As the maximum load current and short-circuit current of the connected lines (calculated value) are about 200A and 9kA respectively in the 1989/90 fiscal year, it was found that there is no problem at present.

4.3.6 Other Facilities

(1) 11kV Switching Facilities

All 11kV switching facilities in the Kathmandu area are of indoor metal enclosed cubicle type. There are 3 types of 11kV cubicle type circuit breaker: bulk oil type, minimum oil type and vacuum type. Details are shown in Table 4.13.

(a) Bulk oil type (English Electric's products)

There are 49 cubicles in total, but they have been operated for more than 25 years. Their rated current is 400A and short circuit capacity is 7.88kA. Considering the present fault level of the system (see Table 7.6), it is urgently required to replace those cubicles.

(b) Bulk oil type (Yorkshire's products)

There are 18 cubicles installed in the year 1980. There are no questions on the rated short circuit capacity of 20kA in those cubicles. However, some cubicles in the Teku substation seem to be overheated. Taking account of the fact that the cubicle burnt down in the Lainchaur substation in July 1990 was of this type, it is desirable to replace all of these cubicle.

(c) Bulk oil type (Indian products)

Although there are 14 cubicles of this type in the New Chabel substation and there are no rating problems observed at present, the existing cubicles rated with current of 800A (15MVA) for the transformer circuits are to be replaced when transformers are replaced. Besides, troubles on the operating mechanism of breakers are reported.

(d) Lainchaur Substation

As discussed above, Yorkshire's oil-filled breakers that burnt down in the Laichaur substation were tentatively replaced with Chinese products, but technical characteristics of these Chinese breakers are not certain as no technical papers concerning the breakers are available.

(e) Minimum oil Type

There are 47 cubicles of minimum oil type which were installed under the Kulekhani I project, the reinforcement project for the distribution network in the Kathmandu Valley and the Marsyangdi project. There are no questions on the rated short circuit capacity of more than 20kA.

(f) Vacuum type

There are 28 cubicles of this type in the New Baneswar substation and the K2 switching station installed under the reinforcement projects for the distribution network in the Kathmandu Valley. There are no questions on their functions and on the rated short circuit capacity of 25kA.

(2) Protection Devices

Pilot wire relays are main protection devices for transmission lines in the Kathmandu Valley including the 11kV Ring Main.

However, the pilot wires, especially on 11kV system are broken at many locations and almost all of the protection systems on the 11kV lines are not used at present.

(3) Metering Instruments

The feeder circuits of old cubicles with bulk oil type circuit breakers such as English Electric's and Yorkshire's products are provided with only ammeters, while newly installed cubicles are provided with ammeters, watt-meters, watthour meters and var-meters or power factor meters. For some cubicles, CTs have improper current ratios.

CHAPTER 5

POWER MARKET

CHAPTER 5
POWER MARKET

5.1 Whole Nepal

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 the Whole Nepal

Year	Generation (GWh)	Peak Demand (MW)	Sold Energy (GWh)	Losses (GWh)	(%)
1980/81	235.4	59.5	164.4	71.0	30.2
1981/82	275.2	75.1	186.4	88.8	32.3
1982/83	347.0	83.7	235.6	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	163.3	25.8
1988/89	672.3	149.5	496.2	176.1	26.2
1989/90	769.7	176.2	548.1	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)

The following facts are noted from the above table:

(a) Sold energy in the country is growing with a very high rate of 14.3% during the recent 10 years.

(b) Demand growth in the former 5 years is higher than that in the latter 5 years. Demand potentials in the country suppressed by shortage of power sources have been developed upon commissioning of the Kulekhani I and Devighat power stations.

(1) Generation

Records of generation by plant type, imports from India and exports to India in the recent 10 years are as given below:

Energy Demand in Nepal

(GMh)

Year	Hydro	Mini-Hydro	Diesel	Imports	Exports	Requirements in Nepal
1980/81	161.9	13.1	15.8	44.6	3.8	231.6
1981/82	196.1	11.8	10.5	56.8	5.2	270.0
1982/83	266.0	12.1	5.6	63.3	6.0	341.0
1983/84	290.1	12.3	14.2	65.8	10.3	372.1
1984/85	323.2	12.0	3.3	82.1	10.6	410.2
1985/86	415.4	12.9	2.1	58.1	21.5	467.0
1986/87	515.3	17.7	5.4	32.6	20.5	550.5
1987/88	540.0	18.4	3.4	65.2	16.0	611.0
1988/89	527.9	21.1	9.3	113.9	17.6	654.7
1989/90	686.2	19.4	0.1	64.0	23.3	746.4

Table 5.1 shows monthly generation of major hydropower stations in the period of 1983/84 to 1989/90.

(2) Sold Energy

Sold energy by region and by consumers' category in 1989/90 is summarized in Table 5.2. Particulars of the energy sold are mentioned below:

(a) Sold energy of the Central region shares 70.3% of that of the whole country. Especially, that of the Bagmati zone including the Kathmandu area shares 47.8% of that of the whole country. Those of the Western and Eastern regions follow the Central region with shares of 14.1% and 11.9%, respectively.

(b) In terms of category of consumers, the domestic sector shares the greatest portion, 42.0% of the whole consumption, followed by the industrial sector (32.6%), noncommercial sector (8.6%) and commercial sector (6.2%).

(c) Energy consumed by the domestic consumers in the Bagmati zone including the Kathmandu area shares the biggest portion or 57.5% of the total regional consumption.

(d) The biggest industrial demand area is the Narayani area in the Central region sharing 33.8% of the industrial demand of the whole country, followed by the Eastern region(Biratnagar zone, 21.8%) and the Lumbini zone(8.2%) in the Western region.

(e) In terms of non-commercial demand, the Bagmati zone shares 58.7% of the whole non-commercial demand of the country.

(f) The commercial demand (for hotels, restaurants, etc.) of the Bagmati zone consumes 80.3% of total commercial demand in the country.

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 gorwth was caused by the revision of the country's tariff system in the year 1983 and 1985.

(3) Number of Consumers and Electrification Ratio

Table 5.3 shows the number of customers by current tariff category ruled in the year 1985, while the historical records of electrification ratio in the whole Nepal and the Bagmati zone are given in Table 5.4, which discloses that 8.9% in the total population benefits by electricity.

As for the Kathmandu Valley, the electrification ratios by area at the year 1989/90 are given below:

Electrification Ratio at 1989/90

	Kathmandu	Lalitpur	Bhaktapur	Total
Population (*1)	514,547	224,292	217,434	956,273
Households (*2)	85,758	37,382	36,239	159,379
Customers	83,637	29,598	19,591	132,826
Elect. ratio (%)	97.5	79.2	54.1	83.3

(Remarks)
*1: See Table 2.6
*2: 6 persons per household.

(4) Load Curve and Load Factor

The daily load curve of the interconnected system on January 5,1990 when the highest demand was recorded is illustrated in Figure 5.1 together with generation by major power stations. The load duration curve of the same day is shown in Figure 5.2 and the hourly generation records of each power station are detailed in Table 5.5. The daily load factor of the day was 62.2%. As seen in the daily load curve in Figure 5.1, there are two peaking times; the higher peak at 18:00 to 19:00 pm and the lower peak at around 8:00 am.

Annual load factors in the recent 5 years are shown in the following table:

Historical Annual Load Factors

Particulars			85/86	86/87	87/88	88/89	89/90
Total Energy	(A)	(GWh)	488.5	571.0	627.0	672.3	769.7
Imports	(B)	(GWh)	21.5	20.5	16.1	17.6	23.3
Net Generation	(A-B)	(GWh)	467.1	550.6	610.9	654.7	746.4
Maximum Power		(MW)	113.7	123.0	135.2	149.5	171.6 (*1)
Annual Load Factor		(%)	46.9	51.1	51.6	50.0	49.6

*1: See Table 5.5

Monthly peak demands in the morning and evening in 1989/90 were as follows:

Monthly Peak Demand(MW)

Month	Evening Peak	Morning Peak	Month	Evening Peak	Morning Peak
Jul/Aug	128.9	84.9	Jan/Feb	170.3	139.8
Aug/Sep	127.9	90.2	Feb/Mar	150.9	114.4
Sep/Oct	135.0	90.9	Mar/Apr	150.7	109.9
Oct/Nov	146.6	110.4	Apr/May	149.6	109.3
Nov/Dec	167.7	125.7	May/Jun	153.3	108.7
Dec/Jan	171.6	137.5	Jun/Jul	153.4	104.5

A notable feature of power demand in Nepal is that the annual 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.

5.2 Kathmandu Valley (Bagmati Zone)

Figure 5.3 shows the load curve of the interconnected system of January 5,1990, when the highest demand in the country was recorded. The daily load factor 62.2% in the whole area was, 62.3% in the Bagmati zone and 61.4% in other areas.

Energy sales in the Bagmati zone in 1989/90 were as below:

Energy Sales in Bagmati Zone

Division/Branch	Area(sq.km)	Sales(GWh)
Kathmandu Central		112.89
Kathmandu East	395	34.55
Kathmandu West		43.23
Lalitpur	385	44.23
Bhaktapur	119	14.55
Kavre	1,396	4.76
Rasuwa/Nuwakot	2,665	3.62
Sindhu/Dolkha	4,468	3.61

Table 5.6 details monthly energy sales by tariff category in the Kathmandu Valley, which consists of Central/East/West Kathmandu, Lalitpur and Bhaktapur divisions, in the year 1989/90. Maximum power demand recorded at 17:00 pm on January 5, 1990 of each substation and switching station in the Kathmandu Valley is summarized in Table 5.7. Those demands were estimated based on the recorded current of each feeder, since many 11kV feeder cubicles have been provided with only ammeters and voltmeters.

In additon, Annex-2 and 3 illustrate daily load curves on January 5 and October 10, 1990 of the loads connected to 132/66kV and 66/11kV transformers, substations and swithcing stations.

5.3 Demand Density in Kathmandu Valley

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

(a) Locations of the distribution transformers and their installed capacities.

(b) Records of energy sales by each billing unit.

It is noted that the survey on energy sales in the billing units was limited to the period of 2 months from December 16,1989 to February 15,1990 (Nepalese months of Poush and Magha), because of the short period allowed for the survey.

Records of Energy Sales

Divisions	Number of Units	Energy Sales(MWh) (Poush)	(Magha)	Total
Kathmandu Central	31	11,636	10,733	22,369
Kathmandu East	13	3,171	3,148	6,319
Kathmandu West	33	4,060	3,861	7,921
Lalitpur	31	4,027	3,919	7,946
Bhaktapur	23	1,352	1,423	2,775

Figure 5.4 shows demand density in the Kathmandu Valley represented by the installed capacity of distribution transformers per square killometer, which was worked out on the assumptions that:

a) Diversity factor of load is 1.0, and
b) Demand factor of transformer is 94%, which is estimated from the actual average demand factor of transformers in Lalitpur in 1990.

Figure 5.5 shows demand density by billing units in the Kathmandu Valley which was calculated from the annual energy sales in 1989/90, estimated distribution losses and annual load factor (45%).

5.4 Power Tariff System

Sources of NEA's revenue are basically electric energy sales and exports of energy and others. Other sources of revenue are as follows:

(a) Services of maintenance offered to consumers.
(b) Fees for replacement and shift of energy meters.
(c) Application fees.
(d) Installation charges.
(e) Charges or fees for other kinds of services like pole shifting.

Power tariff revision in the country is permitted only by the consent of the Government, and since 1980, tariff has been raised by 43% in 1980, 44% in 1985 and 18% in 1988.

The current power tariff classifies consumers into 11 categories such as domestic, industry, commercial (hotel, restaurant, etc.), non-commercial, water supply, agriculture, transport (trolley bus, cable car, etc.), temple, street light, temporary installation and exports to India.

Energy consumed in the country is billed for the basic charge defined by the amount of contract capacity and for the amount of energy consumption, with addition of rental charge of energy meters.

Current power tariff system as of May 1989, which is effective at present, is shown in Table 5.8.

CHAPTER 6

DEMAND FORECAST

CHAPTER 6
DEMAND FORECAST

6.1 Previous Demand Forecast

There are power demand forecasts for the Nepal power system previously performed by NEA with assistances of foreign consultants. Forecasted figures and appropriateness of the methodologies applied are analyzed in detail in the NEA's "Electricity Load Forecast - 1986" (hereinafter referred to as "1986 demand forecast").

The latest forecast for the whole country was conducted by EDF (Electricite de France International) in December 1989 under the financial assistance of the World Bank (hereinafter referred to as "EDP forecast"). Outlines of the 1986 demand forecast and the EDF forecast (medium) are given below:

Comparison of Power Demand Forecasts

Year	1986 D. Forecast		EDF Forecast (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

Details of the 1986 demand forecast and the EDF forecast are summarized in Tables 6.1 and 6.2, respectively.

6.2 National Demand Forecast

6.2.1 Introduction

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 for 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.

Forecast for this Project is established under the following steps in consideration of such consistency.

(1) Firstly, the nationwide demand is forecasted. The demand forecasts for the Bagmati zone including the Kathmandu Valley and other regions are prepared separately.

(2) Utilizing the forecast for the Bagmati zone conducted in (1) above, demand for each area such as Kathmandu Central, Kathmandu East, Kathmandu West, Lalitpur and Bhaktapur area covered by each branch office of NEA (Division) is worked out.

(3) Based on the growth rates forecasted in (2) above, above demand forecast for each substation and switching station is processed.

This Section 6.2 discusses the methodology of nationwide forecast and results of the forecast over a period of 20 years till the year 2010/11 based on the actual records of the year 1989/90 (Nepalese year 2046/47).

While examing 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 on 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 (mainly hotels)
(d) Agricultural demand (mainly irrigation pumps)
(e) Others

It is noted that the demand forecast performed for this Project covers the electricity consumers in Nepal excluding energy exports to India.

6.2.2 Domestic Demand

Since the demand forecast for this Project is aimed at planning the extension and reinforcement of transmission and distribution system in the Kathmandu Valley, demand forecasts for subdivided areas are performed separately. In this forecast, different methods have not been applied to urban and rural areas.

Domestic demand in a certain year is sum of (i) energy consumption of consumers which have been supplied (old consumers) and (ii) energy consumption of new consumers which will be connected to the system in that year (new consumers). Accordingly, the total energy consumption of the domestic consumers (Di) in the year (i) is expressed by the following equation:

$$Di = Di\text{-}1 \times (1+Ai) + Vi \times (Ci\text{-}Ci\text{-}1)/2$$

where, Di-1 : energy consumption of domestic consumers in the year (i-1)
Ai : growth rate of energy consumption of old domestic consumers in the year (i)
Vi : energy consumption per new domestic consumer in the year (i)
Ci-1 : number of domestic consumers in the year (i-1)
Ci : number of domestic consumers in the year (i)

(Ci-Ci-1) represents the number of new consumers in the year (i).

In forecasting, it is assumed that energy supply to new domestic consumers starts from the middle of the year.

(1) Projection of Population

WECS report "District-Specific Energy Supply/Demand" No.4/4/270488/1/1 Seq.No. 282 projected population of Nepal by region till the year 2000. However, the growth rate used in the report was assumed to increase year by year as shown in the following table and it is different from the projection by the Central Statistic Bureau of Nepal (refer Section 2.4), accordingly.

Projection of Regional Annual Average Growth Rates(WECS)

Region	1981-85	1985-90	1990-95	1995-00
Eastern	3.06%	2.49%	2.87%	3.47%
Central	2.35%	2.07%	2.41%	2.94%
Western	3.01%	1.96%	1.91%	1.74%
Mid Western	3.09%	2.41%	2.90%	3.19%
Far Western	3.29%	2.41%	2.54%	2.84%
Nation	2.84%	2.23%	2.51%	2.87%

The projection of WECS is not referred to in this Project. This study assumes that the growth rate of national population will be 2.66% in 1989/90, 2.5% in the year 2000 and 2.3% in 2010 based on the actual average growth rate in the period of 1971 to 1981 and that the rate in the Bagmati area will be 1.8% in 1989/90, 1.7% in 2000 and 1.6% in 2010 based on the actual annual growth rate of 1.76% from 1971 to 1981.

(2) Number of Household Members

The 1981 population census revealed that the average number of persons per household was 5.8 in whole Nepal and 5.9 in the Bagmati area. However, NEA assumed in its 1986 demand forecast that an average household has 6 members for the reason that a power consumer is not necessarily a unit of household.

This study also applies an assumption of 6 persons/household for both the Bagmati area and others.

(3) Electrification Ratio

NEA's 1986 demand forecast assumed the increase in the number of new consumers as follows:

(a) 20,000 consumers per annum in the period of 10 years from 1985/86 to 1994/95,
(b) Addition of 4,000 consumers per annum in the next 10 years, and
(c) Up to 60,000 consumers per annum in 2004/05.

The assumption results in that 18% of total population in the year 2004/5 will receive the benefit of electricity.

On the other hand, EDF's forecast assumed that electrification ratios in the medium and high growth scenarios would be 20% in 2000/01 and 25% in 2010/11, resulting in that the average increase of new consumers connected with the power system would be 41,000 per annum by 1995/96, 58,000 per annum by 2000/01 and 51,000 per annum thereafter.

This study sets the assumptions for electrification ratio as follows;

(a)	Whole country	:	actual ratio in 1989/90 to be 8.9% and target in 2000/01 to be 20%.
(b)	Bagmati Area	:	actual ratio in 1989/90 to be 42.5% and target in 2000/01 to be 70%.

Connection to new consumers depends not only on consumer's needs but also on extension and reinforcement of the transmission and distribution networks.

Since scale of generation, transmission and distribution facilities in the initial development stage of power network is usually small, and also since specific urban areas only are electrified, the national average electrification ratio will remain low.

Growth rate of electrification ratio will increase in proportion to expansion and development of the power system, and the growth rate will reach its maximum when approximately 50% of total population receives power supply. Thereafter, the growth rate will be lowered by slow development of networks

due to such difficulties as expansion to hilly areas or sparsely populated areas, in ability of payment by unelectrified households or other reasons.

Such tendency is approximated in the Gompertz curve in this study. Figure 6.1 compares the growth of electrification ratios assumed in this study and the growth rate worked out on the basis of the past trend of the electrification ratio in the whole country including that of the Bagmati area for 10 years.

(4) Unit Energy Consumption

Unit energy consumption per consumer will be affected by two factors, i.e., growth of consumption due to increase of income of consumers and decrease of consumption due to increase of new consumers in the electrified areas. The latter factor indicates generally that new consumers are comparatively poorer than old consumers.

The unit energy consumption in this study is assumed as follows:

(a) Unit energy consumption elasticity of old consumers to GDP will be represented by a factor of 2.0 by 1995/96, 1.75 by 2005/06 and 1.2 thereafter.

(b) Annual energy consumption of new consumers will be half of the average consumption in the previous year.

(5) Growth of GDP

GDP in the recent 9 years converted to the 1974/75 price level and its growth rate are summarized in Table 6.3. Average annual growth rates of GDP in the recent 9 and 5 years were as below:

Average Annual Growth Rate of GDP

Period	GDP	Agricult.	Non-agricult.
1981/82-1989/90 (9 years)	4.09%	4.22%	3.89%
1985/86-1989/90 (5 years)	4.00%	4.54%	3.18%

This study employs the following growth rates of GDP applied in the EDF's demand forecast.

1990/91 ..... 2.3%(Agriculture : 3.2%)
1991/92-1995/96..... 4.3%(Agriculture : 3.2%)
1995/96-2010/11..... 5.2%(Agriculture : 3.5%)

Since the growth rate of 3.2% of the agricultural sector applied by EDF in the above forecast seems low compared with the experienced actual growth, this study assumed the rate of agricultural sector to be 4.2%. Under the assumption, the average annual growth rates of GDP in this study are estimated as below:

Period	Whole	Agricult.	Non-agricult.
1990/91	2.3%	3.2%	1.9%
1991/92-1995/96	4.3%	4.2%	4.5%
1995/96-2000/11	5.2%	4.2%	6.7-6.3%

Table 6.4 shows the annual growth rates of GDP in consideration of transition of the composition of agricultural and non-agricultural sectors.

6.2.3 Other Demands

Demand forecasts for four consumer categories other than domestic, namely industry, commerce, agriculture and others are prepared separately in this study.

(1) Industrial Demand

The industrial demand is separately forecasted for the following 2 groups.

(a) Naturally growing demand of the existing industrial customers and demand of comparatively small scale new industries
(b) Demands of comparatively large scale industries under construction and under definite construction schedules

Existing and comparatively small scale new industries

Demands of the existing and comparatively small scale new industries are examined based on relations between actual energy consumption and non-agriculture GDP, and the forecasted growth rate of non-agricultural GDP is applied for long term demand forecast.

Non-agricultural GDP, average annual growth rate of industrial demand and elasticity of industrial demand to GDP in the recent 9 years (1981/82-1989/90) and the recent 5 years (1985/86-1998/90) were as follows:

	1981/82-89/90	1985/86-89/90
GDP annual growth rate of non-agriculture sector	3.89%	3.18%
Growth rate of industrial demand	12.90%	12.74%
Elasticity to GDP	3.29	4.00

The reason that the elasticity of the recent 5 years is higher than that of the recent 9 years is that industries in the Eastern region, which had been supplied previously from Indian grid, were connected to NEA's power system after the extension of the 132kV system to the Biratnagar area in 1985.

This study assumes the elasticity of industrial demand growth to non-agricultural GDP to be as below, taking into account that the above demand includes demand of such new and comparatively large scale industries as the Hetauda cement factory.

1990/91 and 1991/92	.....	3.0
1992/93 - 1995/96	.....	2.5
1996/97 - 2000/01	.....	2.0
2001/02 - 2010/11	.....	1.5

The high elasticity to GDP before 1995/96 is assumed to continue, because more areas in Terai will be electrified during this period.

For simplicity of assumption, the same elasticity will be applied for both the Bagmati and other areas.

Demand of factories under construction and under fixed construction schedule

NIDC (Nepal Industrial Development Corporation) issued a report in March 1989 with construction plans of new factories planned in the country. EDF demand forecast report estimated total demand of 6 large factories selected from those factories to be facilitated with capacity of more than 200 kVA from the NIDC report (refer Table 6.5).

Year	Demand (GWh)
1990/91	8.16
1995/96	62.90
2000/01	111.20
2010/11	190.00

Further details are shown in Table 6.6.

This study uses the abovementioned figures to forecast demand of new large scale factories.

Demand in the base year for demand forecast

The base year for the power demand forecast in this study is 1989/90. Industrial demand in the whole country and that in the Bagmati area in the base year were 178.3GWh and 43.08GWh, respectively.

(2) Commercial Demand

Power demand in the commercial sector is forecasted using the relation between actual energy consumption and non-agricultural GDP and the estimated long term growth rate of non-agriculture GDP.

The non-agricultural GDP, average annual growth rate of commercial demand and their elasticity in the recent 9 years (1981/82-1989/90) and in the recent 5 years (1985/86-1989/90) are as given below.

	1981/82-89/90	1985/86-89/90
Growth rate of non-agri. GDP	3.89%	3.18%
Growth rate of commercial demand	8.28%	14.91%
Elasticity	2.13	4.68

This study assumes the undermentioned elastic factor for the commercial demand.

1990/91 - 1995/96 ..... 2.5
1996/97 - 2000/01 ..... 2.0
2001/02 - 2010/11 ..... 1.5

Demand of new hotels will be covered by the above growth rate, and no other special load is considered in this study.

Total demand of the commercial sector in the whole country and that of the Bagmati area in the base year (1989/90) were 33.71GWh and 27.15GWh, respectively. Commercial demand in the Bagmati area occupied about 80% of total commercial demand in the country.

(3) Agricultural (irrigation) Demand

The agricultural demand is affected by the development progress of new electrified groundwater irrigation projects, electrification of existing irrigation facilities and variable climate.

Groundwater irrigation utilizing shallow or deep tubewells driven by diesel engines is mainly developed in the Terai plain at present. Several new groundwater projects are planned in the plain for accelerating increase of the production.

In addition to the demand forecast based on the planned irrigation projects in the NEA's 1986 forecast report, ADB's 7th Power Project also forecasted the regional agricultural demand.

According to the plan of the Irrigation Department (Ministry of Water Resources), 25% of existing shallow tubewells and all deep tubewells are to be

converted to motor-driven wells by the year 2000, for which requirement of total energy of 339GWh per annum is forecasted.

Table 6.7 shows the demand forecasts for regional irrigation prepared by NEA, 7th Power Project and Ministry of Water Resources.

Experienced demand of irrigation, of which the tariff category was ruled in 1985, was as below:

		1986/87	1987/88	1988/89	1989/90
Demand of irrigation	(GWh)	0	9.36	15.63	11.97
Growth rate	(%)	-	-	67.00	-23.40

This study examines the demand forecast under the following assumptions:

(a) Growth rates of the existing demand and demand under new development projects except for special demands undermentioned (b) are same as that of the estimated agricultural GDP.

(b) The said special demand is that equivalent to amount deducted actual demand in 1989/90 from the EDF forecast, as tabled below:

	1990/91	1.0 GWh
	1991/92	5.0 GWh
	1995/96	23.0 GWh
	2000/01	49.0 GWh
till	2010/11	same rate as agricultural GDP growth rate

Irrigation demands of the whole country and the Bagmati area in the base year (1989/90) were 11.97 GWh and 0.21 GWh (1.7% of the whole country), respectively.

(4) Other Demands

Other demands include those of non-commercial, transport, water-supply, temples, street lights, etc. Most of these demands are in close relation with GDP (income) or variation of domestic demand. The average annual growth

rates of GDP, domestic demand and other demands together with elasticity are shown in the following table:

	1981/82-89/90	1985/86-89/90
Growth rate of GDP	4.09%	4.00%
Growth rate of domestic demand	12.43%	13.27%
Growth rate of other demand	39.98%	8.73%
Elasticity of GDP	9.77	2.18
Elasticity of domestic demand	3.22	0.66

The above table shows that the average annual growth rate of the other demands in the period of 1981/82 to 1989/90 was extremely high compared with that in 1985/86 to 1989/90. This difference was caused by a rapid increase (7 times) of the demand in 1985/86 when the power tariff system of the country was revised.

This study, accordingly, uses the growth rate recorded during the recent 5 years which has not been influenced much by revision of the tariff system, and assumes that the growth rate of the other demands will increase with a rate of 0.7 time that of domestic demand.

Energy requirement of the other demands in the whole Nepal and the Bagmati area in the base year (1989/90) were 69.39GWh and 40.13 GWh (57.8%), respectively.

6.2.4 Energy Losses

Energy losses in the NEA's power system increased from 26.9% in 1988/89 to 29.7% in 1989/90 according to the collected data.

System losses are defined as follows:

$$\text{System Losses} = 1 - \frac{\text{(total national consumption)}}{\text{(national generation + imports) - (exports)}}$$

= (transmission/distribution line losses + station use energy + energy consumption by NEA staff)/(national generation + imports - exports)

Further details of annual energy losses in 10 years period of 1980/81 to 1989/90 are shown in Table 6.8.

This study assumes that the energy losses will decrease by 1% every year till the total system losses become 18%, expecting the effect of the transmission and distribution system reinforcement project implemented in the Terai Plain under ADB's assistance and also the effect of the loss reduction program to be implemented in the Kathmandu Valley.

6.2.5 Annual Load Factor

As seen in Table 6.9 for annual load factor in the past 10 years (1980/81-1989/90), the annual load factor suddenly raised in 1986/87, stayed at a similar level thereafter and slightly declined in 1989/90.

The decline of the load factor in 1989/90 and rapid increase of the maximum demand recorded on January 5, 1990 are likely to be caused by the heating demand due to very low air temperature, and by the increase of cooking demand due to decrease of imported kerosene through India because of the invalidation of the Treaty for Trade and Transit.

Annual load factor in Nepal is considered to be raised by the increase in energy demand for the industry, transport, non-commercial, agriculture and water-supply sectors. On the contrary, the domestic, commercial (mainly hotels and restaurants) and street light demands will lower the load factor.

The industrial demand is a large component to increase annual load factor and although large scale factories are expected to be operated in future, the annual load factor is considered not to vary largely for a long period in future, due to the dominance of domestic demand.

The annual load factor in the year 1989/90 is estimated below:

		Whole Nepal	Bagmati Area	Other Areas
Energy consumption	(GWh)	524.8	261.5	263.3
Energy losses (*1)	(%)	29.7	29.7	29.7
Energy generated	(GWh)	746.5	371.9	374.6
Maximum demand (*2)	(MW)	171.6	96.2	75.5
Annual load factor	(%)	49.6	44.1	56.6

Note: *1 Average loss factor of the country is applied to both Bagmati and other areas.
*2 Demand at 6:00 pm on January 5, 1990 (Demand of 176.2MW was recorded at 6:30 pm on the same day.)

Energy consumption and shares of domestic, industrial and other consumers in the Bagmati and other areas in 1989/90 are given below:

	Bagmati Area		Other Areas	
	Consumption (GWh)	Share (%)	Consumption (GWh)	Share (%)
Domestic	150.9	57.7	80.5	30.6
Industry	43.1	16.5	135.2	51.3
Others	67.5	25.8	47.6	18.1
	261.5	100.0	263.3	100.0

The above 2 tables show that the ratio of energy consumption of domestic to industrial consumers influences the annual load factor in the Bagmati and other areas.

This study assumes that the annual load factor in the Bagmati area will increase to 50% and that in the other areas to 60% with an increase rate of 0.2% per annum.

6.2.6 Results of Demand Forecast

Power demand for 20 years from 1989/90 to 2010/11 forecasted in this study is detailed in Table 6.10 and a summary of the results is given 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
	100.0	100.0	100.0	100.0	100.0
Others					
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
	100.0	100.0	100.0	100.0	100.0

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.

Results of demand forecasts conducted by EDF (high and medium) and this study are illustrated in Figures 6.1 and 6.2. As seen in the figures, demand forecasted in this study lies between those of high and medium growth scenarios of the EDF forecast.

6.3 Areawise Demand Forecast in Kathmandu Valley

6.3.1 General

Detailed areawise demand forecast is required for formulating the extension and reinforcement plan for the power transmission and distribution system in the Kathmandu Valley.

This section discusses the following particulars:

(a) Areawise demand forecasts for the Kathmandu Central, Kathmandu East, Kathmandu West, Lalitpur and Bhaktapur branch offices utilizing results of demand forecast for the Bagmati area obtained in Section 6.2.

(b) Demand forecasting for each substation and switching station in the areas based on the maximum demand recorded on January 5, 1990 and the growth rates of demand of each branch office.

Those forecasts will be conducted for the 10 years period till 2000/01 with the base year of 1989/90.

6.3.2 Current Power Demand at Each Station

Energy sales of each branch office in the period of December 16 to February 15 (Poush and Magha in the Nepal calender month) of 1985/86 and 1989/90 were as follows:

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
Latipur	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

Records in the table clarified that:

(a) The highest growth rate of energy sales in the recent 5 years was recorded in the Kathmandu East area. Those in the Kathmandu West and Bhakatapur areas also were at a similar level.

(b) The growth rate in the Kathmandu Central area, the highest demand density area was the lowest.
It seems that the energy demand in the area is reaching saturation.

The maximum demand at each substation and switching station in the Kathmandu Valley on January 5, 1990 when the highest demand was recorded is given in Table 5.7 of Chapter 5.

6.3.3 Areawise Demand Forecast

(1) Methodology

The ratio method is applied for areawise demand forecast. This method is mainly used for the population projection and is based on the following assumptions.

(a) Growth rate of population or demand for most areas and communities is related to growth rate of state and national population or demand.

(b) Growth rate in a limited area is projected from an estimated figure in larger area.

Following formula is applied for the forecast:

$$Pi/Pt = ki \quad \text{or} \quad Pi = ki * Pt$$

where, Pi = population or demand in study area (ki).
Pt = population or demand of state or nation involving study area.

This study examines the demand forecast using the above ratio with a time factor as follows:

$$ki, tj = Ki\ (tj)$$

where, ki, tj = ratio of demand at time tj in the study area (i) to the whole demand.

Historical records of ratios of sold energy of each NEA's branch office to total sold energy in the Bagmati area are as shown in the following table.

Ratio of Sold Energy

(%)

	1984/85	1989/90
Kathmandu Central	50.97	45.19
Kathmandu East	10.51	12.77
Kathmandu West	13.45	16.00
Lalitpur	15.88	16.06
Bhaktapur	4.82	5.61
Kavre	1.73	1.73
Sindhuli/Dolakha	1.28	1.28
Rasuwa/Nuwakot	1.36	1.36
Total	100.00	100.00

Since records in 1984/85 of Kavre, Rasuwa/Nuwakot and Sindhuli/Dolakha were not available, the ratios in 1989/90 are adopted for those areas in 1984/85.

(2) Results of Demand Forecast

Forecasted demand of each study area and its ratio to the total demand of the Bagmati area are given below, and its details are given in Table 6.11.

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
Kavre	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

(3) Demand Density by Billing Unit (Refer: Section 5.3)

The ratio method was further applied to estimate the future demand in smaller areas, i.e. billing unit, which has certain basic data for analysis such as energy sales.

The results of the forecast are illustrated in Figure 6.4 for 1995/96 and Figure 6.5 for 2000/01.

6.3.4 Power Demand Forecast for Each Station

(1) Growth Rate of Regional Demand

Losses

Losses of transmission lines, transformers and distribution lines are assumed as below:

	Transmission Lines & Transformers	Distribution Lines	Total
1989/90	9.7%	20.0%	29.7%
1995/96	9.0%	15.0%	24.0%
2000/01	8.0%	11.0%	19.0%

Annual Load Factor

Following assumption are introduced to the annual load factors at substations and switching stations in the Kathmandu Valley based on the collected records of actual energy sales and loss factors assumed above.

	Bagmati (*1)	Kathmandu
1989/90	44.1%	42.4%
1990/91	45.5%	44.2%
2000/01	46.4%	45.7%

Note: (*1) Refer to Table 6.10.

Growth Rate of Power Demand

Maximum demands of each area were forecasted applying the above distribution line losses and annual load factor to the energy sales forecasted in Section 6.3.3, as below:

(MW)

Area	1989/90	1995/96	2000/01	Growth Rate (89/90-00/01)
Kathmandu Central	39.77	52.68	69.85	5.25 %
Kathmandu East	11.23	21.74	37.35	11.54 %
Kathmandu West	14.08	26.69	45.26	11.20 %
Lalitpur	14.13	22.24	33.50	8.17 %
Bhaktapur	4.93	9.23	15.64	11.06 %
Kavre	1.52	2.36	3.51	7.88 %
Sindhuli/Dolakha	1.20	1.85	2.76	7.88 %
Rasuwa/Nuwakot	1.13	1.75	2.60	7.88 %

(2) Forecast of Peak Demand of Each Station

Table 6.12 shows the maximum demand of each substation and switching station forecasted by examing the present feeding area of each station and growth rate of the areawise demand, and it is summarized is as follows:

(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

CHAPTER 7

MASTER PLAN FOR REINFORCEMENT AND EXTENSION OF TRANSMISSION SYSTEM INCLUDING RING MAIN SYSTEM

CHAPTER 7

MASTER PLAN FOR REINFORCEMENT AND EXTENSION OF TRANSMISSION SYSTEM INCLUDING RING MAIN SYSTEM

7.1 Basic Criteria for System Reinforcement and Extension

In order to establish an effective and economical reinforcement and extension plan for the power transmission network, overload of transformers and/or transmission lines, voltage drop and system losses are deemed to be important criteria to determine the reinforcement and extension scale.

Power flow analysis with the help of computer simulation will be made for examining the troubles like overload and excessive voltage drop on the network as well as for calculation of system losses, which will be actualized with demand growth in the Kathmandu Valley.

(1) Overload of Facilities

Overload of facilities is examined under operating conditions with (abnormal) and/or without (normal) outage of any one facility like transformer, transmission line, etc. Even in case of any abnormal operating condition, power system has to maintain stable power supply to consumers as far as possible. In the study, outage of one circuit of transmission line is deemed as abnormal operating condition for analysis.

To maintain reliable power supply, criteria for overload were assumed as given below taking into account necessary lead time for procurement of equipment and materials, and construction schedule including arrangement of budget for that purpose and design.

- under normal operating condition

demand factor of transformer	below 100% at peak time
load current of conductor	below continuous allowable current

- under abnormal operating condition

demand factor of transformer	below 120% at peak time
load current of conductor	below continuous allowable current.

(2) Voltage Drop at 11kV Buses

The limits of acceptable voltage drop at 11kV buses under normal and abnormal operating conditions are assumed as follows taking into account voltage drop on the 11kV line feeders fed from substations and switching stations;

- under normal operating condition	:	7 %
- under abnormal operating condition	:	10 %

(3) Transmission Losses

Total transmission loss in the planned system is calculated by computer simulation of power flow. Transmission loss is taken into account in the project evaluation for selecting an optimal investment plan.

7.2 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 11kV 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 is shown in the Figure 7.1.

For analysis in the future stages, power flow calculations were conducted year by year with forecasted demand on the modified system. Remedial plans were formulated so as to solve problems which were observed on the system.

(2) System Constants

Particulars of the generators, transformers, transmission lines and ring main distribution lines in the current system are shown in Table 7.1, 7.2 and 7.3. The power flow calculation was executed using these values.

(3) 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, when peak demand of the year 1989/90 was recorded, was adopted for the base year. For the analysis in the future stages, the forecasted demand of each station for each year stated in the Section 6.3.4 (Table 6.12) is used.

The power factor of the load was assumed at 95% based on the actual power factor around 97% in log sheet data collected for the study.

(4) Voltage Regulation

Voltage at 11kV 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.

The ranges of tap ratio of the existing transformers are shown below.

Substation Name	Voltage (kV)	Tap Ratio (%) (High Voltage Side)
Balaju	132/66	+/- 10
Balaju	66/11	+/- 10
Siuchatar	132/66	+/- 10
Siuchatar	66/11	+5/-15
New Chabel	66/11	+/- 10
Lainchaur	66/11	+/- 10
Baneswar	66/11	+5/-15
New Patan	66/11	+5/-15

7.3 Generation Expansion Plan for System Analysis

NEA formulated a plan for energy balance between demand and supply capacity based on its demand forecast, in which the following improvement and development of the power system are programmed.

(a) Load management of the system.
(b) Development of medium speed diesel generators by the year 1999.
(c) Development of Arun 3 hydroelectric project (402MW) in 2 phases, the first phase with 268MW by 2001 and the second phase with 134MW by 2005.
(d) Development of Upper-Arun hydroelectric project (360MW) by 2009.

Balance of demand and supply capacity in the country till the commissioning of the Arun 3 power station is estimated 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

The imbalance of demand and supply of peak power and energy in the country will appear after the year 1994/95 as seen in the above table. For covering the deficit, it is required to construct medium-speed diesel power stations or gas-turbine power stations with short construction period.

Analysis of the power system by 200/01 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 are assumed to be installed at the existing Hetauda substation for simplification of analysis.

7.4 Catalogue of System Reinforcement and Extension Alternatives

7.4.1 General

In order to solve the problems pointed out in Section 4.3 and to maintain reliable power supply to the Kathmandu Valley upto the year 2000/01, the following works are considered as alternatives for reinforcement and extension of the power transmission system.

7.4.2 Rehabilitations

(1) Rehabilitation of Lainchaur Substation

As 66kV and 11kV switchgears of the substation were burnt down, power is supplied through 11kV cubicles temporally installed without 66kV switchgear. Rehabilitation of this substation, however, is scheduled to be financed by another donor.

(2) Rehabilitation of 11kV Underground Cable

The 11kV underground cables from the Lainchaur substation to K2 switching station had been damaged at the time of site investigation in 1990, however NEA has rehabilitated the cables by itself in middle of 1991.

7.4.3 New Construction

(1) New Bhaktapur Substation

Construction of a new substation (New Bhakutapur) near the existing Bhaktapur switching station is conceivable to improve inferior system reliability and voltage drop in this area. Initially the substation will be provided with 66/11kV transformers, which will be graded up to 132kV in future. Power will be supplied from the New Chabel substation by a 66kV line and pi connections of the 66kV Patan - Sunkosi line and of the 11kV Thimi - Bhaktapur line will be made.

(2) K3 Substation

Construction of a new substation in the downtown area near the Exhibition Ground is conceivable to meet the growing demand in the area. The substation will have 66/11kV transformer and be supplied with power through a new 66kV overhead line from the Siuchatar substation.

(3) Chapagaon Substation

The objective of constructing this new substation at Chapagaon is to improve voltage regulation in the area, especially in the Godawari area. Power to this area is presently supplied through 11kV feeders from the Baneswar substation, and the voltage drop of the feeders is already very high, 8.5%. Power is fed from the Siuchatar substation through a 132kV line, or from the New Patan substation through a 66kV line.

(4) 132kV Transmission Line : Siuchatar S/S - New Bhaktapur S/S

Construction of a 132kV double circuit line from the Siuchatar substation to the New Bhaktapur substation is conceivable to feed power to the New Bhaktapur and Chapagaon substations.

(5) 132kV Transmission Line : Siuchatar S/S - Balaju S/S

Construction of a 132kV single circuit line between the Siuchatar and Balaju substations is conceivable to maintain reliable power supply to the Kathmandu Valley from Marsyangdi power station. In this case, new 132kV GIS for one circuit is needed at Balaju. However, the existing 132kV GIS has no provision for future extension and also no space is provided. In order to avoid much disturbance, pi connection from the existing Marsyangdi - Balaju line to the Siuchatar substation is also conceivable as an alternative idea.

(6) 66kV Transmission Line : Siuchatar S/S - K3 S/S

Construction of a 66kV double circuit line between the Siuchatar to K3 substations is conceivable to reinforce power to the K3 substation. The line route is planned along the side of the Balkhu, Bagmati and Tukucha

rivers, and the route of the existing 11kV Patan to K2 line will be useful for the section between the Bagmati river and the K3 substation.

(7) 66kV Transmission Line : Siuchatar S/S - Teku S/S

Construction of a 66kV line between the Siuchatar to Teku substations is conceivable to feed power to the upgraded Teku substation. In case that K3 substation is constructed, pi connection from one circuit of the Siuchatar to K3 66kV line will be made at the Teku substation. In case that K3 is not constructed, the 66kV double circuit line will be constructed between Siuchatar and Teku substations.

(8) 66kV Transmission Line : New Chabel S/S - New Bhaktapur S/S

Construction of a 66kV single circuit line from New Chabel substation to New Bhaktapur substation is conceivable to feed power to the latter. The line will be aligned along the side of the eastern mountains in the Kathmandu Valley.

(9) 66kV Transmission Line : Balaju S/S - Lainchaur S/S

Construction of an additional 66kV line from the Balaju substation to Lainchaur substation is conceivable to maintain reliable power supply. The Lainchaur substation is at present supplied with power through a 66kV single circuit overhead line. It is obvious that load shedding covering a wide area is not avoidable due to outage of the existing 66kV line, because all demand of the Lainchaur and K2 substations is served through the 11kV Patan-K2 line and this causes overload of the line. In order to avoid such load shedding, a double circuit line is essential for the Lainchaur substation. Though the existing line route is usable for the planned line, load shedding in the central area will be needed during the reconstruction of the double circuit line.

(10) 66kV Transmission Line : Patan S/S - Chapagaon S/S

Construction of a 66kV single circuit line between the New Patan to Chapagaon substations is conceivable in case that Chapagaon substation is to be fed from the New Patan substation.

(11) 11kV Underground Cable : Teku S/S - K2 S/S

Installation of two circuits of 11kV underground cable from the Teku substation to K2 switching station is conceivable as an alternative plan in case that K3 substation is not constructed.

(12) 132kV Switching Station

Construction of a new 132kV switching station near the Siuchatar substation is conceivable to establish a reliable and operation-oriented 132kV system in the Kathmandu Valley. The 132kV Marsyangdi line and Kulekhani II line will be connected to this switching station which distributes power to Siuchatar and Balaju substations through the existing 132kV lines and to a new substation in Bhaktapur area by a 132kV line to be newly constructed.

7.4.4 Reinforcement and Extension

(1) Additional Stringing : Siuchatar S/S - Patan S/S 66kV Line

Addition of a second circuit on the existing 66kV double circuit towers between the Siuchatar and Patan substations is conceivable to improve reliability of power supply to the Patan, Baneswar and city center areas. In case that New Bhaktaputr substation is supplied from the 132kV switching station or Siuchatar substation through a 132kV transmission line in early stage, this work will be postponed in a few years.

(2) Connection between Trisuli P/S and Devighat P/S

As already explained in Section 4.3.2, 66kV connection of Trisuli and Devighat power stations is conceivable in order to operate both power stations effectively. For this connection, the existing Trisuli and Devighat lines can be utilized.

(3) Upgrading of Teku Switching Station to 66kV Substation

In order to meet the growing demand in the downtown area, upgrading the Teku switching station to a 66kV substation is conceivable.

(4) Addition of Transformer Capacity

In order to relieve transformers from overloading, additional installation and/or replacement of transformers at substations will be required.

(5) Additional Stringing : 132kV SW/S - Siuchatar S/S 132kV Line

If the 132kV switching station is constructed, the existing 132kV line between Kulekhani II power station and the Siuchatar substation can be used for connecting the 132kV switching station and the Siuchatar substation. This existing line is of single circuit construction on double circuit towers. In order to strengthen reliability of power supply between the two stations, stringing of a second circuit between the 132kV switching station and Siuchatar substation is conceivable.

(6) Additional Stringing on the Existing 132kV Lines

In case that new generating plants are constructed outside the Kathmandu Valley to meet growing demand and generated power is transmitted to the Kathmandu Valley through the existing 66kV and 132kV lines, the following additional stringing works may be needed;

a) Additional stringing on the 132kV Kulekhani II P/S - Siuchatar line.
b) Additional stringing on the 132kV Hetauda - Kulekhani II P/S line.

7.5 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, taking into account the future power demand forecasted in Chapter 6.

If some troubles like excessive voltage drop (7% under normal operating condition and 10% under abnormal operating condition) or overload are observed on the power transmission network through the power flow analysis, proper countermeasures are selected from the catalogue of alternatives explained in Section 7.4 and their effectiveness to the system improvement is examined again through the system analysis for selection of an optimum countermeasure in the year. Examinations of the power supply system are repeated year by year throughout the study horizon of this Master Plan Study.

(1) Immediate Plans

No power supply problems like excessive voltage drop and overload of transformers and transmission lines are observed in the system under the normal operating condition. However, under the abnormal operating condition, the following power supply difficulties are observed:

Outage of 66kV Siuchatar - Patan Line (1cct)

A large portion of loads in the areas served by the New Patan and Baneswar substations have to be supplied from the Laincaur substation through the 11kV ring main line, because effective output of the Sunkosi power station is considerably small and not enough to satisfy the demand. Then transformers at the Lainchaur substation are overloaded to around 200%, and 11kV underground power cables between the Lainchaur substation and K2 switching station are also overloaded (180%). Excessive voltage drop of more than 10% is observed at 11kV buses at the Patan and Baneswar substations, and the Thimi and Bhaktapur switching stations.

In order to avoid such power supply difficulty, addition of a second circuit line to the existing 66 kV Siuchatar-Patan line on double-circuit towers is the most effective and economical solution.

Outage of 66kV Balaju-Lainchaur Line

All loads served from the Lainchaur substation and K2 switching station have to be supplied from the Patan substation through a 11kV double-circuit overhead line when the Balaju-Lainchaur line is in outage condition. As a result, the 11kV line is overloaded to about 110%.

From technical point of view, construction of another 66kV single circuit line is more attractive than reinforcement of the overloaded 11kV line, because a 11kV system is not adequate for bulk power supply to the city center areas in future.

However, addition of another 66kV single line between the Balaju and the Lainchaur substations is not considered in this stage, because:

(a) route length of the existing line is only 2.3 km and probability of outage due to faults and/or damages seems to be considerably low, and

(b) overload on the 11kV line is not so serious at this stage and will be improved by means of shifting a part of loads supplied from the K2 and the Lainchaur stations to the Balaju, Teku and New Chabel stations.

Outage of 66kV Patan-Baneswar Line

Extensive load-shedding will be inevitable in the areas served by the Baneswar substation, because the Sunkoshi power station is not capable to satisfy all demand.

In order to improve the above contraint, new construction of a 66kV single circuit line between New Patan and Baneswar is effective, but not recommendable due to the difficulty in land acquisition. As an alternative, formulation of a 66kV ring system by construction of a new 66kV substation at Bhaktapur and construction of a new 66kV line between Bhaktapur and New Chabel is most appropriate solution.

(2) Plans upto 1992/93

Under the normal operating condition, the following power supply difficulty is observed.

a) Overload of transformer at Baneswar (107% in the year 1992/93)
b) Excessive voltage drop of 11kV bus at Bhaktapur switching station

As a countermeasure against (b) above, construction of a new substation at Bhaktapur (hereinafter called "New Bhaktapur substation") and connection with the existing 66kV Sunkosi line will be a most appropriate solution.

In addition to the above, it is very important to construct a new 66kV line between Bhaktapur and New Chabel in order to form a 66kV ring system surrounding the Kathmandu city and to significantly improve reliability of power supply. Construction of the new substation and transmission line will reliese problems due to outage of the 66kV Patan-Baneswar line.

After improvement by the abovementioned countermeasures, no power supply difficulty is expected under any normal and abnormal operating conditions. As explained in (1) and (2) of Section 4.3.2, however, power supply shortage in the whole system will occur due to outage of the 132kV Marsyangdi-Baratpur line and/or the 66kV Trisuli-Balaju line, and operation of diesel engine generators will be needed for peak-load hours. Therefore, the following countermeasures should be taken:

(a) pi connection of the 132 Marsyangdi-Balaju line to the Siuchatar substation.

(b) Modification of the 66kV switchgear of the Trisuli power station and jumper connection between both Trisuli and Devighat power stations.

(3) Plans upto 1995/96

The following power supply difficulties are observed on the following transformers and 11kV lines, and augmentation of transformers and construction of new substations are needed.

a) Overload of 11kV underground cables between Lainchaur and K2 due to outage of the 11kV Patan-K2 line (1993/94).
b) Overload of 132/66kV transformer at the Siuchatar substation (1994/95)
c) Overload of 66/11kV transformers at the New Bhakatapur substation (1995/96)
d) Overload of 66/11kV transformers at the Balaju substation and 11kV overhead Balaju-Teku line due to outage of the 11kV Siuchatar-Teku line (1995/96)

In order to improve the above constraint (a), construction of new substation in the central area of Kathmandu city where governmental offices and other important buildings are concentrated is the most attractive in order to achieve stable and reliable power supply to the area.

For the above constraint of (d), the Teku switching station should be upgraded to a 66kV substation with a 18MVA transformer.

(4) Upto 2000/01

The following power supply difficulties are observed:

a) Overload of 66/11kV transformers at the New Chabel substation (1996/97)
b) Overload of 66/11kV transformers at the Lainchaur substation (1997/98)
c) Overload of 66/11kV transformers at the Teku substation (1998/99)
d) Overload of 66/11kV transformers at the Balaju substation (1998/99)
e) Excessive voltage drop of 11kV bus at New Bhaktapur substation due to outage of the 66kV Patan-Baneswar line (1998/99)
f) Overload of 66/11kV transformers at New Bhaktapur substation (2000/01)

To improve the power supply constraint (e), upgrading of the 66kV New Bhaktapur to 132kV is the most optimum plan from the viewpoint of reinforcement and extension of the power supply system in Kathmandu Vally in future.

In addition to the abovementioned measure of reinforcing and extending of the power transmission system in the Kathmandu Valley, addition of second circuit line to both the 132kV Hetauda - Kulekhani II line and 132kV Kulekhani II - Siuchatar line on the double circuit towers is required in the late 1990's for transmitting bulk power from outside Valley prior to the extension of 220kV transmission line from the Arun No. 3 power station to the Valley.

7.6 Selected Reinforcement and Extension Plans

As a result of the power flow analysis explained in the previous section, a sequence of investments to the selected alternatives is determined as shown in Table 7.4 as "Scenario-A", taking into account the urgency and importance of improvement, the construction period and the construction cost including difficulty of land acquisition.

Single line diagrams of the system improved by the Scenario-A at the stages of 1995/96 and 2000/01 are shown in Figure 7.2 and 7.3 respectively.

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 132kV power supply system covering the whole Valley is needed in future to increase power transmission capacity of the 66kV system.

<u>Scenario-B</u>

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

In this case, the following sub-projects in Scenario-A will not be required:

a) Addition of a second circuit to the 66kV Siuchatar-Patan line
b) Construction of a new 66kV line between Bhaktapur and New Chabel

In this scenario, the necessity of connection of the 132kV Marsyangdi line to the Siuchatar substation will remain unchanged.

Scenario-C

In Scenarios-A and B, some extension of 132kV 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 132kV ring system is formed surrounding Kathmandu city, aquisition of necessary land space for extension of 132kV switchgear and transmission lines may become very difficult.

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

This scenario has also an advantage compared to the others that reconstruction of 132kV GIS at Balaju will not be required in forming a 132kV ring system in future.

In addition to the power flow analysis explained in Section 7.5, a similar simulation study on the above two scenarios has been conducted, and the proposed sequence of investments for the reinforcement and extension of the system is given in Table 7.4.

Single line diagrams for both scenarios in 1995/96 and 2000/01 are illustrated in Figures 7.4 to 7.7.

7.7 Short Circuit Analysis

(1) Calculation Condition

The rated short-circuit capacity of the existing switchgear equipment was examined assuming three phase short circuit on the planned system, with the following conditions.

a) Fault point

Buses of 11 kV at each substation and switching station in the Kathmandu Valley are taken as fault point.

b) Power systems

The short circuit calculation was executed on the following seven cases:

The existing system in 1989/90
The system of scenario-A in 1995/96
The system of scenario-A in 2000/01
The system of scenario-B in 1995/96
The system of scenario-B in 2000/01
The system of scenario-C in 1995/96
The system of scenario-C in 2000/01

c) Loading condition

The peak load conditions same as those for the power flow analysis were assumed.

d) Generating plants

For the years of 1989/90 and 1995/96, only the existing power stations are taken into account since power supply shortage is relatively small in these years and for the year 2000/01 an imaginary generating plant having a capacity of 222MVA is considered at the 132kV bus of the Hetauda substation as explained in Section 7.3.

The transient reactances of the generators used in the calculation are as follows;

	unit %
Marsyangdi	28.00
Kulekhani I	26.00
Kulekhani II	28.00
Trisuli	34.30
Devighat	28.00
Sunkosi	30.00
Hetauda	17.40
Imarginary generator	40.00 /1

/1 : reactance of transformer is included

(2) Result of Calculation

The results of calculation and the rated breaking current of the existing 11kV circuit breakers are shown in Table 7.5.

The short circuit currents of the existing system at Patan, Teku and Royal Palace already exceeded the rated breaking current. In order to avoid the recurrence of accidents like the bursting at the Lainchaur substation, urgent replacement of 11kV cubicles at these stations is needed.

As explained in Sections 7.5 and 7.6, power supply constraints such as excessive voltage drops and overload of lines will be improved by the reinforcement and extension of the 66kV and 132kV systems. However, insufficiency of rupturing capacity is noted when the rated breaking strength of the existing 11kV cubicles is compared with short-circuit current in the future power supply system as shown in Table 7.5.

The rated breaking strength of the oldest 11kV cubicles manufactured by English Electric Co. (Bulk Oil type) is 7.88kA. This is too small compared with the short-circuit requirement of the existing power supply system. The calculated short-circuit currents of the systems to be reinforced and extended will exceed the rated capacity of the existing 11kV cubicles at the following switching stations. The rated capacities of the remaining cubicles will be higher than the calculated short-circuit current up to 2000/01.

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

The 11kV cubicles in the above table, rated capacity of which is lower than the calculated short-circuit current in 1989/90, are to be urgently replaced, even though the probabilily of occurrence of short-circuit fault on the 11kV bus circuit or at the points near the switching station is relatively low. When these cubicles are replaced, it is also required to replace other cubicles installed in the same stations, which are of bulk oil type and of the same type cubicles which caused a fire at the Lainchaur substation. For new substations, necessary 11kV cubicles will be installed for local supply. Summary of reinforcement of 11kV cubicles is given below and its details are shown in Table 7.6.

Number of 11kV Cubicles

	Urgent	1995/96	2000/01	Total
a) Replacement	19	25	6	50
b) Addition	-	4	-	4
c) Shift	-	6	-	6
d) New Substation	-	22	10	32
Total	19	57	16	92

7.8 Evaluation of Extension and Reinforcement Plans

7.8.1 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 GOJ.

Since Nepal is a land-locked country being surrounded by Tibet and India, all equipment and materials including construction tools and equipment have to be transported through India over a long distance, and further to the Kathmandu Valley through steep mountain areas.

Construction cost of each sub-project is summarized below and further details are given in Table 7.7, 7.8 and 7.9. The construction cost includes procurement cost of equipment, materials, tools and construction equipment in the foreign currency and locally available materials such as cement, steel bars, building materials and other miscellaneous materials in the local currency, but does not include engineering services, land compensation, land acquisition, land formation and overhead and general expenses of NEA, etc.

Reinforcement and Extension of Transmission System

The total construction cost of each scenario selected in Section 7.6 is as follows:

(US$ 1000)

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

11kV Ring System

For the 11kV ring system, as explained in Section 7.7, only replacement of the existing old 11kV cubicles with new equipment is required. Summary of necessary replacements of 11kV cubicles is as follows.

Reinforcement of 11kV Cubicles

		Nos.	Amount (US$1,000)
(1)	Upto 1995/96	76	3,385.7
(2)	Upto 2000/01	16	828.6
(3)	Total	92	4,214.3

7.8.2 Evaluation of Reinforcement and Extension Plans for Power Transmission System

Criteria for the selection of an optimum sequence of investments for the sub-projects worked out in Section 7.6 are:

a) The construction cost including operation cost is cheap, and
b) The system losses are small.

Selection of the least cost investment scenario is performed by comparing overall present worth costs of sub-projects in each scenario and system loss cost of kW losses and kWh losses.

(1) System Losses

The loss cost consists of kW losses and kWh losses which are evaluated based on the construction cost of medium speed diesel power plant (4 x 6.5MW) which is under construction in the Eastern region, and fuel cost of the said diesel plant including variable operation and maintenance cost.

The kW value and kWh value for assessing an optional investment sequence for sub-projects are US$ 130/kW/year and US$ 0.075/kWh, respectively. A detailed explanation on such values is given in Table 7.10.

(2) Results of Evaluation

The present worth calculation was made with a discount rate of 10%, and its results are summarized 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

Note: Unit = US$ 1000

(3) Sensitivity Analysis

The economic viability of the sequence of investments was tested against major factors where uncertainties are involved.

a) Sensitivity to changes in discount rate

	8%	10%	12%
(a) Scenario-A	42,988	39,223	35,941
(b) Scenario-B	43,199	39,820	36,860
(c) 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	44,518
Scenario - B	34,296	39,820	45,344
Scenario - C	36,077	42,073	48,070

Note: Unit = US$ 1000

7.8.3 Conclusion

As a result of the evaluation made in the previous section, Scenario-A is economically justified.

From the results of power flow analysis for various cases, the following are pointed out:

(1) The present power supply network has no power supply constraint under the normal condition. However, under such abnormal condition as outage of one circuit of transmission line, several constraints like overload and excessive voltage drop are observed. Therefore, it is recommended to take necessary actions to remove such constraints with top priority.

(2) In order to improve the power supply reliability of the system, it is most effective and attractive to form a ring system surrounding the Kathandu city. In this case, it is an economical solution taking into account forecasted demand in the area to form a ring firstly by utilizing the existing 66kV transmission lines.

(3) In connection with (2) above, it is strongly recommended to construct a new substation in the Bhaktapur area and a 66kV transmission line from the New Chabel substation as early as possible.

CHAPTER 8

MASTER PLAN STUDY ON EXTENSION AND REINFORCEMENT OF 11KV DISTRIBUTION SYSTEM IN KATHMANDU VALLEY

CHAPTER 8
MASTER PLAN STUDY ON EXTENSION AND REINFORCEMENT OF 11KV DISTRIBUTION SYSTEM IN KATHMANDU VALLEY

8.1 General

One or some of the following countermeasures are usually applied in plans for reinforcement and improvement of distribution systems to meet the requirement of the systems.

(1) For improvement of voltage regulation and technical energy loss:

(a) addition of a new distribution substation,
(b) upgrading of conductors or cables,
(c) boosting of line voltage,
(d) shift of load to another line,
(e) installation of automatic voltage regulator,
(f) addition of number of circuits or new lines, or
(g) extension of the existing 11kV lines.

(2) For increase of line capacity:

(a) upgrading of conductors or cables,
(b) boosting of line voltage,
(c) shift of load to another line, or
(d) addition of number of circuits or new lines.

(3) For improvement of power supply reliability:

(a) adoption of insulated cables,
(b) shift of load to another line,
(c) addition of number of circuits or new lines,
(d) application of multi-circuit switches, or
(e) addition of sectionalizing switches.

(4) For balancing of utilization factor of distribution transformers:

(a) re-location of the existing transformers,
(b) addition of new transformers, or
(c) phase balancing of transformers.

The improvement of the existing distribution network in the Valley was examined and planned up to the year 2000/01 taking account of application of the abovementioned countermeasures.

8.2 Issues of Existing Feeders by the Year 2000/01

8.2.1 General

It is surmisable that the following issues will occur in the distribution system in the Valley, unless adequate reinforcement or improvement works are implemented.

(a) Voltage Regulation and Losses

Unless any reinforcement and improvement of the system is put in effect, voltage regulation and energy losses in the network will continue to increase in proportion to growth of power demand and natural deterioration of the existing facilities. Besides the reinforcement of the facilities, particular regulations for banning energy pilferage and severe application of the regulations are strongly recommended.

(b) Insufficiency of Distribution Transformer Capacity

The existing transformer capacity of 195MVA in total seems sufficient for the recent maximum demand of 85 to 100MW. However, taking account of capacity reduction of the existing transformers due to their deterioration, removal of deteriorated transformers and unbalanced location of transformers in the system, the present installation is not adequate.

Under this situation, additional transformers will be required to meet the growing demand and for replacement of the deteriorated transformers.

(c) Requirement of new 11kV Lines

In proportion to demand growth of various kinds of loads in wider areas, supply reliability of the existing system will furthermore be aggravated.

In order to prevent such aggravation of the supply reliability of the system, improvement and/or reinforcement of the existing feeders and addition of such adequate facilities as sectionalizing switches, auto reclosers or underground cabling will be necessary.

(d) Inaccurate Demand Meters

Periodical calibration of customers' energy meters is required for accurate billing of energy sales. Otherwise, unreasonably less revenue from actually delivered energy will affect NEA's financial state, and complaints from customers about billing will increase.

8.2.2 Examination

For concrete clarification of issues in the existing network, the voltage regulation and conductor current carrying capacity of each existing feeder were examined up to the year 2000/01, taking account of the future demand growth. Results of the study are summarized in Table 8.1. In the study, the voltage regulations of each feeder are predicted under the following assumptions:

(a) Conductors and cables presently in operation will neither be removed, upgraded nor reinforced, and will remain as they are.

(b) Load on each feeder will be equally distributed along their whole length, since no real records on the actual load distribution on feeders are available.

(c) Power factor of each feeder will remain unchanged from the present average figure until the year 2000/01, although industries will be rapidly developed in the Valley, because the anticipated development of industries will not be on such a large scale as to alter the present system power factor.

(d) Load growth on each feeder are based on the demand forecast examined in Chapter 6 aforementioned.

Maximum allowable voltage drop of 11kV lines in the system is assumed at 7.5% of the rated system voltage.

The examination disclosed that voltage regulations or current capacity of the existing conductors and cables on the following 11kV feeders should be improved before the year 2000/01.

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

Although it is not expressed in the computation of the above voltage drops and conductor capacities, NEA needs to improve supply reliability, in particular, for the center of Kathmandu town as well as to improve and reinforce low tension distribution lines in the Valley for reducing voltage drops and energy losses.

8.3 Reinforcement Plans

8.3.1 11kV Distribution Lines

Improvement and reinforcement of the existing 11kV feeders in the divisional power system abovementioned are planned with the following countermeasures.

(1) Kathmandu Central Division

(a) Budhanilakantha Feeder:

The feeder is supplying power from the Maharajgunj switching station to the area located over a distance of 3.8 km north of the station. The current carrying capacity of the existing ACSR Rabbit conductors on the feeder will become insufficient for the power demand in the year 1999/2000.

Accordingly, the existing conductors should be graded up to ACSR Dog type before that year.

(b) Distribution System in Town Center:

Since the town center is heavily congested with houses and the existing power system in the area is complicated, its expansion or improvement will not be easily implemented. To meet growing demand, improve power supply reliability and reduce voltage drops at the end customers, improvement of the system in the area will be carried out through application of insulated cables and underground cables, addition of distribution transformers and extension of 11kV and low tension lines.

(2) Kathmandu East Division

(a) Airport Feeder from New Chabel Substation:

The current carrying capacity of the existing ACSR Rabbit conductors will become insufficient in the year 1994/95 and the voltage regulation of the feeder is forecasted to exceed the allowable value in the year 2000/01. The existing conductors will be replaced with bigger conductors of ACSR Dog type.

(b) Boudha-Jorpati Feeder:

In order to increase the current carrying capacity of the existing conductors whose capacity will be insufficient for the load current in the year 1990/91 and to improve the excessive voltage drop forecasted to occur in the year 1993/94, a new feeder will be required, together with sectionalizing switches for increase of supply reliability.

(c) Sundarijal Feeder from New Chabel Substation:

In the year 1998/99, the feeder's voltage regulation is estimated to exceed the allowable extent of 7.5%. The existing HDCC (Hard Drawn Copper Conductor) 12.9 sq.mm conductors will be upgraded to ACSR Dog type before that year.

(d) Baneswar Feeder from Chabel Switching Station:

The conductor carrying capacity of the existing ACSR Rabbit conductors will turn insufficient in the year 1994/95. The voltage regulation of the feeder will also exceed the allowable value in the year 1998/99. The conductors will be timely replaced with those with a bigger size of ACSR Dog type.

(e) Sundarijal Feeder from Chabel Switching Station:

The voltage drop of the existing feeder is 8.4% exceeding the allowable extent. The load current on the feeder will also exceed the current carrying capacity of the existing conductors in the year 1996/97. The conductors will be upgraded with ACSR Dog type conductors on new supports for improving the present situation.

(f) Baneswar Feeder from New Baneswar Substation:

The current carrying capacity of the existing ACSR Dog conductors will not be sufficient for the estimated load current on the feeder in the year 2000/01. A new feeder will be provided before that year.

(g) Airport Feeder from New Baneswar Substation:

The voltage regulation of the feeder will exceed the allowable extent in the year 1993/94, and the current capacity will also be lower than the forecasted load current in the year 1995/96. It is necessary to shift the present load to another feeder, to upgrade conductors and/or to add a new feeder.

(h) Godawari-1 and 2 Feeders from New Baneswar Substation:

The voltage drop of the Godawari-1 feeder will be 7.87% in the year 1993/94, while that of the Godawari-2 feeder has already exceeded the allowable extent in the year 1989/90. Some or all of load on the feeders will be shifted to the Patan diesel power station through arrangement of supply routes.

(i) Shankhhamul Feeder from New Baneswar Substation:

The forecasted load current will exceed the current carrying capacity of the existing conductors in the year 2000/01. The existing ACSR Dog conductors will be replaced with bigger conductors, or a new feeder will be constructed.

(j) Patan Feeder from Thapathali Switching Station:

It is forecasted that in the year 1999/2000 the load current of the feeder will exceed the current carrying capacity of the existing ACSR Dog conductors. To meet the forecasted demand before that year, the existing feeder will be reinforced by an additional feeder.

(3) Kathmandu West Division

(a) Kirtipur Feeder from Siuchatar Substation:

Excessive voltage drop is forecasted to occur on the Kirtipur (Ropeway) in the year 1994/95, and the current capacity of the existing ACSR Dog conductors will become insufficient for the forecasted load current in the year 2000/01. A new 11kV feeder will be constructed to feed power to the area as well as to the existing cement factory.

(b) Thankot Feeder from Siuchatar Substation:

The Thankot feeder will face difficulty in supply of quality power to the industrialized area in the year 1992/93 due to the excessive voltage drop. Frequent trippings of circuit breakers on the feeder are recorded since it is running over a long distance. Addition of a new feeder and/or upgrading of the existing conductors will be required.

(c) Dharmasthali Feeder from Balaju Substation:

The load current on the feeder will exceed the current capacity of the existing ACSR Rabbit conductors in the year 1996/97. On the other hand, the voltage drop of the feeder will reach 7.7% in the year 1997/98. The feeder will be upgraded with larger conductors in combination with improvement of the B.I.D. feeder from the same substation.

(d) B.I.D. Feeder from Balaju Substation:

The forecasted load current of the feeder will exceed current capacity of the existing ACSR Rabbit conductors in the year 1992/93. The feeder will be improved through upgrading of conductors, addition of a new feeder or load shift to another feeder taking account of countermeasures to the abovementioned Dharmasthali feeder.

(4) Lalitpur Division

(a) Old Patan-1 and 2 Feeders from New Patan Substation:

The current capacities of the existing conductors on the feeder-1 and 2 will be insufficient for the forecasted load currents in the years 1993/94 and 1996/97, respectively. The existing conductors will be upgraded with larger conductors before the said years.

(b) Pharping Feeder from Patan Diesel Power Station:

The voltage drop of the feeder will be 8.2% in the year 1995/96 and current carrying capacity of the existing ACSR Rabbit conductors is forecasted to be insufficient for the load current in the year 2000/01. Improvement of the

feeder will be made by installation of an additional feeder or upgrading of conductors.

(c) Mangal Bazar Feeder from Patan Diesel Power Station:

Forecasted load current on the feeder will exceed current carrying capacity of the existing ACSR Raccoon conductors in the year 2000/01. The conductors will be upgraded before that year.

(5) Bhaktapur Division

(a) Byasi Feeder from Bhaktapur Switching Station:

The Byasi feeder is supplying power to the center of Bhaktapur town in a ring system together with the Brick feeder. It is forecasted that in the year 2000/01, the current carrying capacity of the existing Dog conductors on the Byasi feeder will be insufficient for the load current on the feeder. Improvement of the situation will be made through upgrading of conductors or addition of a new feeder.

(b) Banepa Feeder from Bhaktapur Switching Station:

The feeder with single and double circuits supplies power from the Bhaktapur switching station to demand areas scattered up to Banepa village over about 13 km. Voltage drop of the feeder is forecasted to be more than 7.5% in the year 2000/01. Before that year, an additional feeder will be constructed after detailed review of the load forecast in consideration of shift of some load on the feeder to the existing Nalinchowk feeder.

(c) Nagarkot Feeder from Bhaktapur Switching Station:

The voltage drop of the feeder will be 8.56% exceeding the allowable extent in the year 1994/95. Even if the existing conductors of ACSR Dog and Rabbit types would be upgraded with larger conductors, it will be difficult to maintain the voltage regulation to reasonable extent. It is planned to construct a new feeder from the switching station toward the Nagarkot village for diverting the existing load flow.

8.3.2 Distribution Transformers

Total capacity of distribution transformers installed in Kathmandu Valley was around 195MVA as of 1990/91 as seen in Table 8.2.

The field investigation by NEA in the Lalitpur area disclosed that a number of transformers with a capacity of 15MVA or 7.7% of the total capacity in the area are urgently required to be improved by replacement with larger units or by adding new units, since their overload utilization factor reach more than 130%. As the initial utilization factor is generally selected at 60 to 70%, the total capacity of transformers to be added will amount to 15MVA which is equivalent to the capacity of transformers operated beyond the factor of 130%.

After 1989/90, additional transformers will be installed in proportion to the increase of the power demand. The capacity of distribution transformers to be added for the next 10 years is shown in Table 8.3. In the table, the capacity of transformers to be added is computed under an assumption that 5% of total demand will be consumed by 11kV customers.

8.3.3 Multi-circuit Switch

Since the short-circuit capacity for the year 1995/96 will be beyond the rating of equipment, the existing multi-circuit switches installed in Supermarket, Mahabauda and Mint should be replaced with switches of larger capacity.

Most of the existing 11kV cables are branched from bus conductors of the related pole transformers, and therefore even partial repair of a cable or its ancillaries requires an interruption of power supply by all feeders connected with the transformers. From such inconvenience of the system operation and maintenance and also as the demand increase, installation of additional multi-circuit switches is required. However, this plan will be further examined by NEA, since there will be difficulty of land acquisition for installation of the switches.