BASIC DESIGN STUDY REPORT
ON
ESTABLISHMENT OF LOAD DISPATCHING CENTER
AND
REINFORCEMENT OF KATHMANDU VALLEY DISTRIBUTION NETWORK
IN
THE KINGDOM OF NEPAL

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JAPAN INTERNATIONAL COOPERATION AGENCY

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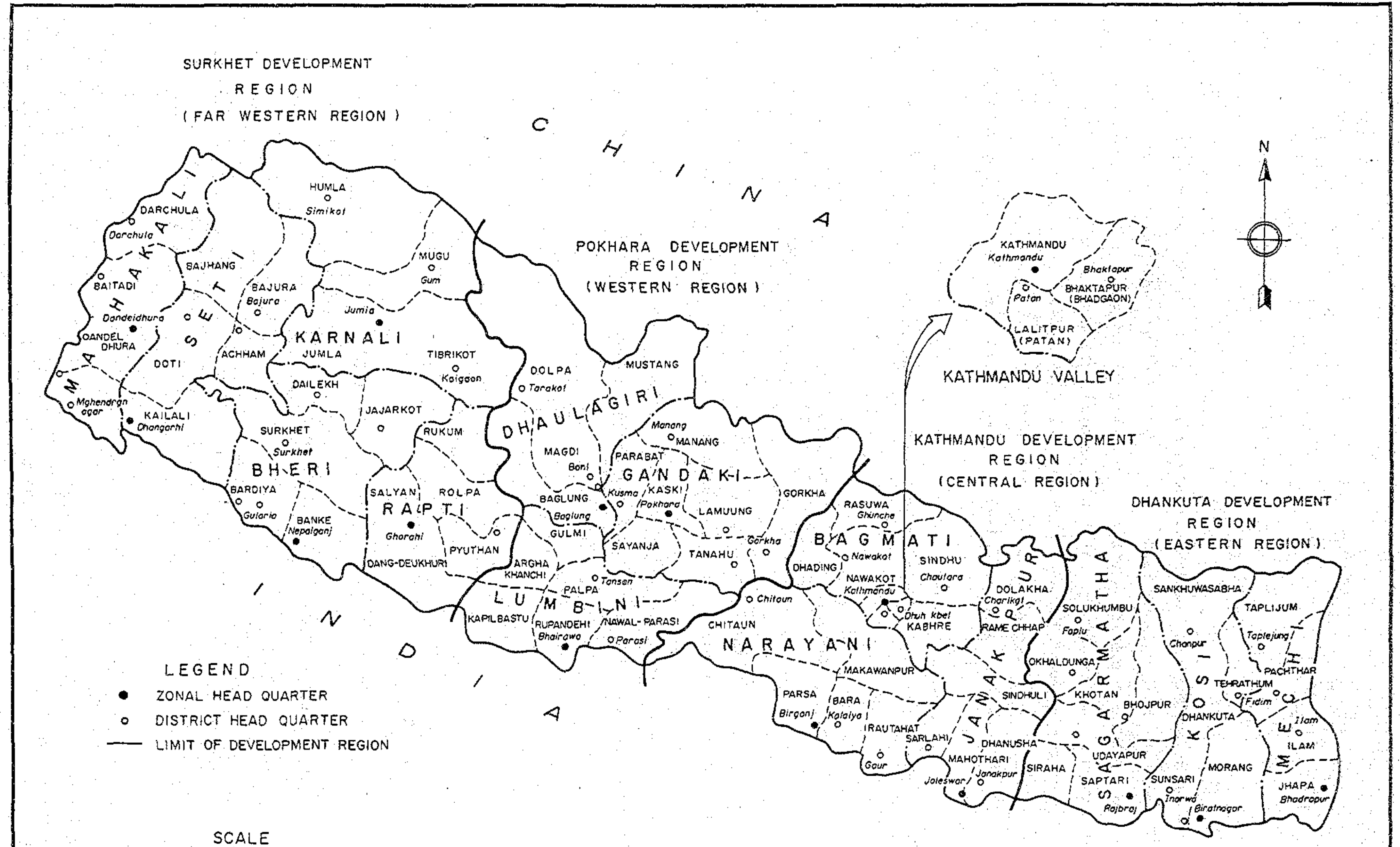

Location Map

PREFACE

In response to the request of the Government of the Kingdom of Nepal, the Government of Japan decided to conduct a Basic Design Study on the Establishment of a Load Dispatching Center and the Reinforcement of the Distribution Network, and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent to Nepal a study team headed by Mr. Hiroyuki Noguchi, Grant Aid Division, Economic Cooperation Bureau, Ministry of Foreign Affairs from October 30 to December 2, 1984.

The team had discussions on the project with the officials concerned of the Government of Nepal and conducted a field survey in Kathmandu Velley area.

After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the project and contribute to the promotion of friendly relations between two countries.

I wish to express my deep appreciation to the officials concerned of the Government of the Kingdom of Nepal for their close cooperation extended to the team.

April 1985

Keisuke Arita
President
Japan International Cooperation Agency

SUMMARY

Nepal, where most of the land is steep and mountainous, is endowed with abundant water resources with an estimated hydro potential of 83,000 MW. Since Nepal possesses no other natural resources than water resources, the government lays an emphasis on its development and its efficient utilization. For Nepal which is suffering from the lack of foreign currency reserve and difficulty in importing coal and petroleum, the efficient utilization and stable supply of hydropower is a key factor for its socio-economic development and upgrading the people's living standards.

In 1980/81, charcoal shared 94 per cent of the total national energy supply. Energy supply by charcoal, however, is not expected to meet the future increase in national energy demand since the necessity for protecting decreasing forest resources has been rising. Hydropower development is being required to supplement the charcoal energy sources as well.

In the late 1970's, the power supply in the Kathmandu Valley was in the worst condition. Power failure occurred frequently and there was large voltage drop due to the insufficiency in power supply capacity and improperness of the transmission and distribution network, which considerably hindered people's normal daily life.

Under such circumstances, the Japanese Government, in response to the request of the His Majesty's Government of Nepal (HMG/N), conducted in 1978 the feasibility study for the reinforcement of the transmission and distribution system and the establishment of a load dispatching center taking into account the demand increase up to the year 1990/91. On the basis of this study, the reinforcement projects of the distribution network in the Kathmandu Valley were undertaken by Japanese Government grant aid programs in 1980 and 1982 in parallel with the construction of the Kulekhani Hydroelectric Project. As a result, power supply conditions in the Valley were significantly improved.

To cope with the future increase in power demand up to 1990/91, HMG/N is constructing the Kulekhani No.2 Power Station (32 MW, scheduled to be completed in 1986/87) and Marsyangdi Power Station (66 MW, 1988/89) at present. Establishment of a new load dispatching center and reinforcement of the distribution network in the Kathmandu Valley are becoming urgent to meet future increase in power demand and to ensure a stable power supply in concert with the augmentation of power generation capacity.

Therefore HMG/N prepared a plan to establish a load dispatching center and to reinforce the distribution network in the Kathmandu Valley, and submitted an official requests to the Japanese Government for extending a grant aid to realize a project.

In response to the official request of HMG/N, the Japanese Government decided to conduct a basic design study for the establishment of a load dispatching center and the reinforcement of the distribution network in the Kathmandu Valley and JICA dispatched a study team to Nepal from October 30 to December 2, 1984. Based on the discussions with the officials concerned of HMG/N and the results of field survey, the study team confirmed the scope of the study and carried out the basic design study in Japan.

This report presents the basic design of the proposed facilities on the basis of the discussions in Nepal and the analysis of the data and information collected during the field survey.

Basic Design

(1) Establishment of Load Dispatching Center

HMG/N is currently promoting a long-term development plan for power generation, power transmission system and distribution system with foreign aids. Efficient and smooth operation of a series of power stations and overall power system will be achieved by establishing a centralized control system with a load dispatching center which gives directives concerning the adjustment of power generating output and operation of the overall power system.

It was decided by the present study that the load dispatching center be located in the premises of the present Electricity Department in Kathmandu. The load dispatching center will be furnished with a system diagram board for supervising the power system and the communication network for sending load dispatching directives and for data transmission from power stations and substations. Major supervision and telemetering items will be automatically indicated on the system diagram board and other indications will be made manually according to information over telephone. Main communication pathes between the load dispatching center and the power stations and substations will be established through power line carrier (PLC) channels on the transmission lines and multiplex UHF channels.

Cable lines, VHF channels and public telephone are also planned to be utilized to supplement the above systems. Though the planned load dispatching center will supervise the power system for power supply to the Kathmandu Valley, consideration was made for possible future expansion of the power system.

Since this will be the first load dispatching center in Nepal, preparation of operation manuals appropriate for Nepalese engineers is included in the Project.

The building of the load dispatching center will be two story construction and each story will be provided with the following rooms.

1st story : Total area is 297 m^2 with 148.5 m^2 for the K2 Substation switchgear room and the remaining for the communication manager room, office room (in charge of communication), meeting room, and resting room.

2nd story : Total area is 297 m^2 with 118.8 m^2 for the load dispatching room (system diagram board and desks arranged around the board), 42.8 m^2 for the main equipment room (radio communication equipment, telephone exchanges, master unit) and the remaining for the load dispatching manager room, office room (in charge of load dispatching).

The period for implementation of the project is about 21.5 months from the signing of the note of exchange, including preparation of tender documents, tendering, construction contract, manufacturing, installation and commissioning.

(2) Reinforcement of Distribution Network in Kathmandu Valley

As mentioned previously, the reinforcement projects of the distribution network implemented in 1980 and 1982 by grant aid programs from the Japanese Government contributed significantly to the improvement of the power supply conditions of the Kathmandu Valley coupled with the completion of the Kulekhani No.1 Power Station. However, due to a rapid increase in power demand and the increase in power supply capacity thereafter, the following have come to arise as problems at present.

1) Total capacity of 66/11 kV transformers in the Kathmandu Valley will become insufficient after 1987/1988.

2. Due to insufficiency in rupturing capacity of 11 kV switchgear and inappropriate circuit arrangement, it is difficult to meet the increasing power demand with high reliability.

3) Improvement of the distribution network and increase in its capacity are necessary to meet the increasing power demand.

Basic design was made for the following facilities which were judged to possess the highest urgency by the present study and to which HMG/N also gave high priority.

1) Construction of Baneswar Substation

Construction of the Baneswar Substation and associated transmission facilities for augmentation of the capacity of 66/11 kV transformers in the Kathmandu Valley and for power supply to the Baneswar area. Four 6 MVA transformers will be installed. (One is for emergency use.) Planned installed capacity is 18 MVA for the time being. The building of the substation will be one story construction in 200 m^2 and accommodated with a main control room with switchboards and switchgear (170 m^2) and other appurtenant rooms.

2) Renewal of K2 Substation

Renewal of the K2 Substation for power supply to the central part of Kathmandu city. Specifically augmentation of rupturing capacity of 11 kV switchgear and improvement of circuit arrangement. Equipment of K2 Substation to be renewed will be placed in the building of load dispatching center to be constructed in the premises of the Electricity Department.

3) Reinforcement of the Distribution Network in the City Areas

i) Installation of distribution lines related to the construction of the Baneswar Substation, and for increasing demand in the city area. (27 km in total)

ii) Installation of distribution transformers to meet load increase. (62 units)

iii) Provision of sectionalizing switches for improving reliability of power supply and for facilitating switching over of distribution circuits. (20 units.)

iv) Procurement of distribution facilities necessary for operation and maintenance by the Nepalese side (4,200 watt-hour meters and 6 units of VHF communication equipment).

The period for the implementation of the project is about 20.5 months from the signing of the exchange of note.

When the construction of the load dispatching center and the reinforcement of distribution network are implemented, the responsible agency will be the Nepal Electricity Authority which will be newly established in 1985 by amalgamating the Electricity Department and the Nepal Electricity Corporation. Operation and maintenance of the load dispatching center are planned to be undertaken by Nepalese engineers, and for this purpose, establishment of an appropriate organization and staff training will be necessary. As for the distribution network, there will be no problem in operation and maintenance of the planned distribution network by Nepalese engineers alone, in view of NEC's long experience in the operation and maintenance of the transmission and distribution network.

Under the centralized control system with the load dispatching center, the most efficient operation of the overall power system becomes possible, consequently bringing about an efficient utilization of water resources, decrease in number of power failures and shortening of power interruption time.

By the full utilization of the load dispatching center, the total power supply system will be able to maintain quantity (power supply to meet demand), quality (stability of voltage and frequency) and reliability (power supply with least interruption).

While the main objective of establishing the load dispatching center is to ensure a reliable power supply to the Kathmandu Valley, the present plan has a room to expand the system to the nationwide scale in future.

The construction of the Baneswar Substation is significant not only in that it will supply power to the Baneswar area, but also in that it will partly share the load with the Chabel Substation in the city center. Consequently the Baneswar Substation will contribute to solve the shortage in capacity of 66/11 kV transformers in the Valley in the near future. The renewal of the K2 Substation will ensure stable power supply to the center of Kathmandu city and will also make it easy to cope with future demand increase. Reinforcement of the distribution network in the city area will upgrade the quality of service and will increase reliability of power supply regardless of demand increase.

Stable power supply to the Kathmandu Valley will strengthen the functions of the capital city, promote commercial and industrial activities and contribute to stabilizing people's daily life. Thus, the Project will take an essential role in the achievements of the power development plan as well as economic development plans of the Kingdom of Nepal.

The project will also contribute to the full utilization of the Kulekhani No.1 Power Station completed with co-finance of OECF and World Bank and to the power supply from the Kulekhani No.2 Power Station, now under construction under OECF loan, to Kathmandu Valley.

Thus innumerable benefits are expected to be created by the implementation of the project. The project, in this regard, has a great significance in being implemented under a grant aid program of the Japanese Government.

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CHAPTER 1 INTRODUCTION

Kathmandu Valley, where the capital of Nepal, Kathmandu, is located, is the center of Nepal in all aspects of politics, economy, industry, and culture. In spite of its importance, Kathmandu has been suffering from problems related to power supply such as frequent power failure and large voltage drop due to an insufficient power generation capacity and incomplete distribution network. This situation of power supply in the Kathmandu valley was improved to a substantial degree by the expansions of distribution networks in 1980 and 1982, which were performed as grant aid programs of the Japanese Government, and the completion of the Kulekhani No.1 power station with the capacity of 60 MW in March 1982 partly financed by Overseas Economic Cooperation Fund of Japan (OECF). Rapid increase of population and resultant power demand since then with a growth rate of more than 10 per cent per annum are currently requiring further reinforcement of the distribution networks. Necessity is also rising for the establishment of the integrated operation and maintenance system of the whole network system to cope with the enlargement of the power system.

Under these circumstances, the HMG/N requested to the Government of Japan the establishment of a load dispatching center and reinforcement of the distribution network in the Kathmandu Valley. In response to the request, the Japanese Government dispatched a study team headed by Mr. Hiroyuki Noguchi to Nepal from October 30 to December 2, 1984 through Japan International Cooperation Agency (JICA). The study team conducted the survey focusing on the following items.

- Review of the feasibility study conducted by JICA in 1978
- Current problems and improvement plan of the power system
- Present conditions of the power transmission and distribution network in the Kathmandu valley.
- Collection of data necessary for basic design

Composition of the study team, schedule and minutes of discussions are attached as Appendices I, II, III and IV respectively.

Composition of the present report after Chapter 2 is as follows.

Chapter 2: Background of the project dealing with general condition of Nepal, long-term economic development plan and necessity for power development.

Chapter 3: Present condition and problems of the power system

Chapter 4: Basic design of load dispatching center

Chapter 5: Basic design of distribution network

Chapter 6: Project evaluation

Chapter 7: Conclusions and recommendations

CHAPTER 2 BACKGROUND OF THE PROJECT

2.1 General Conditions

Nepal is a land-locked country lying in the south of Himalayan Range between China and India. Its rectangular shaped land covers an area of 147,180 km^2 with a length of about 800 km from east to west and a width of 130 - 240 km from north to south. Nepal is topographically divided into three areas; Terai plain in the south, hilly area in the middle and Himalayan Range area in the north. Terai Plain is an relatively flat zonal area. This area is the richest part of the country in agricultural production with more than 65% of the total cultivated area in Nepal. Relatively fertile valleys are scattered along rivers in the central hilly area. Kathmandu developed as the capital of Nepal lies in one of these fertile valleyes, Kathmandu Valley. The central area of the Kathmandu Valley has the altitude of 1,300 m and is surrounded by hills at an altitude between 2,000 m and 2,500 m.

Himalayan Range area in the north is covered by snow throughout a year and development of this area is significantly delayed. Water resources is the largest and only natural resources in Nepal. Most of major rivers originate in Himalayan Range, run through steep valleys to the south and finally flow into the Ganges river. These rivers are endowed with abundant discharge due to an annual precipitation of about 1,800 mm and the existence of glaciers in Himalayan Range which function as natural reservoirs. Potential sites for hydroelectric power generation are found at many locations. While total power generation potential is logically estimated to be 83,000 MW, only about 20,000 MW has been identified and 124 MW or 0.6% of this identified potential has been actually developed so far./1

Population of Nepal was estimated to be about 16,200 x 10^3 in 1984. The average population growth rate between two population censuses in 1971 and 1981 was 2.7% per annum. Population density was 110 per km^2 as of 1984, Kathmandu Valley embodies three cities of Kathmandu, Patan and Bhaktapur.

/1 UNDP/World Bank, "Nepal, Issues and Options in the Energy Section" August 1983.

Total population of the Kathmandu Valley was estimated to be 836 x 10^3 (in 1983/84) and an annual growth rate between 1971 and 1981 was 3.5% which was higher than the national average. Gross national products (GNP) was US$2,620 x 10^6 in 1983 and GNP per capita was $170 in the same year. Nepal is the typical agriculture country. Agriculture sector shared 55% of the gross domestic products (GDP) in 1982 and 90% of work force was engaged in agriculture in 1976. On the contrary, agricultural land is only 2,326 x 10^3 hectare or 16.5% of the total area due to mountainous topographic condition of the country. Increase in land productivity is, in this sense, essential theme. Main agricultural products are rice, wheat and maize. Paddy production shares 50 to 60% of the total grain production. Manufacturing sector, on the contrary, shared only 4% of GDP in 1982 and 0.7% of the total work force in 1976. Basic capital goods are all imported. Manufacturing sector is composed mainly of agriculture related home industries and small scale industries. In recent years, however, the manufacturing production showed a remarkable growth: annual growth rate of 14.8% in 1981/82 and 18.8% in 1982/83.

Major export commodities are jute, jute products, rice and timber. Major import commodities include manufactured goods, machinery, transport equipment and food. Main trade partner is India; import from India shared 46.3% of the total import value and export to India accounted for 66.7% of the total export value.

Nepal has been suffering from increasing trade deficit for a long time. Trade deficit which was $200 x 10^6 in 1979/80 increased by 80% in three years and reached $360 x 10^6 in 1982/83.

On the other hand, balance of payments, which had been enjoying surplus due to inflow of foreign capita, finally went into deficit in 1982/83 when trade deficit superceded foreign capital inflow. This condition has been increasing a necessity of various types of foreign aid, both bilateral and multilateral (Table 2.2).

Foreign loan and aid accounted for 52.2% and 75.4% of the overall government expenditure and development expenditure respectively in 1982/83. Official development aid (ODA) provided to Nepal amounted $\$200 \times 10^6$ in 1982 of which 54.8% was by bilateral aid and 45.2% by international agencies. Among member countries of Development Assistance Committee (DAC), Japan provided the biggest amount of ODA accounting for 26.3% of the total bilateral aid to Nepal.

2.2 Economic Development Plan

HMG/N started to implement long-term economic plans in 1956/57. During the 10 years period from 1971/72 to 1981/82, annual growth rate of GDP averaged 3.0%, while population increased at a growth rate of 2.7% annually. As a result, growth of GDP per capita during this period was quite small. The current Sixth Five Year Plan (1980/81 - 1984/85) sets the annual economic growth target of 4.3% and puts forward the following major development policies.

(1) Emphasis on agriculture sector

(2) Development of small scale industries for the creation of job opportunities for low income people.

(3) Increase of foreign currency earning by export promotion and tourism development.

(4) Development of natural resources, mainly water resources, and conservation of forest resources.

During the first two years of the Sixth Plan, agriculture production increased satisfactorily due to favorable weather conditions and target growth rate of GDP was almost attained. In 1982/83, however, agriculture production dropped drastically because of drought and consequently GDP growth rate recorded minus 1.4%. On average, the annual GDP growth rate stayed at 3.5% during the first three years of the Sixth Plan (Table 2.3).

Under the condition that the agriculture sector is the main stay of Nepalese economy, drought gave serious impact not only on the agriculture sector but also on various aspects of national economy such as price increase and deterioration of balance of payments due to fall in export. To overcome this situation, HMG/N revealed the new economic

(1) Stabilization and increase of agriculture production by further development of water resources and irrigation system and increase of job opportunities.

(2) Encouragement of private investment

(3) Restraint of inflation

(4) Protection of forest resources

In the Seventh Five Year Plan which is scheduled to start in June 1985, the economic growth target is set at 4.5% per annum.

2.3 Water Resources Development and Power Sector

To attain the increase and stabilization of agriculture production, development of irrigation system is inevitable for stable supply of irrigation water. Water resources development should be accordingly promoted to accelerate the electrification of rural areas to prevail pump irrigation and tubewell irrigation as well as to secure irrigation water. Increase in power supply will bring about benefits in various fields such as the development of small and medium scale industries (mainly agro-processing industries), development of transportation service industries and fullfilment of basic needs of inhabitants through rural electrification. Thus water resources development, especially for power supply, is the key for development of Nepal which is not endowed with any other natural resources.

As shown in the table below, total energy consumption in Nepal reached about 2,980 x 10^3 TOE (ton oil equivalent) in 1980/81, of which 94% was supplied by charcoal. Power supply amounted to only 14,000 TOE or 0.5% of the total energy consumption.

Energy Consumption Structure at Nepal in 1980/81

(Unit: 1,000 TOE)

Purpose	Charcoal or Biomass	Petroleum	Coal	Power/1	Total
Domestic	2,760.1	30.3	-	6.6	2,797.0
Transportation	-	64.5	3.0	-	67.5
Commerce and Manufacturing	45.9	8.2	45.0	6.5	105.6
Agriculture	-	4.7	-	-	4.7
Other	-	-	0.4	0.4	0.8
Total	2,806.0/2	107.7	48.4	13.5	2,975.6

/1: Power sold

/2: Charcoal is 2,723,000 TOE and the rest is residue of animals and plants

Source: UNDP/World Bank, "Nepal: Issues and Options in the Energy Sector" August 1983

Forest in Nepal decreased from 6,400 x 10^3 ha in 1963/64 to 4,300 x 10^3 ha in 1980/81 and it is prospected that charcoal alone cannot meet future increase of energy demand. The above survey jointly conducted by UNDP and World Bank estimates that energy supply by charcoal will increase only by 2% by 2009/10 and electric power supply is expected to rise significantly.

HMG/N presented the specific policies for water resources development in "Water, The Key to Nepals Development" in 1982. As far as power generation projects are concerned, the following three projects are at present under way and scheduled to start operation during the Seventh Five Year Plan period. Studies or designs are planned to be conducted for other six projects during this period.

1) Kulekhani No.2 Power Station (32 MW) financed by OECF.

2) Andi Khola Power Station (5.1 MW) financed by United Nations Missionary Fund

3) Marsyangdi Power Station (66 MW) by multilateral finance of World Bank, Germany and others.

In the field of power transmission and distribution systems in the Kathmandu Valley, the Japanese Government prepared the development plan of transmissions and distribution systems, which took into consideration the power generation development plan until the year 1990/91 in 1978. Based on this, grant aid was given by Japanese Government for the reinforcement of power distribution system of the Kathmandu valley in 1980 and 1982. Foreign aid has been provided mainly from Asian Development Bank (ADB) and such countries as France and Finland.

CHAPTER 3 PRESENT POWER SYSTEM AND ITS CURRENT PROBLEMS

3.1 Present Power System

3.1.1 Electric Power Supply Activities in Nepal

The electric power supply activities in Nepal and the planning and execution of construction works are currently managed by the following governmental organizations:

(a) Electricity Department of Government (ED)

The Electricity Department of the Ministry of Water Resources is responsible for the planning and execution of electric power development porjects in Nepal. Normally, after commissioning, ED hands over the completed projects to NEC. However, some facilities in the Far Western Region are retained and operated by ED.

(b) Nepal Electricity Corporation (NEC)

NEC is a governmental corporation which operates power facilities and supply electricity to the public in Nepal. The management of the Eastern Electricity Corporation in the Eastern Region was merged with NEC in July 1982. Butwal Power Company in the Western Region has already stopped its operation and its franchised areas have been taken over by NEC.

The both of ED and NEC are under management of the Ministry of Water Resources of HMG/N. The organizations of HMG, ED and NEC are as shown in Fig. 3.1, 3.2 and 3.3, respectively.

In order to carry out the power supply service efficiently, it is scheduled that ED and NEC will be amalgamated into Nepal Electricity Authority (NEA) in 1985. The establishment of NEA has already been approved by HMG/N and with the organization proposed as shown in Fig. 3.4.

The maintenance of the distribution network in the Kathmandu Valley is currently undertaken by Transmission and Distribution Department of NEC. The maintenance organization of the valley is divided into Kathmandu, Patan and Bharatpur according to the administrative divisions of the valley. The Patan and Bhaktapur divisions undertake the maintenance of the distribution network in the respective cities, and the Kathmandu division look after not only the distribution network but also the 66 kV and 33 kV transmission lines in the valley.

The number of person now engaging in the maintenance of the distribution network in the Kathmandu Valley is 210 for Kathmandu, 120 for Patan and 96 for Bhaktapur as shown in Table 3.1.

NEC has an organization for carrying out distribution network projects. Considering its long time experience for the maintenance works, it is judged that NEC is capable enough to maintain the distribution network planned in this report.

3.1.2 Current Power Generating Facilities

Power consumed in the Kathmandu Valley is normally supplied by hydropower plants around the Kathmandu Valley. Particulars of the plants are given below:

Hydropower Plants around Kathmandu Valley

Name of Plant	Installed Capacity
Kulekhani No.1	2 x 30,000 kW
Trisuli	7 x 3,000 kW (Max. output 6 x 3,000 kW)
Devighat	3 x 4,800 kW
Sunkosi	3 x 3,350 kW
Gandak	3 x 5,000 kW
Panauti	3 x 800 kW
Sundarijal	600 kW
Pharping	400 kW
Godawari	30 kW
Total	120,880 kW

Four major power plants, the Kulekhani No.1, Trisuli, Sunkosi and Gandak are connected to the Central Nepal Power System (CNPS) with 66 kV and 132 kV transmission lines. The 66 kV power system for the Devighat Power Plant is operated with a 66 kV interconnection with CNPS.

Four small power stations, Panauti, Sundarijal, Pharping and Godawari, are connected with the 33 kV and 11 kV systems in the valley.

Among the major hydro power plants, only the Kulekhani No.1 Power Station is provided with a reservoir having a substantial storage capacity for seasonal regulation. The reservoir impounds water during the rainy season and generates large power during the winter season when the other power stations are operated at small output in spite of the large system demand. Actually, the present power system is much dependent on this power station.

The Trisuli Power Station which had been designed based on the river flow during the dry season, can be operated at its full output throughout the year with the help of a daily regulating pondage. The Sunkosi Power Station have a daily regulating pondage but the Gandak Power Station is a run-of-river station. The output of these two power stations decreases to about half during the extreme dry months of the year as shown in Table 3.2. The operation of the Gandak Power Station has to be stopped for cleaning rubbish on the screen once every day.

Particulars of thermal power plants are given below. These power stations are operated in order to fill up the deficiency in the power supply capacity of the hydropower plants caused by extremely dry weather or outage of hydro-generating units.

Thermal Power Plants around Kathmandu Valley

Name of Plant	Type of Plant	Installed Capacity
Hetauda	Diesel	14,470 kW
Patan	"	1,490 kW
Kathmandu	"	1,728 kW
Bharatpur	"	600 kW
Various private	Steam	2,400 kW
Total		20,688 kW

In the recent few years, need to operate NEC owned diesel generators are very rare. As seen in Table 3,6, there are no records to have operated diesel generators in the Central Region during the year, 1983/84.

The list of generating facilities in Nepal as of 1982, other than the Central Region is shown in Table 3.3. The total output is 8,019 kW in the Eastern Region, 5,564 kW in the Western Region and 1,602 kW in the Far Western Region. In expectation of the 132 kV transmission systems which are now under construction, one from Hetauda to Biratnagar in the Eastern Region and the other from Dumkibas to Butwal in the Western Region and further to Nepalganj in the Far Western Region, there have been no strenous effort for increasing the generating facilities in the areas. Therefore, in these areas, the deficiency in power supplying capacity has relied on import from India.

3.1.3 Current Transmission Facilities

Only the Central Nepal Power System (CNPS) is the interconnected power system in Nepal. CNPS interconnects the major cities in the Central Region, Kathmandu, Hetauda and Birganj with the major hydro-power plants, Kulekhani No.1, Trisuli and Sunkosi, with 66 kV transmission lines. Toward the end of the 1970s, a 132 kV extension was completed between the Hetauda Substation and Gandak Power Station near the Indian border via the Bharatpur Substation, from where a new extension upto Pokhara has been completed in 1982. At present, the 66 kV Devighat -

New Chabel power system is operated without 66 kV interconnection with CNPS. This system is connected with CNPS through the 11 kV system.

Particulars of the existing 132 kV and 66 kV transmission lines are shown in Table 3.6. The total length of the 132 kV transmission lines is 249 km and that of the 66 kV lines is 220 km, and the total length is 469 km.

Most of these transmission lines are in the Central Region except for short length in the Western Region around Dumkibas, Gandak and Pokhara. In addition, 132 kV transmission lines from Hetauda to Biratnagar and from Dumkibas to Nepalganj via Butwal are under construction.

Location of the transmission lines which are existing or now under construction are shown in Fig. 3.5.

3.1.4 Current Distribution Network in Kathmandu Valley

(a) Trunk System

The trunk system of the power supply network in the Kathmandu Valley is shown in Fig. 3.6. In addition to the four 66/11 kV substations, Siuchatar, Balaju, Patan and New Chabel, there are eight 11 kV substations which are connected to the 11 kV trunk system. Feeders of 11 kV are connected to these substations. Most of the 11 kV trunk system was constructed in 1960's and the main lines are overhead lines with ACSR conductors of 200 mm^2 (Panther) strung on double circuit steel poles. The two lines which have been constructed under the previous two distribution network projects use other types of conductors, 240 mm^2 ACSR for the Siuchatar-Teku Section and 200 mm^2 copper cables for the Teku-Thapathali Section. The total length of the 11 kV trunk lines is 43 km.

Among these 11 kV trunk lines, the two sections, Balaju-Mahajganj-Chabel-New Chabel and New Chabel-Bhaktapur-Thimi-Patan, are normally operated with interconnection. For the other sections, however, the radial power supply system is applied and connection with two sources is avoided in operation of each substation. The connection under normal operation is illustrated in Fig. 3.7.

(b) 11 kV Feeders

With the extension of the 11 kV distribution network by the two reinforcement projects of the Kathmandu Valley distribution network under Japanese grant aid, the flat areas in the valley has almost covered with the distribution network. The total length of 11 kV distribution lines is about 440 km and the total capacity of distribution transformers is about 86,000 kVA. The sequence of each phase of reinforcement is shown below:

Sequence for Extention of Distribution Network in Kathmandu Valley

	In 1978	First Phase Reinforcement (1980)	Second Phase Reinforcement (1982)
HT Distribution Lines (km)			
11 kV lines	250	342	422
3.3 kV lines	64	39	20
Total	314	381	442
Distribution Transformers (kVA)			
11 kV/400-230 V	31,640	57,260	84,330
3.3 kV/400-230 V	8,820	4,000	2,000
Total	40,460	61,260	86,330

Supply of each feeder from a certain substation is in many cases flexible by changing over of sectionalizing switches. Summary of distribution facilities for each substation is roughly estimated as follows:

Distribution Facilities for each Substation in Kathmandu Valley

Name of Substation	Number of Feeders	Total Length (km)	Total capacity of Transformers (kVA)
K2	6	21 (2.0)	7,500 (400)
Teku	9	46 (16.0)	13,100 (1,200)
Thapathali	4	9	3,200
Lainchaur	5	10	9,700
Siuchatar	2	47	3,900
Balaju	4	36 (2.0)	9,600 (400)
Maharajganj	3	23	3,200
Chabel	5	70	11,000
New Chabel	0	0	0
Patan	7	120	16,930
Bhaktapur	5	50	7,200
Thimi	2	10	1,000
Total	52 lines	442 (20)	86,330 (2,000)

Note: Figures in parentheses represent those for the 3.3 kV system.

Length of 11 kV feeders in the city areas is mostly around 3 km and is around 5 km for the longest. Length of 11 kV feeders toward rural area is long and many of them are 10 to 15 km.

The number of 11 kV feeders in the Kathmandu Valley is 52 and their total loads are grouped as follows:

0 - 2 MVA ---------- 38 feeders
2 - 3 MVA ---------- 6 feeders
3 - 4 MVA ---------- 8 feeders

There is no category for "flat tariff" in the tariff structure in Nepal and supply to all the consumers is made through a watthour meters. Due to insufficiency in the number of instruments, many consumers are supplied with a principle of supplying two consumers with a common watt-hour meter.

(c) Management of Power Supply System

At present, periodical measurement of distribution transformer loadings has not been conducted regularly. Transformer loading condition are checked, only when some problems are expected, when some problems have occurred or when NEC received complaints from consumers, in order to seek for countermeasures.

The 11 kV side voltage is controlled by adjusting on-load tap changers on 66/11 kV main transfomers. The tap changers are provided with mechanisms to change over tap position automatically so as to keep the secondary side voltage at a constant level. In Nepal automatic mechanisms are not usually used and the tap positions are adjusted manually. The 11 kV bus voltage is usually set at around 10.5 kV, lower than the rated voltage of 11 kV. The high tension side voltage of the distribution substation is usually set at 10.5 to 10 kV.

Each distribution transformer is usually provided with an externally operated no-load tap changer which is operated in case that the low tension supply voltage is judged to be abnormal. It was told that the low tension supply voltage to consumers is maintained within voltage drop of around 10 per cent so as to allow fluorescent lamps to light, and that recently there have been no compliants from consumers.

3.1.5 Current Power System Operation

At present, the generation schedule of each power station is prepared monthly by the NEC headquarters by showing the generating output of each station for each hour. Such a schedule is delivered in writing instruction to each station for execution from time to time. However, so far as inspected by the study team, it was noted that such instructions have not always been observed well. Actually, some power stations were operated with smaller output than instructed while the others were operated at larger output. It was supposed that the power stations were operated depending on the conditions of the generating equipment and availability of water with less regard to the instructions from the headquarters.

It was also observed that there was no manual nor clear idea for scheduled maintenance of power system equipment, method of operation of overall power system, and other system managements.

3.1.6 Current Communication System

For communication power stations and substations, within CNPS, power line carrier (PLC) communication equipment which utilize 66 kV and 132 kV transmission lines are provided. Present conditions of such PLC terminals are as shown in Table 3.5. Conditions are good for the sectiors provided under the Kulekhani Hydroelectric Project; between Balaju-Siuchatar-Kulekhani No.1-Hatenda, between Siuchatar and Patan and between Devighat and New Chabel. Conditions are not good but communication is possible for the sections; Trisuli-Balaju, Sunkosi-Patan and Bharatpur-Pokhara. For the Sunkosi-Patan section employing the vacuum tube system, spare parts have already been depleted and long time service can not be expected. The equipment for the sections, Hetanda-Parawanipur-Birganj and Hetanda-Bharatpur-Gandak, are out of order.

The present PLC system and the systems now under construction are illustrated in Fig. 3.8. These PLC terminal equipment have been planned project by project and in their specifications no considerations have been made for intercommunication among the systems. These PLC systems are not provided with backup systems with the radio system or any other means and for the communication purpose, operators are obliged to rely on the public telephone system which takes long time to get connection.

Though many stations were provided with telephone exchanges, all but several small relay group exchanges under the Kulekhani Hydroelectric Project were out of order.

3.2 Current Conditions of Demand and Supply

3.2.1 Data for Demand and Supply

Available data for demand and supply in Nepal are the generator output (MW value) and generated energy (MWh value) at each generation end, sold energy at the consumer ends, inter-region exchange of energy (between the Central and Western Regions) and energy exchange with India. There are no available data for the power which passed substations. The balance between the generated energy and the sold energy is recorded as the loss energy.

The data for demand and supply for the years 1975/76 through 1983/84 are shown in Table 3.10. The peak demand of the non-interconnected power system as of 1983/84 is about 90 MW and the energy generation is 365 GWh at the generation end. The population in the middle of 1983/84 is estimated at 16 million and the above values correspond to per head demand of 5.6 W in terms of peak demand and 22.8 kWh in terms of power generation. The average annual increase of power consumption was 11.7 per cent in this period.

The share of the Central Region in the power consumption in the whole of Nepal is high. In 1983/84 the energy consumption in this area occupied about 75 per cent of the whole of Nepal. Further, in terms of sold energy during 1982/83, the Kathmandu Valley occupied about 79 per cent of the Central Region. From these data it is considered that the Kathmandu Valley consumes almost 60 per cent energy of the whole of Nepal.

In 1983/84, peak and energy demand of the Kathmandu Valley is assumed to be 60 MW and 216 GWh respectively. The population in the valley was 836,000. Then the per head figures for peak demand and energy consumption are obtained to be 72 W and 258 kWh respectively, each of which corresponds to more than 10 times that of the whole Nepal. The average increase rate of the energy consumption is 11 per cent and is lower than that of the whole of Nepal.

The peak generation and generated energy for each month of the year 1983/84 in the Central Region are shown in Figs. 3.9 and 3.10, respectively. In the Kathmandu Valley electric heaters are used during the winter season. Therefore, the peak demand of the year is usually recorded in December or January. According to the data, demand in the summer season goes down to between 70 and 80 per cent of that the winter season.

During the late 1970s, the power demand of the Kathmandu Valley had been suppressed due to insufficiency in generating capacity and improperness of the distribution network, which resulted in comparatively low growth rate of the power consumption. In March 1982 the first phase of the reinforcement project of the Kathmandu Valley distribution network and the Kulekhani No.1 Power Station were completed almost at the same time. Thus the above restrictious were lifted, and in 1982/83 large increase in power consumption was recorded and the recorded figures of 1983/84 well corresponded to those forecasted in the feasibility study in 1978. It can be concluded that though the power demand itself had been suppressed, the potential demand had increased normally. In 1983/84 the peak demand was about 60 MW as compared with the forecasted 59.4 MW (peak demand of CNPS in 1983/84 in 76 MW as seen in Table 3.6 and the peak demand of the Kathmandu Valley is assumed to be 79 per cent of 76 MW). Decrease in the load factor in 1981/82 was caused by the increase in the peak demand enabled by the above two project and by the unchanged energy consumption which was brought by the fact that the above two projects had been completed toward the end of the year.

From 1982/83 to 1983/84 the power consumption increased by only 2.8 per cent. It is assumed that this was caused by the 58 per cent tariff increase which was effected in April 1983. Though the peak demand increased by 10 per cent, there had been tendency toward energy saving in order to curtail expenditure for power consumption

The record of power consumption (actually sold energy) by each consumer category for the period 1975/76 through 1982/83 is shown in Table 3.7. At the time of the tariff revision in April 1983, Non-Commercial, Irrigation and Water Supply, and Transportation, which were included in the former category of Commercial were separated as new categories. After distributing the loss energy to all the categories, the increase rate of each category was obtained as follows:

Residential	8.1 per cent per annum	
Industrial	17.8	"
Commercial/1	17.9	"
Others	15.7	"
Total	12.2 per cent per annum	

/1 : Commercial is based on the former classification.

According to the above it is found that the increase rates for the Industrial and Commercial categories are very high.

The total power consumption in the three regions other than the Central Region such as, Eastern, Western and Far Western Regions, in 1983/84 was about 92 GWh, corresponding to about 25 per cent that of the whole of Nepal. However, the average growth rate of these regions from 1975/76 through 1983/84 is 14.4 per cent per annum and is much higher than that of Nepal. The tendency of power demand increase in irregular, reflecting the fact that the defficiency in power supply capacity forced supplemental imports from India which had been sometimes uncertain. The power consumption increase from 1982/83 to 1983/84 was not much influenced by the last tariff increase and the power demand had increased as usual.

3.2.2 Loading Conditions of Each Substation

Generally no wattmeter is provided at the substation in the Katmandu Valley. Power flow at each substation is checked only by the current readings. The power flow is assumed base on the current readings and the assumed power factor of 85 per cent.

The loading of each substation and the power flow on each trunk line in the Kathmandu Valley at 6:30 pm on 21 December, 1984, one of the typical heavy load days in 1984, are illustrated in Fig. 3.11. The obtained loading of each substation is compared with the demand which is forecasted during the feasibility study in 1978 as given below:

From the above data, it is found that though the Balaju transformers are heavily loaded, the transformers at the Siuchatar and New Chabel Substations are operated at rather light load.

The daily load curve for the Kathmandu Valley power system on the same day is shown in Fig. 3.12. This curve represents a typical evening peak pattern of the Kathmandu Valley.

3.2.3 Electrification Ratio

The number of consumers by category in the Kathmandu Valley as of 1983/84 is shown in Fig. 3.14. The electrification ratio of the domestic category for each region is shown below:

Electrification Ratio for Domestic Category

Name of Area	Population	Number of Houses /1	Number of Consumers	Electrification Ratio (%)
Kathmandu	461,000	82,300	63,782	77.5
Patan	200,000	35,700	19,750	55.3
Bhaktapur	175,000	31,300	11,701	37.4
Whole Area	836,000	149,300	95,233	63.8

/1 : Number of person per house hold is assumed to be 5.6.

The electrification ratio of the Kathmandu Area is comparatively high and is followed by those of the Patan and Bhaktapur Areas. The electrification ratio for the whole area is calculated to be about 64%, which is rather high considering the present situation of Nepal.

3.3 Demand Forecast

For preparing a demand forecast for the certain area, there are several approaches (1) the method to forecast future demand from the forecast GDP growth on the economic development plan, (2) the method to forecast the future demand by analyzing the past data and (3) the method to sum up the demand forecasts of various demand items. In Nepal, GDP has recorded low but comparatively steady growth, 3 to 4 per cent per annum, and the power consumption has also recorded steady growth. As a general tendency of a developing country the ratio of the power demand growth against the GDP growth is very high. Available data generally do not allow to analyze future tendency of GDP to forecast future demand and therefore international agencies recently follow the practice mentioned in (2) above, the forecast the future demand from the past data. Also in this case, data for category-wise detailed analysis are not available and the future demand is forecasted from the past tendency for the demand growth.

ED prepared a load forecast in 1983 for generation planning. The past growth of the power demand during 8 years from 1975/76 to 1983/84 was 11.7 per cent per annum on average. In the regions other than the Kathmandu Valley, however, a higher growth rate can be expected by supply capacity with sufficient reserve. The power demand of these regions has been suppressed for a long time due to shortage in power supply. Thus, the average growth rate was assumed to be 12 to 13 per cent per annum.

As for the power exchange with India, the power has been exported at one point, only at Birganj, while the power has been imported at 15 points along the Indian border in order to fill up deficiency in power supply. The power supply to these areas will be gradually converted to the supply from the Nepalese power system with the reinforcement of the transmission and distribution network.

The Indian sides adjacent to the Nepalese border are now suffering from the lack of power supply and they have a strong desire to import power from Nepal. At present the committed export from Nepal is only at Birganj, 5 MW (22 GWh), but the export from the Gandak Power Station has

Comparison of Loading of Each Substation (kW)

Name of Substation	Loading in 1984/85	Forecast Peak Demand 1983/84	1984/85	1985/86
K2 S/S	4,900	16,860	18,490	19,130
Teku S/S	8,700	14,190	15,550	17,250
Lainchaur S/S	6,800	-	-	-
Thapathali S/S	2,100	-	-	-
Patan S/S	11,100	7,110	7,790	8,640
Siuchatar S/S	2,500	-	-	-
Balaju S/S	6,000	5,670	6,210	6,890
Maharajganj S/S	2,100	3,990	4,370	4,980
Chabel S/S	7,100	6,450	7,070	7,850
Bhaktapur S/S	4,700	1,780	1,950	2,170
Thimi S/S	300	1,060	1,160	1,290
Total	56,300	57,110	62,590	68,200

Loading in total is not so different from the forecasted demand. By each Substation, however, the figures are more or less different and it is noted that the load distribution of the city center area had greatly changed due to the construction of new substations. The loadings of the Patan Substation had grown larger than expected due to the increase in the industrial load.

The loading of the 66/11 kV transformers at each main substation is given below:

Loading of Main 66/11 kV Transformers in Kathmandu Valley

Name of Substation	Transformer Capacity (MVA)	Transformer Loading (MVA)	Percentage (%)
Siuchatar	36	13.2	36.7
Patan	36	22.7	63.1
Balaju	22.5	22.7	100.9
New Chabel	18.9	7.4	39.2

been commenced. In the demand forecast, the maximum exporting power is assumed to reach 25 MW in 1988/89.

The recent power demand forecasts for the interconnected Nepalese power system are compared in Table 3.9, Fig. 3.13 and Fig. 3.14. Based on the actual growth from 1981 to 1983 than the expected growth the 1983 forecast was lower than the 1981 forecast. From 1985 to 1987, the interconnected power demand is assumed to increase at a high rate with the interconnection of the Eastern, Western and Far Western Regions and after that the power demand is assumed to increase at a steady rate of 12 to 13 per cent per annum according to forecast based on trend without price elasticity.

As for the domestic demand in the Kathmandu Valley, the effect of the tariff increase to the power demand is evident. For a normal consumer with monthly income of several hundred Rupia, monthly payment to an average consumption of 60 to 65 kWh will occupy about 10 per cent of the income. Between 1982/83 and 1983/84, the power demand of CNPS increased by 2.8 per cent, while the increase for the other regions was 11.8 per cent on average. On March 14, 1983, the further increase in the power tariff being 35 per cent on average has been announced publicly. Thus, the decrease in the power demand growth would be unavoidable.

Taking account of all the above factors, the future power demand of the Kathmandu Valley upto 1990/91 is forecasted as given below.

Macroscopic Forecast

The power demand of the Kathmandu Valley, which has increased at a high rate under one of the world cheapest tariff system, is assumed to increase at a similar rate observed above, as the per head consumption in the area is still low compared to similar cities in developing countries. By assuming that the power demand will grow from 1983/84 to 1984/85 at a rate of 8 per cent per annum taking into account the effect of the second tariff increase in March 1985 and 11 per cent per annum thereafter, the future power demand is obtained as given below:

Power Demand Forecast of Kathmandu Valley

Year	Energy Demand (GWh)	Peak Demand (MW)	Load Factor (%)
1983/84	215.8	54.6	45.1
1984/85	233.1	58.6	45.4
1985/86	258.7	64.6	45.7
1986/87	287.1	71.2	46.0
1987/88	318.7	78.6	46.3
1988/89	353.8	86.7	46.6
1989/90	392.7	95.6	46.9
1990/91	435.9	105.4	47.2

Microscopic Forecast

For reference, the total demand is also forecasted by suming up the demand for the Domestic, Industrial, Commercial and Others Categories. The future increase rate for each category is forecasted based on the past tendency.

(a) According to the power saler date of 1982/83, the power demand of the Kathmandu Valley was about 79 per cent of that CNPS.

(b) The Domestic consumption is much affected by the tariff increase and is assumed to remain the same for 2 years from 1982/83 and to increase thereafter at a rate of 7 per cent per annum, slightly lower than the past average.

(c) As for the Industrial demand, there will be a tendency to save energy consumption after the tariff increase and will return later to the level in the recent past. The increase rate for the first 2 years is assumed to be 12 per cent taking into account a tendency toward energy saving and 15 per cent thereafter.

(d) For the Commercial demand the same increase rate as that for the Industrial demand is assumed.

(e) For the others demand, much saving of energy consumption cannot be expected. The increase rate is assumed to be 11 per cent for the initial 2 years and 13 per cent thereafter.

Thus the power demand up to 1990/91 is obtained as given below.

The forecasted demand 107.3 MW in 1990/91 is almost same with the macroscopic forecasted one in the same year (105.4 MW). Thus in this report, the macroscopic forecast is adopted.

Power Demand Forecast of Kathmandu Valley

Year	Energy Demand (GWh)					Peak Demand (MW)	Load Factor %
	Domestic	Industrial	Commercial	Others	Total		
1982/83	103.7	66.0	32.6	7.5	209.8	49.2	48.7
1983/84	103.6	69.8	34.6	7.8	215.8	54.6	45.1
1984/85	103.6	78.2	38.8	8.7	229.3	57.7	45.4
1985/86	110.9	89.9	44.6	9.8	255.2	63.7	45.7
1986/87	118.6	103.4	51.2	11.1	284.3	70.6	46.0
1987/88	126.9	118.9	58.9	12.5	317.2	78.2	46.3
1988/89	135.8	136.7	67.8	14.1	354.4	86.8	46.6
1989/90	145.3	157.2	77.9	16.0	396.4	96.5	46.9
1990/91	155.5	180.8	89.6	18.0	443.6	107.3	47.2

3.4 Problems of Power System

3.4.1 Ongoing Development Plans

As stated in Clause 2.3, at present two major hydroelectric projects, Second Kulekhani and Marsyangdi, are going on. These projects are planned to meet the nation-wide power demand with the completion of the nation-wide transmission line projects. The future power development projects will also be planned, taking into account the power demand of the whole of Nepal. The power transmission line projects associated with these projects are planned for power supply to the Kathmandu Valley as well as to the national power grid.

The nation-wide 132 kV transmission network projects, 33 kV secondary transmission network projects, distribution network projects in 30 local towns and rural electrification project associated with mini-hydropower projects are under execution with financial assistance by the Asian Development Bank and other agencies. As for the power system operation and reinforcement of the distribution network in the Kathmandu Valley, there are no other plans for execution.

3.4.2 Problems of Power Network Operation System

(a) Problems of Power Station Operation System

As mentioned in Clause 3.1.5, at present the monthly operation plan of each hydro power station is prepared in the NEC head office. An instruction showing generating output of the power station for each hour is sent to each power station. However, so far as observed by the basic design study team, these instructions were not always followed well by the power stations. Some power stations were operated at smaller output and the others were operated at larger output. It is supposed that operating output of indivisual power station was decided not only by the instruction of the head office but also based on conditions of generating equipment. The balance of the demand and the total output of the other power stations was filled by the Kelekhani No.1 Power Station. So far as there is sufficient reserve in the generating capacity, there will not be serious problems. However, a systematic operation will be required if the relation between the demand and supply becomes tight. During the site investigation, it was observed that the system frequency sometimes fluctuated by about 1.5 Hz. As a large variation in the system frequency gives negative effects on rotating machines so that the frequency variation shall be controlled within the range of 50 ±0.5 Hz by manual adjustment.

It was also observed that there was no established idea for proper scheduling and execution of equipment inspection and maintenance.

(b) Improperness of Communication System

Due to improperness of the communication network mentioned in Clause 3.1.6, mutual communication among the power stations and substation is very difficult, which makes quick response to a change in the power system operating conditions and emergency operation impossible.

(c) System Faults

Statistics of system faults for the recent three years, 1980/81 through 1982/83 are as shown in Table 3.10. The following are observed up from the obtained data:

(i) The number of system trippings with duration of 10 minutes to 1 hour had substantially decreased after the commissioning Kulekhani No.1 Power Station.

(ii) There are about 10 system faults every year, but most of them will be avoidable by properly managing the power system operating conditions.

(iii) A substantial increase in the number of substation trippings in 1982/83 with duration of 10 minutes to 1 hour seems to have been caused by transmission line trippings due to overheating of a shunt reactor which was installed for the operation of the 132 kV Pokhara Line at the Bharatpur Substation.

(iv) There are no significant changes in the number of 11 kV feeder trippings during the recent 3 years.

3.4.3 Problems of Kathmandu Valley Transmission and Distribution Network

(a) Problems of Transmission Network

During the site investigation by the basic design study team, it was found that among the 66 kV transmission lines for power supply to the Kathmandu Valley, the line between Kulekhani No.1 Power Station and Siuchatar Substation had been operated stably with very small chance of fault but the supply interruption had happened very often on the other three lines, Trisuli-Balaju, Devighat-New Chabel and Sunkosi-Patan. According to information obtained at site, there are several supply interruptions a month during the windy and rainy seasons. It seems that such faults had been caused by the contacts or contiguity of swinging line conductors to standing trees. Patrols of line routes and tree cutting before entering into the critical seasons would be essential. Most of the system faults of the Kathmandu Valley had been triggered by such transmission line faults, which leads to separation of the connected power station from the power system and system failure.

Many of the substations are provided with double-bus arrangement. However, it was found that most of the buscouplers are out of order. The present manual operation of on-load tap changers on transformers sacrifices the stability of the power system voltage.

(b) Need for Increasing Substation Capacity

The total installed capacity of the 66/11 kV main transformers in the Kathmandu Valley is as given below:-

Siuchatar S/S	1-phase, 6 MVA x 3 x 2 banks	36.0 MVA
Patan S/S	Same as above	36.0
Balaju S/S	1-phase, 3.75 MVA x 3 x 2 banks	22.5
New Chabel S/S	3-phase, 6.3 MVA x 3 sets	18.9
Total		113.4 MVA

Note: Two 6 MVA transformers from China which are at the Patan Substation, are not taken into account.

Taking into account the power factor (0.85) and the diversity factor (1.2) of the load, the above main transformers will be able to meet the total demand of around 80 MW. This almost corresponds to the forecasted power demand of 1987/88. Separated operation of the New Chabel Substation from CNPS and the fact that it is very difficult to fully utilize the capability of the main transformers shall also be taken into consideration. Thus the additional installation of one 66/11 kV transformer is required at the latest by 1987/88.

(c) Insufficiency of 11 kV Circuit Breaker Capacity

The old 11 kV switchgears in the Kathmandu Valley were installed in 1960s and their rupturing capacity is rated at 150 MVA. Taking into account the increase in the power system capacity, the rupturing capacity of recent switchgear has been increased to 400 MVA but many switchgear of old substations on the 11 kV system such as K2, Patan, Teku, etc. are still rated at 150 MVA.

After the completion of the Kulekhani No.2 Power Station expected in 1986/87 and Marsyangdi Power station in 1988/89, the rupturing capacity of 150 MVA for the 11 kV switchgear is apparently not enough. Therefore, the existing switchgear are to be replaced with those having larger rupturing capacity.

On the condition that all the generators are connected in parallel, the short circuit capacity at the secondary side of the Siuchatar Substation is calculated to be about 140 MVA at present, about 160 MVA after the completion of the Second Kulekhani Hydroelectric Project and about 200 MVA after the interconnection of the Marsyangdi Hydropower Station.

(d) Problems of Distribution Network

The Kathmandu Valley is administratively divided into Kathmandu, Patan and Bhaktapur. For these areas, the reinforcement of the distribution network has been implemented in two phases utilizing the grant aids from GOJ for the fiscal years of 1980 and 1982. As the result, the distribution network covers almost all the flat areas of the valley. However, due to the recent large increase in the power demand, further improvements have become necessary as mentioned below:-

i) The main transformers at the Balaju Substation becomes overloaded depending on the system operating conditions. Countermeasures are required to shift some of the Balaju loads to Siuchatar, to increase the Devighat output by increasing the descharge from the Trisuli Power Station, to separate the 11 kV interconnection with the Chabel Substation and others.

ii) There is strong desire to convert the present 3.3 kV supply to the city center of Kathmandu city to the 11 kV supply.

iii) There are many locations which require separations, connection changes, etc. of 11 kV distribution lines in order to improve reliability and quality of power supply.

iv) During the peak load time, the average utilization rate (peak load/total transformer capacity) of distribution transformers is about 60 per cent, which is much higher than the maximum reasonable limit of 50 per cent (generally 30 to 40 per cent for the Japanese Power Companies). Therefore, there are many locations where insufficient capacity of distribution transformers results in excessive temperature rise of the transformer, interruption of supply to consumers, drop of supply voltage to consumers and other problems.

v) There are some distribution facilities which have been damaged but not yet been remedied.

vi) In the city centers of Bhaktapur and Kathmandu, disharmony of ordinary pole-mounted transformers with the old histric view of the area was sometimes claimed by the public.

vii) In rural areas, there are still a great number of Panchayats which have not yet been electrified in spite of their applications for the supply of electricity.

3.5 Power Tariff System and Revenue and Expenditure of NEC

The power tariffs of NEC effective at the end of 1984 are shown in Table 3.11. In order to secure necessary funds to service development debts, the average tariffs were raised by about 58 percent on 15 April 1983. A further 35 percent increase of the tariff effective from 14th March 1985 has already been publicly announced. An uniform tariff system is employed covering all over the country.

Details of revenue and expenditure of NEC as of 1982/83 are shown in Table 3.12. The amount of depreciation is about 1.8 million US Dollars and seems to be not enough for the total asset of NEC being roughly estimated to be 300 to 350 million US Dollars.

The repayment to development loans is not clearly indicated.

Revenue and expenditure from 1978/1979 through 1983/84, converted to US Dollar, are given in the following table.

Balance of Revenue and Expenditure of NEC

(Unit: US$1,000)

Fiscal Year	Revenue	Expenditure	Balance
1978/79	3,136	3,550	- 414
1979/80	3,990	2,944	+ 1,046
1980/81	4,921	4,734	+ 187
1981/82	5,283	5,477	- 194
1982/83	8,480	8,091	+ 389
1983/84 (estimated)	12,087	8,288	+ 3,799

CHAPTER 4 BASIC DESIGN OF LOAD DISPATCHING CENTER

4.1 Planning for Establishment of Load Dispatching Center

4.1.1 Purpose of Establishing Load Dispatching Center

For stable supply of electricity of high quality, the trend of power demand and the operating conditions of power system facilities, such as power stations, transmission lines and substations, must be supervised carefully all the time and proper measures shall be taken for power system operation and for avoidance of spreading of faults as well as quick restoration when any fault has occurred on the power system. In order to carry out such systematic operation of the power system, it is planned to establish a load dispatching center in Kathmandu, and to supervise the power system collectively in the load dispatching center and to send operating instructions (load dispatching directives) to each power station and substation (remote station).

The scope of the power system to be taken care of by the load dispatching center under this project will be the CNPS area only, the Kathmandu Valley and the Hetauda and Birganj areas. Therefore, the selected facilities for the load dispatching center are very simple ones to satisfy the minimum requirements to secure stable power supply to the Kathmandu Valley.

Thus, the purpose of establishing the load dispatching center is to manage the power system systematically and operate the whole power system for stable supply of power to the Kathmandu Valley and for effective utilization of water resources, the most important indigenous energy resources.

4.1.2 Basic Concept for Establishing Load Dispatching Center

As mentioned in Clause 3.1.5, at present there are no facilities in Nepal for carrying out the load dispatching functions. The communication system is also not properly arranged so as to cover all the power system and each power station is obliged to operate its generating sets in its own judgement.

The Kulekhani No.1 Power Station (60 MW) has a reservoir with substantial capacity and is greatly contributing to maintaining the balance of demand and supply. The Kulekhani No.2 Power Station is planned to be operated, utilizing the discharge from the No.1 Power Station. The former will be operated following the operation pattern of the latter so that these two power stations combined will have similar effect as the increase in the installed capacity of the present Kulekhani No.1 Power Station from 60 MW to 92 MW.

In 1970s there were two individually operated 66 kV transmission lines from the Trisuli and Sunkosi Power Stations for the power supply to the Kathmandu Valley. Under the Kulekhani Hydroelectric Project, the Kulekhani No.1 Power Station and Siuchatar Substation were constructed along the 66 kV transmission line between the Balaju and Hetauda Substations. Furthermore, another line was constructed between the Siuchatar and Patan Substations for interconnection with the Sunkosi power system. There is a 132 kV transmission line between the Hetauda Substation and the Gandak Power Station located near the Indian border in the Western Region. With the completion of the Kulekhani No.1 Power Station and interconnection of the power systems, reliability of the recent power supply system has been much improved as manifested by the substantial decrease in the number of system faults after 1982 shown in Table 3.10. For further improving the reliability of the power system and meeting the reinforcement of the power system, a system is required to issue operating instructions from the center based on the operating conditions of the overall power system.

4.1.3 Facilities to be Supervised and Location of Load Dispatching Center

The names of power stations and substations which will be supervised by the planned load dispatching center are given below:-

Name of Power Station		Output (MW)	Name of Substation	Capacity (MVA)
Kulekhani No.1	(Hydro)	60	Siuchatar	36
Kulekhani No.2	(")	32	Balaju	22.5
Trisuli	(")	18	Patan	36
Devighat	(")	14.4	New Chabel	18.9
Sunkosi	(")	10.05	Hetauda/1	6.0
Gandak	(")	15	Bharatpur	10.5
Hetauda	(Diesel)/1	14.47		

Note: /1 Hetauda diesel power station and substation are located in the same compound.

Of the above 13 stations, the Hetauda Power Station and Hetauda Substation can be regarded as one remote station. Therefore, the total number of remote stations is 12.

The operating data of the major remote stations, the Siuchatar Substation, Kulekhani No.1 Power Station (including the No.2 Power Station) and Hetauda Substation (including diesel power plant will be sent automatically to the load dispatching center through the PLC and UHF channels, but those of the other remote stations will be sent over telephone.

Location of the load dispatching center is selected within the premises of ED, in view of convenience in operation and maintenance and easiness in reference to responsive staff in emergency cases, as the result of the comparison with alternatives at the Siuchatar Substation as the center of the PLC network and the premises of ED in Kathmandu. Connection of the power system related to the load dispatching system is shown in Fig. 4.1.

4.1.4 Functions of Load Dispatching Center

(a) Control of Demand and Supply Balance

(1) Plan for Control of Demand and Supply Balance of the Next Day

At first a daily load curve for the next day is assumed empirically and statistically, referring to the past daily load curves, whether forecast for the next day, events of the next days, and other factors. Then the load curve, river flow, operating system of each power station(run-off-river, with regulating pondage or with reservoir), etc. are systematically studied and instructions are sent to all power stations for the number of units to be operated, operating output, sequence of operation, etc.

In case that the expected demand can not be met by hydropower stations, operation of the standby diesel generators will be studied and necessary instruction will be sent.

In preparation of the demand forecast, not only the power demand in the Central Region but also the power export to India from the Birganj Substation and Gandak Power Station, and the power transfer to the Eastern and Western Regions have to be taken into account.

(2) Control of Demand and Supply Balance of the Day

During the power system operation everyday, the program which is prepared on the previous day is to be modified from time to time in order to absorb the imbalance between the forecast demand and the actual demand and irregular fluctuation of the power demand. Also system frequency is to be supervised, and in case that any fluctuation is noticed, an instruction will be sent for adjustment of the governor setting of a regulating power station.

(b) Power System Operation

(1) Supervision of Power Flow

Power flow of each transmission line is to be supervised all the time, and in case that any abnormality is noticed, instructions will be sent so as to control the power flow within the normal operating limits by line changeover, adjustment of generator output, control of reactive power sources, etc.

(2) Control of System Operating Voltage

The bus voltage at the major points of the power system will be supervised on the system diagram board, and in case that the value runs out of the normal operating limits, instructions will be issued so as to bring the voltage within the limit by adjusting generator terminal voltage, reactive power sources, tap setting of tie transformers, etc.

(3) Schedule for Maintenance of Large Consumers

Schedules of supply stoppages and maintenance works of large scale consumers with high tension supply shall be reported to the load dispatching center,and such schedules shall be referred to in preparing demand forecasts and a schedule of line maintenance.

(4) Power System Operation

Operation of major switchgear of the power system, tap changing of the tie transformers, adjustment of reactive power sources, etc. shall be conducted according to instructions from the load dispatching center. In case any change of the circuit status is required due to a power system fault, demand-supply situation, etc., instructions for necessary operations will be issued.

(5) Data Transmission

Operating conditions of the power system are to be displayed on the system diagram board. Data of the major stations of CNPS, Siuchatar Substation, Kulekhani No.1 Power Station (including Kulekhani No.2 Power Station) and Hetauda Substation (including diesel plant), are sent automatically by sueprvision (of on-off conditions of main circuit breakers) and telemetering signals (for measured values). Data of other stations will be sent over by telephone with predetermined interval or when any change occurs.

(c) Reservoir Operation

Water discharge of each hydro power station is to be decided from time to time, taking into account the river regime, load curve of the demand, high and low flows, etc. Best effort shall be attempted for effective utilization of water resources by supervising the reservoir water level and inflow to the reservoir.

As for power stations with daily regulating pondage, use of water shall be studied on daily basis, but for the Kulekhani No.1 Power Station the annual utilization plan of water shall be prepared referring to the reservoir water level from time to time.

(d) Power System Protection

The load dispatching center shall keep the records of setting of major protective relays in each power station and substation. In case that any change of relay setting is required from results of relay operation during faults, instructions for modification will be issued.

(e) Record Collection

The collection and arrangement of everyday operation records are very important functions of the load dispatching center. The records to be collected are those for power generation, river flow or reservoir water level, power flow, power demand, meteorology, equipment operations, faults, and others.

After completion of the load dispatching center, its operation and maintenance will be undertaken by NEA which is planned to be established in 1985. In case that the starting operation of NEA is behind the schedule the construction will be looked after by NEC with cooperation of ED and the system will be operated and maintained by NEC after the completion.

For smooth execution of operation and maintenance of the load dispatching center, establishment of a proper organization as mentioned in Clause 4.1.5 and staff training before setting to the actual operation are essential.

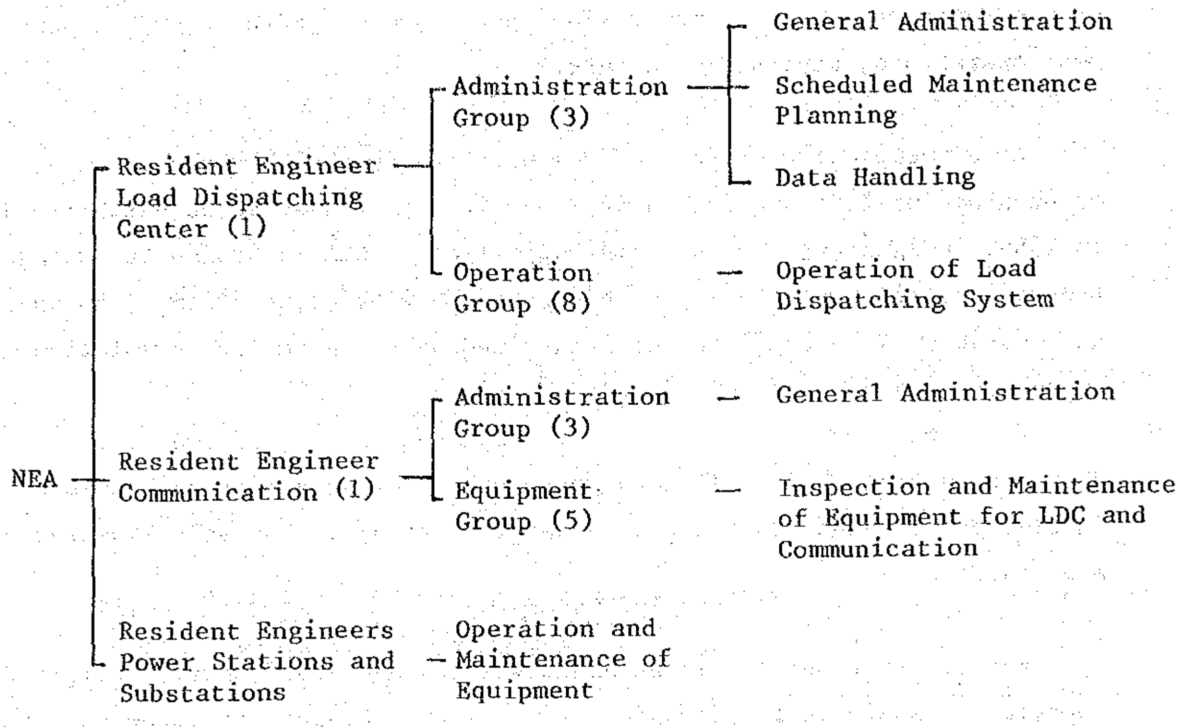
For carrying out the maintenance work by NEA staff only, sufficient quantity of spare parts including print circuit boards are to be supplied by manufacturers and periodical instruction works as mentioned below shall be performed according to the manuals prepared by the consultant and manufacturers.

(a) Routine inspection
(b) Monthly inspection
(c) Yearly inspection

Such inspections are to be performed in cooperation with each power station and substation.

4.1.5 Organization of Load Dispatching Center

To perform the operation and maintenance of the load dispatching center by Nepalese staff only, a new organization shall be established in the proposed NEA, consisting of the load dispatching group and the communication group. It is recommended that NEA shall control the organization with work divisions as given below:



Note: Figures in parentheses show the proposed number of staffs.

Proposed flows of various activities are as shown in Fig. 4.1. For smooth operation of the load dispatching functions, good coordination should be maintained between the load dispatching center and all components of the power system, power stations, transmission lines and substations.

4.1.6 Facilities for Load Dispatching System

The load dispatching system will consist of the following facilities.

(a) Building for Load Dispatching Center

The load dispatching center will be established in the premises of ED and the building for the load dispatching center will be constructed under this planned project.

(b) Equipment for Load Dispatching System

Equipment necessary for the load dispatching system are given below:

(1) Load dispatching center

- Master unit
- System diagram board
- Power source facilities

(2) Remote station

- Interface equipment
- Remote terminal unit
- Power source facilities

(c) Communication Facilities

For carrying out the load dispatching function, the establishment of communication pathes among the load dispatching center, power stations and substations is essential. Purposes of the communication are classified as follows:-

(1) Voice communication channels for sending load dispatching directives.

(2) Data transmission channels for collecting necessary data

(3) Administrative telephone channels

4.2 Basic Design of Load Dispatching Center

4.2.1 Basic Plan

The load dispatching center is a facility quite new to Nepal and requires comparatively high technique in operation and maintenance. As this is the first test case, a very simple system will be designed so that the system can be operated and maintained by Nepalese staff only. Such being the case, the first load dispatching center aims principally at formulating preliminary idea for accepting new techniques of the load dispatching system.

Therefore actual design will be made taking into account future extension of the system. As compared in Clause 4.2.7, the system planned in this report is much simpler compared with the system in the official request from HMG/N.

4.2.2 Buildings Plan of Load Dispatching Center

(a) Site Selection

Location of the building for the load dispatching center is selected at the place where a repair shop and a store are standing at the back of the ED head office building. The existing structures shall be demolished and the site shall be cleared by the Nepalese side prior to starting construction of the building. The proposed location of the building shown in Fig. 4.3.

(b) Arrangement in Building

The planned building accommodates not only equipment for the load dispatching center but also staff in the organization mentioned in Clause 4.1.5. Facilities of the K2 Substation to be constructed utilizing the grant aid fund from the Government of Japan will also be arranged in the same building. The minimum space for equipment required for future extension is considered.

Due to the limitation of the land space for construction, the building will be double stories. Among the two main rooms, load dispatching room and K2 Substation switchgear room, the latter cannot be arranged upstairs as large size cable ducts must be constructed in the room for laying many power cables. Therefore it is decided to arrange the K2 Substation switchgear room downstairs and the load dispatching room upstairs.

The proposed arrangement of the rooms is given below:

Ground floor: K2 Substation switchgear room, communication manager room, office room (for 8 staff in charge of communication), resting room (for temporary rest of shift staff), meeting room (for meeting on operation plan, etc.), kitchen and lavatory, of which total area amounts to 297 m^2.

First floor: Load dispatching room, main equipment room, office room (in charge of load dispatching), load dispatching manager room, kitchen and lavatory, of which total area amounts to 297 m^2.

Main equipment in major rooms for load dispatching center is shown below:

K2 Substation switchgear room (148.5 m^2)	:	11 kV cubicle, switchboard, desks
Load dispatching room (118.8 m^2)	:	system diagram board, control desks
Main equipment room (42.8 m^2)	:	VHF radio communication equipment, telephone exchanges, master unit

The floor plan of the load dispatching Center is shown in Fig. 4.4.

(c) Building Construction Plan

The building will be constructed by a Nepalese contractor with materials available in Nepal. Specifications of the building are as given below:-

Structural Materials

1) Foundation : Reinforced concrete
2) Column, beam, floor and stairs : Reinforced concrete
3) Wall : Brick masonry
4) Roof : Wooden truss

Exterior Finish

1) Roof : Corrugated asbestos cement sheet
2) Wall : Local paint on cement mortar
3) Door and window : Wooden made with oil paint finish

Interior Finish

1) Floor : Terrazo tile, cement mortar and mosaic tile
2) Wall : Local paint on cement mortar, cement mortar finish and ceramic tile
3) Ceiling : Oil paint on plywood and oil paint on asbestos cement sheet

4.2.3 Communication Facilities

(a) Composition of Communication Network

The communication among the load dispatching center (LDC) and the remote stations consists of the multi-channel UHF channels between LDC and the Siuchatar Substation and the PLC communication channels on the 66 kV and 132 kV transmission lines.

Both of the UHF channels and PLC channels will employ band width of 4 KHz and among this 4 KHz band width, 300 to 3400 Hz will be used for both of voice communication and data transmission.

The existing PLC equipment will be utilized as far as applicable. The PLC equipment supplied under the Kulekhani Hydroelectric Porject have band width of 3 KHz and can be applied for voice communication at accompanied by data transmission. In addition, the PLC equipment for the Devighat-New Chabel section are in good condition and is planned to be used as they are (refer to Clause 3.1.6, Current Communication System).

Summary of the establishment plan of the PLC system is as described below:

- Among the PLC terminals for the load dispatching use supplied under the Kulekhani Hydroelectric Project, those for the Siuchatar-Balaju section and Siuchatar-Patan section will be used as they are.

- The PLC terminals for the Siuchatar-Kulekhani No.1 section and Kulekhani No.1-Hetauda section for the load dispatching use will be shifted to the Patan-Sunkosi section and Balaju-Trisuli section respectively.

- New PLC terminals with 4 kHz band width, suitable for both of voice communication and data transmission, will be installed for the Siuchatar-Kulekhani No.1 section and Kulekhani No.1 - Hatauda section.

- New PLC terminals with 3 kHz band width will be installed for the Hetauda-Bharatpur-Dumkibas-Gandak sections and the Hetauda-Birganj section.

- The PLC terminals for administrative use supplied under the Kulekhani Hydroelectric Project (between Balaju, Siuchatar, Kulekhani No.1 and Hetauda and between Siuchatar and Patan) and relay group type telephone exchanges will be used as they are.

- The 2-channel PLC terminals to be supplied under the Second Kulekhani Hydroelectric Project between Siuchatar, Kulekhani No.2 and Hetauda, one channel each for the load dispatching use and for administrative use, have band width of 4 KHz and will be used for this planned project.

Taken into account extentions which are expected in the future stage, UHF radio terminal sets will be of 24 channels equipped with 12 channels.

For communication paths between LDC and Siuchatar Substation, the UHF radio system and the cable carrier system were compared and the radio system was selected for the following reasons:

i) The radio channel is more stable against outside disturbances such as cable damages, collision by cars, fires nearby the lines, etc.

ii) When the communication cables are hang on distribution line poles, the required ground clearance of 5 m cannot be maintained. In the city area of Kathmandu, the cable height will be 4 to 4.5 m. Additional cost is required for hanging cables on poles to be newly erected.

In order to secure direct communication between LDC and the Devighat Power Station, a telephone cable will be laid between the Trisuli Power Station and Devighat Power Station. This telephone cable can also be used to communicate each other between the two power stations for proper operation of the two power stations in series.

For communication between LDC and the New Chabel Substation, the public telephone system will be utilized and for communication with the Baneswar Substation, one circuit will be extended from the relay group telephone exchange in the Patan Substation.

For communication between the Hetauda Substation and the three small substations on the transmission line to the Birganj Substation, Amelkhgunj, Simura and Parwanipur the VHF channel with the minimum cost will be used.

The proposed communication network is illustrated in Fig. 4.5.

(b) Communication Network for Load Dispatching Use

Communications for the load dispatching use are for

i) Voice communication for load dispatching
ii) Data transmission necessary for load dispatching

One voice communication channel and two data communication channels can be accommodated in one frequency band of 300 to 3,400 Hz. For voice communication, 300 to 2,000 Hz will be used and 2,160 to 3,400 Hz for data transmission. Two frequencies, 2,520 Hz and 3,000 Hz, will be allocated for 200 baud data transmission in accordance with Class R 38A of CCITT.

The remote stations will be called by sending polling signals from LDC to send necessary data for load dispatching. In reply, the remote stations will send data to LDC.

For voice communication, the remote station is called by operating the push-button pulse sender at the operator's console in LDC. It is also possible to call the LDC from the remote stations by operating the push-button switches on the telephone sets. This channel shall be used exclusively for load dispatching purpose for sending load dispatching directives from LDC to remote stations and for exchange of information between LDC and the remote stations.

(c) Telephone Communication for Administration Use

With the system installed under the Kulekhani Hydroelectric Project, the dial communication is possible between the extensions connected to the relay group telephone exchanges which are attached to the PLC terminal sets for the administrative communication. There are 5 stations in the existing system, Balaju, Siuchatar, Kulekhani No.1, Hetauda and Patan, to which one station will be added at LDC; and the administrative communication among the 6 stations will become possible.

In addition, the dial communication between Siuchatar, Kulekhani No.2 and Hetauda will also be possible through the telephone exchange at the Kulekhani No.2 Power Station to be installed under the Second Kulekhani Hydroelectric Project.

(d) VHF Communication

For communication between the Hetauda Substation and the three small substations of Amelkhgunj, Simura and Parawanipur on the 66 kV line to Birganj, one set of VHF radio communication equipment will be provided for each station.

The UHF radio system will be of simplex, press-to-talk communication type employing the 150 MHz band to enable necessary communication at minimum cost.

(e) Power Source Facilities

The power sources necessary for the operation of the PLC terminals and UHF radio equipment are DC 48 V, and Alkaline storage battery sets will be supplied with chargers.

4.2.4 Equipment Necessary for Load Dispatching System

The load dispatching system will consist of the following facilities.

(a) Load Dispatching Center

Composition of facilities in the load dispatching center is shown in Fig. 4.6.

(1) Master unit (MU)

Functions of the master unit are to call remote station, to collect data from remote stations and to process the data for sending to the system diagram board and for other purposes.

(2) System diagram board (SDB)

Essential data of the power system operation, status of circuit breakers and telemetered values from remote stations are indicated on the system diagram board. Arrangement on the board is as shown in Fig. 4.7. The sent out power to the Baneswar, Birganj and Pokhara Substations and the power flow of the transmission line to the Janakpur Substation will be indicated by value at respective sending end. The surface of the system diagram board will consist of mosaic units for easy modification of the circuit indication in case of any change and extension of the power system in the future stage.

(3) Power source facilities

The DC 110 V power source for operation of the above MU and SDB is planned to be provided from the K2 Substation which will be installed in the same building.

(b) Remote Stations

(1) Interface equipment

Necessary signals of the remote station are converted in this equipment for transmission of data to LDC. Open and close of circuit breakers are signalized to on-off signals and measured values are transformed to DC voltage for further conversion to digital signals in the remote terminal unit.

(2) Remote terminal unit (RTU)

The function of this equipment is to send data of each remote station when a polling signal from the load dispatching center is received. In this equipment the status of circuit breakers and measured values of the telemetering items will be coded into the binary signals for transmission to the load dispatching center.

(3) Power supply system

RTU is planned to be operated by a DC 110 V source, which will be supplied from the station service power source of each power station and substation.

4.2.5 Preparation of Operation Rules and Manuals

Before starting actual operation and maintenance of the load dispatching center, rules and manuals related to the operation and maintenance shall be prepared and distributed to all the stations concerned. Such rules and manuals will include but will not be limited to the followings:

(a) Rules for Power System Operation (Refer to Appendix VI)
(b) Rules for Operation of Facilities in the Power System
(c) Rules for Issuing Load Dispatching Directives
(d) Procedures for Scheduled Inspection and Maintenance of Power Facilities
(e) Operation Rule for each Power Station and Substation
(f) Rules for Relay Setting
(g) Rules for Operation of Communication Facilities
(h) Rules for Maintenance of Communication Facilities

4.2.6 Staff Training

As the proposed load dispatching center concept is quite new to Nepal and involves comparatively high class technique, staffs who will be engaged in the operation and maintenance after the completion of the center shall be trained for the proper functioning of the completed system.

Such training will be executed through the following two processes:

(a) Training during Erection and Testing

During this stage, all the staff for operation and maintenance should be trained in order to acquire knowledge and to acquaint themselves with the equipment to be operated and maintained after the completion of the center. The staff should be incorporated in the erection crew and be trained through actually engaging in the erection and testing works.

(b) Training during Availability Test

After completion of the load dispatching center, the availability test by the manufacturer is required during the initial period of commercial operation. By attending all phases of the operation during this period, the final round of training for operation and maintenance should be conducted.

4.2.7 Comparison with System in Formal Request

As mentioned in this chapter the proposed system is designed much simpler compared with the system in the formal request from HMG/N so that the completed system can be operated and maintained by Nepalese staff only. Comparison of the main functions is given below:

Item	Formal Request	Selected System
1) Location of LDC	Siuchatar S/S	Within premises of ED
2) Computer	2 sets	Nil
3) SDB	Remote indication	Remote and manual indication
4) Number of RTU	16	3
5) Power system to be supervised	System complete in 1986	Within CNPS
6) Power source of LDC	Uninterrupted power supply system	Storage battery only
7) Load dispatching telephone channel	1-channel (partially 2-channel)	1-channel
8) Administrative telephone channel	4-channel for main portion (2-channel for end portion)	Existing system (1-channel for main portion only)

4.2.8 Other Facilities

Enough spare parts, testing equipment and special tools necessary for the operation and maintenance of the completed system must be supplied under the project and available all the time for the maintenance works.

Major component parts of the load dispatching system consist of printed circuit boards. In case any printed circuit board is damaged, the damaged board shall be replaced with the spare board; the damaged board shall be sent to the manufacturer for repair and the repaired board is to be stored again as a future spare unit. This work is to be done with expense of the Nepalese side.

4.3 Organization for Implementation

4.3.1 Executing Agency

As mentioned in Clause 3.1.1, the present ED and NEC are scheduled to be amalgamated into NEA in 1985. After starting operation of NEA, the project will be looked after by NEA. In case that the establishment of NEA is delayed, NEC will be in charge of the project implementation in cooperation with ED.

4.3.2 Construction Plan

After signing the exchange note the project will be implemented in the following order:

- Signing of exchange note
- Consultant contract
- Detialed design and preparation of tender document
- Tender and conclusion of contract
- Design by contractor and approval by consultant
- Manufacturing and inspection
- Transport to site
- Construction of load dispatching center building
- Erection of euqipment and testing

The contractor shall carry out wave propagation tests soon after the conclusion of the contract, for confirmation of the conditions for radio communication.

The construction supervision will be undertaken by the consultant. In Japan, during the manufacturing stage, the Consultant will be in charge of reviewing and approving contractor's design and also inspecting equipment before dispatch. During the construction stage at the site, the consultant will be in charge of supervising building construction, equipment erection and completion test in cooperation with the NEA staff.

During such site erection, staff training as described in Clause 4.2.6 shall be undertaken.

The required dates for execution after the signing of the Exchange Note are estimated as follows:

Consultant Contract	:	1 month after the signing of the Exchange Note
Tender Call	:	3 months after the signing of the Exchange Note
Tender and Evaluation	:	4 months after the signing of the Exchange Note.
Construction Contract	:	4.5 months after the signing of the Exchange Note
First Shipment	:	12.5 months after the signing of the Exchange Note
Last Shipment	:	16.5 months after the signing of the Exchange Note
Site Construction	:	12.5 - 21.5 months after the signing of the Exchange Note

Thus the project can be completed within 21.5 months. The implementation time schedule is shown in Fig. 4.8.

4.3.3 Operation and Maintenance

As seen in the organization chart in Clause 4.1.5, the minimum number of staff necessary for the operation and maintenance is about 20. Among these people, the actual operation of the load dispatching center will be undertaken by 4 shifts, each shift consisting of 2 persons. As the chief of each shift has to have broad authority in the power system operation, utmost care shall be taken in member selection and training.

Operation and maintenance of the load dispatching center will be undertaken exclusively by the Nepalese staff of NEA. Each maintenance work is required to be carried out according to instruction and manuals prepared by the consultant and manufacturer.

4.3.4 Purchase and Transportation Plan

The equipment and materials with tools for construction required for the Project will be basically purchased in Japan. These are due to be transported from Japan to Calucatta in India by sea and be conveyed to Kathmandu by inland transportation. Materials for the civil and buildings works will be purchased locally.

All equipment and materials from Japan will be unloaded at Calucatta port. The ocean transport takes about 3 weeks. Departures of vessels are concentrated to the end of the month or the beginning of the next month.

It sometimes take long time for both unloading and custom clearance at the port, therfore, necessary to consider 2 or 3 weeks of anchorage.

From Calucatta to Kathmandu, there are 2 ways of inland transportation which are by railway and by truck. Since railway often causes uncertain of time schedule and problem of security due to transshipment of cargoes, truck transportation is recommendable for the Project. Inland transportation by truck takes about 2 weeks.

Through the transportation route as mentioned above, the cargoes from Japan can reach Kathmandu in one-half or 2 months. This is the time for the dry season and some allowance had better be granted in the rainy season.

4.4 Contributions by the HMG/N

The contributions which shall be taken by the HMG/N are as follows;

(1) Clearance of the site of the Load Dispatching Center

The clearance of the site including the demolishment of the existing structures will be undertaken by the HMG/N as described in Clause 4.2.2,(a). The cost is estimated at NRs. 216,000.

(2) Operation and Maintenance of the Load Dispatching Center

Operation and maintenance of the load dispatching center will be taken on by the HMG/N as described in Clause 4.3.3. The annual cost is estimated as shown below;

	NRs./Month		Month		Number		NRs.
Dispatching and communication managers	5,800	x	12	x	2	=	139,200
Engineers (A)	2,900	x	12	x	6	=	208,800
Engineers (B)	1,800	x	12	x	13	=	280,800
Electricians and workers	1,100	x	12	x	5	=	66,000
Subtotal							694,800
Overhead (25%)							172,800
Spareparts and others							216,000
Total							1,083,600

CHAPTER 5 BASIC DESIGN ON REINFORCEMENT OF DISTRIBUTION NETWORK IN KATHMANDU VALLEY

5.1 Outline of the Project

5.1.1 Purpose of the Project

The distribution network in the Kathmandu Valley has been greatly improved with the implementation of Stage I of the Kathmandu Valley Transmission and Distribution Network Project, for which the feasibility report (dated January 1979) was prepared in 1978. However, in the Kathmandu Valley, the power demand has been increasing at a rate exceeding 10 per cent per annum along with the population increase of 3.5 per cent per annum and the increase in the per capita consumption due to the increase in the industrial production and other factors. It has become necessary to reinforce the supply capacity to meet the power demand increase in the near future.Under such situation the official request from HMG/N was submitted.

In order to meet the increasing power demand in Nepal two major hydropower stations, Kulekhani No.2 (32 MW) with target completion in 1986/87 and Marsyangdi (66 MW) with target completion of 1988/89, are now under construction. In the Kathmandu Valley, reinforcement of the distribution network has become necessary in order to secure stable supply of electric power of good quality in the near future. The purpose of this project is to define the plan for the reinforcement of the distribution network in the Kathmandu Valley taking into account the expected increase in the power demand and the contents of request from the HMG/N.

5.1.2 Details of the Project

Site investigation was made for all the items in the request accompanying staffs of ED and NEC. Taking into account the urgency for each item and the priority presented by the HMG/N, the details of the Project were decided as given below:

(a) Substation Works

i) New construction of Baneswar Substation

This substation is planned to solve the problem for insufficiency in 66/11 kV transformer capacity in the Kathmandu Valley and to meet the increase in the power demand in the Baneswar area. The present total capacity of the step-down transformers can meet the power demand only up to 1987/88. By adding the transformer of 18 MVA capacity at the Baneswar Substation and constructing the Lainchaur Substation (10 MVA) under the Marsyangdi Hydroelectric Project, the total transformer capacity will be able to meet the power demand up to around 1990/91.

ii) Renewal of K2 Substation

The purpose of this work is to attain stable supply of electric power meeting the increase in the power demand in the center of Kathmandu city. As the rupturing capacity of the 11 kV switchgear of the K2 Substation will become insufficient due to the increase in the power system capacity after the completion of the Kulekhani No.2 and Marsyangdi Power Stations, these switchgear will be replaced. In order to avoid the total failure of the substation and to improve the reliability of power supply, the single bus system of the 11 kV switchgear will be split into four sections.

(b) Reinforcement of Distribution Network in City Areas

(b-1) Construction of distribution lines

i) Construction of 11 kV lines related to the new construction of the Baneswar Substation.

ii) New construction of 11 kV lines and amendment of distribution voltage to meet the increase in the power demand.

iii) New construction and repair of 11 kV lines to improve reliability of power supply.

(b-2) Supply and installation of distribution transformers in order to meet power demand on the low tension side.

(b-3) Supply and installation of sectionalizing switches in order to improve reliability of supply.

5.1.3 Supply of Distribution Equipment and Materials

Among the items in the requests from the HMG/N, the follwings will be supplied under the Project.

i) Watt-hour meters

As mentioned in Clause 3.1.4, there is no classification for "Unmetered" against small scale residential consumers and supply to all of the consumers is made through watt-hour meters. Even at present, the number of watthour meters is not enough, therefore for meeting the increase in the number of consumers expected in the near future supply of watt-hour meters is required. The number of watt-hour meters was planned to be limited to the minimum required and decided as given below.

Single phase, 2-wire, 230 V	15/60A	1000 NOS
	10/40A	1000 "
	5/20A	2000 "
3-phase, 4-wire, 400 V	15/60A	100 "
	7.5/30A	100 "

ii) VHF radio equipment

At present, one set of VHF radio equipment is furnished at the NEC head office in Kathmandu. By installing one set in the Bhaktapur office of NEC and arranging five mobile sets loaded on vehicles, the communication between the NEC offices and the working sites become possible for the changing over the sectionalizing switch, etc. Thus, the reliability of supply can be improved through prompt separation of fault sections, limitation of fault sections, shortening of period of supply interruption, etc. VHF radio equipment to be supplied are given below;

VHF radio equipment (3-channel)	6 sets
DC power source facility (stationary)	1 set

Note: A DC power source facility with a rectifier will be supplied for the stationary station only. For mobile sets, car batteries will be used.

5.2 Basic Design

5.2.1 Basic Design of Baneswar Substation

(a) Selection of Substation Site

As mentioned in Clause 3.4.3(b), the total installed capacity of 66/11 kV transformers in the Kathmandu Valley will become insufficient in the near future and a new unit is required to be installed at the latest by 1987/88. There are two methods to increase the total substation capacity: to increase capacity of the existing substation and to add a new substation. The Siuchatar Substation is located too far for construction of 11kV lines to feed the load center area and enough space for addition of the transformer is not available in the Balaju and Patan Substation. For the Balaju Substation, there is a plan to enlarge and modify the design under the Marsyangdi Hydroelectric Project. In consideration of these, construction of new Substation was decided for the Project.

As the result of the site survey, it was found that both of the Baneswar and Lainchaur sites are suitable for construction of a new substation. The sites are comparatively close to the city center of Kathmandu and are separated from other substations by several kilometers.

It was informed by ED that the Lainchaur Substations will be constructed at 10 MVA capacity under the Marshangdi Hydroelectric Project. This proves that there is no need to consider the Lainchaur Substations under this project.

Under such situation, it was concluded that the Baneswar site would be appropriate for construction of a new substation. In addition, the Baneswar area is now becoming a new residential area and is located near to the important loads such as the airport and trolley bus. Thus, large increase in power demand is expected and the construction of the substation would be contribute to stable power supply to these loads.

The land for Baneswar Substation shall be prepared by the Nepalease side prior to starting detailed design for construction.

(b) Selection of Substation Capacity

Present demand for which Baneswar Substation will be responsible is 5 to 6 MW, but a high growth rate of demand exceeding 10 percent per annum as a lot of housing constructions are progressing. In consideration of interchangeability of the main transformers with those in the other substations, capacity of main transformers is selected at 18 MVA consisting of three sets of single phase 6 MVA trasformers, which is the same as those in Siuchatar and Patan Substations. The supply area of this substation can be changed easily by connection changes of sectionalizing switches on the distribution network. As the substation site is not far from the city center area of Kathumandu, it is practical to install underground cables up to the K2 and/or Thapathali Substation for taking over some load in the supply area of these substations. Thus, this substation will be helpful to meet the demand increase in the city center area as well.

By the implementation of the Baneswar Substation, the total installed capacity of the stepdown substations in the Kathmandu Valley will become 131.4 MVA and will meet the power demand up to around 1988/89. Then, with the completion of the Lainchaur Substation (10 MVA) as a part of the Marsyangdi Hydroelectric Project, the total installed capacity will be enough to meet the demand up to 1990/91 under the service level as of the end 1984.

(c) New Construction of Baneswar Substation and Associated Works

The power to the Baneswar Substation will be branched at the Patan Substation and sent through a 66 kV transmission line of about 4.8 km in length. Thus, together with the construction of the Baneswar Substation, the extension of the Patan Substation and the construction of the 66 kV line are required.

1) *New construction of Baneswar Substation*

- 18 MVA transformer consisting of 4 sets of single-phase, 66/11 kV, 6 MVA unit will be installed including a spare unit.

- Though there are one incoming circuit and one bank of transformers for the first stage implementation, for design of the outdoor switchyard a future extension upto two incoming/outgoing circuits and two banks of transformers is taken into account.

- Protection of the 66 kV transmission line is planned to be effected by pilot wire relays and a communication cable line will be erected between the Patan and Baneswar Substation on the existing distribution line poles. This cable can also be used for telephone communication between the both substations.

- The number of 11 kV line feeders is eight including future extension. In addition, the transformer secondary circuit cubicle, station service cubicle and DC supply panel will be furnished.

- Facilities for the Baneswar Substation are as follows;

  - Main transformers: Single phase, 66/11 kV, 6 MVA 4 sets
  - 66 kV switchgear : Circuit breaker (with current transformers) 1 set, Disconnecting switches 3 sets, Arrester 3 sets
  - Control board for the 66 kV circuit
  - Cubicles : 11 kV 9 panels (1 - Transformer secondary, 8 - Feeders)
    Auxiliary 2 panels (1 - Station services, 1 - DC circuit)

The building of Baneswar Substation will be a single-story (200 m^2) including a main control room (170 m^2: installing 11 kV cubicle, transformer control board, etc.). Specifications of the building are the same as ones of load dispatching center described in Clause 4.2.2, (c).

Connection and layout of the Baneswar Substation are shown in Figs. 5.2 and 5.3 respectively.

2) Extension of Patan Substation

- The 66 kV outdoor switchyard for branching power from the Sunkosi Substation are planned to be installed at the site of the outdoor switchyard for receiving the Sunkosi power. The outgoing facilities for two circuits, for the Baneswar Substation and for the Sunkosi Power Station, will be installed at the same place. The existing switchgear for the Sunkosi line will be used after relocation.

  - The control switchboard for the Baneswar line will be arranged in the control room for the Kulekhani Project.

  - Necessary facilities are given below:

    - 66 kV switchgear : Circuit breaker (with current transformers) 1 set, Disconnecting switch 2 sets
    - Steel structures and bus facilities for two 66 kV circuits
    - One set of control board

Connection and layout of the Patan Substation are shown in Figs. 5.4 and 5.5 respectively.

3) New construction of 66 kV transmission line

- Only the right of way for the existing Sunkosi line is available for taking out a 66 kV overhead line from the Patan Substation. Therefore, for the one kilometer section upto The ring road, double circuit towers will be constructed, one circuit of which will be used for the Baneswar line and the other circuit for the Sunkosi line.

- From the ring road crossing site to the Baneswar Substation, one circuit line is required. In consideration of future addition of one circuit, double circuit towers strung on one circuit will be constructed.

- Facilities for the 66 kV transmission lines are given below;

  . Steel towers are of double circuit construction

  . For conductors, ACSR with sectional area of 150 mm^2 (wolf) will be used in view of interchangeability with the Kulekhani lines.

  . For insulator sets, strings with five insulator discs of IEC standard which are same as those for the entire Kulekhani system, will be used.

Transmission line route map and drawings for steel towers and insulator sets are shown in Figs. 5.6, 5.7 and 5.8 respectively.

5.2.2 Basic Design of K2 Substation

11 kV switchgear for the K2 Substation will be arranged in the building for the load dispatching center in the premises of ED. Its arrangement is shown in Fig. 4.4.

As explained in Clause 3.4.3, the rupturing capacity of circuit breakers will be changed from 150 MVA to 400 MVA (20 KA), which is the present standard for the power system in Nepal and the same as that for the Kulekhani system.

In stead of the present single-bus system without a buscoupler circuit breaker, the multi-bus system with three buscoupler circuit breakers will be employed. By separate operation of four sections under the normal operation, supply interruption under a fault condition can be limited to the minimum.

Major work items are given below:

- Installation of 18 panels of 11 kV and 2 auxiliary panel (4-incomings, 3-bus couplers, 11-feeders, 1-station service, 1-DC supply) in the new building.

- Change of cable connections from the existing substation to the new building.

Connection of the substation is shown in Fig. 5.9.

5.2.3 Basic Design on Reinforcement of Distribution Network

For deisgn of electrical facilities for the planned distribution network, the criteria similar to the one applied for the former reinforsment of the distribution network, executed in 1980 and 1982 are planned to be used. Details are given in Appendix VII.

Outline of each work item to be executed under the project is as given below:

(a) Construction of New Lines Related to Construction of Baneswar Substation

There are many distribution lines in this area. Therefore, it is planned to distribute the power of the substation to the existing distribution network by constructing connecting lines to the existing system.

The newly constructed lines will be overhead lines with ACSR 95 mm^2, 2.6 km in total, and underground lines with Al 200 mm^2, 0.4 km in total.

(b) Construction of Distribution Lines to Increase Supply Capacity

- Addition of one circuit (200 mm^2 ACSR Panther) on the double circuit of the 11 kV Chapagaon Line.

  Meeting the increase of power demand in the southern part of Patan city and improvement of reliability of supply by splitting a long distribution line with many branches.

- Power supply to the supermarket area, currently supplied at 3.3 kV, with two 11 kV lines from two substations as the 11/3.3 kV tie transformers for 3.3 k V power supply are already overloaded due to increase in power demand of this area. The work involves extension of an underground cable of the Bhimsensthan Feeder from the Teku Substation and extension of the Maha Baudha Feeder from the K2 Substation with both the overhead and underground portions.

(c) New Construction and Rehabilitation of 11 kV Lines to Improve Reliability of Supply (Modification of Load Allocation between Substations, Splitting of Long Distribution Lines, etc.)

- Construction of the Swayambhu Feeder from the Siuchatar Substation (ACSR 95 mm^2)

  Shifting of the Balaju load to the Siuchatar Substation, and improvement of reliability of power supply and stability of supply voltage by splitting a long feeder.

- Supply to the Kalimati Feeder from the Siuchatar Substation (ACSR 95 mm^2)

  Shifting of the Teku load to the Siuchatar Substation and improvement of reliability of supply.

- Connection of the Thankot Feeder to the Siuchatar Substation (underground cable Al 200 mm^2)

  Feeder splitting and shifting of the Teku load to the Siuchatar Substation

- Supply to the Baudha Feeder from the New Chabel Substation (ACSR 95 mm^2)

  Splitting of the long feeder to the local area and the airport feeder. Shifting of the Chabel load to the New Chabel Substation and improvement of reliability of the airport feeder.

- Construction of two feeders from the Bhaktapur Substation for connection to the Banepa Feeder and local Diwacob Feeder (ACSR 95 mm^2)

  Splitting of distribution lines and improvement of reliability of supply.

- Interconnection of the Trolley Bus Feeder and Baneswar Feeder by renewal of the existing underground cable (Al 200 mm^2)

  Increase of supply capacity to the Baneswar area and improvement of reliability of supply to this area

- Renewal of the existing underground cable at the Shahid Gate Path (Al 100 mm^2)

  Increase of supply capacity and improvement of reliability of supply.

- Repairing of the road crossing underground cable near Patan Zoo

  Shifting of the feeder load currently supplied from the Teku Substation to the Patan Substation and increase of supply capacity to this area.

(d) Addition of Distribution Transformers

Additional installation of distribution transformers is planned so as to increase the power supply capacity of the low tension systems to the areas for which power supply capacity is already full. Transformers will be installed at the locations where such addition is urgently needed, which does not necessarily mean to meet future expected load. At some locations, the extension of 11 kV lines and construction of low tension lines are required for power supply to additional stepdown transformers.

(e) Supply of Metal-enclosed Transformers

So as to match with the scenery of the sites surrounded by old historical relics in Bhaktapur city, it is planned to supply and install three transformers encased in steel cubicles.

There was a request by the city council to relocate ordinary pole mounted transformers and consideration was given to that this matter is very important to attract visitors.

(f) Installation of Sectionalizing Switches on 11 kV lines

Manually operated sectionalizing switches are planned to be installed on the 11 kV lines, either at appropriate points of long feeders, at points of branching the lines, at points interconnecting different systems or at other necessary locations.

The sectionalizing switches will be helpful in separating the damaged portions in case of any fault on the line and for interconnnection with the other systems and, thus contributing to improving the reliability of power supply.

Locations of the distribution net works to be reinforced by the Project are indicated in Figs. 5.10 and 5.11 and standard furnishings of poles are illustrated in Figs. 5.12 and 5.13.

Work quantity for the reinforcement of the distribution network is summarized below (Details are given in Appendix VIII).

i) New 11 kV line .... 24.89 km
   - Overhead lines .... 18.90 km
   - Underground cable lines .... 5.99 km