FEASIBILITY STUDY REPORT

ON

THE ESTABLISHMENT OF UREA

FERTILIZER PLANT

IN

THE KINGDOM OF NEPAL

(SUMMARY)

SEPTEMBER 1984

JAPAN INTERNATIONAL COOPERATION AGENCY

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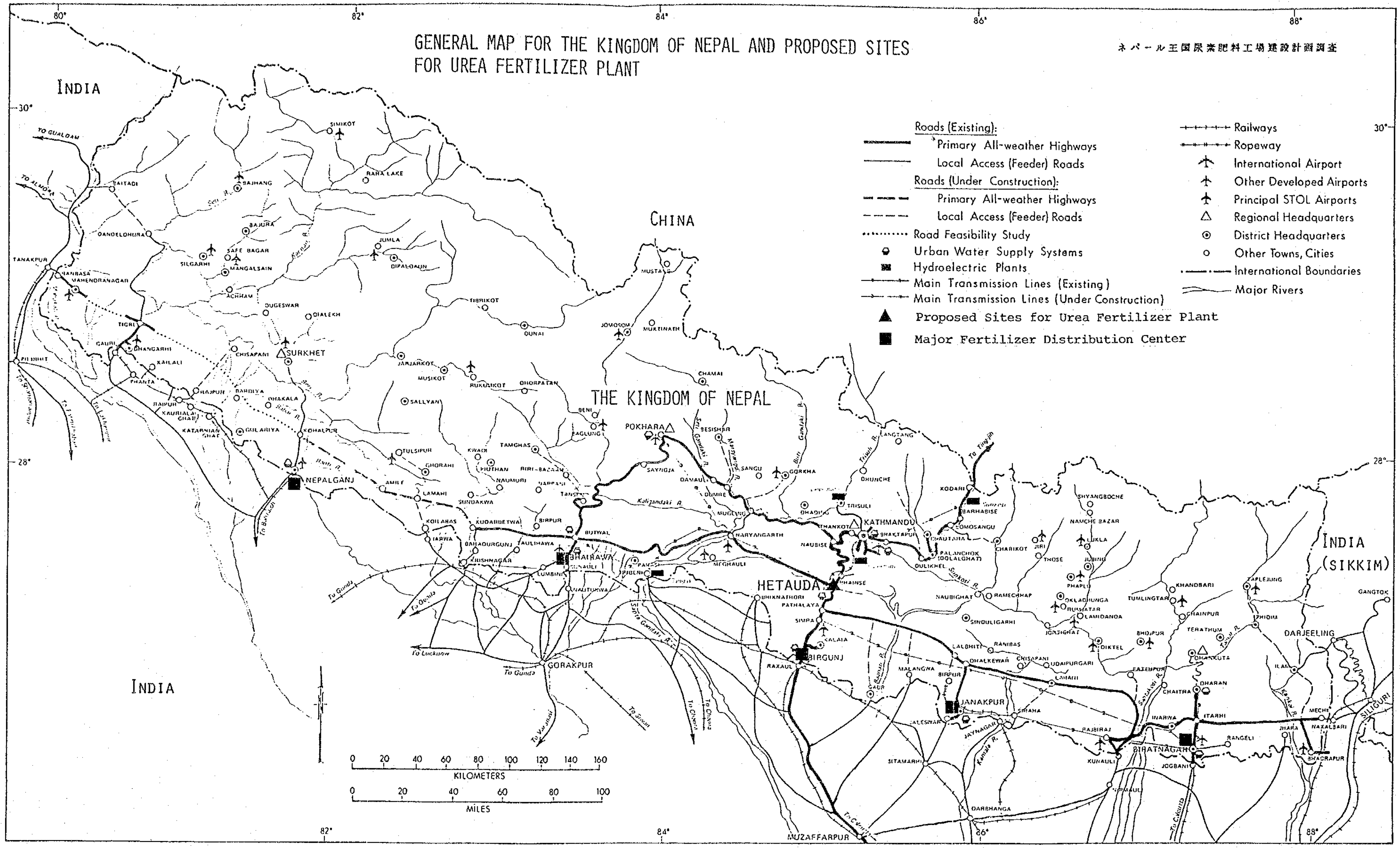

GENERAL MAP FOR THE KINGDOM OF NEPAL AND PROPOSED SITES FOR UREA FERTILIZER PLANT
ネパール王国尿素肥料工場建設計画調査
Roads (Existing):
Primary All-weather Highways
Local Access (Feeder) Roads
Roads (Under Construction):
Primary All-weather Highways
Local Access (Feeder) Roads
Road Feasibility Study
Urban Water Supply Systems
Hydroelectric Plants
Main Transmission Lines (Existing)
Main Transmission Lines (Under Construction)
Proposed Sites for Urea Fertilizer Plant
Major Fertilizer Distribution Center
Railways
Ropeway
International Airport
Other Developed Airports
Principal STOL Airports
Regional Headquarters
District Headquarters
Other Towns, Cities
International Boundaries
Major Rivers
INDIA
CHINA
THE KINGDOM OF NEPAL
INDIA (SIKKIM)
KATHMANDU
HETAUDA
POKHARA
NEPALGANJ
BHAIRAWA
BIRGUNJ
JANAKPUR
BIRATNAGAR
SURKHET
GORAKPUR
DARJEELING
MUZAFFARPUR
0 20 40 60 80 100 120 140 160
KILOMETERS
0 20 40 60 80 100
MILES
80°
82°
84°
86°
88°
30°
28°

ABBREVIATIONS

General

C & F	Cost & Freight
CIF	Cost, Insurance and Freight
Financial Year	July 16 to July 15 in Nepal
FOB	Free on Board
IRR	Internal Rate of Return
Rs	Nepalese Rupees
ROI	Return on Investment
NPV	Net Present Value
N.A.	Not Available
S/W	Scope of Work
USD	U.S. Dollar
Exchange Rate (Effective Jan. 15, 1984)	USD 1.00 = Rs 15.65 = Yen 230.00 Rp 1.00 = USD 0.06390 = Yen 14.697 Indian Rupee 1.0 = Rs 1.450 (The exchange rate with the US Dollar has been unified since September 19, 1981)

Organization and Others

ADB	Agriculture Development Bank
AIC	Agricultural Inputs Corporation
APROSC	Agricultural Projects Services Center
AMC	Agricultural Marketing Corporation
CEDA	Center for Economic Development and Administration, Tibhuvan University
CDR	Central Development Region (Bagmati, Janakpur and Narayani, The Kathmandu Valley is a portion of Bagmati)
CIDB	Cottage and Village Industries Development Board
DADO	District Agricultural Development Officer
DCVI	Department of Cottage and Village Industries
DOMG	Department of Mines and Geology
Dooars	Dooars Transport (Private) Ltd.
ED	Electricity Department
EDR	Eastern Development Region (Mechi, Kosi and Sagarmatha)
EEC	Eastern Electricity Corporation
FAO	Food and Agriculture Organization

FWDR	Far Western Development Region (Seti and Mahakali)
The Fifth Plan	The Fifth Development Plan (1975 to 1980)
Godown	Storage House
The Hills	The Mahabharat Hills of Nepal
The Himalayas	The North Mountain Area of Nepal
HMG	His Majesty's Government
HMGN, HMG/N	His Majesty's Government of Nepal
HCC	Himal Cement Co. (PVT) Ltd.
HCI	Hetauda Cement Industries Ltd.
IAAS	Institute of Agriculture and Animal Science
IPB	Industrial Promotion Board
IR	Indian Railways
ISC	Industrial Services Centre
JDBN	Jute Development Board of Nepal
JICA	Japan International Cooperation Agency
JT/JTA	Junior Technician/Junior Technical Assistant under
MFAI	Ministry of Food, Agriculture and Irrigation
MOF	Ministry of Finance
MOI	Ministry of Industry
MOWR/MWR	Ministry of Water Resources
MWDR	Mid Western Development Region (Rapti, Karnali and Bhari)
NBL	Nepal Bank Limited
NBOS	Nepal Bureau of Standard
NBM	Nepal Bureau of Mines
NEC	Nepal Electricity Corporation
NFC	Nepal Food Corporation
NIDC	Nepal Industrial Development Corporation
NIS	Nepal Institute of Standards
NPC	National Planning Commission
NRB	Nepal Rastra Bank
NTC	Nepal Transport Corporation
Panchayat	Local Organization at Village Level
Sajha, Saja	Cooperative Societies
SHDB	Small Hydel Development Board
The Sixth Plan	The Sixth Development Plan (1981 to 1986)
The Terai	South low lands plain of Nepal
TCN	Transport Corporation of Nepal
UCI	Udayapur Cement Industries Ltd.
UNIDO	United Nations Industrial Development Organization
UNDP	United Nations Development Program
WDR	Western Development Region (Dhaulagiri, Gandaki and Lumbini)

Units

Acre, A	1 Acre = 4,047 m^2
ata, atg	Atomospheric Pressure Absolute, Gauge
BBL	Barrel
BSCF, BCF	Billion SCF
BSCFD	Billion SCF per Day
BTU	British Thermal Unit, 1.0 BTU = 0.252 Kcal
Bushel	1.0 Bushel = 34.25 Liters
Crore	1.0 Crore = 10.0 Million
DWT	Deadweight Ton
EL	Elevation Level
Ha	Hectare, 1 ha = 10,000m^2 = 2,471 Acres (A)
HHV	High Heating Value
GW	Giga Watt, Billion Watt
Gallon	1.0 US Gallon = 0.003785 m^3
Katha	1.0 Katha = 0.666 Ropani = 339.158 m^2
kVA	Kilovolt-ampere
kW	Kilowatt
kWh	Kilowatt-Hour = 3.413 BTU
Lakh	1.0 Lakh = 100,000
LHV	Low Heating Value
MW	Mega Watt, Million Watt
MMBTU	Million BTU
MMSCF	Million SCF
MMSCFD	Million SCF per Day
MSCF	Thousand SCF
MSL	Mean Sea Level
Nm^3	Normal Cubic Meter measured at 0°C and 1.0 atm.
psi	Pound per Square Inch 1.0 psi = 0.07031 kg/cm^2
Ropani	1.0 Ropani = 508.737 m^2 = 5,476 ft^2
SCF, CF	Standard Cubic Feet measured at 60°F and 14.7 lb/in^2 1.0 SCF = 0.0283 Nm^3
SCFD, CFD	Standard Cubic Feet per Day
STB	Standard Tankage Barrel 1.0 STB = 159 Litre (60°F)
TSCF, TCF	Trillion SCF
TPD	Ton per Day
TPH	Ton per Hour
TPT	Ton per Ton
TPY	Ton per Year
Ton, ton	Metric Ton

Fertilizer

AN	Ammonium Nitrate Fertilizer
AS	Ammonium Sulfate Fertilizer
BPL	Bone Phosphate of Lime in terms of $Ca_3(PO_4)_2$, BPL/P_2O_5 = 2.1853
CAN	Calcium Ammonium Nitrate Fertilizer
CN	Calcium Nitrate Fertilizer
CX	Complex Fertilizer
DAP	Diammonium Phosphate Fertilizer
N	Nitrogen nutrient expressed in terms of N
NP/NPK	Compound Fertilizer or Complex Fertilizer
MAP	Monoammonium Phosphate Fertilizer
MOP	Muriate of Potash, Potassium Chloride Fertilizer
SOP	Sulfate of Potash, Potassium Sulfate Fertilizer
Urea	Urea Fertilizer

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INTRODUCTION

The "Urea Fertilizer Project in the Kingdom of Nepal" is a project which His Majesty's Government of Nepal (HMG/N) envisages to develop, with interest in establishing a urea fertilizer plant, the first one for manufacturing chemical fertilizer in the country. Nepal's economy has been largely dependent on the agriculture sector, which accounts for about 60% of the Gross Domestic Product (GDP). Urea fertilizer is one of the important inputs for the country's agriculture. The requirements for this fertilizer, however, are now met by imports.

The HMG/N seeks to promote the domestic production of urea fertilizer by efficient utilization of indigenous resources—water and hydropower.

Under this background the HMG/N has requested the Government of Japan for technical assistance for conducting a feasibility study on the establishment of a urea fertilizer plant in the Kingdom of Nepal which will be provided under the technical cooperation programs of the Government. In response to this request the Japan International Cooperation Agency (JICA), the official agency responsible for the implementation of the technical cooperation programs, has dispatched its study team to the Kingdom of Nepal in January, 1984, and then has proceeded with a precise and thorough investigation and examination of the project. This report presents a summary of the outcome of the JICA study on the aforementioned project.

Chapter 1 Outline of the Project

1-1 Outline of the project

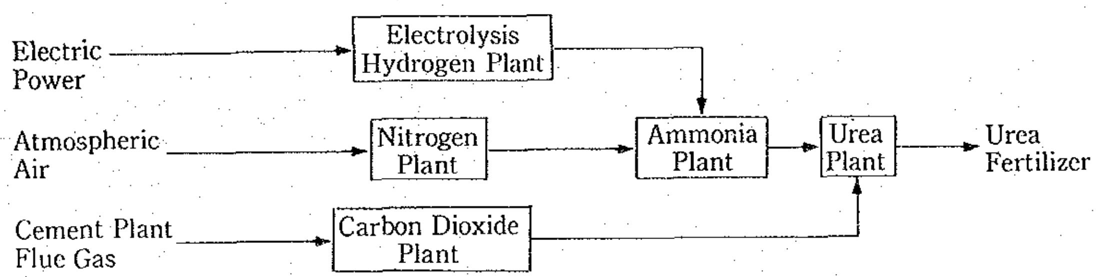
The outline of the project for the establishment of a urea fertilizer plant in the Kingdom of Nepal proposed as the conclusion of this study, is to construct a urea fertilizer plant with a 275 TPD capacity which would be located in Hetauda and targeted to be on-stream in 1991.

The production process applied for urea synthesis is to react ammonia from water electrolysis hydrogen utilizing surplus electric power (secondary energy) generated in accordance with the development of hydropower plant projects in Nepal with carbon dioxide recovered from the cement plant flue gas. The product urea fertilizer is sold in domestic market in Nepal.

The outline of the project is described hereunder;

(1) Production process

Major process scheme of urea fertilizer production is as follows:



(2) Production capacity, and raw material and utility consumption

Item	Quantity	Supply
Raw Material and Utility		
— Electric Power	76.1 mw	Nepal Electricity Corp.
— Industrial Water	4,800 TPD	Self Supply (free of chrge)
— Atmospheric Air	19,000 Nm^3PH	Self Supply (free of charge)
— Cement Plant Flue Gas	32,450 Nm^3PH	Hetauda Cement Ind., Ltd. (free of charge)
— Coal	76.8 TPD	Import from India
— Fertlizer Bag	6,060 Sheet PD	Nepal domestic product
Product		
— Urea Fertilizer, Bagged	275 TPD	Sell to Agricultural Inputs Corp.

(3) Project execution organization

It is assumed that a new state organization would be established for the promotion of the project as a national project, and simultaneously seek technical assistance of internationally experienced consultants for the execution of the proposed project.

(4) Project location

A new site of 500 m × 200 m area would be developed at the west side of the cement plant of Hetauda Cement Ind., Ltd. in Hetauda for the construction of the urea fertilizer plant.

(5) Plant construction schedule

It is assumed that the plant construction contract would be awarded by international competitive bidding among internationally experienced contractors under a lump-sum and full-turn-key type contract, and the construction schedule is projected as follows:

- Plant construction contract award : January, 1988
- Mechanical completion of plant : January, 1991
- Commencement of commercial production: July, 1991

(6) Organization and personnel

The head office would be located in Kathmandu and the urea fertilizer plant in Hetauda. There would be six departments for general affairs, production, utilities, maintenance, storage and loading, and engineering management with total personnel of 319 including 7 executives.

(7) Product sales plan

All urea fertilizer product would be sold in the domestic market through Agricultural Inputs Corp. The annual sales and price projection are as follows:

Year	Product sales	Product selling price
1991/92	51,500 TPY	US$486/ton
92/93	55,300	520
93/94	59,100	554
94/95	59,100	593
95/96	65,600	632
:	:	:
2000/01	69,700	871

(8) Investment cost required and financing plan

(Unit: US$, Million)

Total Project Cost		Financing Plan	
— Foreign currency portion	119.87 (82.8%)	— Equity	43.44 (30%)
— Local currency portion	24.92 (17.2%)	— Loan	101.35 (70%)
Total	144.79	Total	144.79

1-2 Outline of project facility

The urea fertilizer plant would be located in Hetauda and would be designed to be operable continuously as far as possible under constraints of electric power supply (seasonal and hourly fluctuation) and of carbon dioxide supply from the cement plant flue gas.

Major facilities are listed as follows:

(1) Process Plant	
— Hydrogen Plant	28.4 TPD
— Nitrogen Plant	132 TPD
— Ammonia Plant	160 TPD
— Carbon Dioxide Plant	207 TPD
— Urea Plant	275 TPD
(2) Storage Facility	
— Hydroen Gas	33,000 Nm^3
— Nitrogen Gas	2,000 Nm^3
— Ammonia	1,750 ton
— Carbon Dioxide Gas	20,000 Nm^3
— Urea Fertilizer	
— Bagging Facility	40 TPD
— Loading Facility	100 TPD
— Bulk Storage	2,100 ton
— Bagged Storage	7,000 ton
(3) Utility Facility	
— Electric Power Receiving	86 MW
— Raw Water Treatment	183 TPH
— Water Demineralizer	32 TPH
— Cooling Water Tower	6,500 TPH
— Steam Generator	27.5 TPH
— Instrument and Plant Air	1,500 Nm^3PH
— Emergency Power Generator	0.8 MW
(4) Auxiliary Facility	
— Administration Buidling	800 m^2
— Maintenance Office	400 m^2
— Maintenance Shop	1,320 m^2
— Analytical Laboratory	400 m^2
— Chemicals and Spare Parts Storage	320 m^2
— Canteen	800 m^2
— Guard House	30 m^2
— Parking Lot	150 m^2
— Medical room	200 m^2
— Plant Laboratory	30 m^2
(5) Off-site Facility	
— Housing Colony (92 Houses)	6,010 m^2

The site area of the urea fertilizer plant is 200 m × 500 m and it is located at the west side of HCI, Hetauda.

1-3 Financial analysis and economic evaluation

(1) Financial analysis

The financial projections of the project have been prepared in the form of pro-forma financial statements, and on the basis of the projected financial statements the financial analysis of the project has been made. The results of the analysis are summarized below.

	IRR in current prices (%)		IRR in constant prices (%)	
Electricity Price	Before tax	After tax	Before tax	After tax
— 80% of the base estimate	3.70	3.06	*	*
— 60% of the base estimate	8.17	6.16	2.23	0.37
— 40% of the base estimate	11.78	9.38	5.59	3.36
— 20% of the base estimate	14.87	12.24	8.48	6.02
— No value	17.61	14.84	11.03	8.44

Note *: negative returns

The above analysis, as the base estimate, uses a 1984 electricity price of US¢3.56/kWh calculated on the basis of the present tariff and escalated at 6% per annum.

(2) Economic evaluation

The results of the economic assessment of the project are presented by means of the following indicators.

— Economic internal rate of return (ERR)	8.2%
— Economic net present value (ENPV)	US$1.08 millions in 1984 constant price terms (at 8% discount rate)
— Net foreign exchange savings	US$37.38 millions/year (average in 15 years)
— Net value added ratio	54.0% of annual production cost (average in 15 years)
— Creation of employment opportunities (direct and indirect)	400 persons

The analysis of ERR uses the economic electricity cost of US¢1.182/kWh which has been calculated on the basis of the long run marginal cost for energy (LRMC) estimated as US¢6.82/kWh for firm energy and US¢1.17/kWh for secondary energy, in 1984 constant price terms, by referring to the capital cost for the Sapta Gandaki hydropower project, and also taking into account of the consumption pattern of firm energy and secondary energy for the project.

It must be further noted that the net foreign exchange savings and the net value added ratio (ratio of domestic costs in the production costs) have been calculated on the assumption that the electricity is supplied at a rate set as 40% of the present tariff level. As far as this assumption applies, the production cost will be lower than the import prices except for the initial three years. On the other hand, the foreign exchange cost will always be lower than the import prices.

Chapter 2 Summary of the Study Results

2-1 Agriculture and fertilizer markets in Nepal

(1) Overview of fertilizer consumption

In 1982/83 the fertilizer consumption in Nepal was 22,900 N tons of nitrogen fertilizer, 7,200 P_2O_5 tons of phosphate fertilizer, and 900 K_2O tons of potassium fertilizer. Among them, consumption of nitrogen fertilizer has increased steadily with an annual growth of 17% averaged for the period from 1966/67 to 1982/83, while that of phosphate fertilizer has stagnated, and that of potassium fertilizer showed a decrease in recent years.

Ratios of phosphate and potassium consumption against nitrogen consumption were 1:0.3:0.04 ($N:P_2O_5:K_2O$), which demonstrates a high ratio of nitrogen consumption compared to that of phosphate and potassium fertilizer. Nevertheless Nepal's consumption of nitrogen fertilizer per hectare of arable land was only 7.4 N kg/ha, which is low compared to the world average or that of other countries in South-West Asia (Table 1 and Figure 1).

In view of the past trend of nitrogen consumption in Nepal, during the period of 1973 through 1975, the consumption growth stagnated due to the price hike of imported fertilizer caused by the oil crisis, but thereafter the consumption has increased at 13% per annum in average.

In reviewing the past consumption trend of nitrogen fertilizer by type, the consumption of ammonium sulphate accounted for around 70% of total nitrogen consumption until the latter half of the 1960's, but with the consumption of urea having increased gradually it accounted for more than 60% in the latter half of 1970's, and further it exceeded 65% in 1980 through 1982. By contrast, the consumption of ammonium sulphate shrank to around 5% of the total, whereas that of compound fertilizer accounted for about 25% (Table 2). However, it was often found that farmers were compelled to use compound fertilizer without regard to their preference because other types of nitrogen fertilizer required by them were not available.

(2) Cultivation practice and fertilizer application

The agriculture in Nepal can be grouped into the following three regions on the basis of geographic characteristics, as well as regional characteristics for transportation and distribution in the country.

A. Terai area which is a plains area located along the border with India

B. Kathmandu Valley area developed on the outskirt of Kathmandu and the hill areas along the main roads in Nepal

C. Inaccessible remote hill and high hill areas

Nepal's principal crops are cereal including rice, maize, wheat and millet; jute; oil seeds; tobacco; and potato. Rice accounts for 64% of total cereal production, and is grown mainly in Terai and Kathmandu Valley. Rice is the rainy season crop in low land areas, while up-land rice, maize and millet are the rainy season crop in hill areas. Wheat, barley, buckwheat and beans are the typical winter crops. In addition to rice, jute is an important export crop mainly grown in Eastern Terai. Tobacco is grown in Central and Eastern Terai mainly for the domestic market, and sugarcane is grown in Central Terai, also for domestic use. Potato is grown throughout the country, and used for own-consumption as a supplementary crop of rice and maize (Table 3).

It is estimated that fertilizer consumption broadly consists of 50% for wheat, 35% for rice, and the remaining 15% for other crops. As most wheat grown is that of improved varieties which have extremely low yield if there is no fertilization, this crop uses a greater quantity of fertilizer than does for rice. Most rice is grown in the rain-fed areas, although there are irrigated fields in some areas. In these irrigated areas, as stable yields can be gained, fertilizer is widely applied. In contrast, in the rain-fed area, farmers have less incentive to accept an increase in input costs for improving production, because of unstable yields. For cereals except wheat and rice, little fertilizer is used. Sugarcane and tobacco are grown as cash crops by fairly large scale farmers, and fertilizer is generally applied on these crops.

In regard to regional distribution of the nitrogen fertilizer consumption, around 80% of the total was consumed in Kathmandu Valley and Terai areas, and the consumption in High Hill and Hill areas accounted only for 20%. Central Terai and Kathmandu Valley are the largest consumption areas in Nepal, consuming 32% and 30% of total, respectively.

(3) Outlook of factors affecting nitrogen fertilizer demand

Among the various factors which are considered to influence Nepal's demand for nitrogen fertilizer, the major ones are as follows:

A. Economics of fertilizer use

B. Availability of irrigation and/or drainage facilities

C. Development and diffusion of high-yielding varieties

D. Purchasing ability of farmers and/or availability of credit systems for fertilizer purchase

E. Possibility of timely supply of fertilizer

F. Knowledge on the effects of fertilizer on yield

The outlook for these factors would form the basis for forecasting fertilizer demand in future. The fertilized area ratio (ratio of fertilized area to cultivated area) estimated for major crops is 12% for rice, 59% for wheat, and 3% for maize. In the case of sugarcane, tobacco and jute, all the cropped areas are likely to have received fertilizer. Ratio of the fertilized area to the cultivation area of improved varieties is estimated as only 16% for maize against 70 to 85% for rice and wheat. In the case of rice, the improved varieties have high importance for fertilizer use as compared to the local varieties, and the diffusion of improved varieties therefore is essential for promotion of fertilizer use. Farmers cultivating the improved varieties of wheat and maize have the potentiality to increase the application of fertilizer up to the recommendation level. The diffusion rates of improved varieties to total cultivation area in the past were 18% for rice, 15% for maize, and 85% for wheat. In the case of rice and maize, as there are several factors hampering the diffusion of improved varieties, a rapid growth of their cultivation can not be expected.

Expansion of irrigated farms is another factor for promoting fertilizer consumption. At present, however, the area of irrigated farms accounts for around 10% of arable land (approximately 2.3 million ha.). The area of irrigated farms can be expected to increase gradually, and the fertilized area would also increase accordingly. Most farmers have weak purchasing power. In order to create a stable demand for fertilizer, improvement of the credit system is essential. However, although the present system is insufficient, there is no plan to improve the system. This situation may limit the results of future efforts to increase fertilizer consumption. In Nepal fertilizer supply often fails to be delivered in a timely manner, and this has been the great impediment constraining fertilizer use in the remote areas. The construction of roads will continue in the future and accessible areas may be expected to be expanded gradually. Further, once the domestic production of fertilizer starts, the distribution plan may become well organized so that it can contribute to promoting of increases in fertilizer consumption. Extension services at present are insufficient. The services may be improved gradually, but immediate improvement can not be expected.

(4) Outlook of demand for nitrogen fertilizer, and projected sales

Shown below is the future demand for nitrogen fertilizer in Nepal which has been forecasted by taking the foregoing outlook into account (Table 4 and Figure 2).

Year	Demand (1,000 N tons)
1982	20.9
1985	22.5
1990	27.3
1995	32.3
2000	33.4

As stated earlier, urea is predominantly used at present. It is judged from the agronomical point of view that urea is the most suitable type of nitrogen fertilizer for use in Nepal. Although compound fertilizer has been used to some extent, it has not necessarily represented farmers' preference of fertilizer type. Therefore it may be possible to convince farmers to use urea. The sales of urea projected by taking these factors into account is as follows (Table 5).

Year	Urea demand (tons in product)
1990	44,500
1995	63,200
2000	69,000

(5) Marketing and distribution of urea

HMG/N put fertilizer importation and distribution under its control, and the Agricultural Inputs Corporation (AIC), a state-owned corporation handles it exclusively. In retail markets, except some areas where private retailers handle fertilizer distribution, HMG/N guides the unit cooperatives so that they handle the distribution as much as possible. It is anticipated that this system will continue in the future. AIC has fertilizer storages throughout the country. It is possible to perform well-organized distribution by utilizing those storages.

(6) Sales price of urea fertilizer

HMG/H sets the fertilizer price at a uniform level for all the country. In case that the official price is lower than the actual costs for imports and distribution, and also that the fertilizer is distributed to Hill and High Hill areas requiring costly transportation, HMG/N provides AIC with subsidies to compensate for any losses incurred.

When the urea fertilizer plant is built, the sales price to AIC may be determined by the authority of HMG/N. Hence it might not be appropriate to predict the future price based on the prevailing prices in Nepal, but it may be appropriate to forecast the price based on the prices for imported fertilizer. The following is the ex-factory urea sales price projected on the foregoing assumptions.

Calendar Year	Projected sales price (US$/ton in bagged)	
	1984 Cosntant Prices	Current Prices
1983	260	245
1985	286	303
1990	319	453
1991	322	484
1995	332	630
2000	342	869

2-2 Technical aspects

(1) Outline of proposed project

The outline of the proposed project for the establishment of a urea fertilizer plant in Nepal is summarized as follows:

— Product:	— Prilled Urea Fertilizer in Bags
— Production Capacity:	— 275 TPD
— Location:	— Hetauda, Nepal
— Raw Materials and Production Process:	— Ammonia production from water electrolysis hydrogen and air fractionated nitrogen — Carbon dioxide recovery from cement plant flue gas — Urea synthesis from ammonia and carbon dioxide
— Commencement of Commercial Production:	— Mid-1991 (provided that No. 1 of Sapta Gandaki is completed by early 1991)

The above project concepts are derived from the following rationale:

A. Selection of product type

The market study reveals that the consumption of urea fertilizer in Nepal would be the largest among various nitrogen fertilizers in future. Although minor levels of consumption of several other nitrogen fertilizers is anticipated, it is not practical to produce a multiple number of nitrogen fertilizers in one small plant because of economy of scale. Hence it is appropriate to select urea fertilizer as the one fertilizer produced at the first fertilizer plant in Nepal.

B. Raw materials and production processes

The most generally used production process for manufacturing urea is to feed hydrocarbons as major raw materials at an ammonia plant to produce liquid ammonia as well as carbon dioxide, both of which are then supplied as intermediates to a urea plant to produce urea fertilizer.

In Nepal, however, there is no hydrocarbons, such as coal, natural gas, petroleum and biomasses commercially available for the production of ammonia and urea. The only possibility is to produce urea fertilizer based on ammonia produced from hydrogen generated by water electrolysis thereby efficiently utilizing hydropower and water resources, and also on carbon dioxide recovered from cement plant flue gas.

C. Production capacity of urea fertilizer plant

To determine production capacity of the proposed plant, the following three basic factors should be carefully studied:

- Completion year of the plant
- Marketability of the product
- Supply of electric power and carbon dioxide

To improve the economics of the project, it is desirable to establish a maximum scale plant as far as the marketability of the product and also the suppliability of electric power and carbon dioxide permit.

It is also important to include in the design of plant facilities and operational patterns of the urea fertilizer plant countermeasures for the limited suppliability of electric power which can be anticipated due to the monthly supply and demand fluctuations during the year and also hourly fluctuation during a day.

Taking into consideration the above factors, it is concluded that the optimum production capacity is 275 TPD.

D. Target year of commencement of commercial production

Generally it takes at least five years from the start for the planning and construction of a urea fertilizer plant; therefore it is appropriate to target the completion of the plant in 1989 at the earliest. Taking into consideration the marketability of urea and suppliability of electric power in 1989 and onward, it is concluded that the optimum completion year of the plant would be 1991 and the commencement of the commercial production would be from mid-1991.

(2) Supply and demand of electric power and suppliability of electric power for the project

Most electric power generated in Nepal is supplied by the public sector. The Ministry of Water Resources is responsible for the electric power development in Nepal and its Electricity Department is managing the planning and construction of electric power station, and transmission and distribution lines.

The total generating capacity of the public sector is 144 MW of which 84% is by hydropower and 16% is by diesel electric power generators. The capacity in the private sector is 12 MW. In addition, 52 GWh is imported from India in accordance with the Nepal-India Agreement. In 1981/82 the import and export were 57 and 5 GWh respectively, resulting in net import of 52 GWh which is equivalent to 19% of the total supply in Nepal.

The transmission system is the most advanced in the Central Region. In this region there is the trunk line connecting Kathmandu, Hetauda and Birganj which is further linked with the 132 kV line from the Eastern and Western Regions.

The average annual growth rate of electric power supply in Nepal for eleven years from 1970/71 to 1981/82 is 15%, leading to 270 GWh in 1981/82. Traditionally a supply deficit has been observed as electric power developments were delayed. Recently the situation has been improved because of the completion of Kulekhani No. 1; however, it is anticipated that again in a few years supply would be in deficit. The present demand pattern is mostly for household use which has a share of approximately 50% of total demand. Industrial uses need 30%. Anticipating the present and future industrialization plans in Nepal, it is thought that the demand pattern of electric power would show a similar situation in future.

The demand increase projected at the Electricity Department of Nepal is summarized as follows:

Projected Electric Power Demand in Nepal

	Annual demand		Peak demand		
Year	Demand, GWh	Average annual growth, %	Demand, MW	Average annual growth, %	Average Load factor
1982/83	284.9	—	67.8	—	0.48
1992/93	1,299.4	16.4	293.1	15.8	0.51
2001/02	3,345.5	11.1	723.3	10.6	0.53

Note: Electric power demand for the urea fertilizer plant is not included.

The Electricity Department is now implementing the construction of Kulekhani No. 2 (32 MW) and Andhikhola (5 MW), and has decided on the construction of the Marsyangdi (66 MW) hydropower plant. After the completion of these three plants, the total generating capacity of Nepal in 1988/89 would be 255 MW and its annual supply would be 1,181.5 GWh.

Succeeding to these projects, the construction of Sapta Gandaki (225 MW) is planned. Although the completion date of the plant has not yet been fixed, the Electricity Department is targeting the completion of No. 1, No. 2 and No. 3 of Sapta Gandaki in 1991/92, 1992/93 and 1993/94, respectively.

Taking into consideration the above demand projection and also development plans, it is anticipated that the supply and demand would be improved temporarily in 1988/89 but again it would be tightened in 1990/1991 onward if the completion of Sapta Gandaki is delayed. The implementation of Sapta Gandaki will have great impact on future electric power supply regardless of the implementation of a urea fertilizer plant project in Nepal (Refer to Figure 3).

The increased demand would be supplied from Sapta Gandaki by 1995/96 if the completion of Sapta Gandaki is realized as targeted, however after that the deficit situation would be chronic if the post-Sapta Gandaki hydropower projcts would not be implemented.

Although in Nepal the potential for the development of new hydropower projects is high enough to meet the electric power demand increase in the future, there are some possibilities for delays in realization. It is recommended that the decision should be made by HMG/N for the promotion of the urea fertilizer plant project in view of its judgement on the certainty of long term electric power suppliability in future because a long term supply assurance of electric power is a basic premise for the existence of a urea fertilizer plant.

Major existing hydropower plants in Nepal are of the run-of-river type and therefore there is a big difference in supply of electric power between dry season and wet season. On the other hand, the demand increases during the dry season and the supply and demand situation is tightened in the dry season every year.

The hydropower plants which will be constructed in the future are also basically run-of-river type and therefore the possibility for great improvement of such a situation is also low in the future. Under such situations, it is anticipated that a large surplus of electric power would be observed during the rainy season in contrast to the tight and deficit situation in the dry season.

There is an extreme difference in demand between peak hours and off-peak hours in a day, and the average load factor against the daily maximum is from 50 to 60%. These phenomena are due to the fact that the household demand share is the largest component of demand in Nepal and it is considered that such phenomena would also exist in future.

The expected electric power consumption by the urea fertilizer plant project is as follows according to the capacity of the plant:

Daily production capacity of urea fertilizer plant	Electric power consumption		
	Hourly	Daily (24 hours)	Monthly (30 days)
	(MW)	(MWh)	(GWh)
— 100 TPD	27.68	664.2	19.93
— 200 TPD	55.35	1,328.4	39.85
— 300 TPD	83.03	1,992.6	59.78

Note: Unit consumption is 6,642 kWh/ton of urea fertilizer

Basically it is taken for granted that the operation of the urea fertilizer plant should be continuous all day long and it is necessary then to supply enough electric power steadily all the year round to maintain stable operation of the plant. Assuming the above mentioned seasonal and hourly fluctuations of electric power surplus, there is insufficient suppliability of electric power even for a small scale urea fertilizer plant (100 TPD capacity) when the Marsyangdi hydropower plant is completed in 1988/89 and therefore the urea fertilizer plant project should be implemented so as to meet the completion of No. 1 of Sapta Gandaki hydropower plant.

After the completion of Sapta Gandaki, a large amount of surplus energy would be generated except during a few months in the dry season for at least seven years, and therefore it is possible to operate a urea fertilizer plant having up to 300 TPD capacity for nine to ten months continuously every year.

However from 1997/98, the supply again would be tight, and therefore assurances of the completion for not only Sapta Gandaki but also the subsequent post-Sapta Gandaki projects are required.

It is also required to allow for the annual maintenance shut-down of the urea fertilizer plant as well as for closing down the whole plant completely for a few months during the dry season when the electric power supply is tight. The urea fertilizer plant should be designed to be operable even at lower operation loads under the limited supply conditions of electric power.

It is necessary to utilize surplus electric power as far as possible by planning facility design and operation pattern of the urea fertilizer plant as mentioned above and to eliminate any influence on peak demand of electric power. It may be possible, if electric power is supplied from diesel power plants with high priority to the urea fertilizer plant, to increase the operability to some extent but not enough to maintain stable operation at full production capacity.

(3) Supply source of carbon dioxide and its suppliability

For the production of urea fertilizer, a long term and stable supply of carbon dioxide is also essential. The unit consumption of carbon dioxide for urea fertilizer production is 0.75 ton/ton of urea; therefore it is required to secure a supply source of carbon dioxide with 207 TPD capacity to match the urea fertilizer plant with 275 TPD as is proposed for Nepal. The supply source of carbon dioxide for industrial uses in Nepal is limited to the dilute carbon dioxide contained in flue gas from cement plant, which can be recovered by absorption processes using hot carbonate or organic amines solution.

There are two potential sources of cement plant flue gas in Nepal:

A. Himal Cement Co. (PVT) Ltd. (HCC)

— Production Capacity	: 160 TPD of clinker
— Production Performance	: 124.4 TPD of clinker 132 TPD of bagged cement
— Production Process	: Black Meal Shaft Kiln
— Production Process	: Black Meat Shaft Klin
— Plant Location	: Chobar, Kathmandu
— Present Status	: In operation (Last 7 years)

B. Hetauda Cement Ind., Ltd. (HCI)

- Production Capacity : 730 TPD of clinker
- Production Process : Suspension Pre-heater Dry Rotary Kiln
- Plant Location : Hetauda
- Present Status : Under Construction (Expected completion by the end of 1984)

The flue gas from HCC is at present not suitable in quality and in quantity as a supply source of carbon dioxide to a urea fertilizer plant with 275 TPD capacity. Although HCC has an expansion plan which will be completed in 1986 and the suppliability of carbon dioxide will be increased to two and a half times, enough for a urea fertilizer plant with 355 TPD capacity upon the completion of the expansion plan but quality-wise there is no possibility for improvement.

The cement plant at HCI has not yet been put on-stream and as the specification of raw materials and fuel have not been fixed, it is impossible at present to specify the supply conditions of flue gas to the urea fertilizer plant. However, it is estimated that the suppliability of carbon dioxide in quantity is large enough for the proposed urea fertilizer plant with a 275 TPD capacity.

It is also anticipated that the quality of flue gas is favorable as the carbon dioxide source for the urea fertilizer plant judging from the process scheme of cement production. Therefore the utilization of flue gas at HCI is proposed because the supply conditions at HCI are more favorable than those at HCC.

(4) Proposed site for urea fertilizer plant

As is explained above the supply of carbon dioxide is from the cement plant flue gas at HCI, therefore the site for the urea fertilizer plant must be located in the vicinity of the HCI cement plant site in Hetauda.

It is concluded from the comparison study between Chobar, Kathmandu and Hetauda that the Hetauda location is more favorable at not only regarding supply conditions of carbon dioxide but also the various site conditions required for the urea fertilizer plant. Therefore it is proposed to establish the urea fertilizer plant in the vicinity of HCI in Hetauda. The major reasons are explained as follows:

A. The distance between proposed site and transmission line of electric power is shorter in Hetauda and also reliability of electric power supply is greater in Hetauda.

B. An ample supply of high quality industrial water is obtainable in Hetauda.

C. Enough land area for the proposed plant is available, and soil conditions are favorable, in Hetauda.

D. Transport of equipment and construction materials is easy and economical as the Hetauda site is located in shorter distance for transport from Calcutta, the port of entry.

E. Physical distribution of product urea fertilizer is more easily accomplished from Hetauda.

F. Infrastructure is well developed in Hetauda.

(5) Outline of the urea fertilizer plant

The outline of major facilities of the proposed urea fertilizer plant are described hereunder. The facilities are designed to be operable at the minimum of 50% of daily capacity utilization and to maintain continuous operation as far as possible under supply constraints of electric power (seasonal and hourly fluctuation) and also supply fluctuation of carbon dioxide at the cement plant.

A. Process plant		
— Hydrogen Plant	28.4	TPD
— Nitrogen Plant	132	TPD
— Ammonia Plant	160	TPD
— Carbon Dioxide Plant	207	TPD
— Urea Plant	275	TPD
B. Storage facility		
— Hydrogen Gas	33,000	Nm^3
— Nitrogen Gas	2,000	Nm^3
— Ammonia	1,750	ton
— Carbon Dioxide Gas	20,000	Nm^3
— Urea Fertilizer		
— — Bagging	40	TPH
— — Loading	100	TPH
— — Bulk Storage	2,100	ton
— — BaggedStorage	7,000	ton
C. Utility facility		
— Electric Power Receiving	86	MW
— Water Treatment	183	TPH
— Water Demineralizer	32	TPH
— Cooling Water Tower	6,500	TPH
— Steam Generation	27.5	TPH
— Instrument and Plant Air	1,500	Nm^3PH
— Emergency Power Generation	0.8	MW
D. Auxiliary facility		
— Administration Building	800	m^2
— Maintenance Office	400	m^2
— Maintenance Shop	1,320	m^2
— Analytical Laboratory	400	m^2
— Chemicals and Spare Parts Storage	320	m^2
— Canteen	800	m^2
— Guard House	30	m^2
— Parking Lot	150	m^2
— Medical Room	200	m^2
— Plant Laboratory	30	m^2

E. Off-site facility
— Housing Colony (92 Houses) 6,010 m^2

The area of the urea fertilizer plant site is 200 m × 500 m and is west of HCI, Hetauda.

(6) Implementation and management of the urea fertilizer plant project

The entity which will implement the urea fertilizer plant project has not yet been established.

Although the basic policy of the HMG/N has not yet been formulated, it is assumed that the project would be executed by a new state organization, judging from the specific features of the project, once the project is approved by HMG/N.

It is also assumed that the new state execution body would be organized and managed by appointing experienced specialists for implementing an industrial project in Nepal and also by engaging internationally experienced consultants from the foreign countries.

It is considered safe and practical to assume that the construction contract of the urea fertilizer plant would be awarded by competitive bidding among experienced and qualified foreign contractors under a turn-key and lump-sum type contract because of the specific nature of the project. It is important to prepare counter-measures to eliminate any risks and disadvantages generally associated with such type of contract.

The construction schedule assumes that the plant construction contract award would be in January, 1988, the plant completion would be in January, 1991 and the commencement of commercial production would be in July, 1991.

The managerial organization of the urea fertilizer plant is assumed to be at the head office in Kathmandu. The plant organization at Hetauda would have six departments for general affairs, production, utilities, maintenance, product storage and loading, and engineering management. The total number of personnel required is 319 including 7 executives. The product urea fertilizer is assumed to be sold at the Hetauda plant to the AIC.

(7) Technical assistance services required for plant construction and operation

It is observed that in connection with implementation of the project, the entity to execute the project may need to secure technical assistance services by retaining internationally experienced consultants for preparation of plans as well as supervision of plant construction and commercial operation of the plant.

Major activities required at each stage of the project implementation are summarized as follows:

A. Necessary services prior to plant construction contract award

- Detailed study on the site conditions and final selection of plant site

- Detailed study on the suppliability of cement plant flue gas at HCI, Hetauda after the commencement of the operation

- Preparation of invitation for bid for the construction contract of urea fertilizer plant

- Prequalification of contractors

- Preparation of execution plan of the project, schedule, budget and manning plans

- Evaluation of construction contract proposals and negotiation for contract award

B. Necessary services during construction of plant

- Reviewing and checking of the basic and detailed designs submitted by the contractor for owner's approval and provision of instruction to the contractor in regard to any revision of the design

- Monitoring and controlling the progress of activities, such as schedule and budget control and also reporting to the government organization and financial institutions

- Establishing an organization for the start-up and training for the subsequent operation and maintenance

C. Necessary services during early commercial operation stage

- Commissioning of the plant

- Establishment of operation and maintenance systems

- Arrangement for the assignment of responsibilities as well as standard operating procedures

- Implementation of routine tasks through on-the-job training

It will be highly efficient to obtain the systematically organized technical assistance services of an internationally experienced firm for at least two years after the commencement of commercial production, and a budget for this is allocated in the project cost estimates in this study.

2-3 Financial analysis and economic evaluation

(1) Estimates of total financing requirement

The total financing required for completion of project, including contingency, pre-operation expenses, initial working capital, and interest during construction, is estimated as follows.

		(US$, Millions)
Foreign exchange portion	:	119.87
Local currency portion	:	24.92
Total financing required	:	144.79

The major assumptions used for the above estimates are summarized below;

A. Project schedule

- Commencement: Early-1988

- Completion (commencement of commercial operation): Mid-1991

B. Base project cost

Estimated on the basis of 1984 prices.

C. Contingency

— Physical contingency: Estimated at 5% of the base project cost

— Price contingency: Escalation of 3.5% p.a. for foreign exchange portion and 6% p.a. for local currency portion

D. Interest during construction

Assuming an equity/debt ratio of 30:70, and also provisionally assuming the following terms and conditions for loans because financing sources have not yet been determined:

—Foreign Loans

Interest:	5% p.a.
Grace period:	Equal to construction period
Repayment period:	15 years after commencement of commercial operation

— Local Loans (taken out only for short term financing)

Interest:	15% p.a.
Repayment:	within one year

The financing plan for the project, formulated on the basis of the total financing requirement as well as the major assumptions as presented above, is summarized below.

(US$, Million)

	Foreign exchange portion	Local currency portion	Total
Equity capital:	18.52	24.92	43.44
Loans:	101.35	—	101.35
Total financing:	119.87	24.92	144.79

(2) Electricity price, and economic electricity cost

Although electricity supply/demand conditions show significant differences between the dry season and rainy seasons, and hourly load also fluctuates to a substantial extent, the present tariff schedule for industrial uses sets a flat rate applied throughout the year without month-of-year or time-of-day rates.

According to the present tariffs, the electricity price for the urea fertilizer plant is estimated as NRs. 0.57/kWh (US¢ 3.56/kWh). The NEC's electricity tariffs are under the control of HMG/N. Before 1981/82, HMG/N had adopted the policy of keeping electricity tariffs at low price levels, and therefore the electricity price that year was as low as 30% of the long run marginal cost for electricity (LRMC), as well as 50% lower than the level required to obtain a 6% rate of return on assets employed. This placed NEC in a very difficult financial position.

The World Bank's appraisal mission for the Marsyangdi hydropower project recommended a 130% increase in tariffs. In 1983, paying attention to this recommendation, HMG/N revised the tariffs upward by 58% in average.

All of the hydropower plants developed to date are small in scale and most are the run-of-river type. Hence the cost for electricity generated is fairly high. However it is likely that the LRMC may decline in the future, because the Sapta Gandaki project and subsequent projects planned to be completed in the 1990's are medium-scale plants having installed capacity greater than 200 MW. The LRMC for the 1990's at a 6% discount rate is estimated as US¢6.82/kWh for firm energy, and US¢1.07/kWh for secondary energy respectively in 1984 constant price terms, which is equivalent to US¢3.87/kWh as a weighted average.

When compared with the estimated LRMC, the present electricity tariff for industrial uses (US¢3.56/kWh) is level at about 50% of the LRMC for firm energy, whereas it is as high as three times of the LRMC for secondary energy because the present tariff has no special rate for such energy. If a special rate for the secondary energy consumers like this project is adopted by taking the LRMC for that energy into account, it would stimulate the demand for secondary energy. At present there is no definite indication of the HMG/N's long term policy for electricity pricing. Nevertheless HMG/N may consider to set a special rate for this project if necessary after reviewing (a) impacts on feasibility of the project which electricity price would cause, and (b) any effects on the electricity sector which the project would produce.

In view of the foregoing situations, the base estimate for the financial analysis uses the price based on the present tariff (US 3.56/kWh) and annually escalated at 6%. At the same time, assuming that a concessional rate is set for the project, sensitivity analysis is made by changing the price level in order to identify an electricity price level which forms the basis for this project as being financially viable. This analysis can serve to provide HMG/N with the basis for determining the electricity price for the project.

The economic analysis of the project is made on the basis of the estimated LRMC as discussed earlier. At peak demand time, the operation of the hydrogen unit will be stopped, while ammonia and urea plants will be operated at a lower load. Further, the plant operation will be entirely shut down for two and a half months during the dry season when the electric power supply condition is tight. By this means, the overwhelming majority of the electricity requirements for the urea fertilizer plant can be met by otherwise unutilized secondary energy. On this assumption, the economic electricity cost for the project, in 1984 constant price terms, is estimated as US¢1.182/kWh. Thus the economic assessment of the project uses the given economic electricity cost.

(3) Operating cost estimate and financial analysis of the project

The production cost for one ton of the urea fertilizer produced, which is based on the electricity price according to the present tariff and assuming 6% annual escalation, and includes interest on loans and depreciation, is estimated, in current price terms, as given below (Table 8).

Year	Electricity price	Electricity cost per ton of urea (A)	Production cost per ton of urea (B)	A/B
	(US¢/kWh)	(US$/ton)	(US$/ton)	(%)
1991/92	5.35	355.3	836.0	42.5
1995/96	6.76	443.0	854.3	51.9
2000/01	9.04	600.4	980.5	61.2
2005/06	12.10	803.7	1,025.6	78.4

The cost level, as shown above, far exceeds the import price forecasted for the respective year. It is essential to lower the electricity price, as well as to adopt electrolysis technology which requires minimum electricity consumption, in order to make the urea fertilizer production cost comparable to the price for imports. In this study, several types of commercially proven electrolysis technologies have been studied, and as a result the production cost has been estimated by assuming the adoption of an electrolysis technology which has demonstrated the most efficient performance. Hence the only possible measure to reduce the production cost should be to lower the electricity price. Based on the thus estimated production cost, the financial projections of the project have been prepared in the form of pro-forma financial statements for the 15 years economic life, and the financial analysis has been made according to the projected financial statements. The results of the analysis are summarized below.

A. Anual income

The annual revenue of the project has been calculated in accordance with the projected sales and selling price which have been forecasted in the market study. The projection indicates that the revenue will be US$25.0 million in the first year (1991/92), and will increase to US$40.8 million in the fifth year (1995/96), US$60.7 million in the tenth year (2001/02), and US$86.4 million in the 15th year (2005/06). However, since the production cost is high, the net income after tax will be in deficit over the whole period of economic life, as far as the electricity price is based on the present tariff. If the electricity price could be lowered by 60%, the financial position can be fairly improved so that the project income can gain an operating profit during the whole life except the initial three years, and the accumulated losses can be written off in the seventh year. The financial position will be substantially improved by lowering the electricity price by 80%. In this case, the project will gain an operating profit every year except the initial two years, and the accumulated losses incurred during the initial two years will be written off in the third year.

B. Cash-flow

If the operating losses continue for a few years, the project would encounter difficulties in financial liquidity. Capital intensive projects requiring a large amount of capital investment, like this project, are usually unable to gain an operating profit during the initial two to three years. Nevertheless, if operating losses continue longer than that period, such a project would lose financial soundness due to cash-flow difficulties. If the electricity price is lowered to a level lower than 40% of the present tariff level, the project could be operated with stable cash-flow.

C. Debt service capacity

In view of the debt service coverage ratio analyzed for the project, it is expected that the project will be well capable to sustain debt service capacity, if the electricity price is lowered to a level lower than 40% of the present tariff level.

(4) Profitability of the project

The internal rates of return on investment (financial return rates) of the project have been analyzed on the basis of the projected financial statements. The results of this analysis are summarized below.

Electricity Price	IRR in currrent prices (%)		IRR in constant prices (%)	
	Before tax	After tax	Before tax	After tax
— 80% of the base estimate	3.70	3.06	*	*
— 60% of the base estimate	8.17	6.16	2.23	0.37
— 40% of the base estiamte	11.78	9.38	5.59	3.36
— 20% of the base estimate	14.87	12.24	8.48	6.02
— No value	17.61	14.84	11.03	8.44

Note *: negative returns

Financial profitability of the project appears to be low, and the project therefore will not have sufficient profitability so as to attract investment by the private sector, as well as commercial financing. This project thus could be materialized only by means of HMG/N's public investment as well as financing with concessional loans, and economic benefits rather than financial profitability for the project would be more important criteria for HMG/N's decision making on investment. In this context economic benefits of the project are analyzed. It must be noted, however, that even if the implementation of the project is decided by HMG/N from the national point of view, the project must meet the minimum financial conditions required for sustaining financial liquidity and sound financial structure which is capable of debt service. The premises for satisfying these conditions are:

A. HMG/N's decision on setting the special rate of electricity for the project so that the project can be supplied with electricity priced at lower than 40% of the present tariff level

B. Equity capital more than 20% of the total financing requirement (preferably not less than 30%)

C. Financing with soft-term loans

(5) Economic analysis and socio-economic evaluation

A. Economic return of the project

The primary objective of this project, from the national economic point of view, is to contribute to economic development by means of producing urea fertilizer to substitute for the imports of this fertilizer which the country requires for agricultural development. In the light of this objective, the economic returns of the project have been analyzed in terms of the economic internal rate of return (ERR) and the economic net present value (ENPV). The results of this analysis are summarized below.

- ERR 8.2%
- ENPV US$1.08 million in 1984 constant price terms (at 8% discount rate)

The above analysis uses the economic electricity cost of US¢1.182/kWh in 1984 constant price terms. This economic cost, as stated earlier, has been estimated on the basis of the LRMC assessed for the 1990's, and also by taking into account the assumption that the project will efficiently utilize otherwise unutilized secondary energy, so that the assessment has been made on the basis of reasonably valued economic cost of the energy resource. The analyzed returns reveal that, although the project's economic return seems to be low, without cost penalty exacted from other resources, it could generate a return slightly higher than the opportunity cost for capital resources prevalent in the Kingdom of Nepal, namely 8% per annum. In this context it may be assessed that this project could have economic effects on the national economy to the minimum extent that can barely justify the investment.

B. Effects on foreign exchange savings

The project's effects on foreign exchange savings are analyzed by the following two parameters.

- Net value added ratio, which is the ratio of domestic costs in the production cost, calculated pursuant to the provision of Industrial Enterprises Act in the Kingdom of Nepal

- Net foreign exchange savings, which is calculated as the net total of the foreign exchange savings which may accrue by substitution for the imports of urea fertilizer, after deducting the outlays of foreign exchange which may be incurred for the production of urea fertilizer.

The net value added ratio and net foreign exchange savings estimated for the case where the electricity is supplied at a rate set as 40% of the present tariff level, shows 54% of annual production cost (average in 15 years) for the former and US$560.75 million for 15 years (averaged at US$37.38 million per annum) in current price terms. If the electricity price for the project is as low as 40% of the present tariff rate, the production cost will be lower than the import prices except for the initial three years. On the other hand, the foreign exchange cost will always be lower than the import prices. These figures indicate that the project could contribute to foreign exchange savings.

C. Other economic benefits

Since the requirements for urea fertilizer are met by imports, the supply of this fertilizer has been often short due to difficulties in timely procurement of the required quantities, and this shortage has impeded agricultural production. This project could contribute to the country's agricultural development, since the domestic production could ensure the timely supply of urea fertilizer as required.

In addition to the contribution to the country's agriculture, this project would also contribute to the creation of employment opportunities, by permanent direct employment of about 300 persons and indirect employment of 100 persons who would be directly or indirectly engaged in the plant operation, in addition to the employment of about 1,000 persons for plant construction. Further, the project would have external effects on relevant industries and regional development. If those indirect benefits are taken into account, the economic returns of the project may be larger than the quantitatively assessed returns, and therefore it may be assessed that the project would be economically feasible.

Chapter 3 Conclusion and Recommendations

3-1 Conclusion

(1) Marketability of urea fertilizer

In view of farmers' practices in using urea fertilizer and its suitability for agriculture in Nepal, it is likely that this fertilizer will come to have a dominant share in Nepal's nitrogen fertilizer consumption, and its domestic demand will reach approximately 51,000 tons in 1991/92 and 70,000 tons in 2000/01, so that in and after 1991/92 the country's urea fertilizer markets will have a sufficient scale to absorb the output of an urea fertilizer plant having production capacity of 250 to 300 TPD. The Agricultural Inputs Corporation (AIC), a state-owned corporation, is the sole agency for marketing and distribution of fertilizer in Nepal. This arrangement is expected to continue in the future. When a urea fertilizer plant is established in Nepal, all of the output from the plant will be taken by AIC. As AIC has organized a network and facilities for fertilizer distribution throughout the country, they will be capable to undertake the marketing and distribution of the urea fertilizer to be produced.

(2) Technical feasibility of the project

For defining the project scheme for a urea fertilizer plant, the primary importance is assigned to selection of the processes for manufacturing ammonia and carbon dioxide which are intermediate materials for manufacturing urea fertilizer. The ammonia manufacturing process varies depending upon the hydrogen source used. As water and electricity are indigenous resources available in Nepal, this project will adopt a process which manufactures ammonia by synthesis of hydrogen generated by electrolysis of water, with nitrogen obtained by air fractionation. For carbon dioxide, the most economical source in Nepal is to recover this from cement plant flue gas. Adoption of these processes is technically feasible, since the process for generating hydrogen by electrolysis of water is commercially proven, and the principal process technology for recovering carbon dioxide from cement plant flue gas has been established for commercial application. The processes for obtaining nitrogen by air fractionation, ammonia synthsis, as well as urea manufacturing are all commercially proven. Nevertheless, the assurance of reliable supply of electricity and cement plant flue gas is a prerequisite for planning the urea fertilizer plant based on those process technologies and ensuring long term stable operation of the plant.

A. Availability of electricity

In the near future, following the completion of Kulekhani No. 2 hydropower plant (32 MW) and Andikhola hydropower plant (5 MW) which now are under construction, the construction of Marsyangdi hydropower plant (66 MW) will be started. It is likely that, with the completion of the Marsyangdi project, Nepal's electricity supply will have a surplus over domestic demand to some extent for one to two years after 1988/89, but thereafter the supply condition will again be tight.

HMG/N has a plan to carry out the Sapta Gandaki hydropower project (225 MW), after the Marsyangdi project. The Sapta Gandaki project consists of three stages of construction, in which the first stage is to be completed in 1991/92. If this project is completed as now planned, Nepal will have a large surplus supply of energy except for two to three months in the dry season when the electricity supply/demand used to be tight, as well as at the daily peak time (four to five hours in morning and evening), so that electricity generated by this surplus energy will be available for the urea fertilizer plant. Hence it is foreseen that, if the Sapta Gandaki project is implemented, and each stage of the construction is completed as per the schedule particularly with regard to the completion of the first stage in 1991/92, at least for five years starting in that year, there will be assurance that there will be adequate electricity supply to operate a urea fertilizer plant having a capacity up to 300 TPD with annual capacity utilization averaging 83% of full capacity based on 330 on-stream days per annum.

At present the availability of electricity for the years beyond that period can not be foreseen, because there are no definite plans for the implementation of hydropower projects to be developed following the Sapta Gandaki. Nevertheless Nepal has great potential for hydropower developments. Basic studies and investigation for the development of hydropower projects following the Sapta Gandaki project are underway. If those projects are implemented in time as per the master plan, Nepal may have surplus energy capacity available for use at the urea fertilizer plant in the rainy season as well as daily off-peak time so that the plant can be operated by efficient utilization of surplus energy without burdening peak load, because the envisaged hydropower projects will have installed capacity exceeding 200 MW.

In actuality, however, the assurance that the Sapta Gandaki project and subsequent projects will be implemented in time must be assumed as prerequisites to ensure the long term stable supply of electricity for the urea fertilizer plant. This study has examined the planning of the urea fertilizer plant, on the assumption that the first stage of Sapta Gandaki project will be completed in 1991/92 as per targeted schedule. It must be emphasized, however, that, prior to the decision on implementation of this project HMG/H should carefully investigate the timing of the development of future hydropower projects including the Sapta Gandaki project, and set the schedule for this project to meet the development of those hydropower projects in future.

B. Availability of cement plant flue gas

The existing cement plant is that of the Himal Cement Co., (PVT) Ltd. (HCC) located at Chobar, Kathmandu, the capacity of which is 160 TPD of clinker. Another plant is being constructed at Hetauda by Hetauda Cement Industries, Ltd. (HCI). This plant will be completed by the end of 1984, and will have the capacity of 750 TPD of clinker. Supply conditions of flue gas were investigated for both plants. As the result, it is judged that flue gas from the HCI's plant is more suitable for recovering carbon dioxide, since this plant adopts a modern process. The quantity of the flue gas available from this plant is also adequate. Hence it is judged that the flue gas from the HCI's plant is adequate as the source for carbon dioxide to be supplied to the urea fertilizer plant.

As the urea fertilizer plant will use the HCI's cement plant flue gas, the plant will have to be located adjacent to that in Hetauda. When compared with the site area adjacent to the HCC's cement plant at Chobar, Kathmandu, the site conditions of the area near HCI, Hetauda are superior to those of HCC, Kathmandu.

As the conclusion of this study, the following project concept is proposed.

A. Establish a 275 TPD urea fertilizer plant which is to be located adjacent to the HCI's cement plant site in Hetauda, and

B. Set the completion target for the urea fertilizer plant as 1991/92 to meet the schedule set for the Sapta Gandaki project.

It must be noted, however, that the HMG/N's assurance on the long term stable supply of electricity is assumed as an essential condition for this proposal. Therefore it is recommended that, prior to the decision on the implementation of the project, HMG/N should carefully investigate this aspect. If HMG/N determines that this condition will be satisfied, the project is judged to have satisfactory conditions to be technically feasible.

(3) Financial viability of the project and its economic effects

If a 6% annual escalation of electricity price is assumed, it is judged that, if the present tariff pricing at US¢ 3.56/kWh is applied to the electiricity supplied to the urea fertilizer plant, this project would not be financially viable, because the production cost of the project seems to be far higher than the price of imported urea in future. If it is possible to set a concessional rate for the project at a price level lower than 40% of the present tariff price, however, the project may be marginally able to sustain a financially viable structure. Even in such an event, this project will not be attractive to private sector investors or commercial financing sources, because financial profitability of the project would be low.

The economic return of the project is assessed as 8.2%, which is below the common standard of an acceptable return rate. However, this project may be able to gain returns slightly more than the opportunity cost for capital resource prevalent in the Kingdom of Nepal (8% per annum), and therefore the project is expected to attain the minimum of economic returns, although by a small margin, as required for a favorable investment decision on the project. At the same time, it is expected that the project could contribute to foreign exchange savings of the country, while contributing to agricultural development by means of assuring stable supply of urea fertilizer, as well as increases in employment and other effects on the economic development of the country. In view of these effects, it is assessed that the project is likely to be economically feasible, although by a small margin.

It must be noted, however, that the setting of a concessional rate of electricity for the project, as recommended earlier, is essential for the project to be financially viable. As this project is so conceived as to maximize efficient utilization of unutilized secondary energy without burdening the peak load, the consumption of electricity by the project would not cause any increase in electricity supply costs, but it would rather contribute to reduce the costs by improving average load. Hence even if electricity is supplied at a concessional rate specially set for the project, it would result in increases in net operating income of NEC, rather than causing a financial burden.

(4) Overall evaluation

Summing up the foregoing discussions, the following two conditions are esssential for this project.

A. Assurance of HMG/N on the definite implementation of the Sapta Gandaki project and subsequent hydropower projects at times beneficial to the urea fertilizer project

B. Setting of a concessional rate for electricity to be supplied for the project, at a level lower than 40% of the present tariff rate

The overall evaluation of the project leads to the conclusion that, if the above conditions are adopted, the project will satisfy by a small margin the minimum requirements to justify the investment as being appropriate from the national economic point of view.

3-2 Recommendations

(1) Among several conditions, in particular assurance of the long term stable supply of electricity is a prerequisite for this project to be technically feasible. It is recommended that, prior to the final decision on this project, the possibility on the timely implementation of the Sapta Gandaki project and subsequent hydropower projects be ensured by the HMG/N.

(2) Reducing electricity cost is essential for the project to be financially viable. It is recommended that the HMG/N consider to set a concessional rate of electricity for the project at a level lower than 40% of the present tariff rate.

(3) Since the HCI's cement plant in Hetauda is still under construction, at present there are no data showing actual analysis of flue gas composition. It is recommended to conduct the measurement and analysis of the flue gas when the plant starts operation so that the actual composition can be confirmed for refinement of the basic design of the carbon dioxide removal plant in the urea fertilizer plant.

(4) It is recommended that, when the HMG/N's decision has been made to implement the project, immediate steps be taken to organize an executing entity for the project, as well as a project team consisting of experienced engineers and staff in Nepal and assisted by qualified foreign consultants so that the project can be launched for implementation under a responsible organization. This organization should have authority and responsibility to coordinate with the management of the HCI's cement plant which will supply flue gas to the urea fertilizer plant so that arrangements for optimum operation can be made for both the cement plant and the urea fertilizer plant.

Table 1 PAST TREND OF FERTILIZER CONSUMPTION IN NEPAL

(Unit: Nutrient ton)

Year	N	P_2O_5	K_2O	Total
1965/66	342	90	12	444
1966/67	1,070	276	104	1,450
1967/68	1,839	728	167	2,734
1968/69	2,382	659	159	3,200
1969/70	3,380	1,049	156	4,585
1970/71	4,111	1,081	214	5,406
1971/72	5,554	1,952	462	7,968
1972/73	7,698	3,150	1,052	11,900
1973/74	9,003	3,167	918	13,088
1974/75	8,923	2,849	886	12,658
1975/76	8,423	2,491	1,352	12,266
1976/77	10,696	2,780	1,422	14,898
1977/78	13,013	3,383	1,079	17,475
1978/79	14,115	3,692	1,456	19,263
1979/80	14,480	4,277	1,178	19,935
1980/81	16,984	4,993	587	22,564
1981/82	17,976	5,003	771	23,750
1982/83	22,896	7,167	912	30,975

Source: AIC

Table 2 PAST TREND OF NITROGEN FERTILIZER CONSUMPTION BY TYPE IN NEPAL

(Unit: N ton)

	1965-69 Average	1970-74 Average	1975-79 Average	1980-82 Average
Urea	93 (5.1)	2,140 (30.3)	7,556 (61.1)	12,751 (66.1)
Ammonium sulphate	1,215 (67.4)	2,920 (41.4)	1,577 (12.7)	900 (4.7)
Di Ammonium Phosphate	- (-)	- (-)	- (-)	106 (0.6)
CX (20-20-0)	457 (25.4)	1,959 (27.7)	2,295 (18.8)	5,119 (26.6)
CX (23-23-0)	12 (0.7)	30 (0.4)	166 (1.3)	276 (1.4)
CX (15-15-15)	0 (0.0)	12 (0.2)	754 (6.1)	124 (0.6)
CX (5-6-7)	- (-)	- (-)	2 (0.0)	2 (0.0)
Other N	26 (1.4)	4 (0.0)	0 (0.0)	2 (0.0)
Total N	1,803 (100.0)	7,065 (100.0)	12,350 (100.0)	19,280 (100.0)

Note: Figures in the parentheses mean the percent of total N.

Source: AIC

Table 3 AGRICULTURAL PRODUCTION IN NEPAL

(Unit: ton)

	1971/72				1982/83			
	High Hill	Hill	Terai	Kathmandu Valley	High Hill	Hill	Terai	Kathmandu Valley
Paddy	43,933	344,876	1,851,385	103,632	44,330	390,680	1,297,430	100,180
Maize	76,586	402,678	225,328	54,134	56,730	358,920	227,280	75,310
Wheat	29,621	58,638	99,502	35,433	16,980	145,050	444,460	50,140
Millet	17,654	87,669	17,291	6,886	16,110	87,100	17,840	3,820
Sugarcane	1,042	27,712	212,493	3,573	650	41,180	574,740	-
Jute	-	2,287	55,752	20	N.A.	N.A.	N.A.	N.A.
Oilseed	671	11,766	44,008	1,000	520	13,210	55,750	400
Tobacco	80	367	6,458	-	-	160	6,480	-
Potato	52,658	127,465	89,383	23,862	77,830	190,620	104,520	28,210

Note: N.A. = Not avairable

Source: Dept. of Food & Agricultural Marketing Series, Nepal

Table 4 PROJECTED DEMAND FOR NITROGEN FERTILIZER IN NEPAL

(Unit: ton)

Region	1982 (Actual)	1985	1990	1995	2000
Eastern Dev. Region	1,372	1,721	2,404	2,476	2,511
High Hill	55	54	67	81	95
Hill	354	285	447	466	474
Terai	963	1,382	1,890	1,929	1,942
Central Dev. Region	15,702	16,825	19,751	23,805	15,383
High Hill	864	925	957	963	967
Hill	1,987	2,162	2,446	2,706	2,716
Kathmandu Valley	6,234	6,743	7,591	9,597	8,971
Terai	6,617	6,995	8,757	10,539	11,700
Western Dev. Region	2,787	3,051	3,974	4,661	4,941
High Hill	16	30	24	18	17
Hill	888	890	1,113	1,339	1,548
Terai	1,883	2,131	2,837	3,304	3,376
Mid-Western Dev. Region	777	597	870	887	1,064
High Hill	5	10	10	10	9
Hill	115	93	189	193	195
Terai	657	494	671	684	860
Far-Western Dev. Region	286	295	321	498	513
High Hill	15	9	9	18	17
Hill	18	45	47	47	48
Terai	253	241	265	433	448
Total	20,924	22,489	27,320	32,327	33,383
High Hill	955	1,028	1,067	1,090	1,105
HIll	3,362	3,475	4,242	4,751	4,981
Kathmandu Valley	6,234	6,743	7,591	9,597	8,971
Terai	10,373	11,243	14,420	16,889	18,326

Table 5 EXPECTED SALES VOLUME OF UREA

(Unit: ton)

	Total Demand for Nitrogen Fertilizer		Expected Ureas' Share of Total Nitrogen Demand	Maximum Expected Sales Volume of Urea*/
	N ton	As Urea		
1985	22,500	48,900	72.5%	35,500
1990	27,300	59,300	75.0%	44,500
1995	32,300	70,200	90.0%	63,200
2000	33,400	72,600	95.0%	69,000

Note: */ Yearly change in the "maximum expected sales volume of urea" is as follows.

1990	44,500
1991	48,800
1992	52,600
1993	56,400
1994	60,100
1995	63,200
1996	64,700
1997	65,900
1998	67,100
1999	68,100
2000	69,000

Table 6 PROJECTION OF UREA PRICE

(Unit: US$/ton - Constant Prices at 1984)

	1983 (Estimated)	1985	1990	1995	2000
CIF Calcutta (Bagged), (A)	192	225	255	269	279
Cost up to retailers, (B)	93	93	93	93	93
Total import costs, (A+B) (ex-retailers)	285	313	348	362	372
Transportation cost from the project site to the market, (C)	9	9	9	9	9
Retailer mark-up, (D)	16	18	20	21	21
Ex-factory price, (A+B) - (C+D)	260	286	319	332	342

Note: 1/ Based on the projected price in Table 2-6.

(CIF calcutta, bagged price) = (FOB US Gulf, bulk price) + (Freight form US Gulf) + (Bag/Bagging costs)

Freight rate from US Gulf = US$35/ton

Bag/Bagging costs = US$20/ton

Table 7 ESCALATED CAPITAL COST ESTIMATE

NEPAL UREA PROJECT (275 TPD)

(Unit: US$MIL.)

	BASE PROJECT COST		PHYSICAL CONTINGENCY		PRICE CONTINGENCY		TOTAL PROJECT COST (AS COMPLETED)		
	FOREIGN	LOCAL	FOREIGN	LOCAL	FOREIGN	LOCAL	FOREIGN	LOCAL	TOTAL
A. LAND ACQUISITION	0.0	0.59	0.0	0.03	0.0	0.10	0.0	0.72	0.72
B. SITE PREPARATION	1.35	0.15	0.07	0.01	0.18	0.04	1.60	0.20	1.80
C. PLANT DIRECT COST									
C-1 PROCESS UNITS	38.41	1.81	1.92	0.09	7.86	0.67	48.19	2.57	50.76
C-2 UTILITY FACILITIES	10.17	0.53	0.51	0.03	2.04	0.19	12.72	0.75	13.47
C-3 AUXILIARY FACILITIES	1.94	0.82	0.10	0.04	0.38	0.29	2.42	1.15	3.57
C-4 OFFSITE FACILITIES	1.70	2.31	0.09	0.12	0.32	0.79	2.11	3.22	5.33
D. SPAREPARTS, CATL. & CHEM.	2.33	0.0	0.12	0.0	0.59	0.0	3.04	0.0	3.04
E. CONST. & ERECTION LABOR	9.87	3.44	0.49	0.17	2.23	1.42	12.59	5.03	17.62
F. CONST. EQUIPMENT	7.82	0.0	0.39	0.0	1.38	0.0	9.59	0.0	9.59
G. TRANSPORT, INSURANCE & DUTY	2.00	2.59	0.10	0.13	0.40	0.94	2.50	3.66	6.16
H. INDIRECT FIELD EXPENCES	0.33	0.49	0.02	0.02	0.07	0.20	0.42	0.71	1.13
I. ENGINEERING SERVICES	9.31	0.85	0.47	0.04	1.80	0.30	11.58	1.19	12.77
J. PROJECT MANAGEMENT SERVICES	2.45	0.37	0.12	0.02	0.48	0.13	3.05	0.52	3.57
K. PRE-OPERATION EXPENSES	0.29	1.90	0.01	0.10	0.08	0.92	0.38	2.92	3.30
L. BASE PROJECT COST	87.97	15.85	4.41	0.80	17.81	5.99	110.19	22.64	132.83
M. INITIAL WORKING CAPITAL	0.0	0.0	0.0	0.0	0.0	0.0	0.40	2.28	2.68
N. INTEREST DURING CONSTRUCTION	0.0	0.0	0.0	0.0	0.0	0.0	9.28	0.0	9.28
O. TOTAL FINANCING REQUIRED	87.97	15.85	4.41	0.80	17.81	5.99	119.87	24.92	144.79

Table 8 PROJECTED UREA PRODUCTION COST BY CHANGES IN ELECTRICITY PRICE
(Capacity 275 TPD: Bagged Urea)

(Unit: US$/ton)

Year	Base Estimate		20% Reduction		40% Reduction		60% Reduction		80% Reduction		100% Reduction	
	Current Price	1984 Const. Price	Current Price	1984 Const. Price	Current Price	1984 Const. Price	Current Price	1984 Const. Price	Current Price	1984 Const. Price	Current Price	1984 Const. Price
1991/92	836.0	556.0	764.9	508.7	693.9	461.5	622.8	414.2	551.7	366.9	480.7	319.7
1992/93	848.2	532.2	772.8	484.9	697.5	437.6	622.2	390.4	546.8	343.1	471.5	295.8
1993/94	839.7	497.0	759.8	449.7	680.0	402.5	600.0	355.1	520.3	308.0	440.4	260.7
1994/95	842.1	470.2	757.4	422.9	672.8	375.7	588.1	328.4	503.5	281.2	418.8	233.9
1995/96	854.3	450.0	764.6	402.8	674.8	355.5	585.1	308.2	495.4	261.0	405.7	213.7
1996/97	871.8	433.3	776.7	386.0	681.6	338.7	586.5	291.5	491.4	244.2	396.3	196.9
1997/98	894.9	419.6	794.1	372.3	693.2	325.0	592.4	277.7	491.6	230.5	390.8	183.2
1998/99	920.4	407.1	813.5	359.8	706.6	312.5	599.8	265.3	492.9	218.0	386.1	170.8
1999/2000	948.9	395.9	835.6	348.7	722.3	301.4	609.0	254.1	495.8	206.9	382.5	159.6
2000/01	980.5	386.0	860.4	338.7	740.3	291.4	620.3	244.2	500.2	196.9	380.2	149.7
2001/02	838.9	311.5	711.7	264.3	584.4	217.0	457.1	169.8	329.8	122.5	202.6	75.2
2002/03	881.0	308.7	746.1	261.4	611.2	214.1	476.2	166.8	341.3	119.6	206.4	72.3
2003/04	925.9	306.0	782.9	258.8	639.8	211.5	496.8	164.2	353.8	116.9	210.8	69.7
2004/05	974.0	303.7	822.4	256.4	670.8	209.2	519.2	161.9	367.6	114.6	216.1	67.4
2005/06	1,025.6	301.7	864.9	254.4	704.2	207.1	543.5	159.9	382.8	112.6	222.2	65.4
Average (1991/92 - 2005/06)	898.8	405.3	788.5	358.0	678.2	310.7	567.9	263.4	457.7	216.2	347.4	168.9

Notes: 1/ Excluding interest for short-term loan which will be borrowed for recovering cash defisit incurred due to financial losses
2/ Using deflater of 6% p.a. for calculating the production cost in 1984 constant prices

Figure 1 FERTILIZER CONSUMPTION TREND IN NEPAL

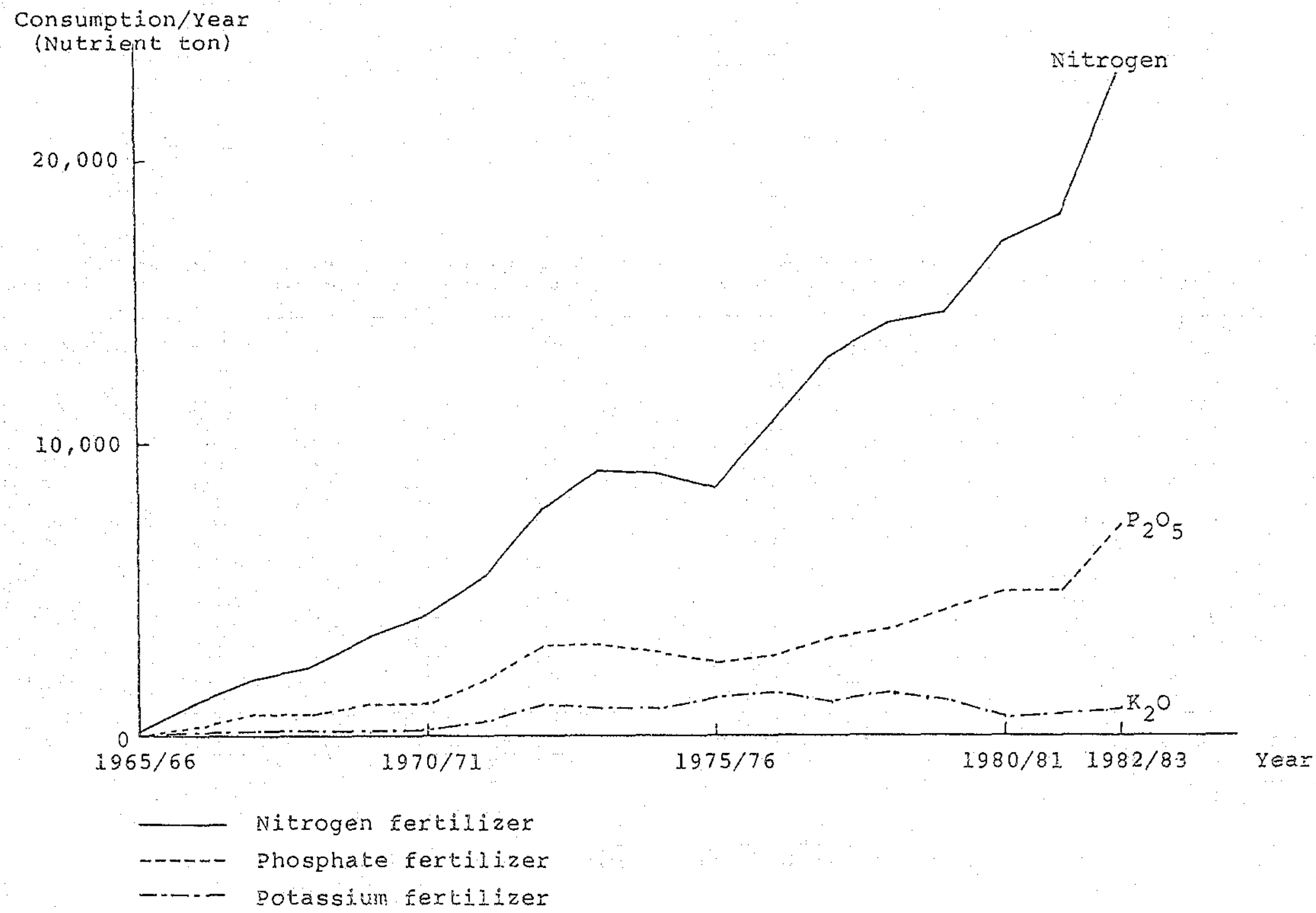


Figure 2 PAST TREND AND PROJECTION OF NITROGEN FERTILIZER CONSUMPTION IN NEPAL

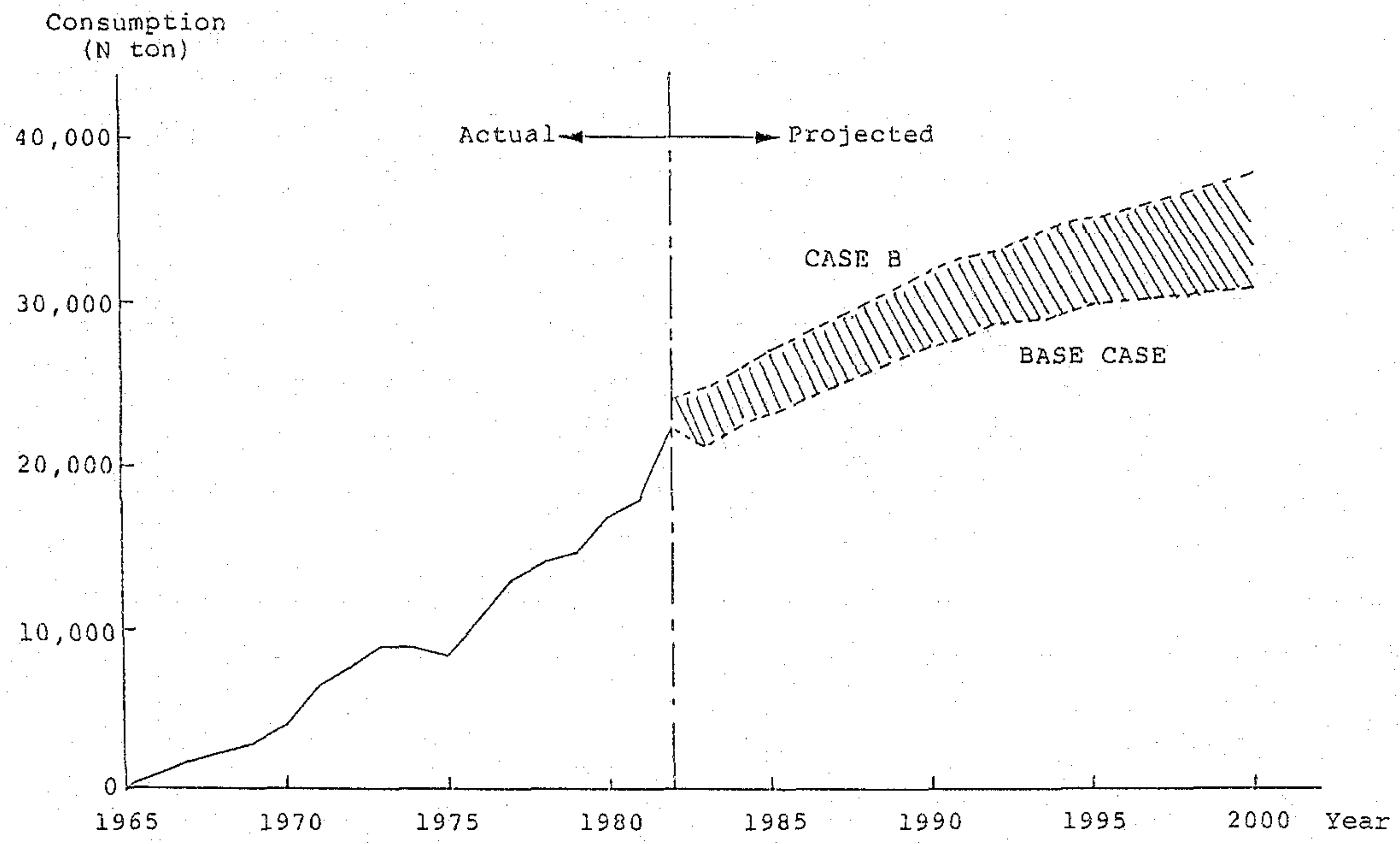
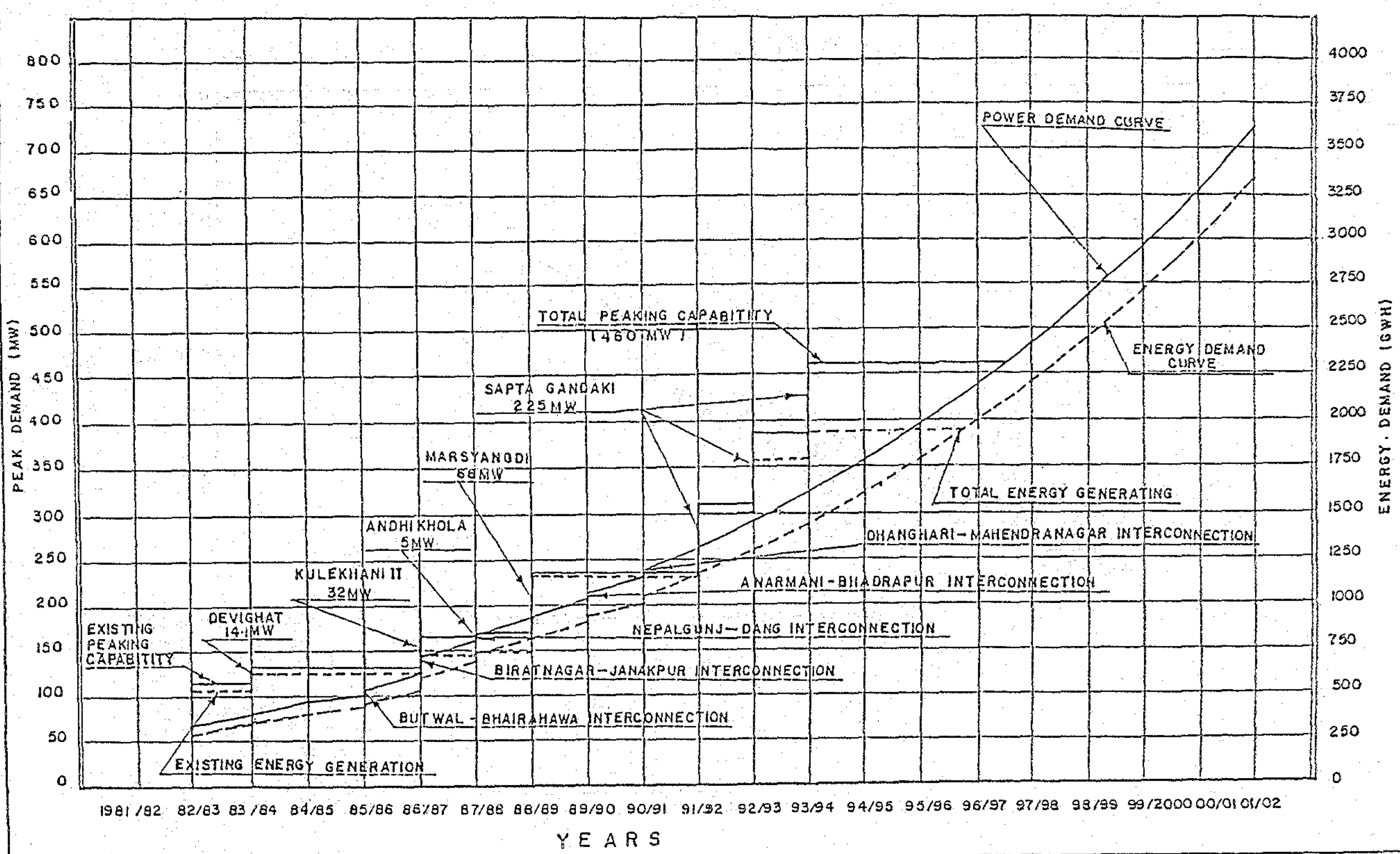


Figure 3 NEPAL POWER SYSTEM INTEGRATED DEMAND AND GENERATION EXPANSION



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