CHAPTER 9

ON-GOING REINFORCEMENT PROJECTS IN THE KATHMANDU VALLEY

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9.1 General

To meet the rapid power demand growth in the Kathmandu Valley which accounts for more than half of NEA's billing, several projects for reinforcement/upgrading of the existing transmission and distribution system are under progress or will be implemented in very near future.

This chapter briefly describes these projects.

9.2 Power Sector Efficiency Project

At the request of HMG/N, IDA and ADB conducted a diagnostic study of the Power Sector of Nepal in 1987 (Power Sector Review (PSR), Jan. 15,1988), and IDA prepared the Third Technical Project (Cr.1902-NEP) to help NEA implement the PSR recommendations relating to preparation for investments in generation, transmission and distribution, upgrading of existing generation facilities, electricity tariff and improving NEA's operational efficiency. Under the Cr.1902-NEP, the following major studies have been conducted by NEA with assistance of consultants.

(a) Long-run Marginal Cost and Tariff Study
(b) Updating of Least Cost Generation Expansion Plan
(c) Ten-Year Transmission and Distribution Master Plan
(d) Rural Electrification Ten-Year Master Plan
(e) Feasibility Study for Upgrading and Refurbishing the 35MW Trisuli-Devighat Complex

Due to the problems discussed in the above-mentioned studies and the need to fill the generation gap prior the Arun Hydroelectric Project commissioning, the Power Sector Efficiency Project was formulated to address power rehabilitation investment needs and NEA's institutional development as well as to support actions in energy conservation and assist in the implementation of the Marsyangdi Catchment Management Pilot Project (MCMPP).

The major objectives of the project are to support the implementation of the agreed strategy set out in the PSR through:

(a) augmenting effective generating capacity, reducing losses and improving the load factor to meet the projected demand (in total by 40MW equivalent) at the least cost;

(b) strengthening NEA's institutional performance, and

(c) enhancing energy conservation measures.

To meet these objectives, the Project includes:

(a) rehabilitation/upgrading of the 35MW Trisuli-Devighat hydroelectric plants and other existing hydropower and diesel generation plants, including provision of spare parts and maintenance facilities;

(b) reinforcement/upgrading of the existing transmission and distribution system in the Kathmandu Valley;

(c) provision of equipment and materials to implement Phase III of the Loss Reduction Program;

(d) technical assistance to improve the effectiveness of NEA's management, to train higher level and support staff, to improve billing and consumer management, and to provide consultant services;

(e) provision of equipment and furnishings for the NEA's headquarter office and a training center;

(d) implementation of the MCMPP, and

(g) energy audits of major industries.

The component of the above item (b) is titled "HV Transmission/Substation Reinforcement in the Kathmandu Valley" and includes the investment to: (i) increase the 66kV transmission capacity; (ii) augment the 66kV transformer capacity and construct two 66/11kV substations; (iii) construct 132kV and 66kV transmission lines; and (iv) provide equipment, spare parts and tools. The scope of works for the HV Transmission/Substation Reinforcement in the Kathmandu Valley is summarized in Table 9.1.

9.3 Loss Reduction Project

Annual system losses of the interconnected system averaged 27% to 32% of gross generation during 1985/86 to 1989/90 and such high system losses have been a critical problem affecting NEA's operational and financial performance. Technical and non-technical losses have each contributed about half of the system losses. The technical losses are caused primarily by improperly and inadequately planned distribution system such as overloaded transformers, overextended lines, underrated lines, poor service connections, poor power factor, etc., while improper billing, illegal connections and incorrect metering are the primary causes of the non-technical losses (see Annex-4).

Under the Marsyangdi Hydroelectric Project (Cr.1478-NEP), IDA provided financing for Phase I of NEA's Loss Reduction Program (LRP). The System Loss Study was carried out by BEI (UK) in 1986, which identified a phased approach to loss reduction over a five (5) year period. Under the same financing, the first two years of the LRP(Phase II) aimed at achieving loss reduction in the Kathmandu Valley over about two year period, and provided for:

(a) resealing of 100% of customer installations and rehabilitating 40% of electrical services,

(b) phase balancing of 60% of electrical services,

(c) trial installation of 55km of aerial bundled conductors,

(d) equipping a meter test station in the Kathmandu Valley, and

(e) upgrading of statistical metering at generation, import and export points.

Phase III of the LRP would continue Phase II in the Kathmandu Valley and extend the successful elements to the rest of the country. The equipment and materials to be procured under Phase III are listed in Table 9.2.

Phase III works was firstly scheduled to be financed under the above-mentioned Power Sector Efficiency Project,but eliminated from the Project as a result of loan negotiation held in Washington from April 29 to May 3, 1991. Then HMG/N has requested that the remaining loan for the Marsyangdi Hydroelectric Power Project be reallocated to cover the above-mentioned LRP(Phase III).

9.4 Others

In addition to the above-mentioned reinforcement of power transmission and distribution system in the Kathmandu Valley, the following reinforcement works are scheduled to be implemented:

Additional stringing of second circuit conductors on the double circuit towers between Siuchatar and Patan

This work is planned to be done by NEA by March 1992. The necessary 66kV switching station and its control and protection equipment at both the Siuchatar and Patan substations are scheduled to be procured under the Power Sector Efficiency Project.

Restoration of Lainchaur substation

HMG/N has requested KfW to finance the restoration of the 66kV GIS (Gas Insulated Switchgear) and 11kV feeder cubicles. The 66/11kV substation was constructed under financing of KfW at the end of 1989, but burnt down in July 1990 by a spreading fire of 11kV cubicles which had been installed at the old building in 1982 and shifted to the new GIS building under the above project.

CHAPTER 10

DESIGN CRITERIA

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DESIGN CRITERIA

10.1 Local Climatic Condition

Climatic records in the Kathmandu Valley are summarized in the Tables 2.2 to 2.5. Absolute extreme high air temperature and minimum air temperature historically recorded in the Kathmandu airport are 32.3°C and -3.5°C, respectively. However, for the safe design purpose, the same conditions as those applied for the last 2 phase projects in the Reinforcement Project of Kathmandu Valley Distribution Network will be applied for design of facilities in this Project as mentioned below:

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

The maximum wind velocity to be applied for the Project is assumed at 25m/s, since extremely highest wind velocity recorded in the Kathmandu International Airport was 52 knots (equivalent 26.75m/s) and the velocity of 25m/s has been applied for the last 2 phase projects without any trouble.

10.2 Design Wind Pressures

The wind pressures to be taken into account in design of project facilities are as follows:

(a)	conductors and wires	:	35 kg/m^2
(b)	lattice structures	:	130 kg/m^2
(c)	tubular structures	:	31 kg/m^2
(d)	insulators and hardware	:	55 kg/m^2
(e)	equipment	:	100 kg/m^2

10.3 Sag Computation

Sags of overhead conductors will be computed under the following assumptions.

(a) maximum conductor temperature to be 60°C taking account of temperature rise due to current flow.

(b) minimum conductor temperature to be 0°C, although ambient minimum temperature is minus 5°C, taking account of such case that maximum wind blow at extremely minimum air temperature is very rare.

(c) EDS (Every Day Stress) to be computed at 20°C.

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

(e) maximum sag of conductors to be assumed under the conditions of maximum conductor temperature in still air.

10.4 Minimum Factors of Safety

(a) structures, tubular poles, other kinds of supports under maximum working loads on them against their ultimate strengths 2.5

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

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

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

10.5 Minimum Clearances Required

The following minimum clearances from conductors will be applied:

(a) 132kV line above general terrain... 7.0 m
(b) 66kV line above general terrain .... 6.0 m
(c) 66kV line at main road crossing... 7.0 m
(d) 11kV line above general terrain .... 6.1 m
(e) 11kV line at main road crossing... 6.6 m

(f) 66kV tower steelworks from live conductors:

suspension type tower	: still air & 20° swing	645 mm
	: 40° swing	525 mm
	: 55° swing	400 mm
tension type tower	: still air & 15° swing	645 mm
	: 40° swing	400 mm

(g) separation between 11kV bare conductor and LT bare conductor........ 1.0 m

(h) separation between 11kV bare conductor and LT insulated cable........ 0.8 m

(i) 11kV phase spacing of bare conductors.................................... 0.8 m

(j) vertical spacing between 11kV bare conductors............................ 1.0 m

(k) 11kV phase spacing of cables.. 0.4 m

(l) LT phase spacing of conductors.. 0.3 m

10.6 BIL of Electrical Equipment

(a) Highest rated voltage : 132kV...145 kV

: 66kV...72 kV

: 11kV...12 kV

(b) Impulse withstand voltage : 132kV.......................................650 kV

: 66kV.......................................350 kV

: 11kV.......................................75 kV

(c) Impulse withstand voltage for L.A : 132kV.............................550 kV

: 66kV.............................300 kV

: 11kV.............................90 kV

10.7 Standards Applied

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

Erection of the facilities will be executed in conformity to NEA's practices and regulations and rules in force in Nepal. Safety measures for workers and the public will be especially and severely controlled under the Project.

CHAPTER 11

FEASIBILITY DESIGN OF HIGH VOLTAGE SYSTEM INCLUDING RING MAIN SYSTEM

CHAPTER 11
FEASIBILITY DESIGN OF HIGH VOLTAGE SYSTEM INCLUDING RING MAIN SYSTEM

11.1 Selection of Sub-projects for Feasibility Study

11.1.1 Criteria for Selection

In the master plan study described in Chapter 7, eleven (11) sub-projects were identified as urgent and important measures to be implemented up to 1995/96 for reinforcement of the existing high voltage (HV) transmission system in the Kathmandu Valley.

On the other hand, as explained in Chapter 9, the reinforcement projects of the existing system in the Kathmandu Valley under financial assistance of IDA and other donors are in progress in parallel with this study. For the Power Sector Efficiency Project, a loan negotiation has been held in Washington from April 29 to May 3, 1991, and implementation of the project is expected to be started soon. Especially for the Transmission/Substation Reinforcement in the Kathmandu Valley of the Power Sector Efficiency Project (hereinafter called PSEP), the draft tender documents for supply and installation have been prepared by a French consultant and submitted to NEA in May 1991.

Almost all sub-projects of the PSEP are included in the Master Plan established under this study, but its proposed implementation schedule is slightly different from that of the Master Plan.

For selecting the sub-projects to be implemented under this project, the reinforcement works under other projects explained in Chapter 9 are supposed to be implemented as scheduled. The remaining reinforcement countermeasures to meet the projected peak demand in 1995/96, therefore, are taken up as sub-projects for this study, and selected under the following conditions.

Basic Configuration of Power Supply System

A single line diagram of the power supply system after completion of all reinforcement works explained in Chapter 9 is given in Figure 11.1 and it is considered as a basic power supply system for selecting sub-projects under the Study.

However, a part of scope of works mentioned in the draft tender documents for the PSEP (see Table 9.1) is slightly changed in accordance with an opinion of NEA:- to extend a 66 kV double circuit line (132 kV design) from New Bhaktapur to near Burhanilkantha and to connect with the existing 66 kV Devighat-New Chabel line instead of direct connection to the New Chabel substation.

Selection of Sub-projects

Facilities to be overloaded and 11 kV buses under excessive voltage drops are examined through power flow analysis of the system under several conditions with and without forced outage of any one circuit of transmission lines. Where some constraints are observed in the system, necessary and effective countermeasures are taken to improve them as sub-projects under the Study.

For examining the existing 11 kV switching equipment on the ring main system, the results of short-circuit analysis (see Table 7.5) are used.

11.1.2 Results of System Analysis

Power flow analyses on the above-mentioned system have been conducted with the projected peak demand in 1995/96. Results of major cases of analyses are summarized as follows:

(1) Normal Condition (Case No. NC-1)

Voltage of 11 kV buses of all substations and switching stations is kept within the specified value of minus 7% due to adjustment of taps of transformers. No overload will occur on any transmission line. Overload of transformers is discussed in Section 11.1.3.

(2) Forced Outage of 66 kV Balaju-Lainchaur line (Case No. ANC-1)

The 66 kV Balaju-Lainchaur line serves normally all of the loads of the Lainchaur substation and also about 60% to 70% of the loads of the K2 switching station in the central area of the Kathmandu city.

The forced outage of the line will, therefore, cause following issues and a large scale load shedding in the central area.

<u>Voltage Drop of 11 kV Buses</u>

Such excessive and unacceptable voltage drops nearly 30% will occur on the 11 kV buses at the K2 and Royal Palace switching stations and Lainchaur substation. Voltages of other 11 kV buses in the system will be still within acceptable range, i.e. minus 10%, though voltage drops will increase about 1% to 3% in comparison with those under normal condition, Case NC-1.

<u>Overload of Transmission Lines and Transformers</u>

The 11 kV Patan-K2 double circuit line will be overloaded about 180% and 66/11 kV transformers at Patan about 140%, because all loads served through the Balaju-Lainchaur line are shifted to the 66 kV Siuchatar-Patan line and 11 kV Patan-K2 line. However, load on the 66 kV Siuchatar-Patan double circuit line will still be within the allowable carrying capacity of the line, i.e. about 68% (70 MVA).

As countermeasures for the above issues, the following alternatives may technically and economically be feasible.

(a) Addition of another 66 kV single circuit line between Balaju and Lainchaur.

(b) Construction of a new 66/11 kV substation near K2 switching station (K3 substation).

For the above-mentioned countermeasure (a), construction of a 66 kV underground cable line had been planned in the Ten Year Transmission and Distribution Master Plan established by a French consultant to avoid the difficulty of land acquisition for construction of another overhead line. However, the plan is finally eliminated from the scope of works of the PSEP shown in Table 9.1. The reason for elimination of the plan from the scope of works seems to be (i) high construction cost of the 66 kV underground cables and (ii) very low probability of occurrence of forced outage of the line with only 2.3 km length.

Although construction of the 66/11 kV K3 substation is costly in comparison with construction of another 66 kV single circuit line between Balaju and Lainchaur, it is recommended to construct the K3 substation prior to the construction of another 66 kV Balaju-Lainchaur line, because:

(a) it is the most effective way to achieve reliable power supply in the central area of Kathmandu in long term,

(b) if construction of the K3 substation is delayed, land acquisition for the facilities will become more difficult, because of rapid housing development along the planned 66 kV line route, and

(c) in order to avoid land acquisition problems due to construction of another overhead line and/or underground cable line between Balaju and Lainchaur and to minimize construction cost, it seems to be the most attractive way to reconstruct a overhead double circuit line on the existing line route. As afore-mentioned, however, it is a very serious issue to stop power supply from Balaju through the existing 66 kV line for construction of the double circuit overhead line.

The K3 substation, however, should be constructed after the completion of the reinforcement works of the PSEP, because the new 66 kV overhead double circuit line for the K3 substation will be tapped from the 66 kV Siuchatar-Teku double circuit line to be constructed under the PSEP and addition of 66 kV GIS for Teku substation may be required.

The 66 kV line between Balaju and Lainchaur, if the K3 substation would be constructed, may not be needed by 1997/98 or later.

(3) Forced Outage of 66 kV Trisuli-Balaju line (Case No. ANC-2)

No issues such as excessive voltage drops on 11 kV buses and overload of the lines and transformers except 132/66 kV transformer at Siuchatar are observed in the system. In this case, however, overload factor of the 66 kV Trisuli-Devighat line will increase to about 60% from 30% under normal condition, Case NC-1.

(4) Forced Outage of 66 kV Patan-Baneswar line (Case No. ANC-3)

No issue is observed in the system. In this case, however, overload factor of the 66 kV Baneswar-New Bhaktapur line will increase to about 60% from 25% under normal condition, Case NC-1.

11.1.3 Utilization Factor of Transformers

In addition to the above-mentioned analyses, power flow analysis on the same system with the projected peak demand in 1997/98 under normal condition is conducted in order to confirm the timing of augmentation of transformer capacity (Case No. NC-2). The calculated utilization factors of transformers in these analyses are as below:

Substation	Voltage Ratio	Capa-city	Utilization Factor (%)				
	(kV)	(MVA)	NC-1	ANC-1	ANC-2	ANC-3	NC-2
Siuchatar	132/66	37.8	101	108	103	99	111
	66/11	36.0	57	57	57	68	66
Balaju	132/66	45.0	81	83	83	82	89
	66/11	20.0	82	86	79	88	96
N. Patan	66/11	36.0	62	143	62	72	76
Baneswar	66/11	36.0	70	70	70	70	85
Lainchaur	66/11	36.0	61	0	60	81	70
N.Chabel	66/11	18.9	87	89	88	81	99
N.Bhaktapur	66/11	20.0	55	66	61	37	62
Teku	66/11	36.0	44	44	44	46	52

From the above table, load on the 132/66 kV transformer at the Siuchatar substation will exceed the rated transformer capacity and it seems not necessary to augment the transformer capacity taking into account the duration of peak hours, i.e. about 4 hours. However the 132/66 kV transformer is expected to be overloaded around 190% under forced outage condition of the 132 kV Siuchatar-Balaju line. Therefore, another unit with same capacity, i.e. 37.8MVA is recommended to be added in the Siuchatar substation by the year 1995/96.

Overload of 66/11 kV transformer at the Patan substation under the outage condition of the 66 kV Balaju-Lainchaur line will be improved by adding a 66 kV second circuit line between Balaju and Lainchaur and/or construction of the K3 substation. No other augmentation of transformer capacity may be required by around 1998/99.

11.1.4 11 kV Switching Equipment

The calculated short circuit current at 11 kV buses exceeds the rated breaking current of circuit breakers up to 2000/01 at the following stations:

Station	Rated Current (kA)	Nos. of Panels	Short Circuit Current (kA)		
			1989/90	1995/96	2000/01
Old Patan	7.9	11	12.6	13.5	16.1
Teku	7.9	11	9.1	13.9	20.1
	20.0	6	9.1	13.9	20.1
Royal Palace	7.9	5	9.1	13.3	16.2
Old Chabel	7.9	10	7.8	10.8	13.0
Thimi	7.9	6	4.7	6.9	8.4

Note : Underlined figures mean that the calculated short circuit current will exceed the rated breaking current of circuit breaker in the corresponding year.

Among above-mentioned 11 kV feeder cubicles, feeder cubicles of the existing Teku switching station will be replaced with new ones under the PSEP. Therefore, replacement of cubicles at Old Patan, Old Chabel and Royal Palace is needed in early stage under this project.

11.1.5 11 kV Underground Cable between Lainchaur and K2

Power demand in the most populated central area of Kathmandu is served from the K2 switching station, to which electric power is supplied through 11 kV underground cable line from the Lainchaur substation and 11 kV double circuit overhead line from the Patan substation.

This power supply system to the center of Kathmandu was formed in the early 1960's. The present underground cable line between Lainchaur and K2 was also constructed at that time along the Darbar Marga road.

The main features of the existing 11 kV underground cable line are as below:

Cable	:	11 kV, lead sheathed paper insulated cable
conductor	:	copper, 240 sq.mm x 3-cores
No of cable	:	1-cable
Line length	:	1.75 km

Due to the remarkable deterioration of cables, troubles on the cables have frequently occurred. Houses are built on the underground cable line route in some parts of the line, and it is difficult to find the place of troubles and to repair them accordingly. In 1990, the cable line was in outage for 6 months in total. Although it was restored by NEA, reliability of the line is still uncertain.

For maintaining stable and reliable power supply to the center of Kathmandu, construction of a new cable line is urgently required.

11.2 Rated Breaking Current of 11 kV Circuit Breaker

As shown in Table 4.13, the rated breaking current of the existing 11 kV cubicles varied in wide range between 7.88 kA of very old stations installed in 1960's and 40 kA of the Thapathali switching station installed under Japanese Grant Aid in 1983. The stations of which short-circuit current calculated in accordance with the proposed extension plan in the master plan exceeds the rated breaking current of circuit breakers are given in Section 11.1.4.

On the other hand, the rated breaking current of circuit breakers to be newly installed should be decided taking account of the long term power system extension plan in order to avoid frequent replacement.

In this study, therefore, a power supply system in the Kathmandu Valley around the year 2005/06 is estimated as shown in Figure 11.2 based on the following present plans:

(a) Electric energy generated by the Arun No. 3 hydropower project (402 MW) will be transmitted to the Valley through 220 kV transmission line by 2005/06.

(b) The receiving point in the Valley of the bulk power from the Arun No. 3 power station is Bhaktapur area.

(c) For distributing the bulk power from Arun to the substations in the Valley, construction of a new 132 kV ring system is planned.

A three-phase short-circuit analysis of the estimated power supply system shown in Figure 11.2 has been conducted and the calculated short-circuit current at 11 kV bus of each station is as below:

Station	Current (kA)	Station	Current (kA)
New Patan	20.2	Royal Palace	18.8
Siuchatar	24.5	Maharajgunj	7.1
Balaju	23.0	Old Chabel	14.4
Lainchaur	22.2	Thimi	10.6
New Chabel	19.6	K-2	20.7
Baneswar	17.5	Thapathali	18.2
Teku	25.3	K-3	22.5
New Bhaktapur	27.7	Chapagaon	15.4

The above table shows that the maximum short-circuit current of 27.7 kA may be observed at the 11 kV bus of the New Bhaktapur to be constructed under the PSEP. A rated breaking current of 25 kA, however, is adopted for 11 kV circuit breaker to be newly installed under the Project, because the calculated shot-circuit currents at 11 kV buses of the Old Patan, Royal Palace and Old Chabel switching stations and the K3 substation to be newly constructed are 20.2 kA, 18.8 kA, 14.4 kA and 22.5 kA, respectively.

11.3 11 kV Underground Cable Line between Lainchaur and K2

To maintain high reliability of power supply to the center of Kathmandu, a new cable line is to be constructed along the Kanti Path as shown in Figure 11.3 and Annex-7 in detail.

The main features of the new cable line are summarized below:

Cable	:	11 kV vinyl sheathed cross linked polyethylene insulated steel armored cable
Conductor	:	copper conductor, 325 sq.mm x 1-core
No. of cable	:	4 cables including spare cable
Line length	:	1.9 km

The site erection works of the underground cable line will include:

- check survey of the cable line route,
- trench work with filling of gravel, sand and brick for the cable protection,
- laying of the cable in the trench including the joint and termination works, and connection to the existing 11 kV outgoing feeder cubicles at the Lainchaur substation and K2 switching station,
- back-filling of the trench and re-pavement of the road surface, and
- commissioning test

Note: The 11 kV feeder cubicles at the Lainchaur substation are planned to be replaced under the financial assistance of KfW.

The cable will be laid in the trench filled by sand at more than 1.2 meter depth, as shown in Figure 11.4.

11.4 Augmentation of Transformer at Siuchatar Substation

11.4.1 General

As a result of system analysis discused in Section 11.1.3, the estimated load on the existing 132/66 kV, 37.8 MVA transformer at the Siuchatar substation will exceed the rated transformer capacity in the year 1995/1996. In order to improve overload of the transformer, an additional transformer with the same capacity is to be installed and operated in parallel with the existing one.

The features of the transformer augmentation plan are as follows:

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

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

(b) 132 kV transformer bay equipped with

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

(c) 66 kV transformer bay equipped with

one circuit breaker, 72 kV, 600A, 20 kA
two disconnecting switches, 72 kV, 600A
one single phase potential device, $\frac{66}{\sqrt{3}}$ KV/110V, and
three lightning arresters, 75 kV, 10 kA

(d) Control and protection relay board equipped with

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

One line connection diagram and outdoor switchyard layout plan are given in Figures 11.5 and 11.6.

11.4.2 Facilities

Following are outlines of the equipment to be newly installed at the substation and the specifications of the main equipment are summarized in Table 11.1.

(a) Transformer

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

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

(b) 132 kV Switchgear Equipment

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

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

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

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

(c) 66 kV Switchgear Equipment

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

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

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

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

(d) Control Board

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

11.5 11 kV Switching Station

11.5.1 General

As explained in Section 11.1.4, the rated breaking capacity of the existing oldest 11 kV circuit breakers (Bulk Oil type) manufactured by English Electric Co. and installed in 1960's on 11 kV lines at the following stations is lower than the computed short-circuit current in the year 1990/91 as shown below.

Switching Station	Rated Capacity	Short-Circuit Current in 1989/90	Number of Cubicles
Old Patan	7.88 kA	12.6 kA	11 nos.
Royal Palace	7.88 kA	9.1 kA	5 nos.
Old Chabel	7.88 kA	7.8 kA	10 nos.

In order to avoid recurrence of accidents like the switchgears destroyed by fire led by the bursting of the circuit breaker at the Lainchaur substation, the existing cubicles at the above stations are to be replaced with new 11 kV cubicles mounted with vacuum type circuit breaker with a breaking capacity of 25 kA, taking account of available space for the cubicles.

11.5.2 Cubicles

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

	Equipment	Incoming Line	Ring Main Line	Outgoing Feeder	Bus Coupler	Transformer Circuit (*1)
1)	Copper bus	1	1	1	1	1
2)	Circuit breaker 12 kV, 25 kA	1200A	800A	800A	1200A	800A
3)	Current transformer single phase	3x1200-600/5	3x600-300/5	3x600-300/5	3x1200/5	3x150-75/5
4)	Over current relays	3	3	3	3	3
5)	Over current ground relay	–	1	1	–	–
6)	Reclosing relays	–	–	1	–	–
7)	Ammeter with selector switch	1	1	1	–	1
8)	Watt meter	1	1	1	–	1
9)	Watthour meter	1	1	1	–	1
10)	Var meter	1	1	1	–	1
11)	Power factor meter	–	1	1	–	–

Remarks: *1: for Royal Palace switching station

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

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

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

- One copper bus bar
- One grounding bus bar
- Two disconnecting switches, 12 kV, 600A
- One draw-out type disconnecting fuse switch, 11 kV 20 AF, 6 AT
- Three single phase potential transformers
- Ten molded circuit breakers
- One station service transformer, 3-P 100 kVA, 11 kV/400-230V
- Three current transformers, 200/5A
- Three over current relays
- One under voltage relay
- One ammeter with selector switch

- One voltmeter with selector switch
- One lot of control switches

The battery and battery charger:

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

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

11.5.3 Major Equipment in Cubicles

An outline of the equipment to be mounted on the new cubicles is given below and the specifications of main equipment are summarized in Table 11.1.

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

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

The station service transformer in the 11 kV cubicle together with disconnecting power fuse switch on its primary side will be three phase, 11 kV/400-230V, 100 kVA, dry epoxy-resin molded, self-cooled type considering its maintenance free operation and high reliability against fault.

Current transformers and potential transformers 11 kV will be of molded type.

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

Battery for DC power source will be of high grade, Nickel-Cadmium alkaline enclosed seal type, 110 volt, 100 ampere-hour contained in a cubicle combined with battery charger of 50 ampere capacity of thyristor design for continuous use.

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

11.5.4 Replacement of 11 kV Cubicles

(a) Royal Palace Switching Station

The existing cubicles for two ring main lines linking to the Lainchaur and K2 switching stations, two transformer primary circuits (11 kV/400-230V, 1,000 kVA) and one feeder circuit are to be replaced with new 11 kV cubicles.

Five new replacing cubicles will be installed at the same place of the existing cubicles. In addition to these cubicles, one spare feeder cubicle and one battery and charger will also be installed. The connecting diagram and indoor cubicles layout plan are shown in Figures 11.7 and 11.8.

(b) Old Chabel Switching Station

The existing cubicles for four ring main lines (Maharajgunj SW/S, Balaju S/S and New Chabel S/S-1 & -2), five feeder circuits and one spare are to be replaced with new 11 kV cubicles.

Ten new replacing cubicles will be installed at the same place of the existing cubicles.

In addition to the above, one station service transformer cubicle, one bus coupler cubicle, one battery and charger cubicle and two feeder cubicles for new feeder lines to be constructed under the Project will be also installed. The connection diagram and indoor cubicles layout plan are shown in Figures 11.9 and 11.10.

(c) Old Patan Switching Station

The existing cubicles for six ring main lines (New Patan S/S-1 & -2, Teku SW/S-1 & 2, Thimi SW/S-1 & 2) and six feeder circuits are to be replaced with new 11 kV cubicles.

Fifteen new cubicles in total including cubicles for bus coupler, station service circuit, battery and charger, two feeders to be used under the Project and two spare feeders will be installed in the existing 11 kV indoor switchgear room in the Sunkosi substation and their circuit breakers will be operated from the control board to be installed in the control room of the New Patan substation. The connection diagram and indoor cubicles layout plan are shown in Figures 11.11 and 11.12.

The existing 11 kV cubicles except for one cubicle each for the station service transformer, generator and incoming line for New Patan substation will be dismantled by NEA.

(d) Site Works

The site replacement works of the cubicles will include:

- temporary relocation of the existing cubicles for installation of the new cubicles and storing the existing cubicles in the warehouse after completion of the works (Royal Place and Old Chabel switching stations)
- removal of the existing cubicles and storing them in the warehouse (Sunkosi S/S only)
- installation of new cubicles including cabling
- installation of control board (New Patan S/S only)
- tests

11.6 K3 Substation and 66 kV Transmission Line

11.6.1 K3 Substation

To meet the growing demand in the center of Kathmandu Valley and to improve excessive voltage drops of 11 kV buses at the K2, Royal Palace and Lainchaur stations as explained in Section 11.1.2, a new substation (named K3 substation) is to be constructed at a place near the Exhibition Ground along the Tukucha river. Power to the K3 substation will be supplied from the Siuchatar substation through a 66 kV double circuit line being tapped off a new 66 kV double circuit line to be constructed under the PSEP between the Siuchatar and Teku substation.

The single line connection diagram and arrangement of substation equipment are shown in Figures 11.13 and 11.14.

Taking into account the fact that the abovementioned substation site is located in densely populated area, the outdoor cubicle type gas insulated single bus switchgear arrangement is adopted for the 66 kV switchgear. The 11 kV switchgear equipment including station service transformer will be contained in indoor type metal cubicles. Control boards to remotely control the switchgear will be installed in the control room of the substation building together with low voltage switchgears and 11 kV cubicles.

The new K3 substation is to be constructed with the following features:

(a) Seven units of transformers, 66/11 kV 1-phase, 6 MVA, including one spare, equipped with:

- three busing current transformers on primary side, 200/5A, 40 VA
- one busing current transformer on secondary neutral circuit, 200/5A, 40 VA
- three busing current transformers on secondary side, 1,200/5A, 40 VA

(b) Two 66 kV line bays, each equipped with:

- three lightning arresters, 75 kV, 10 KA
- one circuit breaker, 72 kV, 600A, 20 kA
- two disconnecting switches, 72 kV, 600A
- two earthing switches
- three single phase current transformers, 600-300/5/5A, 40 VA
- one line trap
- one coupling capacitor

(c) One 66 kV bus bar equipped with

- six sets of single phase capacitor voltage transformers, $\frac{66}{\sqrt{3}}$ kV / 110 V
- one disconnecting switch, 72 kV, 660 A
- two earthing switches

(d) Two 66 kV transformer bays, each equipped with:

- one circuit breaker, 72 kV, 600A, 20 kA
- one disconnecting switch, 72 kV, 600A
- two earthing switches

(e) One lot of 11 kV indoor type metal enclosed switchgear with SF6 or vacuum type withdrawable circuit breakers, equipped with:

- two transformer incoming feeders, mounted with the following instruments and devices (for each feeder)

  One copper bus bar
  One circuit breaker, 12 kV, 1,200A, 25 kA
  One potential transformer, 1-P$\frac{11\text{ kV}}{\sqrt{3}}$ / 110 V
  Six current transformers, 1-P 1200-600/5A
  Three over current relays
  One voltage regulate relay
  One ammeter with selector switch
  One volt meter
  One watt meter
  One watt hour meter
  One var meter
  One lot of control switches
- one bus coupler, complying with the specifications Section 11.5.2
- one feeder for station service transformer, complying with the specifications in Section 11.5.2
- ten outgoing feeders, complying with the specifications in Section 11.5.2

(f) One lot of low tension switchgear

- one set of battery and charger, complying with the specifications in Section 11.5.2

(g) One lot of control and protection relay boards

The substation equipment is outlined below. The specifications of main equipment are summarized in Table 11.1.

(a) Transformers

The 66/11 kV transformer for power receiving from the Siuchatar substation will be single phase, 6 MVA, outdoor use, oil immersed, natural cooled unit with on-load tap changer (66 kV +5/-15%). The connection of windings will be star-star with delta on tertiary side for stabilized winding. Bushing current transformers will be provided on the primary side for protection relays, the secondary side for the voltage control devices of on-load tap changer, and also on the neutral of the secondary side for protection relay.

(b) 66 kV switchgear

The 66 kV switchgear will be of single bus outdoor cubicle type, SF6 gas insulated switchgear (GIS). A circuit breaker, two maintenance earthing switches, current transformers and a branching conductor to main bus bar will be housed in a common chamber.

(c) 11 kV switchgear

The 11 kV switchgear will be housed in indoor metal-clad cubicles comprising two sets for transformer secondary circuit, one set for bus coupler, 10 sets for 11 kV feeder circuit and one set for station service transformer.

The circuit breaker will be of indoor, draw-out SF6 or vacuum type rated at 12 kV, 1200A for secondary side of main transformer and bus coupler and 800A for each feeder, with 25 kA interrupting current.

The station service transformer will be of three phase dry epoxy-resin molded and self-cooled type for maintenance-free and high reliability operation. It will be installed in the 11 kV cubicle together with power fuse disconnecting switches on the primary side.

(d) Low tension switchgear

The low tension switchgear for AC 400/230V and DC 110V circuit will be arranged in indoor metal enclosed cubicles and located in the control room. AC power is to be supplied from the station service transformer through cables.

The battery for DC power source will be of Nickel-Cadmium alkaline enclosed seal type contained in a cubicle combined with battery charger of thyristor type and all accessories required for automatic operation.

(e) Control equipment

Control boards will be of indoor duplex panel type, equipped with control switches, meters, fault indicators, etc. on the front panels and protection relays on the rear panels.

(f) Grounding

Grounding will be in a grid system with horizontally buried conductors extending over the entire substation yard. The grounding conductors will be 125 sq.mm bare stranded copper conductors and buried about 80 cm below ground surface. The conductors will be connected to each other by clamps at all junctions and provided with driven copper clad steel rods of 25 mm in diameter and 3 m long, for obtaining the resistance of less than 1-ohm.

The grounding conductors of the control building, cubicles, equipment and structures will be connected to the grid by multiconnection to equalize all ground potentials in the substation site.

For lightning arresters and neutral of transformers, the grounding will be reinforced locally with copper plates of 1 m by 1 m wide and 3 mm thick.

(g) Site works

The site erection works of the K3 substation will include:

- earth filling work for the substation site
- control building works
- grounding works
- installation of substation equipment and facilities
- civil works for foundation of equipment, cable duct, drainage, access road and fence.
- lighting and water supply facilities

11.6.2 66 kV Transmission Line between Teku and K3

To feed power to the K3 substation, a new 66 kV double circuit transmission line will be constructed over 2.8 km from the Siuchatar - Teku line in practice of pi branch to the K3 substation.

The route is planned on the left bank of the Bagmati river over about 1.3 km from the point of pi connection, and then crossing the river of 210 meters wide at the confluence of the Tukucha river. After crossing the river, the route of the existing 11 kV Patan-K2 line along the Tukucha river will be used for the new line to the K3 substation. The line route is illustrated in Figure 11.15 and Annex-8 in detail.

The transmission line is designed as 66 kV double circuit of vertical formation on supports of steel towers for ACSR Bear conductors and two overhead groundwires of 38 sq.mm in the section between the pi branching point and a point after the river crossing as shown in Figure 11.16. In the section to be constructed on the existing 11 kV line, the power conductors and groundwires are to be supported by H-type steel poles in a horizontal formation as shown in Figure 11.17, and at the parts crossing the main roads, 66 kV XLPE underground cables will be laid under the bridges.

Main features of the transmission line will be as follows:

(a) Overhead tower line

Line voltage	66 kV
Number of circuit	2
Support	Self-supporting, broad based, lattice galvanized steel tower of double circuit type
Conductor	ACSR Bear
Overhead groundwire	2 x 38 sq.mm
Conductor arrangement	Vertical
Insulators	Disc insulators 254 mm x 6 units
Approx. route length	1.3 km

(b) Overhead pole line

Line voltage	66kV
Number of circuit	2
Support	H-type steel poles
Conductor	ACSR Bear
Overhead groundwire	2 x 38 sq.mm
Conductor arrangement	Horizontal
Insulators for tension poles	Disc insulators 254 mm x 6 units
Insulators for suspension poles	Post insulators
Approx. route length	1.4 km

(c) Underground cable line

Cable	66 kV polyethylene sheathed cross linked polyethylene insulated steel armored cable
Conductor	Copper conductor, 500 sq.mm x 1-core
No. of cable	3 cables
Route length	320 meters in total of two sections

11.6.3 Soil Investigation

Soil bearing tests were conducted by using a portable sounding tester at the K3 substation site and the proposed routes for the 66 kV line between Teku and K3, and the line between Balaju and Lainchaur. The test results are given in Annex-6 of this report.

CHAPTER 12

FEASIBILITY STUDY OF EXTENSION AND REINFORCEMENT FOR 11KV FEEDERS AND LOW TENSION LINES

CHAPTER 12
FEASIBILITY STUDY OF EXTENSION AND REINFORCEMENT FOR 11KV FEEDERS AND LOW TENSION LINES

12.1 General

As discussed in the foregoing Chapter 8, several main feeders will be facing excessive voltage drop, excessive technical energy loss and further aggravation of supply reliability before the year 2000/01. In this feasibility study, plans for reinforcement and improvement of feeders are limited to the feeders urgently required to be implemented before the year 1995/96. The plans include extensions and reinforcement works for improvement of not only the voltage regulation but also supply reliability including low tension systems.

(i) Those feeders should be reinforced by such measures as upgrading their existing conductor size, diverting load flow to other feeders, adding new feeders, upgrading the present voltage or adding distribution transformers.

(ii) In order to reduce frequent trips of feeders, particular portions of specific feeders should be altered from the existing bare overhead line to insulated cables or underground cables, which will also contribute to safety of inhabitants in densely populated areas.

(iii) New lines should be constructed with distribution transformers to meet growing demands of newly developed industries or developing areas under the city plan for improvement of the present unreliable power supply.

Those reinforcement and improvement plans discussed hereinafter are examined in detail as the urgent countermeasures for the areas and feeders which are anticipated to face serious conditions before the fiscal year 1995/96.

(1) Major 11kV feeders to be improved

Following are feeders and their related facilities to be reinforced and improved with respect to the voltage regulation, current carrying capacity of the existing conductors and supply reliability.

(a) System improvement in Kathmandu town center : Central
(b) Boudha-Jorpati feeder from New Chabel S/S : East
(c) Branch line of Balagau-Gokarneswar : East
(d) Baneswar feeder from New Chabel S/S : East
(e) Airport feeder from New Chabel S/S : East
(f) Sundarijal feeder from New Chabel S/S : East
(g) Thankot feeder from Siuchatar S/S : East
(h) BID feeder and Dharmasthali feeder : West
(i) Godawari-1 feeder from New Baneswar S/S : Lalitpur
(j) Godawari-2 feeder from New Baneswar S/S : Lalitpur
(k) Pharping feeder from Patan diesel P/S : Lalitpur
(l) Nagarkot feeder from Bhaktapur Sw/S : Bhaktapur

(2) Other 11kV feeders and facilities

Besides the above-mentioned plans for the major feeders, there are other 11kV feeders and related distribution lines to be urgently reinforced, extended or improved in the Valley power system, as listed below:

(a) Nayabazar feeder to be connected with Budhanilakantha feeder in the Kathmandu Central division
(b) Kirtipur feeder in the Kathmandu West division
(c) Upgrading of 3.3kV system in the Kathmandu West division
(d) BID feeder in the Kathmandu West division
(e) Old Patan-1 feeder in the Lalitpur division
(f) A section of Nagarkot feeder in the Bhaktapur division
(g) Thimi feeder extension in the Bhaktapur division
(h) Various branch feeders in the Kathmandu Central, Kathmandu East, Kathmandu West, Lalitpur and Bhaktapur divisions
(i) Low tension lines such as in Tripureswar area, Jaisi Dewal area, etc. in the Kathmandu Central division
(j) Low tension lines such as in West Battishputally area, Prayagmarga area, etc. in the Kathmandu East division
(k) Low tension lines such as in Nagaon area, Kalanki area, etc. in the Kathmandu West division
(l) Low tension lines such as in Tufe Pani area, Satdobato area, etc. in the Lalitpur division

(m) Low tension lines such as in Nonkhel Mahat village, Dadhikot ward No.6, etc. in the Bhaktapur division

(3) Principles of recommended reinforcement plans

Following measures will principally be taken for reinforcement and improvement of 11kV feeders and low tension lines.

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

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

(c) Supports to be newly erected in the congested areas or narrow streets will be of one-shoulder conductor arrangement type for saving necessary insulation distance to houses or other objects.

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

Based on those principles, concrete plans for reinforcement and improvement of each feeder and low tension line will be established.

12.2 Extension and Reinforcement of Major Feeders

In this section, detailed plans for extension and reinforcement of the feeders which are listed up in the aforementioned Section 12.1 are discussed. Reference maps to each plan are illustrated on Figures 12.2 to 12.6.

12.2.1 Kathmandu Central Power Division

(1) System Improvement in the Town Center

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

It seems that town reconstruction to improve such crowded areas is impossible in the present situation and therefore the way to supply reliable and stable power to the customers in the congested areas is to extend 11kV system by underground cables from the existing 11kV network. Overhead lines to be added in the narrow spaces should be on one-shoulder conductor arrangement.

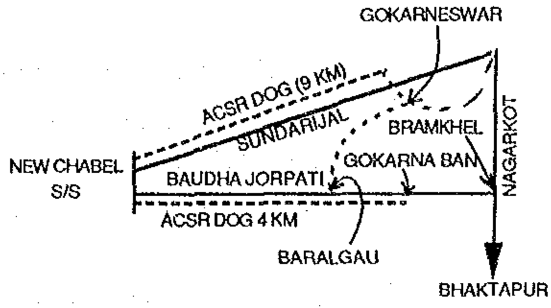
Materials and equipment required for the improvement plan is detailed in Table 12.1.

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

12.2.2 Kathmandu East Power Division

(1) Boudha-Jorpati Feeder

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



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

Details of materials and equipment required for the plan are shown in Table 12.1.

(2) New Branch Line between Baralgau and Gokarneswar

New industries are developed along the road between Baralgau and Gokarneswar. Extension of lines from the existing branch lines thereabout to the industrialized area is difficult due to topographical condition.

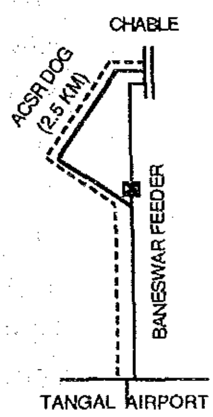
The Division Office proposes a new line from Baralgau town to Gokarneswar (3 km) branching the newly reinforced Boudha-Jorpati line planned in (1) above along the road. The proposal deems reasonable.

Poles applied for the plan will be on one-shoulder conductor arrangement for safety of the line and the public in the narrow space.

Materials and equipment required for the plan are detailed in Table 12.1.

(3) Baneswar Feeder

The existing ACSR Rabbit feeder (between the Chabel switching station and junction of the Tangal feeder over 2.5 km) should be upgraded before the year 1994/95. The existing supports for the feeder are too old to support new conductors and there are a number of such steel supports with their lowest portion being corroded and temporarily repaired with inadequate steel plates only.



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

Table 12.1 details materials and equipment required for the plan.

(4) Airport Feeder from New Chabel Substation

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

The existing conductor will be upgraded with ACSR Dog (current capacity of 320A) for increasing current capacity. Materials and equipment including replacement of some existing facilities are listed in Table 12.1.

(5) Sundarijal Feeder

The feeder is very old and has a small line capacity with single circuit of small HDCC (Hard Drawn Copper Conductor) 12.9 sq.mm on simple steel structures. A number of branch lines from the feeder are erected with ACSR. Damaged portions on the HDCC feeder have been repaired by using ACSR without application of bi-metal connectors, causing corrosion of conductors at those connections. Regardless of such poor electric facilities, this area is being developed under the city plan, accompanied with high demand growth.

For improving the excessive voltage drop of the feeder, a single circuit of ACSR Dog will be constructed on new supports over 10km from the New Chabel substation up to the connecting point with another Sundarijal feeder from the Bhaktapur substation at Mahakal village, as seen in the sketch for the aforementioned Boudha-Jorpati Feeder.

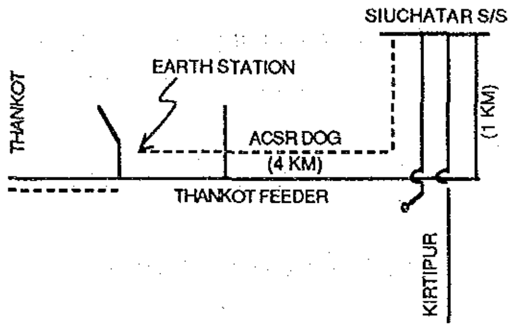
The new feeder will be constructed in the same right of way as the existing feeder up to the Basnetgau village, to avoid difficulty of land acquisition, and thereafter the feeder will be diverted to the Gokarneswar village and aligned along the motorable road to Mahakal village. Under this alignment,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

Main materials and equipment required for the plan are estimated in Table 12.1.

12.2.3 Kathmandu West Power Division

(1) Thankot Feeder

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



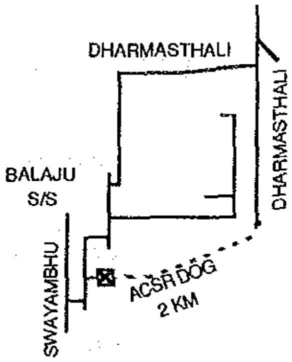
There are 134 industrial and commercial customers working along the highway, in the load scale of 4 kW to 680 kW in such various sorts of business as steel processing, rice mill, textile, foodstuff, plastic or carpet manufacturing, etc. Total load commerce was 3,200 kW as of the end of 1990.
Besides construction of the new feeder, the existing Thankot feeder between Balambu and Thankot will be upgraded by replacement of the existing ACSR Rabbit with ACSR Dog over 4km for reducing voltage drop and meeting demand growth in the area.

Main materials and equipment required for the plan is estimated in Table 12.1.

(2) Extension of Dharmasthali Feeder

The existing Balaju Industry District (B.I.D) feeder is supplying power from the Balaju substation to not only BID but also public consumers therein. The existing feeder should be upgraded with ACSR Dog for increasing the current capacity. Another new feeder will be required in the District before the year 1992/93, if the District will further expand the industrial scale. However, upgrading and reinforcement of the feeder over 1 km distance will be implemented by NEA in cooperation and negotiation with the District, since all electrical facilities in the premises are operated, maintained and managed by the District at its full responsibility.

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



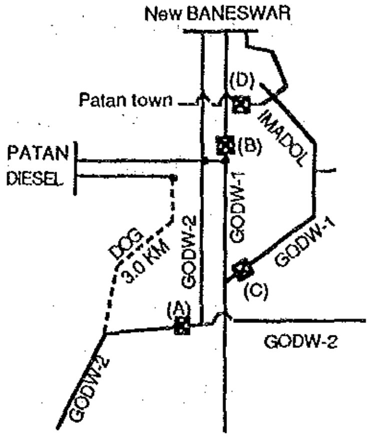
Major materials and equipment required for the extension of the Dharmasthali feeder are estimated in Table 12.1.

12.2.4 Lalitpur Power Division

(1) Godawari-1 & 2 Feeders from the Existing New Baneswar Substation

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

In order to reinforce the running Godawari-2 feeder, one of the unused tap-off feeders is to be newly extended to an existing angle point on the Godawari-2 feeder with ACSR Dog over 3 km from the present end point southward along the ring road and the existing motorable road up to the Capagau village.



In addition, an existing sectionalizing switch(A) on the Godawari-2 line will be opened.
Owing to the arrangement, the Godawari-2 feeder will have 2 supply sources and will be operated independently; one from Patan diesel power station to cover the western system of the existing Godawari-2 feeder and another from the Baneswar substation to the eastern system of the feeder.

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

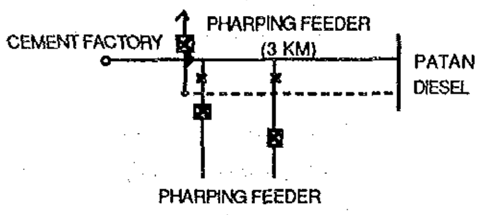
The plan will require the materials and equipment estimated in Table 12.1.

There is such a fact that power factor of this feeder is recorded at very low value because of operation of a marble factory located in the vicinity of Godawari. It is strongly recommended to provide static condensers for improvement of the power factor of the factory as early as possible.

(2) Pharping Feeder

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

The factory causes excessive voltage drop on the feeder and troubles to reliable power supply to other consumers.



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

The plan will contribute to improvement of the voltage regulation and the power supply reliability for both the public consumers and the cement factory.

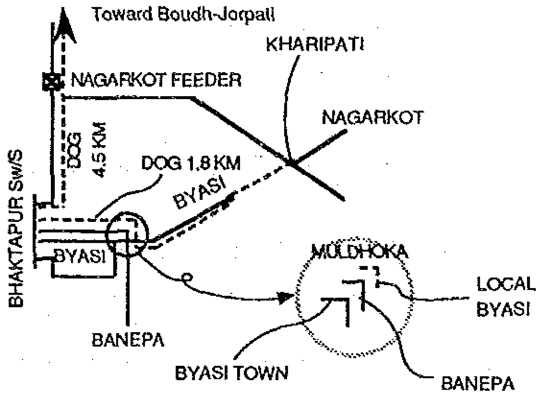
The new feeder will be constructed in the same route of the existing line to avoid troubles of acquiring new right of way for construction of the new feeder. Supports of the new feeder in the section will be of double circuit type, and the existing conductors will be restrung on the new double circuit type supports. Power supply to the factory and other consumers on the existing feeder can temporarily be made through other feeders during the construction of the new feeder. Power interruption required for construction of the new feeder will be therefore not a constraint.

Materials and equipment required for the plan are shown in Table 12.1.

12.2.5 Bhaktapur Power Division

(1) Nagarkot Feeder

The Nagarkot area is supplied with power from the existing Bhaktapur switching station over 17 km by the Nagarkot feeder equipped with a single circuit of HDCC 12.9 sq.mm and a single circuit of ACSR Rabbit. Receiving voltage at the customers' end is reported to be 170V against the rated 230V.



An improvement plan is to divert the supply route and to shift load in the area into 2 feeders by the following modifications.

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

(b) The existing Byasi feeder is extended over 2.5 km toward Kharipati along a road. A new single circuit line of ACSR Dog will be constructed in this 2.5 km section. The Nagarkot area will be supplied through an alternative route of Byasi and newly extended feeders of 12km long, which will shorten the supply distance by 6 km

(c) In order to increase reliability of power supply to the Bhaktapur town and Nagarkot area, a new double circuit line of ACSR Dog will be constructed from the switching station to the Muldhoka village.

For the planned new line between the switching station and the point, double circuits supports will be constructed over 1.8 km and the existing Banepa feeder in this section will be restrung on the new supports to avoid difficulty of acquiring the new right of way.
An additional distribution cubicle will be provided for the new feeder at the planned new Bhaktapur substation under the PSEP.

(d) The existing ACSR Rabbit conductor on the Byasi feeder (2km) between the Muldhoka village and the existing end of the feeder will be replaced with ACSR Dog conductor for upgrading its current carrying capacity.

Materials required to implement the above-mentioned arrangement are estiamated in Table 12.1.

12.2.6 Total Requirement of Materials and Equipment

Total quantities of materials and equipment required for implementation of the aforementioned 11kV main feeders and their related facilities are summarized below:

Items	Quantity
(a) ACSR (bare aluminium conductor)	174 km
(b) 11kV underground cable (3 core)	4.9 km
(c) 11kV insulated overhead cable..........................	17 km
(d) Pole : common use for 11kV and L.T	344 nos.
(e) 11kV sectionalizing switch..............................	30 sets
(f) Number of transformer units...........................	79 units
(g) Capacity of transformers	7,875 kVA
(h) Related L.T overhead cable	151 km
(i) Related L.T pole..	330 nos.
(j) 11kV drop-out switch..................................	50 pcs
(k) 11kV lightning arrester	50 pcs

General drawings of poles to be employed for the Project are shown in Figures 12.7 to 12.9.

12.2.7 Facilities provided by NEA

NEA will provide the Project with the following facilities in advance of commencement of site erection by the Contractor(s):

(a) right of way for construction of the works.

(b) permission for right of way for construction of the underground cable works.

(c) removal of telecommunications cables from the existing power poles to be replaced.

(d) all necessary procedures of tax exemption for import of materials and equipment for the Project and tools and vehicles of Contractors required for execution of the Project, subject to the approval of HMG/N.

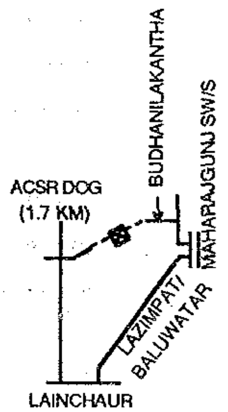
12.3 Extension and Reinforcement of Other Feeders and Lines

Extension and reinforcement plans for the feeders determined to be implemented in the aforementioned Section 12.1 (2) are discussed in details in this section. Reference maps to each plan are illustrated in Figures 12.2 to 12.6.

12.3.1 Kathmandu Central Power Division

(1) Interconnection of 11kV Feeders

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



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

The plan includes a new single circuit of ACSR Dog over 1.7 km with a section switch at the interconnecting point and 2 units of 100 kVA pole mounted transformers as well as the related materials for L.T line of 2 km long.

Required materials and equipment are estimated in Table 12.2.

(2) Additional Materials and Equipment

In order to improve the power supply reliability and voltage regulation of various lines in the division area, various materials and equipment are additionally required. Those are estimated in Table 12.2.

(3) Airport Feeder from Baneswar Substation

The voltage regulation of the feeder from the Baneswar substation will exceed the allowable extent in the year 1993/94. NEA is now implementing a countermeasure for improvement and reinforcement of the feeder to prevent aggravation of the supply reliability in the area. Further reinforcement of the feeder will not be required before the year 1995/96, accordingly.

12.3.2 Kathmandu East Power Division

(1) Additional Materials and Equipment

Housing and industries are developed in the eastern part of the division area under a new town planning. It is reported that the voltage of L.T lines in such developing areas is around 150V against the rated voltage of 230V because of shortage of 11kV lines and long low tension lines extended from existing overloaded small capacity transformers.

To improve the situation and to meet naturally growing demand and new demand due to development of town planning, materials and equipment are required for upgrading of conductor sizes and extension of 11kV systems.

Details of the required materials and equipment are shown on Table 12.2.

12.3.3 Kathmandu West Power Division

(1) Interconnection of Kirtipur Feeders

The feeder from the Siuchatar substation (Kirtipur-S) is interconnected with another Kirtipur feeder from the Teku substation (Kirtipur-T). Voltage drop of the Kirtipur-S is estimated at 7.8% in the year 1994/95, while voltage drop of the Kirtipur-T will be 0.7% in the year. If loads in the section-3 of the Kirtipur-S feeder will be shifted to the Kirtipur-T feeder, voltage drop of the Kirtipur-S will be much improved so as to be less than 7.5% by the year 2000/01. Voltage drop of the Kirtipur-T will increase due to power supply to the section-3 of the Kirtipur-S, but it will be still less than 5% in the year 2000/01. Accordingly, no reinforcement will be required for the feeders, but only shifting of partial load from the Kirtipur-S feeder to the Kirtipur-T feeder will reduce the excessive voltage drop of the feeder.

Besides the above load shifting, in order to increase supply reliability, interconnection will be established between both the Kirtipur feeders at Panga village and Carghare village over 1.5 km. Owing to the linkage, power will be supplied to the area through a loop system.

Materials and equipment required for the plan are detailed in Table 12.2.

(2) Additional Materials and Equipment

In order to improve and reinforce the exiting system, materials and equipment shown in Table 12.2 are required.

(3) Other Improvement Plans

Implementation of the following works for improvement and reinforcement of the system is required.

Through discussions with NEA head office, it was concluded that those works would be implemented by NEA at their expense and responsibility.

(a) Upgrading of 3.3 kV System :

Three areas in Kirtipur town and an area near the Swayambhu temple are still supplied with power by a 3.3 kV system being stepped down from 11kV feeder. This 3.3 kV system will be upgraded to 11 kV.

(b) Tahachal Feeder :

People have carelessly and illegally built a number of houses under the feeder, and yet they regardlessly complain of public safety to the Division Office. NEA will take necessary steps to cope with the situation. The actual insulation clearances to houses and other facilities from the feeder at present seem sufficient both vertically and horizontally.

(c) B.I.D Feeder :

BID requests NEA to increase supply reliability and supply capacity to its district. NEA delivers energy to BID through NEA's feeder to BID substation. All electrical facilities except the feeder in the District are operated and maintained by BID at its responsibility. Supply reliability is to be improved by rearrangement of the system as mentioned in Section 12.2.3(2) above. NEA will also take necessary reinforcement measures for increasing the supply capacity through extension of a new feeder when it will really be required by the District.

12.3.4 Lalitpur Power Division

(1) Old Patan-1 Feeder

The existing cables of the feeder should be replaced with cables of larger size before the year for increasing the feeder capacity.

In implementing modification of the Patan diesel power station under the Project, the cables on both the old Patan-1 and 2 feeders will be upgraded to meet future demand growth.

(2) Additional Materials and Equipment

In order to improve and reinforce the other power supply systems in the Division, various kinds of materials and equipment are required additionally. Those are detailed in Table 12.2.

12.3.5 Bhaktapur Power Division

(1) Reinforcement of a Section of Nagarkot Feeder

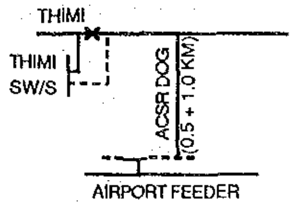
A section between Cangunariyan and Bramhakhel villages of the Nagarkot feeder is at present unused because of such incomplete facilities as one phase conductor only. After completion of the new Bhaktapur substation under the PSEP of IDA, it is anticipated that Nagarkot feeder will also supply power from the substation towards Boudha-Jorpati. Accordingly, the section will be restored under the

Project with a single circuit of ACSR Dog on new supports over 2km. Reference is made in the sketch for the Nagarkot feeder in the aforementioned 12.2.5(1).

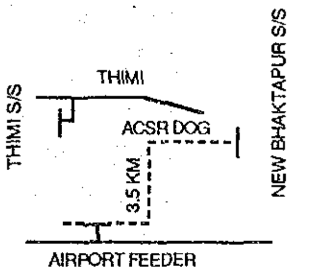
Materials and equipment required for the plan are estimated in Table 12.2.

(2) Thimi Feeder Extension

In consideration of the future development of industrial zone along the Kathmandu-Bhaktapur highway, the Division Office proposes to construct a branch feeder between the existing Thimi feeder and Airport branch feeder.



However, it is recommendable that instead of the proposed line, a new feeder will be constructed from the new Bhaktapur substation to the developing industrial area along the highway as shown in the right lower sketch.



The new line over 3.5km from the new Bhaktapur substation will supply more stable and quality power to the industries and houses in the area. The line will also be extensible along the highway to cover future demand growth.

Materials and equipment needed to implement the extension from the new substation are listed in Table 12.2.

(3) Additional Materials and Equipment

Other areawise improvement plan of 11 kV feeders in the distribution system are also required to ensure reliable and stable power supply to customers.

Table 12.2 shows necessary materials and equipment for implementation of the plan.

12.3.6 Total Requirement of Materials and Equipment

Total quantities of materials and equipment required for implementation of the aforementioned 11kV feeders and their related facilities are detailed in Table 12.2.

Following is a summary of the major items of those materials and equipment required for the Project.

Items	Quantity
(a) ACSR (bare aluminium conductor)........................	60 km
(b) 11kV underground cable (3 core).........................	17.6 km
(c) 11kV insulated overhead cable	23 km
(d) Pole : common use for 11kV and L.T....................	980 nos.
(e) 11kV sectionalizing switch................................	50 sets
(f) Number of transformer unit.................................	189 units
(g) Capacity of transformers...................................	18,050 kVA
(h) Related L.T overhead cable................................	37 km
(i) Related L.T pole..	135 nos.
(j) 11kV drop-out switch......................................	520 pcs
(k) 11kV lightning arrester....................................	520 pcs

The total required capacity of distribution transformers under the Project is estimated at about 26,000 kVA from the abovementioned plans including that of major feeders estimated in Section 12.2. While, total capacity of the transformers to be added to the Valley system by the year 1995/96 is estimated at 54,000 kVA as seen in Table 8.3. Total capacity of the transformers of 26,000 kVA required for this Project and about 30,000 kVA having been directly ordered by NEA is comparable with the estimated capacity of 54,000 kVA.

Multi-Circuit Switches listed in Table 12.2 are proposed by NEA to be installed at the following 5 sites:

(1) Balambu (near earth station) on the Thankot feeder,
(2) Khokna on Pharping feeder,
(3) Thaiba on Godawari-1 feeder,
(4) Manmaiju on Dharmasthali feeder and
(5) Bramhakel on Sundarjal feeder.

12.3.7 Maintenance Tools and Equipment

Following tools, vehicles and equipment are recommended to be supplied to NEA for proper operation and maintenance of the system.

(a) Tools :

Hydraulic compressor for conductor joints ...... 5 sets
Chain block : 5 tons x 3 m .... 5 nos.
Lever block : 1 ton .... 5 nos.
Hand operated winch : 1 ton .... 5 sets
Snatch block : 100 mm dia .... 25 nos.
Wire tensioner : 1.5 ton .... 25 nos.
Tension meter : 1 ton .... 5 sets
Aluminium pulley : 300 mm dia................ 50 pcs
Aluminium pulley : 120 mm dia................ 50 pcs

(b) Vehicles :

4 WD working truck w/insulated elevator bucket. 5 nos.
3 ton pick-up truck.................................. 5 nos.
Light maintenance vehicle............................ 2 nos.

(c) VHF Radio Equipment :

VHF tranceiver radio set .... 25 sets
VHF antenna and pole for base point............. 5 sets

(d) Measuring Equipment :

Megger ....10 nos.
Earth tester (0-10/100/1000 ohm)..................10 nos.
Clamp tester...10 nos.
Phase meter ....10 nos.
Voltage detector ....10 nos.
Cable fault locator .... 1 set

12.4 Recommended Reinforcement Plan for Low Tension Lines

(1) General

As discussed in the foregoing sections, serious issues of the present and future low tension (L.T) distribution systems are energy losses, voltage drops and shortage of materials to response to increasing demands.

(a) System Energy Losses:

The "Loss Reduction Programme (LRP)" under the financial and technical assistance of IDA is under way with supply of materials and equipment for reducing non-technical and technical losses in the country, as mentioned in Chapter 9.

The present plans prepared by NEA under LRP are summarized in Table 9.2. As seen in the table, a number of materials and equipment are to be procured for the purpose of not only reducing the energy loss but also improving the voltage regulation of 11kV and L.T systems.

(b) Voltage Drops:

LRP's implementation will also have an effective impact of improvement of excessive voltage drops in the L.T system. Additional reinforcement and improvement of L.T system under the Project will be planned in close cooperation with LRP.

(c) Improvement and Reinforcement of L.T Lines:

The existing L.T lines in a number of areas should be improved and reinforced for copying with increasing demands in proportion to the extension of 11kV lines and additional distribution transformers.

(d) Provision of Meter Calibration Center:

The existing NEA's calibration center is capable of calibrating 20 to 30 units per day, which will not be sufficient for periodical calibration of demanding meters in the whole country.

Three (3) meter calibration centers are to be developed under LRP; one in the Kathmandu Valley and the others in the Eastern and Western regions. The new Kathmandu center is under construction in the Swayambhu area. Construction of such facilities will, thereby, not be required under the Project.

(2) Details of Plans

In addition to the L.T materials and equipment related to the 11kV reinforcement and improvement plans discussed in Sections 12.2 and 12.3, various plans for improvement and reinforcement of the L.T systems are required.

Details of the major improvement and reinforcement plans in each power division are noted in Annex-5.

Following are principles for application of the required materials and summary of items and quantities of those materials.

(a) Insulated Cables:

In order to prevent power pilferage and for public safety, new and extended L.T lines in the congested areas will be constructed with insulated cables. Insulated cables will also be utilized for sections which require upgrading of conductors for meeting increasing demands in those areas. Bare conductors will be applied for such areas that no pilferage of energy and no danger to the lines and the public are anticipated, i.e. lines along main streets or roads with a sufficient clearance from houses/buildings, or comparatively depopulated areas.

Insulated cables will principally be erected with spool insulators on L.T poles or 11kV poles commonly used. In particular areas where no space for construction of poles is available, the cables may unavoidably be installed on walls of buildings and/or houses in the center of towns.

(b) Underground Cables:

Some of the existing L.T lines in the Kathmandu town are crossing over heavy traffic roads without a sufficient clearance or routed in extremely narrow space. Underground cables will be required to be laid down in such areas for the safe operation and maintenance of the system. The cables will be directly buried in the ground at a 0.6m to 1.0m depth, backfilled with sand and covered by protective bricks or equivalent materials.

(c) Poles:

A number of the existing poles have been aged and deteriorated. Those poles should be replaced with new and adequate poles as well as new insulators and fittings. Since locally manufactured concrete poles (8m long) are as heavy as 530kg and should be erected by a machinery, they will be used in only in areas accessible to vehicles. Poles supplied under the Project will therefore be of a jointable steel tube type which is easily transported and erected.

(d) Moulded Case Circuit Breakers:

Most of the existing L.T feeders are directly connected to distribution transformers without distribution switch boxes. Such connection causes unsafe operation and maintenance works of lines and transformers. In order to increase supply reliability and safe operation/maintenance of the systems, distribution switch boxes will be installed at some of the existing distribution transformers. The switch boxes will be of moulded case circuit breaker type (MCCB) enclosed by galvanized metal box with a specified trip current.

(3) Required Materials:

Materials and equipment required for the reinforcement and improvement of L.T systems are detailed in Table 12.3.

Following is a summary of the major materials and equipment to be utilized in each Division.

Work Items		Kathmandu Central	Kathmandu East	Kathmandu West	Lalitpur	Bhaktapur	Total
Conductor:							
ACSR Weasel	(km)	15	15	15	85	60	190
ACSR Rabbit	(km)	40	20	25	55	35	175
Insulated Cable							
(Al-OW)	(km)	84	5	0	12	16	117
Underground Cable							
(XLPE)	(km)	4	0	0	0	0	4
Poles	(pcs)	150	200	230	550	415	1,545
Spool Insulators							
w/fitting	(set)	800	800	1,000	2,200	2,000	6,800
Moulded Case C.B	(unit)	141	50	45	181	149	566

Note: * Al-OW : Outdoor-used Vinyl Insulated Aluminium Cable
* XLPE : Crosslinked Polyethylene Insulated Polyvinyl Chloride Sheathed Cable

(4) Local Erection Works:

Most of local erection works under the Project will be executed by Japanese Contractor(s) in compliance with the detailed requirements specified in the contract documents.

In the Project area there are several such places where houses and buildings overabound with only narrow paths, or where the existing lines/cables are fixed on walls of houses or buildings. It seems difficult for foreigners to carry out the works in those areas without the cooperation of inhabitants. NEA's assistance to contractor(s) is always required throughout the Project execution. In those areas, prearrangement by NEA/related authorities and full-time attendance of NEA's representatives are, in particular, required.

12.5 Effect of Extension and Reinforcement Plans

Implementation of the plans will contribute the following effects to the power system. Expected improvement of the voltage regulation and technical energy loss are also noted in each plan.

12.5.1 Kathmandu Central Power Division

(1) Reliable power supply to the developing area in the Maharajgunj area along the ring road will be secured owing to interconnection of the Nayabazar and Budhanilakantha feeders, because the area can be always supplied by either one feeder. Voltage drop and technical loss will also be effectively improved by the plan.

(2) Power supply to the customers in the center of Kathmandu town will be secured by addition of distribution transformers and extension of the existing feeders for improvement of voltage drops and also by installation of new underground cables in the congested areas for safety operation.

(3) Application of insulated cables for low tension will contribute to reduction of non-technical energy losses.

12.5.2 Kathmandu East Power Division

(1) Boudha-Jorpati Feeder

Due to construction of a new Boudha-Jorpati feeder, the voltage drop will be improved from forecasted 10% to 3.0% in the year 1995/96, and technical energy loss estimated at 2,600MWh/year in 1995/96 will be reduced to 330MWh/year. Save of energy loss will be more than 87% every year, which will save construction of additional generating facilities and increase the NEA's revenue for improvement of its financial state.

Improvement of the voltage regulation and the reduction of energy loss due to implementation of the plan will be as below:

Voltage Drop (%)	94/95	95/96	96/97	97/98	98/99	99/00	00/01
Without Reinforcement	8.67	9.95	11.37	12.98	14.81	16.85	19.18
After Reinforcement	2.56	2.95	3.36	3.84	4.38	4.99	5.68

Energy Loss (MWh/year)	94/95	95/96	96/97	97/98	98/99	99/00	00/01
Without Reinforcement	1,997	2,607	3,401	4,434	5,772	7,478	9,688
After Reinforcement	249	328	428	558	727	942	1,220

(2) New Branch Line to Gokarneswar

Industries being developed along the road via Arubari will be supplied with stable and quality power from a new feeder to be constructed along the road to Gokarneswar. The feeder will promote further development of new industries in the area.

(3) Upgrading of Airport Feeder

The upgraded Airport feeder from the New Chabel substation will improve the voltage regulation and reduce the energy loss as below:

Voltage Drop (%)	94/95	95/96	96/97	97/98	98/99	99/00	00/01
Without Reinforcement	3.44	3.99	4.61	5.31	6.11	7.71	8.02
After Reinforcement	2.04	2.36	2.73	3.14	3.61	4.15	4.75

Energy Loss (MWh/year)	94/95	95/96	96/97	97/98	98/99	99/00	00/01
Without Reinforcement	444	598	795	1,056	1,396	1,840	2,408
After Reinforcement	224	301	400	532	703	927	1,213

It is noted that the current carrying capacity of the upgraded conductors will be surpassed by the forecasted load current in the year 1997/98. Future reinforcement of the feeder should be comprehensively conducted together with load flow shift between both Airport feeders from the New Chabel substation and the New Baneswar substation based on the demand forecast to be frequently reviewed.

(4) Sundarijal Feeder

A new Sundarijal feeder upgraded with ACSR Dog will reduce the voltage drop from 13% estimated in the year 1995/96 to 4% and technical energy loss to 25% of that of the non-reinforced line. Voltage regulation of the upgraded feeder will be in the allowable extent even beyond the year 2000/01.

Voltage Drop (%)	94/95	95/96	96/97	97/98	98/99	99/00	00/01
Without Reinforcement	11.93	13.19	14.46	15.91	17.46	19.16	21.06
After Reinforcement	3.91	4.32	4.74	5.21	5.71	6.28	6.90

Energy Loss (MWh/year)	94/95	95/96	96/97	97/98	98/99	99/00	00/01
Without Reinforcement	484	592	711	860	1,034	1,248	1,507
After Reinforcement	122	150	180	217	261	315	381

(5) Baneswar Feeder

Renovation of the existing Baneswar feeder from the Chabel substation will reduce the voltage drop and technical loss as much as 40% as seen below:

Voltage Drop (%)	94/95	95/96	96/97	97/98	98/99	99/00	00/01
Without Reinforcement	4.76	5.51	6.37	7.34	8.43	9.67	11.09
After Reinforcement	2.94	3.40	3.93	4.52	5.20	5.96	6.94

Energy Loss (MWh/year)	94/95	95/96	96/97	97/98	98/99	99/00	00/01
Without Reinforcement	293	393	525	696	920	1,211	1,592
After Reinforcement	164	220	294	389	513	676	889

12.5.3 Kathmandu West Power Division

(1) Thankot Feeder

A new Thankot feeder will mainly supply power to the area up to Balambhu (Earth Station) and the upgraded existing feeder will supply power to further areas. Reinforcement of the Thankot feeder thereby will contribute not only to promotion of industries and commerce development along the Kathmandu-Thankot highway but also to stable power supply to meet those growing demands in the area under the independent two feeders.

Owing to the reinforcement, the voltage regulation and energy loss in the area will be respectively improved to as much as 25% and 18% of the present conditions.

Voltage Drop (%)	94/95	95/96	96/97	97/98	98/99	99/00	00/01
Without Reinforcement	9.31	10.39	11.57	12.91	14.40	16.05	17.85
After Reinforcement	2.40	2.67	2.98	3.32	3.71	4.13	4.59

Energy Loss (MWh/year)	94/95	95/96	96/97	97/98	98/99	99/00	00/01
Without Reinforcement	879	1,094	1,358	1,690	2,103	2,611	3,229
After Reinforcement	157	196	243	303	377	468	579

(2) BID Feeder

BID, the biggest industrial estate in the Kathmandu Valley, will benefit by stable power supply due to feeder arrangement for its exclusive use, separately from other demand centers.

(3) Kirtipur Feeder

Owing to the partial load shift of the Kirtipur feeder from the Siuchatar substation to another Kirtipur feeder from the Teku substation, both voltage regulation and energy loss will be much improved so that no reinforcement will be required for both feeders beyond the year 2000/01, and total energy loss of both feeders will be reduced to more than 50% compared with that under the existing load distribution. Contribution of such load diversion without any investment is certainly great.

Voltage Drop (%)	94/95	95/96	96/97	97/98	98/99	99/00	00/01
Kirtipur (Siuchatar)							
Before Load Shift	7.76	8.79	9.89	11.09	12.51	14.02	15.75
After Load Shift	-	4.03	4.54	5.09	5.74	6.43	7.22
Kirtipur (Teku)							
Before Load Shift	0.40	0.41	0.43	0.48	0.53	0.57	0.62
After Load Shift	-	2.56	2.84	3.15	3.49	3.85	4.27

Energy Loss (MWh/year)	94/95	95/96	96/97	97/98	98/99	99/00	00/01
Kirtipur (Siuchatar)							
Before Load Shift	611	782	992	1,247	1,586	1,992	2,514
After Load Shift	-	247	313	394	501	629	794
Kirtipur (Teku)							
Before Load Shift	6	7	9	10	12	14	17
After Load Shift	-	112	137	169	208	253	311

12.5.4 Lalitpur Power Division

(1) Godawari-1 and 2 Feeders

Owing to modification and reinforcement of the existing Godawari-1 and 2 feeders, power supply to the areas covered by the feeders will be improved through voltage regulation within the allowable extent beyond the year 2000/01. The voltage drop and energy loss will be reduced to 37% and 19% respectively of those of the existing feeders. Reliability of power supply will also much improved by separation of their supply route due to setting of new sectionalizing switches and auto-reclosers.

Voltage Drop (%)	94/95	95/96	96/97	97/98	98/99	99/00	00/01
Godawari-1 Feeder							
Without Reinforcement	8.50	9.17	9.94	10.79	11.74	12.72	13.80
After Reinforcement	4.57	4.93	5.34	5.80	6.31	6.84	7.42
Godawari-2 Feeder							
Without Reinforcement	10.70	11.56	12.50	13.53	14.70	15.92	17.62
After Reinforcement	4.11	4.43	4.80	5.19	5.64	6.11	6.63

Energy Loss (MWh/year)	94/95	95/96	96/97	97/98	98/99	99/00	00/01
Godawari-1 Feeder							
Without Reinforcement	603	702	824	972	1,150	1,352	1,591
After Reinforcement	224	262	307	362	428	503	592
Godawari-2 Feeder							
Without Reinforcemnt	956	1,115	1,304	1,529	1,805	2,115	2,489
After Reinforcement	182	212	248	291	343	402	473

(2) Pharping Feeder

Excessive voltage drop of the Pharping feeder will be improved by addition of a new line, and supply reliability will be increased by separation of feeder into two (2); the existing feeder for only the cement factory located at the end of the feeder and a new feeder for other customers.

Following are effects to the voltage regulation and energy loss by the reinforcement plan.

Voltage Drop (%)	94/95	95/96	96/97	97/98	98/99	99/00	00/01
Without Reinforcement	-	8.21	9.26	10.40	11.68	13.14	14.74
After Reinforcement							
Existing Feeder	-	2.46	2.78	3.12	3.50	3.94	4.42
New Feeder	-	1.32	1.49	1.67	1.87	2.11	2.36

Energy Loss (MWh/year)	94/95	95/96	96/97	97/98	98/99	99/00	00/01
Without Reinforcement	-	443	563	710	895	1,133	1,425
After Reinforcement							
Existing Feeder	-	40	51	64	81	102	128
New Feeder	-	45	58	73	92	116	146

12.5.5 Bhaktapur Power Division

(1) Improvement of Nagarkot Feeder

(a) Stable power supply to the Bhaktapur town will be secured by a complete separation from other feeders.

(b) Addition of a new line will increase the power supply capacity and reduce the voltage drop and technical energy loss of the Banepa and Nagarkot feeders.

Voltage Drop (%)	94/95	95/96	96/97	97/98	98/99	99/00	00/01
Without Reinforcement	8.56	9.86	11.35	13.03	14.89	17.03	19.45
After Reinforcement							
Existing Feeder	2.26	2.61	3.00	3.44	3.93	4.50	5.14
New Feeder	2.62	2.98	3.40	3.87	4.39	4.98	5.64

Energy Loss (MWh/year)	94/95	95/96	96/97	97/98	98/99	99/00	00/01
Without Reinforcement	303	402	532	701	915	1,197	1,562
After Reinforcement							
Existing Feeder	51	68	90	118	155	202	264
New Feeder	43	56	73	94	121	156	200

(c) Reliability of power supply to the Nagarkot area will be increased due to extension of the Byasi feeder to connect to the Nagarkot feeder. The new extension line will also contribute to more reliable and stable power supply to the areas along the line.

(2) New Feeder from Bhaktapur

A new extension line from the new Bhaktapur substation to the highway will promote further industrialization and area development in the district with reliable and stable power supply.

(3) Extension of Nagarkot Feeder

Improvement of an unused section between Boudha-Jorpati feeder and Nagarkot feeder will increase supply reliability in both areas due to power supply flexibility.

12.5.6 Low Tension System

(1) Application of Insulated Cables

Application of insulated cables will be effective (a) to prevent energy pilferage from direct line-tapping, (b) to increase safety of the public and (c) to increase supply reliability by reducing short circuit faults on lines.

(2) Application of and Upgrading to Larger Conductors

Application of larger section conductors will reduce energy loss of conductors and voltage drop at the customers' end. Reduction of energy losses will save construction of new generating facilities leading to improvement of NEA's financial state. Reduction of voltage drop will improve the quality of power supply to the customers.

(3) Extension of Lines

Extension of lines with adequate sizes of conductors and cables as well as addition of distribution transformers will meet demands of the waiting consumers and increase in capacity required by the present customers.

It will result in raise of electrification in the Valley, improvement of people's living standard and increase of NEA's revenue.

CHAPTER 13

COST ESTIMATE AND CONSTRUCTION SCHEDULE

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COST ESTIMATE AND CONSTRUCTION SCHEDULE

13.1 General

This chapter explains the estimate of construction cost of each sub-project for substations, transmission lines and distribution systems discussed in Chapters 11 and 12. The cost is estimated in Japanese Yen for both CIF at site and local erection works allocating to portions to be spent in Japan and Nepal. In addition, implementation schedule of the Project is also discussed in this chapter, taking account of implementation stages.

13.2 Cost Estimate

13.2.1 Basis of Cost Estimate

The Project costs are estimated on the following basis:

(1) Supply and erection of materials and equipment will be executed by a Japanese contractor.

(2) CIF of materials and equipment is estimated on the Japanese market prices as of June 1991.

(3) Local erection costs are estimated on the basis of Kathmandu and Japanese market prices as of June 1991.

(4) No price escalation is considered in both CIF and erection costs. Anticipated price escalation is separately estimated as a lump sum at the annual increasing rates of 5% in Japanese market and 10% in Nepalese market.

(5) Engineering fee is estimated on the same bases as the above-mentioned CIF and erection works.

13.2.2 High Voltage Transmission System

Following are the estimated costs for extension and reinforcement plans for the high voltage transmission system discussed in Chapter 11.

Description	CIF	Erection			Total		
	(Foreign) (¥1,000)	(Foreign) (¥1,000)	(Local) (¥1,000)	(Total) (¥1,000)	(Foreign) (¥1,000)	(Local) (¥1,000)	(Total) (¥1,000)
(a) 11kV Cubicles	246,900	128,500	14,700	143,200	375,400	14,700	390,100
(b) 11kV Underground Cable Line	60,100	102,900	22,100	125,000	163,000	22,100	185,100
(c) K3 Substation & 66kV Line	951,900	364,700	137,000	501,700	1,316,600	137,000	1,453,600
(d) 132/66kV Transformer	269,300	108,200	16,700	124,900	377,500	16,700	394,200
Total Cost	1,528,200	704,300	190,500	849,800	2,232,500	190,500	2,423,000

It is to be noted that costs allocated for "Local" in the tables in this Section mean the procurement costs in Nepal, but do not mean the local currency budgeted by HMG/N.

13.2.3 Distribution System

Following are the estimated costs for extension and reinforcement plans for the 11kV feeders and low tension lines selected in Chapter 12.

Feeder	Division	CIF	Erection			Total		
		(Foreign) (¥1,000)	(Foreign) (¥1,000)	(Local) (¥1,000)	(Total) (¥1,000)	(Foreign) (¥1,000)	(Local) (¥1,000)	(Total) (¥1,000)
Bouddha-Jorpati	(East)	61,900	37,800	7,700	45,500	99,700	7,700	107,400
Godawari-1 and 2	(Lalitpur)	33,400	20,300	4,200	24,500	53,700	4,200	57,900
Sundarijal	(East)	73,100	44,600	9,100	53,700	117,700	9,100	126,800
Thankot	(West)	61,500	37,500	7,700	45,200	99,000	7,700	106,700
Kirtipur	(West)	14,300	8,700	1,800	10,500	23,000	1,800	24,800
Pharping	(Lalitpur)	41,700	25,500	5,200	30,700	67,200	5,200	72,400
Airport (New Chabel)	(East)	22,000	13,400	2,800	16,200	35,400	2,800	38,200
Baneswar	(East)	39,300	24,000	4,900	28,900	63,300	4,900	68,200
Nagarkot	(Bhaktapur)	89,400	54,500	11,200	65,700	143,900	11,200	155,100
Center of Kathmandu Tower	(Central)	7,200	4,400	900	5,300	11,600	900	12,500
Sub-total		443,800	270,700	55,500	326,200	714,500	55,500	770,000
Center of Kathmandu Town	(Central)	46,700	28,500	5,800	34,300	75,200	5,800	81,000
Dharmasthali	(West)	17,600	10,700	2,200	12,900	28,300	2,200	30,500
Baralgau-Gokarneswar	(East)	34,100	20,800	4,300	25,100	54,900	4,300	59,200
Interconnection on Ring Road	(Central)	20,000	7,400	1,500	8,900	27,400	1,500	28,900
Nagarkot-Bramhakhel	(Bhaktapur)	19,600	7,200	1,500	8,700	26,800	1,500	28,300
Additional Materials	(Central)	133,600	49,400	10,100	59,500	183,000	10,100	193,100
Additional Materials	(East)	60,000	22,200	4,500	26,700	82,200	4,500	86,700
Additional Materials	(West)	71,600	26,500	5,400	31,900	98,100	5,400	103,500
Additional Materials	(Lalitpur)	236,700	87,400	17,900	105,300	324,100	17,900	342,000
Thimi	(Bhaktapur)	36,100	13,400	2,700	16,100	49,500	2,700	52,200
Additional Materials	(Bhaktapur)	93,700	34,600	7,100	41,700	128,300	7,100	135,400
Sub-total		769,700	308,100	63,000	371,100	1,077,800	63,000	1,140,800
Low Tension Materials	(Central)	134,700	24,400	5,000	29,400	159,100	5,000	164,100
Low Tension Materials	(East)	49,400	9,000	1,800	10,800	58,400	1,800	60,200
Low Tension Materials	(West)	52,800	9,500	2,000	11,500	62,300	2,000	64,300
Low Tension Materials	(Lalitpur)	156,200	28,300	5,800	34,100	184,500	5,800	190,300
Low Tension Materials	(Bhaktapur)	120,100	21,700	4,500	26,200	141,800	4,500	146,300
Sub-total		513,200	92,900	19,100	112,000	606,100	19,100	625,200
Tools and Vehicles		67,700	0	0	0	67,700	0	67,700
Total Cost		1,794,400	671,700	137,600	809,300	2,466,100	137,600	2,603,700

The above feeders are listed by order of priority as shown in Table 13.1.

13.2.4 Total Project Cost

Following is the total project cost of the transmission system and distribution system estimated above.

Particulars	CIF (Foreign) (¥1,000)	Erection (Foreign) (¥1,000)	Erection (Local) (¥1,000)	Erection (Total) (¥1,000)	Total (Foreign) (¥1,000)	Total (Local) (¥1,000)	Total (Total) (¥1,000)
(1) Transmission system	1,528,200	704,300	190,500	894,800	2,232,500	190,500	2,423,000
Subtotal	1,528,200	704,300	190,500	894,800	2,232,500	190,500	2,423,000
(2) Distribution System							
(a) 11kV Main Feeders	443,800	270,700	55,500	326,200	714,500	55,500	770,000
(b) 11kV Other Feeders	769,700	308,100	63,000	371,100	1,077,800	63,000	1,140,800
(c) Low Tension Lines & Others	580,900	92,900	19,100	112,000	673,800	19,100	692,900
Subtotal	1,794,400	671,700	137,600	809,300	2,466,100	137,600	2,603,700
(3) Total of (1) and (2)	3,322,600	1,376,000	328,100	1,704,100	4,698,600	328,000	5,026,700

It is noted that the total construction cost tabled above covers all of plans proposed by NEA and recommended by the JICA study team to be implemented by the year 1995/96.

In addition to the above costs of supply and erection, Engineering Fees for design and supervision of the Project as well as Contingency for price escalation are required to be included in the total budget of the Project.

The Total Project Cost will be, therefore, as below:

	Foreign (¥1,000)	Local (¥1,000)	Total (¥1,000)
(1) Supply and Erection	4,698,600	328,100	5,026,700
(2) Engineering Fees	320,000	0	320,000
(3) Contingency	611,500	80,000	691,500
Grand Total	5,630,100	408,100	6,038,200

Note: Contingency

Foreign Portion : 5% annum

Local Portion : 10% annum

13.3 Stage Development

13.3.1 Period of Development

It will be almost impossible to complete any one sub-project mentioned above in a single budgetary year taking account of the necessary periods for "Exchange of Note" between both Governments, tender/contract, manufacturing of materials and equipment, transportation, local erection and test.

The Project will be implemented stagewise in a period of two (2) years, accordingly, i.e. 1st year for design, manufacturing and shipment and 2nd year for local erection and test.

13.3.2 Stage Development of Project

As seen in the above cost estimates, the total Project cost will amount approximately to ¥6,038,000,000.

The fund for the Project will be limited. In order to examine the stagewise implementation of the Project so as to suit the availability of fund, the sub-projects are classified by order of priority.

(1) Priority Order of Recommended Sub-projects

Priority order of the sub-projects is determined in consideration of the following criteria.

(a) The transmission system plays an important role as the source of power supply to the Valley in which no generating facilities are operated at present. In this respect, implementation of the reinforcement and improvement of the transmission system is in principle ranked higher.

The first priority is given to the urgently required sub-projects for the transmission system including reinforcement of substations, swithcing stations and 11kV trunk lines which have been recommended by the Study Team and not included in the PSEP under IDA.

(b) The second priority is given to the sub-projects for 11kV main feeders by order of ranking in the distribution system.

(c) The third priority is given to the sub-projects for construction of the K3 substation with its related 66kV transmission line and addition of a 132/66kV transformer to the Siuchatar substation as the next urgent sub-project in the transmission system.

(d) All other sub-projects are expected to be implemented simultaneously following the above sub-projects within the available fund.

(2) Recommendation of Stage Development

Basing on the recommended priority, the stage development and the costs are lined up as below:

Sub-Project	CIF & Erection (¥1,000)	Accumulation (¥1,000)
Phase-1 Project		
(1) 11kV Cubicles	390,100	390,100
(2) 11kV U/G Cables	185,100	575,200
(3) 11kV Priority Feeders	770,000	1,345,200
(4) Engineeering Services	160,000	1,505,200
Total of (1) - (4)	1,505,200	
Contingency	79,800	
Total of Phase-1 Project	1,585,000	
Phase-2 Project		
(1) K3 S/S & 66kV T/L	1,453,600	1,453,600
(2) Transformer to Siuchatar	394,200	1,847,800
(3) 11kV Other Feeders	1,140,800	2,988,600
(4) Low Tension Lines	625,200	3,613,800
(5) Tools for O&M	67,700	3,681,500
(6) Engineering Services	160,000	3,841,500
Total of (1) - (6)	3,841,500	
Contingency	611,500	
Total of Phase-2 Project	4,453,000	
Total	6,038,000	

The Phase-1 project for 11kV feeders covers the following subprojects while all other subprojects for 11kV feeders are included in the Phase-2 project.

(a) Boudha-Jorpati feeder
(b) Godawari-1 and 2 feeders
(c) Sundarijal feeder
(d) Thankot feeder
(e) Kirtipur feeder
(f) Pharping feeder
(g) Airport feeder from the New Chabel substation
(h) Baneswar feeder
(i) A portion of Kathmandu center
(j) Nagarkot feeder

It is to be noted that the abovementioned costs are based on the prices as of June, 1991 and that costs of each sub-project should be altered if the above priority is amended, because allocation for general expenses, costs of erection tools, expenses for expatriate experts, etc. for sub-projects would be changed.

13.4 Construction Schedule

Figure 13.1 shows a comprehensive implementation time schedule of the Project. Supply of materials and equipment will be completed in the first year, while the site erection works will be carried out within the second year in each phase.

Following are considered to be key activities to complete the Project within the time.

(1) Exchange of Note to be concluded at the earliest date in the budgetary year.

(2) Earliest agreement and certification of the Engineering Services.

(3) Customs clearance at the Calcutta port and inland transport through Indian territory.

(4) NEA's pre-arrangement for smooth customs clearance of cargoes, acquisition of land for new facilities, obtainment of right of construction, people's understanding of and cooperation to the Project, necessary power interruption for the works, etc.