No. 57

MASTER PLAN AND FEASIBILITY STUDY ON EXTENSION AND REINFORCEMENT OF POWER TRANSMISSION AND DISTRIBUTION SYSTEM IN KATHMANDU VALLEY IN NEPAL

SUMMARY

DECEMBER 1991

JAPAN INTERNATIONAL COOPERATION AGENCY

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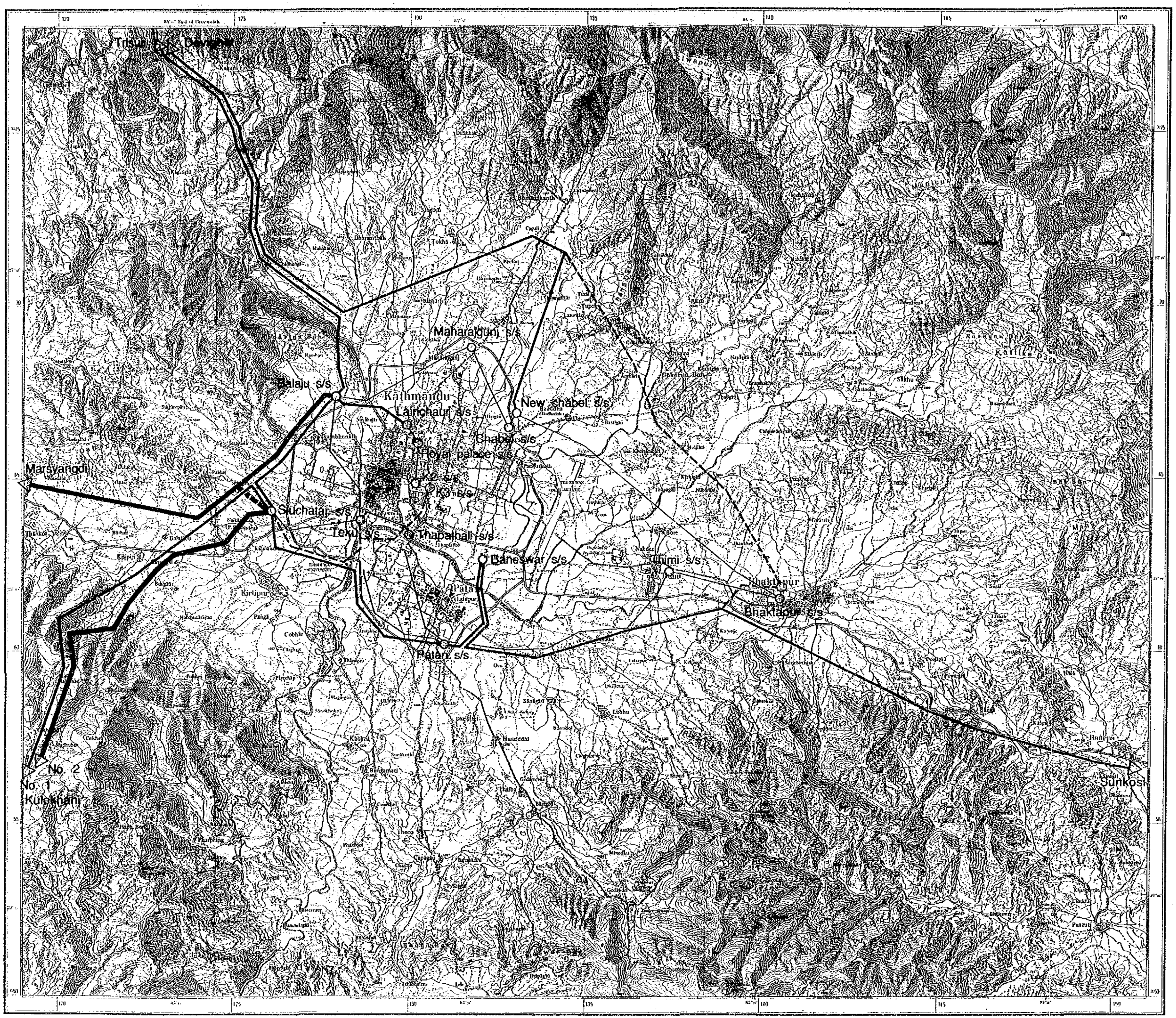


LEGEND

132KV LINE

66KV LINE

11KV LINE

132KV LINE (PLANNED BY 1995)

66KV LINE (PLANNED BY 1995)

SCALE

0 5km

KATHMANDU VALLEY

TABLE OF CONTENTS

1. Background and Objectives of the Study

1.1 Background of the Study

The Kathmandu Valley is the center of Nepal in all respects of politics, administration, economics, finance, culture, etc. encompassing the capital, Kathmandu. However, the power supply in the late 1970's to the early 1980's was in a miserable state and people's life in the Valley was considerably hindered by frequent power blackouts and excessive voltage drops due to insufficiency in power generating capacity and inadequacy in power distribution network.

In order to improve such situation, the network reinforcement projects were implemented under three grant aids from GOJ in the 1980's and generating facilities such as the Kulekhani I and II, Devighat and Marsyangdi power stations including power transmission and substation facilities were also commissioned in the Valley.

Though the power supply system has remarkably improved under these projects, the system will face over-loading soon due to the rapid demand growth in the Valley. Under such circumstance, HMG/N requested the GOJ to conduct this study.

1.2 Objectives of the Study

The objectives of the Study are;

(a) to establish a master plan for the ten years from 1991 to 2000 for the extension and reinforcement of the power transmission and distribution system to meet demand growth in the Kathmandu Valley, and

(b) to perform feasibility study on the power transmission and distribution facilities which are selected in the master plan as urgent and important reinforcement countermeasures to be implemented within the coming five years.

The scope of works agreed between NEA and JICA is given in ANNEX-1 attached hereto.

2. Power System in Nepal

2.1 Generating Facilities

The total installed capacity of power generating facilities in Nepal was 257 MW, but their possible output was 228 MW in total as of 1990. Most of those facilities (98%) are interconnected with 132 kV and 66 kV transmission line (Central Nepal Power System, CNPS). Installed capacities by plant types are summarized below:

Facilities	CNPS	Others	Total
Hydro	227.2 MW	1.9 MW	229.1 MW
Diesel	25.0 MW	3.1 MW	28.1 MW
Total	252.2 MW	5.0 MW	257.2 MW

In addition to the existing facilities, the following power plants are under construction:

(a) Diesel power plant of 26 MW (4 x 6.5 MW units) in Biratnagar area (1992)

(b) Andikola hydropower plant of 5 MW (1991)

(c) Jhimruk hydropower plant of 12 MW (1995)

2.2 Power Transmission Facilities

The transmission line voltages employed at present in the country are 132 kV, 66 kV and 33 kV. Since the voltage of 132 kV was firstly employed for the line between the Gandak power station and the Hetauda substation in 1979, the 132 kV system has been extended over the country.

Figure 2.1 indicates the existing transmission system in the whole Nepal.

A general information on transmission lines and transformers in the country is given below:

Transmission Lines and Substation Facilities

Voltage	Transmission Line (Circuit-km)	Capacity of Transformer Whole system	(MVA)*1 Bagmati Area
132 kV	1,000.0	213.8 *2	82.8
66 kV	379.5	188.7	153.9
Total	1,379.5	402.5	236.7

Note: *1 excluding step-up transformers at power stations
*2 including 132/66 kV transformers

2.3 Power Network in Kathmandu Valley

Power to the Kathmandu Valley is supplied from the Marsyangdi and Kulekhani II power stations through 132 kV transmission lines and from the Kulekhani I, Trisuli, Devighat and Sunkosi power stations through 66kV transmission lines, and in order to distribute electric power to consumers inside the Valley, the following facilities are provided:

- Two (2) 132/66/11 kV substations (Siuchatar and Balaju)
- Four (4) 66/11 kV substations (New Patan, Baneswar, Lainchaur and New Chabel)
- Nine (9) 11 kV switching stations (Teku, Royal Palace, Maharajgunj, K2, Old Patan, Old Chabel, Thapathali, Thimi and Bhaktapur)
- Sixty eight (68) 11 kV feeder lines of 560 km in total

Power supply system in the Kathmandu area involving the Ring Main System is illustrated in Figure 2.2.

As explained in Section 1.1, some facilities and distribution networks in the Valley have been rehabilitated and reinforced under 3 projects (years 1980, 1982 and 1986) which utilized the grant aids from the GOJ, as given below:

Historical Records of Distribution Network in Kathmandu Valley

	1978	1980 1st Phase	1982 2nd Phase	1986 3rd Phase
(a) Distribution Line (circuit-km)				
11 kV	250	342	422	450
3.3 kV	64	39	20	0
Total	314	381	442	450
(b) Distribution Substation (MVA)*1				
11/0.4-0.23 kV	31.64	57.26	84.33	93.23
3.3/0.4-0.23 kV	8.82	4.00	2.00	2.00
Total	40.46	61.26	86.33	95.23

Note:*1 Not including transformers installed by hospitals, factories, and others at their own expenses.

Owing to those three projects, about 84% of the population in the Kathmandu Valley was enjoying the benefit of electricity against 8.9% in the whole country as of 1990.

2.4 Current Problems on Network in Kathmandu Valley

Although a considerably high voltage drop is observed at some parts of the existing distribution network, this does not seriously affect the current power distribution under normal operating condition. However, some hindrances to stable power supply take place on the existing transmission and distribution network under operating conditions with outage of any one facility such as transmission line or transformer, as listed hereunder.

a) Power supply shortage in Patan, Baneswar and city central areas due to outage of the 66 kV Siuchatar-Patan line,

b) Power supply shortage in the area served from the Baneswar substation due to outage of the 66 kV Patan-Baneswar line,

c) Power supply deficit of the interconnected system due to outage of the 132 kV Marsyangdi-Bharatpur line,

d) Power supply deficit of the interconnected system due to outage of the 66 kV Trisuli-Balaju line,

e) Restoration of the Lainchaur substation which was burnt down in July 1990,

f) Rating of 66 kV and 11 kV circuit breakers, etc.

3. Power Market

3.1 Power Demand

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

Power Market of Whole Nepal

Year	Generation (GWh)	Peak Demand (MW)	Sold Energy (GWh)	Losses (GWh)	Losses (%)
1980/81	235.4	59.5	164.4	71.0	30.2
1981/82	275.2	75.1	186.4	88.8	32.3
1982/83	347.0	83.7	235.6	111.4	32.1
1983/84	382.4	96.8	252.3	130.1	34.0
1984/85	420.8	104.5	293.0	127.8	30.4
1985/86	488.5	113.7	341.4	147.1	30.1
1986/87	571.0	123.0	402.6	168.4	29.5
1987/88	627.0	135.2	465.2	161.8	25.8
1988/89	672.3	149.5	496.2	176.1	26.2
1989/90	769.7	176.2	548.7	221.6	28.8
Average annual growth (%)					
80/81-85/86	15.7	13.8	15.7	15.7	
85/86-89/90	12.0	11.6	12.6	10.8	
80/81-89/90	14.1	12.8	14.3	13.5	

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

Growth rates of demand by category in the interconnected system in the recent 10 years are as below:

Demand Growth by Category

Category	1980/81 (GWh)	1989/90 (GWh)	Annual Average Growth Rate(%)
Domestic	79.0(48%)	231.4(42%)	12.7
Industry	53.8(33%)	178.3(33%)	14.2
Others	31.6(19%)	138.4(25%)	17.8
Total	164.4(100%)	548.1(100%)	14.3

Demand categorized as "Others" in the above table grew at a high rate. Such high growth was caused by the revision of the country's tariff system in the year 1983 and 1985.

Total number of domestic customers in the whole country is 274,491 and 8.9% of the total population is benefitting by electricity. As for the Kathmandu Valley, electrification ratio in the year 1990 was 83%.

In the daily load curve of the power system, there are two peaking times; the higher peak is recorded at 18:00 to 19:00 pm and the lower peak at 8:00 am. Monthly peak demands in the morning and evening in 1989/90 were as follows:

Monthly Peak Demand(MW)

Month	Evening Peak	Morning Peak
Jul/Aug	128.9	84.9
Aug/Sep	127.9	90.2
Sep/Oct	135.0	90.9
Oct/Nov	146.6	110.4
Nov/Dec	167.7	125.7
Dec/Jan	171.6	137.5

Month	Evening Peak	Morning Peak
Jan/Feb	170.3	139.8
Feb/Mar	150.9	114.4
Mar/Apr	150.7	109.9
Apr/May	149.6	109.3
May/Jun	153.3	108.7
Jun/Jul	153.4	104.5

A notable feature of power demand in Nepal is that the annually highest demand is recorded in the winter season when heating is required, and the summer peak demand is about 70 to 80% of the winter peak demand.

In the winter season, output of hydropower stations, especially that of run-of-river type hydropower stations decreases because of low discharge of rivers. Since the power supply structure of Nepal is typically hydropower dominant, the development plan of power sources in Nepal should be examined taking this fact into due consideration.

3.2 Demand Density in Kathmandu Valley

The following surveys were conducted for examination of the present demand density in the Kathmandu Valley in 1989/90.

(a) Locations of distribution transformers and their installed capacity.
(b) Records of energy sales by each billing unit.

Two kinds of demand density in the Valley are given in Figure 3.1 and 3.2.

4. Demand Forecast

4.1 Previous Demand Forecast

Results of current two power demand forecasts performed by NEA and EDF are summarized below:

Comparison of Power Demand Forecasts

Year	1986 D. Forecast		EDF 1989		Actual	
	(GWh)	(MW)	(GWh)	(MW)	(GWh)	(MW)
1985/86	473.3	107.1	-	-	488.5	103.0
1986/87	557.5	124.0	-	-	571.0	123.0
1987/88	635.5	141.1	611.0	141.0	627.0	135.2
1988/89	709.7	157.7	656.0	150.0	672.3	149.5
1989/90	787.0	177.4	691.0	160.0	769.7	176.2
1995/96	1,281.3	286.5	1,176.8	269.0	-	-
2000/01	1,705.4	381.2	1,910.0	436.0	-	-
2005/06	2,225.7	510.3	2,822.8	632.0	-	-

(Note) : GWh=Energy generation, MW=Peak demand

4.2 National Demand Forecast

Forecasts of power demand for each area in the Kathmandu Valley or for each substation and switching station are essential to formulate the extension and reinforcement plans of the power transmission and distribution system in the Valley. The areawise demand forecast should be consistent with the demand forecast for the regional and national systems.

Firstly, therefore, the nationwide demand over a period of 20 years till the year 2010/11 is forecasted. While examining the nationwide forecast, the territory of the country is for convenience' sake, divided into 2 areas; the Bagmati zone and other zones for the reason that reliable projection data of population by zones in the country over the period to be examined have not been obtained.

The forecast is examined for the following 5 consumer categories classified by NEA:

(a) Domestic demand
(b) Industrial demand
(c) Commercial demand
(d) Agricultural demand
(e) Others

Results of power demand forecasted for 20 years in this study are summarized below.

Energy Generation Forecast (GWh)

Area	1989/90	1995/96	2000/01	2005/06	2010/11
Bagmati	371.9	600.0	925.8	1,378.4	1,986.3
Others	374.6	719.0	1,208.1	1,829.0	2,736.6
Whole Nepal	746.5	1,319.0	2,133.9	3,207.4	4,722.9

Maximum Demand (MW)

Area	1989/90	1995/96	2000/01	2005/06	2010/11
Bagmati	96.1	150.8	227.8	332.0	468.5
Others	75.5	142.0	234.5	349.1	520.7
Whole Nepal	171.6	292.8	462.3	681.1	989.2

Share of Energy Consumption (%)

Area	1989/90	1995/96	2000/01	2005/06	2010/11
Bagmati					
Domestic	57.7	57.9	57.9	58.6	57.8
Industry	16.5	18.4	20.3	21.1	22.9
Others	25.8	23.7	21.8	20.3	19.3
Other Area					
Domestic	30.6	28.7	28.6	30.6	30.9
Industry	51.4	54.3	56.3	56.5	58.0
Others	18.0	17.0	15.1	12.9	11.1

Energy requirement in the Bagmati area was about 50% of the total requirement of the country in the year 1989/90. However, its share would fall down to 43% in 2000/01 and 42% in 2010/11.

4.3 Areawise Demand Forecast for Kathmandu Valley

Based on the results of demand forecast for the Bagmati area obtained in the previous nationwide forecast, areawise demand forecasts for the Kathmandu Central, Kathmandu East, Kathmandu West, Lalitpur and Bhaktapur branch offices were worked out.

For that purpose, records of energy sales of each branch office in the period of two months (Nepalese months of Poush and Magha) of 1985/86 and 1989/90 were collected with assistance of NEA counterpart personnel. These data were also used for examining demand density in the Valley at present (see Section 3.2) and its future trend (see Section 4.4). Annual averaged growth rates of energy sales by branch office are given below:

Records of Energy Sales (MWh)

	1985/86			1989/90			G.R
	Poush	Megha	Total	Poush	Megha	Total	(%)
Kathmandu C	7,772	8,059	15,831	11,636	10,733	22,369	9.03
Kathmandu E	1,593	1,671	3,264	3,171	3,148	6,319	17.95
Kathmandu W	2,237	1,938	4,175	4,060	3,861	7,921	17.36
Lalitpur	2,546	2,387	4,933	4,027	3,919	7,946	12.66
Bhaktapur	723	772	1,495	1,352	1,423	2,775	16.71
Total	14,871	14,829	29,700	24,246	23,084	47,330	12.36

Notes: Poush = December 16 to January 15
Megha = January 16 to February 15

For estimating share of energy sales of each branch office in future, a ratio method with time factor was applied. The results of areawise demand forecast are as given below.

Regional Forecast of Energy Sales (% & GWh)

	1989/90		1995/96		2000/01	
	Ratio	Demand	Ratio	Demand	Ratio	Demand
Kathmandu Central	45.19	118.16	38.02	173.35	33.19	248.84
Kathmandu East	12.77	33.38	15.69	71.56	17.75	133.07
Kathmandu West	16.00	41.84	19.23	87.84	21.50	161.24
Lalitpur	16.06	41.97	16.05	73.20	15.02	119.35
Bhaktapur	5.61	14.66	6.66	30.38	7.43	55.73
Kabhre	1.73	4.53	1.70	7.77	1.67	12.50
Sindhuli/Dolakha	1.36	3.56	1.34	6.10	1.31	9.82
Rasuwa/Nuwakot	1.28	3.36	1.26	5.76	1.24	9.28
Total	100.00	261.45	100.00	455.96	100.00	749.87

4.4 Forecast of Peak Demand of Each Station in Kathmandu Valley

Maximum demand of each substation and switching station was forecasted by examining the present supply area of each station, growth rate of the areawise demand obtained in Section 4.3, estimated energy losses of transmission lines, transformers and distribution networks, and estimated load factor.

The forecasted peak demands are summarized below.

(MW)

Substation	1989/90	1995/96	2000/01	Growth (%)
Kathmandu - 2	12.40	16.86	21.77	5.25
Teku	9.03	13.13	17.94	6.44
Lainchaur	6.89	9.37	12.10	5.25
Thapathali	5.30	7.20	9.31	5.25
Maharajgunj	1.97	2.68	3.46	5.25
Old Chabel	8.08	12.66	18.40	7.77
New Chabel	1.74	3.35	5.78	11.53
Baneswar	13.50	23.51	37.32	9.68
Siuchatar	6.34	11.99	20.38	11.20
Balaju	5.37	10.15	17.26	11.20
Old Patan	7.22	11.57	17.13	8.17
Bhaktapur	5.61	10.00	16.18	10.11
Thimi	1.78	3.34	5.64	11.05
Trisuli	1.20	1.89	2.76	7.87
Sunkosi	1.56	2.46	3.59	7.87
Total	87.99	140.14	209.02	8.18

5. Master Plan for Reinforcement and Extension of Transmission System including Ring Main System

5.1 Basic Criteria for System Reinforcement and Extension

Overload of transformers and transmission lines, voltage drop and system losses are deemed to be important criteria to determine the reinforcement and extension scheme.

The power flow analyses were conducted under both the operating conditions with (abnormal) and without (normal) outage of one circuit of transmission line.

The criteria for judging whether the planned power supply system is reliable and technically acceptable or not, are as follows:

		Normal	Abnormal
Overload:	Transformer	100%	120%
	Line	100%	100%
Voltage drop (11 kV bus)		7%	10%

5.2 Basic Conditions for Power Flow Analysis

(1) Power Network

The objective network system for power flow analysis includes all the transmission lines, substations, switching stations and the 11 kV ring main distribution lines in the Kathmandu Valley and the power stations with related transmission lines outside the Valley. The existing network configuration as of January 5, 1990 was considered as a basic power network for the analysis, and remedial plans were formulated so as to solve problems which were observed on the system as a result of the power flow analysis with forecasted demand. A single line diagram in 1990 is given in Figure 2.2.

(2) Maximum Load of Each Station for the System Analysis

The actual load of substations and switching stations recorded at 19:00 pm on January 5, 1990 was adopted for the base year. For the analysis in the future stages, the forecasted demand of each station for each year stated in Section 4.4 is used.

(3) Voltage Regulation

Voltage at 11 kV buses in the system is supervised and regulated by changing tap ratio of transformers at substations. The tap ratio is controlled in the range of actual ratios of the existing transformers and +/- 10% for the transformers to be additionally installed under this study in order to minimize the investment cost for the reinforcement of the power system.

5.3 Generation Expansion Plan for System Analysis

Balance of demand and supply capacity in the country till the commissioning of the Arun 3 power station is estimated by NEA as given below:

Deficit of Power Supply

Year	Deficit in the Country	
	Power (Peak) (MW)	Energy (GWh)
1994/95	15	3
1995/96	42	42
1996/97	69	118
1997/98	99	213
1998/99	129	333
1999/00	169	487

Analysis of the power system by 2000/01 in the Kathmandu area should be conducted taking into account the balance of supply and demand in the system. Accordingly, imaginary generating facilities equivalent to the deficit is assumed to be installed at the existing Hetauda substation for simplification of analysis.

5.4 Result of Power Flow Analysis

Stable and reliable electric power supply in the Kathmandu Valley has been examined under both normal and abnormal operating conditions by power flow analysis.

If some troubles like excessive voltage drop (7% under normal operating condition and 10% under abnormal operating condition) or overload were observed on the power transmission network as a result of the power flow analyses, proper countermeasures are selected from the catalogue of alternatives and their effectiveness to the system improvement is examined again through the system analysis for the selection of an optimum countermeasure in the year.

The countermeasure selected throughout the study horizon is given as "Scenario-A" in Table 5.1.

In Scenario-A, the construction of the New Bhaktapur substation and the 66kV New Bhaktapur-New Chabel line is the most appropriate countermeasure to remarkably improve power supply reliability of the power transmission and distribution system in the Kathmandu Valley. As an alternative plan, the following plans are conceived for further comparative studies, since adoption of a 132 kV power supply system covering the whole Valley is needed in future to increase power transmission capacity of the 66 kV system.

Scenario-B

At the time when a new substation is constructed at Bhaktapur in the Scenario-A, a 132/66 kV substation is to be constructed at the same place in addition to a 66/11 kV substation, together with a 132 kV line between Siuchatar and New Bhaktapur which will form a part of the 132 kV ring line system in future.

Scenario-C

In Scenarios-A and B, some extension of 132 kV switchgear at the Siuchatar substation is required and some difficulties in land acquisition are expected for extension of substation area and for construction of transmission lines. Especially in future when a 132 kV ring system is formed surrounding Kathmandu city, acquisition of necessary land space for the extension of 132 kV switchgear and transmission lines may become very difficult.

To avoid such difficulty, a new 132 kV switching station is planned to be constructed near Thankot when a new 132/66/11 kV substation is constructed at Bhaktapur in the Scenario-B, to which both the existing 132kV Kulekhani II and Marsyangdi lines are connected.

A similar simulation study on the above two scenarios has been conducted, and the proposed sequences of investments for the reinforcement and extension of the system are given in Table 5.1 together with Scenario-A.

5.5 Short Circuit Analysis

The rated short-circuit capacity of the existing switchgear equipment was examined by three-phase short circuit analysis on the abovementiond planned system.

As a result of the analysis, the calculated short-circuit currents of the system to be reinforced and extended will exceed the rated capacity of the existing 11 kV cubicles at the following switching stations during the study horizon.

Switching Station	Rated Capacity	Short-circuit Capacity *1	Number of Cubicles
1989/90			
1) Old Patan	7.88kA	12.5kA	11
2) Teku	7.88kA	9.1kA	11
3) Royal Palace	7.88kA	9.1kA	5
1995/96			
4) Old Chabel	7.88kA	10.8kA	10
5) Old Patan *2	13.10kA	13.5kA	1
2000/01			
6) Thimi	7.88kA	8.4kA	6

Remarks : *1 : Scenario-A
*2 : Diesel generator circuit

5.6 Evaluation of Extension and Reinforcement Plan

(1) Construction Cost

Construction cost of each sub-project selected in the previous sections was estimated on the basis of current tendency of international market price, geological conditions of the sites, and the past three reinforcement projects for the distribution network in the Kathmandu Valley implemented under the grant aids from the GOJ, and summarized as below.

(US$ 1000)

		Scenario - A	Scenario - B	Scenario - C
(1)	Up to 1995/96	23,400	26,914	29,487
(2)	Up to 2000/01	19,135	13,639	13,639
(3)	Total	42,535	40,553	43,126

(2) Optimum Investment Plan

For selecting an optimum investment plan, each investment scenario is evaluated by converting the investment capital and system losses of each project stream to the present value as given below:

	Scenario - A	Scenario - B	Scenario - C
(a) Investment cost	26,806	27,620	29,981
(b) System losses	12,417	12,200	12,092
Total	39,223	39,820	42,073

Remarks: a) Unit = US$1000
b) Discount rate = 10%
c) Loss value: US$130/kW/year and US$0.075/kWh

In addition to the above evaluation, the economic viability of the sequence of investment was tested against major factors where uncertainties are involved.

a) Sensitivity to changes in discount rate

	8%	10%	12%
Scenario - A	42,988	39,223	35,941
Scenario - B	43,199	39,820	36,860
Scenario - C	45,475	42,073	39,091

Note: Unit = US$ 1000

b) Sensitivity to changes in construction cost

	-20%	0	+20%
Scenario - A	33,861	39,223	44,584
Scenario - B	34,296	39,820	45,344
Scenario - C	36,077	42,073	48,070

Note: Unit = US$ 1000

As a result of the evaluation, Scenario-A is economically justified.

6. Master Plan Study on 11 kV Distribution System

It is anticipated that the following serious issues will occur soon in the distribution system of the Valley, unless adequate reinforcement and improvement measures are taken.

(a) Excessive voltage drop and increase of energy losses,
(b) Insufficiency of distribution transformer capacity,
(c) Shortage of distribution lines, and
(d) Inaccurate demand meters.

For concrete clarification of issues in the existing network, the voltage regulation and conductor current carrying capacity of each feeder were examined up to the year 2000/01, taking account of the future demand growth. The examination revealed the following feeders to be reinforced and improved before the year 2000/01.

Power Division	Name of Feeder	Issue on Feeder	Predicted Year
Kathmandu Central	Budhanilkantha	capacity	1999/00
Kathmandu East	Airport (N. Chabel)	capacity	1994/95
	Airport (Baneswar)	drop	1993/94
	Boudha-Jorpati	capacity	1990/91
	Sundarijal (N. Chabel)	drop	1998/99
	Sundarijal (O. Chabel)	drop	1989/90
	Baneswar (O.Chabel)	capacity	1994/95
	Baneswar (Baneswar)	capacity	2000/01
	Godawari-1	drop	1993/94
	Godawari-2	drop	1989/90
	Shankhamul	capacity	2000/01
	Patan	capacity	1999/00
Kathmandu West	Kirtipur (Ropeway)	drop	1994/95
	Thankot	drop	1992/93
	Dharmasthali	capacity	1996/97
	B.I.D	capacity	1992/93
Lalitpur	Old Patan-1	capacity	1993/94
	Old Patan-2	capacity	1996/97
	Pharping	drop	1995/96
	Mangal Bazar	capacity	2000/01
Bhaktapur	Byasi	capacity	2000/01
	Banepa	drop	1998/99
	Nagarkot	drop	1994/95

Note: "Capacity" and "Drop" in the above table mean "insufficient conductor current carrying capacity" and "excessive voltage drop", respectively.

Although it is not expressed in the computation of the above table, a number of other 11 kV feeders and low tension lines are also required to be reinforced and improved for reducing voltage drop and energy losses and also for restoring supply reliability.

Implementation of the reinforcement and improvement of the distribution system was classified into (a) the sub-projects to be completed up to the year 1995/96 and (b) the sub-projects to be completed thereafter to the year 2000/01. The former sub-projects were further examined in the feasibility study for the urgent implementation.

7. On-going Reinforcement Projects in Kathmandu Valley

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

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. 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) Update 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

(1) Power Sector Efficiency Project

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, NEA's institutional development, the support actions in energy conservation, etc.

In the Power Sector Efficiency Project, the reinforcement and upgrading of the existing transmission and distribution networks in the Valley are also included (hereinafter called "PSEP"). It aims 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.

(2) Loss Reduction Program

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 operation and financial performance. Nontechnical losses due to improper billing, illegal connections and incorrect metering have contributed about half of the system losses.

In order to reduce such high system losses, mainly non technical losses, 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.

Phase III of the LRP would continue Phase II in the Kathmandu Valley and extend the successful elements to the rest of the country.

(3) 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:

(a) Additional stringing of second circuit conductors on the double circuit towers between Siuchatar and New Patan by NEA upto March 1992.

(b) Restoration of Lainchaur substation to be financed by KfW

8. Feasibility Study on Selected Sub-projects

8.1 General

Sub-projects urgently required for improvement and reinforcement of the transmission and distribution systems were selected for their implementation before the year 1995/96 for the following major objectives.

(a) Increase of the system capacity
(b) Replacement of the existing aged and deteriorated facilities

(c) Improvement of voltage regulation and overload of 11 kV feeders and low tension lines

(d) Reduction of the current high energy losses

8.2 High Voltage Transmission System

As explained in previous Chapter, the reinforcement project of the system in the Kathmandu Valley under financial assistance of IDA (PSEP) and other donors are in progress in parallel with this study. Almost all sub-projects of the PSEP are included in the master plan established under this study.

For selecting sub-project to be implemented under this project, the reinforcement works under other projects explained in Chapter 7 are supposed to be implemented as scheduled. That is, power flow analysis with a similar study in Chapter 5 on the system after the completion of the reinforcement works of the PSEP have been conducted with the projected peak demand in 1995/1996, and the following reinforcement countermeasures to meet the demand are selected:

(1) Construction of New K3 Substation:

To meet the growing demand in the center of the Valley and to improve excessive voltage drops of 11 kV buses at the K2, Royal Palace and Lainchaur stations, a new substation (K3) will be constructed at a place on the Ring Main line between the New Patan substation and the K2 switching station. Power to the K3 substation will be supplied from the Siuchatar substation through a new 66 kV double circuit line being tapped off a 66 kV double circuit line to be constructed between the Siuchatar and Teku substations under the IDA project.

(2) Addition of 132/66 kV Transformer at Siuchatar Substation:

In order to improve overloading of the existing transformer in the Siuchatar substation, additional transformers are required to be installed in the substation together with the related switchgears for parallel operation with the existing transformers.

The reinforcement plans of the superannuated facilities on the ring main system examined in the previous chapter are not included in the works under financial assistance of IDA. Therefore, the following reinforcement countermeasures of the facilities are urgently required.

(3) Augmentation of 11 kV Switching Station:

In order to increase capacity of the existing 11 kV power facilities to meet the growing demands, total 36 new cubicles will be required for replacement and addition to the Old Patan, Royal Palace and Old Chabel switching stations.

Beside, the replacement of cubicles at the existing Teku switching station to be replaced with new ones under the PSEP are not considered in this project.

(4) Construction of 11 kV Underground Cable Line:

To maintain the high reliability of power supply to the center of Kathmandu, a new underground cable line will be constructed over 1.9 km route length between the existing Lainchaur substation and the K2 switching station. The cable will be a single core of 11 kV cross linked polyethylene insulated vinyl sheathed steel armored 325 sq.mm.

8.3 Distribution System

Sub-projects selected in the distribution system were as follows:

(1) Urgently Required Reinforcement and Improvement of 11 kV Main Feeders in the Master Plan explained in Chaptger 6:

(a) Boudha-Jorpati feeder
(b) Sundarijal feeder
(c) Godawari-1 and Godawari-2 feeders
(d) Thankot feeder
(e) Baralgau-Gokarneswar feeder
(f) Pharping feeder
(g) Airport feeder from the new Chabel substation

(h) Baneswar feeder
(i) Nagarkot feeder
(j) A portion of center of the Kathmandu town
(k) Dharmasthali feeder

Total quantities of materials and equipment required for implementation of the mentioned above 11kV main feeders and their related facilties 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 unit	79	units
(g)	Capacity of transformers...........................	7,875	kVA
(h)	Related L.T overhead cable........................	151	km
(i)	Relatred L.T pole	330	nos.
(j)	11kV drop-out switch	50	pcs
(k)	11kV lightning arrester.............................	50	pcs

(2) Reinforcement and Improvement of Other 11kV Feeders:

The following sub-projects are required to be implemented continuously following the feeders mentioned above.

(a) A portion of the center of Kathmandu town
(b) Load re-sharing of Kirtipur feeders
(c) Airport feeder (Baneswar S/S)
(d) Connection of Naya Bazar and Budhanilkantha feeders on the ring road
(e) Renovation of Nagarkot-Bramhakhel feeder
(f) New branch feeder from Thimi feeder
(g) Other various feeders in each power division

Following is a summary of the major items of materials and equipment required for the above 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........................	31 km
(i)	Relatred L.T pole	135 nos.
(j)	11kV drop-out switch	520 pcs
(k)	11kV lightning arrester............................	520 pcs

(3) Reinforcement and Improvement of Low Tension Lines

A number of portions in the low tension networks of each power division are too aged and deteriorated to supply stable power to the customers. Reinforcement and improvement of various sections in the networks are urgently required.

Following is a summary of the major materials and equipment to be constructed 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 Aluminum Cable
* XLPE : Crosslinked Polyethylene Insulated Polyvinyl Chloride Sheathed Cable

(4) Tools and Equipment:

For ensuring proper operation and maintenance of transmission lines and distribution lines, several kinds of mechanical tools, vehicles and others are needed by NEA.

Similar tools and vehicles were supplied under the last JICA projects for the Kathmandu distribution system. However, those have been almost deteriorated.

8.4 Implementation Priority of Selected Sub-Project

After selection of the sub-projects, they were ranked with the project priority in consideration of the following criteria.

(a) The transmission system is playing an important role as the power source into 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 will be given to the urgently required sub-projects of the transmission system including reinforcement of substations, switching stations and 11 kV trunk lines which have been recommended by JICA's Study Team and not included in the PSEP under IDA.

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

(c) The third priority sub-project will be K3 substation with its related 66 kV transmission line and addition of 132/66 kV 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.

8.5 Effect of the Project

Completion of the Project will bring about the following effects to the Valley system.

(a) Stable power supply due to renovation of power facilities which are deteriorated and insufficient in capacity,

(b) Effective utilization of generated energy due to reliable energy supply and reduction of energy losses,

(c) Acceleration of industrialization due to the reinforced and improved system,

(d) Satisfaction of customers' requirement for quality energy and increase of energy consumption,

(e) Saving of fuel woods and imported energy due to utilization of enregy saved from electric energy losses,

(f) Improvement of NEA's operation and maintenance costs due to reinforced and improved facilities,

(g) Improvement of NEA's financial state by reduction of energy losses and operation/maintenance costs and reduction of supply interruption owing to upgraded power facilities, and

(h) A raise in the people's living standard owning to increase of supply of qualified energy.

The Project will bring direct benefits to the people living in the Valley and indirect benefits to the whole country in respect of energy saving in the Valley which consumes about 50% of total power generated in the country.

9. Construction Cost and Schedule

9.1 Construction Costs

Construction costs required for the sub-projects to be implemented up to the year 1995/96 were estimated on the basis of Japan and Kathmandu market prices as of June 1991.

Considering the disbursement of the available fund, it was assumed that the Project will be developed stagewise and therefore the sub-projects were classified into the Phase-1 and Phase-2. The Phase-1 project covers

(a) augmentation of 11 kV switching station,
(b) construction of 11 kV underground cable, and
(c) urgently required sub-projects for 11 kV feeders,

while, the Phase-2 project covers

(d) new K3 66/11 kV substation with the related 66 kV transmission line,
(e) addition of 132/66 kV transformers and switchgears to the existing Siuchatar substation,
(f) other 11 kV feeders, and
(g) low tension lines in each power division.

The estimated construction costs of those projects are as below:

Phase-1 Project

(i)	CIF and Erection	1,345,200,000
(ii)	Engineering Services	160,000,000
(iii)	Contingency for Escalation	79,800,000
	Total	¥1,585,000,000

Phase-2 Project

(i)	CIF and Erection	3,681,500,000
(ii)	Engineering Services	160,000,000
(iii)	Contingency for Escalation	611,500,000
	Total	¥4,453,000,000

9.2 Construction Schedule

Completion of each project will take two (2) years, taking account of necessary periods for "Exchange of Note" between both Governments, detailed design of the Project, tender/contract, manufacturing of materials and equipment, transportation, erection and test.

The first year will be for design, manufacturing, factory inspection and shipping. The second year will be for inland transportation of materials and equipment, erection and commissioning test.

The Phase-1 project will be completed in two (2) years and thereafter the Phase–2 project will follow. Total project period will be then four (4) years.

10. Economic and Financial Evaluation

10.1 General

Economic and financial internal rates of return (EIRR and FIRR) are used as an index for evaluation of the reinforcement and extension projects for the power transmission and distribution networks in the Kathmandu Valley, including projects to be implemented with assistance of IDA and other donors.

Investment costs of these projects to be used for the calculation of EIRR and FIRR are summarized below:

(Unit: US$1,000)

	HV System		MV System	LV System		
	PSEP	JICA	JICA	LRP	JICA	Total
1991/92	4,600	-	-	1,104	-	5,705
1992/93	4,830	-	7,112	1,190	-	13,132
1993/94	4,830	-	4,170	1,190	-	10,190
1994/95	1,840	10,124	6,359	482	4,312	23,117
1995/96	-	5,864	3,736	-	1,083	10,670
Total	16,100	15,986	21,367	3,966	5,394	62,813

Note: JICA = Projects selected in this study

Revenue from the additional energy sales in the Valley which may become possible due to such reinforcement works is considered as benefits. Additional energy sales in the Valley are worked out on the basis of demand forecasts in this study as follows:

(GWh)

	91/92	92/93	93/94	94/95	95/96	96/97
Bagmati	308.5	340.3	375.0	413.7	456.0	504.0
Kavre, Trisuli & Sunkosi	13.5	14.8	16.3	17.9	19.6	21.6
Kathmandu	295.0	325.5	359.0	395.8	436.4	482.4
Additional Sales	-	30.5	64.0	100.8	141.4	187.4

As for estimation of unit benefit for the benefit calculation, the long-run marginal cost (LRMC) for EIRR and the theoretical tariffs for FIRR proposed in the Draft Report for LRMC and Tariff Study (Dec., 1990) given below are used for base cases.

Customer Group	Existing Tariffs	Theoretical Tariffs	LRMC
(Generation)	-	-	Rs. 1.28
HV Customer	Rs. 1.13	Rs. 1.04	Rs. 2.01
MV Customer	Rs. 1.47	Rs. 1.50	Rs. 3.34
LV Customer	Rs. 1.40	Rs. 3.21	Rs. 5.35
Average	Rs. 1.40	Rs. 2.75	-

Difference between LV customers' tariff and HV customers' tariff is applied as the unit benefit.

10.2 Economic and Financial Evaluation

All the costs involved in the plans are measured as economic costs by applying the standard conversion factor of 1.0 for the foreign currency portion and 0.9 for the local currency portion of the project cost. Proposed LRMC in Section 10.1 is used as the unit benefit for the economic evaluation, i.e. Rs. 3.34/kWh, and EIRR is computed at 35.1%.

For the financial evaluation, the proposed theoretical tariffs are adopted for the estimation of the unit benefit. FIRR is computed at 21.3% based on Rs. 2.17/kWh.

10.3 Sensitivity Analysis

The viability of the reinforcement and extension of the network in the Valley is tested against major factors where uncertainties are involved.

For electrical tariffs, as proposed in the Draft Report of LRMC and Tariff Study, some revision of the existing tariffs will be made in near future, but not decided yet. In this study, therefore several tariff levels are examined for their effects on the viability of the plans. The results are summarized below:

EIRR

Unit Benefit	EIRR
a) Base case	35.1%
b) -15% of LRMC	29.2%
c) -30% of LRMC	23.2%
d) Theoretical tariffs	21.5%

FIRR

Unit Benefit	FIRR
a) Base case (theoretical tariff)	21.3%
b) -15% of theoretical tariff	17.7%
c) -30% of theoretical tariff	13.8%
d) Existing tariff level	9.0%

For capital costs and O/M costs, the change of EIRR and FIRR caused by cost increase has been examined as below:

		EIRR	FIRR
a) Base case		35.1%	21.3%
b) Const. cost:	+10%	31.5%	19.2%
	+20%	28.6%	17.4%
d) O/M cost:	+25%	34.6%	20.8%
	+50%	34.0%	20.3%

10.4 Conclusion

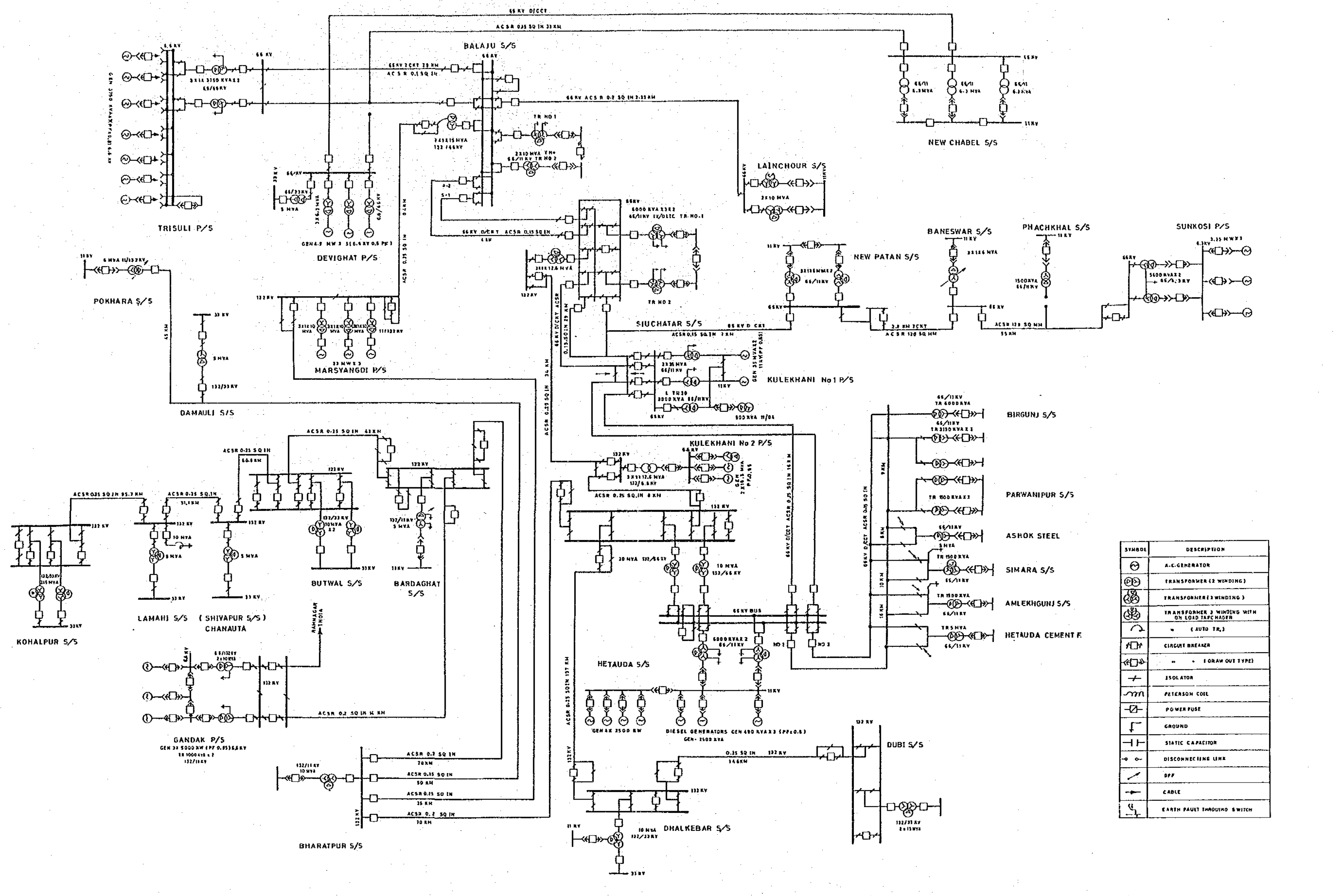
As presented above, it can be said that the envisaged optimal reinforcement and extension plans for the networks in the Valley are quite feasible from the economic and financial points of view.

TABLE

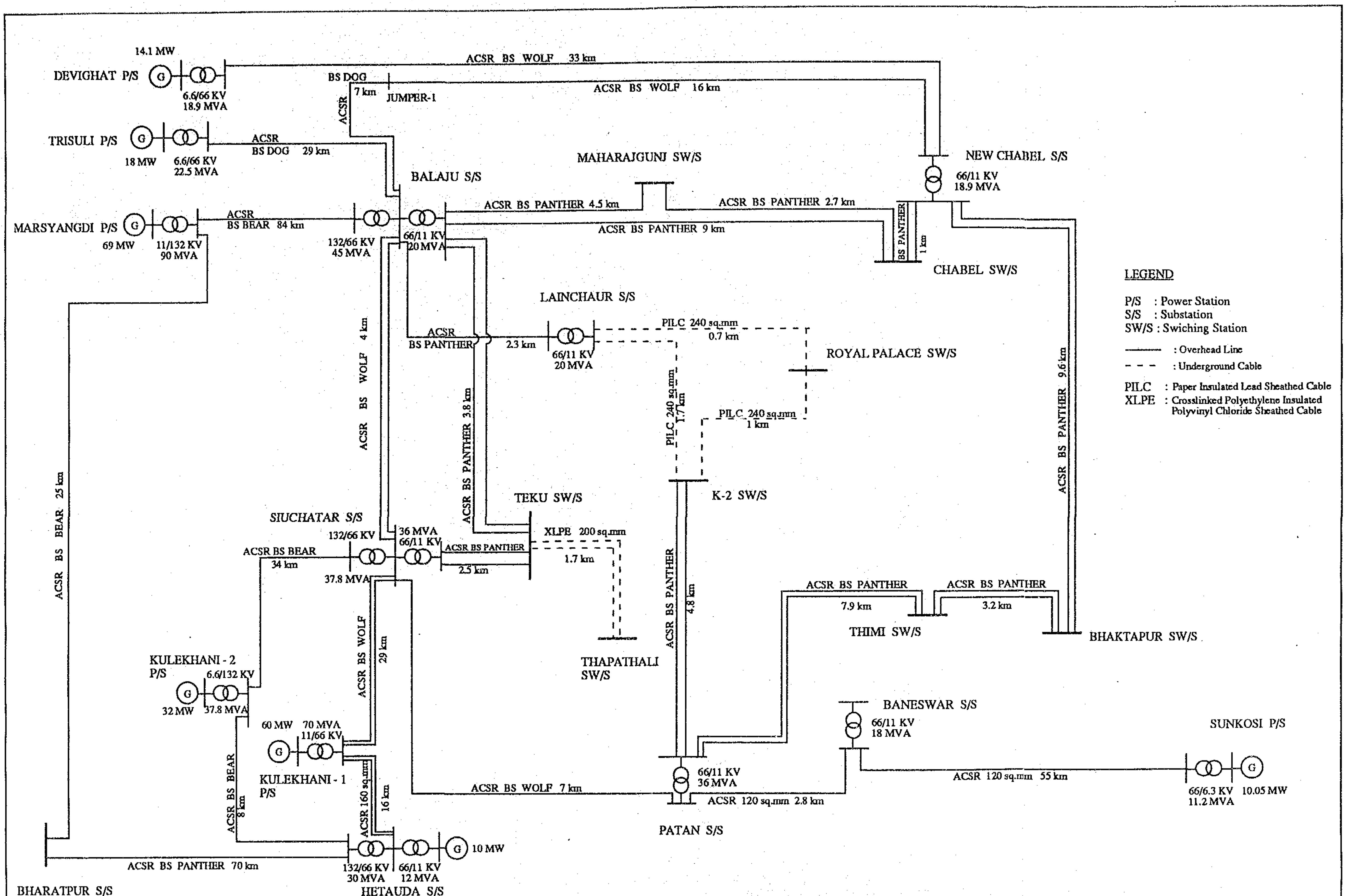
Table 5.1 Selected Reinforcement and Extension Plans

Year	Sub-project of Scenario A	Sub-project of Scenario B	Sub-project of Scenario C
1990/91	(1) 2nd circuit of 66kV Siuchatar - Patan line includ. 66kV T/L bay at Patan and Siuchatar		
1991/92	(2) Creation of 66/11kV New Bhaktapur S/S,1x10MVA includ. connection of Sunkosi line and 11kV line (3) 66kV 1cct New Bhaktapur - New Chabel line includ. 66kV switchgear at New Chabel	(1) Creation of 132/66kV New Bhaktapur S/S, 132/66kV 45MVA and 132/11kV 1x18MVA includ. connection of Sunkosi line and 11kV line (2) 132kV Siuchatar-New Bhaktapur line, 1st cct includ. 132kV switchgear at Siuchatar	(1) Creation of 132kV switching station near Thankot (2) Creation of New Bhaktapur S/S, 132/66kV 1x45MVA and 132/11kV 1x18MVA, includ. includ. connection of Sunkosi line and 11kV line (3) 132kV Siuchatar-New Bhaktapur line (1st cct) includ. 132kV switchgear at Siuchatar
1992/93	(4) Modification of 66kV switchgear at Trisuli P/S and jumper connection between Trisuli and Devighat (5) Connection of Marsyangdi line to Siuchatar S/S includ. 132kV switchgear(2 T/L bays) (6) Addition of 66/11kV transformer at Baneswar includ. 66kV switchgear,2x18MVA in total	(3) Modification of 66kV switchgear at Trisuli P/S and jumper connection between Trisuli and Devighat (4) Connection of Marsyangdi line to Siuchatar includ. 132kV switchgear (5) Augmentation of 66/11kV transformer at Baneswar includ. 66kV switchgear	(4) Modification of 66kV switchgear at Trisuli P/S and jumper connection between Trisuli and Devighat (5) Augmentation of 66/11kV transformer at Baneswar includ. 66kV switchgear
1993/94	(7) Creation of 66kV K3 S/S, 2x18MVA includ. 11kV switchgear for transformer circuit (8) 66kV Siuchatar-K3 2cct line includ. switchgear at Siuchatar	(6) Creation of 66kV K3 S/S, 2x18MVA includ. 11kV switchgear for transformer circuit (7) 66kV Siuchatar-K3 2cct line includ. switchgear at Siuchatar	(6) Creation of 66kV K3 S/S, 2x18MVA includ. 11kV switchgear for transformer circuits (7) 66kV Siuchatar-K3 2cct line includ. switchgear at Siuchatar
1994/95	(9) Addition of 132/66kV transformer at Siuchatar includ. 132kV and 66kV switchgear		
1995/96	(10) Upgrading of Teku SW/S to 66kV 1x18MVA S/S includ. incoming lines from Siuchatar-K3 line (11) Addition of 66/11kV transformer at New Bhaktapur, 2x10MVA in total	(8) Augmentation of 132/66kV transformer at Siuchatar includ. 132kV and 66kV switchgear (9) Upgrading of Teku SW/S to 66kV 1x18MVA S/S includ. incoming lines from Siuchatar-K3 line	(8) Augmentation of 132/66kV transformer at Siuchatar includ. 132kV and 66kV switchgear (9) Upgrading of Teku SW/S to 66kV 1x18MVA S/S includ. incoming lines from Siuchatar-K3 line
1996/97	(12) Replacement of 66/11kV transformers at New Chabel S/S from 3x6.3MVA to 2x18MVA	(10) Replacement of 66/11kV transformers at New Chabel S/S from 3x6.3MVA to 2x18MVA	(10) Replacement of 66/11kV transformers at New Chabel S/S from 3x6.3MVA to 2x18MVA
1997/98	(13) Replacement of 66/11kV transformers at Lainchaur from 2x10MVA to 2x18MVA (14) Creation of 66/11kV Banepa S/S includ. connection of Sunkosi line and 11kV cubicles	(11) Replacement of 66/11kV transformers at Lainchaur from 2x10MVA to 2x18MVA (12) Creation of 66/11kV Banepa S/S, 1x10MVA includ. connection of Sunkosi line and 11kV cubicles	(11) Replacement of 66/11kV transformers at Lainchaur S/S from 2x10MVA to 2x18MVA (12) Creation of 66/11kV Banepa S/S includ. connection of Sunkosi line and 11kV cubicles
1998/99	(15) 132kV Siuchatar-New Bhaktapur 2cct line (16) Upgrading of New Bhaktapur S/S to 132kV includ. 132kV switchgear at Siuchatar (17) Creation of 132/11kV Chapagaon S/S, 1x18MVA (18) Addition of 66/11kV transformer at Teku S/S, 2x18MVA in total (19) Replacement of 66/11kV transformers at Balaju S/S from 2x10MVA to 2x18MVA	(13) 2nd circuit of 132kV Siuchatar - New Bhaktapur line includ. 132kV switchgears (14) Addition of 66/11kV transformer at Teku S/S, 2x18MVA in total (15) Creation of 132/11kV Chapagaon S/S, 1x18MVA (16) Replacement of 66/11kV transformers at Balaju from 2x10MVA to 2x18MVA (17) Augmentation of 132/11kV transformer at New Bhaktapur, 2x18MVA in total	(13) 2nd circuit of 132kV SW/S - New Bhaktapur line includ. 132kV switchgears (14) Addition of 66/11kV transformer at Teku S/S, 2x18MVA in total (15) Creation of 132/11kV Chapagaon S/S, 1x18MVA (16) Replacement of 66/11kV transformers at Balaju from 2x10MVA to 2x18MVA
1999/00	(20) Installation of static condenser at New Bhaktapur 66kV bus, 2x10MVA	(18) Installation of static condenser at New Bhaktapur 66kV bus, 2x10MVA	(17) Installation of static condenser at New Bhaktapur 66kV bus, 2x10MVA (18) Augmentation of 132/11kV transformer at New Bhaktapur, 2x18MVA in total
2000/01	(21) Augmentation of 132/11kV transformers at New Bhaktapur, 1x18MVA		

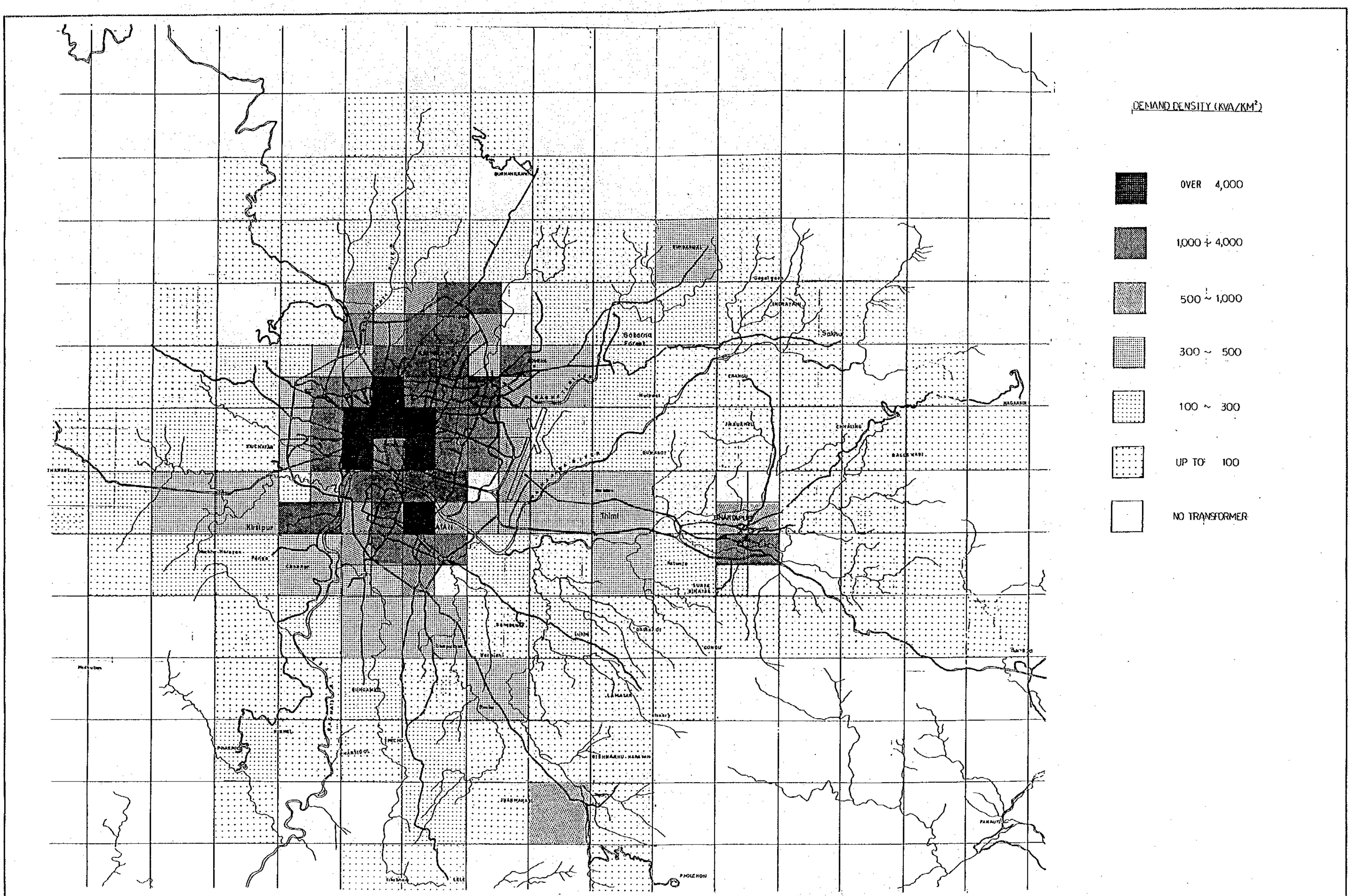
FIGURES



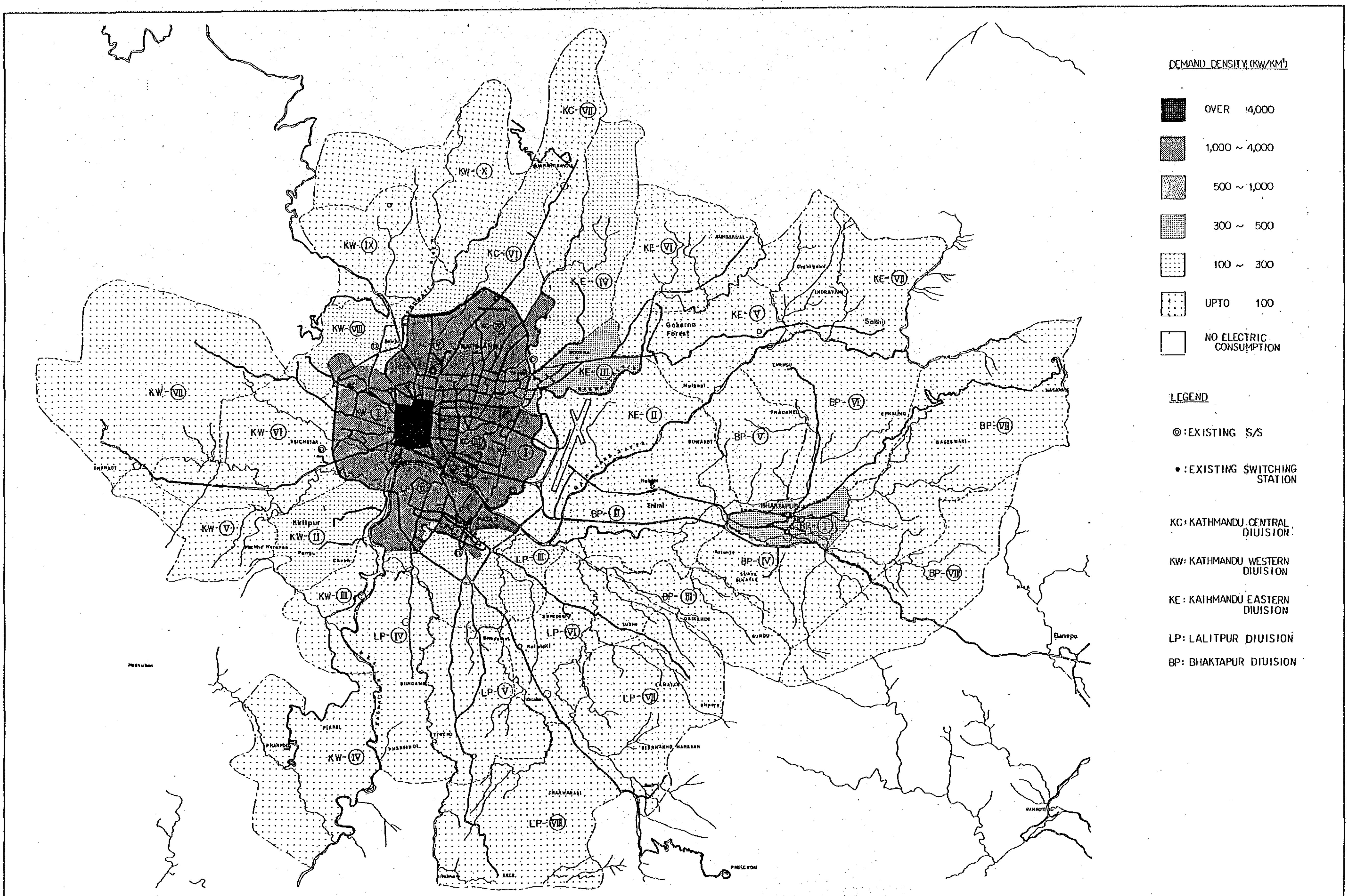
MASTER PLAN AND FEASIBILITY STUDY ON EXTENSION AND REINFORCEMENT OF POWER T/L AND D/L SYSTEM IN KATHMANDU VALLEY	NEPAL ELECTRICITY AUTHORITY JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE	Fig. 2.1 Power System Diagram of Central Nepal Power System



MASTER PLAN AND FEASIBILITY STUDY ON EXTENSION AND REINFORCEMENT OF POWER T/L AND D/L SYSTEM IN KATHMANDU VALLEY	NEPAL ELECTRICITY AUTHORITY / JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Fig. 2.2 Single Line Diagram of Existing Transmission and Distribution System



MASTER PLAN AND FEASIBILITY STUDY ON EXTENSION AND REINFORCEMENT OF POWER T/L AND D/L SYSTEM IN KATHMANDU VALLEY	NEPAL ELECTRICITY AUTHORITY	TITLE Fig. 3.1
	JAPAN INTERNATIONAL COOPERATION AGENCY	Demand Density - Capacity of Transformers per sq. km (kVA/sq.km)



MASTER PLAN AND FEASIBILITY STUDY ON EXTENSION AND REINFORCEMENT OF POWER T/L AND D/L SYSTEM IN KATHMANDU VALLEY	NEPAL ELECTRICITY AUTHORITY / JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Fig. 3.2 Demand Density by Billing Unit (kW/sq.km)

ANNEX

SCOPE OF WORK
FOR
MASTER PLAN STUDY
AND
FEASIBILITY STUDY
ON
EXTENSION AND REINFORCEMENT
OF
POWER TRANSMISSION AND DISTRIBUTION SYSTEM
IN
KATHMANDU VALLEY

AGREED UPON BETWEEN
NEPAL ELECTRICITY AUTHORITY
AND
THE JAPAN INTERNATIONAL COOPERATION AGENCY

KATHMANDU
MARCH 19, 1990

TAKASHI NODA	K.C. THAKUR
LEADER	MANAGING DIRECTOR
PRELIMINARY STUDY TEAM	NEPAL ELECTRICITY
THE JAPAN INTERNATIONAL	AUTHORITY
COOPERATION AGENCY	

I. INTRODUCTION

In response to the request of His Majesty's Government of Nepal (hereinafter referred to as "HMG/N"), the Government of Japan has decided to implement the Master Plan Study and Feasibility Study on Extension and Reinforcement of Power Transmission and Distribution System in Kathmandu Valley in accordance with the relevant laws and regulations in force in Japan.

Accordingly the Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for the implementation of the technical cooperation programs of the Government of Japan, will undertake the Study in close cooperation with the authorities of HMG/N.
Nepal Electricity Authority (hereinafter referred to as "NEA") shall act as counterpart agency to the Japanese Study Team and also coordinating body in relation with other governmental and non-governmental organizations concerned for the smooth implementation of the Study.

The present document sets forth the Scope of Work with regard to the Study.

II. OBJECTIVE OF THE STUDY

The objective of the Study is to formulate the Master Plan and to assess technical, economic and financial feasibility of the project for Extension and Reinforcement of Power Transmission and Distribution System in Kathmandu Valley.

2

III. SCOPE OF THE STUDY

The study consists of the following two (2) parts :

1. Master Plan Study
2. Feasibility Study

The Scope of the Study for the respective parts are itemized as follows :

1. Master Plan Study

1-1. Collection and Review of Data

Collection and review of existing data, study reports and relevant information for the Study.

1-2. Field Survey

(1) Existing power generation, transmission, substation and distribution line facilities.

(2) On-going and planned projects sites for power generation, transmission, substation and distribution networks.

(3) Existing telecommunication facilities and load dispatching facilities.

(4) Power supply reliability.

(5) System loss and counter measures for loss reduction.

(6) Tariff system.

(7) Load shedding and blackout.

1-3. Power Demand Forecast

(1) Integrated power demand forecast for twenty (20) years from commencement of the Master Plan Study.

(2) Areawise power demand forecast for ten (10) years from commencement of the Master Plan Study.

1-4. Planning of Power Transmission and Substation Facilities

(1) Study on load flow analysis and system stability.

(2) Study on application of 11kV, 33kV, 66kV and 132kV voltages.

(3) Study on upgrading of existing 11kV substations to 66kV.

(4) Study on ring system of transmission line.

(5) Formulation of optimum plan for power transmission and substation facilities.

- Construction plan of transmission line.
- Plan for new construction, reinforcement and rehabilitation of substation facilities including existing circuit breakers.

1-5. Planning of Distribution Line Facilities

(1) Study on adoption of 11 kV multi-circuit switching gear for underground cable.

(2) Study on application of underground cable and insulated overhead line cable.

(3) Formulation of optimum plan for new construction, reinforcement and rehabilitation of distribution line facilities.

1-6. Implementation Schedule

1-7. Cost Estimation

2. Feasibility Study

Feasibility Study shall be conducted for the works which will be executed within five (5) years from commencement of this Feasibility Study.

2-1. Detailed Field Survey for Candidate Construction Site

2-2. Feasibility Design

Feasibility Design shall be prepared for the projects identified in the Master Plan such as :

(1) Transmission line.

- Route, voltage, conductor size, number of circuit, support, etc.

(2) Substation.

- Number of bank, unit transformer capacity, protective relay system, insulation system, number of feeder, etc.

(3) Distribution network.

- Route, voltage, number of phase, conductor size, overhead or underground system, insulation method, etc.

2-3. Implementation Schedule

2-4. Cost Estimation

2-5. Economic Evaluation and Financial Analysis

5

IV. STUDY SCHEDULE

The whole work will be conducted in accordance with the tentative time schedule as shown in Appendix.

V. REPORT

JICA shall prepare and submit the following reports in English to NEA according to the attached schedule.

1) Inception Report . . . . 30 copies
2) Progress Report . . . . 10 copies
3) Interim Report . . . . 30 copies
4) Draft Final Report . . . . 30 copies

NEA shall forward his comments on the Draft Final Report to JICA within one (1) month after receiving the reports.

5) Final Report . . . . 50 copies

This report shall be submitted two (2) months after receiving the comments on the Draft Final Report from NEA.

VI. UNDERTAKING OF HMG/N

1. To facilitate the smooth conduct of the Study, HMG/N shall take the following necessary measures :

(1) To secure the safety of the Japanese study team,

(2) To permit the members of the Japanese study team to enter, leave and sojourn in Nepal for the duration of their assignment therein,

and exempt them from alien registration requirements and consular fees,

(3) To exempt the members of the Japanese study team from taxes, duties and any other charge on equipment, machinery and other materials brought into or taken out of Nepal for the conduct of the Study,

(4) To exempt the members of the Japanese study team from income tax and charges of any kind imposed on or in connection with any emolument or allowance paid to the member of the Japanese study team for their as services in connection with the implementation of the Study,

(5) To provide the necessary facilities to the Japanese study team for remittance as well as utilization of the funds introduced into Nepal from Japan in connection with the implementation of the Study,

(6) To secure permission for entry into private properties or restricted areas for the conduct of the Study,

(7) To secure permission to take all data and documents (including photographs) related to the Study out of Nepal to Japan by the Study team, and

(8) To provide medical services as needed. Its expenses will be chargeable on the members of the Japanese study team.

2. HMG/N shall bear claims, if any arises against the members of the Japanese study team resulting from, occuring in the course of, or otherwise connected with the discharge of their duties in the implementation of the Study, except when such claims arise from gross negligence or willfull misconduct on the part of the Japanese study team.

7

3. NEA shall, at its own expense, provide the Japanese study team with the followings, in cooperation with other relevant organizations :

(1) Available data and information related to the Study,

(2) Counterpart personnel,

(3) Suitable office space with necessary equipment in Kathmandu,

(4) Credentials or identification cards,

(5) Necessary vehicles with drivers, fuel and spare parts for the implementation of the Study, and

(6) Any other necessary communication facilities during the course of the Study, such as telephone, telex and tranceivers etc.

VII. UNDERTAKING OF JICA

For the implementation of the Study, JICA shall take the following measures :

(1) To dispatch, at its own expense, the Japanese study team to Nepal, and

(2) To pursue technology transfer to the Nepalese counterpart personnel in the course of the Study.

VIII. CONSULTATION

JICA and NEA shall consult with each other in respect of any matter that may arise from or in connection with the Study.

8

<u>Appendix TENTATIVE SCHEDULE</u>

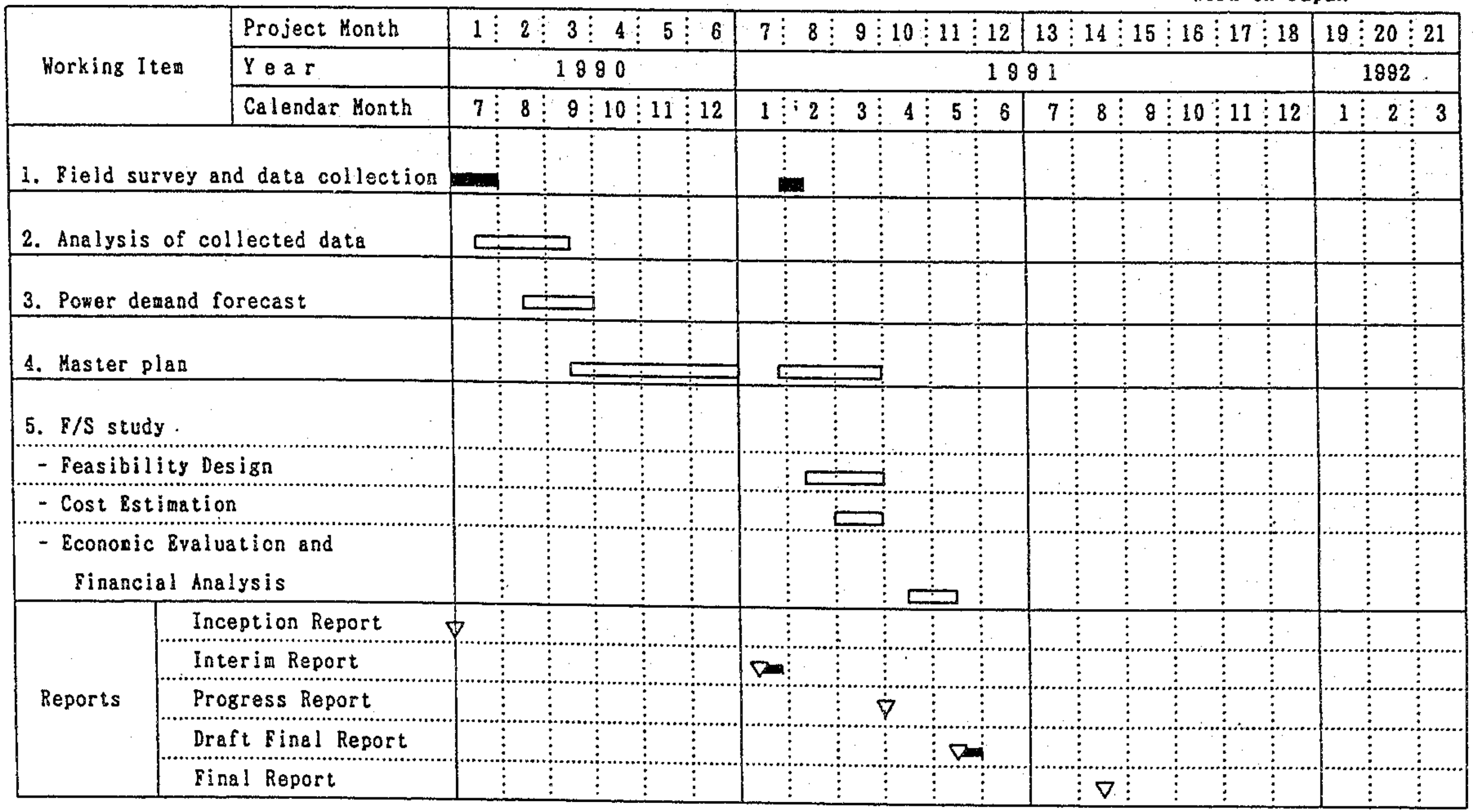
Master Plan and Feasibility Study on

Extension and Reinforcement of Power Transmission and Distribution

in Kathmandu Valley

■ Work in Nepal by JICA

□ Work in Japan



MINUTES OF MEETING

Subject: Master Plan Study and Feasibility Study on Extension and Reinforcement of Power Transmission and Distribution System in Kathmandu Valley.

Venue : Nepal Electricity Authority, Kathmandu.

Date : March 11, 1990 to March 19, 1990.

Participants :

NEA (Nepal Electricity Authority)

1. Mr. K.C. Thakur
   Managing Director

2. Mr. T.B. Pradhanang
   Director-In-Chief
   Distribution and Consumer Services
   Directorate

3. Dr. M.R. Tuladhar
   Director,
   Technical Service Department.

4. Mr. S.B. Pun
   Director,
   Bagmati Department.

JICA (Japan International Cooperation Agency)

1. Mr. Takashi Noda
   Team Leader, JICA.

2. Mr. Shinji Shibata
   Coordinator, JICA.

3. Mr. Toshinori Honma
   Electrical Engineer, JICA.

4. Mr. Yoshiyuki Kudo
   Electrical Engineer, JICA.

Discussions were held at NEA office in Kathmandu between NEA officials and members of JICA Preliminary Study Team (hereinafter referred to as "the JICA Team") from March 11, 1990 to March 19, 1990 in connection with the Draft Scope of Work for Master Plan Study and Feasibility Study on Extension and Reinforcement of Power Transmission and Distribution System in Kathmandu Valley. After extensive discussions the following points were mutually agreed by both parties:

1. The JICA Full Scale Study Team will review the Load Forecast Study report prepared by NEA / EDF.

2. NEA requested the JICA Team to train two of NEA Engineers on Distribution Planning in Japan for technology transfer.

3. NEA explained the JICA Team that some of the existing Network Facilities in Kathmandu Valley need urgent improvement such as :

   a. To increase the transformer capacity at (i) Baneswar (ii) Lainchaur and (iii) New Chabel 66/11 KV substations.

   b. To Construct a 132 KV pie-connection on the Marsyangdi-Balaju Transmission Line to connect Siuchatar 132 KV Substation with Marsyangdi Hydro Power Station for the enhancement of the system operation flexibility.

   c. To string second circuit between Siuchatar and Patan at 66 KV substations.

   d. To construct a 66 KV switching substation at Raniban to connect Devighat and Trisuli Power Stations at 66 KV.

   e. To Construct a 66 KV substation at existing 11 KV switching station at Teku.

4. NEA also explained the JICA Team that :

   a. NEA will provide the JICA Full Scale Study Team necessary office space in Kathmandu.

   b. NEA will assist the JICA Full Scale Study Team to procure vehicle rental services and the cost will be borne by the JICA Full Scale Study Team.

   c. NEA will provide telephone.

11

5. Both parties agreed to cooperate with each other for the benefit of the Study.

6. The Scope of Work and the conditions therein is subject to the approval of HMG/N which will be obtained before the end of May 1990.

Kathmandu,
March 19, 1990

(K.C. Thakur)
Managing Director
NEA

(Takashi Noda)
Team Leader
JICA

12