882	4,444	47,604	(23%)
- Others	37,611	12,229	590	1,797	14,613	(39%)
Total	588,761	209,901	47,158	16,981	274,039	(47%)

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

Electrification ratios as of June 1991 were as below:

<u>Electrification Ratio</u>

	Household	Customer	E.R (%)
Nepal	3,345,052	304,941	9.1
Kathmandu Valley	203,142	139,147	68.5
a) Kathmandu	129,083	87,972	68.2
b) Lalitpur	45,997	30,603	66.5
c) Bhaktapur	28,062	20,572	73.3

KTM-BD-153E

Table 2.1 Existing Generating Equipment

(As of end/1991)

Power Plant	Unit Nos.	Unit Capacity (kW)	Installed Capacity (kW)	Available output (kW)	Date in Services	Region	Remarks
A. Major Hydro Plants							
a.1) Existing Plants							
1. Trisuli	7	3,000	21,000	18,000	1962/70	Central	6-unit only operable
2. Sunkosi	3	3,350	10,050	5,800	1973	Central	
3. Gandak	3	5,000	15,000	9,400	1979	Western	
4. Kulekhani No.1	2	30,000	60,000	60,000	1982	Central	
5. Devighat	3	4,700	14,100	14,100	1984	Central	Tandem with Trisuli
6. Kulekhani No.2	2	16,000	32,000	32,000	1986	Central	Tandem with Kl-1
7. Marsyangdi	3	23,000	69,000	63,000	1990	Western	
8. Andhi Khola	2	2,550	5,100	5,000	91/06/02	Western	
Total	23		226,250	207,300			
a.2) Under Construction							
1. Jhmruk Piuthan	3	4,000	12,000		(1994)	Western	
B. Integrated Small Hydro Plants							
b.1) Existing Plants							
1. Panauti	3	800	2,400		63/64	Central	
2. Sundarijal	2	300	600			Central	
3. Phewa(Pokhara)	4	272	1,088		66/69	Western	
4. Seti	3	500	1,500		1985	Western	
5. Butwal(Tinau)	2	470	940		1974	Western	
	1	345	345				
Total	15		6,873				
C. Isolated Small Hydro Plants							
c.1) Existing	53		5,416				31stations
c.2) Under Construction	11		2,650				5 stations
D. Diesel Plants							
1. Hetauda	-		14,450	10,000		Central	
2. Morang(B.nagar)	4	6,500	26,000	26,000	1991	Eastern	
3. Others	-		14,213	440			
	4		54,663	36,440			
E. Solar Power Plants			130				3 sites

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

Sources : NEA's information and 1990/91Annual Report

KTM-BD-151E Table 2.2 Existing 11kV Ring Main System

No.	11kV Line		Circuit	Voltage	Length	Conductor
	(From)	(To)		(kV)	(km)	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	New 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	Royal Palace	SC(UGC)	11	1.0	240 sq. mm
9	K-2	Lainchaur	SC(UGC)	11	1.7	240 sq. mm
10	Lainchaur	Royal Palace	SC(UGC)	11	0.7	240 sq. mm
11	Maharajgunj	Old Chabel	SC	11	2.7	0.2 sq. in
12	Old Chabel	New Chabel	DC	11	1.0	0.2 sq. in
13	New 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	New Patan	DC(Cable)	11	0.05	0.1 sq. in

Sources : NEA

Remarks : UGC = Under ground power cables
SC = Single circuit
DC = Double circuit

Table 2.3 11kV Switching Equipment in 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(German)	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(German)	-
Switching Station										
1) Teku	-	4	7	-	-	11	7.88	Bulk Oil	English Elec.(UK)	1
	-	4	2	-	-	6	20.00	Bulk Oil	Yorkshir(UK)	2
2) Royal Palace	-	2	1	2	-	5	7.88	Bulk Oil	English Elec.(UK)	1
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	Bulk Oil	English Elec.(UK)	2
6) Old Chabel	-	4	6	-	-	10	7.88	Bulk Oil	English Elec.(UK)	4
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	Yorkshir(UK)	2

Remarks : Lainchaur substation : under construction (to be completed in May, 1992)

CHAPTER 3

OUTLINE OF THE PROJECT

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3.1 Project Objectives

As aforementioned, Kathmandu is the most important center of Nepal and if the power supply system in the Kathmandu Valley is not addressed soon it will face problems such as over-loading, excessive voltage drop on the distribution system, deterioration of power supply reliability, etc., since the system demand is growing at a higher rate than that forecasted in the past. The Project aims not only to support the political and economical activity of the capital of Kathmandu, but also to contribute to betterment of living standards and increase the employment opportunities in the industrial sector through stable and reliable power supply. It will also improve the cost efficiency by reducing system losses and operation and maintenance costs by reinforcement of the power transmission and distribution facilities which need countermeasures urgently.

3.2 Examination of the Request

3.2.1 Necessity and Appropriateness of the Project

Necessity and appropriateness of the Project have been confirmed through a series of discussions with officials of HMGN and NEA, detail site investigation and analysis in Japan. The finding are as follows:

(a) Similar projects for reinforcement of power transmission and distribution facilities in the Valley are under way, (refer to Section 3.2.2), and cover the upper and lower stream portions of power supply system. The Project does not overlap with these projects and directly meets the requirements of the people in the Valley.

(b) Most of the 11 kV trunk lines cover both the urban and rural areas, however, customers in rural area are facing excessive voltage drops, while customers in urban areas are facing frequent power supply outage due to line faults 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.

(c) In order to reduce the frequency of circuit breaker tripping, which is the main cause of short circuits and line-to-ground faults from the use of bare conductors, insulated cables will be adopted for both 11 kV and low tension lines. Insulated cables are also effective in lengthening the life of circuit breakers and minimizing the maintenance cost of clearing of right-of-way.

(d) The Ring Main system was established in the 1960s and some equipment installed at that time is now out of date. The rated capacity of circuit breakers in city area is lower than the expected short circuit current in the system which has increased because of the expansion of the power supply system in Nepal. Some of the old 11 kV equipment is planned to be replaced under the Project to avoid further problems.

(e) Damaged equipment in the Royal Palace switching station will hinder power supply to the downtown area, since the switching station is a relay point for the power supply. Therefore, to have a stable power supply it is very important to improve the old equipment in the existing switching station and to install new equipment for easy operation and maintenance.

(f) There is shortage of qualified reliable contractors for erection of the distribution system are not available in Nepal. Most of the routine extensions and rehabilitation works on the distribution system are done by NEA staff itself. Therefore, in order to complete the work in time a supply and erection contract should be considered for the implementation of the Project.

(g) About 68% of total population (110 thousand) in the Valley enjoys electricity supply at present, including many government offices, banks, foreign agencies, hotels, etc. The Project will have a large effect on the political and economical stability in the country.

3.2.2 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)

As explained in Section 2.1.2, the HV Transmission/Substation Reinforcement Project in the Kathmandu Valley aims to augment the capacity of the power transmission facilities in the Valley and consists of the following.

(a) Construction of a 132 kV transmission line for connecting the Marsyangdi - Balaju line to the Siuchatar substation.

(b) Upgrading the Teku switching station to a 66 kV substation and construction of a related 66 kV transmission line.

(c) Augmentation of transformers at the Baneswar and Lainchaur substations.

(d) Construction of a new 66 kV substation in Bhaktapur area and a transmission line (132 kV design) between the new substation and Bulhanilkanth and incoming line from the Sunkosi-Patan line.

Commencement of the above project has been delayed due to the issue of electricity tariff increase recommended by IDA. The tender for supply and erection of the project, however, is in progress. The HMGN has applied a new electricity tariff with about a 60% increase in rate since November 1991.

Though procurement of power transmission line materials and substation equipment and erection under PSEP will be done in parallel with the implementation of the Project, the construction schedule of the Project will not be disturbed by PSEP, except for connecting 11 kV distribution lines to the new Bhaktapur substation, which will be done by NEA after completion of the Bhaktapur substation, no work sites for the Project will overlaped with PSEP.

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

All switching equipment of 66 kV and 11 kV at the Lainchaur substation burnt down in July 1990 by fire in a 11 kV cubicle. The restoration of the switching equipment is in progress under the finance from KfW, as part of additional works for the Marsyangdi Hydroelectric Project. It is anticipated to be completed by the end of May this year.

11 kV cubicles for connecting the cables between the Lainchaur substation and the K2 switching station to be constructed under the Project are installed under the restoration works. There is no problem for the implementation of the Project.

(3) Additional stringing of second circuit conductors on the 66 kV double circuit towers

This work is planned to be done with finance from NEA. The necessary conductors have already been procured. Besides tenders for procurement of the insulators and hardware materials, and erection work are scheduled to begin in a short time.

The necessary 66 KV switching equipment at both the Siuchatar and Patan substation is included in the PSEP.

This plan has no direct relationship with the Project, but will contribute to the improvement of unreliable power supply to the Patan, Baneswar and Baktapur area.

(4) Loss Reduction Project (LRP)

Phase II of LRP is in progress and Phase III will continue with reallocation of the remaining loan for the Marsyangdi Hydroelectric Power Project. The Phase III of LRP includes improving the connections of low tension distribution lines and service wires for the consumers and replacement of improper energy meters in a part of and out of the Kathmandu Valley. This plan will not disturb the Project, since LRP covers the lower stream portions of the power distribution system which will be improved under the Project.

3.2.3 Components of the Project

The components of the Project requested by the HMGN for the extension of the grant aid from the GOJ and selected in the Basic Design Study are as follows:

	Components requested by HMGN	Components selected in the Basic Design Study
1.	Replacement of 11 KV cubicles at the Royal Palace, Old Patan and Old Chabel	Selected
2.	11 KV underground cable laying between the Lainchaur substation and the K2 switching station	Selected
3.	Reinforcement and improvement of main 11 KV feeders	Selected
4.	Additional 132/66 KV transformer at the Siuchatar substation	Not selected
5.	Construction of a new K3 substation	Not selected
6.	Extension and reinforcement of a 11KV and low tension distribution line	Not selected
7.	Maintenance tools	Partially selected

The Project components requested by HMGN are selected on the basis of the feasibility study enforced by JICA in 1991.

The results of discussions and examinations with NEA on the basic design study are shown in attached Appendix "Minutes of Meeting". Four project components mentioned above have a high priority in the feasibility study report and are selected for this basic design study.

The reinforcement and improvement works of the selected facilities are appropriate countermeasures, explained below, for maintaining stable and reliable power supply in the Valley and preventing excessive voltage drop and increase of system losses. However, the remaining three items are recommended to be implemented in the future, since reinforcement of those facilities is needed to improved the problems which will occur around 1995/96.

(1) *Replacement of 11 kV cubicles*

The rated breaking capacity of the 11 kV cubicles at the Royal Palace, Old Patan and Old Chabel switching stations is lower than the computed short-circuit current of the present system. These cubicles will be replaced with new ones having ample breaking capacity against the estimated short-circuit current, in order to avoid recurrence of accidents such as the death of operators and fire caused by the bursting of the circuit breaker from the fault current of a short-circuit on the system at the Lainchaur substation.

The replacement of cubicles will contribute greatly to reliable power supply to the Kathmandu Valley.

(2) Laying underground cables between the Lainchaur substation and the K2 switching station

Power demand in the most populated central area of Kathmandu is delivered from the K2 switching station of which electric power is supplied through 11 kV underground cables lines from the Lainchaur substation and 11 kV double circuit overhead lines from the New Patan substation.

The power supply in the center of Kathmandu is unreliable due to the deterioration of the existing underground cables which were constructed in the early 1960s. In case some trouble occurs on the cable line, the power demand in the central area will be supplied from the New Patan substation. Under this condition, load shedding will be necessary to avoid overloading the main transformers in the New Patan substation and 11 kV overhead lines in this area.

Replacement of the underground cable lines between the Lainchaur substation and the K2 switching station will improve and maintain stable and reliable power supply to the center of Kathmandu.

(3) Extension and reinforcement of major feeders

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

(a)	Boudha - Jorpati feeder	Separation of supply area in rural and city areas with an additional new feeder
(b)	Sundarijar feeder	Upgrading of existing conductors and modification of a part of the line route
(c)	Godawari-1 &-2 feeders	Separation of the supply area with an additional new feeder and change of supply station
(d)	Thankot feeder	Addition of another line for the high demand density area and upgrading of existing conductors
(e)	Kiritpur feeder	Adjustment the share of demand from the existing substation
(f)	Pharping feeder	Separation of demand for factory and domestic consumers with an additional new feeder
(g)	Airport feeder	Upgrading of existing conductors
(h)	Baneswar feeder	Upgrading of existing conductors
(I)	Nagarkot feeder	Separation of the supply area and upgrading of existing conductors
(j)	System improvement in downtown	Extension of branch lines and installation of additional transformers

The above mentioned feeders are having serious problems with excessive voltage drop, frequent tripping of circuit breakers and power loss due to usage of under size conductors, compared with the actual demand. These problems are described in the study report. The decision to enforce the reinforcement and improvement of these feeders is urgently required.

(4) Additional 132/66 kV 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 the year 1995/96. In order to improve overload of the transformer, an additional transformer with same capacity is to be installed.

A 132 kV transmission line for connecting the Marsyangdi - Baraju line to the Siuchatar substation and upgrading the Teku switching station to a 66 kV substation and construction of a related 66 kV transmission line, for the reinforcement of the power supply and separation of the load on the Siuchatar substation, to be constructed under PSEP are an essential part for effective utilization of the additional transformer. Therefore, this component is eliminated from the Project.

(5) Construction of a new K3 substation

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

Completion of the new 66 kV transmission line to be constructed under PSEP is a necessity for implementation of this component. Therefore, this component is eliminated from the Project.

(6) Extension and reinforcement of 11 kV and low tension distribution line

This component which are not urgently required and deeply related to PSEP is eliminated from the Project.

(7) Maintenance tools

For proper operation and maintenance of the system, supply of tools, vehicles, VHF radio and measuring equipment to NEA were recommended in the feasibility study.

The equipment and a part of the tools and vehicles are supplied under the Project.

3.2.4 Contents of Requested Major Facilities

For implementation of the Project, the major equipment requested by HMGN and its necessity are summarized below:

	Requested major facilities	Necessity
1.	Royal Palace, Old Chabel and Old Patan switching stations	Rated breaking capacity of circuit breaker is lower than computed short-circuit current. It is necessary to replace these cubicles for maintaining stable and reliable power supply.
2.	Replacement of underground cable between the Lainchaur substation and the K2 switching station	These cables were constructed more than 20 years ago and troubles on the cables have frequently occurred due to the remarkable deterioration of the cables. Replacement of cables will greatly improve the present unreliable power supply condition.
3.	11 kV major feeders	Serious issues like the excessive power loss and voltage drop on some feeders have occurred due to the shortage in capacity of distribution facilities in size of conductors and number of feeders. It is necessary to extend and reinforce these feeders for maintaining stable and reliable power supply.
4.	Maintenance tools and vehicles	These tools and vehicles are used for effective execution of maintenance and operation of the distribution facilities

The requested facilities were carefully examined from the technical and economical points of view, some parts of the original plans in the feasibility study report have been modified as below:

(1) The replacement of low tension cubicle in the Royal Palace switching station

The existing low tension cubicles in the Royal Palace switching station are out of date like the 11 kV cubicles. Trouble on the low tension cubicles may affect the entire power distribution system in Kathmandu, and replacement of the low tension cubicles is an advisable measure.

(2) The replacement of the 1,000 KVA, 11,000/400 V transformers at the Royal Palace switching station

The existing transformers are also becoming obsolete. The replacement of transformers is an advisable measure, for the same reasons mentioned above.

(3) Modification of line conductors from ACSR to insulated HAL wires

The tripping frequency of the circuit breaker of the feeders, including the ring main lines and transformer circuits in the Kathmandu Valley, was recorded 29 times per feeder per year. The deterioration of reliable power supply was caused by these frequent trippings.

The tripping of circuit breakers is usually caused by a short circuit fault in conductors and the earth fault, due to the touch of a tree to a line.

At present, bare conductors are mainly used as the line conductor of the existing 11 kV and low distribution lines in the Kathmandu Valley. Felling and trimming of trees along the distribution lines are necessary to remove the risk of earth faults. However, it is becoming difficult to get permission from the concerned authorities for felling and trimming trees in recent years because of concern about protection of the environment.

The adoption of the insulated wire is a proper measure to prevent of earth and short-circuit faults, it will not only decrease the tripping frequency of the circuit breakers but also reduce the maintenance cost for felling and trimming trees.

(4) Installation of a double-circuit underground cable line between the Lainchaur substation and the K2 switching station

A double circuit underground cable line will be installed between the Lainchaur substation and the K2 switching station, instead of the originally planned single circuit, for the following reasons.

The reliability of the power supply of double circuit construction is much higher than that of a single circuit one. Additional cost due to adoption of double circuit construction is minimized by adoption of 240 sq. mm, 3-cores, 2-cables instead of 325 sq. mm, 1-core, 4-cables recommended in the feasibility study and the work volume for cable laying is similar. Further, it is clear that to install one more circuit in the future in addition to the original single circuit is not only costly but also difficult to control traffic.

(5) Modification of the underground cable route

The existing underground cable line between the Lainchaur substation and the K2 switching station is double circuit construction and has been laid in the same route. Only one-circuit is connected to the Royal Palace switching station.

In the feasibility study, replacement of the cable for direct connection of the Lainchaur substation and the K2 switching station was recommended. However, the cable route via the Royal Palace switching station was also studied during field survey, in accordance with the strong request of NEA, and, finally, it was judged as more effective to form the cable line system through the Royal Palace switching station for the following reasons:

(i) The difference in the distance for the direct connection route and the route via the Royal Palace switching station is very small. The construction cost for each line is also almost the same. By connecting a new cable to the Royal Palace switching station, the reliability of the power supply to the Royal Palace is greatly improved.

If the direct connection option is taken, power supply to the Royal Palace is serviced by the existing overaged cable. It means that the probability of a fault occurring is very high.

(ii) The alignment of the cable has been planned taking into account the trees lining on both sides of the road outside of the Royal Palace, in this case, the cable is laid in the center of road. Adversely, such construction method causes another problem, i.e. difficulty of erection work, excavation, cable laying and connection, back-filling, etc., while under heavy traffic in daytime.

In order to avoid such difficulties, the route of cable, to be connected to the Royal Palace switching station, will be moved to inside the Royal Palace.

(6) Laying of communication cable

The existing 11 KV ring main lines have pilot wires for line protection. However, the existing underground communication cable between the Lainchaur substation and the K2 switching station is not working properly.

In order to ensure the operation and maintenance of the line connecting power supply to the center of Kathmandu, a communication cable will be laid together with the underground power cable between the Lainchaur substation and the K2 switching station via the Royal Palace switching station

3.2.5 Necessity of Technical Assistance

As previously stated, the network reinforcement projects were implemented under three grant aids from GOJ in the 1980s. The core of the technical staff of NEA for the maintenance and operation of the distribution system was trained by the engineers of the contractor through on the job training under the three projects.

Under the project, NEA staff training for operation and maintenance will be conducted by the engineers of the contractor through on the job training as explained in Section 4.1.4. Therefore, they will not need to engage specialists for technical assistance.

3.2.6 Basic Consideration on Assistance for the Project

As mentioned in the preceding sections, the effect, actuality and capability for implementation of the Project are confirmed. Likewise, an appropriateness of the implementation of the Project under grant aid from GOJ has been confirmed, since the effect of the Project accords with the system of the grant aid.

The basic design will be made considering the outline of the Project and on the assumption of a grant from GOJ. However, part of the project components requested by HMGN should be modified as aforementioned.

3.3 Outline of the Project

3.3.1 Organization for Maintaining Distribution Facilities

Operation and maintenance 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 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 January 1991 is given below, and the staff list of DCS is given in Table 3.1 attached hereto.

Offices	Technical	Administrative	Total
1) Kathmandu Area			
a) Regional office	7	7	14
b) KTM East branch office	67	58	125
c) KTM Central branch office	197	179	376
d) KTM West branch office	137	100	237
2) Lalitpur-Bhaktapur Area			
a) Regional	4	14	18
b) Lalitpur branch office	183	137	320
c) Bhaktapur branch office	124	98	222

Note: Kaure branch office outside Kathmandu is also under the management of Lalitpur-Bhaktapur divisional office. But Rasuwa/Nuwakot and Sindhu/Dolakha branch offices are directly under Bagmati regional office.

3.3.2 Location and Conditions of the Project

The locations of switching stations and distribution lines in each plan are shown in Fig. 3.1.

(1) Replacement of cubicles of 11 kV switching stations

Old Patan switching station

The Old Patan switching station is in the Lalitpur division and located on the south side of the Patan city and inside the ring road.

The New Patan and Sunkosi substations and the diesel power station are located in the same area. The existing facilities of the Old Patan switching station are in the diesel power station building. The existing cubicles of the Old Patan switching station will be replaced with new cubicles under the Project. Taking into account the difficulty in construction of the facilities and the overaging building, the new cubicles will be installed in the 11 kV cubicle room of the Sunkosi substation which is not used at present. To unify the operation and maintenance of the existing substation equipment and the newly installed 11 kV cubicles in the Sunkosi substation, a remote control panel for operation of the switching station will be installed in the control room of the New Patan substation.

Royal Palace switching station

The existing Royal Palace switching station is in the Royal Palace which is located in the center of Kathmandu.

The new cubicles will be installed in the building to be constructed by NEA on the edge of the west side in the Royal Palace.

Old Chabel switching station

The Old Chabel switching station belongs to the Kathmandu East division and is located on the east side of Kathmandu city and inside the ring road.

The access road from the ring road to the switching station is narrow and may obstruct heavy-duty trucks.

(2) Underground cable laying between the Lainchaur substation and the K2 switching station

The underground cable will be laid from the Lainchaur substation, which is located in the northeast of the Kathmandu city, to the K2 switching station, through the switching station newly installed in the Royal Palace and along a north-south main road passing through the center of Kathmandu in front of the Royal Palace. The main road has an acceptable width of 18m , light traffic and wide footpaths on both sides.

(3) Extension and reinforcement of major 11 kV feeders

The major 11 KV feeders selected for the Project, except the lines in the city center, are extended from the ring main to the suburbs of Kathmandu. The land in the route of the lines is undulating plain.

3.3.3 Outline of the Facilities

From the result of the basic design survey, some modifications on the contents of the Project were requested by HMGN and were explained in Section 3.2.3 and 3.2.4. An outline of each component in the Project which meets the system of assistance of GOJ is given below:

(1) Replacement of 11 kV cubicles

The major facilities for replacement of 11 KV cubicles at three switching stations are summarized below:

	Old Patan Switching Station	Royal Palace Switching Station	Old Chabel Switching Station	total
11 KV Feeder Cubicle	12	4	12	28
11 KV Bus Coupler Cubicle	1	-	1	2
TR. Primary Circuit Cubicle	-	2	-	2
St. Transformer Cubicle	1	-	1	2
DC Cubicle	1	1	1	3
Remote Control Cubicle	1	-	-	1
TR. Secondary Circuit Cubicle	-	2	-	2
D - G Cubicle	-	1	-	1
Transformer 1000 KVA	-	2	-	2
Low tension Panel	-	2	-	2

(2) Underground cable laying between the Lainchaur substation and the K2 switching station

Route : Lainchur substation - Royal Palace switching station - K2 switching station

Route length : 2.2 km

No. of circuit : 2 circuits

Cable : 11 kV cross linked polyethylene insulated, vinyl sheathed steel armored cable, 240 sq.mm x 3 cores

Others : Communication cable, 0.6 mm x 6 P

(3) 11 kV main feeders

The line length and its countermeasures for each feeder to be reinforced are summarized below:

	Feeder	Length (Km)	Countermeasure
(a)	Boudha - Jorpati feeder	4.0	Construction of another feeder and upgrading of existing conductors
(b)	Sundarijal feeder	9.2	Construction of a part of the line and upgrading of the existing conductors
(c)	Godawari-1 & -2	3.6	Construction of line and separation of supply area
(d)	Tankot feeder	8.5	Construction of another feeder and upgrading of existing conductors
(e)	Kiritpur feeder	1.5	Linking of feeders by construction of one new line
(f)	Pharping feeder	3.2	Additional construction of one line on existing line
(g)	Airport feeder	2.3	Upgrading of existing conductors and replacement of part of supports
(h)	Baneswar feeder	2.3	Upgrading of existing conductors and replacement of part of supports
(i)	Nagarkot feeder	4.3	Upgrading of existing conductors, replacement of poles, division of supply area
(j)	Bayasi feeder	4.61	Upgrading of existing conductors, construction of line and separation of supply area
(h)	Kathmandu center	4.4	Construction of transformers and their related lines
	Total	47.9	

Materials and equipment required for implementation of the above-mentioned 11 kV main feeders are summarized below:

11 kV insulated conductors	:	175 km
Low tension insulated conductors	:	159 km
Distribution transformers	:	71 units (7,150 kVA)
Poles for 11 kV distribution lines	:	878 nos
Poles for low tension distribution lines	:	415 nos
11 kV CV cables	:	6.7 km

(4) Maintenance tools, measuring apparatus and equipment

(a) Maintenance tools : 1 lot

(b) 4 WD working truck with elevator bucket : 2 nos

	Three ton truck	:	2 nos
	Light maintenance truck	:	2 nos
(c)	VHF radio equipment	:	1 lot
(d)	Measuring equipment	:	1 lot

KTM-BD-407

Table 3.1 Staffs of Distribution & Consumer Services Directorate (Jan. 1991)

(I) Technical Staffs

	Total		Directorate		Central-Eastern Dept.		Bagmati Dept.		Western Dept.		Commercial Dept.		Technical Services Dept.		6th Power Project		7th Power Project	
Level	Perma-nent	Temp-rary	Perma-nent	Temp-rary	Perma-nent	Temp-rary	Perma-nent	Temp-rary	Perma-nent	Temp-rary	Perma-nent	Temp-rary	Perma-nent	Temp-rary	Perma-nent	Temp-rary	Perma-nent	Temp-rary
12	1	0	1															
11	5	0			1		1		1		1		1					
10	15	1			4	1	2		3		3		2		1			
9	26	8	1		7	3	8		4	1	3		3			4		
8	20	4	1		4	3	4		8	1	1		2					
7	87	25	1		28	9	23	3	24	4	7		4			9		
6s	10	0					10											
6	15	0			2		10		1		2							
5	170	59			56	27	50	4	48	6	10		6			22		
4	253	54			82	17	77	4	84	9	10					24		
3	470	28	8		172	8	189	3	74	17	23		4					
2	482	29			225	4	182	4	59	21	16							
1	406	14	10		112	9	237	4	32	1	15							
Sub-	1,960	222	22	0	693	81	793	22	338	60	91	0	22	0	1	59	0	0
Total		2,182		22		774		815		398		91		22		60		0

(II) Administrative Staffs

	Total		Directorate		Central-Eastern Dept.		Bagmati Dept.		Western Dept.		Commercial Dept.		Technical Services Dept.		6th Power Project		7th Power Project	
Level	Perma-nent	Temp-rary	Perma-nent	Temp-rary	Perma-nent	Temp-rary	Perma-nent	Temp-rary	Perma-nent	Temp-rary	Perma-nent	Temp-rary	Perma-nent	Temp-rary	Perma-nent	Temp-rary	Perma-nent	Temp-rary
10	1	0									1							
9	3	0	2								1							
8	11	1	6		1	1	1		1		2							
7	26	2	4		7	1	7		6		2					1		
6	28	1	6		9	1	7		4		1		1					
6s	1	0	1															
5	150	34	14		38	13	52	3	37	5	9					13		
4	243	48	4		47	17	138	4	51	6	3					21		
3	466	26	7		128	15	254	2	60	9	13		4					
2	13	2			12	2	1											
1	172	86	3		75	28	65	8	23	18	3		3			32		
Sub-	1,114	200	47	0	317	78	525	17	182	38	35	0	8	0	0	67	0	0
Total		1,314		47		395		542		220		35		8		67		0
Grand	3,074	422	69	0	1,010	159	1,318	39	520	98	126	0	30	0	1	126	0	0
Total		3,496		69		1,169		1,357		618		126		30		127		0

CHAPTER 4

BASIC DESIGN

CHAPTER 4
BASIC DESIGN

4.1 Basic Consideration for Design

The basic considerations for the design of the distribution system are i) to ensure high reliability and safety, ii) to apply similar design with the existing facilities for easy operation and maintenance, and iii) to build the system with flexibility for future expansion.

4.1.1 Natural Conditions for Design

The natural conditions like ambient temperature, wind velocity, earthquake, and thunder storm in the project area are very important factors for the design of the distribution facilities. The basic design criteria were worked out from historical climatic records for the eleven (11) years from 1976 to 1986 and the present design standard of NEA.

4.1.2 Special Site Conditions for Erection

Site erection works for the Project facilities will be carried out in accordance with the standard and/or practice of NEA. However, it is noted in Nepal that the finishing works including 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 prevailing cost to be bone by the contractor.

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

Costs of Finishing Works

Kind of pavement	NRs/sq.m
Asphalt paving road	522.94
Concrete paving road	500.00
Stone laying road	168.44
Brick laying footpath	500.00

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

4.1.3 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.

4.1.4 Operation and Maintenance Capability of NEA

Through the past three grant aid projects for the reinforcement and improvement of the power distribution system inplemented in the 1980s, the capability of NEA for operation and maintenance of the system has been proved. The training on management technique of the load and voltage on the system is being conducted under the Loss Reduction Project. Trouble with distribution transformers and other equipment due to over loading and an uncertain load management of the system is expected to be improved.

The training of linesmen belonging to the regional/district/local offices of NEA will be conducted by the Japanese contractor during site erection as follows:

(a) The works of disconnecting and reconnecting of the service wires to the consumers, which are necessary for construction of new and renewal of distribution lines, are to be carried out by NEA. The practical use of the working teams of NEA is effective to execute the overall project works and to minimize the power stoppage for erection.

(b) Under the Loss Reduction Project, insulated wires are partially used for low tension lines in the Kathmandu Valley, and NEA's linesmen were trained for erection of the insulated wires. The insulated wires will also be used as line conductors for almost all of the 11 kV and low tension distribution lines under the Project. Tools and materials for the erection of insulated wires will be procured under the Project and ample quantities will be supplied taking into account not only the erection but also the proper operation and maintenance of the distribution system after completion. The transfer of technical knowledge to the technical staff of NEA is made on-the-job-training basis through site erection works which are executed at the same time in all areas under the control of the district and local offices of NEA in the Kathmandu Valley.

(C) The core technical staff of NEA for operation and maintenance of the power distribution system in the Kathmandu Valley has been trained under the past three grant aids projects and their technical knowledge will be further improved through on-the-job-training during the Project.

4.1.5 Facilities for the Project

The facilities to be provided under the Project, will be designed and chosen avoiding the adoption of high technology and taking into account of the easy operation and maintenance of the system, and the present technical level of NEA. Besides, the maximum safety of the workers engaged in the operation and maintenance and inhabitants shall be ensured.

4.1.6 Construction Schedule

The Project will be implemented in two stages as shown in Table 4.1, not only because of the total work volume of the Project but also the necessary period for manufacturing of equipment and materials, transportation via India and erection.

In this study, the necessary period for each component is estimated as below:

- Manufacturing of poles, fittings, cables, conductors, etc. — 4 to 6 months
- Manufacturing of switching equipment and transformers — 8 to 10 months
- Transportation from Japan to the site wia India — 2 months

4.2 Design Conditions

4.2.1 Climatic Conditions

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 for the past three reinforcement projects in the Kathmandu Valley Distribution Network will be applied for the design of the Project, briefly as follows:

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

The maximum wind velocity applied to the Project is 25 m/s, since the highest wind velocity recorded in the Kathmandu International Airport was 52 knots (equivalent 26.75 m/s) and 25 m/s has been applied for the past three projects without any trouble.

4.2.2 Design Criteria

(1) Design wind pressures on structures

The wind pressures worked out from the above-mentioned wind velocity are 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 (pole, etc.)	:	31 kg/m^2
(d)	Insulators and hardware	:	55 kg/m^2
(e)	Equipment (transformer, etc.)	:	100 kg/m^2

(2) Sag computation calculation

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 ambient minimum temperature is minus 5°C, the likelihood of such case, that is maximum wind velocity at minimum air temperature, is very rare.

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

(d) Minimum factor of safety of conductor stress at maximum wind pressure at 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, other kinds of supports under maximum working loads against their ultimate strength..2.5

(b) Conductors under the maximum working tensions against their ultimate tensile strengths 2.5

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

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

(4) Required minimum clearances

The following minimum clearances from conductors will be applied:

(a) Lowest point of conductors above ground

	11 kV Line	L/T Line
road crossing	6 m	6 m
along road	5 m	5 m
general train	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) BIL of 11 kV electrical equipment

(a) Highest rated voltage .... 12 kV
(b) Impulse withstand voltage .... 75 kV
(c) Impulse withstand voltage for L.A .... 90 kV

(6) Standards applied

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

4.3 Basic Design

4.3.1 Extension and Reinforcement Plan

The extension and reinforcement plan of 11 kV switching stations, underground cable line and distribution lines under the Project are as mentioned below:

(1) 11 kV switching stations

The existing cubicles at the Royal Palace, Old Chabel and Old Patan will be replaced with new cubicles and additional new cubicles will also be installed.

(a) Royal Palace Switching Station

The existing cubicles for two ring main lines, two transformers and their primary circuits, and two feeder circuits will be replaced with new 11 kV cubicles. In addition, one battery and charger cubicle, one D/G cubicle, and two low tension cubicles will also be installed. All cubicles except one low tension cubicle will be installed in the new switching station to be constructed by NEA.

The connecting diagram and cubicle layout plan are shown in Figures. 4.1 and 4.2.

(b) Old Chabel Switching Station

The existing cubicles for four ring main lines, five feeder circuits, and one spare feeder cubicle are to be replaced with new 11 kV cubicles. In addition, one station transformer cubicle, one bus coupler cubicle, one battery and charger cubicle, and two feeder cubicles for new feeder lines, to be constructed under the Project, will also be installed. All these cubicles will be installed in the existing switching station.

The route of cables between the cubicles and dead end poles, and the connection diagram and cubicle layout plan are shown in Figures 4.3, 4.4 and 4.5.

(c) Old Patan Switching Station

The existing cubicles for four ring main lines and six feeder cubicles are to be replaced with new 11 kV cubicles. Fifteen new cubicles in total including cubicles for bus coupler, station service transformer circuit, battery and charger, and two feeder circuits for new feeder lines, to be constructed under the Project, will be installed in the existing 11 kV switchgear room in the Sunkoshi substation. Their circuit breakers will be operated from the control board to be installed in the control room of the New Patan substation in order to unify the operation of the existing substation equipment and these 11 kV cubicles. The routes of cables between cubicles and dead end poles, are shown in the connection diagrams and cubicle layout plan in Figures 4.6, 4.7, and 4.8.

(2) Underground cable line

The existing overaged 11 kV underground cable line between the Lainchaur substation and the K2 switching station will be replaced with a new one. The new cable line has a double circuit configuration and one circuit connection to the Royal Palace switching station as in the existing system. In addition, for operation and maintenance purposes, one communication cable will be also laid together with the power cables.

In the study, the original cable line route has also been changed. It is now routed through the Palace in order to avoid the traffic problem during erection.

Cable line route and cable trench are shown in Figures 4.9 and 4.10, respectively.

(3) 11 kV distribution lines

(a) Town center (KTM-1)

The downtown area is densely populated and congested with buildings and houses not only along main roads but also in their interior areas. Branch roads from the main roads into the interior areas are so narrow that they are not accessible to vehicles. The 11 kV overhead lines are not aligned. A number of low voltage lines are obliged to be extended over long distances through mazes, the cables will have to be being hung on the walls of buildings and houses, accordingly. Long low voltage lines serve customers with power that is subject to excessive voltage drop such as 170V to 180V against the rated voltage of 230V which can also cause frequent power failures.

IIn order to improve such situations, 11 kV underground cables will be extended from the existing network in Bagbazar, Paniphokari and Tripureswar areas, and transformers, with ample capacity, will be installed.

(b) Godawari-1 & 2 feeders from the existing New Baneswar substation

The existing Godawari-1 feeder extends from the New Baneswar substation over 35.4 km to its end at Phulchoki in the mountains and Godawari-2 extends to Chapagau and Lubhu areas over 40.4 km to several ends southward. Both feeders were originally extended from the existing Patan diesel power station, and tap-off sections of the original lines from the power station still remain unused with ACSR Dog over about 1.0 km route.

In order to reduce the loads on the Godawari-2 feeder, one of the unused tap-off feeders is to be extended to Chapagau village with HAL Dog over 3 km from the present end point southward along the ring road and along the existing motorable road, and connected to another branch of the Godawari-2 feeder.

In addition, an existing sectionalizing switch on the Godawari-2 line will be opened. Owing to this condition, the Godawari-2 feeder will have 2 supply sources that will be operated independently; one from Patan diesel power station to cover the Chapagau section of the existing Godawari-2 feeder and another from the Baneswar substation to the Lubhu section of the feeder.

Another tap-off feeder at the Patan diesel power station will be connected to the Godawari-1 feeder at its original point with provision of a sectionalizing switch being off on the Baneswar side. A new sectionalizing switch is to be installed at an exit point of the Godawari-1 branch line to the Imadol feeder in off condition. Thus, the Godawari-1 feeder after being connected with the Patan diesel power station will supply power to its southern part only. Besides, as an existing sectionalizing switch, installed near a crossing point of the Godawari-1 feeder and the Imadol feeder, will be opened, areas covered by the Imadol feeder and a Godawari-1 branch line will also be directly supplied from the New Baneswar substation. Under this arrangement, voltage regulation and supply reliability will obviously be improved.

(c) Boudha-Jorpati feeder

The feeder is located along the main road in the section of the town near Gokarna Ban and passes through hilly areas to the Bramhakhel village located on the Nagarkot feeder from the Bhaktapur switching station. A number of industries like carpet and furniture manufacturers are being developed between the new Chabel substation and Gokarna Ban.

A new feeder is required at Gokarna Ban to meet the increasing demand there, in addition, to improve the voltage regulation of the existing feeder, the existing ACSR Rabbit should be upgraded to HAL Dog in the section. The new feeder will be aligned along the main road over 4.0 km without difficult acquisition of the right-of-way.

(d) Thankot feeder

In order to reduce excessive voltage drop and to meet the growing demand of industries established along the highway to Thankot, a new 11 kV line will be constructed with a single circuit of HAL Dog from the Siuchatar substation to the Earth Station near Balambu over 4 km away. The line will be constructed in the right-of-way of the highway to avoid troubles with land acquisition.

Besides construction of the new feeder, the existing Thankot feeder between Balambu and Thankot will be upgraded by replacement of the existing ACSR Rabbit with HAL Dog, over 4 km, this should reduce voltage drops and meet the demand growth in the area.

(e) Baneswar feeder

The existing ACSR Rabbit feeder (between the Chabel switching station and the junction of the Tangal feeder, over 2.5 km) should be upgraded before the year 1994/95. The existing supports for the feeder are overaged and have not enough strength to support new conductors.

A new 11 kV feeder in the section will, accordingly, be constructed with a single circuit on new supports, over 2.5 km, with one shoulder conductor arrangement for maintaining safe clearances to buildings along the road. Right-of-way for the feeder is available along the main road.

(f) Town center (KTM-2)

Same as KTM-1, 11 kV system from the existing 11 kV network will be extended to the Kaldhara, Jyabahal, and Hiumat areas.

(g) Airport feeder from the New Chabel substation

The feeder is equipped with a single circuit of ACSR Rabbit over 2.6 km. Forecasted load current of the feeder will exceed the current carrying capacity (200A) of the existing Rabbit conductor in 1994/95.

The existing conductor will be upgraded with HAL Dog (current capacity of 320A) for increasing current capacity.

(h) Pharping feeder

The existing Pharping feeder from the Patan diesel power station supplies power to public consumers and a cement factory located at the end of the feeder.

The factory which has a contracted capacity of 5,000 kVA causes excessive voltage drop on the feeder and causing unreliable power supply to the public consumers.

The reinforcement plan is to construct a 3.5 km feeder to the Thanagau village located near the factory for the purpose of exclusive supply to the public consumers, while the existing feeder will be used for supply to the factory only.

(i) Sundarijal feeder

The feeder is very old and has a small line capacity with a single circuit of small Hard Drawn Copper Conductor (HDCC) 12.9 sq.mm on simple steel structures. Damaged portions on the HDCC feeder have been repaired using ACSR without application of bi-metal connectors, causing corrosion of conductors at those connections. Despite poor power transmission facilities, this area is being developed under the city plan, as high demand growth is expected.

For improving the excessive voltage drop of the feeder, a single circuit of HAL Dog will be constructed on new supports over 10 km from the New

Chabel substation up to the connecting point with the Sundarijal feeder from the Bhaktapur substation at Mahakal village.

The new feeder will be constructed in the same right-of-way as the existing feeder up to the Basnetgau village, to avoid the difficulty of land acquisition, and thereafter the feeder will be diverted to the Gokarneswar village and aligned along the motorable road to Mahakal village. Under this alignment, the existing Sundarijal feeder in the Basnetgau-Mahakal villages will be used for feeding power to local consumers in the section, while the existing lines along the motorable road, other than the branch lines, will be replaced with a new feeder.

(j) Town center (KTM-3)

Same as KTM-1, 11 kV system will be extended from the existing 11 kV network to the Yangal, Chaundevi, Makarajgunj, and Bansbari areas.

(k) Nagarkot feeder

The Nagarkot area is supplied with power from the existing Bhaktapur switching station, over 17 km, by the Nagarkot feeder equipped with a single circuit of HDCC 12.9 sq.mm and a single circuit of ACSR Rabbit. Receiving voltage at the customers' end is reported to be 170V against the rated 230V. The recommended improvement plan is to divert the supply route and to separate the existing supply area into two feeders by the following modifications.

(i) The existing Nagarkot feeder will supply the demand area up to the Kharipati village by the existing sectionalizing switch opened at the point. The section of HDCC 12.9 sq.mm over 4.5 km will be replaced with HAL Dog on new supports.

(ii) The conductors of ACSR Rabbit on the existing Byasi feeder extend from the Bhaktapur switching station to 2.5 km before Kharipati along the road, they will be replaced with HAL Dog conductors and a new single circuit line of ACSR Dog will be extended over 2.5 km upto the Kharipati village. The Nagarkot area will be supplied by the upgraded Byasi and newly extended feeder and it also means that the existing distance is shortened by 6 km.

(iii) In order to avoid the difficulty of land acquisition for the new feeder, a new double circuit line of ACSR Dog for both the Byasi and Banepa feeders will be constructed from the switching station to the Muldhoka village over 1.8 km in the same right-of-way as the existing Byasi feeder, and the existing Banepa feeder in this section will be restrung on the new supports.

An additional distribution cubicle will be provided for the new feeder at the planned new Bhaktapur substation under the PSEP.

(l) Kirtipur Feeder

The power to the Kirtipur area is being supplied by both the Kirtipur feeder from the Siuchatar substation and the Kirtipur feeder, same name, from the Teku substation. Both feeders are interconnected at the end of feeders, but separated by a sectionalizer on the feeder from the Teku switching station. Voltage drop on the feeder from the Siuchatar substation is estimated at 7.8% in the year 1994/95, while voltage drop on the feeder from the Teku substation will be only 0.7% in the same year. Part of the load on the feeder from the Siuchatar substation will be shifted to the feeder from the Teku substation by relocating a sectionalizer. As a result of the relocation, the voltage drop on the feeder from the Siuchatar substation will be much improved so as to be less than 7.5% by the year 2000/01. Voltage drop on the feeder from the Teku substation will increase due to a shift in loads, but it will be still less than 5% in the year 2000/01.

Besides the above load shifting, in order to increase supply reliability, inter-connection will be established between both the Kirtipur feeders at Panga village and Charghare village by construction of a new feeder, over 1.5 km.

4.3.2 Project Facilities

(1) Distribution line facilities

General layout plans of support for 11 kV and low tension lines are given in Figures 4.11 to 4.14.

(a) Poles

Poles for 11 kV and low tension lines will be a jointable steel tubular type and will be 11.2m and 9m 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 underbrace of steel made to increase the strength, and stay wires with steel anchors, drive type, which will be also used wherever conductor tensions are not balanced as at dead ends and angle points.

(b) Conductors

Tripping frequency of the distribution circuit breakers due to short-circuit fault from line to line contact and earth fault from tree to line contact is very high. To reduce the frequent trips of feeders, insulated HAL conductors will be used instead of the existing bare ACSR conductors.

HAL Dog conductors will be used for the main lines and HAL Rabbit for the branch lines.

(c) Insulators

Pin and disk insulators are to be used for supporting of 11 kV line conductors and spool insulators for low voltage line conductors. The conductors will be fixed to the insulators by insulated bind wires.

(d) Arms

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

(e) Distribution transformers

Distribution transformers will be of outdoor use, three-phase oil immersed type with a voltage ratio of 11 kV/400-230 V. The ratings of the distribution transformers will be classified into three different capacity of 50 kVA, 100 kVA, and 200 kVA.

The distribution transformer is to be installed on a platform supported with H-type poles.

(f) Fuse cut-out switches

For protection of the transformers from over-load, fuse cut-out switches will be installed on the primary side of the transformers. The cut-out switches will be of 11 kV 100 A, drop out type. The fuses for cut-out switches will be of 3A, 7A, and 15A for each transformer capacity.

(g) Lightning arresters

Lightning arresters will be of 11 kV, 5 kA, and are mounted on the end of lines, primary side of the transformers, secondary side of the line switches and at the joint of underground cables and overhead lines.

(h) Line switches

Line switches will be of 11 kV, 200 A for branch lines, 400 A for main lines and of air break type. The line switches will be installed on the branch points of the main feeder on and long distance lines, to isolate line troubles and/or a section of the line for maintenance work.

(i) Grounding

The lightning arrester, case of the line switch, transformer tank, secondary neutral and other metal parts required for the safe operation will be grounded by means of a grounding rod.

Copper coating steel rods will be used for grounding.

(2) Underground Cable Line between the Lainchaur Substation and the K2 Switching Station

Cables will be of 11 kV, copper conductors of 240 sq.mm x 3-cores, vinyl sheathed cross linked polyethylene insulated steel armored cable.

The cable head ends will be of premould stress cone type and the straight through joint of the cables will be installed in the concrete pit for their protection.

(3) Switching station facilities

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

Equipment	Incoming Line	Ring Main Line	Outgoing Feeder	Bus Coupler	Transformer Circuit (*1)
1) Copper bus	1	1	1	1	1
2) Circuit breaker 12 kV, 25 kA	1200A	1200A	800A	1200A	800A
3) Disconnecting switch 12 kV, 600A	-	-	-	2	-
4) Current transformer single phase	3 x 600 - 400 - 200/5	3 x 600/400 -200/5	3 x 400 - 200 - 100/5	3 x 1200/5	3 x 150-75/5
5) Over current relays	3	3	3	3	3
6) Over current ground relay	-	1	1	-	-
7) Reclosing relays	-	-	1	-	-
8) Ammeter with selector switch	1	1	1	-	1
9) Watt meter	1	1	1	-	1
10) Watthour meter	1	1	1	-	1
11) Var meter	1	1	1	-	1
12) Power factor meter	-	1	1	-	-

Remarks: *1: for the Royal Palace switching station

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

- Three lightning arresters
- Three single phase potential transformers
- One under voltage relay
- One voltmeter with selector switch

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

- One draw-out type disconnecting fuse switch, 11 kV 20VAF, 6 AT
- Three single phase potential transformers
- Ten molded circuit breakers

- One station service transformer, 3-P 50 kVA, 11 kV/400-230V
- Three current transformers, 100/5A
- Three over current relays
- One under voltage relay
- One ammeter with selector switch
- One voltmeter with selector switch
- One lot of control switches

Transformer secondary cubicle at the Royal Palace Switching Station:

- One circuit breaker, 600V, 1,600A
- Three single phase potential transformers, 400/110V
- Three single phase current transformers, 1,600/5A
- One under voltage relay
- Three over current relays
- One ammeter with selector switch
- One voltmeter with selector switch
- One watthour meter
- One lot of control switches, lamps and other necessary instruments and devices

Low-tension distribution panel-1 at the Royal Palace switching station

- One circuit breaker, 600V, 1,600A
- Four 3-poles molded circuit breakers, 600v, 100 AF
- One 3-pole molded circuit breaker, 600V, 30 AF
- One lot of control switches, lamps and other necessary instruments and devices

Low-tension distribution panel-2 at the Royal Palace switching station

- One circuit breaker, 600V, 1,600A
- Three single phase potential transformers, 400/110V
- Three single phase current transformers, 200/5A
- Three over current relays
- One ammeter with selector switch
- One voltmeter with selector switch
- Six 3-poles molded circuit breakers, 600V, 225 AF
- Four 3-poles molded circuit breakers, 600V, 100 AF
- One lot of control switches, lamps and other necessary instruments and devices

The batteries and battery chargers:

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

Remote control board at Patan substation:

The control board at the Patan substation will be of indoor duplex panel type, equipped with control switches, meter, fault indicators, etc. for remote control of the new cubicles installed in the switchgear room of the Sunkosi substation.