BASIC DESIGN STUDY REPORT

ON

THE PROJECT FOR EXTENSION AND REINFORCEMENT OF POWER TRANSMISSION AND DISTRIBUTION SYSTEM IN KATHMANDU VALLEY (PHASE-3)

IN

THE KINGDOML OF NEPAL

NOVEMBER 2002

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.

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 Project for Extension and Reinforcement of Power Transmission and Distribution System in Kathmandu Valley (Phase-3) and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Nepal a study team from April 10 to May 1, 2002.

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

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

I wish to express my sincere appreciation to the officials concerned of His Majesty's Government of the Kingdom of Nepal for their close cooperation extended to the teams.

November 2002

川上隆朗

Takao Kawakami
President
Japan International Cooperation Agency

November, 2002

Letter of Transmittal

We are pleased to submit to you the basic design study report on the Project for Extension and Reinforcement of Power Transmission and Distribution System in Kathmandu Valley (Phase-3) in the Kingdom of Nepal.

This study was conducted by Nippon Koei Co., Ltd., under a contract to JICA, during the period from March, 2002 to November, 2002. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Nepal and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

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

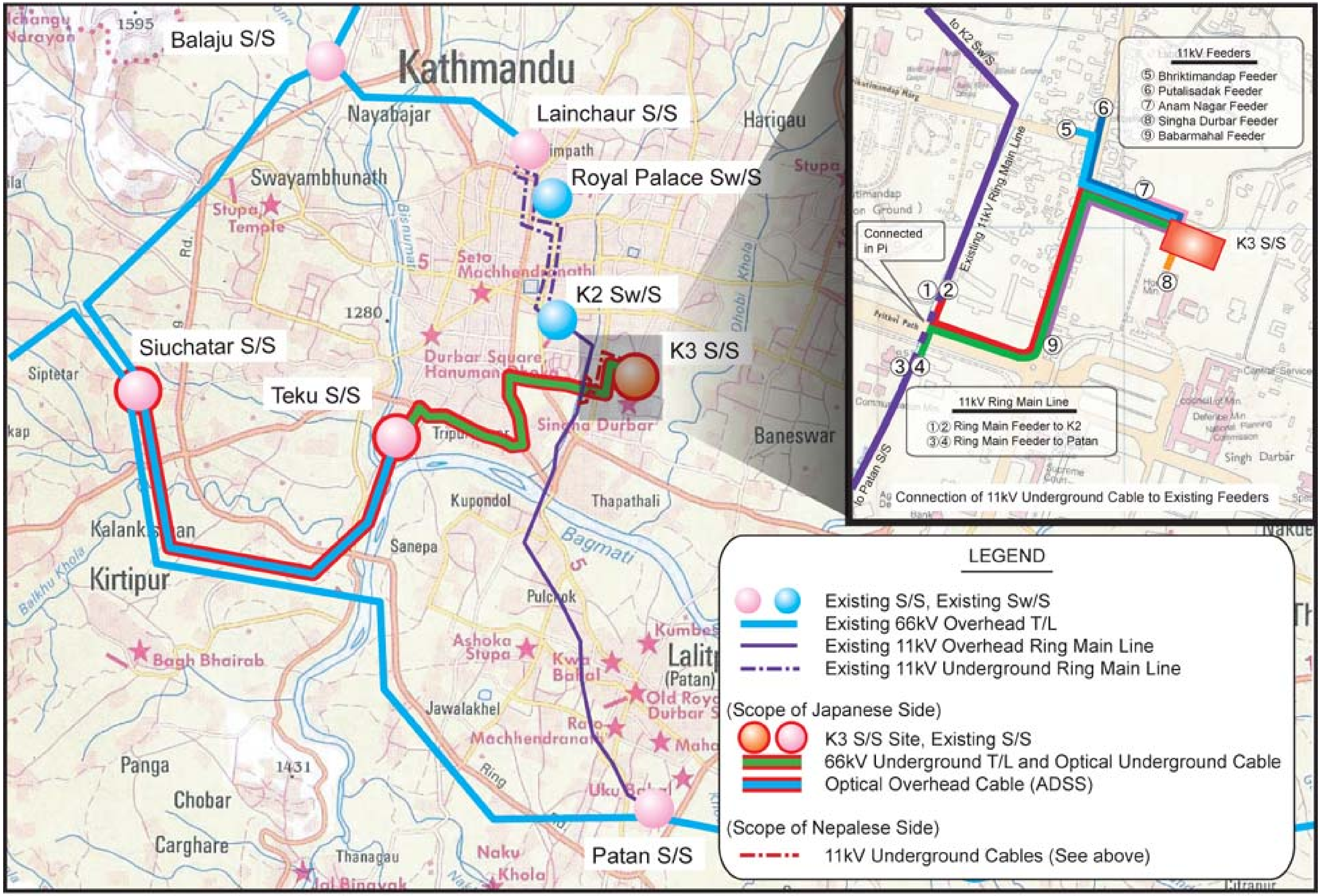
Very truly yours,

Tomoyasu Fukuchi

Project manager,
Basic design study team on
The Project for Extension and
Reinforcement of Power Transmission
and Distribution System in Kathmandu
Valley (Phase-3)

Nippon Koei Co., Ltd.

LOCATION MAP



Project Area and Concerned Facilities

PERSPECTIVE

List of Figures & Tables

<Table>

<Figure>

<Photograph>

Abbreviation

ADB	:	Asian Development Bank
ANSI	:	American National Standards Institute
ASTM	:	American Society for Testing and Materials
BHN	:	Basic Human Needs
BS	:	British Standard Institution
CB	:	Circuit Breaker
CV	:	Cross-linked polyethylene insulated and polyvinyl chloride sheathed power cable
CVV	:	Polyvinyl chloride insulated and sheathed control cable
D/L	:	Distribution Line
DOR	:	Department of Roads
DS	:	Disconnecting Switch
EIA	:	Environmental Impact Assessment
GDP	:	Gross Domestic Product
GWh	:	Gigawatt-hour
HMG/N	:	His Majesty's Government of Nepal
IEC	:	International Electrotechnical Commission
IEE	:	Initial Environmental Examination
IPP	:	Independent Power Producer
IS	:	Indian Standards
ISO	:	International Organization for Standardization
ITU	:	International Telecommunication Union
JCS	:	Japanese Cable Maker's Association Standard
JEC	:	Japanese Electromechanical Committee
JEM	:	Japanese Electrical Commission
JIS	:	Japanese Industrial Standard
MW	:	Megawatt
NEA	:	Nepal Electricity Authority
S/S		Substation
SW/S		Switching Station
T/L		Transmission Line
TR	:	Transformer

SUMMARY

Until early 2002, the most important issue of the power sector in Nepal is the shortage of the generation capacity. Since the early 1990s, this shortage caused frequent load shedding, i.e., scheduled power stoppage especially during the dry season when the hydropower stations lose the water flow for generation. However, such situation has been improved by the construction of new hydropower stations such as Kali Gandaki A station completed in July 2002. Middle Marsyangdi and other several hydropower stations are also to start operation soon and those stations are expected to solve the present issue of the shortage of generation capacity until around the year 2013.

The relatively smooth development of the generating facilities stated above, however, has disclosed the weakness of power transmission and distribution facilities in Kathmandu, the capital in Nepal. In addition, the recent prevalence of computer equipment raised public interest to eliminate the present unreliable power supply with frequent interruption

There are two specific problems which cause the unreliable power supply. One is the limited current carrying capacity of the 11kV Ring Main Line and the other is the limited capacity of the 66/11kV transformers in Patan Substation (S/S). At present, the power supply to the central Kathmandu depends on K2 switching station (SW/S). K2 SW/S is located in the premises of Nepal Electricity Authority (NEA) head office and the power for this station is supplied through 11kV Ring Main Line from Patan S/S and Lainchaur S/S. The current carrying capacities of both 11 kV Ring Main Line from Patan S/S to K2 SW/S, and the 11kV Underground Line from Lainchaur S/S to K2 SW/S are limited. During the peak time the load shedding for some areas or load shifting to the other separate substations become necessary to manage the power shortage. Even the failure of one circuit among those lines will cause failure of power supply in wide area in Kathmandu. For the transformers in Patan S/S being overloaded, any failure of one bank among the two will also cause blackout of wide area. Construction of a new substation, K3, together with new transmission line to replace the K2 SW/S is the drastic measure for those problems in the power sector.

The Project for Extension and Reinforcement of Power Transmission and Distribution System in Kathmandu Valley (Phase-3), (the Project) includes the construction of K3 S/S, and is recommended in the Final Report of the Master Plan and Feasibility Study on Extension and Reinforcement of Power Transmission and Distribution System in Kathmandu Valley in Nepal (1991, JCA).

The Project was within the scope of "Extension and Reinforcement of Power Transmission and Distribution System in Kathmandu Valley (Phase-II)" (1994～1997), according to the master plan. However, since development of the power stations had not been satisfactory at that time, it was judged that the construction of K3 S/S was unfavorable for power balance in Nepal. It can be easily forecasted that the construction will raise the un-welcomed demand of electricity in the central

Kathmandu. Thus, the construction of K3 was postponed. Since the postponement was determined, His Majesty's Government of Nepal (HMG/N) has been requesting the Government of Japan to extend the Japan's Grant Aid for this Project again.

Based on the request, the Government of Japan had decided to conduct the "Basic Design Study on the Project, having the construction of K3 S/S as its main component. Hence, the Japan International Cooperation Agency (JICA) had dispatched a Basic Design Study Team to Nepal from April 9 2002 to May 2, 2002. The Team held several discussions and conducted field surveys at site. In Japan, the Study Team continued analysis of data brought back, then finalized the Draft Basic Design Report, and explained the report to HMG/N during the second dispatch from August 31 to September 12, 2002.

Through the series of investigations and analysis, the Project components were formulated as shown below.

1) Construction of K3 S/S
2) Construction of 66 kV Underground Transmission Line（Teku S/S－K3 S/S）
3) Modification of Teku S/S
4) Extension of 66 kV switchgear at Siuchatar S/S
5) Installation of Remote Terminal Unit (RTU) at K3 S/S
6) Installation of Optical Fiber Cable（Siuchatar S/S－K3 S/S）

The Project components stated above were selected throughout the study of the application and other request, based on the following 4 criteria.

(1) Realization of Basic Effects
Components shall be the equipment or facilities directly contribute to realization of the main aims of the Project, i.e. improvements of power supply capacity and reliability.

(2) Difficulty of Execution by Recipient Country
Procurement and installation of the components shall be financially and technically difficult, if such procurement and installation are made by Nepalese side.

(3) Contribution to Continuous and Effective Operation/Maintenance
Components shall contribute to continuous and effective operation/maintenance of the whole Project equipment or facilities.

(4) Contribution to Completeness of Project Facilities
Even if the components are not the main equipment or facilities, the components shall be essential to realize the effects of the Project as a whole.

The components requested by HMG/N, and the components finally formulated as the scope of the Grant Aid through the procedures described above scope of the Grant Aid, are compared and tabulated in Table－1.

Table－1 "Requests in Application or during Site Survey" and "Components for the Project and Reason"

Requests in Application or during Site Survey	Components for the Project and Reason
1. Construction of K3 S/S	
(1) Construction Site A vacant lot of riverbank of Tukucha river	（Changed） Premises of Singha Durbar. Markets were constructed in the Tukucha river side and this interrupts land acquisition.
(2) 66/11 kV Transformer (TR) 6MVA single-phase type TR 7 sets （6 sets + 1 set for spare）	（Changed） 18 MVA 3-phase type TR 2 sets 3-phase type is employed due to a limited space. Recent technical innovation realized high reliability of TR, so that a spare is cancelled for economical reason.
(3) 66kV Switchgear GIS type	（As per application）
(4) Control and Relay Panels for 66 kV circuits 11 kV and Low Voltage Cubicles	（As per application）
2. 66 kV Transmission Line (T/L) Type ： Overhead T/L Route ： Along Bagmati river and Tukucha river	（Changed） Type ： Underground T/L Route ： Along main streets Due to environmental change, land acquisition and EIA become serious problem if overhead T/L is employed.
3. Modification of Teku S/S "Additional 66kV switchgears may be required"	（Included in Components） Installation of additional switchgear or cable terminals, and modification Due to employing underground T/L, this modification becomes indispensable.
4. Extension of 66kV switchgear at Siuchatar S/S "Additional 66kV switchgears may be required"	（Included in Components） Extension of switchgear for 1 bay Siuchatarf S/S is the power source for K3 S/S. Hence, the extension of switchgear is indispensable.
5. Remote Terminal Unit (RTU) Request during the site survey.	（Included in Components） Installation of RTU in K3 S/S For effective operation of K3 S/S by remote control from new LDC under construction, it is added in the scope.
6. Optical Fiber Cable Request during the site survey.	（Included in Components） Installation of Optical Fiber Cable This is essential not only for remote controlling but also protection for transmission line.
7. 11kV Underground Cable Request during the site survey.	（Excluded from Components） It was judged that NEA is capable enough to carry out the work, including the material procurement.

It is estimated that, 5 months are required from E/N to the completion of the detailed design, and other 15 months are necessary for the completion of procurement, installation and construction.

Implementation of the Project will create the following beneficial effects :

(1) Direct Effects

a) By constructing the new K3 S/S near the existing K2 SW/S, reliable power supply to the central Kathmandu can be secured.

b) Possibility of power failure at wide area in Kathmandu, due to the shortage of the capacity of 11kV Ring Main Lines to K2 SW/S, and of transformers in Patan S/S can be eliminated.

Indices for the above effect b) are shown in Table－2. The indices show the days per year of load shedding with the numbers of the consumers influenced in the figures of household and population, if the additional transformers are not installed under the Project. The first row from the right indicates the days of load shedding can be zero if the Project is implemented.

Table－2 Estimated Days of Load Shedding

Without Project Implementation				With Project
Fiscal Year	Consumers Influenced (Household)	Consumers Influenced (Population)	Days of Load Shedding (Days/Year)	Days of Load Shedding (Days/Year)
2005/06	2,700	14,100	9	0
2006/07	6,600	34,300	21	0
2007/08	10,600	55,300	47	0
2008/09	14,900	77,300	76	0
2009/10	19,300	100,300	103	0
2010/11	23,900	124,300	153	0
2011/12	28,700	149,300	187	0

(2) Indirect Effects

a) Reliable power supply in central Kathmandu obtained through the Project will stimulate the domestic economy.

b) Contribution of the Project to BHN（Reliable power supply to hospitals or schools etc.）can be expected.

c) Technology for maintenance obtained through the construction by Nepalese engineers, can be utilized by themselves for operation of K3 S/S and other substations in the whole Nepal.

In order to realize the effects of the Project, to maintain the effects, and to sustain the long-term operation of the Project facilities, due execution of the following matters by Nepalese side is essential.

(1) To connect K3 S/S and the existing 11kV distribution lines by 11kV underground cables, as soon as the construction of K3 S/S is finished.

(2) To carry out the periodical inspection for the facilities, with the aim of maintaining satisfactory performance of the facilities and early detection of troubles.

From the point of view of management and budget, NEA is capable enough for execution of the above two works.

Problems of land acquisition will not come out because the new substation is to be constructed in the government owned land, and the new 66kV transmission line is to be constructed in the public roads. Those facilities will not make any unfavorable influences to the inhabitant or environment.

TABLE OF CONTENTS

CHAPTER 1
BACKGROUND OF THE PROJECT

CHAPTER 1 BACKGROUND OF THE PROJECT

Power supply to the central Kathmandu is dependent on the K2 SW/S at present. The K2 SW/S is located in the lot of headquarter of Nepal Electricity Authority (NEA), and the power supply is made by 11 kV feeders from the Patan substation (S/S) and the Lainchaur S/S as shown in Figure 1-1.

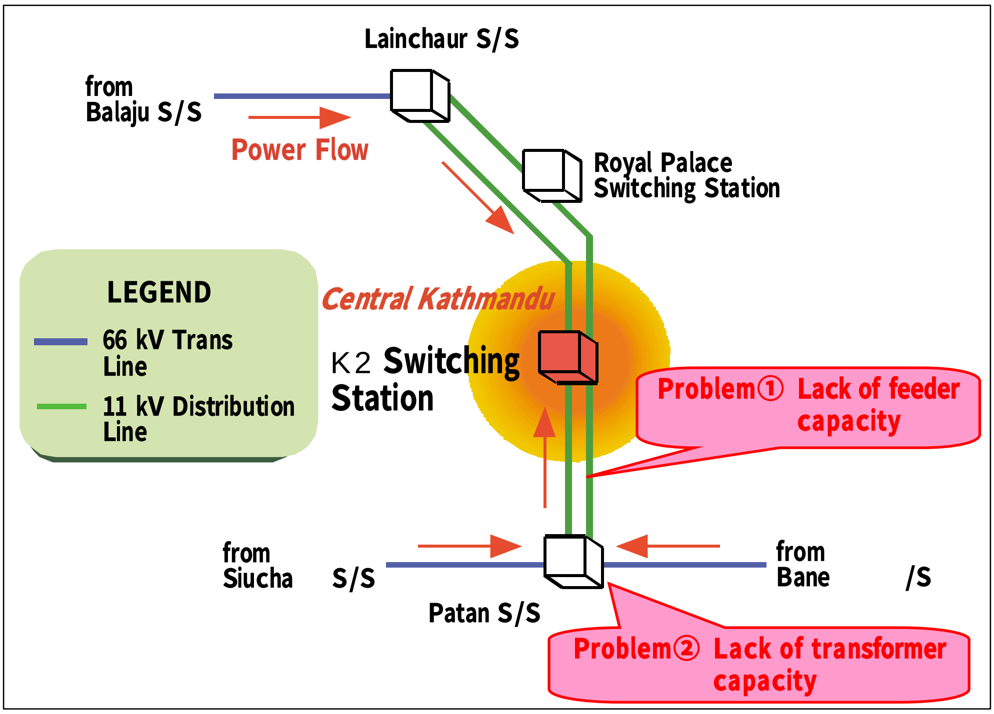


Figure 1-1 Power Supply to K2 SW/S

As of 2002, following issues are exposed on the power supply to the K2 SW/S.

① Lack of capacity of feeders to K2 SW/S

Conductor size of feeders from the Patan S/S to the K2 SW/S is about 125 mm^2 and the conductor is aging. The current carrying capacity is 10 MW (290 A x 2) by double circuit. According to NEA, because at the winter peak time of 2001/2002 the transmitted power of the feeders reached 100 % of the capacity, load shedding (i.e. scheduled power shutdown), and load shifting to the Bhaktapur S/S were made to supply the power to the K2 SW/S. Normally, transmission line of double circuits is designed with the conductor size, by which the required current for the S/S can be transmitted by only one circuit, during the accident on the other circuit. However, the feeders to the K2 SW/S can not meet this requirement. In other words, blackout in wide area would be caused by an accident even on the single line of the feeders.

② Lack of transformer capacity at Patan S/S

Usually, the peak load in Nepal including Kathmandu City occurs in winter season due to use of heaters. At the Patan S/S, the peak load value on June 2001 had exceeded the 66/11 kV transformer capacities (2 x 18 MVA). After that, by load management such as shifting the load of the Patan S/S to other stations, the peak load had been reduced to 83% of the transformer capacity in November 13, 2001. However, if an accident on any one of the transformers happens, it causes blackout in wide area. Even without accident, load shedding prevails to solve the overloaded condition.

In this way, by load shedding or load shifting, overload condition could have been cleared up to winter of 2001/02. It is urgently hoped to solve the problem because the transformers should go through at least two more winter seasons under current condition until the Project completes.

It is urgently needed to solve the above mentioned condition by reinforcing power supply capability to the central Kathmandu and cutting down of load of the Patan S/S. For that purpose, construction of the K3 S/S is absolutely imperative.

The existing condition and the condition after this Project are shown in Figure 1-2. In the existing circumstances, power is supplied from the Patan S/S to the K2 SW/S by the 11kV feeders of limited capacity. However, after this project, the overloads on the Patan S/S and the 11 kV feeders would be eliminated by supplying power through new route with the 66 kV transmission line having enough capacity

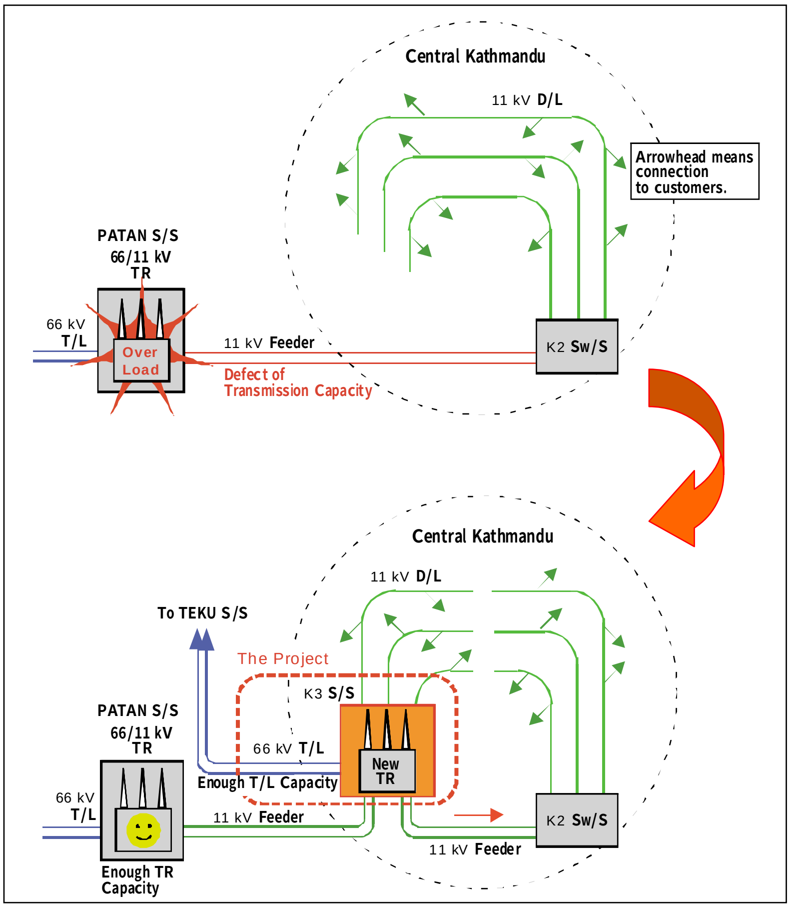


Figure 1-2 Status before/after K3 S/S Construction

Furthermore, in case of any fault on the 11 kV feeders between the Patan S/S and the K2 SW/S, the customers supplied by the existing 11 kV feeders were forced to suffer from blackout in the past. However, there will be no possibility of long blackout under faults on one circuit by power supply after the 66 kV double circuit transmission line is constructed.

Location of K2 SW/S and K3 S/S is shown in the figure of the opening page "Project Area and Concerned Facilities".

CHAPTER 2

CONTENTS OF THE PROJECT

CHAPTER 2 CONTENTS OF THE PROJECT

2.1 Basic Concept of the Project

(1) Master plan and project target

This Project is proposed by the Final Report of the Master Plan[1]. In the master plan, a concrete plan, in which targeted to develop facility of power supply in Kathmandu valley, to improve reliability of power supply and to decrease power loss, for reinforcement of transmission and distribution system was proposed. This Project is to construct a 66 kV substation (K3 S/S) in the central area of Kathmandu to achieve the targets in the said master plan.

Implementation of the Projects according to the master plan has proceeded under the Japanese Grant Aid[2] from outskirts of Kathmandu where inhabitant used to have fewer advantages in electrical service. This Project is the last component recommended in the master plan.

At first implementation of this Project was included in the plan of Phase-II (1994 - 1997). However, at that time the development of the power generation was behind the schedule and the generation capacity has shortage. This Project was postponed because implementation of the Project was considered to create the un-welcomed potential demand of Kathmandu area.

After that development of power generation has progressed smoothly, so, it can be said that the shortage of generation capacity is overcome. On the other hand, the lack of the capacity of transmission network, substation and distribution network due to increase of demand has become a new bottleneck of the power supply to the Kathmandu City. In this circumstance, this Project is now adopted aiming at the improvement of the ability and quality of power supply, especially at the Kathmandu central area.

(2) Outline of the Project

At present, the electric power supply to the Kathmandu central area is made by several 11 kV switching stations. In this Project, the electric power supply by the 66kV transmission line system is selected, which will have more capacity and reliability in comparison with the supply by 11 kV system. Then, the power is to be distributed through the K3 S/S to central area. By this, it is expected to drastically improve the capacity and reliability of the power supply to the center area of Kathmandu.

Works to be covered by this Project are as follows.

1) Construction of the K3 S/S
2) Construction of the 66 kV underground transmission lines (K3 – Teku)
3) Modification work at the Teku S/S

[1] Master Plan and Feasibility Study on Extension and Reinforcement of Power Transmission and Distribution System in Kathmandu Valley in Nepal (1991, JICA)

[2] Extension and Reinforcement of Power Transmission and Distribution System in Kathmandu Valley (Phase-I & II), 1992 - 1997

4) Extension of the 66 kV switchgear bank at the Siuchatar S/S
5) Installation work of the Remote Terminal Unit (K3) at the K3 S/S
6) Installation of optical fiber cable for the transmission line protection and the existing SCADA (K3 - Siuchatar)

2.2 Basic Design of the Requested Japanese Assistance

2.2.1 Design Policy

2.2.1.1 Basic Policy

(1) Scope of Japanese Grant Aid scheme is determined based on the following items as judgment criteria.

a) Realization of Basic Effects
b) Difficulty of Execution by Recipient Country
c) Contribution to Continuous and Effective Operation/ Maintenance
d) Contribution to Completeness of Project Facilities

"Realization of Basic Effects" is the item to study whether the components in the scope directly contribute to realization of the basic effects of the Project, i.e. improvement of power supply capacity and reliability.

"Difficulty of Execution by Recipient Country" is the item to study financial and technical difficulties of execution of components in the scope, in case of purchasing and construction of the components by Nepalese side.

"Contribution to Continuous and Effective Operation/ Maintenance" is the item to study whether the components in the scope duly contribute to continuous and effective operation/ maintenance of the whole Project equipment or facilities.

"Contribution to Completeness of Project Facilities" is the item to study how the components in the scope are essential to realize the effects of the Project as a whole, even if the components are not main equipment or facilities.

The components, which strongly "contribute" and "have more difficulty", were included in the scope of the Grant Aid with higher priority.

The priority of work items for Japanese Grant Aid scheme, resulted by this evaluation is shown in Table 2-19.

(2) Selection of the site

In this Project, selection of the sites are to be made for the two items, those are, the site for the K3 S/S and the site for the 66 kV transmission line route.

For both site selection, the criteria for selection are as follows.

a) Possibility of land acquisition
b) Influence to environment
c) Easiness or simplicity of operation and maintenance
d) Security
e) Easiness of construction works
f) Accomplishment of project purpose

Detail of site selection is described in Subclause 2.2.2, Basic Plan.

(3) Judgment criteria of facility scale and material selection

Facility scale

The main facilities, for which the selection of their scales or capacity is very important, are transformers of the K3 S/S and the 66 kV transmission line between the Teku and K3. The scales of other facilities are decided in accordance with scale of those main facilities.

(Transformer capacity of K3 S/S)

The transformer capacity is determined according to the following conditions.

a) Base of the demand forecast is the peak load of the K2 SW/S[3] in 2001.
b) Demand forecast is made based on the ratio of annual demand increase of Kathmandu.
c) Target demand is to be the value within about 10 years, based on the calculation by a) and b).[4]
d) Target demand calculated in c) is selected for the capacity of one transformer. Two (2) numbers of transformers[5] are installed in the K3 S/S.

(Conductor size of 66 kV transmission line between Teku and K3)

Conductor size of single circuit should have enough capacity for total transformer capacity of the K3 S/S and the Teku S/S[6]. Moreover, additional margin for the future extension of the transformer at the K3 S/S is also considered because the transmission line conductors could not be replaced easily after once they are strung.

[3] The area where the K3 S/S is scheduled to supply the power is also the area where the K2 SW/S supplies at present. Power supply to the K2 SW/S would be made from the K3 S/S after completion of this Project.

[4] Peak demand in Kathmandu, 119.03MW in 1996 increased to 147.87MW in 2001, with the annual ratio of 4.4%. The peak demand of the K2 SW/W in 2001, 12MW becomes 18MW after 10 years, if the ratio of 4.4% is considered.

[5] N-1 criterion is used worldwide when the scale of electrical facility is determined. By applying N-1 criterion, electric power is supplied continuously even under the situation that one of the transformers or transmission line circuits is in trouble or under regular maintenance as if the whole facilities operate normally.

[6] When the existing 66 kV transmission line between the Siuchatar S/S and Teku S/S is in trouble, the Teku S/S would be energized from the K3 S/S.

Material selection

Selection of the materials, i.e., overhead line or underground cable for 66 kV transmission line, is the most important study. In this study, the following points were the main criteria.

a) Possibility of land acquisition
b) Environmental influence

For the other equipment, generally the easiness of operation and maintenance was considered for the selection. Switchgear equipment in the K3 S/S was selected considering the compactness because of limited area and situation of the site.

2.2.1.2 Policy on Natural Conditions

(1) Temperature

Kathmandu has a warm climate, and monthly average temperature is shown in Table 2-1.

The recorded highest temperature was 35.2ºC in May, 1994, and the lowest temperature was –3.0 ºC in January, 1998.

Table 2-1 Monthly max. and min. temperature in Kathmandu (Unit : ºC)

	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec		average	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1991	17.7	2.1	22.9	3.8	25.3	8.2	27.5	10.7	28.6	15.5	27.8	19.0	28.2	20.3	27.9	19.7	27.8	18.4	26.7	12.5	22.1	5.7	19.1	2.5	25.1	11.5
1992	17.6	2.4	19.1	3.1	27.8	7.4	30.5	11.1	27.5	14.1	29.4	17.9	28.2	19.2	28.5	19.5	28.4	17.8	25.9	12.7	23.4	6.5	19.7	2.5	25.5	11.2
1993	18.5	2.8	21.8	5.4	23.1	5.9	26.8	10.6	27.9	15.4	28.7	18.7	28.3	20.3	27.9	20.1	27.5	18.1	27.1	13.2	23.4	8.1	21.1	3.9	25.2	11.9
1994	20.0	2.7	20.7	3.4	25.3	9.4	28.3	10.7	29.6	15.5	29.3	19.4	29.1	20.2	28.9	19.8	28.2	18.5	26.8	11.5	23.5	6.3	20.4	2.2	25.8	11.6
1995	17.8	1.1	19.6	4.2	25.4	7.5	29.3	10.4	31.5	16.4	27.8	20.1	27.7	19.8	28.2	19.5	27.6	18.1	27.0	13.2	23.2	8.0	19.5	4.7	25.4	11.9
1996	18.4	2.4	21.1	4.8	25.8	9.7	28.5	10.6	30.7	15.8	27.6	18.7	27.6	20.4	27.8	19.7	27.7	18.6	26.1	13.6	24.4	8.2	21.0	3.2	25.5	12.1
1997	18.0	1.7	19.5	3.0	25.0	7.6	24.6	10.6	28.5	13.8	29.4	18.0	28.6	20.2	28.6	19.9	28.0	18.2	25.2	10.6	22.9	7.1	18.5	3.8	24.7	11.2
1998	19.2	1.6	21.6	4.5	23.4	7.4	27.0	11.4	28.6	17.0	30.2	20.0	27.8	20.2	28.3	20.2	29.2	18.8	29.0	15.3	25.4	9.2	22.2	3.3	26.0	12.4

These temperatures are within the range of "Normal service condition" (for outdoor switchgear, minus 10.0ºC～40ºC) stipulated in IEC. No special conditions will be applied for equipment procured in this Project.

(2) Humidity

The humidity in Kathmandu is comparatively high. Humidity becomes more than 80 % on most days from June to February. Monthly average humidity is shown in Table 2-2.

Table 2-2 Monthly average humidity in Kathmandu (Unit: %)

	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec		average	
	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
1991	96	65	88	44	84	47	72	48	78	60	82	74	85	80	88	81	87	79	91	70	93	68	95	64	86	65
1992	98	69	92	57	71	36	56	35	75	63	77	65	81	76	85	83	85	82	90	73	91	67	96	70	83	65
1993	97	71	91	55	80	44	72	53	74	66	79	73	85	82	87	82	89	84	89	75	95	72	95	68	86	69
1994	96	67	92	56	83	56	61	42	69	57	83	73	83	78	85	80	87	84	89	67	90	69	96	67	85	66
1995	96	69	93	63	77	45	62	41	60	48	87	77	83	81	85	82	86	80	91	78	94	74	97	84	84	68
1996	98	75	94	63	77	54	64	44	63	55	81	78	86	79	87	83	87	80	90	76	93	75	96	66	85	69
1997	97	68	94	73	78	53	77	64	72	54	76	64	83	82	89	81	86	77	91	72	93	69	97	74	86	69
1998	96	63	93	58	81	58	73	54	79	71	77	68	88	81	90	85	86	81	88	78	91	74	98	59	87	69

However, this humidity does not require any special requirement for the equipment used.

(3) Precipitation

Kathmandu valley receives about 1,000 – 1,700 mm of precipitation in a year as average of Nepal (In Tokyo, the precipitation is about 1,400 mm). The rainy season is in May – September with about 100 – 500 mm of precipitation in a month. Maximum precipitation is 100 mm in a day. Average monthly precipitation during 1991 – 1998 is as follows.

Table 2-3 Monthly precipitation in Kathmandu (Unit: mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1991	21	11	45	106	145	114	190	281	128	0	0	25	1,068
1992	6	17	0	45	70	233	224	220	209	51	16	3	1,093
1993	10	15	42	87	185	204	296	294	156	15	2	0	1,306
1994	27	19	14	8	142	414	254	446	243	0	12	0	1,579
1995	3	29	40	3	61	591	336	404	101	38	62	7	1,674
1996	71	15	7	47	58	338	319	486	207	52	0	0	1,600
1997	16	6	14	100	90	245	511	371	71	12	5	87	1,528
1998	0	21	67	43	117	194	292	302	51	60	9	0	1,155
ave.	19.3	16.6	28.6	54.9	109	292	303	351	146	28.5	13.3	15.3	1,375

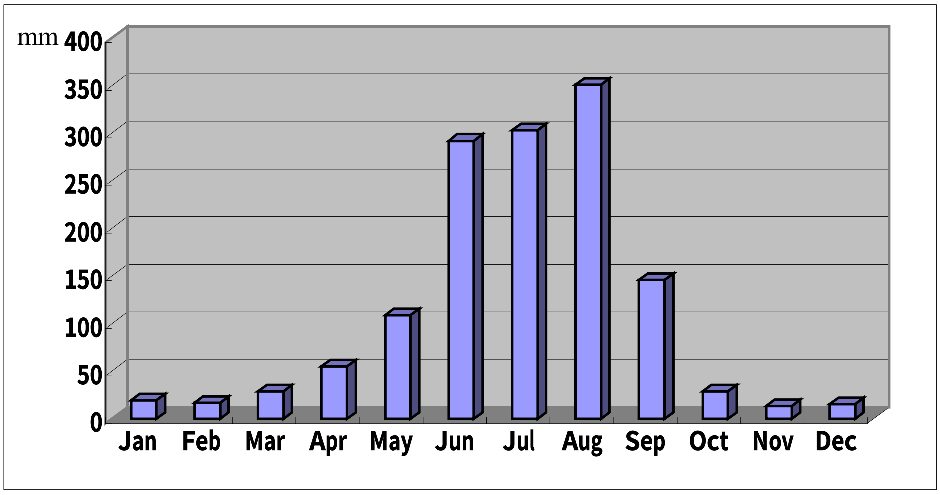


Figure 2-1 Monthly precipitation in Kathmandu (average mm in 1991 – 1998)

This precipitation does not affect the design of the equipment procured under the Project. However, as described in Subsection 2.2.4.1, inland transportation becomes difficult during the rainy season, and excavation of the public roads is prohibited during the rainy season.

(4) Wind scale

Maximum wind velocity observed at Kathmandu airport meteorological observatory in 1994, is 26.75 m/s, which is less than the value in Japan.

From the above-mentioned natural conditions, the materials and facilities to be selected under this Project will not employ any special design against natural conditions.

2.2.1.3 Policy on Conditions of Socio-economy

Because the construction work of the substation building could be done by the local contractor, design and cost estimation were made on the local bases. By taking this step, the local firms could have chances to join the Grant Aid projects and the materials available in local market could be used in this Project as much as possible, this would give good effects to the local economy.

People in Nepal have generally moderate character, but the Maoist (anti-government armament organization) makes terrorism recently. Therefore, attention on security should be paid during the transportation & storing of materials, and construction. That is, to store the materials and equipment in the K3 S/S premises in Singha Durbar or other substation premises as much as possible is preferable. Also assistance of local police may be requested through Nepalese Government during inland transportation, as far as possible.

2.2.1.4 Policy on Material Procurement and Construction

(1) Authorization and permission on the Project execution

Land for K3 S/S

NEA, which is the executive agency of recipient country's government, has got permission already from concerned authority to construct a substation in the yard of Singha Durbar. (Refer to Appendix-4 : Minutes of Discussion, and Appendix-6 : Land allocation for the construction of the substation at Singha Durbar)

Permission of Road Excavation

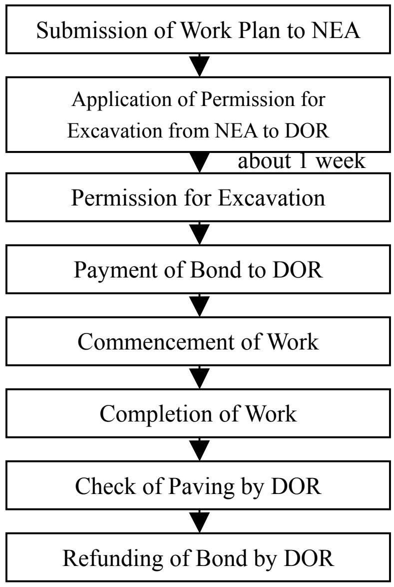


Figure 2-2 Process of Getting Permission for Excavation

Permission for road excavation to install underground cable is needed. NEA would get this permission from the Road Department based on the excavation work schedule made by a contractor. The process of getting permission for the excavation is shown in Figure 2-2. Application of this permission should be made as early as possible to carry out the construction work smoothly.

EIA

According to the Environmental Protection Act, 2053, execution of Initial Environmental Examination (IEE) or Environmental Impact Assessment (EIA) is obliged prior to any project implementation. In case the impact to the environment by the project is small,

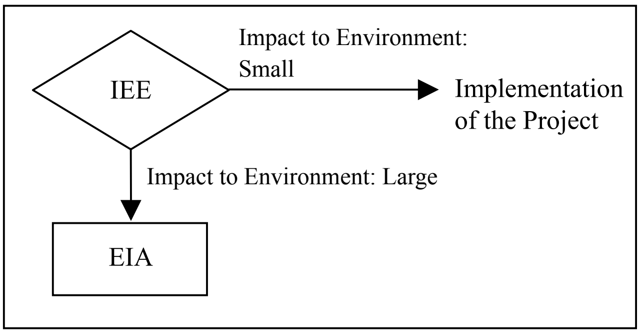


Figure 2-3 IEE and EIA

then only IEE is carried out. However, if the impact by the project is judged to be large, EIA will be required as shown in Figure 2-3.

According to NEA, EIA is surely needed for the construction of 66kV transmission line, if the line is of overhead type and it goes across the important areas such as parks or city area. However, from the past experiences, NEA expects that IEE is enough for this Project because the underground transmission line is designed and the line route goes through the public roads. It is recommended that confirmation on this matter is made as early as possible.

(2) Standard

Basically internationally accepted standards such as IEC, JIS, BS, and ASTM will be employed in the design of this Project. However, the international standard like IEC especially, does not specify every detail respect of the electrical equipment. Thus, in case there is any detailed items not specified in IEC or NEA's specifications, such as structure of cubicle and thickness of its plate, the Standards of The Japanese Electrical Manufacturer's Association (JEMA) would also be applied as supplement of IEC.

Main standards to be used for the Project are shown in Table 2-4 with the related items, but not limited to.

Table 2-4 Main standards to be used

Item	Main Standards
Transformer, GIS, Outdoor Switchgear	IEC
Control Panel, Cubicle	IEC、JEM
Cable, Wire	IEC、BS、JCS
Telecommunication Equipment including optic fiber cable	IEC、ITU
Architecture & Civil Design and Material Geological Investigation	BS、ASTM、JIS、IS
Others (Steel structures, Insulator, etc.)	ANSI、ISO、BS

(3) Level of local manpower and materials

It is judged from the experience of the past similar projects that the capability and quantity of local manpower are enough for this Project if the instructions of Japanese technicians were available. This point is reflected to the construction plan.

The local materials to be procured are limited to the civil and building materials only.

2.2.1.5 Policy on Use of Local Contractor

It is a policy to utilize local contractors as much as possible, because the technical level of the local contractor is acceptable level under the appropriate instructions and control.

Regarding the construction of the K3 S/S, it is planned that the K3 S/S would be constructed by the local contractors under the control of a Japanese contractor.

Regarding the installation of the equipment, Japanese staff takes charge of important works such as management of each construction teams (i.e. substation equipment installation team and 66 kV cable installation team), 66 kV cable jointing work and wiring check of control cables. Other works would be done by local workers.

2.2.1.6 Policy on Control and Management Capability of Implementation Agency

Transmission Line/Substation Construction Department, which is under control of Transmission & System Operation Bureau, is the implementation agency in charge of this Project. After completion of the Project, operation and maintenance work would be done by the Grid Operation Department of the said Bureau. The Grid Operation Department has been taking charge of operation and maintenance for many existing substations already. Those departments of NEA have no problems with regard of project implementation.

The connection work of 11kV underground cables from the K3 S/S to existing 11 kV distribution lines is to be made by NEA as agreed. The work would be actually done by Kathmandu Central Division of Distribution & Customer Service. Because the department has experienced the similar works in the past, capability of the connection work will not be a problem. Thus, it is strongly expected that the cable connection works to be done by the Nepalese side is made in parallel with the 66 kV cable installation works of Japanese side, so that the road excavation will not be repeated.

However, it must be noted that their work speed would not be the same as the speed by Japanese side. Furthermore, preparation of the necessary budget or tendering for the materials procurement will take time with Nepalese own procedures. Considering such uncertain factors, the good cooperation between Nepalese side and Japanese side is required during the cable installation works by the both side.

2.2.1.7 Selection of Facilities and Equipment

Regarding the main equipment of the K3 S/S such as transformers, GIS, 11 kV cubicles and 66 kV power cables, and switchgear for the Siuchatar S/S, standard class Japanese-made equipment will be used. Such equipment can continue operation over 20 or 30 years under the suitable maintenance.

The switchgear at the Siuchatar S/S should be of conventional type following the existing switchgear, because operation and maintenance of the new switchgear can be made in common with the existing one.

A substation building has an auxiliary function to accommodate the indoor type substation equipment. Thus, local materials or products will be basically used for its construction.

2.2.1.8 Method of Construction and Procurement, Construction Schedule

The 66 kV underground cable installation and civil works of substation should be completed before the rainy season from June to August. And such work schedule will not be employed so that the cable installation or other soil works are done both before and after the rainy season with temporary stoppage. Such stoppage of soil works will not be cost-effective. Installation of substation equipment and indoor wiring work can be continued during rainy season.

Excavation with excavators would be applied mainly. However, excavation by manpower is also applied for the place where a excavator could not be mobilized in, such as underground cable work at the narrow road. Night work might be employed for the excavation work especially at a crowded road

For the construction schedule, it would take about a half year for design and manufacturing of materials and equipment, about 1.5 months for transportation, and about 10 months for construction including the rainy season when the road excavation is prohibited. After overlapping each work items efficiently, still 12 months are necessary to complete the construction after the contract for construction is verified. Detail of the implementation schedule is explained in Sub-clause 2.2.4.8.

2.2.2 Basic Plan

2.2.2.1 Total Plan

(1) Summary

In addition to the items requested in Application Form, some other items were also requested at the time of the site survey. All the items finally requested by Nepalese side, and final items to be covered by Japanese Assistance with reason of selection are listed below.

Table 2-5 Requested items and Final scope of Japanese assistance

Requested Items	Final Scope of Japanese Assistance
(1) Construction of K3 S/S	○
(2) Construction of 66 kV transmission line (Teku S/S – K3 S/S)	○
(3) Modification at Teku S/S	○
(4) Extension of 66 kV switchgear at Siuchatar S/S	○
(5) Installation of RTU at K3 S/S	○
(6) Installation of optical fiber cable (Siuchatar S/S – K3 S/S)	○
(7) 11 kV underground distribution lines	Excluded

Note: ○ : Items included in Scope of Japanese Assistance.

[Reasons of selection]

Item (1) – (4)

The items No. (1) to (4) included in the scope of Japanese Assistance are the equipment and facilities which directly contribute to the improvement of the capability and reliability of power supply to the Kathmandu center area.

In other words, these equipment and facilities are selected as they are indispensable items for realizing the basic effects. And another reason of selection is that the construction of the K3 S/S and 66 kV transmission line by Nepalese side are judged difficult technically and financially.

Item (5) & (6)

The items No. (5) and (6) included in the scope of Japanese Assistance are the equipment and facilities which would greatly contribute to the continuous and effective operation and maintenance of power supply system in Kathmandu central area.

Operation and maintenance are being made by the Load Dispatching Center[7] (LDC) to supervise and control the power stations and substations intensively. The Remote Terminal Unit (RTU) is the equipment for power stations and substations to be supervised and to be controlled and the RTU has functions to send the data to LDC and to receive the control command from the LDC.

NEA is planning to upgrade the function of the LDC to realize highly efficient and reliable network operation. NEA proceeds to construct a new LDC by the German grant aid in the Siuchatar S/S yard at present. Power stations, which are connected to the power network, of 5 MW or more and substations of 66 kV or more would be supervised and controlled by the LDC, which would be completed in February 2003. The K3 S/S will also be supervised and controlled by the LDC to operate efficiently as a part of power network. In this way, it can be said that the RTU highly contributes to not only effective operation but also long term operation and maintenance of the K3 S/S.

Optical fiber cable is applied for data communication of supervising and control between the LDC and the K3 S/S, and is also applied for 66 kV transmission line protection between the Siuchatar S/S and K3 S/S. Because the transmission line protection system by optical fiber cable, named "Current differential relaying system" has high reliability by detecting a fault on the transmission line accurately. The system will contribute the long term operation and maintenance of this Project.

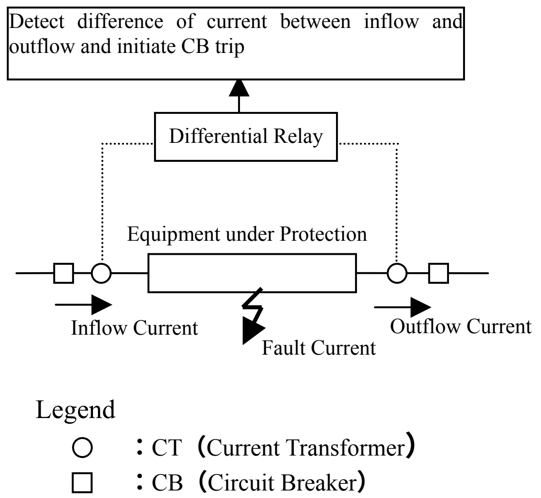


Figure 2-4 Current Differential Relaying System

[7] The existing LDC has been constructed by Japanese Grant Aid financial cooperation in 1987 at the NEA head office site.

11kV underground line

Including construction of 11 kV underground line in the scope of Japanese Assistance was requested strongly by the Nepalese side. However, this work was excluded from the scope.

The construction cost of those 11 kV connection lines is estimated to be 0.1% of the total annual budget of NEA's operation and maintenance in FY2000/2001. No special arrangement for the budget allocation by Nepalese Government seems necessary.

11 kV underground lines are to connect the K3 S/S and the existing 11 kV distribution lines. Unless those works are completed, no effects of the Project will be realized. Although this is the important component of the Project, it can be judged that, technically and financially, this work can be done by Nepalese side, while the timely completion of the work is the matter to be well managed.

Arrangement of the main facilities of the Project described above is shown in the figure "Project Area and Concerned Facilities" in the opening page.

(2) Deviation from Application Form

This Project has been planned on the basis of Master Plan made in 1991, and the application form dated June 2000 was also made according to the Master Plan. Therefore, there are many items to be reconsidered, such as site condition changed greatly comparing with the condition of those days in 1991.

The requests and the selected components with reason for selection are shown as follows.

Table 2-6 “Requests in application or during Site Survey” and “Components for the Project and Reason”

Requests in Application or during Site Survey	Components for the Project and Reason
1. Construction of K3 S/S	
(1) Construction Site A vacant lot of riverbank of the Tukucha river	(Changed) Premises of Singha Durbar The reason for change and result of study of alternative plans are shown in [Reason for change-1]
(2) 66/11 kV transformers (TR) 6 MVA single-phase type TR 7 sets (6 sets + 1 set for spare)	(Changed) 18 MVA 3-phase type TR 2 sets Space for substation is smaller than the site of Master Plan. Spare transformer is cancelled by economical reason and recent technical innovation of reliability of transformers.
(3) 66 kV switchgear GIS type 66 kV circuit: 4 circuits 66 kV bus: single bus system	(As per application)
(4) Control and Relay Panels for 66 kV circuits 11 kV cubicles (Metal enclosed type) Station TR, Low Voltage Cubicles	(As per application)
2. 66 kV transmission line (T/L) Type : Overhead T/L Route : Along Bagmati river and Tukucha river	(Changed) Type : Underground T/L Route : Along main street The reason for change and result of study of alternative plan are shown in [Reason for change-2]

3. Modification at Teku S/S "Additional 66 kV switchgear may be required"	(Included in Components) Installation of additional switchgear and modification Due to employing underground T/L, modification becomes necessary.
4. Extension of 66 kV switchgear at Siuchatar S/S "Additional 66 kV switchgear may be required"	(Included in Components) Extension of switchgear for 1 bay Siuchatar S/S is the power source for K3 S/S. Hence, the extension of switchgear is indispensable.
5. Remote Terminal Unit (RTU) Request during the site survey	(Included in Components) Installation of RTU in K3 S/S For effective operation of K3 S/S by remote control from new LDC under construction, it is added in the scope.
6. Optical Fiber Cable Request during the site survey	(Included in Components) Installation of Optical Fiber Cable This is essential not only for remote controlling but also protection for transmission line.
7. 11 kV Underground Cable Request during the site survey	(Excluded from Components) It was judged that NEA is capable enough to carry out the work, including the material procurement.

[Reason for change-1]

Site for Substation

3-candidate sites for substation including Bagh Bazar site mentioned in the application form were compared and studied.

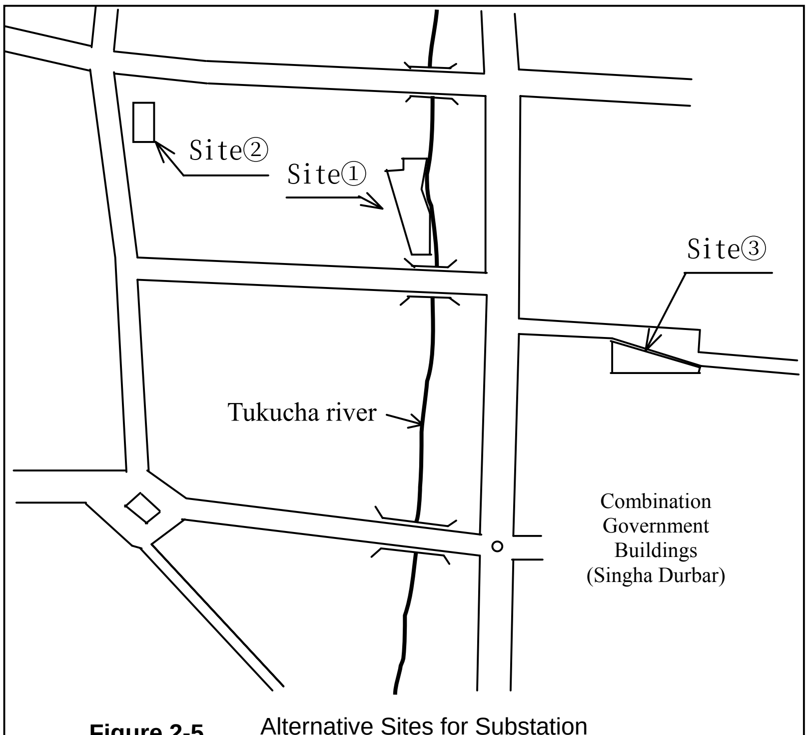


Figure 2-5 Alternative Sites for Substation

① Site of Application Form: Bagh Bazar

Site of the K3 S/S was planned at a vacant lot along the Tukucha River of the Bagh Bazar area in the Application form. However, the lot has already been utilized as market, which is the one of the biggest market in Kathmandu. Because the land acquisition of the area is impossible, this idea has been cancelled.

② NEA Headquarter Compound

As an alternative plan of ①, NEA headquarter compound was proposed. However, this compound has narrow margin for construction of substation. And there is anxiety of attacking by the antigovernment force because the area is on-limits for public.

③ Singha Durbar (Combination Government Building Compound)

As further alternative plan, this site has the following advantages.

- Security during construction and after completion
- Easiness of the 11 kV feeder connection work to the existing distribution lines
- Effects of reducing the load of the existing nearby substations and reducing the transmission loss of power, because this site is near the Putalisadak and Kalikasthan areas where there is heavy demands
- Possibility of extension of substation capacity by NEA in future to meet with the increment of electrical power demand, because there is another vacant lot belonging to the Government.

Table 2-7 Comparison of 3 candidates for substation site

Candidate sites / Items for comparison	**Plan by Application** **Bagh Bazaar** Note 1)	**NEA Site** **Durbar Marg** Note 1)	**Final Site** **Singha Durbar** Note 1)
Possibility of Land Acquisition	× Impossible	○	○
Effect on Environment	○	□ Necessary to cut existing Parking space	○
Easiness of Operation & Maintenance	○	× Impossible to extend in future	○
Security	×	□	○
Easiness of Construction	□	○	○
Effect for realize of the Project	○	○	○
Result	×	×	○

Note 1) **Evaluation**

× : Difficult or Disadvantageous ○ : Very Easy or more Advantageous

□ : Rather Easy or Advantageous

[Reason for change-2]

Underground Transmission Line

The 66 kV transmission line route of application form was planned with overhead line. However, the situation around the planned line route has changed. Due to densely built-up houses and other facilities along the original overhead line route, underground line system has been chosen.

The original overhead line route and 2 alternatives of underground line routs are shown in Figure 2-7.

① Transmission line route of Application Form
Overhead line: Blue dotted line in Figure 2-7

② Underground line route of plan-A
Underground line (Final plan): Red line in Figure 2-7

③ Underground line route of plan-B
Underground line (Alternative plan): Red line and partially red dotted line in Figure 2-7

[Reason for Selection of Underground Line]

Comparison of general advantage and disadvantage of overhead line and underground line is shown in Table 2-20. It is clear that the underground line has more advantages even with its higher cost. And, although the overhead line route mentioned in the application form is along the Bagmati River, there is a plan of constructing park on the river bank named "UN Park"[8]. Therefore it was judged that the land acquisition of the river bank was difficult. Furthermore, construction of the tower and/or post is impossible at the consecutive part of the route toward the north along the Tukucha River because of cluster of houses. The underground line is selected considering the said general advantages and peculiar issues of the overhead line route of original plan.

[Reason for final underground line route selection]

The alternative plan-B (red dotted line in Figure 2-7) is also studied. However, that plan has difficulty of space for crossing the Tukucha River. Meanwhile, the final route plan-A maintains enough space to cross the river and has shorter route length. On this account underground line plan-A is selected as the final plan. The short cut route crossing the army compound and/or residential area were not employed because the urban redevelopment is expected in future and route along the main street is more recommendable for the maintenance.

For the plans of the K3 S/S site and the 66 kV transmission line route, the comparison between the alternatives, from the application stage to the final plan, is shown in more detail in Figure 2-8 from (1/3) to (3/3).

[8] Construction of UN park has been planned since 4 years ago by the Urban Development Housing Bureau of Ministry of Public Service

In Plan 3 of Figure 2-8 (3/3), 66 kV underground cable route runs Bhrikutimandap Marg, i.e., Plan (B) of Figure 2-7 is shown. However, the final route employed Prithvi Path, south side by one block, because of the technical difficulty of Tukucha River crossing, i.e., Plan (A) of Figure 2-7 is selected.

2.2.2.2 Substation Equipment and Facilities

Outline specifications of main substation equipment is shown in Tables 2-8, 2-9, 2-10 for each substation.

(1) K3 S/S

Table 2-8 Outline specifications of main substation equipment for K3 S/S

Name of item	Quantity	Specification	Purpose of use
1) Main transformer (Note-1)	2 units	18/22.5 MVA (ONAN/ONAF) 3-phase type Rated voltage: 66/11 kV Oil immersed type (Accessories) Conservator Radiator OLTC (On Load Tap Changer) BCT (Bushing type Current Transformer)	To transform the voltage of 66 kV to 11 kV for distribution Most important equipment of substation
2) Gas Insulated Switchgear (GIS)	1 set	Rated voltage: 72.5 kV Rated current: 80 A Breaking current: 20 kA (Component) Transmission line bay: 2-bay Transformer bay: 2 bay Bus-tie bay for section of bus (with only disconnecting switch): 1 bay	To switch the electric power of 66 kV, and to break the fault current at the accident on the transmission line and transformer.
3) Control panel for GIS transmission line bay	2 panels	(Component) Switches and meters to operate the switchgears in the 66 kV GIS transmission line bay Relays to protect underground transmission line	To operate the GIS for transmission line To protect the underground transmission line
4) Control panel for transformer	2 panels	(Component) Switches and meters to operate the switchgears in the GIS transformer bay, transformer and bus tie equipment Relays to protect transformers	To operate the GIS transformer bay, transformer and bus tie equipment To protect the transformers

Name of item	Quantity	Specification	Purpose of use
5) 11 kV switchgear (Cubicles)	1 set	Rated voltage: 12 kV Breaking current: 25 kA (Component) Incoming feeder circuit breaker cubicle (1-CB in 1-cubicle): 2 nos. Outgoing feeder circuit breaker cubicle (2-CBs in 1-cubicle): 6 nos. Bus tie circuit breaker cubicle: 1 no. Station service transformer cubicle (11/0.4-0.23kV, approx. 100kVA) : 1 no.	To switch the electric power of 11 kV. To break the fault current on the distribution line feeder etc..
6) AC low voltage cubicle	1 set	Metal enclosed type	To supply low voltage AC power to GIS, control panels, relays, 11 kV cubicles and station service auxiliary power circuits. To operate/protect the auxiliary power circuit such as lighting
7) DC cubicle	1 set	Rated voltage: DC 110 V (Component) Battery charger, Distribution panel Alkaline rechargeable batteries	To supply uninterruptible DC power source for control circuits such as GIS, control panels, etc To protect DC circuits
8) Terminal unit for optical communication system	1 set.	Wave length: 1.31 μm Core: 8 cores Speed: 2 Mbps (Component) Terminal box for optical cable Optical/Electrical signal converter Multiplexer	Terminal unit for optical cable from Teku S/S (Protection for T/L, tele-control and communication)
9) Remote Terminal Unit (RTU)	1 panel	Binary signal: approx. 130 nos. Analogue signal: approx. 30 nos.	Terminal unit for tele-control from Siuchatar LDC
10) Telephone system	1 set	Intercom by cable communication and external telephone link	Communication among control room, manager room and cubicle room etc., and external telephone line
11) 66 kV CV cable	150 m	For 66 kV line voltage Single core 500 mm^2 Copper conductor	Connection from GIS to main transformer
12) Gas insulated end terminal for 66 kV cable	6 nos.	66 kV CV cable SF6 Gas use Single core 500 mm^2	End terminal for GIS side of above cable 11)
13) Oil immersed end terminal for 66 kV cable	6 nos.	66 kV CV cable Insulation oil use Single core 500 mm^2	End terminal for transformer side of above cable 11)
14) 11 kV CV cable	400 m	11 kV Single core 325 mm^2 Duplex per phase Copper conductor	Connection from main transformer secondary terminal to 11 kV cubicle

Name of item	Quantity	Specification	Purpose of use
15) Indoor type end terminal for 11 kV cable	24 nos.	11 kV CV cable Indoor, air insulation type Single core 325 mm^2	Both end terminal for above 11 kV cable of 14)
16) Miscellaneous materials	1 lot	Control cable Cable rack Copper conductor for grounding, etc.	Auxiliary materials for installation and operation of the equipment stated above

(Note-1)

(Reason for selection of voltage class)

The voltage class of 66/11 kV was selected by the following reasons.

Nepalese standard transmission and distribution line voltages are 132 kV, 66 kV, (33 kV for limited area) and 11 kV. The voltage class was selected among them because standardization of the voltage class will minimize operation and maintenance cost.

And voltage class should be selected from the above stated classes to minimize the initial cost and transmission loss. In other words, selection of high voltage of 132 kV for short distance like this Project will cause excessive initial cost and less effect of loss reduction. Selection of voltage class of lower than 33 kV is not economical because even though the initial cost is lower but loss becomes large. The 66 kV is optimum design for the K3 S/S same as the Teku S/S and the Baneswar S/S, which are the existing substations of almost same scale as the K3 S/S. And, the 11 kV is optimum for distribution line voltage class, because the existing distribution lines around the K3 S/S are of 11 kV.

(2) Siuchatar S/S

Because the existing switchgear of the Siuchatar S/S consists of the conventional outdoor type switchgear, the outdoor type switchgear is also selected for the extension switchgear in this Project for maintenance purpose.

Table 2-9 Outline specifications of main substation equipment for Siuchatar S/S

Name of item	Quantity	Specification	Purpose of use
1) Gas circuit breaker	1 no.	Rated voltage: 72.5 kV Rated current: 800 A Breaking capacity: 20 kA Motor charged spring type Including support structure	To break the huge fault current safely
2) Disconnecting switch for feeder circuit	1 no.	Rated voltage: 72.5 kV Rated current: 800 A Including grounding switch and support structure	To keep open the circuit steadily after breaking by circuit breaker. For transmission line circuit with a grounding switch for safety
3) Disconnecting switch for bus circuit	2 nos.	Rated voltage: 72.5 kV Rated current: 800 A Including support structure	To keep open the circuit steadily after breaking by circuit breaker.
4) Current transformer	3 nos.	Rated voltage: 72.5 kV Current ratio : 600-300/5A Burden: 50 VA x 2 cores Including support structure	To convert huge current to measurable current
5) Voltage transformer	1 no.	Rated voltage ratio : 66/√3 kV:110 V Burden: 200 VA x 2 cores Including support structure	To convert huge voltage to measurable voltage

Name of item	Quantity	Specification	Purpose of use
6) Lightning arrester	3 nos.	Rated voltage: 60 kV Discharge current: 10 kA Including support structure	To protect the substation equipment from abnormal high voltage such as lightning
7) Control and relay panel for 72.5 kV switchgear	1 no.	Arrangement of panel is to be same as existing panels. Front: control panel Rear: Relay panel	To operate and control the conventional outdoor type switchgear.
8) Terminal unit for optical communication system	1 set	Wave length: 1.31 μm Core: 8 cores Speed: 2 Mbps (Component) Terminal box for optical cable Optical/Electrical signal converter Multiplexer	Terminal unit for optical cable from Teku S/S (Protection for transmission line, tele-control and communication)
9) Miscellaneous materials	1 lot	Control cable Cable rack Overhead line conductor Insulator set, etc	Auxiliary materials for installation and operation of the equipment stated above

(3) Teku S/S

Table 2-10 Outline specifications of main substation equipment for Teku S/S

Name of item	Quantity	Specification	Purpose of use
1) Lightning arrester	3 nos.	Rated voltage: 60 kV Discharge current: 10 kA	To protect the substation equipment from abnormal high voltage such as lightning
2) Line protection relay panel for 66 kV transmission line	1no.	Self supported type Current differential transmission line protection relay	Teku S/S side equipment to protect the transmission line to K3 S/S
3) Terminal unit for optical communication system	1 set	Wave length: 1.31 μm Core: 8 cores Speed: 2 Mbps (Component) Terminal box for optical cable Optical/Electrical signal converter Multiplexer	Terminal unit for optical cable from K3 S/S and Siuchatar S/S (Protection for transmission line, tele-control and communication)
4) Voltage transformer	3 nos.	Rated voltage ratio: 66/√3 kV:110 V Burden: 200 VA x 2 cores Including modification of support structure	To convert big voltage to measurable voltage
5) Miscellaneous materials	1 lot	Control cable Lead wire, etc	Auxiliary materials for installation and operation of the equipment stated above

2.2.2.3 Transmission Line Materials

The specifications of major materials for transmission line are shown in Table 2-11.

Table 2-11 Outline specifications of main transmission line materials

Name of item	Quantity	Specification	Purpose of use
1) 66 kV CV cable	23 km (For 3.5 km transmission line)	66 kV line voltage Single core 500 mm^2 Copper conductor	To transmit the power from Teku S/S to K3 S/S
2) Flexible pipe for cable laying	22.7 km (For the cable of above 1))	Polyethylene flexible pipe 125 mm dia.	For cable laying work without keeping excavated road open
3) Air insulation type end terminal for 66 kV	6 nos.	66 kV CV cable Air insulation Single core 500 mm^2	To tap from existing overhead line to underground line in front of Teku S/S
4) Gas insulated end terminal for 66 kV cable	6 nos.	66 kV CV cable SF6 Gas Single core 500 mm^2	To connect 66 kV cable to GIS at K3 S/S
5) Straight joint for 66 kV cable	84 nos.	66 kV CV cable Single core 500 mm^2	To joint for above cable 1)
6) Cable trough for Tukucha river crossing	1 set	Steel made 6 nos. of 66 kV cable and 1 no. of optical cable	For crossing point of Tukucha river.
7) Underground optical cable	3.9 km (For horizontal length of 3.5 km)	SM type 8 cores	For communication between Teku S/S and K3 S/S
8) Overhead optical cable	5.0 km	SM type 8 cores Self-supported type (ADSS)	For communication between Siuchatar S/S and Teku S/S. To be procured from third country (Note-2)

(Note-2)

(Reason for procurement from the third country)

Composite Fiber Optical Overhead Ground Wire (OPGW) is normally applied to string optical cable on transmission line in Japan. Even though the self-supported type optical cable with supporting wire to be strung on distribution line is produced in Japan, optical cable of high-tension type for long span stringing along with transmission line without supporting wire (ADSS) is not produced in Japan. Therefore, the overhead optical cable (ADSS) would be procured from the third country to cope with the existing system under German project.

2.2.2.4 Substation Building Construction

(1) Site arrangement plan

Singha Durbar selected as the site of this Project is combination government building compound for various ministries and administrative agencies of Nepalese government, and its location is center of the ring road surrounding Kathmandu area, in other words it is located at the center of Kathmandu. There is a guarantee of security in the area because the 1 km x 1 km square compound is surrounded by high brick wall and entrance gate is strictly guarded. Because of the combination government building, the infrastructures such as electrical distribution line, telephone line, water supply system and sewerage system, are well prepared.

The scheduled site for the K3 S/S is indicated in Figure 2-6. Figure 2-7 shows the location in the overall Kathmandu.

Figure 2-6 Scheduled site for K3 S/S

The location of the K3 S/S is planned at the middle of northern edge of Singha Durbar premises. Outside of the wall, the substation site is facing a branch road from a main road named Ram Shah St. which is running from north to south at the west side of Singha Durbar. Traffic of the branch road is relatively light.

The site has a triangle shape. The length of the edge of the site along the existing wall is about 70 m. The site is sloping. The elevation of the east side is higher and the west side is lower with the difference of about 3 m. Predetermined area of substation building is concaved as shown in the basic design drawing Fig. C-1.

General arrangement of the substation is so planned that the west wide area is for a substation building and the middle part is for parking area, and then the far east narrow part is for planting as seen in Fig. C-2.

The access road to the site is available from southern side. However, because of the level difference by the concave, leveling is necessary before construction starts.

①from Outside to Inside, view of Singha Durbar

②from Inside to Outside, view of Singha Durbar

Photograph 2-1 K3 S/S Site

(2) Building construction plan

The size of the substation building is determined with basic space for the equipment and with the maintenance space for the equipment. And arrangement of the cubicle room at the ground floor is designed with minimum extension space for future. The height of the ground floor is determined from the maintenance of GIS, and the height of the first floor is from control rooms, so that the roof of the transformer room is higher than technically required height. However the roof is maintained flat and is made simple. Description of the main rooms of the K3 S/S building is shown in Table 2-12.

Table 2-12 Description of the main rooms

Name of rooms	Use/Space	Note
Ground floor	(Ref. drawing Fig.C-3)	
1) Transformer room	Installation of 2 units of transformers (Approx. 150 m^2)	Even though the transformers could be installed outside, the transformers are installed indoor because of landscape conservation, noise prevention, and hiding of important facilities to prevent the attack by anti-government force.
2) GIS and cubicle room	Installation of GIS and cubicles (Approx. 170 m^2)	Includes the space for maintenance and future extension.
3) Mini-work shop	Space for repairing of GIS and cubicles (Approx. 10 m^2)	This space is next to the GIS and cubicle rooms without partition. There is an actual working space of much more than 10 m^2.
4) Store room	Space for storage of spare parts and tools (Approx. 20 m^2)	

5) Battery room	Space for storage of batteries (Approx. 10 m^2)	
6) Entrance foyer and toilet etc.	(Approx. 30 m^2)	
1st floor	(Ref. drawing Fig. C-4)	
6) Control room	Installation of control, communication panels and low voltage panels (Approx. 60 m^2)	
7) Manager room	Manager room (Approx. 30 m^2)	
8) Office room	Space of office (Approx. 40 m^2)	3 operator per shift (3 shifts per day) and 2 or 3 engineers for stand-by are considered.
9) Meeting room	Meeting room (Approx. 20 m^2)	Meeting of a manager and staff is considered.
10) Kitchen, dinning and others	(Approx. 80 m^2)	

(3) Geological condition

The result of geological site investigation, which is subcontracted in Kathmandu, suggests that the allowable bearing capacity of soil is 12 ton/m^2 at the depth of -2.5 m. No special foundations such as piles will be used. Footing foundation will be used.

2.2.3 Basic Design Drawings

The basic design drawings are attached hereto and the list of those drawings is shown in Table 2-13.

Table 2-13 List of Basic design drawings

1	C-1	K3 S/S	Topographical Map
2	C-2	K3 S/S	General Arrangement
3	C-3	K3 S/S	Ground Floor Plan (GIS, Cubicle and Transformer Room)
4	C-4	K3 S/S	1st Floor Plan (Control Room, Office and Manager Room)
5	C-6	K3 S/S	Front View (South Side) and Rear View (North Side)
6	C-7	K3 S/S	Side View (East Side & West Side)
7	C-8	K3 S/S	Section at A-A of Fig. C-3 & Fig. C-4
8	C-12	K3 S/S	Arrangement of Lighting Fixture at Gound Floor
9	C-13	K3 S/S	Arrangement of Lighting Fixture at 1st Floor
10	C-14	K3 S/S	Connection Diagram of AC/DC Lighting Panel
11	KS-1	K3 S/S	Single Line Diagram
12	SS-1	Siuchatar S/S	66 kV Switchgear
13	TS-1	Teku S/S	Cable Termination and Substation Equipment
14	TS-2	Teku S/S	Teku S/S Plan
15	TL-1	66kV T/L	66kV Underground Cable Route and Cable Joint
16	TL-2	66kV T/L	T/L Cable Conduit and Joint Space

2.2.4 Procurement and Construction Plan

2.2.4.1 Procurement Policy

(1) Source of procurement and transportation route

Equipment and materials to be procured under this Project are the equipment and materials necessary for construction of substation and transmission line, and most of the materials would be procured from Japan except overhead optical cable which would be procured from the third country. Transportation route of the procured goods to Kathmandu is as follows.

Japan – ocean transport – India (Calcutta) – inland transport – Nepal (Kathmandu)

The third country procurement is made from European Union (EU), and then ocean transport would be done from EU to India (Calcutta) in this case.

Custom clearance of Nepal side is made at Birgunj boundary between Nepal and India. Inland transportation is made during dry season (October - March), because the transportation route from Calcutta to Kathmandu is steep mountain pass and the road is used to close over the long term by landslide and fallen rocks.

(2) Exploitation of local procurement

Regarding the equipment and materials of substation and transmission line, there are no local manufacturers. Local procurable materials are for civil and building construction of substation building.

2.2.4.2 Construction Policy

(1) Exploitation of local contractor

The local contractor could be exploited for the substation building work under the control of Japanese contractor. And the local contractor could be exploited for the substation and transmission line equipment installation work under the control of a Japanese contractor except technically sensitive works stated in following clauses.

(2) Necessity of foreign technical supervisor

The 66 kV underground cables have already been installed by foreign contractors at the several existing power stations and substations in Nepal. However, the local contractor has experienced to lay the cables up to 11 kV class normally.

On the other hand, regarding the 66 kV cable, trifling defect at the construction stage causes the fatal damage on the cable. Especially, because the infection of impurity in the jointing part of 66 kV cable leads directly to ground fault of the cables, dispatching the Japanese engineers and technicians, such as underground cable construction engineers, chief inspectors for cable joint work and technicians for cable end terminator, is absolutely essential.

Regarding the substation equipment, especially on the transformer and GIS, because not only the infection of impurity to the equipment is closely-linked to the duration of life of them but also there is manufacturer's original technical know-how, the detached engineers from a manufacturer, such as substation construction engineers and technicians for assembly, alignment and test, are required.

Regarding the optical cable for communication, because connection work of optical fiber cores could not be done by local technicians, the detached engineers from manufacturer, such as communication engineers and technician for optical fiber cable terminators, are required.

And because the test after installation should be done under manufacturer's responsibility, the testing engineer should be dispatched.

(3) Implementation agency of recipient country

Implementation agency of Nepal in this Project is Nepal Electricity Authority (NEA), and department in charge is Transmission Line/Substation Construction Department of Transmission & System Operation Bureau.

The Department has the staff of 11-engineers and 12-administrative officers or assistant staffs such as computer operators. For implementation of this Project, one of the above mentioned engineers and assistant staffs would be assigned as counterparts.

2.2.4.3 Implementation Condition on Procurement

The procurement of the materials except overhead optical fiber cable to be procured from the third country is made in Japan. There are no special conditions on materials procurement.

Because the specifications should be interfaced with the cable applied in the LDC project financed by Germany, the overhead optical fiber cable would be procured from Germany, i.e., EU. As already explained in the clause 2.2.2.3, there is not equivalent cable made in Japan. If the Japanese OPGW or optical cable with supporting wire were applied as alternative, material and construction cost would be higher and it is economically disadvantageous.

2.2.4.4 Implementation Condition on Construction

(1) Prohibition on road excavation

The Road Department does not allow the road excavation work during June to August of rainy season. Then, the 66 kV cable work with cable jointing and cable end termination work after laying cable should be completed before rainy season to prevent the defective work. Therefore, pipe installation, cabling, and re-pavement works should be done before the end of May.

(2) Interface with the existing power network

Because the K3 S/S is the new substation and is to be constructed apart from the existing power system, power interruption on the existing system for construction purpose is not necessary.

For the extension work at the Siuchatar S/S, the work is to be done next to the existing outdoor switchgear bay, long term power interruption is not necessary. The extension can be made by shutdown of one of the two bus conductors.

At the Teku S/S, power interruption for the modification work is necessary only a few days, because the modification work is on the circuit unused.

Schedule of the work with power interruption is to be proposed by a contractor and checked by a consultant engineer. Then, if the schedule is found reasonable, the power interruption will be arranged by NEA. In the past Grant Aid projects (Phase-I and Phase-II), positive cooperation and assistance had been given by NEA for the interruption.

(3) Safety work

Underground cable work is carried out in the public road. To prevent any accidents caused by construction work on the public, arrangement of partition wall, watch man and guide plate at the excavation sites should be made. The work should be carried out in the night as much as possible.

Because the construction works at the 3 substations are to be carried out in the isolated sites from public, accident prevention is possible to take steps to prevent an accident among the workers themselves. Therefore, usual safety measures are placed particular emphasis on traffic accident of the work vehicles, injury on workers, and so on.

(4) Access control to Singha Durbar

The access to Singha Durbar is strictly controlled by the army. Passes with photographs are necessary for those who will work in Singha Durbar. Foreigners can enter by showing his passport. And access in the midnight (22:00 – 16:00) is prohibited.

Documents required for obtaining the pass are as follows.

- Identification document: 1 copy (Nepalese: ID card and Citizenship Certificate, Foreigner: Passport)
- Photograph: 2 pieces (same as Passport photo)
- Letter of request to the competent authority (NEA) to process application of the pass
- Car number for entry (Private car without pass is not allowed to enter)
- List of materials and tools carried on (Goods are to be checked by the list when getting in and out at the check point)

2.2.4.5 Scope of Works

Scope of works, regarding the construction, procurement and installation for Japanese side and Nepalese side are shown in Table 2-14.

Table 2-14 Scope of Works for Japanese side and Nepalese side

Work item／Procured item		Japan	Nepal
K3 S/S			
	1. Substation Equipment（including RTU）	○	
	2. Building Construction	○	
	3. Initial Leveling of Site		○
Siuchatar S/S			
	1. Substation Equipment including installation	○	
Teku S/S			
	1. Substation Equipment including modification	○	
66kV transmission line			
	1. 66kV underground cable and optical cable	○	
11kV distribution line			
	1. 11kV distribution line (connection to existing distribution line including procurement)		○

Work boundary on the 11 kV electric power system between Japanese side and Nepalese side is at the terminal of 11 kV cubicle in the K3 S/S. The 11 kV distribution line work, which is Nepalese scope and is to connect terminals of the 11 kV cubicles and existing 11 kV distribution lines with underground cables, is technically easy for Nepalese side since NEA has experienced the similar works during the usual operation of his system.

The route of the 66 kV underground transmission line will run in parallel with Nepalese side's 11 kV cable routes from the point near the gate of Singha Durbar to the K3 S/S. If Nepalese side and Japanese side execute the cable installation works without any coordination, both sides have to carry out excavation and backfilling of the same road. Due to the heavy traffic around Singha Durbar, work schedule of Japanese side is so made that the pipes for cable installation is to be laid underground and backfilled in the same day without leaving any holes overnight. It will be effective and preferable if Nepalese side executes 11 kV cable installation simultaneously while the Japanese side is doing the same work, to prevent the repeated excavation of the same road.

Practically it is rather difficult to expect the both sides to do the above stated works simultaneously, due to the differences of work speed and manner. However, to prevent excavation of the blacktop around Singha Durbar repeatedly, Nepalese side is advised to execute his cable installation while Japanese side executes the same work.

2.2.4.6 Procurement Plan

(1) Quality control of materials

As the quality control of materials, check and approval of shop drawings, witness of shop inspection before shipping, witness of day-to-day inspection during construction and commissioning test shall be carried out.

Regarding the optical fiber cable procured from the third country, witness of shop inspection before shipping would be omitted. Then, approval of shop drawings, check of type test report and inspection at the installation would be criteria on quality judgment.

(2) Scope of spare parts

Absolutely imperative spare parts are supplied to maintain the effect of this Project continuously. Spare parts are categorized into "consumables" and "spare parts for repair". In this Project, consumables such as lamps, fuses, trip coils of circuit breaker, etc., and spare parts for repair to be replaced or re-filled promptly in case of failure such as SF6 gas, relays, meters, etc., are supplied.

Quantity of the spare parts is for about 2-years operation.

(3) Defect liability period

The defect liability period is 1-year.

2.2.4.7 Consultant Supervision

(1) Basic policy of construction supervision

The construction sites of this Project are three (3) substations and four (4) transmission line sites (concurrent work by 4 teams for transmission line). A consultant has obligation to supervise the 7 sites about daily progress and issues and to coordinate the workflow of each construction team including the manufacturer’s shop in Japan, and then to lead the Project to the completion without delay finally.

The site representative of the consultant engineer should keep close communication with relative parties to carry on the supervising works smoothly. And, he should coordinate the work from the beginning to the completion, keeping agreed matters with the related parties.

For example, the consultant will take care about application of pass for the contractor’s personnel at the same time of launching the work. And especially on the underground cable work, he should recommend a prevention measure on the trouble and/or accident with public to the contractor. At the same time, he should check the quality of construction on the both substation and transmission on daily base.

Furthermore, the information of the Project, such as progress, issues, future schedules will be shared among NEA and the contractor under coordination of the consultant through the weekly meeting etc..

(2) Specialty of supervisor

Regarding the supervision on construction of the K3 S/S, the consultant supervisors having the following specialty should be dispatched.

① Installation of substation equipment

An expertise supervisor is needed, who knows the mechanism of each equipment such as transformer, GIS, etc, and has the professional knowledge about sequence and connection diagrams to make the unerring judgment on the control system of the equipment.

② Civil and building work for substation

An expertise supervisor is needed, who knows the foundation for heavy equipment and building facilities. And because the different construction method comparing with Japan would be applied by the local contractor, the supervisor should have an ability and experience to make judgment on any issues regarding construction works by the local contractor beyond the binding of Japanese standard or Japanese practice.

③ Underground cable work

Even though it is one of the electrical works, the cable laying work of the 66 kV underground cable is quite different from substation work etc. and is of unique field. Not only the electro-technical ability but also the knowledge of cabling laying work through the long span piping with messenger wires without damage on the cables, and of quality control on cable joint work, and of safety control.

④ Communication work

An expert on communication system and on the tele-control system of substations, in other words, an expert on the SCADA, is needed.

2.2.4.8 Implementation Schedule

It will take 4.5 months for detailed design (from the consultant agreement to approval on the detailed design) and of 15 months for procurement and construction (from approval on the tender documents to the taking-over). Because the road excavation in rainy season (June -August) is prohibited, the underground line work should not be carried out in this season. And inland transportation in rainy season also should not be carried out because of dangerous transportation condition.

Project implementation schedule is shown in table 2-21.

2.3 Obligation of Recipient Country

2.3.1 Works to be executed by Nepalese Side

In this Project, the following works are the obligation of Nepalese side.

(1) 11 kV distribution line

The cable laying and connection work from 11 kV cubicles at the K3 S/S to the existing 11 kV distribution lines is obligation of Nepalese side as described in Sub clause 2.2.2.1.

Planned connection work to the existing 11 kV overhead distribution lines is consisting of 7-feeders (9-circuits) by underground cables.

Table 2-15 Existing 11kV overhead distribution lines to be connected to K3 S/S

Circuit	Name of feeder	No. of circuit	Route length (m)
①②	Ring Main (K2 S/S side)	2 - circuits	700 x 2
③④	Ring Main (Patan S/S side)	2 - circuits	650 x 2
⑤	Bhrikuti Mandap Feeder	1- circuit	300
⑥	Putalisadak Feeder	1- circuit	300
⑦	Anam Nagar Feeder	1- circuit	50
⑧	Singha Durbar Feeder	1- circuit	20
⑨	Babarmahal Feeder	1- circuit	450
Total route length			3,820

Note: Route lengths shown above are outline horizontal length of route, and not actual cable length

Each underground cable route is shown in Figure 2-9.

(2) Initial leveling of substation site

Because the substation site is lower than surrounding ground level, the rain water will flow into the site. Hence, initial leveling work of the substation site should be carried out by Nepalese side. The expected volume of soil for filling would be 1,800 m^3 approximately.

(3) Customs and Import Duty

Any customs and import duties are to be borne by Nepalese side, except "Take back deposit", which shall be deposited by a Japanese contractor for the returnable goods. In case any formalities by HMG/N are required for importing, those works are to be done by Nepalese side immediately.

(4) Taking permission of construction

NEA would submit the design drawings of building to the Singha Durbar redevelopment committee for approval when the design of substation was fixed. It would be checked mainly whether the exterior appearance of the building will match the other buildings in the premises. Permission by the other authority, such as Kathmandu municipality, Ministry of Construction, etc., is not required.

(5) Initial Environmental Examination

On the occasion of construction of the 66 kV transmission line and the K3 S/S if necessary, Initial Environmental Examination (IEE) would be carried out by Nepalese side. Considering the implementation schedule of this Project, IEE and other necessary approval on the environmental matters if any, should be preferably completed or obtained before the Exchange of Notes.

(6) Other duties and formalities

Except the items stated above, the following respects are under Nepalese obligation.

- Construction of water supply and sewerage system up to the site of the K3 S/S
- Construction of city telephone line up to the site of the K3 S/S
- Procurement of furniture for the K3 S/S, such as desks, chairs etc.
- Construction of boundary wall and garden (if Nepalese side judged necessary.)
- Preparation of the Banking Arrangement (B/A) and Authorization to pay (A/P)
- Tax exemption formality on the Project equipment and materials
- Various types of the tax exemption formality on the Japanese personnel

2.3.2 Project Cost Estimate for Nepalese Side

After implementation of the Project is determined, for executing all the above works, the following costs are to be borne by Nepalese side.

Table 2-16 Cost to be borne by Nepalese side

	Work Items	Cost
①	11 kV Distribution line connection	US$ 115,000
②	Reclamation by soil filling (Preparation of soil and initial leveling)	US$ 13,020
③	Wall construction	US$ 9,105
④	Telephone and water, drainage connection and furniture	US$ 2,500
	Total	US$ 139,625

In addition, the costs of the B/A and A/P are also to be borne by Nepalese side.

2.4 Project Operation Plan

(1) Project Operation

When this Project reaches the stage of operation and maintenance after the completion, the 66 kV transmission line and substation are to be operated by Bagmati Transmission Line Section/Grid OPERATION Division/Transmission & System Operation Bureau, and the 11 kV distribution lines are to be operated by Kathmandu Central Branch Office/Bagmati West Division/Distribution & Consumer Service Bureau.

At the K3 S/S, there would be 3-shifts of operators (2 or 3 operators per shift) and approximately additional 2 for stand-by are to be kept in reserve. Main work items of them are as follows.

- Data logging on the log sheet: Pre-determined date, such as voltage, current, power, etc., should be logged at every 30 min.
- Daily network operation: Operation of the substation equipment according to the order of LDC should be carried out.
- Response to the accident: At the occasion of accident on the distribution lines supplied from the K3 S/S, emergency operation for recovering should be carried out. In the case of accident on the 66 kV transmission line, operators should follow the instructions by LDC.
- Daily maintenance: Daily maintenance and checking should be carried out.

There is no problem in preparing operators required. They could be arranged in NEA.

(2) Maintenance

Daily maintenance and checking items are described as follows.

The maintenance and checking work consists of the daily inspection and periodical inspection with interval of approximately 3 months to 6 months. For example, to find the abnormal sound on the gas insulated equipment leads to finding the corona discharge caused by depleted insulation. Items of daily inspection and periodical inspection are listed below.

Table 2-17 Items of daily inspection and periodical inspection

Object equipment	Daily inspection	3-monthly inspection (unless otherwise mentioned)
GIS	・Abnormal sound ・Abnormal heating at terminals ・Cracking on insulator ・Other abnormal condition	・SF6 gas pressure (3 years interval) ・Operation check (every year) ・Cleaning
Main transformer	・Abnormal sound or vibration ・Abnormal temperature rise ・Insulation oil volume ・Oil leakage	・Absorbent condition (check/replace) ・N_2 gas pressure ・Deterioration test on insulation oil (every year)

Control panel	・ Condition of meters and lamps	・ Cleaning ・ Relay test （5～6 years interval）
11 kV cubicle	・ Abnormal sound and vibration ・ Condition of meters and lamps	・ Cleaning ・ Operation test on circuit breakers ・ Relay test （5～6 years interval）
Alkaline battery	・ Condition of terminals and batteries	・ Gravity test ・ Voltage measurement ・ Equalizing charge

Because the tele-control and supervision system and communication facilities by optical cable are in regular service, in case of trouble on the system, due corrective maintenance will be made.

These works could be carried out by NEA including the repairing work by communicating with the manufacturers if necessary.

(3) Estimated Operation & Maintenance Cost

Estimated annual cost of the operation and maintenance (O & M) for the Project facilities is as shown below.

Table 2-18 Estimated O & M cost

(NRs)

O & M Cost for Equipment (Cost for Spare Parts)	Personnel Cost Personnel Cost (Salary for Operators)	Total O & M Cost (per year)
1,400,000	1,200,000	2,600,000

"O & M cost for equipment" is the estimated cost for the spare parts including consumable parts such as fuses and trip coils for circuit breakers for one year.

The quantities for such spare parts to be provided under the Project are for approximately 2 years operation. Hence, for 2 years after the taking-over of the Project facilities, the required O & M cost per year will be NRs 1.2 million, and after 3 years the cost will be NRs 2.6 million.

Table 2-19 Priority of work items for Japanese Grant Aid scheme

No.		Item	Evaluation (3 step by ◎, ○, △) Point a)	Point b)	Point c)	Point d)	Priority
A.		Substation Equipment					
A.1		K3 Substation Equipment	◎	◎	△	◎	1
	1)	3-Phase, 66/11 kV Transformer, oil immersed, outdoor type, 18MVA(ONAN)/22.5MVA(ONAF),					
	2)	66 kV GIS					
	3)	Control panel, Relays & Other miscellaneous materials					
	4)	11 kV cubicles (2-incoming feeder, Bus-tie, STR & LV/DC cubicles)					
	5)	11 kV cubicles (6-outgoing feeder cubicles)					
A.2		K3 Substation Building Works with Electrical/mechanical Equipment	○	△	◎	◎	2
	1)	Building Works with Electrical/mechanical Equipment					
A.3		Siuchatar Substation	◎	○	△	◎	2
	1)	66 kV Outdoor switchgear					
	2)	Control & Protection equipment					
A.4		Teku Substation	◎	△	○	◎	2
	1)	Lightning arrester, Gantry arrangement & Protection equipment					
B.		66 kV Transmission Line					
B.1		Teku～K3 Underground Line 500mm2、Cu、1 core、2 circuit	◎	◎	△	◎	1
	1)	66 kV XLPE Cable, Cu - 500 mm2 (1 core, 2 circuits)					
	2)	Bushings, Terminations and Other accessories					
B.2		Self Supporting Optic Cable; Siuchatar～Teku Substations	△	○	◎	◎	2
	1)	Self Supporting Optic Cable (8 fibers)					
	2)	Fittings, Closures and Terminal equipment etc.					
C.		RTU					
C.1		K3 Substation	△	○	◎	◎	2
	1)	RTU for K3 Substation					
D.		11 kV Distribution Line					
D.1		11 kV Distribution Line with Accessories					
	1)	Ring Main to K2 (2 circuits)	◎	○	△	◎	2
	2)	Ring Main to Patan (2 circuits)	◎	○	◎	△	2
	3)	Babarmahar Feeder	◎	△	△	○	3
	4)	Bhrikuti Mandap & Putalisadak Feeders	◎	△	△	○	3
	5)	Singha Durbar-Wall & Singha Durbar-Inside Feeders	◎	△	△	○	3

Note:
- Point a) Possibility of Realization of Basic Effects — Possibility : High ◎ - ○ - △ Low
- Point b) Difficulty of Execution by Nepalese side — Difficulty: High ◎ - ○ - △ Low
- Point c) Contribution to continuous and effective operation and maintenance — Contribution: High ◎ - ○ - △ Low
- Point d) Contribution to Completeness of Project Facilities — Contribution : High ◎ - ○ - △ Low

For the meaning of Point a) to Point d), refer to Sub-clause 2.2.1.1..

Table 2-20　Comparison of Overhead line and Underground line

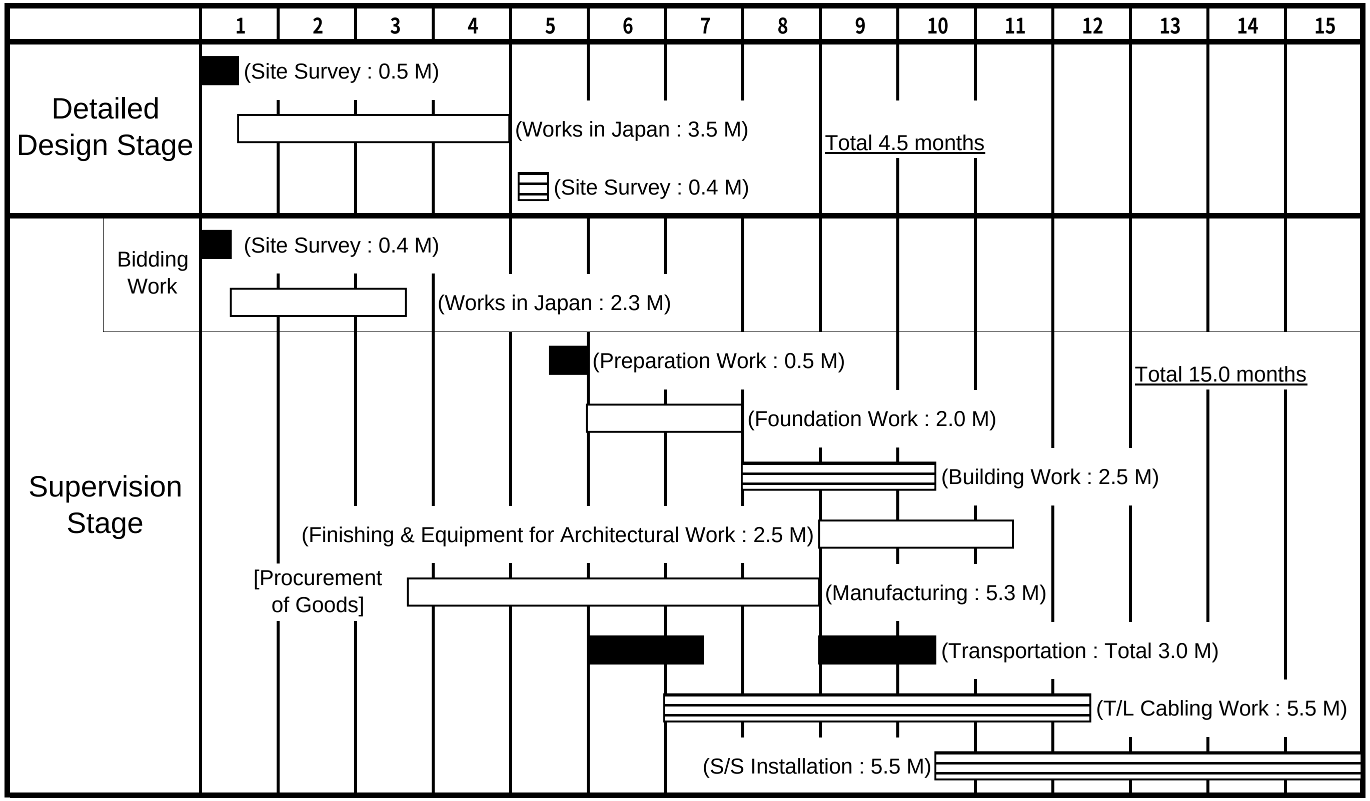
Item	Evaluation[1)]		Supplementary Explanation
	Under-ground line	Over-head line	
Cost（lower is better）			
1. Material cost		◎	Material of underground line (U/G) is higher than overhead line (O/H).
2. Construction cost		○	Construction cost of U/G is higher than O/H.
3. Land expropriation cost	◎		U/G does not require land acquisition, while O/H require acquisition cost for tower and compensation cost for conductor crossing.
Environmental effect（lower is better）			
4. Possibility of inhabitant move	○		None for U/G.　Necessary for O/H.
5. Effect on landscape	◎		None by U/G.　Strong effect by O/H.
6. Electric wave obstacle (TV, Radio)	◎		None by U/G.　Possibility of strong effect by O/H.
7. Influence to the inhabitant under transmission line	◎		None by U/G.　Possibility of electromagnetic effect, danger for contact, lower appraisal of estates by O/H may cause objection from inhabitant.
Construction term（shorter is better）			
8. up to Land expropriation	◎		Only permission from DOR for U/G.　Land acquisition for O/H will cause much delay of Project.
9. up to Environmental influence evaluation	◎		Only Initial Environmental Evaluation (IEE) may be necessary for U/G.　IEE plus Environmental Impact Assessment (EIA) for O/H will be needed.　High possibility of rejection on O/H through EIA.
10. Construction period			Distance is short.　No difference.
Difficulty　（easier is better）			
11. Insure safety	◎		No problem for U/G.　Strong care for O/H is required.　Towers of 20～30m height in city area, stringing works above houses are required for O/H.
12. Difficulty of work		△	Night work for U/G.　Cable connection for U/G is difficult.　Care for safety above houses for O/H is required.　Construction of O/H is technically not difficult.
Operation & maintenance（easier is better）			
13. Safety during operation	◎		No care for U/G is necessary except accident by excavation work. O/H is exposed to possibility of accident.　Care for building construction for O/H is required.
14. Trouble restoration		○	Extremely low possibility of accident for U/G.　Once accident occurs, restoration is difficult for U/G.　Restoration is easy for O/H.
15. Expandability		△	Branching is difficult for U/G.　Branching is easy for O/H. However, very low possibility of branching for K3 substation.
Liability（higher is better）			
16. Reliability of power supply	◎		High for U/G.　Less for O/H because it is exposed.　Ground fault by trees or thunder are examples.
Impact as grant aid			
17. Visual recognition		◎	U/G can not be seen except by small marking on the road. Everybody can see O/H.
18. Image	◎		Inhabitant and tourist will have bad images against O/H
Result	Better	Worse	

Note 1)　**Evaluation**

△:　Normal　　◎:　Excellent

○:　Good　　Blank:　No difference

Table 2-21 Implementation Work Schedule



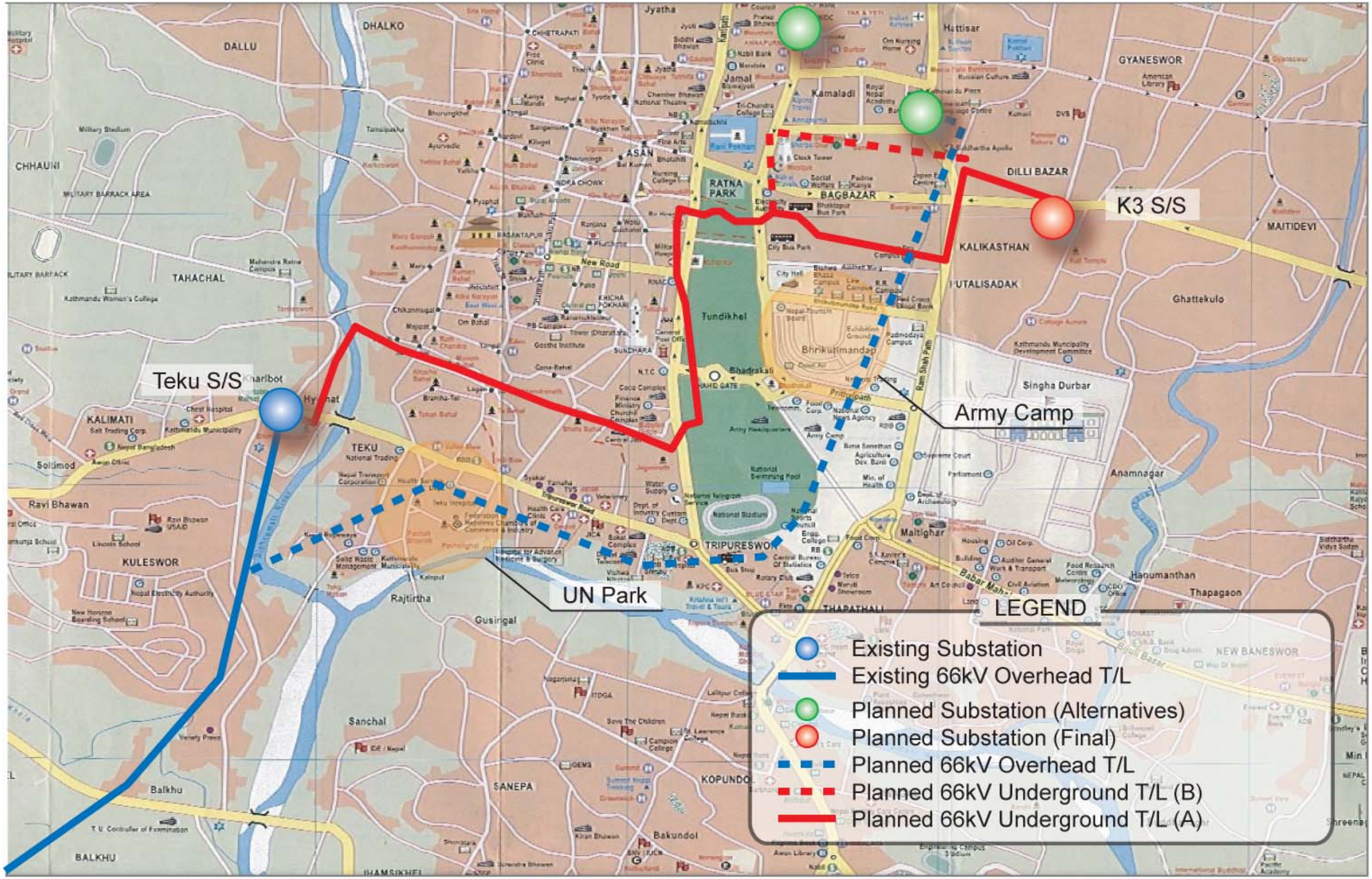


Figure 2-7 Substation Site and Transmission Line Route

Plan 1: ：Originally Requested Plan (From Master Plan Survey)

①Existing 66kV Overhead T/L

②Bagmati River

③Left bank of Bagmati River

・Planned Construction Site of K3 S/S: Bagh Bazar Area

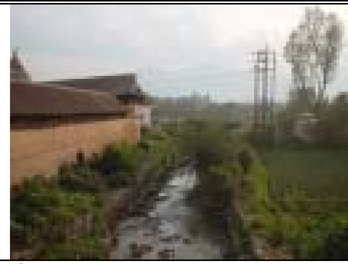
・Length of New 66kV Transmission Line: about 3.2km (Overhead Line)

It goes South along Existing T/L (Photo①) from Teku S/S, goes East on left bank of Bagmati river (Photo②&③) , goes North along Tukucha river（Photo④・⑤）, then comes to Substation site（Photo⑥).

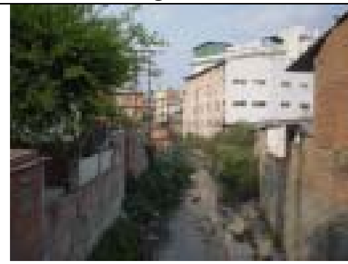
There is enough space in Bagmati river bank. However, there is a plan of UN Park.

Along Tukucha river, full of houses with multi-floors are built. Difficulty of land acquisition can be foreseen.

Nepalese side suggests high possibility of REJECTION on overhead line by EIA.



④Southern Edge of Tukucha River



⑤Built-up Area along Tukucha River

⑥Planned Construction Site of S/S

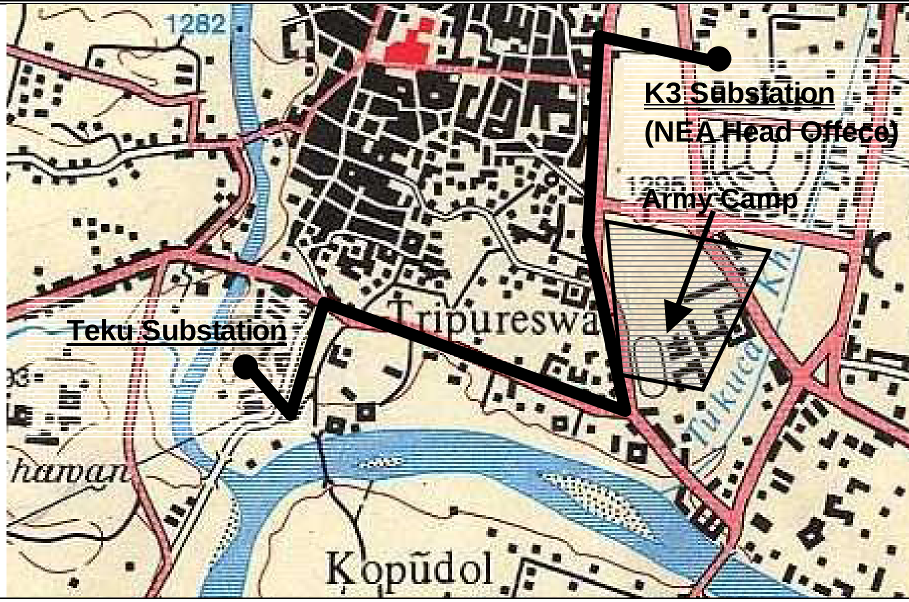
Figure 2-8（1/3） Plan 1: Original Requested Plan

Plan 2: Suggested Route as a Result of Prior Survey by Consultant

①Street in front of Teku S/S

②Lagantol Area

③Tripureshwar Marg Street



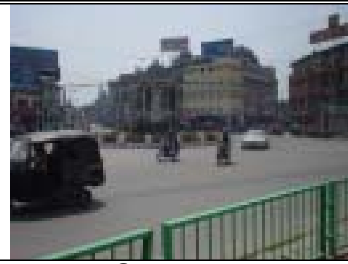
・Planned Construction Site of K3 S/S: <u>inside of NEA Head Office</u>

・Length of New 66kV Transmission Line: <u>about 2.8 km (Underground Line)</u>

It goes North from Teku S/S (Photo①), then goes East along Tripureshwar Marg (Photo③) via intersection (Photo④), goes North again along Kanthi Path (Photo⑤), goes East through pavement passing through Ratna Park (Photo⑥), then comes into site in NEA premises. The cable runs along main street with sidewalk, so if cable is installed on sidewalk side, repairing of blacktop will not be necessary. Of course, at several section, road crossing which require blacktop is necessary.

In Lagantol area (Photo②) on North side of Tripureswar Marg, all roads are narrow and such roads may be demolished in future development. At left bank of Tukcha river, there is Army Camp. Area is not suitable for short cutting of cable route.

Nepalese side suggested possibility of crossing Ratna park, subject to Government approval.



④Intersection

⑤Ratna Park West

⑥Pedestrian Way in front of NEA Head Office

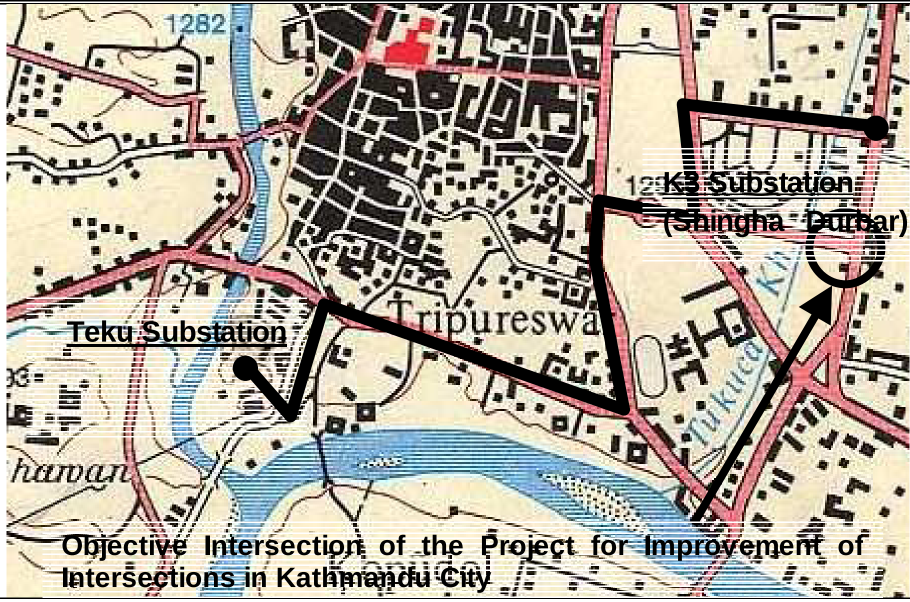
Figure 2-8 (2/3) Plan 2: Power Supply by Underground Transmission Line to K3 S/S in NEA Premises

Plan 3: Finally Requested Plan by Nepalese Side

①Intersection to Prithvati Street

②Radna Park South

③Durbar Marg Street



④Intersection in front of Singha Durbar

⑤Planned Construction Site of K3 S/S

・Planned Construction Site of K3 S/S: <u>inside of Singha Durbar</u>

・Length of New 66kV Transmission Line: <u>about 3.3 km (Underground Line)</u>

It goes same as Plan 2 until it goes North on Kanti Path. From Kanti Path, it turns East to Prithvi Path, then turn North at Bahdarakali intersection and goes along Durbar Marg. It comes to Bhrikutimandap Marg and comes to North side of Singha Durbar which is planned to be final site.

This plan is similar to Plan 2. However, intersection in front of Singha Durbar front gate is one of the objectives of ongoing「Project for Improvement of Intersections in Kathmandu City」. Attention is necessary for planning cable installation to minimize damages on new pavement etc. under this Intersection Project.

Figure 2-8（3/3） Plan 3: Final Requested Plan by Nepalese Side

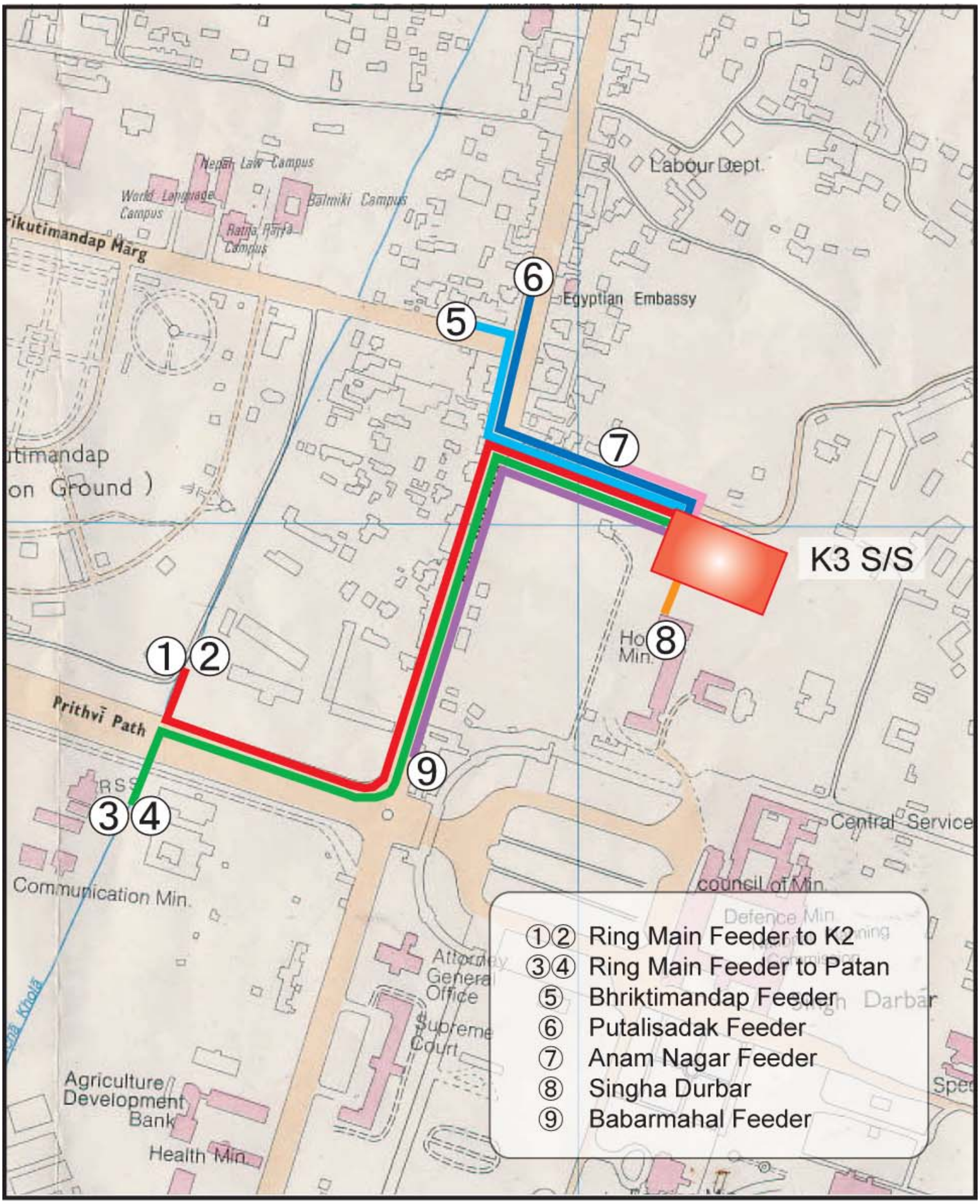


Figure 2-9 Connecting Point of Existing Line and 11kV Underground Transmission Line

CHAPTER 3

PROJECT EVALUATION AND RECOMMENDATION

CHAPTER 3 PROJECT EVALUATION AND RECOMMENDATIONS

3.1 Project Effect

The objective of this Project is to construct the new K3 S/S and the 66 kV transmission line, for establishing reliable and low-loss power distribution in central Kathmandu. The implementation of this Project will produce the following beneficial effects. Those effects are described below with the existing problems.

(1) Direct Effects

① Possibility of power failure for long term and wide area due to the limited capacity of the 11 kV transmission line to the K2 SW/S

Existing Problem

As described in Chapter 1, Background of the Project, the existing 11 kV transmission line to the K2 SW/S is fully loaded at present. This 11 kV line and the K2 switching substation are playing an important role in supplying electricity to central Kathmandu.

In case any one circuit of the existing double circuits of the 11 kV transmission lines from the Patan S/S to the K2 SW/S, or the Lainchaur S/S to the K2 SW/S have a fault, it causes the power failure of wide area in Kathmandu. The existing 11 kV underground transmission lines from the Lainchaur S/S to the K2 SW/S have a very limited transmission capacity because of its system voltage, etc.. The lines had several fatal faults in the past. The existing 11 kV overhead transmission lines from the Patan S/S to K2 SW/S maintain very small clearance from the ground. This means the overhead transmission lines are not reliable with high possibility of ground fault.

Countermeasures

The new K3 S/S is to be constructed within Singha Durbar premises. The place is very close to the existing K2 SW/S. The new 66 kV underground transmission lines are to be constructed as a reliable power source to the K3 SW/S.

Effects

As explained in Subclause 2.2.1.1, point (3), the conductor size of the new 66 kV transmission line is so determined that a failure of any one circuit of the transmission lines, the existing 66 kV overhead transmission line between the Siuchatar S/S and Teku S/S or the new 66 kV underground transmission line between the Teku S/S and K3 S/S, do not affect the operation of the K3 S/S.

In addition, it can be expected that the rate of the failures of the 66 transmission lines consist of underground lines and overhead lines with enough clearance is much lower than the same of the existing 11 kV overhead transmission lines.

② Possibility of power failure for long term and wide area due to the limited capacity of the main transformers in the Patan S/S

Existing Problem

As stated in Chapter 1, Background of the Project, the main transformer in the Patan S/S is nearly loaded at 100% of the rating during winter season during the peak time of the load. In daily operation, the overloaded condition of the transformers in the Patan S/S cannot be observed in the record because of execution of the scheduled load shedding. Otherwise such arrangement is made that the excess load over 100% of the rating is conveyed to transformers of other substations before the transformer in the Patan S/S is overloaded. Anyway, the failure of any one bank of the transformers will cause power failure in wide area in central Kathmandu.

Countermeasures

Two banks of the new transformers with due capacity stated in Subclause 2.2.1.1, point (3), are to be installed in the K3 S/S.

Effects

Even in case one bank of the transformers in the K3 S/S fails, power failure affecting wide area and long time can be avoided.

(2) Indirect effects

The implementation of this Project will also have the following indirect effects.

① The condition of power distribution will be well maintained by reducing the times and duration of power failures, so that the socio-economic activity of Kathmandu city will be activated more than before. Frequency of power failures which have been hindering the economic activity of markets and offices in Kathmandu city will become less.

② Improvement of the reliability of power supply by reducing the power failures by the Project will contribute to improvement of Basic Human Needs (BHN), such as operation and activities of hospital and schools etc..

The numbers of the hospitals and schools, for which the electricity is to be distributed from the K3 S/S after the Project completion, are shown below.

- Large hospital Approx.15
  (Bir Hospital, Army Hospital, Maternity Hospital, Eye Hospital, Model Hospital, Norbic (Heart) Hospital, Himal Hospital, OM Nursery, etc.)

-	Small clinic	Approx. 100
-	University/collage	Approx. 25
-	Other schools	Approx. 75

③ Technical knowledge acquired by the NEA operators during the Project implementation can be utilized for the K3 S/S maintenance work to be executed by NEA himself. Then, such knowledge will also be transferred to other NEA owned stations and will be used for their operation and maintenance.

3.2 Recommendations

To maintain the effectiveness of this Project and to achieve further long term operation of the K3 S/S, the following conditions shall be realized and fulfilled.

① Connection of the 11 kV cubicles and the existing 11 kV distribution lines

It is essential that connection of the 11 kV cubicles and the existing 11 kV distribution lines through the 11 kV underground cables is immediately completed by NEA, as soon as the construction of the K3 S/S is finished. NEA is recommended to prepare necessary budget for this connection work quickly.

② Execution of Periodical Maintenance Works

NEA is recommended to execute the periodical maintenance works mentioned in Subclause 2.4, to detect any trouble in its early stage and to prevent faults and accidents of the equipment installed under the Project.