Chapter 4 Sales of Product Produced from the Project

4-1 Selection of product mix in view of marketability

As described in Chapter 3 (3-4-2), urea is the most suitable straight nitrogen fertilizer to be produced in Nepal in view of agronomy. In addition to the agronomical factor, transportation cost is another essential factor in selection of the suitable product mix. Transportation costs and storaging costs within Nepal account for around 6 to 11% of total fertilizer costs of AIC (or around 15 to 27% of total costs excluding purchasing cost of AIC). When taking into account the fact that fertilizer is transported either on human backs or mules from the AIC depot to farmers via retailers' shops, the higher the analysis of fertilizer is, the more suitable it is for Nepal. Urea is suitable in this point of view also.

With respect to the selection of compound fertilizer or straight fertilizer, the following factors should be taken into consideration. If the compound fertilizer is produced in Nepal, such raw materials as phosphate and potassium have to be imported. The major consuming areas of fertilizer are Terai and Kathmandu Valley, and unless the fertilizer plant is constructed at the border area in Terai, the phosphate and potassium nutrients have to be transported to the plant site inland and transported back again to Terai after formulating the compound fertilizer. In order to avoid such redundant transportation, mixing of these nutrients at the farm or AIC depot may be more recommendable than domestic production of compound fertilizer.

Thus, urea is the most suitable fertilizer in Nepal on the assumption that only one product is produced in Nepal.

4-2 Outlook of market size

The projected demand for nitrogen fertilizer in Nepal is given in Table 2-23, with the assumption that the domestic production of nitrogen fertilizer will be commenced in 1991, and that, as a result, the demand for nitrogen fertilizer will be appropriately met by domestic production – in other words there will be no more shortage or lack of supply after the commencement of domestic production. In calculating the sales plan of urea based on the above projection, the following points were taken into account.

(1) Basically, all of the demand for nitrogen fertilizer may be regarded as that of urea.

(2) A half of applied nitrogen fertilizer on rice is applied as top-dressing while all of it is applied as top-dressing in the case of wheat and maize. In this context, NP or NPK compound fertilizer will be more adequate than straight nitrogen fertilizer, but in view of the economy of raw material transportation, as described above, the use of urea is assumed to be promoted instead of compound fertilizer.

(3) The consumption of NP/NPK compound fertilizer accounts for 27.5% of that of total nitrogen fertilizer at present. However, the consumption of these products is not necessarily the result of farmers' preference for these products, but because of the supply constraints for other products. Therefore, it is possible for these products will be replaced by urea in the future. (Nevertheless, even in the final stage of replacement, 5% of total nitrogen fertilizer demand, which is equivalent to 50% of nitrogen fertilizer demand from industrial crops and vegetables, was assumed to be met by NP or NPK fertilizers.)

(4) The easiness of replacement of demand for NP/NPK by that of urea depends on the extent of the import share among total supply. In this projection, referring to the past trend observed in replacement of ammonium sulphate by urea, the replacement was assumed to take place so that only 40% of present NP/NPK demand will be remain as NP/NPK demand in 5 years and it will further decrease to 15% in 10 years. (In other words, the NP/NPK demand is expected to account for 25% in 1990, and the ratio will be declined to 10% until 1995, which is equivalent to 40% of the ratio in 1990. The ratio will further decrease to 5% until 2000, which is the final lowest level of the demand for NP/NPK.) As a result, the maximum sales potential volume of urea is expected to be 44,500 tons in 1990, 63,200 tons in 1995, and 69,000 tons in 2000 (Table 2-24).

4-3 Product storage and shipment facilities

4-3-1 Seasonal change in the shipment

Most fertilizer in Nepal is applied as basal dressing. The cropping seasons are limited to three seasons a year, and therefore, the consumption of fertilizer is fairly concentrated in certain periods in the year. The shipment pattern of fertilizer by month is shown in Table 2-13 and Figure 2-6. Besides the seasonal fluctuation in shipment, there are many regions where the transportation is impossible in rainy season. These regions are shown in Figure 2-5. For these regions, fertilizer has to be brought in before the rainy season starts. Table 2-25 shows the optimum monthly stock requirement (including that of stock points) calculated on the basis of past figures. The total storaging capacity of stock points was around 57,000 tons in 1979/80 including the facilities under construction. The highest level of total required inventory of urea produced by the Project around a year will be 20,540 tons in April/May in the case of 1995. (63,200 tons of sales volume in 1995 × inventory level in April/May 32.5% = 20,540 tons) The inventory requirement for the residual demand, which is not met by the domestic production and supplied by import, will be 17,200 tons assuming that the required level is 80% of total yearly shippment. (21,500 tons of import requirement in 1995 × inventory level 80% = 17,200 tons) Thus, the highest inventory level of fertilizer will be around 38,000 tons totaling the above two. However, as described above, the storage capacity at present, including that of under construction, is around 57,000 tons in total in Nepal. Therefore, the start-up of this plant will not cause any significant and sudden shortage of storaging capacity. This is mainly due to the fact that the commencement of domestic production will make the control of inventory level of fertilizer more efficient.

However, the above discussion is based solely on the data about the aggregated capacity of storaging facilities in Nepal as a total. Therefore, further study on the arrangement of storage facilities which duely meet the increase in the demand at each regional level would be essential for successful distribution of fertilizer under the new distribution circumstance.

4-3-2 Packaging

The imported fertilizer is packed in 50 kg bags. In some countries, 30 kg bags or 20 kg bags are preferred for fertilizer packaging due to the difficulty in handling 50 kg bags. However, in Nepal, since fertilizer is often transported by human backs or mules, 50 kg bags may be suitable. In case that farmers want to buy small amounts of fertilizer, the unit cooperative can sell it by measure instead of in units of one bag. The present bag specifications required by AIC are as follows, but the use of jute bags should be also taken into account in the Project.

1. Bag capacity	:	50kg net
2. Materials	:	Polypropylene woven bag with an inner polyethylene bag
3. Weight of outer bag	:	Not less than 200 gm
4. Gauge of inner bag	:	Not less than 200 gauge
5. Size of bag	:	40"×20"
6. Fiber construction of outer bag	:	Not less than 14×14 per square inch
7. Others	:	Bag should be stitched with strong synthetic thread

In the case of imports, extra spare bags equivalent to 5% of total are required. It is recommended to provide spare bags for domestic production, equivalent to 1.5% of total production.

4-3-3 Transportation of the product

The demand for fertilizer, which is the basis of this sales plan, is expected to increase by 2% p.a. during 10 years from 1990 to 2000. Further, the rates will be as low as 1.6% and 0.4% p.a. respectively in Hill area and High Hill area. If one compares these rates with that of past 7 years from 1975 to 1982, which were 13.9% p.a. in total, 22.6% p.a. in Hill area, and 41.5% p.a. in High Hill area, the requirement of increase in the transportation facilities will not be large inspite of increase in the fertilizer demand. Besides, since the commencement of domestic production eases the seasonal fluctuation of transportation, such requirement will be lightened further.

Nevertheless, the detailed study on the rearrangement of transportation facilites among the regions will be essential for successful distribution of the urea as well as imported fertilizers in that the supply points of fertilizer will be mostly concentrated to the plant site whereas the supply points at present are distributed among the stock points around the Indian border.

4-4 Product specifications of urea

The product specifications of urea required by AIC for imported urea are as follows:

1. Physical condition	:	White prilled or granular
2. Nitrogen content	:	46% N minimum
3. Moisture content	:	0.6% as H_2O maximum
4. Biuret content	:	1.5% maximum
5. Chemical conditioner	:	Formaldehyde 0.3% minimum or paraformaldehyde 0.08～0.20%
6. Granule size	:	Screen size (Tylor) 90% −6, +16 Mesh minimum 100% −4 Mesh 98% +28 Mesh

4-5 Sales price

4-5-1 Formulation of fertilizer price in Nepal

The fertilizer price has been set by the government (Ministry of Agriculture) since 1972/73, as described in Chapter 2. The factor which most affects the price is the fertilizer price in the border area in India. If the price in Nepal is cheaper than that of India, fertilizers are smuggled to India. If the price in Nepal is more expensive than that of India, fertilizers are smuggled into Nepal. Table 2-27 gives the comparison of the Nepal price with Indian and international market prices. According to this table, the official price in Nepal was still cheaper than that of Indian price. With respect to the imported price in Nepal, it is different from the international market price in that Nepal has imported a large portion of fertilizers by as part of aid programs (i.e., outside the market).

4-5-2 Sales price of urea for the project evaluation

The sales price (ex-factory price) of urea for the project evaluation was projected with the assumption that the urea is sold at the price which is equivalent to the cost of imported urea in the market. The price was projected using the projected international price, which is given in Chapter 2, and adding the costs of transportation to the consumption points. The result is shown in Table 2-28.

Table 2-1 CONSUMPTION OF NITROGEN FERTILIZER IN THE WORLD BY REGION

(UNIT: 1,000 TONS)

	1965/66	1970/71	1975/76	1980/81	1981/82
DEVELOPED MARKET ECONOMIES	10850(57.6)	15645(49.2)	19221(44.6)	22843(37.9)	22032(36.6)
NORTH AMERICA	5050(26.8)	7670(24.1)	10002(23.2)	11604(19.2)	11016(18.3)
WESTERN EUROPE	4814(25.6)	6738(21.2)	8066(18.7)	9848(16.3)	9760(16.2)
OCEANIA	77(0.4)	152(0.5)	177(0.4)	269(0.5)	47(0.1)
OTHER DEV'D MARKET ECON.	909(4.8)	1085(3.4)	976(2.3)	1121(1.9)	1210(2.0)
DEVELOPING MARKET ECONOMIES	2454(13.0)	5242(16.5)	7582(17.6)	11978(19.9)	12772(21.2)
AFRICA	151(0.8)	274(0.9)	442(1.0)	693(1.2)	658(1.1)
LATIN AMERICA	728(3.9)	1358(4.3)	1867(4.3)	2835(4.7)	2864(4.8)
NEAR EAST	440(2.3)	767(2.4)	1324(3.1)	1822(3.0)	2112(3.5)
FAR EAST	1130(6.0)	2837(8.9)	3939(9.1)	6614(11.0)	7116(11.8)
OTHER DEV'G MARKET ECON.	5(0.0)	6(0.0)	11(0.0)	12(0.0)	21(0.0)
CENTRALLY PLANNED ECONOMIES	5524(29.3)	10879(34.2)	16337(37.9)	25515(42.3)	25414(42.2)
ASIA	1603(8.5)	3358(10.6)	4820(11.2)	12828(21.3)	12310(20.4)
EUROPE AND USSR	3921(20.8)	7521(23.7)	11517(26.7)	12687(21.0)	13103(21.8)
WORLD TOTAL	18828(100.0)	31767(100.0)	43140(100.0)	60336(100.0)	60218(100.0)

Note: Figures in the parentheses mean the percentage of world total.
Source: FAO

Table 2-2 PER HECTARE OF ARABLE LAND CONSUMPTION OF NITROGEN FERTILIZER BY REGION

(UNIT: Nkg/ha)

	1970	1976	1981
DEVELOPED MARKET ECONOMIES	39	51	56
NORTH AMERICA	33	44	47
WESTERN EUROPE	67	89	103
OCEANIA	3	5	6
OTHER DEV'D MARKET ECON.	53	53	64
DEVELOPING MARKET ECONOMIES	8	13	19
AFRICA	2	3	4
LATIN AMERICA	10	14	17
NEAR EAST	10	17	24
FAR EAST	11	16	27
OTHER DEV'G MARKET ECON.	5	12	18
CENTRALLY PLANNED ECONOMIES	27	46	65
ASIA	26	59	108
EUROPE AND USSR	27	41	47
WORLD TOTAL	22	32	41

Source: FAO

Table 2-3 OUTLOOK OF SUPPLY AND DEMAND OF NITROGEN FERTILIZER IN THE WORLD

(Unit: Million N ton)

		1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1992/93
Developed Market Economies								
N. America	Supply	10.07	12.29	12.47	12.63	12.61	12.57	-
	Demand	9.58	10.24	11.29	11.65	11.88	12.10	14.50
	Balance	0.49	2.05	1.18	0.98	0.73	0.47	-
W. Europe	Supply	9.76	9.93	10.42	10.54	10.59	10.55	-
	Demand	9.80	9.80	9.90	10.20	10.50	10.80	13.30
	Balance	-0.04	0.13	0.52	0.34	0.09	-0.25	-
Oceania	Supply	0.21	0.21	0.25	0.27	0.28	0.27	-
	Demand	0.30	0.30	0.30	0.30	0.30	0.30	0.40
	Balance	-0.09	-0.09	-0.05	-0.03	-0.02	-0.03	-
Other DME 1/	Supply	1.17	1.10	1.07	1.09	1.07	1.04	-
	Demand	1.20	1.20	1.30	1.30	1.30	1.30	1.45
	Balance	-0.03	-0.10	0.23	-0.21	-0.23	-0.26	-
Developing Market Economies								
Africa	Supply	0.15	0.20	0.30	0.38	0.42	0.44	-
	Demand	0.70	0.80	0.90	0.90	1.00	1.00	1.40
	Balance	-0.55	-0.60	-0.60	-0.52	-0.58	-0.56	-
L. America	Supply	3.00	3.28	3.73	3.98	4.15	4.21	-
	Demand	3.10	3.20	3.40	3.60	3.80	4.00	5.00
	Balance	-0.10	0.08	0.33	0.38	0.35	0.21	-
Near East	Supply	2.09	2.39	2.65	2.75	2.97	3.12	-
	Demand	2.30	2.50	2.70	2.80	3.00	3.10	3.80
	Balance	-0.21	-0.11	-0.05	-0.05	-0.03	0.02	-
Far East	Supply	5.77	6.10	6.61	7.60	8.26	8.81	-
	Demand	7.50	8.00	8.50	9.10	9.60	10.30	13.25
	Balance	-1.73	-1.90	-1.89	-1.50	-1.34	-1.49	-
Centrally Planned Economics								
Asia	Supply	11.31	11.53	11.65	11.81	12.09	12.37	-
	Demand	13.00	13.20	13.50	13.70	14.10	14.50	16.50
	Balance	-1.69	-1.67	-1.85	-1.89	-2.01	-2.13	-
Europe & USSR	Supply	18.84	20.49	12.59	22.12	22.33	22.31	-
	Demand	13.90	14.50	15.20	15.80	16.30	16.86	19.50
	Balance	4.94	5.99	6.39	6.32	6.03	5.51	-
World Total	Supply	62.37	67.52	70.74	73.17	74.77	75.69	-
	Demand	61.38	63.74	66.99	69.35	71.78	74.20	89.10
	Balance	0.99	3.78	3.75	3.82	2.99	1.49	-

Note: 1/ Other Developed Market Economies. Source: FAO/UNIDO World Bank Working Group on Fertilizer.

Table 2-4 WORLD SUPPLY/DEMAND OF NITROGEN FERTILIZER

(N 000 TON)

	1982	1983	1984	1985	1986	1987	1990	1995	2000
ASIA									
CAPACITY	36618	38149	41775	44805	46645	48259	50439	50619	50542
SUPPLY	23945	25092	27351	29367	30762	31937	33553	33803	33794
DEMAND	28172	30097	31670	33253	34776	36130	39247	42355	44047
BALANCE	-4227	-5005	-4319	-3886	-4014	-4193	-5694	-8552	-10253
OCEANIA									
CAPACITY	462	532	532	532	532	532	532	532	532
SUPPLY	346	395	403	403	403	403	403	403	403
DEMAND	386	392	423	427	430	462	472	521	535
BALANCE	-40	3	-20	-24	-27	-59	-69	-118	-132
WEST EUROPE									
CAPACITY	15997	16292	16868	17681	17959	18343	18543	18543	18104
SUPPLY	13257	13475	13982	14780	15084	15398	15620	15620	15379
DEMAND	13209	13396	13603	13811	13971	14128	14494	14798	14972
BALANCE	48	79	379	969	1113	1270	1126	822	407
EAST EUROPE									
CAPACITY	30952	33765	35577	36129	36516	37087	37088	37036	36604
SUPPLY	25092	27182	28762	29442	29685	29971	30377	30335	29988
DEMAND	18589	19241	19842	20419	20969	21518	22894	24961	26976
BALANCE	6503	7941	8920	9023	8716	8453	7483	5374	3012
N. AMERICA									
CAPACITY	16301	16004	16410	16816	16816	16816	16816	16737	16701
SUPPLY	14906	14639	14990	15379	15420	15420	15420	15345	15312
DEMAND	16515	16856	17233	17601	18042	18371	19461	21136	22558
BALANCE	-1609	-2217	-2243	-2222	-2622	-2951	-4041	-5791	-7246
C. AMERICA									
CAPACITY	3433	3771	4128	4492	4492	4492	4492	4492	4492
SUPPLY	2599	2921	3222	3513	3564	3564	3564	3564	3564
DEMAND	1923	2021	2124	2216	2286	2368	2549	2819	3054
BALANCE	676	900	1098	1297	1278	1196	1015	745	510
SOUTH AMERICA									
CAPACITY	1686	1999	2006	2176	2571	2705	3113	3113	3113
SUPPLY	1167	1426	1429	1584	1851	2001	2296	2309	2309
DEMAND	1819	1924	2009	2104	2190	2273	2478	2707	2843
BALANCE	-652	-498	-520	-520	-339	-272	-182	-398	-534
AFRICA									
CAPACITY	2727	3058	3283	3736	4459	4730	4670	4730	4730
SUPPLY	1834	2028	2212	2468	2863	3101	3120	3159	3159
DEMAND	2209	2321	2420	2523	2646	2738	2973	3346	3643
BALANCE	-375	-293	-208	-55	217	363	147	-187	-434
WORLD									
CAPACITY	103176	113570	120579	126367	129990	132965	135693	135802	134818
SUPPLY	83146	87158	92411	96936	99632	101795	104353	104538	103908
DEMAND	82822	86248	89324	92354	95310	97988	104568	112643	118628
BALANCE	324	910	3087	4582	4322	3807	-215	-8105	-14720

Note: Both supply and demand include industrially used nitrogen fertilizer materials and distribution loss.

Source: Study team estimate

Table 2-5 WORLD NITROGEN FERTILIZER AND AMMONIA TRADE IN 1981

(Unit: N'000 ton)

	Ammonia 4/	Urea 4/	NP/NPK 4/	DAP 4/	Unspecified	Total 5/
Export						
W. Europe	1,166	1,285	705	96	1,504	4,756
E. Europe	1,765	2,320	0	0	801	4,886
Africa	28	0	0	73	18	119
N. America	823	964	107	890	1,271	4,055
L. America	1,228	126	0	0	97	1,451
Asia	245	1,055	41	42	187	1,570
Oceania	0	0	0	0	8	8
World Total	5,367 (112) 2/	5,750	853	1,101	3,886	16,957 (112) 2/
Import						
W. Europe	2,644	269	419	364	1,812	5,508
E. Europe	84	307	0	26	75	492
Africa	251	421	57	35	382	1,146
N. America	1,549	405	80	148	1,789	3,971
L. America	252	566	52	129	522	1,521
Asia	547	3,406	159	372	571	5,055
Oceania	0	29	7	18	41	95
World Total	5,367 (40) 3/	5,403	853 (79) 3/	1,101 (9) 3/	5,104 (88) 3/	17,828 (40) 3/

Note: 1/ Unspecified mean the balance which is calculated by subtracting export/import of each products from the total, and includes 1,700 Ntons of ammonium nitrate, and 1,000 Ntons of ammonium sulphate.
2/ Volume exported from unspecified countries, and included in the world total.
3/ Volume destined to unknown countries, and included in the world total.

Source: 4/ IFA and Study team estimate
5/ FAO

Table 2-6 PAST TREND AND PROJECTION OF UREA PRICE IN THE INTERNATIONAL MARKET

(Unit: US$/ton)

	Current Dollars		1984 Constant Dollars		Price Deflator
	FOB Europe 2/ (Bagged)	FOB US Gulf (Bulk)	FOB Europe (Bagged)	FOB US Gulf (Bulk)	
Actural					
1965	95.8		364.3		26.3
1970	48.3		165.4		29.2
1975	198.0		335.6		59.0
1978	144.8	128.0	188.5	166.7	76.8
1979	172.9	145.0	203.2	170.4	85.1
1980	222.1	185.0	240.6	200.4	92.3
1981	216.0	185.1	246.6	211.3	87.6
1982	158.8	132.1	185.1	154.0	85.8
1983 Jan.-June	137.1	127.2	148.1	137.4	92.6 1/
1984					100.0 1/
Projected 1/					
1985		183.8		170.0	108.1
1990		317.4		200.0	158.7
1995		499.3		214.0	233.3
2000		767.6		224.0	342.7

Note: 1/ Assuming 8% p.a. of price escalation from the previous year.

Source: 2/ Green Markets, etc.

Table 2-7 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 available

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

Table 2-8 YIELD OF MAJOR CROPS IN NEPAL 1981

(Unit: kg/ha)

	Paddy	Maize	Wheat
	1,975	1,554	1,038
Hill	2,082	1,533	1,183
Terai	1,898	1,636	1,385
Kathmandu Valley	3,846	1,747	1,879
Nepal Total	1,975	1,581	1,316
India	2,050	1,207	1,649
Pakistan	2,560	1,381	1,640
Bangladesh	1,980	700	1,848
Korea, Rep.	5,745	4,383	2,850
Japan	5,629	3,000	3,060
World Average	2,855	3,370	1,914

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

Table 2-9 CHANGE IN THE YIELD OF MAJOR CROPS IN NEPAL

(Unit: kg/ha)

	1971/72	1975/76	1982/83
Paddy	1,950	2,070	1,449
Maize	1,730	1,620	1,406
Wheat	930	1,180	1,357
Barley	930	930	869
Millet	1,130	1,140	938
Potato	576	5,880	6,300
Sugarcane	16,200	16,770	24,227
Oilseeds	590	610	631
Tobacco	640	720	741

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

Table 2-10 PAST TREND OF FERTILIZER CONSUMPTION IN NEPAL

(Nutrient ton)

	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 2-11 NITROGEN FERTILIZER CONSUMPTION PER HECTARE OF ARABLE LAND AND PERMANENT CROPS IN NEPAL AND S.W. ASIAN COUNTRIES

(Unit: Nkg/ha)

	Average of 1974-76	1981
Nepal	4.0	7.4
Bangladesh	14.5	27.5
Burma	4.1	11.0
India	12.1	22.9
Pakistan	22.3	41.0
Sri Lanka	23.9	41.2

Source: FAO

Table 2-12 IMPORT OF FERTILIZER, NEPAL

(ton)

	Total Import	of which: by aid	(% of total import)	Import in Nutrient tons		
				N	P_2O_5	K_2O
Average of						
1965/66-1969/70	11,238	834	(7.4)	2,298	765	190
1970/71-1974/75	40,878	16,358	(40.0)	9,009	3,030	2,075
1975/76-1979/80	34,821	25,956	(74.5)	12,596	2,611	908
1980/81	49,558	19,485	(39.3)	14,801	3,822	1,665
1981/82	64,620	38,020	(58.8)	20,052	7,239	-
1982/83	99,800	51,400	(51.5)	36,665	7,110	-

Source: AIC

Table 2-13 SEASONAL CHANGE IN THE SHIPMENT AND INVENTORY OF FERTILIZER IN NEPAL

(Unit: % of yearly total)

	Monthly Sales			Inventory		
	1976/77	1977/78	1978/79	1976/77	1977/78	1978/79
Jul./Aug.	6.1	4.2	4.8	105.7	86.3	82.1
Aug./Sep.	4.0	4.2	4.9	103.0	85.8	75.7
Sep./Oct.	27.5	25.3	19.5	80.9	78.4	58.8
Oct./Nov.	6.7	3.6	6.4	67.6	81.9	61.6
Nov./Dec.	8.6	11.5	14.9	54.8	78.2	44.1
Dec./Jan.	5.0	5.3	6.0	60.5	75.8	48.7
Jan./Feb.	2.9	2.8	3.3	68.7	73.0	46.3
Feb./Mar.	0.9	1.5	1.3	76.9	75.7	46.5
Mar./Apr.	2.3	3.4	2.9	81.2	88.2	57.9
Apr./May	17.7	20.6	20.0	101.8	66.0	53.2
May/June	9.1	7.4	5.8	102.8	83.1	61.2
June/Jul.	9.2	10.2	10.2	101.9	87.2	57.9

Source: AIC

Table 2-14 PRICES OF FERTILIZERS AND AGRICULTURAL PRODUCTS

(Unit: NRS/ton)

	1970/71	1971/72	1972/73	1973/74 1/	1974/75	1975/76 2/	1976/77	1977/78	1978/79	1979/80	1980/81 3/
Fertilizer											
Ammonium Sulphate	850	1,000	1,000	1,658	1,658	1,870	1,870	1,870	1,870	1,870	2,400
Urea (A)	1,342	1,535	1,535	2,193	2,193	2,440	2,440	2,440	2,440	2,440	3,100
Complex	1,057	1,557	1,557	2,214	2,214	2,270	2,270	2,270	2,270	2,270	2,800
Agricultural Product											
Paddy (B)	1,260	1,410	1,650	1,760	1,690	1,740	1,590	1,920	1,990	1,930	2,560
Wheat (C)	1,440	1,660	2,290	2,470	3,110	2,510	2,170	2,460	2,600	2,730	3,070
(B/A)	0.94	0.92	1.07	0.80	0.82	0.71	0.65	0.79	0.82	0.79	0.85
(C/A)	1.07	1.08	1.49	1.13	1.42	1.03	0.89	1.01	1.07	1.12	0.99

Notes: 1/ Feb., 1974.
2/ Dec., 1975.
3/ Sept., 1980.
For detail see Table 2-15.

Source: AIC

Table 2-15 ANNUAL AVERAGE (NATIONAL) PRICE OF CHEMICAL FERTILIZER

(Unit: NRS/ton)

S.No.	Fiscal Year	A/Sul.21%N	Urea.46% N.	Complex (20:20:0)	Potash K_2O
1.	1973-74(I)	1,000.00	1,535.00	1,556.60	895.00
	Jan (II)	1,657.70	2,192.70	2,214.30	1,552.70
2.	1974-75	1,657.70	2,192.70	2,214.30	1,552.70
3.	1975-76 (I)	1,657.70	2,192.70	2,214.30	1,552.70
	Sept. (II)	2,200.00	3,050.00	2,670.00	1,050.00
	Dec. (III)	1,870.00	2,440.00	2,269.50	1,572.50
4.	1976-77	1,870.00	2,440.00	2,269.50	1,572.50
5.	1977-78	1,870.00	2,440.00	2,269.50	1,572.50

Source: Agriculture Inputs Corporation.

Table 2-16 PAST TREND OF NITROGEN FERTILIZER CONSUMPTION BY TYPE IN NEPAL

(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 2-17 CONSUMPTION OF NITROGEN FERTILIZER BY REGION IN NEPAL

(N ton)

	1975	1976	1977	1978	1979	1980	1981	1982
Eastern Dev. Region	753	991	1,215	1,284	1,461	1,413	1,540	1,372
High Hill	1	5	11	12	25	31	29	55
Hill	96	132	182	185	224	222	224	354
Terai	656	854	1,022	1,087	1,212	1,160	1,287	963
Central Dev. Region	6,341	7,846	9,512	10,215	11,387	13,047	13,261	15,702
High Hill	80	152	390	360	505	629	679	864
Hill	393	538	941	1,004	1,318	786	1,557	1,987
Kathmandu Valley	3,706	4,348	4,786	5,342	5,505	5,683	5,816	6,234
Terai	2,162	2,808	3,395	3,509	4,059	5,949	5,209	6,617
Western Dev. Region	1,095	1,389	1,786	1,744	2,088	2,103	2,553	2,787
High Hill	-	-	-	-	-	9	18	16
Hill	280	356	492	465	637	593	651	888
Terai	815	1,033	1,294	1,279	1,451	1,501	1,884	1,883
Mid-Western Dev. Region	156	292	333	329	415	325	396	777
High Hill	2	1	1	1	1	3	3	5
Hill	18	40	58	68	84	65	49	115
Terai	136	251	274	260	330	257	344	657
Far-Western Dev. Region	79	178	166	177	147	96	183	286
High Hill	1	0	1	0	3	3	4	15
Hill	20	31	41	39	48	26	58	18
Terai	58	147	124	138	96	67	121	253
Total	8,424	10,696	13,012	13,749	15,498	16,984	17,933	20,924
High Hill	84	158	403	373	534	675	733	955
Hill	807	1,097	1,714	1,761	2,311	1,692	2,539	3,362
Kathmandu Valley	3,706	4,348	4,786	5,342	5,505	5,683	5,816	6,234
Terai	3,827	5,093	6,109	6,273	7,148	8,934	8,845	10,373

Source: AIC

Table 2-18 ESTIMATED CROPWISE CONSUMPTION OF FERTILIZER IN NEPAL

	1974/1975		1975/1976		1976/1977	
	Quantity (ton)	% of total	Quantity (ton)	% of total	Quantity (ton)	% of total
Paddy	12,839	34	10,896	35	13,999	37
Wheat	18,948	52	15,565	50	18,539	49
Maize	1,093	3	1,245	4	1,325	3.5
Industrial Crops*/	2,186	6	1,868	6	2,270	6
Vegetables and others	1,823	5	1,557	5	1,702	4.5
Total	36,439	100	31,131	100	37,835	100

Note: */ Tobacco, Jute and Sugarcane.

Source: AIC and AMSD ("Distribution of Agriculture Inputs in Nepal"), 1978

Table 2-19 ESTIMATE OF FERTILIZED AREA RATIO BY CROP IN 1976/77

Crop	Estimated Fertilizer Consumption (ton) (A)	Recommended Dosage 1/ (kg/ha) (B)	Estimated Area Fertilized (C=A/B) ('000ha)	Cultivated Area (D) ('000ha)	Cultivated Area under Improved Varieties 4/ (E) ('000ha)	Fertilized Area as % of Cultivated Area (C/D) (%)	Fertilized Area as % of area under improved varieties (C/E) (%)
Paddy	13,999	90	155.5	1,261.7	222.6	12.3	69.9
Wheat	18,539	90	206.0	348.3	246.9	59.1	83.4
Maize	1,325	108	12.3	445.6	78.9	2.8	15.6
Industrial Crops 2/	2,270	40	56.8	51.0 3/	7.9	111.4	719.0

Notes: 1/ Applied 90% level of recommended dosage in Central Terai.

2/ The average of recommended dosages of sugarcane, jute, and tobacco weighted by cultivated area.

3/ Sugarcane, jute and tobacco only.

4/ In 1974/75.

Source: Study team estimate

Table 2-20 ANALYSIS OF INCREASE IN THE VALUE OF CROPS BY APPLICATION OF NITROGEN FERTILIZER

Crop	Agroclimatic variation	Market price of crop[1/] (NRS/MT)	Cost of fertilizer[2/] (NRS/Urea MT)	Nitrogen fertilizer response[3/]	Nitrogen fertilizer application level at which the increase in the value of yield is equivalent to[4/]: the cost of fertilizer[5/] (Nkg/ha)	twice of cost of fertilizer (Nkg/ha)	Recommended Dosage (Nkg/ha)
Paddy (I.V.)	Hill	2,250	3,100	$Y=3737+33.67x-0.1445x^2$	106	96	60-80
	Terai	2,250	3,100	$Y=2583+18.32x-0.06159x^2$	125	100	100
	Inner Terai	2,250	3,100	$Y=3094+23.31x-0.08x^2$	127	108	80
Paddy (L.V.)	Inner Terai	2,250	3,100	$Y=2740+21.79x-0.155x^2$	61	51	30
	E. Terai (Morang)	2,250	3,100	$Y=2404+5.84x-0.075x^2$	19	6/	40
	W. Terai (Banke)	2,250	3,100	$Y=1546+11.89x-0.1938x^2$	23	15	40
Wheat	Hill	2,700	3,100	$Y=1666+22.54x-0.03706x^2$	271	237	60-80
	Terai	2,700	3,100	$Y=1528+23.3x-0.065x^2$	160	141	80-100
	Inner Terai	2,700	3,100	$Y=2524+32.14x-0.16x^2$	93	85	80
Maize	M. Hill	2,370	3,100	$Y=1821+3.58x-0.009x^2$	42	6/	Not available
	Hill	2,370	3,100	$Y=1826+39.85x-0.09x^2$	206	190	80-100
	Inner Terai	2,370	3,100	$Y=961+12.16x-0.0306x^2$	177	156	100-120

Explanatory notes:

1/ As of september, 1980. National average retail price.

2/ As of septermber, 1980. At A.I.C.'s godown. Transportation costs and distribution costs after godown and the application costs are not included.

3/ Calculated from the data in Annex II-2.

x: Nitrogen fertilizer applied (N kg/ha.)

Y: Yield (kg/ha.)

4/ When the fertilizer response is given in the formula (1), the increase in the value of yield with application of x Nkgs of nitrogen fertilizer, is calculated by the formula (2).

$$Y = a + bx + cx^2 \quad \text{—— (1)}$$

$$Y' = (b+2cx) \times d \quad \text{—— (2)}$$

Where, x = Nitrogen fertilizer applied (Nkg/ha.)

Y = Yield (kg/ha.)

Y' = increase in the value of yield with application of x Nkgs of nitrogen fertilizer (RS)

d = price of crop (RS/kg)

When the cost of fertilizer is given by e, the nitrogen fertilizer application level, at which the increase in the value of yield is equivalent to n times of cost of fertilizer, can be obtained by the following formula.

$$x = \frac{1}{2c}\left(n \times \frac{e}{d} - b\right)$$

5/ Since the prices of both crop and fertilizer are expressed in market price, if the level is calculated using farmers' gate prices, the result may be less favorable than thus obtained.

6/ Impossible to expect the increase in the value of yield at twice of cost level.

Table 2-21 DIFFUSION OF IMPROVED VARIETIES IN NEPAL

Year	Development Region	Paddy			Wheat			Maize		
		Cultivated Area (A) ('000 ha)	Area under I.V. (B) ('000 ha)	B/A (%)	Cultivated Area (A) ('000 ha)	Area under I.V. (B) ('000 ha)	B/A (%)	Cultivated Area (A) ('000 ha)	Area under I.V. (B) ('000 ha)	B/A (%)
1971/72	Eastern	368.7	13.5	3.7	28.8	17.8	61.8	85.8	2.1	2.4
	Central	417.1	45.7	11.0	83.8	58.9	70.3	144.6	11.5	8.0
	Western	211.3	13.6	6.4	50.1	23.3	46.5	98.9	1.8	1.8
	Far-Western	203.6	8.8	4.3	76.5	8.0	10.5	189.0	4.1	2.2
	Total	1,200.7	81.6	6.8	239.2	108.0	45.2	518.3	19.5	3.8
1972/73	Eastern	353.4	24.9	7.1	35.6	30.1	84.6	88.1	6.0	6.8
	Central	392.7	102.9	26.2	99.8	82.6	82.8	146.5	16.3	11.1
	Western	200.8	33.0	16.4	51.4	37.4	72.8	99.8	7.1	7.1
	Far-Western	193.1	16.3	8.4	79.6	20.9	26.3	192.2	6.2	3.2
	Total	1,140.0	177.1	15.5	266.4	171.0	64.2	526.6	35.6	6.8
1973/74	Eastern	385.4	31.9	8.3	37.3	35.6	95.4	68.1	9.3	13.7
	Central	413.1	106.0	25.7	99.0	89.1	90.0	148.1	31.4	21.2
	Western	214.0	40.7	19.0	54.6	56.4	103.3	101.0	16.1	15.9
	Far-Western	207.6	26.5	12.8	82.3	25.6	31.1	189.7	18.0	9.5
	Total	1,220.1	205.1	16.8	273.2	206.7	75.7	506.9	74.8	14.8
1974/75	Eastern	390.5	42.7	10.9	45.2	50.4	111.5	95.5	8.4	8.8
	Central	415.8	91.4	22.0	104.3	107.3	102.9	149.2	30.5	20.4
	Western	216.0	62.2	28.8	59.0	60.3	102.2	102.0	21.7	21.3
	Far-Western	210.3	26.3	12.5	81.2	28.9	35.6	194.1	18.3	9.4
	Total	1,232.6	222.6	18.1	289.7	246.9	85.2	540.8	78.9	14.6

Source: ARSAP, "Marketing, Distribution and Use of Fertilizer in Nepal." (1977)

Table 2-22 PROJECTION OF DEMAND FOR NITROGEN FERTILIZER AT VARIOUS LEVELS IN NEPAL

(N ton)

	1975	1980	1985	1990	1995	2000
BASE CASE						
Eastern	753	1,413	1,721	2,404	2,476	2,511
Central	2,635	7,364	10,082	12,160	12,985	13,041
Kathmandu Valley	3,706	5,683	6,743	7,591	8,303	8,808
Western	1,095	2,103	3,051	3,974	4,661	4,941
Mid-Western	156	325	597	870	887	1,064
Far-Western	79	96	295	321	498	513
Total	8,424	16,984	22,489	27,320	29,810	30,878
CASE A	9,116	18,342	24,061	28,666	32,327	34,525
CASE B	9,807	19,700	26,918	31,831	35,032	37,841
CASE C	8,374	17,206	22,528	26,663	30,062	32,241

Notes: Case A assumed that the past demand was 10% higher than actual consumption.
Case B assumed that the past demand was 20% higher than actual consumption.
Case C assumed that the past demand was 10% higher than actual consumption, except for Kathmandu valley, where the former was 10% lower than the later.

Table 2-23 PROJECTED DEMAND FOR NITROGEN FERTILIZER IN NEPAL

(Finally Selected Case)

	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	24,354
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 2-24 EXPECTED SALES VOLUME OF UREA

(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.

Year	Maximum Expected Sales Volume of Urea
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 2-25 MONTHLY STOCK REQUIREMENT OF UREA

(Unit: % of yearly shipment total)

	Monthly shipment volume in the past		Projected maximum monthly shipment 1/	Minimum required carry over from the previous month 2/	Optimum carry over from the previous month 3/
	Average of 1976/77-78/79 (A)	Standard error (B)	(C)=((A)+(B)x2)	(C)-4.2	
Jul./Aug.	5.0	1.0	7.0	2.8	20.8
Aug./Sep.	4.4	0.5	5.4	1.2	23.8
Sep./Oct.	24.1	4.1	32.3	28.1	28.1
Oct./Nov.	5.6	1.7	9.0	4.8	12.3
Nov./Dec.	11.7	3.2	18.1	13.9	15.1
Dec./Jan.	5.4	0.5	6.4	2.2	11.7
Jan./Feb.	3.0	0.3	3.6	0.0	14.6
Feb./Mar.	1.2	0.3	1.8	0.0	20.0
Mar./Apr.	2.9	0.5	3.9	0.0	27.1
Apr./May	19.4	1.6	22.6	18.4	32.5
May/Jun.	7.4	1.7	10.8	6.6	21.5
Jun./Jul.	9.9	0.5	10.9	6.7	22.4

Notes: 1/ Assumed the probability of risk for the shipment volume to exceed the projected volume at less than 5%.

2/ Assumed that the production is made evenly all year round, and a half of production volume in the month (or 4.2% of yearly production) can be shipped in the month.

3/ Including the carry over at stock points.

Table 2-26 PRICE AND IMPORT COSTS OF UREA IN NEPAL

	As of 1976/77		As of 1982/83	
	in NRS	in US$	in NRS	in US$
Nepal official price (incl. retailer mark-up)	2,440.00	195.20	3,100.00	231.34
Indian border price	3,140.13	251.21	3,498.87	261.11
	(IRS 2,250.00)		(IRS 2,467.50)	
Average import price in India	(IRS 1,110.09)	123.94	(Not Available)	N.A.
Import Costs				
CIF Calcutta	1,600.13	128.01	2,775.98	207.16
Costs and fees excl. transp costs in India[1/]	377.84	30.23	524.32	39.13
Transportation costs in Nepal	159.18	12.73	237.06	17.69
Other direct costs in Nepal	78.42	6.27	108.82	8.12
Total direct costs	2,215.57	177.25	3,646.18	272.10
Marketing/distribution costs in Nepal	436.03	34.88	481.40	35.93
Total import costs (ex-retail) (incl. retailer mark-up)	2,651.60	212.13	4,127.58	308.03

Source: AIC

Table 2-27 PROJECTION OF UREA PRICE
(At 1984 constant US dollars/ton)

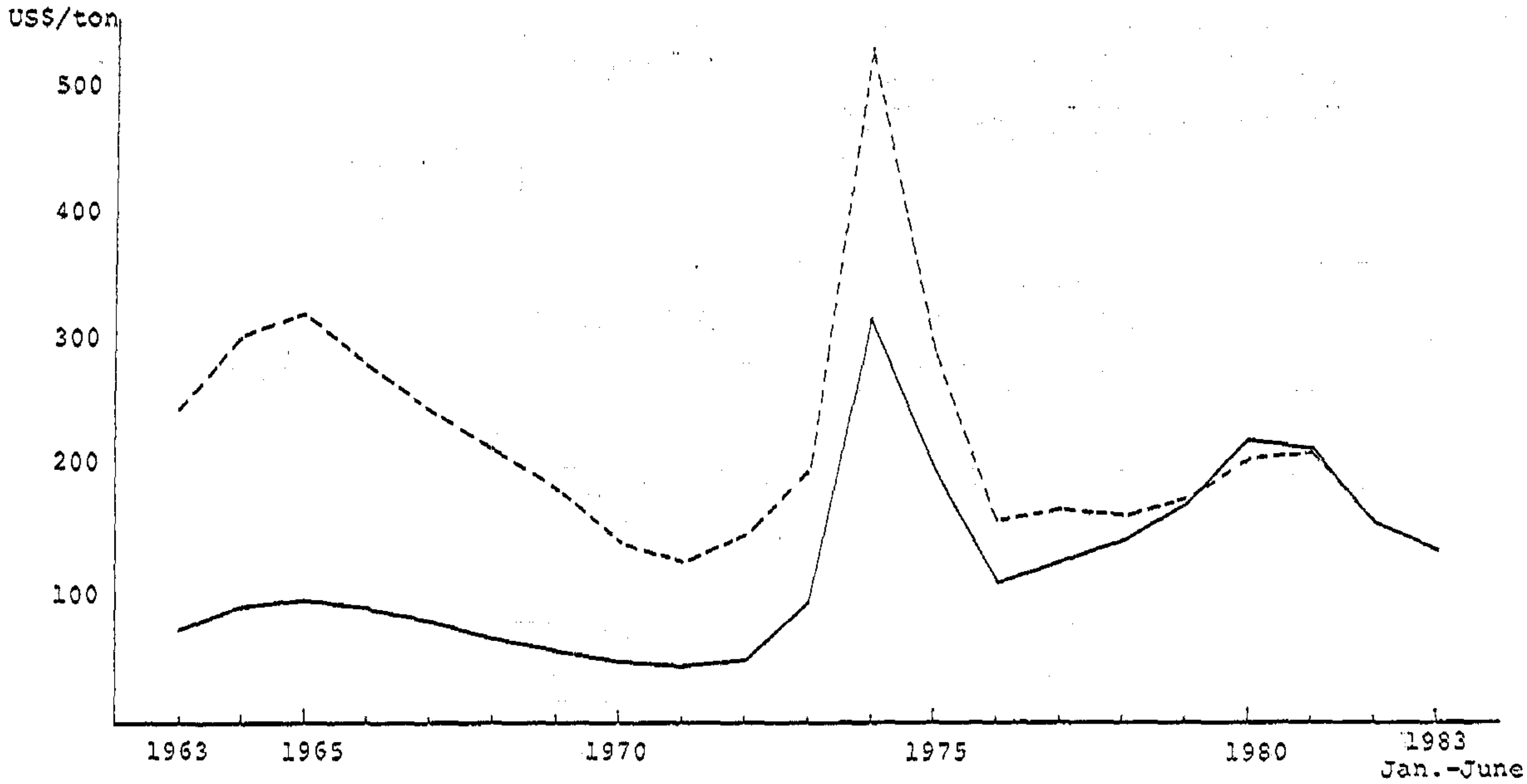
	1983 (Estimated)	1985	1990	1995	2000
CIF Calcutta (Bagged) (A)	192	225	255	269	279
Cost up to retailers (B)	93	93	93	93	93
Total import costs (A+B) (ex-retailers)	285	313	348	362	372
Transportation cost from the project site to the market (C)	9	9	9	9	9
Retailer mark-up (D)	16	18	20	21	21
Ex-factory price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

Figure 2-1 PAST TREND OF INTERNATIONAL MARKET PRICE OF UREA



Note: ——— Current dollars
----- Constant dollars

Source: World Bank

Figure 2-2 TYPICAL CULTIVATION PATTERNS IN NEPAL

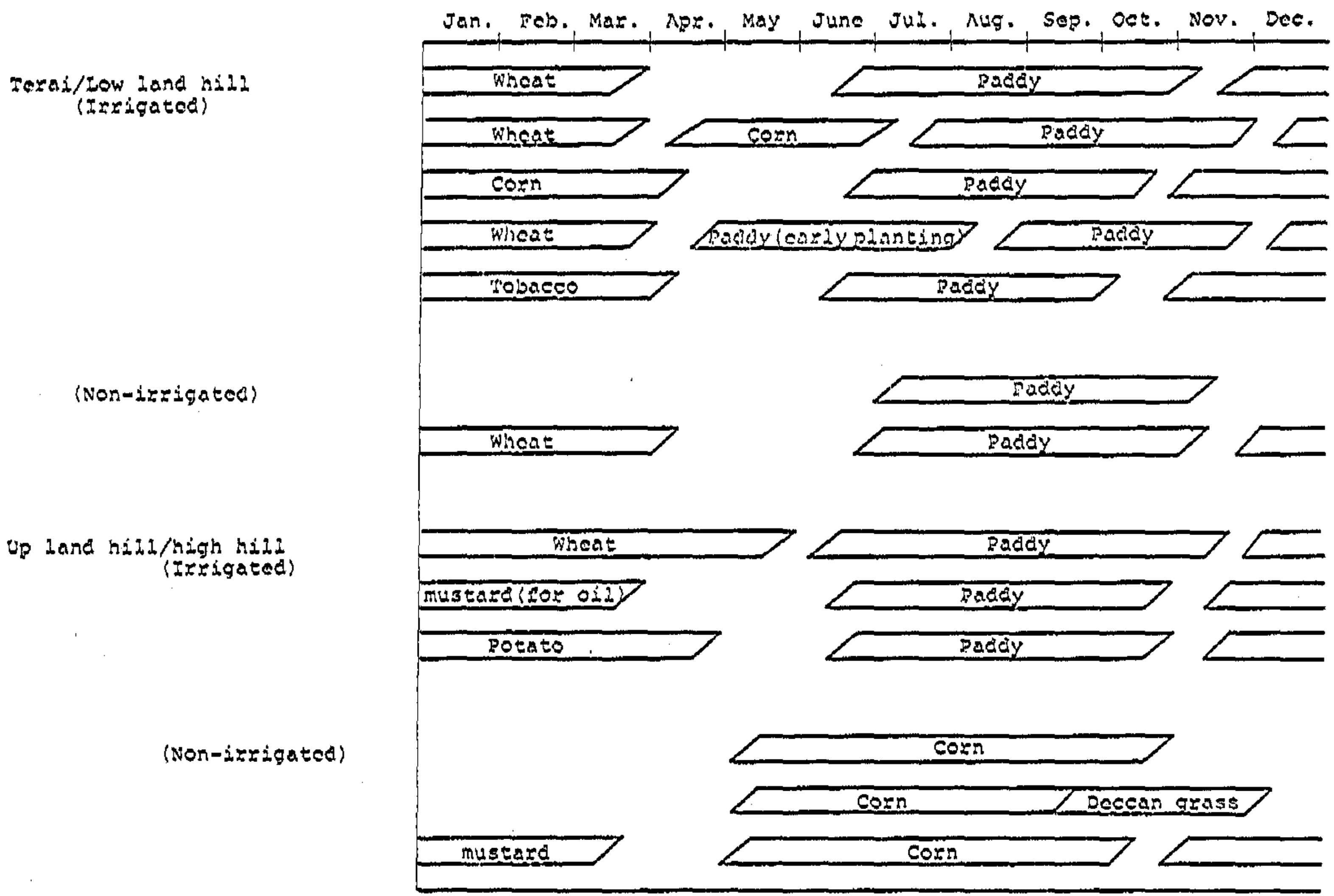


Figure 2-3 FERTILIZER CONSUMPTION TREND IN NEPAL

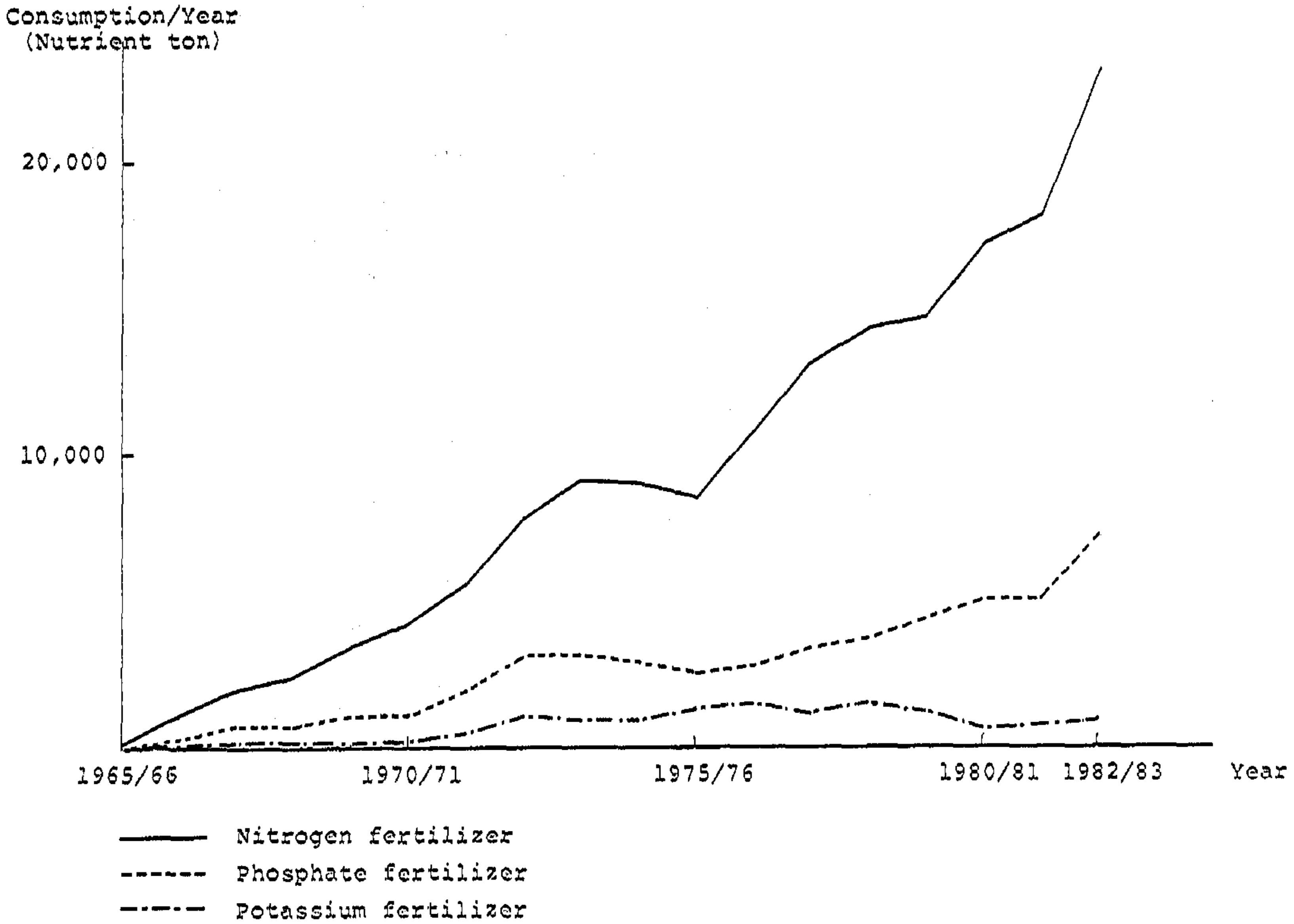


Figure 2-4 DISTRIBUTION CHANNEL OF FERTILIZER IN NEPAL

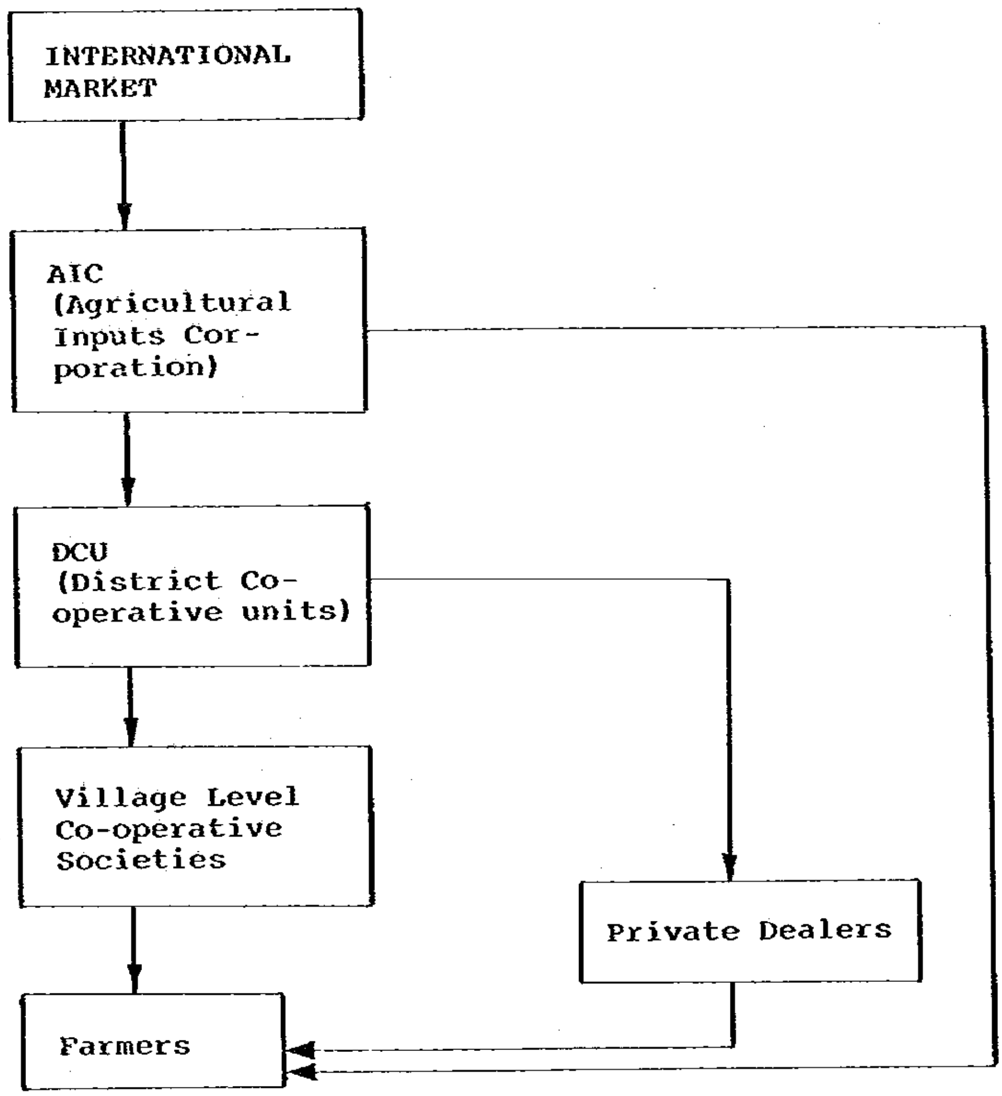
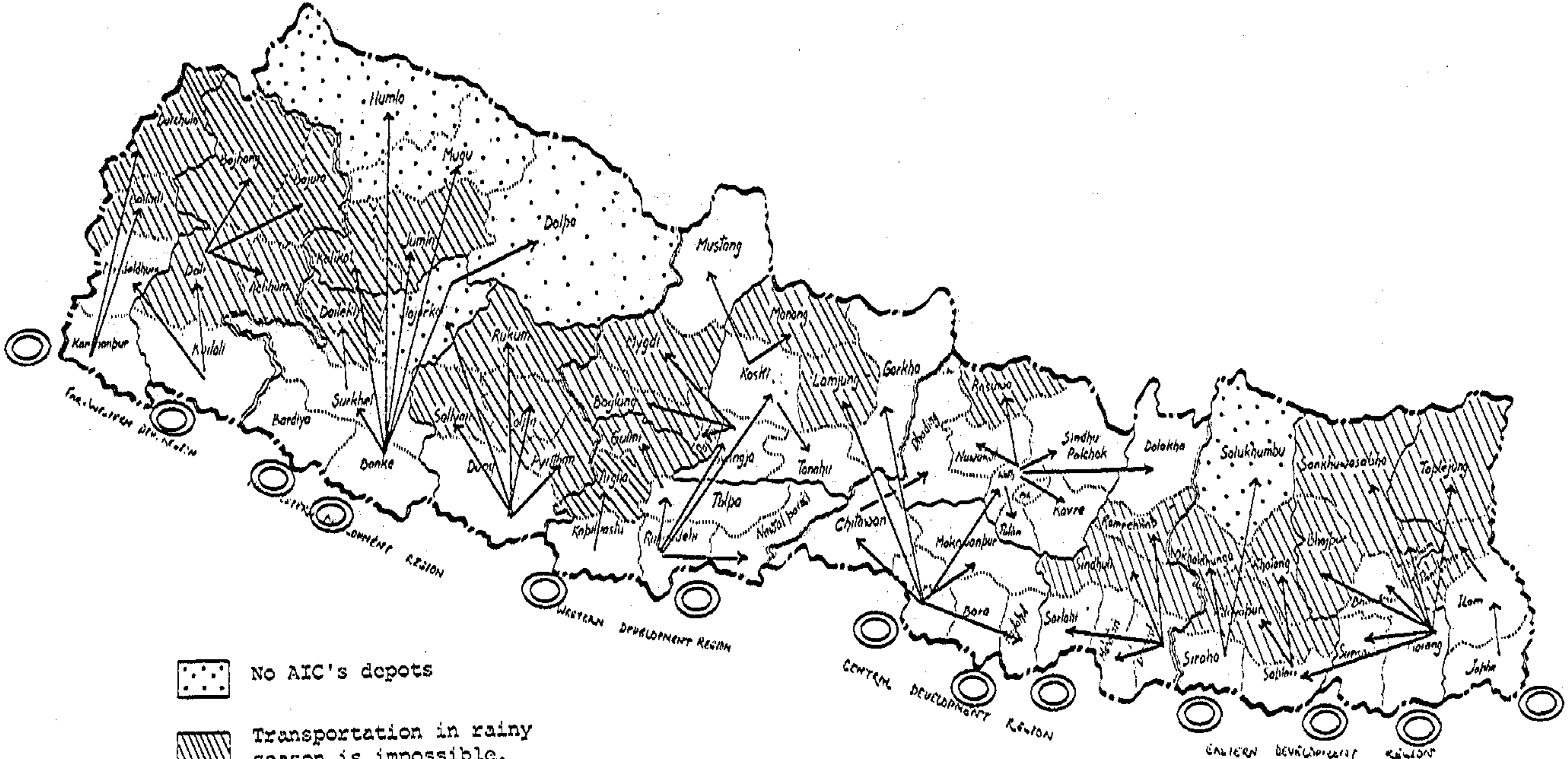


Figure 2-5 DISTRIBUTION OF IMPORTED FERTILIZER IN NEPAL



No AIC's depots

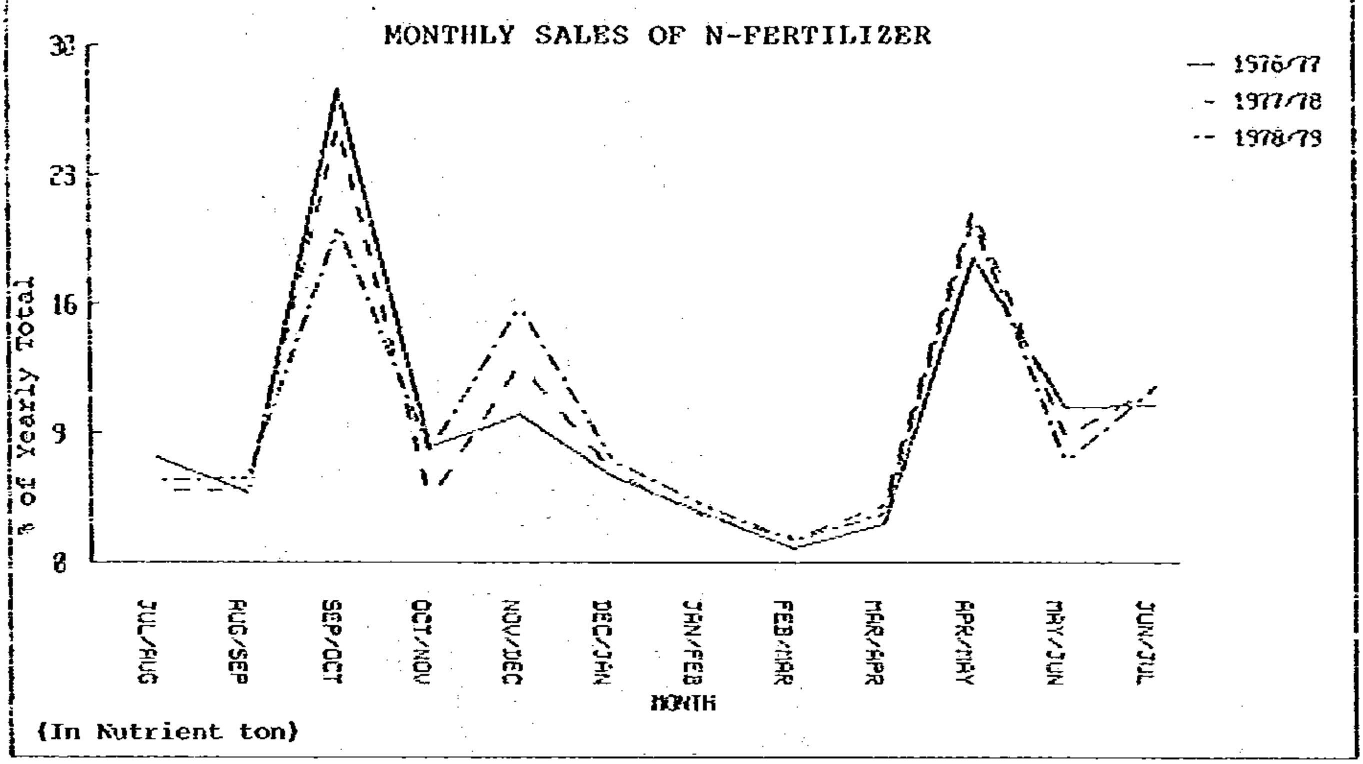
Transportation in rainy season is impossible.

Rail head

Distribution line

Source: AIC

Figure 2-6 SEASONAL CHANGE IN THE SHIPMENT



SEASONAL CHANGE IN INVENTORY

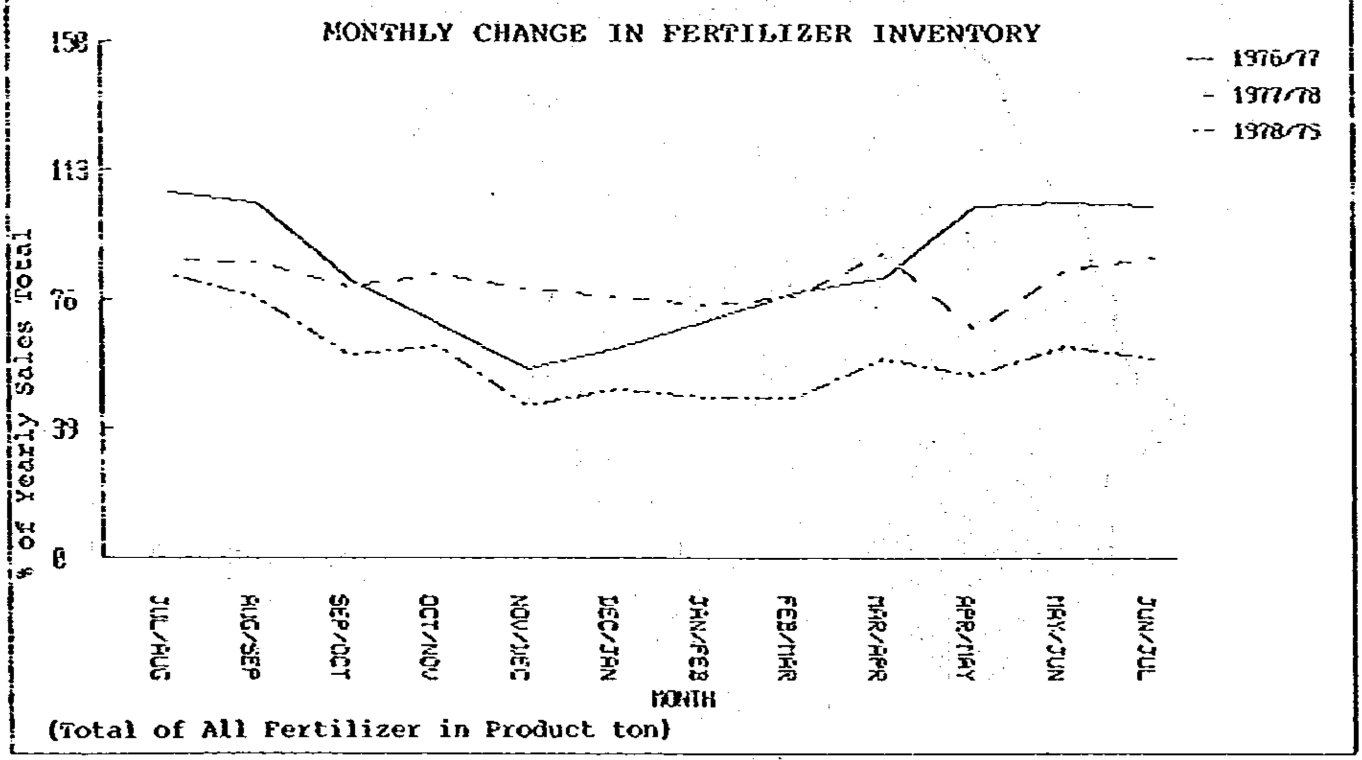
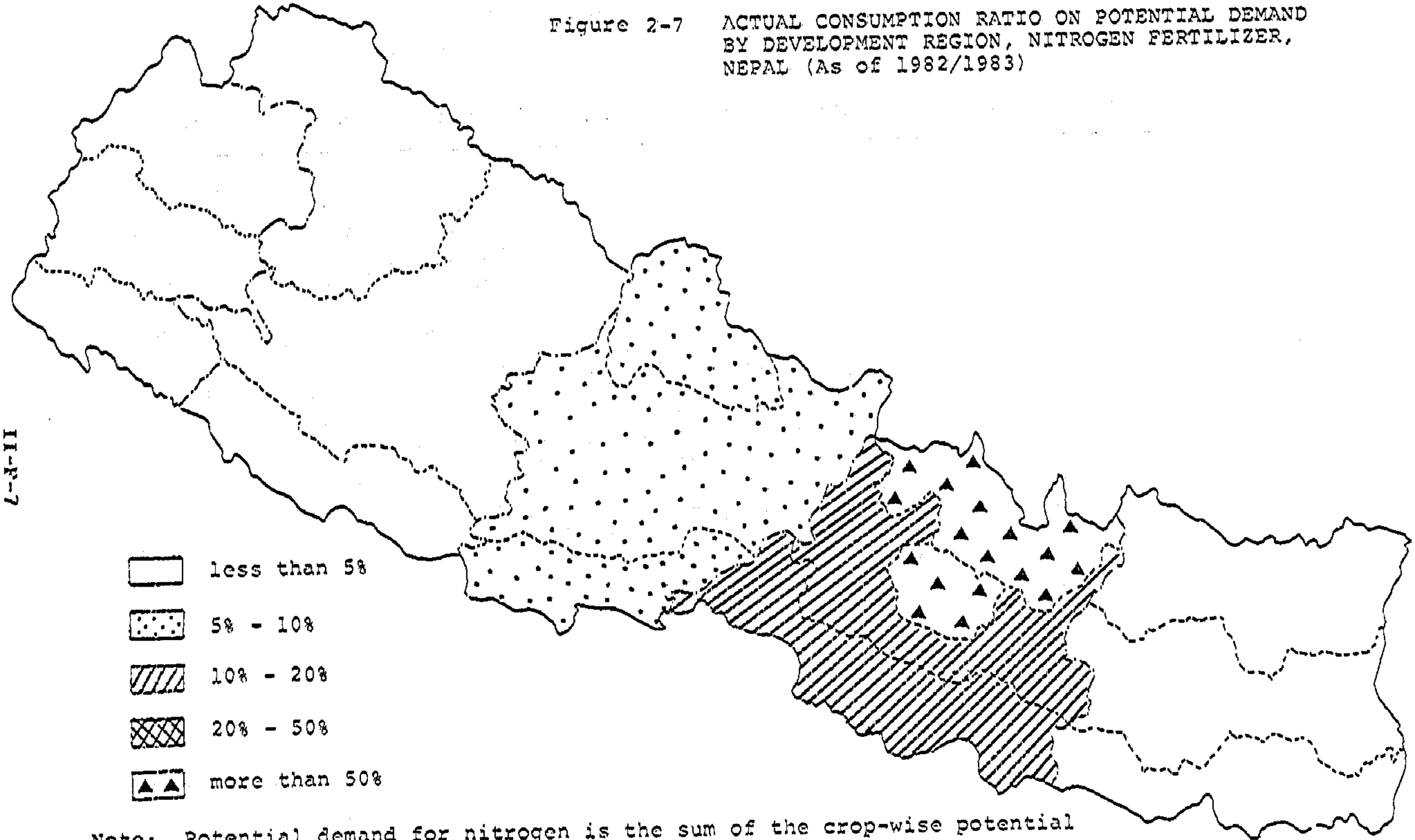


Figure 2-7 ACTUAL CONSUMPTION RATIO ON POTENTIAL DEMAND BY DEVELOPMENT REGION, NITROGEN FERTILIZER, NEPAL (As of 1982/1983)



Note: Potential demand for nitrogen is the sum of the crop-wise potential demands calculated as follows:
(Crop-wise potential demand) = (Recommended dosage of nitrogen) x (Cropped area)

Source: Study team estimate

Figure 2-8 PAST TREND AND PROJECTION OF NITROGEN FERTILIZER CONSUMPTION IN NEPAL

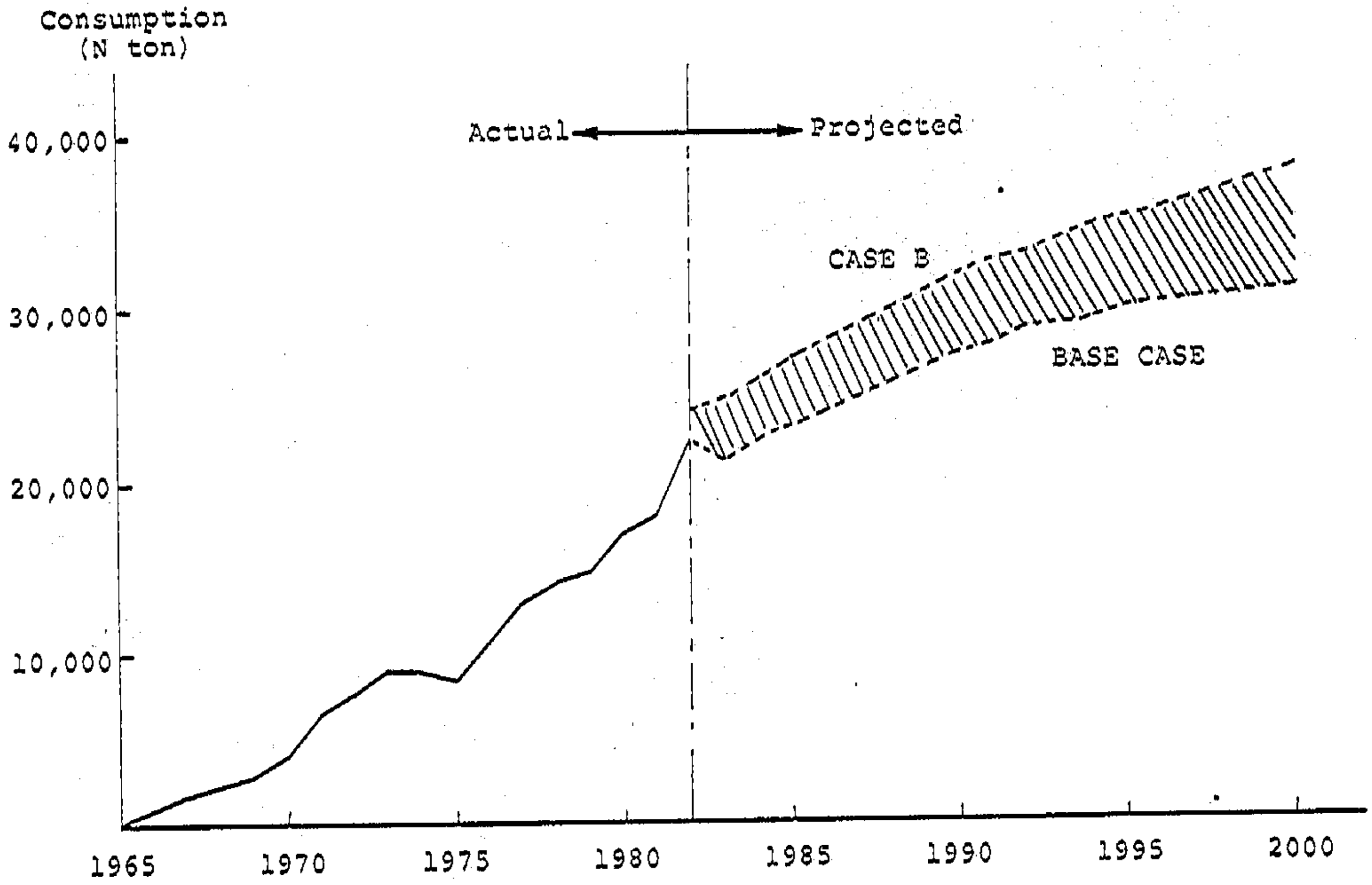
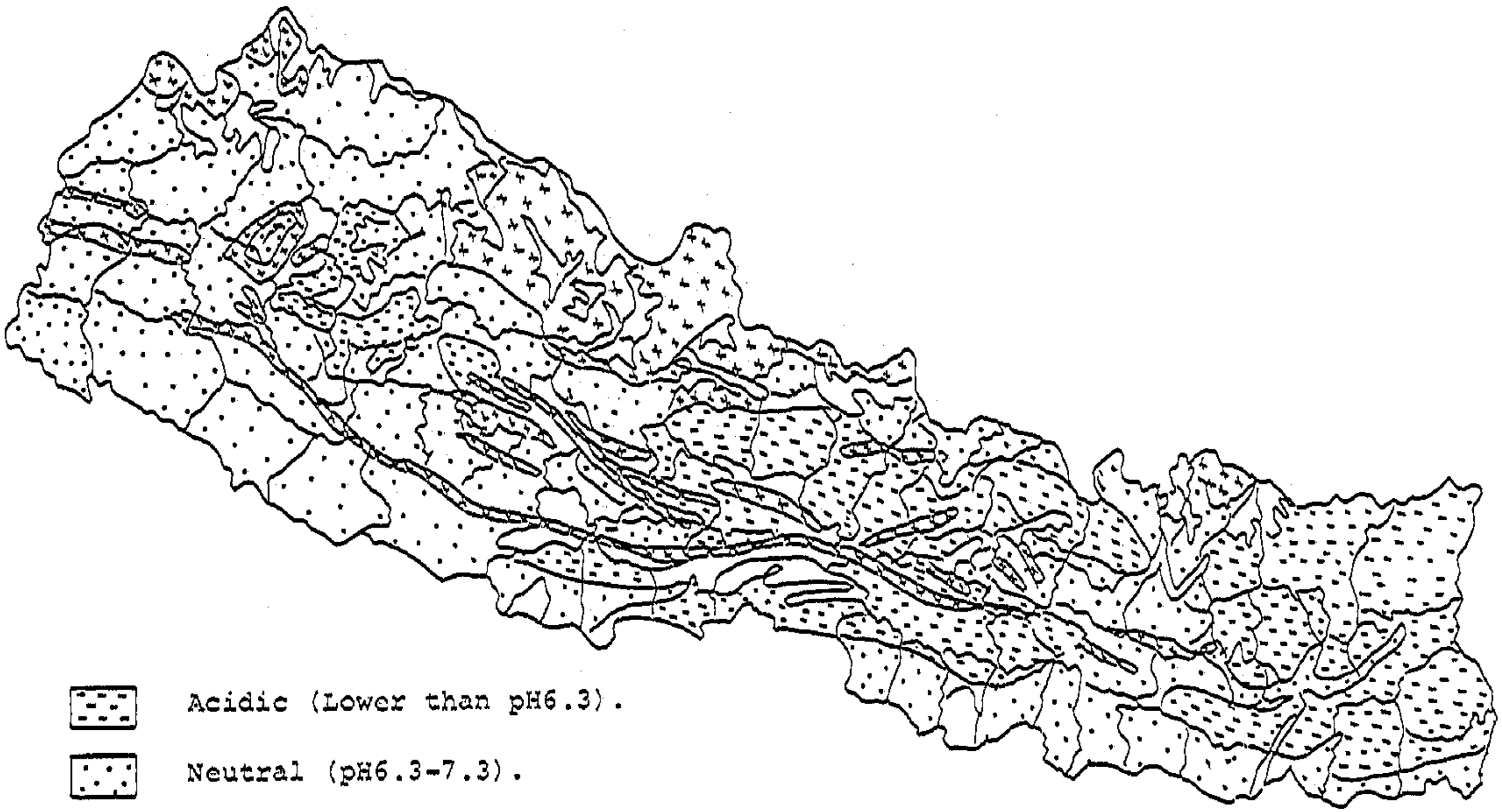


Figure 2-9 SOIL REACTION MAP OF NEPAL
(Provincional)

1:5000000



Acidic (Lower than pH6.3).

Neutral (pH6.3-7.3).

Alkaline (Higher than pH7.3. Rarely exceeds 8.3).

Snow cover.

Source: Division of Soil Science and Agricultural Chemicals, Department of Agriculture.

Part III TECHNICAL ASPECTS

Part III TECHNICAL ASPECTS

Chapter 1 Introduction

Part III describes the study and analysis results of various technical aspects of the establishment of a urea fertilizer plant in the Kingdom of Nepal, regarding the optimum selection of the type of final product, the plant location, capacity of the plant and schedule of plant completion, and further explains the conceptual design, implementation schedule, basic and detailed engineering, procurement, type of construction contract and organization planning of the urea fertilizer plant project.

Regarding the selection of final product, as is discussed in Part II, the most important nitrogen fertilizer in Nepal is urea fertilizer. It is concluded that besides urea, small-scale market demand for other nitrogen fertilizers such as ammonium sulfate or ammonium nitrate is anticipated, but it is neither economical nor practical to produce a multiple number of nitrogen fertilizer products in one plant due to the economies of scale. The type of product most suitable for the first fertilizer plant in Nepal, is determined by this study to be urea fertilizer. The feasibility study by UNIDO in 1981 also recommends setting up a urea plant with a 100 TPD capacity in Nepal.

The generally used process for the production of urea is to consume hydrocarbons as major raw material at an ammonia plant which produces liquid ammonia as the main product as well as carbon dioxide as co-product, and then both intermediates ammonia and carbon dioxide are fed to urea plant to produce urea fertilizer.

However, in Nepal, no domestic hydrocarbon resources such as coal, petroleum, natural gas or bio-masses for the commercial production of urea are available. The only possible way to produce urea fertilizer in Nepal is to produce liquid ammonia from electrolysis hydrogen by utilizing hydropower potential and to seek a carbon dioxide source separately.

Therefore, the most important factors for the selection of the production capacity of the urea fertilizer plant are the suppliability of carbon dioxide and electric power as well as the domestic marketability of urea fertilizer. The following five technical aspects must be carefully investigated to determine the recommendable urea production capacity:

1. Completion year of the plant
2. Domestic marketability of urea fertilizer
3. Supply of electric power
4. Supply of carbon dioxide
5. Countermeasures in facility design and operational pattern of urea fertilizer plant under limited supply conditions of electric power and carbon dioxide

The general trend of urea fertilizer plants, both under construction and in operation throughout the world, is to utilize natural gas as raw material to produce 1,000 to 1,750 TPD of urea at a single-train plant to realize the economies of scale to the maximum extent. Quite different from this, the originally planned capacity for Nepal is 100 TPD. However, it is recommendable to establish a maximum capacity plant as far as the marketability of the product and the suppliability of carbon dioxide and electric power permit, to have assurance of the financial viability of the project.

The results of study on the suppliability of electric power in Nepal reveal that the supply and demand of electric power is greatly imbalanced seasonally during the year and also hourly during the day. Under such limited suppliability of electric power, the special considerations for facility design and operational pattern of the urea fertilizer plant are essential factors for the determination of plant capacity.

It will take at least five years from now on for the planning and construction of a urea plant, and therefore it is reasonable to assume the completion date of the project is 1989 at earliest. The calculation results, on urea marketability, electric power availability, plant capacity and unit production costs, show the optimum scheme is to construct a urea fertilizer plant with 275 TPD capacity which would be completed in 1991 to meet the additional electric power supply from the hydropower plant in Sapta Gandaki.

The selection of plant location is limited to among the adjacent sites of the two cement plant, either Himal Cement Co.,(PVT) Ltd., Kathmandu or Hetauda Cement Ind., Ltd., Hetauda. The study results reveal that the site conditions at Hetauda are better in terms of the suppliability of carbon dioxide and electric power as well as the availability of a large and level area for the plant.

The additional technical aspects studies are on:

(1) Suitability of plant site conditions in Hetauda

(2) Suppliability of carbon dioxide from the cement plant

(3) Basic plan and conceptual design of the urea fertilizer plant, taking into consideration local conditions in Hetauda, type and specification of product and plant capacity, plot plan, design basis, raw material and utility balance, conceptual design of related facilities, and the optimum design and operational pattern of electrolysis, ammonia and carbon dioxide plants

(4) Implementation schedule, type of plant construction contract, organization, personnel and training, and required technical services of consultants and advisors for the realization of urea fertilizer plant

The project plan of 275 TPD urea fertilizer plant, located in Hetauda and completed in 1991, are prepared as an optimum project and which is used for financial analysis and economic evaluation of the proposed project.

Chapter 2 Supply of Electric Power

2-1 Outline of supply of electric power in Nepal

2-1-1 Electric power supply system

Most electric power in Nepal is supplied by the public sector and only a limited quantity is generated and consumed by the private sector. The total generating capacity in the public sector is 128 MW (84%) by hydropower stations and 25 MW (16%) by diesel electric power generators. The total private capacity is 12 MW; 7 MW by diesel and 5 MW by thermal means using coal imported from India. A list of electric power stations is shown in Table 3-1. Additional electric power of 52 GWh (net) is imported from India in accordance with the Nepal-India Agreement of October, 1971 which permits the export and import of electric power through 16 power lines at the border.

Imports and exports were 57 and 5 GWh in 1981/82 resulting net imports of 52 GWh which is equivalent to 19% of total supply of Nepal. The governmental organization responsible for the electric power development in Nepal is the Ministry of Water Resources and its Electricity Department is managing the planning and construction of electric power station, transmission and distribution lines.

The supply of electric power is managed by two organizations. One is the Nepal Electricity Corporation which is public, and which distributes power in the Central, Eastern and Western Development Region of Nepal from seven hydropower plants (51.95 MW) and from eleven diesel plants (21.27 MW). The total generating power at NEC in 1981/82 is 189.84 GWh (hydro; 180.39 and diesel; 9.45 GWh) which is approximately 83% of the generation in Nepal. The second one is the Butwal Power Co., which is private and has a power plant (1.2 MW) in Butwal. The distribution of electric power in the Far Western Development Region is directly controlled by the Electricity Department.

Transmission lines are the most developed in the Central Region. The trunk line connects Kathmandu, Hetauda and Birganj and is further linked with the 132 kV line from the Gandak (Sarajpur) hydropower plant to Hetauda through Bharatpur. Another 132 kV line between Bharatpur and Pokhara links the Central and Western Regions. The new line of 132 kV is now under construction between Hetauda and Biratnagar and will be completed in 1985/86; it will connect the Eastern Region with Central Region by the truck line.

The Electricity Department is now planning to construct a trunk line from Nepalgunj in Far Western Region to Bharatpur through Butwal which will complete the nation-wide overall grid system to cover major regions of Nepal. The power distribution system in Nepal is shown in Figure 3-1.

2-1-2 Supply and demand trend of electric power

The supply and demand of electric power in the last eleven years from 1970/71 to 1981/82 is illustrated in Table 3-2. The average annual growth rate of demand in the period was 15% annually.

The annual demand growth rates fluctuate greatly, namely more than 20% is observed from 1970/71 to 1974/75, decrease to 10% from 1975/76 to 1977/78 and further decrease from 1977/78 to 1980/81. However, such decreases of the growth rate are considered attributable to the limited supply of electric power instead of actual decrease of demand, because during all those period unsufficient conditions of power were observed.

The increase of demand over 20% was observed again in 1981/82 when the hydropower plant of Kulekhani No.1 and the distribution network in Kathmandu was completed. At present, small surplus supply of power exists, but in a few years, it is anticipated that there will be a deficit again.

In the past, most consumption was for household uses, which has accounted for approximately 50% of total demand, of the rest, 30% is for industrial uses and 20% is for commercial, street lighting and irrigation uses.

It is noted that losses of electric power are substantial and is equal to approximately 30% of total supply (or 40% of total generation). From the viewpoint of the present and future industrialization of Nepal, it is expected that the demand pattern of electric power in the future would continue to show this pattern.

2-2 Prospect of electric power supply

2-2-1 Demand forecast of electric power

Studies on the future demand of electric power in Nepal were undertaken by the Electricity Department of Nepal, the Asian Development Bank and also by the World Bank. The results of these studies predict a similar tendency in their demand projections, therefore the study by the Electricity Department is referred to as the basis of the demand forecast of electric power in Nepal made for this study.

In Table 3-3, the demand forecast up to the year of 2002 is shown; during the ten years from 1982/83 to 1992/93, the average annual demand growth of 16.4% is expected and annual total power demand increases from 284.9 to 1,299.4 GWh, the peak demand is from 67.8 to 293.1 MW, and the load factor is from 48 to 51%, respectively. In next nine years from 1992/93 to 2001/02, the average annual increase of 11.1% is expected and the load factor increases to 53% in 2002. In this demand forecast, the increase in electric power demand caused by the realization of the urea fertilizer plant is not included. This additional demand is discussed in 2-4-1 in Part III of the report.

2-2-2 Electric power development plan

Plans to increase electric power generation which would be realized by 1988/89, and suppliability of electric power in Nepal, are shown in Table 3-4. The Electricity Department is now constructing the Kulekhani No. 2 (32 MW) and Andhikhola (5 MW) hydropower plants and is expected to start construction of the Marsyangdi plant (66 MW). After the completion of these plants, the generating capability and annual supply in Nepal would be 254.76 MW and 1,181.50 GWh, respectively, by 1988/89.

Further, the construction of the Sapta Gandaki hydropower plant (225 MW) is now planned. Financing for the project has not yet been determined. Therefore the completion date of the plant has not been decided, but the Electricity Department has set the completion target date of the first, second and third phase of the Sapta Gandaki as 1991/92, 1992/93 and 1993/94, respectively.

The supply and demand forecast, shown in Figure 3-2, is based upon the data illustrated in Table 3-3 and Table 3-4. It also assumes that the completion of Sapta Gandaki is in accordance with the schedule of the Electricity Department. The figure shows that the supply and demand would be balanced up to 1985/86 and then supply would be unsufficient from 1986/87 to 1987/88. The situation will be improved by the completion of the Marsyandi plant in 1988/89. However, if the completion of Sapta Gandaki is delayed, the deficit would be observed even in 1990/91.

The completion of Sapta Gandaki is, therefore the most influential factor in the supply of electric power in Nepal, regardless of the realization of the urea fertilizer plant.

It is anticipated that up to at least 1995/96 the supply will exceed the domestic demand growth, if the Sapta Gandaki is completed from 1991/92 to 1993/94. However, again in after 1996/97 the deficit would be anticipated, therefore unless a series of power plant projects are implemented, even after the completion of Sapta Gandaki, it is clear that the supply would be in chronic deficit.

Several potential sites for development of large scale hydropower plants have been identified by past studies and it is possible to maintain supply to meet future demand, if such projects are implemented. Generally, detailed study and planning, and also a large investments, are required for such projects. The risk of delay is also high as it can be expected to lead to shortage of electric power supply.

At present, therefore, it is not possible to make a reliable projection of supply and demand in the 1990's, because no plan for power plant construction after Sapta Gandaki has been approved. However, to realize the urea fertilizer plant, it is recommended to make and use a reliable projection of electric power supply and demand because long term and stable supply of electric power is an essential requirement for the urea fertilizer plant project.

By investigating the details of these projection, following situations can be anticipated:

(1) A surplus every month of the year is expected from 1985 and 1986, but the maximum monthly surplus is only 15 GWh.

(2) The annual generating capability is less than the projected annual demand from the second half of 1986 to the first half of 1988.

(3) A monthly surplus of 23 to 37 GWh is expected for four months from July, 1988 to May, 1989 and also for three months from May, 1989 to August, 1989 after the completion of Marsyandi. The surplus decreases to less than 20 GWh monthly for six months from November, 1988 to May, 1989, and is further reduced to less than 10 GWh from January to April.

(4) In spite of demand increases, there is no increase in generation capacity from the second half of 1989 to the first half of 1991, and therefore the surplus would be reduced. During the period, only in the five months from July to August, 1989 and May to July, 1990 would there be a monthly surplus of more than 20 GWh.

(5) The surplus will greatly increase when the three stages of Sapta Gandaki are completed in mid-1991, 1992, and 1993. The surplus would be 60 to 70 GWh in July and August of 1991, 50 GWh in September and October and 30 to 40 GWh in November and December, 1991. In 1992, the surplus would be 20 to 30 GWh in January to March but would recover to 46 GWh in April and a surplus level of 60 to 110 GWh would thereafter exist from May to December. In 1993, the monthly surplus is 30 to 47 GWh in January to March and 70 to 160 GWh the rest of the year, and a similar situation is expected in 1994.

(6) The situation in 1995 and onward will depend upon the realization of post-Sapta Gandaki projects. If the projects are delayed, no surplus is expected in January to March and December, 1995, January to April and December, both in 1996 and 1997, and January to April and November to December, both in 1998 and 1999. The rest of the months would have a monthly surplus of more than 60 GWh. After 1999 the surplus would be greatly reduced. Therefore, as mentioned in 2-2-2, it is an essential to guarantee the implementation of Sapta Gandaki and post-Sapta Gandaki projects to supply adequate electric power.

2-3 Demand characteristic of electric power in Nepal

2-3-1 Seasonal demand fluctuation and its influence

The rainy season for four to five months from June to September and the dry season for seven to eight months from October to May are annual observation in Nepal. All hydropower electric generating plants are run-of-river type with one exception Kulekhani No. 1 which is of the water storage type.

The hydropower plants under construction stage are of the run-of-river type for Andhikhola and Marsyandi, and the storage type for Kulekhani No. 2. The planning stage plant for Sapta Gandaki is also a run-of-river type. Therefore, except Kulekhani No. 1 and No. 2, the electric power generation is greatly reduced in the dry season, because it is impossible to store the surplus river water during the rainy season and utilize in dry season.

On the other hand, the demand for electric power increases in the dry season because consumption for home heating increases as the temperature is low during in the dry season. Therefore, the supply and demand situation is very tight in every dry season, especially in January to March. The projected monthly supply and demand are illustrated in Tables 3-5, 3-6 and 3-7, and also in Figure 3-3. In these calculations, the supply from diesel plants is not included, but as the plant capacity of diesel plants is 13 MW, the addition of 7.9 GWh monthly is expected if all these diesel plants are operated.

2-3-2 Hourly demand fluctuation

In Nepal, wide fluctuation of electric power demand is observed, not only from season to season but also hour to hour. Representative hourly demand in July, 1983 (rainy season) and December, 1983 (dry season) is shown in Figure 3-4.

There are two peaks, from 6:00 to 10:00 AM and from 4:00 to 10:00 PM, and a great difference in demand between peak and low demand levels. Average daily demand to the peak load is from 50 to 60%.

These peaks are attributable to the high share of electric power consumption for household use; consumption is concentrated during in the morning and evening for cooking and room heating.

Hourly fluctuation is observed every day of the year, but is relatively high in the dry season (December), when room heating increases.

2-4 Supply problems of electric power for the urea fertilizer plant and its countermeasures

2-4-1 Suppliability prospect of electric power

The consumption of electric power at the urea fertilizer plant is as follows, according to the scale of the design capacity of the plant:

Daily Production Capacity of Urea Fertilizer Plant	Electric Power Consumption		
	Hourly (3,600 Seconds)	Daily (24 Hours)	Monthly (30 Days)
(TPD)	(MWh)	(MWh)	(GWh)
100	27.68	664.2	19.93
200	55.35	1,328.4	39.85
300	83.03	1,992.6	59.78

Note: 6,642 kWh/1.0 ton of urea fertilizer production

The process plants proposed for the urea fertilizer plant are (a) Hydrogen Plant using Water Electrolysis, (b) Nitrogen Plant, (c) Ammonia Plant, (d) Carbon Dioxide Plant and (e) Urea Plant. The continuous operation (three shifts) of such plants is a basic premise for modern chemical process industry, because frequent shut-down and start-up of process plants would damage the catalysts and machinery, and reduce process efficiencies greatly. It is especially critical for ammonia and urea plants which require precise procedures and special precautions for shut-down and restart because the process plants are operated at high pressure and temperature using catalysts with large recycling flows. It also takes more than one day to reach a steady production stage, once the plant is shut down and restarted.

Therefore, the stable and long term supply of electric power is essential for successful operation of the urea fertilizer plant. Moreover, the reduction of capacity utilization is directly reflected in increased production cost because the urea fertilizer plant is highly capital intensive, and fixed cost components are a major part of total production cost. A long term guarantee of ample supply of electric power is the most important and critical factor, as the proposed project would rely on hydrogen gas produced by electrolysis. However as is discussed in section 2-3 of this chapter, there are several critical aspects in the suppliability of electric power, in connection with the implementation of the project. The conclusive analysis on electric power suppliability is summarized as follows:

(1) There will be no surplus electric power, even after the completion of Marsyandi hydropower plant, available for the urea fertilizer plant project. Therefore, the urea fertilizer plant project should be promoted on the basis of assurance of the completion of Sapta Gandaki hydropower project. Even after the completion of Sapta Gandaki, it is required to complete successive post-Sapta Gandaki projects to increase suppliability of electric power, otherwise the surplus would be again becomes critical in 1997/98, four years after the completion of Sapta Gandaki No. 3, regardless of the scale of urea fertilizer plant project. Accordingly, the required supply of electric power would be secured if the completion of the three stage of Sapta Gandaki and subsequent power plants are guaranteed in 1991/92, 1992/93, 1993/94 and 1996/97, respectively.

(2) Even if the above mentioned conditions are fulfilled, it will be impossible to supply enough electric power for full operation of urea fertilizer plant throughout the year, because the existing hydroelectric power plants are run-of-river type and their discharges are greatly reduced during the dry season. To supply enough electric power to the urea fertilizer plant even during dry season, the construction of large scale water storage type hydropower plants, or large scale run-of-river type hydropower plants with excessive surplus capacity during rain season is required. Both of these are capital intensive projects. However it is almost impossible to expect that they will be built, because of the specific nature of electric power demand due to the climatic conditions in Nepal. Therefore it should be assumed that the seasonal fluctuation of electric power supply will continue permanently.

(3) Moreover, the hourly fluctuation also will be continued in the future, because most electric power consumption is for household use and factory use is concentrated during the daytime. Consequently the difference in demand between the peak and off-peak will continue to be great. It is also expected that the construction of factories which consume electric power continuously

throughout the day, like the urea fertilizer plant, will not be done on a large scale in the near future. Therefore, the present hourly pattern of electric power demand will continue.

2-4-2 Countermeasures for the stable operation of the urea fertilizer plant

As is discussed in previous sections, there are inherent constraints on the suppliability of electric power in Nepal. Regarding the assurance of an adequate supply of surplus electric power in the future, as was emphasized, reliance should be placed on the development of the power projects in accordance with the policy of the HMG/N. But even if such guarantees are fulfilled, the suppliability would still be tight during the dry season and peak hours of the day. Therefore, it is necessary to investigate the technical protective countermeasures for the stable operation of the urea fertilizer plant. There are two practical alternatives:

(1) To install captive electric power plant within the urea fertilizer plant and to supplement the supply of electric power when the supply from outside is short or tight.

(2) Most electric power is consumed at the electrolysis plant which could be operated intermittently. Therefore it is possible to keep the ammonia and urea plants operating continuously, if an additional capacity is provided at the electrolysis plant and hydrogen gas storage. Surplus hydrogen gas would be produced during the off-peak period of electric power demand, and stored for later supply to the ammonia and urea plants during periods of peak power demand.

Even if such additional capacity is provided, the urea fertilizer plant could not be operational during the dry season when the electric power supply is very tight. Generally all chemical plants are shut down for maintenance work once a year for several weeks, and such scheduled maintenance shut-down of the urea fertilizer plant should be performed during the dry season to increase the annual capacity utilization. It is also important to design the plant facilities to be operational even at low loads of design capacity.

In this technical study, the conceptual design of the urea fertilizer plant is carried out by taking into consideration such constraints, and especially utilization of off-peak power supply as much as possible and minimization of the increase of peak demand. Although the investment cost of these measurer are high, it is considered inevitable when constructing a urea fertilizer plant under the specific conditions prevailing in Nepal. Theoretically it is possible to increase the capacity utilization of the urea fertilizer plant to some extent, if the diesel power plants are operated during the dry season, but it is still not enough to maintain the full load operation.

Chapter 3 Supply of Carbon Dioxide

3-1 Introduction

The urea process applied at the urea fertilizer plant in Nepal is a standard technology for synthesis of urea fertilizer from liquid ammonia and carbon dioxide, but in the preceding ammonia process is specific to synthesis ammonia from electrolysis hydrogen instead of the standard ammonia technology using hydrocarbons to produce liquid ammonia as well as highly purified carbon dioxide simultaneously. Therefore, it is important for the urea fertilizer plant in Nepal to have a supply source of carbon dioxide, independently from the ammonia plant.

A long-term, stable and low cost supply of carbon dioxide is an essential premise for urea production. Unit consumption of carbon dioxide is 0.75 ton/ton of urea; therefore, it is required to secure a supply of daily 207 TPD of carbon dioxide for daily production of 275 TPD of urea fertilizer.

The industrial supply source of carbon dioxide in Nepal is limited to flue gas from a cement plant, which contains dilute carbon dioxide. There are two cement plants in Nepal, the first one is a small scaled plant of Himal Cement Co.,(PVT) Ltd. (HCC) located in Chobar, Kathmandu and the second one is a medium sized plant of Hetauda Cement Industries Ltd. (HCI), now under construction in Hetauda.

The concentration of carbon dioxide in flue gas is approximately 20%, which is derived from the thermal decomposition of limestone in cement raw materials and also from the combustion of fuel at clinker production.

It is technically possible to recover carbon dioxide from the flue gas by hot-carbonate or amine absorption processes, but these are not considered economical ways to obtain carbon dioxide, because of the low concentration of carbon dioxide, high dust content, high residual oxygen, high fluctuation of gas condition caused by changes in the level of cement plant operation and higher consumption of steam for the recovery of carbon dioxide from the flue gas. No instance has been reported of recovery of carbon dioxide from cement plant flue gas for industrial use, such as commercial production of urea fertilizer, anywhere in the world.

However there is no alternative source of carbon dioxide available in Nepal, and therefore, an extensive investigation and study were made to compare the flue gas conditions at the HCC and HCI, and also to clarify technical problems relevant to the industrial recovery of carbon dioxide from cement flue gas.

3-2 Suppliability of flue gas at Himal Cement

The cement plant of HCC is located on the west bank of Bagmati River in Chobar, approximately 6.0 km south of Kathmandu. The clinker production capacity is daily 160 TPD by the black meal shaft kiln process. The plant has been operating already eight years since the plant completion in 1976. The actual production at present is estimated to be 124.4 TPD of clinker and 132 TPD of bagged cement product.

The standard input conditions related to the suppliability of carbon dioxide are as follows:

Raw Materials Consumption at Himal Cement (PVT)., Ltd.

Raw Materials	Specification, %		Consumption, Dry (TPT of Clinker)
Limestone	CaO; 45.5,	CO_2; 37.5	1.350
Clay	SiO_2; 58.9,	Al_2O_3; 20.5	0.125
Fuel			
- Coke	C; 64.1	H; 0.2	0.095
- Coal	C; 71.6,	H; 2.3	0.095
Atmospheric Air	-	-	3.120
			Total 4.785

The theoretical carbon dioxide production is, therefore 0.95 TPT of clinker, and by assuming carbon dioxide recovery of 90%, the suppliability of carbon dioxide at HCC is calculated to be 106.4 TPD which is equivalent to 142 TPD of daily urea fertilizer production.

Moreover, regarding quality, the flue gas from HCC is inferior because the concentration of carbon dioxide is lower and that of carbon monoxide is higher. This means low combustion efficiency in clinker production, high loss of carbon dioxide and, high risk of explosion at carbon dioxide recovery plant. Therefore it is considered that the flue gas from the HCC plant at present is not suitable as a source of carbon dioxide for a 275 TPD urea production in terms of quality and in quantity.

The flue gas is now discharged to the atmosphere from the stack (33.5 mH × 1.4 mD) and has following analysis and conditions:

Flue Gas Conditions at Himal Cement Co., (PVT) Ltd.

Item	Specification, Wet Basis	
	Volume, %	Weight, %
Flue Gas Analysis:		
- CO	2.27	2.16
- N_2	61.35	58.25
- O_2	9.51	10.40
- CO_2	13.70	20.63
- NO_x	50 ppm	51 ppm
- SO_x	5 ppm	8 ppm
- Dust	4 g/Nm³	0.31
- Moisture	13.19	8.12
Total	100.00	100.00
Flue Gas Quantity: (Per 1.0 Ton of Clinker)	3.123 Nm³	4.077 Ton
Flue Gas Conditions:		
- Temperature, °C	120	120
- Pressure, ata	0.859	0.859
- Flow Rate, m/sec	5.7	5.7
- Height of Discharge, m	33.5	33.5

At HCC, there is an expansion plan to construct the second line of cement plant with 240 TPD daily capacity by the black meal shaft kiln process in the vicinity of existing plant, which will be completed in 1986. Therefore, after 1986, the flue gas suppliability will be increased 2.5 times or to the equivalent of 355 TPD of urea fertilizer production, but there is no possibility to improve the quality of flue gas. The detailed data on the flue gas conditions at the HCC are summarized in Annex III-1.

3-3 Suppliability of flue gas at Hetauda Cement

The cement plant of HCI is now under construction on the east bank of Kukhureni River, the south bank of Karra River and the west side of Lamsure Hill of Chaudaghare, Hetauda.

The clinker production capacity is 750 TPD by the suspension pre-heater dry rotary kiln process and the plant will be completed in December, 1984. The capacity utilization is expected to be 70, 80 and 90% in the first, second and third year, respectively.

The plant is not yet operational and its raw material and fuel conditions have not been finally determined, so it is impossible to confirm the flue gas conditions at present. Expected standard input conditions are as follows:

Raw Materials Consumption at Hetauda Cement Ind., Ltd.

Raw Materials	Specification, %		Consumption, Dry (TPT of Clinker)
Limestone	CaO; 44.7,	CO_2; 36.5	1.438
Clay	SiO_2; 59.5,	Al_2O_3; 19.0	0.087
Iron Ore	Fe_2O_3; 89.3,	SiO_2; 4.6	0.008
Fuel			
- Fuel Oil	C; 85.0,	H; 11.0	0.0268
- Coal	C; 70.0,	H; 5.2	0.0833
Atmospheric Air	-	-	2.213
			Total 3.886

The theoretical carbon dioxide production is, therefore 0.82 TPT of clinker, and by assuming carbon dioxide recovery of 90%, the suppliability of carbon dioxide at HCI is calculated as 553.5 TPD which is equivalent to 738 TPD of daily urea fertilizer production. This quantity is 2.68 times that of the carbon dioxide requirement at a urea fertilizer plant with 275 TPD capacity.

Therefore, it is judged that there is an enough suppliability in quantity at the HCI. The flue gas is designed to be discharged from a stack after electrostatic precipitator treatment, therefore it is suggested to take flue gas from the outlet of the electrostatic precipitator for the supply to the urea fertilizer plant.

The estimated flue gas analysis and conditions are as follows:

Flue Gas Conditions at Hetauda Cement Ind.,Ltd.

Item	Specification, Wet Basis	
	Volume, %	Weight, %
Flue Gas Analysis:		
- CO	0.10	0.10
- N_2	59.72	56.11
- O_2	7.43	8.00
- CO_2	18.42	27.16
- NO_x	150 ppm	155 ppm
- SO_x	50 ppm	80 ppm
- Dust	0.1 g/Nm^3	0.007
- Moisture	14.42	8.72
Total	100.00	100.00
Flue Gas Quantity: (Per 1.0 Ton of Clinker)	3.123 Nm^3	4.077 Ton
Flue Gas Conditions:		
- Temperature, °C	113	113
- Pressure, ata	0.917	0.917
- Flow Rate, m/sec	15.0	15.0
- Height of Discharge, m	10.0	10.0

It is clear that the flue gas from HCI is better in quality and in quantity than that of HCC, as a supply source of carbon dioxide for the urea fertilizer plant. However, the HCI has no performance of actual operation and its fuel, raw materials and operation conditions are not yet determined, making it necessary to investigate these conditions in detail after the start of commercial operation of the cement plant, to confirm the design conditions of the urea fertilizer plant.

Technical data on the flue gas conditions at the HCC are summarized in Annex III-1.

3-4 Conclusions

It is concluded that the flue gas conditions from the cement plant of HCI in Hetauda are better than those of HCC in Kathmandu, as a supply source of carbon dioxide for the urea fertilizer plant in Nepal, which depends upon electrolysis hydrogen as a major raw material.

One of the advantages at HCC in Kathmandu is a long historial performances of operation but the flue gas conditions are not suitable because of its specific process and fuel conditions. It will be possible to supply enough carbon dioxide when the expansion plan is completed in 1986, but no improvement are expected in the quality of flue gas.

The operation of HCI in Hetauda will be commenced in 1985 and the stability of operation of the cement plant during the initial stages will be fluctuated to some extent, but will be stabilized by 1991 when the urea fertilizer plant is scheduled to be completed. During that period, it is important to investigate the operating conditions of the cement plant to establish the design basis and operation conditions of the proposed urea fertilizer plant in Nepal.

It should be recognized that an integrated management system to control the both cement and urea fertilizer plants should be established because the operation of cement plant is critical to the performance of the urea fertilizer plant. Generally, the cement plant would be shutdown for 20 days every eight months to repair the brick of rotary kiln, and for 3 days every two months for minor repair. During these scheduled shutdowns of the cement, the urea fertilizer plant should also be synchronized for maintenance to increase overall capacity utilization. The cement plant is likely to have an unscheduled shutdown for four hours in every ten days, during these shutdowns, the urea fertilizer should not be shutdown. The urea fertilizer plant should have provision for the storage of carbon dioxide to keep operation during the shut-down of cement plant. The urea fertilizer plant also should be designed to be operable at even a half-load level when the supply of carbon dioxide and/or hydrogen is limited.

The process applied for the carbon dioxide recovery should be energy (steam) saving.

The detailed technical data of flue gas at HCC and HCI are summarized in Annex III-1 and their qualitative comparison is shown in Table 3-9.

Chapter 4 Proposed Site for Urea Fertilizer Plant

4-1 Introduction

The most important site selection criterion for the urea fertilizer plant is that there must be suppliability of ammonia and carbon dioxide which are both essential raw materials. In Nepal, the supply of ammonia is by electrolysis hydrogen, and carbon dioxide by recovery from cement plant flue gas, therefore the site for the urea fertilizer is limited in the vicinity of a cement plant.

In Nepal, there are only two candidate sites, one is at Chobar, Kathmandu where a small scaled cement plant of HCC has been operating, and the second one is at Hetauda, where a medium sized cement plant is now under construction and expected to be operational in 1985 after the completion in 1984. Intensive study and comparison has been carried out to identify the best site among these two candidate sites.

During the site selection process, various technical aspects, not only the suppliability of carbon dioxide, but also the suppliability of industrial water, electric power, accessibility for delivery of lengthy and heavy cargoes for the construction of urea fertilizer plant, soil conditions and available site area, infrastructure and physical distribution of product urea fertilizer, have been carefully investigated and compared.

The suppliability of carbon dioxide is already discussed in Chapter 3 where it is concluded that the flue gas from HCI in Hetauda is superior to that of HCC in Kathmandu. Therefore, the study has been concentrated on clarification of the site conditions at Hetauda and to identify any important factors which should be considered during the design and engineering phase of the urea fertilizer plant project.

4-2 General description of alternative sites

4-2-1 Chobar, Kathmandu (vicinity of Himal Cement)

The cement plant of HCC is located in Chobar, 6 km south of Kathmandu and on a narrow plot between Bagmati River and the Kathmandu-Dakkhin Kali Highway. The production of clinker is 160 TPD.

The available site for the urea fertilizer plant is limited to a rectangular (150 m × 300 m) and slightly sloped area, bounded by the existing cement plant, Bagmati River and the highway. The area is now utilized partly as a ball field by HCC employees and the rest is paddy fields. Inside the area, there are a small stream and a brick factory.

The elevation of site is 1,260 meters and atmospheric pressure is 0.859 ata. The south and west boundary of the area is limited by a steep slope to raise 10 meter to the highway. Therefore the total site area available, after the site development works, would be reduced to 30,000 m^2 which is equivalent to the required site for a 100 TPD urea fertilizer plant, and is not suitable for the proposed capacity of 275 TPD.

In the vicinity of the site, there are the township of Chobar, residences of HCC personnel, and small sized factories for brick, lime and carpet production. The soil structure is mostly clay with a high soil bearing capacity at the 20 ton/m^2 level. The bed rock is very deep but a pile foundation has not been used for the cement plant construction. The location maps of HCC in Kathmandu and Chobar are shown in Figures 3-5 and 3-6.

Regarding climatic conditions at Kathmandu, the annual maximum temperature is 32°C (April), minimum is (−)1°C (January) and rain fall is 1,341 mm. The rainy season is from July to September and the dry season is from October to February.

Industrial water would be taken from Bagmati River, but the flow rate during the dry season is low and the quality is also low due to the contamination by the municipal waste water of Kathmandu.

4-2-2 Hetauda (vicinity of Hetauda Cement)

The cement plant of HCI is now under construction in Hetauda, 42 km south of Kathmandu and 60 km north of Birganj at the Nepal-India boader. The plant is located on the east bank of Kukhureni River and west of the Hetauda-Birganj Highway, 4 km south from Hetauda. The elevation is 455 meters and the area is in tropical climatic zone. The site of HCI is rectangular and slightly sloped (3% down toward north) land with a total area of 600,000 m^2 between a small clay hill and Kukhureni River.

There are two or three plots available in the vicinity of HCI for the proposed urea fertilizer plant, however it is concluded that the best site is the land between the cement plant and Kukhureni River. The area is now utilized as paddy fields and there are approximately 25 farmers' houses on it. It is reported that there has been no historical flooding experience at the local hearing by the farmers. However it is suggested to investigate the necessity of anti-flooding precautions at the planning stage of the urea fertilizer plant project.

The soil is mostly a mixture of gravel and sand with a very high soil bearing capacity, 30 to 60 ton/m^2 level. It would not be difficult to secure the flat site area of 100,000 m^2 (200 m × 500 m) for the proposed 275 TPD urea fertilizer plant project.

Hetauda is located in a center of agricultural, industrial and transport industries in Terai and has a population of 60,000. The suppliability of industrial water and electric power are favorable as the three rivers of Rapti, Kukhureni, and Karra River flow together in Hetauda and the hydropower plants of Kulekhani are near Hetauda. Hetauda has the HCI and Hetauda Industrial District which are the largest industrial facility in Nepal. There are 23 factories located in the 132 Ha site of Hetauda Industrial District complex, employing 4,200 workers.

The highest annual temperature is 39°C (April), lowest is 3°C (January) and annual rainfall is 1,948 mm. The rainy season is from March to September and the dry season is from November to February. General map of Hetauda is shown in Figure 3-7.

4-3 Comparison of alternative sites and selection of proposed site

4-3-1 Comparison criteria

The site alternatives for the urea fertilizer plant in Nepal are limited to either the vicinity of HCC in Kathmandu or of HCI in Hetauda because of the suppliability of carbon dioxide. The comparison criteria of proposed alternative sites are as follows:

(1) Suppliability of long-term, stable and low cost electric power for the production of electrolysis hydrogen for the synthesis of intermediate liquid ammonia for the production of urea fertilizer

(2) Suppliability of long-term, stable and low cost cement plant flue gas for the recovery of intermediate carbon dioxide for the production of urea fertilizer

(3) Suppliability of long-term, stable industrial water for the electrolysis of water and the make-up water for the circulating cooling water

(4) Availability of a large and level plant site with high soil bearing capacity

(5) Easy access to the site for the transport of heavy and lengthy cargoes for the construction of the urea fertilizer plant

(6) Transport infrastructure for the shipment of product urea fertilizer to the domestic market in Nepal

(7) Infrastructure for the living environment of the personnel during the construction and operation of the urea fertilizer plant

4-3-2 Comparison evaluation of major factors

The comparison evaluation of the major factors at the site alternatives of Hetauda and Kathmandu are summarized as follows. The details of site conditions are discussed in each section of the report; hereunder only the key issues are explained.

(1) Suppliability of electric power

The supply and demand situation and pricing of electric power are discussed in Chapter 2. The required transmission lines to the proposed urea fertilizer plant in Hetauda and Kathmandu are 0.6 and 8.0 km, respectively. The general conditions at Hetauda are superior to Kathmandu which a large demand of electric power is concentrated and has a large external disturbance for the electric power supply.

(2) Suppliability of carbon dioxide

It is concluded that the supply conditions of flue gas from the cement plant in Hetauda are superior to those of the plant in Kathmandu from analysis and calculation, in quality and also in quantity.

The only drawback at Hetauda is that HCI has no actual performance of flue gas production, so suitably detailed, reliable information on supply conditions and qualities of the flue gas are not available, however there are six year period from the completion and commencement of operation of the cement plant in 1985 to the completion of the urea fertilizer plant which is expected in 1991.

At HCC in Kathmandu, the expansion plan for the second train of the cement plant is expected to be completed in 1986 and the stability of flue gas supply will be improved but no improvement of the quality of the flue gas is expected. The suppliability of carbon dioxide at HCC is inferior in quality and also in quantity.

It is important, as there are still unknown factors at the suppliability of carbon dioxide at HCI, to undertake a detailed technical study after the commencement of commercial production at HCC to confirm the design basis of the proposed urea fertilizer plant.

(3) Suppliability of industrial water

Industrial water would be taken from Bagmati River for Kathmandu and from Kukhureni River for Hetauda. The supply conditions at Hetauda are superior in quantity and in quality to those of Kathmandu. In Hetauda, the ground water level is higher, to obtain a large quantity of high purity water, as the flows of Kukhureni, Karra and Rapti converge in Hetauda.

(4) Soil conditions and available site area

The soil bearing capacity is high both in Kathmandu and in Hetauda but it is impossible to secure a large site area required for the proposed urea fertilizer plant in Kathmandu. General conditions are better in Hetauda.

(5) Equipment and material transport

The transport infrastructure in Nepal are still developing stage, the major equipment of the urea fertilizer plant would be transported from Calcutta to the proposed site by road, 1,150 km to Kathmandu or 860 km to Hetauda. The weight limit of bridges to Kathmandu is 8 tons and 20 tons to Hetauda. The road weight limit will be increased during the dry season by traversing river beds instead of passing over the bridges.

The major transport routes from India to Nepal are shown in Figure 3-8. For the transport to Hetauda, the routes through Birganj and/or Bairawa are commonly used. The transport limit of equipment length and weight during the dry and rainy seasons to Kathmandu and Hetauda are summarized in Annex III-2.

(6) Product physical distribution

Hetauda is at an intersection of the East-West Highway and Kathmandu-Birganj Highway and also in the center of Terai where urea fertilizer is consumed greatly. The ropeway facility between Kathmandu and Hetauda is also available for product transport from Hetauda. Generally the transport infrastructure is well developed in Hetauda.

(7) Infrastructure

Kathmandu is the largest city in Nepal has a 400,000 population and the infrastructure are the most developed. In Hetauda, there are HCI and the Hetauda Industrial District besides the township with a 60,000 population and the development of infrastructure is now proceeding. In this regard, the evaluation results between Kathmandu and Hetauda are considered equivalent.

4-3-3 Conclusions

In comparing the various basic factors for the evaluation of site selection criteria of the urea fertilizer plant, it is concluded that the site in the vicinity of HCI in Hetauda is better situated than that of HCC in Chobar, Kathmandu. The comparison results are shown in Table 3-10.

Chapter 5 Facility Outlines of Urea Fertilizer Plant

5-1 Introduction

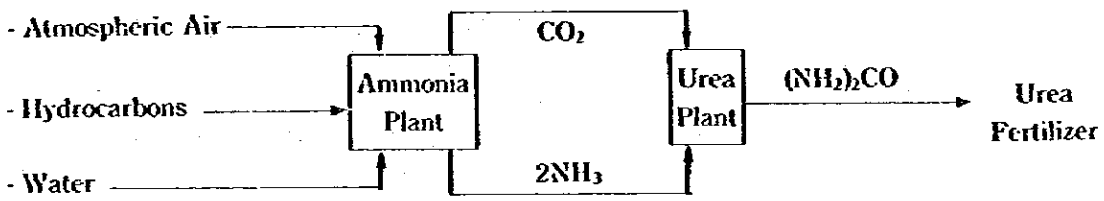
It is concluded from the studies on the product marketability, and suppliability of electric power and carbon dioxide, that the optimum production capacity of the urea fertilizer plant would be 275 TPD.

The production process to be used at the plant would produce urea fertilizer by reacting two intermediates, carbon dioxide (recovered from cement plant flue gas) and liquid ammonia (synthesized from electrolysis hydrogen and recovered nitrogen by cryogenic processing of atmospheric air) which differs from the conventional urea process used throughout the world.

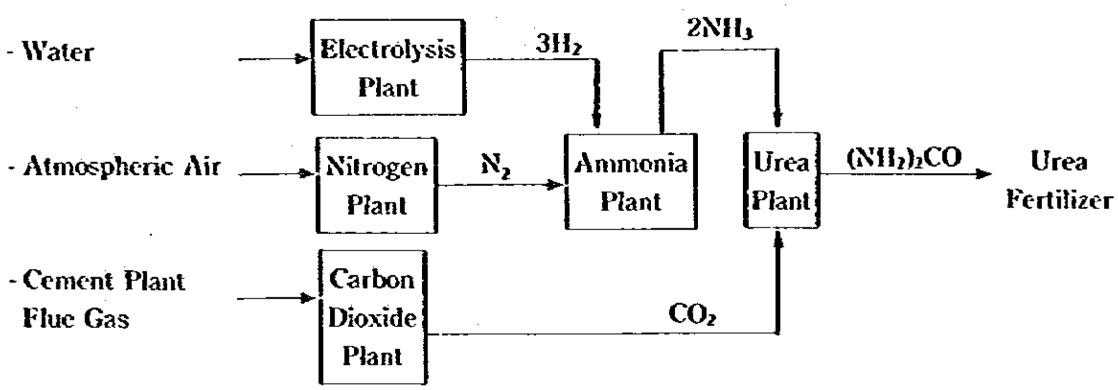
The individual unit processes are used at many industrial plants, but there is no commercial urea fertilizer plant in the world using hydrolysis hydrogen and recovered carbon dioxide from cement factory flue gas in one plant. The differences of the two urea fertilizer production schemes are illustrated as follows:

Urea Fertilizer Production Scheme

(Hydrocarbons Scheme)



(Electrolysis and Carbon Dioxide Recovery Scheme)



The major raw materials and utilities required for the urea fertilizer production at the proposed process in Nepal are the following seven items:

(1) Raw Water
(2) Electric Power
(3) Fuel Coal
(4) Atmospheric Air
(5) Cement Plant Flue Gas
(6) Fertilizer Bag
(7) Catalysts and Chemicals

The two inputs of raw water and atmospheric air are supplied within the battery limit of the plant, and the by-product oxygen is discharged to the atmosphere because there is no identified market under present conditions. The waste water is to be discharged to the river after complete treatment to prevent any environmental problem.

The major facilities of the urea fertilizer plant are classified into five categories:

(1) Process Plant
  - Hydrogen, Nitrogen, Ammonia, Carbon Dioxide, Urea

(2) Utility Plant
  - Water Treatment, Cooling Tower, Steam, Receiving of Electric Power, Cement Plant Flue Gas and Fuel Coal, Waste Water Treatment

(3) Storage, Bagging and Loading Facility
  - Hydrogen, Nitrogen, Ammonia, Carbon Dioxide, Urea (Bulk and Bagged), Bagging, Loading

(4) Auxiliary Facility
  - Administration Building, Maintenance Shop, Analytical Laboratory, Safety and Welfare Facilities

(5) Off-site Facility
  - Residential Colony

The details of the design basis, design philosophy and conceptual design of the urea fertilizer plant in Nepal are explained hereunder.

5-2 Design basis

5-2-1 Outlines of proposed plant site

The plant site in Hetauda is selected after comparing two alternatives, Chobar of Kathmandu and Hetauda as is discussed in Chapter 4.

The urea fertilizer plant will be located at the west side of the HCI cement plant and therefore the cement plant flue gas will be supplied with minimum length of duct connection. The site for the urea fertilizer plant is 500 m × 200 m, on the east bank of Kukhureni River and west of the cement plant.

The proposed site is level and now has 25 farmers' houses on it, and is utilized as paddy fields. The location map of the site is shown in Figure 3-7.

5-2-2 Soil conditions

There are no measured data on soil conditions inside the proposed site, but it is possible to make estimate by using the measured data taken at the site of the cement plant. The site has soil bearing capacity of 30 to 60 ton/m^2 and soil structure is mostly gravel and sand. The ground water level is 3.8 to 8.0 meters below the surface. The detailed soil conditions are shown in Table 3-11.

5-2-3 Climatic conditions

Hetauda is located in the tropical climatic zone in Terai. The annual rainfall is approximately 2,000 mm and the annual maximum and minimum temperatures are 38.8°C (April) and 3.0°C (January). The relative humidity averages 68 to 74%, but the humidity is relatively lower in April when the temperature is the highest because the rainy season is from May to September and the dry season is from November to March. The details of climatic conditions are shown in Table 3-11.

5-2-4 Source of industrial water and water quality

The three rivers, Rapti, Karra and Kukhureni converge in Hetauda. There are no reported data on the discharge of these rivers at Hetauda. However from observations during the dry season, the availability of industrial water is judged adequate to support the urea fertilizer plant, which consumes approximately 4,400 TPD of industrial water.

Hetauda Industrial District is taking 3,000 TPD of industrial water from Karra River and HCI is taking 500 TPD of water from wells (8 meters deep) in the residential colony of HCI, approximately 500 meters east of Kukhureni River.

The water quality is slightly acidic but generally high quality industrial water is obtainable, and especially, is low in hardness and dissolved solids. The details of industrial water quality are shown in Table 3-11.

5-2-5 Supply of electric power

The NEC has high tension distribution lines (66 kV) in Hetauda area and the electric power at HCI (5,000 kWh) will be supplied from them. The distance from the urea fertilizer plant to the NEC substation is approximately 5 km. The distribution towers are already completed but the capacity is not enough for the requirement at the urea fertilizer plant (83 MW), therefore an additional installation of a high tension distribution line is required. A budget for this is included in the project cost estimate of the urea fertilizer plant.

The electric power will be supplied at either 66 or 132 kV and 50 Hz to the urea fertilizer plant. The details are summarized in Table 3-11.

5-2-6 Supply of cement plant flue gas

The anticipated flue gas conditions are discussed in Chapter 3. The concentration of carbon dioxide in the flue gas is estimated as 18 to 20% and the flue gas should be taken from the outlet of electrostatic precipitator of the cement plant. The requirement of flue gas is approximately 30,000 Nm^3PH and a conveyance duct of 0.9 meter diameter, 300 meters long, would be required. The construction cost is estimated and included in the project cost for the urea fertilizer plant project.

5-2-7 Specifications of product ammonia and urea

The urea fertilizer plant will produce urea fertilizer as a final product by using liquid ammonia as an intermediate. The urea fertilizer is free flowing prilled product and will be shipped bagged, 50 kg net, in jute bags. The specifications of liquid ammonia and urea are shown below, in accordance with the internationally traded standards.

Specification of Ammonia and Urea

Specification	Liquid Ammonia	Urea Fertilizer
State	Liquid	Prill
Temperature, °C	(-)30	30
Pressure, atg	0.01	0.00
Analysis, weight %		
- Nitrogen	82.2	46.4
- Biuret	0.0	0.8
- Free Moisture	0.1	0.25
Size Distribution, %	-	95 (1.0 to 2.5 mm)

The details of the design basis for the urea fertilizer plant are summarized in Table 3-11.

5-3 Conceptual design of urea fertilizer plant facilities

5-3-1 Outline of urea fertilizer plant facilities and their design philosophy

The daily production capacity of the urea fertilizer plant is 275 TPD of bagged urea fertilizer and the plant consists of process plants, utility plants, storage facilities, auxiliary facilities and off-site facilities.

For the preparation of the conceptual design of the plants, the following specific factors are taken into consideration:

(1) Ammonia and urea plants should be designed for continuous operation under fluctuating supply of electric power season to season and hour to hour.

(2) Ammonia and urea plants should be designed for keep continuous operation under limited suppliability of cement plant flue gas caused by the fluctuation of cement plant operation.

(3) Ammonia and urea plants should be designed for daily continuous operation even if the electrolysis plant is shut down for three hours in the morning and/or four hours in the evening when the supply of electric power is reduced. (The daily capacity utilization would be 83.3% when the electrolysis plant is shut down for four hours and would be 70.8% when shut down seven hours.)

(4) Ammonia and urea plants should be designed for continuous operation even at 50% load of design capacity when the suppliability of both electric power and carbon dioxide is limited. Both plants would be completely shut down when the 50% load could not be maintained.

The list of major facilities of the urea fertilizer plant is shown in Table 3-2 and their brief explanation is given hereunder.

5-3-2 Process plant

There are five process plants in the urea fertilizer plant, namely the hydrogen plant, nitrogen plant, ammonia plant, carbon dioxide plant and urea plant, and their design capacity is as follows:

	Design Capacity
Process Plant	
- Hydrogen Plant	28.4 TPD (13,300 Nm^3PH)
- Nitrogen Plant	132 TPD (4,440 Nm^3PH)
- Ammonia Plant	160 TPD
- Carbon Dioxide Plant	207 TPD (4,380 Nm^3PH)
- Urea Plant	275 TPD

Each process plant has product and intermediate storage and loading facilities. The storage capacity of hydrogen and carbon dioxide is such as will enable the continuous operation of the ammonia and urea plants during short shut-downs of electrolysis and carbon dioxide plants. Storage and loading facilities would have the following capacities.

	Design Capacity
Storage and Loading 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	
- Bulk	2,100 ton
- Bagged	7,000 ton
- Bagging	40 TPH
- Loading	100 TPH

(1) Hydrogen plant

The hydrogen plant will produce hydrogen gas as an intermediate for the production of liquid ammonia by the electrolysis process of water. The most important piece of equipment for electrolysis is the electrolyzer (bipolar and filter press type) which produces hydrogen gas as well as oxygen gas as co-product by electrolysis of alkali electrolyte. The produced hydrogen and oxygen gases are taken out separately from the electrolyzer as a mixture of gas and electrolyte, and gas and solution are separated. The recovered electrolyte is cooled and returned to the electrolyzer, and the gases are washed to eliminate the electrolyte mists. Oxygen gas is discharged to the atmosphere and hydrogen gas is sent to the ammonia plant directly or indirectly through the hydrogen gas storage holder.

The hydrogen production by electrolysis is described as follows by Faraday's Law:

$$2H_2O + \text{Electricity } (96,500 \text{ Coulomb}/1.008g\text{-}H_2) = 2H_2 + O_2$$

The electric power required is 3.55 kWh/1.0 Nm^3-H_2 at 1.48 volts according to theoretical thermodynamic calculation, however it is commonly 4.22 to 4.88 kWh/1.0 Nm^3-H_2 at 1.60 to 1.80 volts at industrial plants.

The operating conditions at the electrolyzer range from 80 to 90°C in temperature, and 1.0 to 30 ata of pressure. The electrolyte is 25% potassium hydroxide aqueous solution and the purity of hydrogen and oxygen are 99.80 ± 0.1 and 99.60 ± 0.3%, respectively. The electrolysis hydrogen processes are explained in Annex III-3.

The unit consumption of hydrogen gas is 1,989 Nm^3/ton of ammonia and therefore the design capacity of the hydrogen plant is 13,300 Nm^3 PH for the proposed urea fertilizer plant. The block flow diagram of the hydrogen plant is given in Figure 3-9.

(2) Nitrogen plant

The nitrogen plant will produce nitrogen gas as an intermediate for the production of liquid ammonia by the cryogenic fractionation of atmospheric air.

Atmospheric air is at first compressed at the air compressor and washed and cooled to remove moisture and carbon dioxide before sending to the fractionator. The air is cryogenically separated into nitrogen gas at the top of the tower and oxygen liquid at the bottom of the fractionator.

The nitrogen gas is taken from the tower and heated at a heat-exchanger to feed to the ammonia plant directly or indirectly through the nitrogen gas holder.

The liquid oxygen is sent to the heat-exchangers and expansion turbine to recover heat and energy before being discharged into atmosphere.

The design capacity of the nitrogen plant is 4,440 Nm^3 PH and the block flow diagram of the plant is given in Figure 3-10.

(3) Ammonia plant

The ammonia plant will produce liquid ammonia as an intermediate for the production of urea by reacting water electrolysis hydrogen and air fractionated nitrogen. The design capacity of the ammonia plant is 160 TPD and the plant consists of a compression section and an ammonia synthesis section.

(i) Compression section

Nitrogen gas and hydrogen gas are mixed to form a uniform mixture with 1.0 to 3.0 molar ratio, and compressed at the synthesis gas compressor up to 310 atg. The compressor is reciprocating type and driven by an electric motor.

(ii) Ammonia synthesis section

Compressed synthesis gas is fed to the synthesis reactor through a liquid-gas separator. The nitrogen and hydrogen are catalytically reacted under high pressure and temperature to form ammonia. The reaction mixture of ammonia and unreacted synthesis gas is fed to the waste heat boiler to recover the heat of reaction and to produce steam. The gas is further cooled down to condense and separate ammonia as liquid ammonia. The reaction of ammonia synthesis is:

$$3H_2 + N_2 = 2NH_3$$

The design capacity of the ammonia plant is 160 TPD and operating conditions at the ammonia reactor are 310 atg and 400°C. The pressure of recovered steam, which is fed to the urea plant, is 26 atg.

The block flow diagram of the ammonia plant is given in Figure 3-11.

(4) Carbon dioxide plant

The carbon dioxide plant will recover carbon dioxide as an intermediate for the production of urea by absorption treatment of the cement plant flue gas.

The flue gas is at first compressed and washed for dust removal and then fed to the absorption tower to absorb carbon dioxide by circulating absorption solution.

The lean gas is discharged from the top of the absorption tower, and the rich solution with carbon dioxide is heated at the heat exchanger and fed to the regeneration tower where heat is supplied at the bottom of the tower by steam to strip off carbon dioxide. The recovered carbon dioxide gas is cooled and then fed to the urea plant directly or indirectly through the carbon dioxide storage holder.

The lean solution is taken from the bottom of the regeneration tower and then cooled down before being recycled to the carbon dioxide absorption tower.

The design capacity of the carbon dioxide plant is 207 TPD and the absorption solution used is organic amines. The plant should be designed to be an energy-saving type to reduce the consumption of steam.

The block flow diagram of the carbon dioxide plant is given in Figure 3-12.

(5) Urea plant

The urea plant will produce urea fertilizer as a final product by using two intermediates; liquid ammonia and carbon dioxide. The chemical reactions of the urea synthesis are described as follows:

$$2NH_3 + CO_2 = NH_2\,COONH_4 \text{ (Ammonium Carbamate)}$$
$$NH_2\,COONH_3 = H_2O + NH_2\,CONH_2 \text{ (Urea)}$$

The raw materials, liquid ammonia and carbon dioxide, are reacted at high temperature and pressure (temperature; 180 to 200°C and pressure; 150 to 200 atg) in the urea reactor to form ammonium carbamate which is further decomposed to obtain urea solution. The design capacity of the urea plant is 275 TPD.

The reactant from the urea reactor is sent to the decomposer where steam heating is applied to decompose unreacted ammonium carbamate, and excess ammonia and carbon dioxide are recovered. The urea solution is concentrated up to 99% at the vacuum evaporator and then sent to the top of the prilling tower to produce prilled urea. The solidified prilled urea is taken out from the bottom of the prilling tower and sent to the bulk urea storage and urea fertilizer bagging plant.

The recovered ammonia and carbon dioxide are recycled back to the urea reactor for further processing.

The waste water from the urea plant is treated at the hydrolysis tank to remove and recover ammonia and treated water is discharged after mixing with other municipal waste water.

The block flow diagram of the urea plant is given in Figure 3-13.

5-3-3 Utility facility

The major utility facility of the urea fertilizer plant are as follows:

		Design Capacity
(1)	Electric Power Receiving	86 MW
(2)	Raw Water Treatment	183 TPH
(3)	Water Demineralizer	32 TPH
(4)	Cooling Water Tower	6,500 TPH
(5)	Steam Generating	27.5 TPH
(6)	Instrument and Plant Air	1,500 Nm^3PH
(7)	Emergency Power Generation	0.8 MW

Coal is consumed at the steam generating facility and the generated steam is mostly used at the carbon dioxide and urea plant.

5-3-4 Product storage and loading facility

The final product urea fertilizer will be stored to the extent of 2,100 tons in bulk and 7,000 tons bagged, inside the urea fertilizer plant. The bagging capacity is 40 TPH and loading of urea fertilizer to the eight-ton road trucks is 100 TPH to cover the peak shipping requirement.

5-3-5 Environmental protection facility

The discharge gases from the urea fertilizer plant mostly come from the urea prilling tower and waste water comes from the vacuum evaporator. Both of them are to be treated in accordance with the environmental treatment standards observed in the USA, Europe and Japan at present.

The design capacity of the waste water treatment facility is 55 TPH.

The discharge standards are as follows:

(1)	Waste Gas	
	- Urea Dust	50 mg/m³
	- Ammonia	200 ppm
	- Dust	500 mg/Nm³ (24 hours average for coal fired boiler)
	- SOx	K = 17.5
(2)	Waste Water	
	- pH	6.0 to 9.0
	- BOD	50 ppm
	- COD	50 ppm
	- Suspended Solids	60 ppm
	- Temperature	45°C

5-3-6 Auxiliary facility

Major auxiliary facilities in the urea fertilizer plant are as follows:

		Floor Space
(1)	Administration Building	800 m^2
(2)	Canteen	800 m^2
(3)	Maintenance Office	400 m^2
(4)	Maintenance Workshop	1,320 m^2
(5)	Analytical Laboratory	400 m^2
(6)	Chemicals and Spare Parts Warehouse	320 m^2
(7)	Guard House	30 m^2
(8)	Parking Lot	150 m^2
(9)	Medical Room	200 m^2
(10)	Plant Analytical Laboratory	30 m^2

5-3-7 Overall scheme of the urea fertilizer plant

The overall block flow diagram of the urea fertilizer plant is shown in Figure 3-14 and its layout is illustrated in Figure 3-15.

The total area required for the plant is 500 m x 200 m, and the overall requirements of raw materials, utilities, catalysts and chemicals, and fertilizer bags for the production of urea fertilizer product, are shown in Table 3-13 and Table 3-14.

The equipment and materials required for the construction of the plant are estimated to amount to 25,400 freight tons or 8,500 net tons. The largest single pieces of equipment are the ammonia synthesis reactor (1.7 mD × 13.5 mL × 80 tons) and urea synthesis reactor (1.5 mD × 28.0 mL × 90 tons), both of which are to be fabricated in subassemblies, for final assembly at the plant site because of the weight and length limitations for transportation of freight in Nepal.

The engineering and supervising services required would be 910 man-months, and construction and erection labor would require 21,700 man-months. The peak labor force during construction would be 1,800 persons in scale.

5-4 Off-site facilities

The major off-site facility and infrastructure are the residential colony and product shipping road.

The housing for 92 employees, with 6,010 m^2 total floor space on 18,000 m^2 site area, is assumed to be in the form of a residential colony. Housing is classified into five classes as follows:

Class	Floor Space, m^2	Number of Structures
I	180.0	1
II	135.0	6
III	90.0	15
IV	67.5	20
V	46.4	50
		92

A road, 12 m wide and 1,700 meters long would be required to connect the site to the cement shipping road which is now under construction by HCI, Hetauda. A budget for making the road is included in the project cost of the urea fertilizer plant project.

The total earthmoving required for the site development of the urea fertilizer plant is 230,000 m^3 the budget for which is also included in site preparation cost.

Chapter 6 Implementation and Management of Urea Fertilizer Plant Project

6-1 Project execution organization

At present, the organization to execute the urea fertilizer plant project in Nepal has not 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 the HMG/N.

It is also assumed that this new entity would be organized and managed by appointing experienced specialists in industrial project implementation in Nepal and also by seeking experienced consultants from foreign countries.

Highly technical matters must be dealt with in the management of project implementation because the project itself will be the first one in Nepal to involve both great investment cost and complex process schemes which utilize catalytic reactions under high temperature and pressure. The major activities of the new execution body would be to manage a wide range and complex planning and supervising of such as subjects as process design, conceptual design of various facilities, engineering, procurement, inspection and transport of equipment and materials, civil and erection works, and training and commissioning of the plant facilities. Moreover it is expected to be responsible for the scheduling of the completion of the plant, commissioning and commercial production, also for budget control and plant operation up to the commercial production stage.

6-2 Plant construction schedule

It is considered safe and practical to assume that the contract for construction of the urea fertilizer plant would be awarded by the competitive bidding among experienced and prequalified foreign contractors, and be a turn-key and lump-sum type contract which specifies sole responsibility for the initial activities, such as designing, engineering, procurement, erection and construction, and training, to the final activities, such as supervision during performance tests and also the guarantee test operations of the plant, within an agreed and fixed schedule and budget for the implementation of the project.

Therefore, in this study, the construction schedule and budget are formulated in accordance with such assumptions. Although the lump-sum contract is advantageous in securing the budget, schedule and performance guarantees within the basic frame work which is established at an early stage of project implementation, there are some risks involved such as the construction costs would be a little higher including contingencies and risk fees, and technical problems incurred after the completion of the performance guarantee test than those of a cost-plus-fee contract. It is important to prepare countermeasures to eliminate such risks associated with the lump-sum contract.

The overall schedule for the implementation of the urea fertilizer plant project is prepared taking into consideration specific natures and local conditions in Nepal, and also the construction performances experienced at the similar projects in foreign countries and shown in Figure 3-16.

The plant completion is scheduled in January, 1991 after a 36-month construction period, following a contract award in January, 1988. This schedule is projected by considering the tight conditions for the local road transport of heavy and lengthy equipment, especially during the rainy season.

The acceptance of the plant is scheduled for July, 1991 by assuming 6 months of test operation and performance guarantee test period after the mechanical completion of the plant.

The commercial production of urea fertilizer would be commenced in July, 1991 and the project life for the financial analysis would be terminated in 2006 after 15 years of the project life.

6-3 Organization and personnel of urea fertilizer plant

The organization chart and personnel required are shown in Table 3-15. A head office would be located in Kathmandu and a factory organization would be located in Hetauda. The total personnel required is 319 including 7 executives.

The organization in Hetauda would have six departments; general affairs, production, utilities, maintenance, product storage and loading, and engineering management department.

Although a small organization for technical services such as product quality control and physical distribution is included in the organization, no marketing personnel is allocated in the organization because the urea fertilizer is sold at ex-factory in Hetauda to the AIC which will be responsible for its marketing.

6-4 Technical assistance services required for plant construction and operation

It is observed that in connection with implementation of the project, the project executing organization may need to retain technical assistance services by internationally experienced consultants with regard to 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:

(1) 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 of organization

- Evaluation of construction contract proposals and negotiation for contract award

(2) Necessary services during construction of plant

- Review 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, budget 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 system

(3) Necessary services during early commercial operation stage

- Commissioning of the plant

- Establishment of operation and maintenance systems

- Arrangement for the responsibility assignment as well as standard operating procedures

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

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

[illegible]

Table 3-1 EXISTING POWER PLANTS IN NEPAL (1983)

	Type	Installed Capacity (MW)	Peaking Capability	Energy GWH/Yr	Commissioning Year
Pharping	Hydro	0.50	0.40	3.29	1911
Sundarijal	Hydro	0.64	0.64	5.77	1934
Panauti	Hydro	2.40	1.50	5.37	1963
Pokhara	Hydro	1.09	1.00	8.76	1968
Trisuli	Hydro	21.00	18.00	114.55	1969
Sunkosi	Hydro	10.05	6.70	56.67	1972
Tinau (Butwal)	Hydro	0.96	0.96	10.16	1974
Gandak	Hydro	15.00	5.00	43.80	1979
Kulekhani I	Hydro	60.00	60.00	154.70	1982
Devighat 1/	Hydro	14.10	14.10	89.72	1983
Sub-total		125.74	108.30	492.80	
Isolated Small Hydro Plants		1.91	-	-	
Sub-total		127.65	108.30	492.80	
Diesel Plants in the System 2/		21.28	18.73	98.40	
Isolated Diesel Plants		14.67	-	-	
Sub-total		35.95	18.73	98.40	
Steam Plants		4.55	-	-	
Sub-total		4.55			
Grand Total		168.15	127.03	591.20	

Notes: 1/ Two units of Devighat have already been commissioned and the third unit will be commissioned in December 1983.

2/ Diesel plants are used at 60% load factor whenever required.

Source : Electricity Department

Table 3-2 RECORD OF POWER ENERGY SUPPLY IN NEPAL

Year	Domestic	Industry	Commercial	Street Light & Others	Total Utilized Energy	Loss	Total Supplied Energy	Yearly Rate of Increase	Generated	Imported	Exported	Power	Rate of Increase	Yearly Load Factor
	MWH	MWH	MWH	MWH	MWH	MWH			MWH	MWH	MWH	KW		
1970/71	24,866	8,732	4,599	2,713	40,910	19,139	60,049	-	59,413	617	-	15,520	-	44.2
1971/72	32,918	10,714	5,143	2,816	51,591	32,350	74,941	24.8	72,926	2,015	-	20,100	29.5	42.6
1972/73	38,775	13,908	5,962	3,024	61,669	28,414	90,083	20.2	87,206	5,201	2,324	24,590	22.3	41.8
1973/74	47,710	15,757	6,514	3,218	73,199	33,885	107,084	18.9	101,974	8,812	3,702	29,810	21.2	41.0
1974/75	54,090	21,397	7,897	3,816	87,200	36,995	124,195	16.0	114,182	14,634	4,621	36,165	21.3	39.2
1975/76	61,787	32,128	9,173	4,173	107,261	42,965	150,226	21.0	130,794	25,372	5,940	40,245	11.3	44.3
1976/77	65,768	39,036	10,405	4,382	119,591	45,789	165,380	10.1	142,355	29,141	6,116	45,580	13.3	43.3
1977/78	71,348	42,751	13,068	4,488	131,655	54,724	186,379	12.7	159,623	32,726	5,970	50,630	11.1	43.3
1978/79	77,221	47,827	18,020	5,895	148,963	62,988	211,951	13.7	177,485	40,626	6,160	52,360	3.4	47.5
1979/80	74,823	52,809	25,244	9,093	161,969	66,609	228,578	7.8	194,802	38,972	5,196	56,900	8.7	46.9
1980/81	78,570	50,202	26,899	8,226	163,897	67,273	231,443	1.25	190,498	45,070	3,765	58,920	3.5	45.6
1981/82	90,665	61,280	24,633	8,191	184,770	85,255	270,025	16.2	218,449	56,759	5,183	72,880	23.7	42.9
Average Compound Growth Rate	12.5	19.4	16.5	10.6	14.6	14.5	14.6	-	12.6	-	7.6	15.10		

Source : "Electric Power Statistics of Nepal, Planning Evaluation Section, ED"

Table 3-3 ELECTRIC LOAD FORECAST (Integrated System Demand)

Year	Energy Demand (GWH)	Rate of Increase	Peak Demand (MW)	Rate of Increase	Load Factor
1982/83	284.9		67.8		.480
1983/84	344.2		81.2		.484
1984/85	407.5		95.7		.486
		20.6		19.8	
1985/86	453.6		106.1		.488
1986/87	613.6		142.4		.492
1987/88	725.9		167.7		.494
1988/89	830.4		190.7		.497
1989/90	928.6		212.4		.499
		12.4		11.8	
1990/91	1049.5		238.7		.502
1991/92	1167.8		264.5		.504
1992/93	1299.4		293.1		.506
1993/94	1445.6		324.2		.509
1994/95	1608.0		359.2		.511
		11.2		10.7	
1995/96	1788.0		397.1		.514
1996/97	1987.4		439.7		.516
1997/98	2208.1		486.6		.518
1998/99	2452.0		537.2		.521
1999/00	2721.2		594.0		.523
		11.0		10.4	
2000/01	3018.2		655.0		.526
2001/02	3345.5		723.3		.528

Note : Load Centres are assumed to be connected to the Integrated System as per following schedule :

In year 1985/86 Butwal, Tansen, Bhadurgunj, Taulihawa

In year 1986/87 Janakpur, Biratnagar, Rajbiraj, Dharan

In year 1987/88 Nepalgunj, Koilabas, Tulsipur, Ghoarahi

In year 1989/90 Anarmani, Bhadrapur

In year 1990/91 Dhangadi, Mahendranagar

Source : Electricity Department, 1983

Table 3-4 COMMITTED POWER SUPPLY (1989)

Existing Plants	Installed Capacity MW	Peaking Capability MW	Energy GWH/Yr
Hydro	125.74	108.30	492.80
Diesel1/	27.37	23.60	124.00
Sub-total	151.76	131.90	616.80
Planned Projects			
Kulekhani II (1986)	32.0	32.0	94.60
Andhi Khola (1987)	5.0	5.0	20.10
Marsyangdi (1988)	66.0	66.0	450.00
Sub-total	103.0	103.0	564.70
Total capability in 1989	254.76	234.90	1,181.50

Note: 1/ Some isolated diesel plants will be connected to the system by that time.

Source : Electricity Department

Table 3-5 PROJECTED ELECTRIC POWER GENERATING CAPABILITY IN NEPAL (1)

(UNIT: GWH)

		MONTHLY												ANNUAL
APPROXIMATELY HOUR	MONTH IN NEPAL	JUL/AUG SHRAW 744	AUG/SEP BHAD 744	SEP/OCT ASWIN 720	OCT/NOV KARTI 744	NOV/DEC MARG 720	DEC/JAN PAUSH 744	JAN/FEB MAGH 744	FEB/MAR FALG 672	MAR/APR CHAIT 744	APR/MAY BAISH 720	MAY/JUN JESTHA 744	JUN/JUL ASHAD 720	1.0YEAR 8760
ELECTRIC POWER STATION	COM-PLETION YEAR													
TRISULI	1969	8.93	8.93	8.64	8.93	8.64	8.14	8.93	7.41	8.93	8.64	8.93	8.64	103.69
PANAUTI	1963	0.60	1.21	0.89	0.48	0.31	0.25	0.35	0.23	0.24	0.23	0.42	0.19	5.40
SUNKOSI	1972	7.48	7.48	7.24	6.14	3.18	2.35	2.92	1.92	2.48	3.57	7.48	4.69	56.93
PHARPING	1911	0.37	0.37	0.36	0.37	0.36	0.15	0.15	0.13	0.15	0.14	0.37	0.36	3.28
SUNDARIJAL	1934	0.52	0.52	0.50	0.52	0.50	0.45	0.45	0.40	0.45	0.43	0.52	0.50	5.76
PHEWA		0.74	0.74	0.72	0.74	0.72	0.74	0.74	0.67	0.74	0.72	0.74	0.72	8.73
TINAU	1974	0.89	0.89	0.86	0.89	0.86	0.89	0.89	0.74	0.82	0.81	0.74	0.86	10.14
GANDAK	1979	3.75	5.14	5.04	4.95	4.13	4.50	4.48	2.76	3.07	3.35	4.02	3.07	48.26
KULEKHANI-I	1982	7.14	2.55	3.35	7.44	13.85	21.45	22.40	21.62	19.05	13.01	10.27	12.57	154.70
DEVIGHAT	1983/84	7.81	7.81	7.56	7.81	7.56	7.81	7.81	7.06	7.81	7.56	7.81	7.56	91.97
SETI	1983/84	0.74	0.74	0.72	0.74	0.63	0.48	0.41	0.34	0.39	0.53	0.74	0.72	7.18
SUB-TOTAL	1983/84	38.98	36.40	35.88	39.02	40.75	47.22	49.54	43.27	44.12	39.00	42.05	39.89	496.12
KULEKHANI-II	1985/86	6.36	5.55	5.81	5.73	7.85	11.32	11.76	11.03	9.79	6.78	5.43	7.17	94.58
SUB-TOTAL	1985/86	45.34	41.95	41.70	44.74	48.60	58.55	61.30	54.30	53.91	45.78	47.48	47.06	590.71
ANDHI KHOLA	1987/88	3.72	3.72	3.60	3.72	3.60	3.12	3.07	2.62	2.90	3.60	3.72	3.60	40.99
SUB-TOTAL	1987/88	49.06	45.67	45.30	48.46	52.20	61.67	64.37	56.92	56.81	49.38	51.20	50.66	631.70
MARSYANGDI	1988/89	42.41	42.18	41.18	43.90	42.91	38.46	31.17	23.99	24.18	32.98	44.34	42.34	450.04
SUB-TOTAL	1988/89	91.47	87.85	86.48	92.36	95.11	100.13	95.54	80.91	80.99	82.35	95.54	93.00	1081.73
SAPTA GANDAKI -NO.1	1991/92	55.80	55.80	54.00	55.80	54.00	54.31	53.20	46.77	51.48	52.99	55.80	54.00	643.95
SUB-TOTAL	1991/92	147.27	143.65	140.48	148.16	149.11	154.45	148.74	127.68	132.48	135.35	151.34	147.00	1725.71
SAPTA GANDAKI -NO.2	1992/93	55.80	55.80	54.00	55.80	54.00	48.29	40.47	15.52	16.00	32.69	55.80	54.00	538.17
SUB-TOTAL	1992/93	203.07	199.45	194.48	203.96	203.11	202.73	189.21	143.20	148.47	168.03	207.14	201.00	2263.85
SAPTA GANDAKI -NO.3	1993/94	55.80	55.80	54.00	55.80	54.00	26.19	5.06	4.23	2.83	3.46	55.80	54.00	426.97
SUB-TOTAL	1993/94	258.87	255.25	248.48	259.76	257.11	228.92	194.27	147.44	151.30	171.49	262.94	255.00	2690.83
GENERATION (GWH)-1993/94		192.60	189.91	178.91	193.26	185.12	170.32	144.54	99.08	112.57	123.42	195.63	183.60	1968.96

Table 3-5 PROJECTED ELECTRIC POWER GENERATING CAPABILITY IN NEPAL (2)

(UNIT: AVERAGE MWH/HOUR)

		MONTHLY												ANNUAL
APPROXIMATELY	MONTH IN NEPAL HOUR	JUL/AUG SHRAW 744	AUG/SEP BHAD 744	SEP/OCT ASWIN 720	OCT/NOV KARTI 744	NOV/DEC MARG 720	DEC/JAN PAUSH 744	JAN/FEB MAGH 744	FEB/MAR FALG 672	MAR/APR CHAIT 744	APR/MAY BAISH 720	MAY/JUN JESTHA 744	JUN/JUL ASHAD 720	1.OYEAR 8760
ELECTRIC POWER STATION	COM-PLETION YEAR													
TRISULI	1969	12.00	12.00	12.00	12.00	12.00	10.94	12.00	11.02	12.00	12.00	12.00	12.00	11.83
PANAUTI	1963	0.80	1.63	1.24	0.64	0.43	0.34	0.47	0.34	0.32	0.32	0.37	0.26	0.62
SUNKOSI	1972	10.05	10.05	10.05	8.25	4.42	3.16	3.93	2.86	3.33	4.96	10.05	6.52	6.50
PHARPING	1911	0.50	0.50	0.50	0.50	0.50	0.20	0.20	0.20	0.20	0.20	0.50	0.50	0.38
SUNDARIJAL	1934	0.70	0.70	0.70	0.70	0.70	0.60	0.60	0.60	0.60	0.60	0.70	0.70	0.66
PHEWA		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
TINAU	1974	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.10	1.10	1.12	1.00	1.20	1.16
GANDAK	1979	5.04	6.91	7.00	6.65	5.73	6.05	6.02	4.10	4.13	4.65	5.40	4.26	5.51
KULEKHANI-I	1982	9.60	3.43	4.63	10.00	19.24	28.83	30.11	32.17	25.60	18.07	13.80	17.46	17.66
DEVIGHAT	1983/84	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50
SETI	1983/84	1.00	1.00	1.00	1.00	0.88	0.65	0.55	0.50	0.52	0.74	1.00	1.00	0.82
SUB-TOTAL	1983/84	52.39	48.92	49.84	52.44	56.60	63.47	66.58	64.39	59.30	54.16	56.52	55.40	56.63
KULEKHANI-II	1985/86	8.55	7.46	8.07	7.70	10.90	15.22	15.81	16.41	13.16	9.42	7.30	9.96	10.80
SUB-TOTAL	1985/86	60.94	56.38	57.91	60.14	67.50	78.69	82.39	80.80	72.46	63.58	63.82	65.36	67.43
ANDHI KHOLA	1987/88	5.00	5.00	5.00	5.00	5.00	4.20	4.13	3.90	3.90	5.00	5.00	5.00	4.68
SUB-TOTAL	1987/88	65.94	61.38	62.91	65.14	72.50	82.89	86.52	84.70	76.36	68.58	68.82	70.36	72.11
MARSYANGDI	1988/89	57.00	56.70	57.20	59.00	59.60	51.70	41.90	35.70	32.50	45.80	59.60	58.80	51.38
SUB-TOTAL	1988/89	122.94	118.08	120.11	124.14	132.10	134.59	128.42	120.40	108.86	114.38	128.42	129.16	123.49
SAPTA GANDAKI -NO.1	1991/92	75.00	75.00	75.00	75.00	75.00	73.00	71.50	69.60	69.20	73.60	75.00	75.00	73.51
SUB-TOTAL	1991/92	197.94	193.08	195.11	199.14	207.10	207.59	199.92	190.00	178.06	187.98	203.42	204.16	197.00
SAPTA GANDAKI -NO.2	1992/93	75.00	75.00	75.00	75.00	75.00	64.90	54.40	23.10	21.50	45.40	75.00	75.00	61.43
SUB-TOTAL	1992/93	272.94	268.08	270.11	274.14	282.10	272.49	254.32	213.10	199.56	233.38	278.42	279.16	258.43
SAPTA GANDAKI -NO.3	1993/94	75.00	75.00	75.00	75.00	75.00	35.20	6.80	6.30	3.80	4.80	75.00	75.00	48.74
SUB-TOTAL	1993/94	347.94	343.08	345.11	349.14	357.10	307.69	261.12	219.40	203.36	238.18	353.42	354.16	307.17
GENERATION (GWH)-1993/94		258.87	255.25	248.48	259.76	257.11	228.92	194.27	147.44	151.30	171.42	262.94	255.00	2690.81

Table 3-6 PROJECTED ELECTRIC POWER CONSUMPTION IN NEPAL (1)

(UNIT: GWH)

MONTH / APPROXIMATELY IN NEPAL	MONTHLY JUL/AUG SHRAW	AUG/SEP BHAD	SEP/OCT ASWIN	OCT/NOV KARTI	NOV/DEC MARG	DEC/JAN PAUSH	JAN/FEB MAGH	FEB/MAR FALG	MAR/APR CHAIT	APR/MAY BAISH	MAY/JUN JESTHA	JUN/JUL ASHAD	ANNUAL 1.0YEAR 365DAYS
1982/83	18.69	19.94	21.33	23.03	26.85	30.18	31.11	24.60	24.28	21.74	21.79	21.34	284.88
1983/84	22.58	24.09	25.78	27.83	32.44	36.46	37.59	29.72	29.34	26.27	26.32	25.78	344.20
1984/85	26.74	28.52	30.52	32.94	38.40	43.17	44.50	35.19	34.73	31.10	31.17	30.53	407.51
1985/86	29.76	31.75	33.97	36.66	42.75	48.05	49.54	39.17	38.66	34.62	34.69	33.98	453.60
1986/87	40.26	42.94	45.95	49.60	57.82	65.00	67.00	52.99	52.30	46.84	46.93	45.96	613.59
1987/88	47.62	50.80	54.36	58.67	68.41	76.89	79.27	62.69	61.87	55.41	55.52	54.37	725.88
1988/89	54.48	58.11	62.19	67.12	78.26	87.96	90.68	71.72	70.78	63.38	63.51	62.21	830.40
1989/90	60.93	64.98	69.54	75.06	87.51	98.36	101.40	80.20	79.15	70.88	71.02	69.56	928.59
1990/91	68.86	73.45	78.60	84.83	98.91	111.18	114.61	90.63	89.45	80.11	80.26	78.62	1049.51
1991/92	76.62	81.72	87.46	94.39	110.05	123.70	127.52	100.85	99.53	89.14	89.31	87.48	1167.77
1992/93	85.25	90.93	97.32	105.03	122.46	137.65	141.90	112.22	110.75	99.18	99.38	97.34	1299.41
1993/94	94.85	101.16	108.26	116.85	136.23	153.13	157.86	124.84	123.21	110.34	110.56	108.29	1445.58
1994/95	105.50	112.53	120.42	129.98	151.54	170.34	175.59	138.87	137.05	122.74	122.98	120.46	1608.00
1995/96	117.31	125.13	133.91	144.52	168.50	189.40	195.25	154.41	152.39	136.48	136.75	133.94	1787.99
1996/97	130.39	139.08	148.84	160.64	187.29	210.52	217.02	171.64	169.39	151.70	152.00	148.87	1987.38
1997/98	144.87	154.52	165.36	178.48	208.09	233.91	241.12	190.69	188.19	168.54	168.87	165.41	2208.05
1998/99	160.88	171.59	183.63	198.19	231.08	259.74	267.76	211.75	208.98	187.16	187.53	183.68	2451.97
1999/00	178.54	190.43	203.79	219.96	256.45	288.26	297.15	235.01	231.93	207.71	208.12	203.85	2721.20
2000/01	198.02	211.21	226.04	243.97	284.44	319.72	329.58	260.66	257.24	230.38	230.83	226.09	3018.18
2001/02	219.49	234.12	250.55	270.41	315.28	354.39	365.33	288.92	285.14	255.36	255.86	250.61	3345.46

NOTES: 1) YEAR AND MONTH ARE IN NEPAL CALENDAR SYSTEM AND A YEAR STARTS ON JULY 16 AND ENDS ON JULY 15.
2) ELECTRIC POWER DEMAND IS ESTIMATED UNDER INTEGRATED CIRCUIT SYSTEM IN NEPAL.
3) NUMBER OF ANNUAL DAYS ARE ASSUMED AS 365 DAYS FOR ALL THE YEAR.
4) BASE MONTHLY RATES ARE ESTIMATED AS AN AVERAGE OF THREE YEARS HISTORICAL DATA FROM 1972 TO 1974.

Table 3-6 PROJECTED ELECTRIC POWER CONSUMPTION IN NEPAL (2)

(UNIT: AVERAGE MWH/HOUR)

APPROXIMATELY IN NEPAL	MONTHLY												ANNUAL
MONTH	JUL/AUG SHRAW	AUG/SEP BHAD	SEP/OCT ASWIN	OCT/NOV KARTI	NOV/DEC MARG	DEC/JAN PAUSH	JAN/FEB MAGH	FEB/MAR FALG	MAR/APR CHAIT	APR/MAY BAISH	MAY/JUN JESTHA	JUN/JUL ASHAD	1.0YEAR 365DAYS
1982/83	25.12	26.80	29.63	30.95	37.29	40.56	41.82	36.61	32.64	30.20	29.29	29.64	32.52
1983/84	30.35	32.38	35.80	37.40	45.05	49.01	50.52	44.23	39.43	36.49	35.38	35.81	39.29
1984/85	35.94	38.33	42.39	44.27	53.34	58.02	59.81	52.37	46.68	43.20	41.89	42.40	46.52
1985/86	40.00	42.67	47.18	49.28	59.37	64.58	66.58	58.29	51.96	48.09	46.63	47.19	51.78
1986/87	54.11	57.72	63.82	66.66	80.31	87.36	90.06	78.85	70.29	65.05	63.08	63.84	70.05
1987/88	64.01	68.28	75.50	78.86	95.01	103.35	106.54	93.29	83.16	76.96	74.62	75.52	82.87
1988/89	73.23	78.11	86.37	90.22	108.69	118.23	121.88	106.72	95.13	88.03	85.36	86.40	94.80
1989/90	81.89	87.34	96.59	100.89	121.54	132.21	136.29	119.34	106.38	98.44	95.46	96.61	106.01
1990/91	92.55	98.72	109.16	114.02	137.37	149.43	154.04	134.87	120.23	111.26	107.88	109.19	119.81
1991/92	102.98	109.84	121.47	126.87	152.85	166.27	171.40	150.08	133.78	123.80	120.04	121.50	133.31
1992/93	114.59	122.22	135.16	141.17	170.08	185.01	190.72	166.99	148.86	137.75	133.57	135.19	148.33
1993/94	127.48	135.97	150.36	157.05	189.21	205.82	212.18	185.78	165.60	153.25	148.60	150.40	165.02
1994/95	141.80	151.25	167.25	174.70	210.47	228.95	236.01	206.65	184.21	170.47	165.30	167.30	183.56
1995/96	157.68	168.18	185.98	194.25	234.03	254.57	262.43	229.78	204.83	189.55	183.80	186.03	204.11
1996/97	175.26	186.93	206.72	215.92	260.13	282.96	291.70	255.41	227.67	210.69	204.30	206.77	226.87
1997/98	194.72	207.69	229.67	239.89	289.02	314.39	324.09	283.77	252.95	234.09	226.98	229.74	252.07
1998/99	216.23	230.63	255.04	266.39	320.94	349.11	359.89	315.11	280.89	259.95	252.06	255.11	279.91
1999/00	239.97	255.95	283.04	295.64	356.18	387.44	399.40	349.71	311.73	288.49	279.73	283.12	310.64
2000/01	266.16	283.89	313.94	327.91	395.05	429.73	442.99	387.88	345.75	319.97	310.26	314.02	344.54
2001/02	295.02	314.68	347.98	363.46	437.89	476.33	491.03	429.94	383.25	354.67	343.90	348.07	381.91

NOTES: 1) YEAR AND MONTH ARE IN NEPAL CALENDAR SYSTEM AND A YEAR STARTS ON JULY 16 AND ENDS ON JULY 15.
2) ELECTRIC POWER DEMAND IS ESTIMATED UNDER INTEGRATED CIRCUIT SYSTEM IN NEPAL.
3) NUMBER OF ANNUAL DAYS ARE ASSUMED AS 365 DAYS FOR ALL THE YEAR.
4) BASE MONTHLY RATES ARE ESTIMATED AS AN AVERAGE OF THREE YEARS HISTORICAL DATA FROM 1972 TO 1974.

Table 3-7 PROJECTED ELECTRIC POWER SURPLUS IN NEPAL (1)

(UNIT: GWH)

MONTH / APPROXIMATELY IN NEPAL / HOUR		MONTHLY JUL/AUG SHRAW 744	AUG/SEP BHAD 744	SEP/OCT ASWIN 720	OCT/NOV KARTI 744	NOV/DEC MARG 720	DEC/JAN PAUSH 744	JAN/FEB MAGH 744	FEB/MAR FALG 672	MAR/APR CHAIT 744	APR/MAY BAISH 720	MAY/JUN JESTHA 744	JUN/JUL ASHAD 720	ANNUAL 1.0YEAR 8760
1983/84	DEVIGHAT,SETI	16.40	12.31	10.11	11.19	8.32	10.76	11.95	13.55	14.78	12.72	15.73	14.10	151.92
1984/85		12.24	7.88	5.36	6.08	2.35	4.05	5.04	8.08	9.39	7.89	10.88	9.36	88.60
1985/86	KULEKHANI-II	15.58	10.20	7.73	8.08	5.85	10.50	11.76	15.13	15.25	11.15	12.79	13.08	137.10
1986/87		5.08	-1.00	-4.26	-4.85	-9.22	-6.45	-5.71	1.31	1.61	-1.06	0.55	1.09	-22.91
1987/88	ANDHI KHOLA	1.44	-5.13	-9.06	-10.21	-16.21	-15.22	-14.89	-5.77	-5.06	-6.03	-4.32	-3.72	-94.18
1988/89	MARSYANGDI	36.98	29.74	24.29	25.24	16.86	12.17	4.87	9.19	10.22	18.97	32.04	30.79	251.36
1989/90		30.54	22.87	16.93	17.30	7.60	1.77	-5.86	0.71	1.85	11.48	24.52	23.44	153.15
1990/91		22.61	14.40	7.88	7.53	-3.79	-11.04	-19.06	-9.72	-8.46	2.25	15.28	14.38	32.26
1991/92	SAPTA GANDAKI	70.65	61.93	53.02	53.77	39.06	30.74	21.22	26.83	32.94	46.21	62.03	59.52	557.92
1992/93	SAPTA GANDAKI	117.81	108.52	97.16	98.93	80.65	65.09	47.32	30.99	37.73	68.85	107.77	103.66	964.48
1993/94	SAPTA GANDAKI	164.02	154.09	140.22	142.91	120.88	75.79	36.41	22.59	28.09	61.15	152.39	146.71	1245.25
1994/95		153.37	142.72	128.06	129.78	105.57	58.59	18.68	8.57	14.25	48.75	139.96	134.54	1082.84
1995/96		141.55	130.13	114.57	115.24	88.61	39.52	-0.97	-6.98	-1.09	35.01	126.20	121.05	902.84
1996/97		128.47	116.18	99.64	99.12	69.82	18.40	-22.75	-24.20	-18.09	19.79	110.95	106.12	703.45
1997/98		114.00	100.73	83.12	81.28	49.02	-4.98	-46.85	-43.26	-36.89	2.94	94.07	89.58	482.76
1998/99		97.99	83.66	64.85	61.57	26.04	-30.82	-73.48	-64.32	-57.68	-15.67	75.41	71.32	238.87
1999/00		80.33	64.82	44.69	39.80	0.66	-59.33	-102.88	-87.57	-80.63	-36.22	54.83	51.15	-30.35
2000/01		60.84	44.04	22.44	15.80	-27.32	-90.80	-135.31	-113.22	-105.94	-58.89	32.11	28.90	-327.35
2001/02		39.37	21.13	-2.07	-10.65	-58.17	-125.47	-171.05	-141.48	-133.84	-83.87	7.08	4.38	-654.64

Table 3-7 PROJECTED ELECTRIC POWER SURPLUS IN NEPAL (2)

(UNIT: AVERAGE MWH/HOUR)

MONTH APPROXIMATELY IN NEPAL HOUR		MONTHLY JUL/AUG SHRAW 744	AUG/SEP BHAD 744	SEP/OCT ASWIN 720	OCT/NOV KARTI 744	NOV/DEC MARG 720	DEC/JAN PAUSH 744	JAN/FEB MAGH 744	FEB/MAR FALG 672	MAR/APR CHAIT 744	APR/MAY BAISH 720	MAY/JUN JESTHA 744	JUN/JUL ASHAD 720	ANNUAL 1.0YEAR 8760
1983/84	DEVIGHAT,SETI	22.04	16.54	14.04	15.04	11.55	14.46	16.06	20.16	19.87	17.67	21.14	19.59	17.34
1984/85		16.45	10.59	7.45	8.17	3.26	5.45	6.77	12.02	12.62	10.96	14.63	13.00	10.11
1985/86	KULEKHANI-II	20.94	13.71	10.73	10.86	8.13	14.11	15.81	22.51	20.50	15.49	17.19	18.17	15.65
1986/87		6.83	-1.34	-5.91	-6.52	-12.81	-8.67	-7.67	1.95	2.17	-1.47	0.74	1.52	-2.61
1987/88	ANDHI KHOLA	1.93	-6.90	-12.59	-13.72	-22.51	-20.46	-20.02	-8.59	-6.80	-8.38	-5.80	-5.16	-10.75
1988/89	MARSYANGDI	49.71	39.97	33.74	33.92	23.41	16.36	6.54	13.68	13.73	26.35	43.06	42.76	28.69
1989/90		41.05	30.74	23.52	23.25	10.56	2.30	-7.87	1.06	2.48	15.94	32.96	32.55	17.48
1990/91		30.39	19.36	10.95	10.12	-5.27	-14.84	-25.62	-14.47	-11.37	3.12	20.54	19.97	3.68
1991/92	SAPTA GANDAKI	94.96	83.24	73.64	72.27	54.25	41.32	28.52	39.92	44.28	64.18	83.38	82.66	63.69
1992/93	SAPTA GANDAKI	158.35	145.86	134.95	132.97	112.02	87.48	63.60	46.11	50.71	95.63	144.85	143.97	110.10
1993/94	SAPTA GANDAKI	220.46	207.11	194.75	192.09	167.89	101.87	48.94	33.62	37.76	84.93	204.82	203.76	142.15
1994/95		206.14	191.83	177.86	174.44	146.63	78.75	25.11	12.75	19.15	67.71	188.12	186.86	123.61
1995/96		190.26	174.90	159.13	154.89	123.07	53.12	-1.31	-10.38	-1.47	48.63	169.62	168.13	103.06
1996/97		172.68	156.15	138.39	133.22	96.97	24.73	-30.58	-36.01	-24.31	27.49	149.12	147.39	80.30
1997/98		153.22	135.39	115.44	109.25	68.08	-6.70	-62.97	-64.37	-49.59	4.09	126.44	124.42	55.11
1998/99		131.71	112.45	90.07	82.75	36.16	-41.42	-98.77	-95.71	-77.53	-21.77	101.36	99.05	27.27
1999/00		107.97	87.13	62.07	53.50	0.92	-79.75	-138.28	-130.31	-108.37	-50.31	73.69	71.04	-3.46
2000/01		81.78	59.19	31.17	21.23	-37.95	-122.04	-181.87	-168.48	-142.39	-81.79	43.16	40.14	-37.37
2001/02		52.92	28.40	-2.87	-14.32	-80.79	-168.64	-229.91	-210.54	-179.89	-116.49	9.32	6.09	-74.73

Table 3-8 AVAILABILITY OF POWER FOR UREA PLANT
(Months Operable at Different Rates)

	Availability of Power for 100 TPD1/			Availability of Power for 200 TPD2/			Availability of Power for 300 TPD3/		
	Months operable at 100%	Months operable at 50-99%	Months operable lower than 50% a/	Months operable at 100%	Months operable at 50-99%	Months operable lower than 50% a/	Months operable at 100%	Months operable at 50-99%	Months operable lower than 50% a/
1989/90	4	3	5 (4)	-	4	7 (6)	-	1	11 (8)
1990/91	1	3	8 (6)	-	1	11 (8)	-	-	12 (11)
1991/92	12	-	-	7	5	-	3	7	2
1992/93	12	-	-	10	2	-	9	3	-
1993/94	12	-	-	10	2	-	9	1	2
1994/95	9	2	1	9	-	3 (1)	7	2	3 (2)
1995/96	9	-	3 (3)	7	2	3 (3)	7	-	5 (3)
1996/97	7	2	3 (3)	7	-	5 (3)	7	-	5 (3)
1997/98	7	-	5 (5)	7	-	5 (5)	6	1	5 (5)
1998/99	7	-	5 (5)	6	1	5 (5)	6	1	5 (5)

Notes: 1/ Power demand assumed at 20 GWh per month
2/ Power demand assumed at 40 GWh per month
3/ Power demand assumed at 60 GWh per month
a/ Figures in parentheses show a number of months operable at rates lower than 30%
b/ Assuming commencement of operation in 1988/89 for Marsyangdi, 1991/92 for Sapt Gandaki No.1, 1992/93 for Sapt Gandaki No.2, and 1993/94 for Sapt Gandaki No.3, but no additional hydropower installation.

Source: Estimated on the basis of figures shown in Table 3-7

Table 3-9 COMPARISON OF CARBON DIOXIDE SUPPLIABILITY FROM CEMENT PLANT FLUE GAS TO UREA FERTILIZER PLANT IN NEPAL

Comparison	Cement Plants in Nepal: Hetauda Cement Indu., Ltd.	Cement Plants in Nepal: Himal Cement Co.,(PVT) Ltd.
Location	Chaudaghare, Hetauda	Chobar, Kathmandu
Elevation, m	455	1,260
Pressure, ata	0.947	0.859
Carbon Dioxide Suppliability, TPD		
-1984	0	106
-1986	443	217
-1991	554	265
Flue Gas Supply Condition		
-Total Pressure	A	C
-CO_2 Concentration	A	C
-CO Concentration	A	C
-O_2 Concentration	A	C
-Moisture Content	B	B
-Dust Content	A	C
-NO_x, SO_x Concentration	B	B
-Temparature	B	B
-CO_2 Tonnage	A	C
Reliability and Experience		
-1984	C	A
-1991	B	B
Overall Evaluation	A	C

Notes: Evaluation of Carbon Dioxide Suppliability for the Urea Fertilizer Plant; A = Superior, B = Equivalent, C = Inferior

Table 3-10 COMPARISON OF SITE CONDITIONS FOR UREA FERTILIZER PLANT

		SITE ALTERNATIVES	
		Hetauda	Kathmandu
(1)	Electric Power Suppliability	A	C
(2)	Carbon Dioxide Suppliability	A	C
(3)	Industrial Water Suppliability	A	C
(4)	Soil Conditions and Available Space	A	C
(5)	Equipments and Materials Transport	A	C
(6)	Product Transport	A	C
(7)	Environmental Protection	A	C
(8)	Infrastructure	B	B
(9)	Skilled Labor Availability	B	B

Notes: A = Superior, B = Equivalent, C = Inferior

Table 3-11 DESIGN BASIS FOR UREA FERTILIZER PLANT IN THE KINGDOM OF NEPAL

1. Location	Hetauda, Nepal	
Latitude, North	27°24'	
Longitude, East	85°01'	
Altitude, Above Sea Level	445 meter	
2. Meteorological Data		
(1) Theoretical Standard Pressure, mb	959.8	
ata	0.9472	
(2) Temperature, °C -1980		
Maximum, Absolute	38.8 (April 24)	
Minimum, Absolute	3.0 (January 1)	
Monthly Average		
-Maximum	36.1 (April)	
-Minimum	5.8 (January)	
-Annual	22.8	
(3) Precipitation, mm -1980		
Annual	1,948	
Monthly Maximum	461 (June)	
Monthly Minimum	0 (January)	
Daily Maximum	158 (June 19)	
(4) Relative Humidity, % -1980	AM 8:40	PM 5:40
Annual Average	74	68
Monthly Average		
-January	83	74
-April	43	35
-June	74	76
-September	77	79
(5) Atmospheric Air Condition		
Pressure, ata	0.947	
Temperature, °C	23.0	
Relative Humidity, %	70.0	
Composition, kg/kg-Dry Air		
-Nitrogen	0.7453	
-Oxygen	0.2547	
-Dry Air	1.0000	
-Moisture	0.0133	
-Total Air	1.0133	
(6) Design Conditions of Urea Fertilizer Plant		
Temperature, °C	33.0	
Relative Humidity, %	75.0	
Maximum Hourly Precipitation, mm	50.0	
Pressure, ata	0.947	

3. Soil Data

Layer	Below Ground Level meter	Soil	Safety Loading Intensity Ton/m^2
Top Soil	0.0 - 0.5	Soft Clay Silt,	0.0
Strata II	0.5 - 6.0	Gravel, Cobbles and Boulder Mixture	30.0
Strata III - Strata V	6.0 -	Dense Stiff Silty Sand	40.0

4. Ground Water

Ground Water Level Below Ground Level, m	3.8 - 8.0

5. Seismic Factor (Indian Standards)

Horizontal	0.125
Vertical	0.060

6. Wind Factor

Height Above Ground Level m	Wind Pressure kg/m^2
0.0 - 30	100
30 - 35	104
35 - 40	105
40 - 45	108
45 - 50	111
50 - 60	115
60 - 70	118

7. Utility Supply Condition

(1) Electric Power

Receiving Point	Battery Limit of the Urea Fertilizer Plant
Voltage	66 KV or 132 KV
Phase	Three
Frequency	50 Hertz

(2) Cement Plant Flue Gas

Receiving Point	Outlet of Electrostatic-precipitator of the Hetauda Cement Industries, Ltd.
Pressure, at	0.947
Temperature, °C	113.0
Analysis (Wet, Molar Ratio)	
N_2, %	59.7
O_2, %	7.4
CO_2, %	18.4
CO, %	0.1
H_2O, %	14.4
SO_x, ppm	50
NO_x, ppm	150
Dust, mg/Nm^3	100

(3) Coal

Receiving Point	Battery Limit of the Urea Fertilizer Plant
Chemical Analysis, %	
Moisture	2.4
Ash	10.0
Volatile Matter	40.0
Fixed Carbon	47.0
Carbon	70.0
Hydrogen	5.2
Sulfur	3.5
Nitrogen	1.1
Oxygen and Others	7.2
	99.4
Heating Value, kcal/kg	
Gross (High)	7,100
Net (Low)	6,805
Chemical Analysis of Ash	
Ignition Loss	0.60
SiO_2	58.00
Al_2O_3	27.60
Fe_2O_3	5.90
CaO	2.60
MgO	0.80
SO_3	0.28
Na_2O	0.11
K_2O	1.70
TiO_2/V_2O_3	-
MnO_3/NiO	-
P_2O_5	1.25
Cl	-
	98.84

(4) Raw Water

Source;	Wells in the Urea Fertilizer Plant
Pressure;	Atmospheric
Temperature;	Ambient
Analysis, ppm;	

pH	5.5
Electrical Conductivity, *	50
Hardness ($CaCO_3$)	40
Calcium Hardness	13
Magnesium Hardness	27
Suspended Solids	40
Evaporated Presidue	60
COD	5
SO_4	6
Cl	4
Fe	0.15
Alkalinity ($CaCO_3$)	30

* micro-mho/cm

Table 3-12 MAJOR FACILITIES FOR THE PROPOSED UREA FERTILIZER PLANT IN THE KINGDOM OF NEPAL

(1) Urea Fertilizer Plant	Daily Production Capacity of 275 TPD of Bagged Urea	
(2) Location	Hetauda, Nepal	
(3) Major Facility		
Process Plant		
-Hydrogen Plant	H_2 Gas;	13,300 Nm^3PH
-Nitrogen Plant	N_2 Gas;	4,440 Nm^3PH
-Ammonia Plant	Liquid Ammonia;	160 TPD
-Carbon Dioxide Plant	CO_2 Gas;	207 TPD
-Urea Plant	Prilled Urea;	275 TPD
Utility Plant		
-Raw Water Intakes and Treatment	Raw Water;	183 TPH
-Demineralizer	Purified Water;	32 TPH
-Cooling Water Tower	Circulating Water;	6,500 TPH
-Waste Water Treatment	Waste Water;	55 TPH
-Instrument and Plant Air	Compressed Air;	1,500 Nm^3PH
-Steam Generator	Steam;	27.5 TPH
-Electric Power Receiving	Electric Power;	86 MW
-Coal Receiving and Feeding	Coal;	250 Ton
-Emergency Electric Power Generating	Emergency Power;	0.8 MW
Storage and Shipping Facility		
-Hygron Gas Storage	H_2 Gas;	33,000 Nm^3
-Nitrogen Gas Storage	N_2 Gas;	2,000 Nm^3
-Ammonia Storage	Liquid Ammonia;	1,750 Ton
-Carbon Dioxide Storage	CO_2 Gas;	20,000 Nm^3
-Bulk Urea	Prilled Urea;	2,100 Ton
-Bagged Urea	Bagged Urea;	7,000 Ton
-Urea Bagging	Bagged Urea;	40 TPH
-Urea Loading	Bagged Urea;	100 TPH
Auxiliary Facility		
-Administration Office	800 m^2	
-Canteen	800 m^2	
-Maintenance and Engineering Office	400 m^2	
-Maintenance Work Shop	1,320 m^2	
-Laboratory	400 m^2	
-Ware House	320 m^2	
-Gate House	30 m^2	
-Car Port	150 m^2	
-First Aid House	200 m^2	
-Local Laboratory	30 m^2	
Residential Colony		
-Residential Houses	6,010 m^2	
(Floor Space)	(92 Housings)	

Table 3-13 CONSUMPTION FOR UREA FERTILIZER PRODUCTION

	Consumption and production, Ton		
	Unit Product	Hourly	Daily
Production;			
- Urea Fertilizer Prilled and Bagged, Ton	1.000	11.458	275.0
Consumption;			
- Electric Power, MW			
- Hydrogen Plant	5.411	61.9992	1,488.0
- Other Plants	1.231	14.1052	338.5
Sub-Total	6.642	76.1040	1,826.5
- Raw Water, Ton	16	200	4,800.0
- Atmospheric Air, Nm^3	1,520	19,000	456,000.0
- Cement Plant Flue Gas, Nm^3	2,596	32,450	778,800.0
- Fuel Coal, Ton	0.256	3.200	76.8
- Chemicals and Catalysts, USD/Ton-Urea -1984	2.717	33.963	815.1
- Fertilizer Bag, sheet	20.200	252.500	6,060.0

Notes: Electric power consumption for the hydrogen plant is extimated as follows;

- 4.55 kWh/Nm^3-H_2 (Project Life Averaged)
- 1,988.7 Nm^3-H_2/Ton-Ammonia
- 0.580 Ton-Ammonia/Ton-Urea
- 97.0% - Rectifier and Transformer Efficiency

Table 3-14 INPUTS AND OUTPUTS FOR UREA FERTILIZER PRODUCTION

	Inputs				Outputs	
	Hydrogen Gas	Nitrogen Gas	Liquid Ammonia	Carbon Dioxide Gas	Prilled Urea	Bagged Urea
	Nm^3	Nm^3	Ton	Ton	Ton	Ton
Hydrogen Gas, Nm^3	(-)1.00	-	0.828	-	-	-
Nitrogen Gas, Nm^3	-	(-)1.00	0.177	-	-	-
Liquid Ammonia, Ton	-	-	(-)1,000	-	0.58	-
Carbon Dioxide, Ton	-	-	-	(-)1.00	0.75	-
Prilled Urea, Ton	-	-	-	-	(-)1.00	1.00
Bagged Urea, Ton	-	-	-	-	-	(-)1.00
Electric Power, kWh	4,550	0.33	1,028	128	148	-
Process Water, Ton	0.001	-	-	-	-	-
Cooling Water, Ton	0.145	0.036	220	133	112	-
Steam, Ton	-	-	(-)0.90	2.14	1.04	-
Condensate, Ton	-	-	1.00	-	0.90	-
Coal Fuel, Ton	-	-	-	-	-	
Chemicals and Catalysts, USD-1984	-	-	-	-	-	2.72
Fertilizer Bag, Sheets	-	-	-	-	-	20.2
Hourly Production	13,300	4,440	6.66	8.625	11.458	11.458
Daily Production	319,200	106,560	160	207	275	275

Notes: 1) The figure in minus indicates production

2) The final product is bagged prilled urea which are produced from atmospheric air, flue gas from cement plant, electric power, fuel coal, chemicals and catalyst and fertilizer bags as major inputs.

Table 3-15 ORGANIZATION AND PERSONNEL REQUIREMENTS

Feasibility Study: On the Establishment of Urea Fertilizer Plant in the Kingdom of Nepal
Project: Urea Fertilizer Plant
Product: Bagged Urea
Capacity: Prilled Urea; 275TPD
Location: Kathmandu and Hetauda, Nepal

	Organization for the Project	Managing Director, Director	General Manager, Manager	Senior Engineer and Officer	Supervisor, Foreman, Officer	Operator, Worker, Secretary	Total
1.	Head Office and Regional Sales Office - Kathmandu	(6)	(2)	(2)	(3)	(2)	(15)
2.	Urea Fertilizer Plant - Hetauda	(1)	(18)	(31)	(72)	(182)	(304)
2.1	Factory Director's Office	(1)	(1)	(2)	(4)	(4)	(12)
2.2	General Affair Department	(0)	(4)	(7)	(7)	(14)	(32)
	- Administration Section	0	1	1	1	2	5
	- Personnel Section	0	0	1	1	2	4
	- Financing/Accounting Section	0	1	1	1	2	5
	- Housing and Welfare Section	0	0	1	1	2	4
	- Security and Health Section	0	1	1	1	2	5
	- Leagal Section	0	0	1	1	3	4
	- Purchase and Product Sales Section	0	1	1	1	2	4
2.3	Production Department	(0)	(2)	(8)	(16)	(72)	(98)
	- Hydrogen, Nitrogen and Ammonia Plant	0	1	4	8	36	49
	- Carbon Dioxide and Urea Plant	0	1	4	8	36	49
2.4	Utility Department	(0)	(3)	(3)	(12)	(24)	(42)
	- Water Treatment and Steam Boiler	0	1	1	4	8	14
	- Cooling Water Tower and Electric Power	0	1	1	4	8	14
	- Others	0	1	1	4	8	4
2.5	Maintenance and Inspection Department	(0)	(3)	(3)	(20)	(26)	(52)
	- Maintenance Management	0	1	0	2	2	5
	- Mechanical Section	0	0	1	5	6	12
	- Electrical Section	0	1	0	5	6	12
	- Instrumental Section	0	0	1	4	6	11
	- Civil Construction Section	0	0	1	1	2	4
	- Inventory Section	0	1	0	3	4	8
2.6	Product Handling Department	(0)	(2)	(3)	(3)	(28)	(36)
	- Storage Management	0	2	1	1	8	12
	- Bagging Section	0	0	1	1	10	12
	- Loading Section	0	0	1	1	10	12
2.7	Technical and Development Department	(0)	(3)	(5)	(10)	(14)	(32)
	- Production Management	0	1	1	2	2	6
	- Development and Engineering Section	0	1	1	2	2	6
	- Analytical Laboratory	0	1	1	2	6	10
	- Training Section	0	0	1	2	2	5
	- Product Sales Services	0	0	1	2	2	5
3.	Total Personnel for the Project	7	20	33	75	184	319

Notes: 1) Additional contract laborers for product bagging and loading is assumed during peak shipping season.

2) During annual maintenance work for 35 days, additional maintenance supervisor and labor are contracted (Vendor specialist; 10, Inspector; 15, Laborer; 315, Total; 335 persons) whose costs are included in maintenance cost for financial analysis.

Figure 3-1 HYDRO POWER STATIONS AND MAIN POWER TRANSMISSION LINES IN NEPAL

UNDER CONSTRUCTION OR PROPOSED PROJECTS			EXISTING PROJECTS		
1	MARSHYANGDI	40 MW	1	PHARPING	500KW
2	DEVIGHAT	14 "	2	SUNDARIJAL	640 "
3	KANKAI	37 "	3	PANAUTI	2400 "
4	SHARDA	49 "	4	TRISULI	21000 "
5	KULEKHANI No1	60 "	5	POKHARA	1068 "
6	KULEKHANI No2	35 "	6	DHANKUTA	240 "
7	KAMALA	30 "	7	TINAU	960 "
8	BAGMATI	70 "	8	SUNKOSI	10050 "
9	CHISAPANI	3600 "	18	SURKHET	345 "

TRANSMISSION LINES

	UNDER CONSTRUCTION OR PROPOSED	EXISTING
11KV LINE		
33KV LINE		
66KV LINE		
132KV LINE		

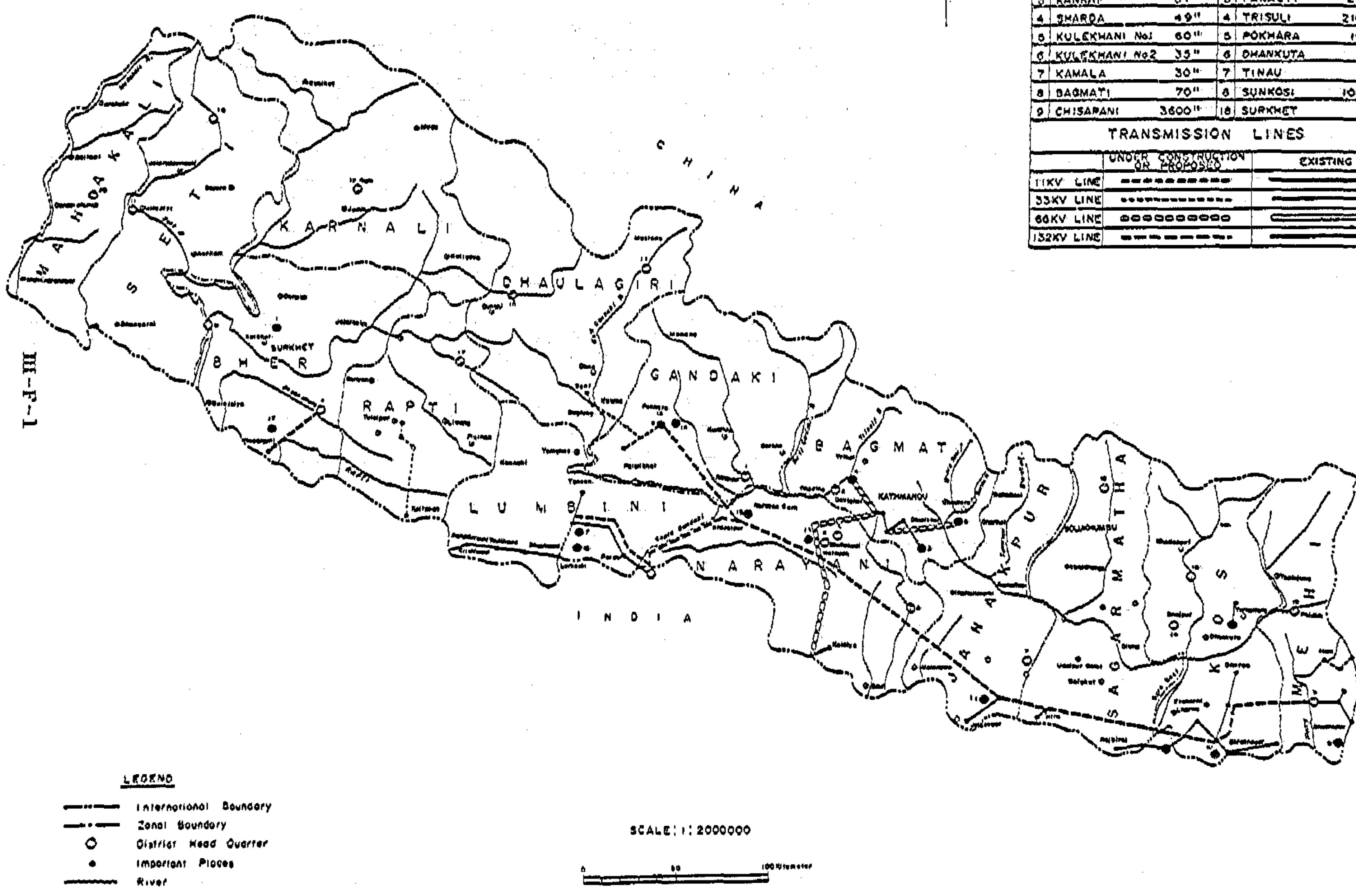


Figure 3-2 NEPAL POWER SYSTEM INTEGRATED DEMAND AND GENERATION EXPANSION

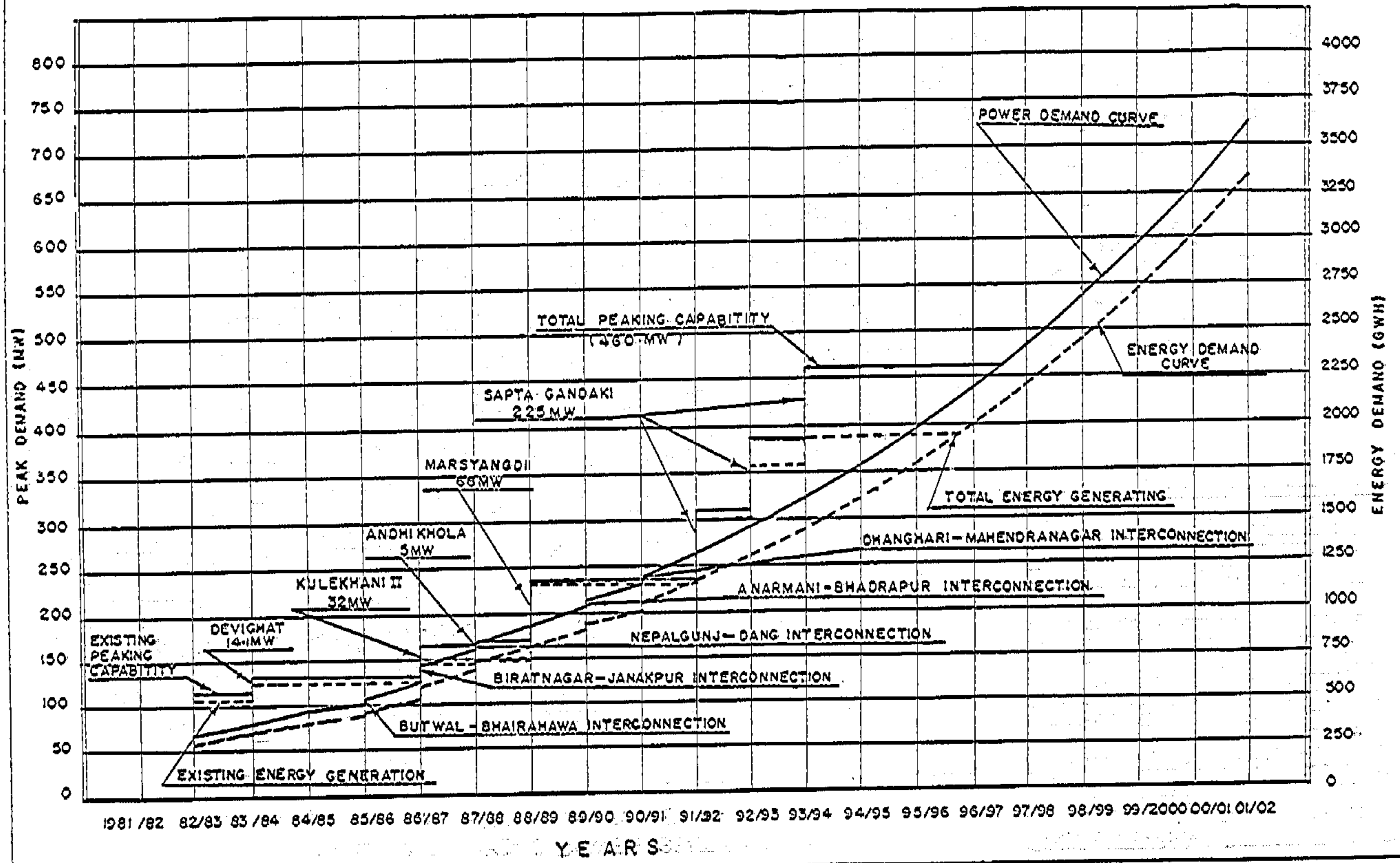
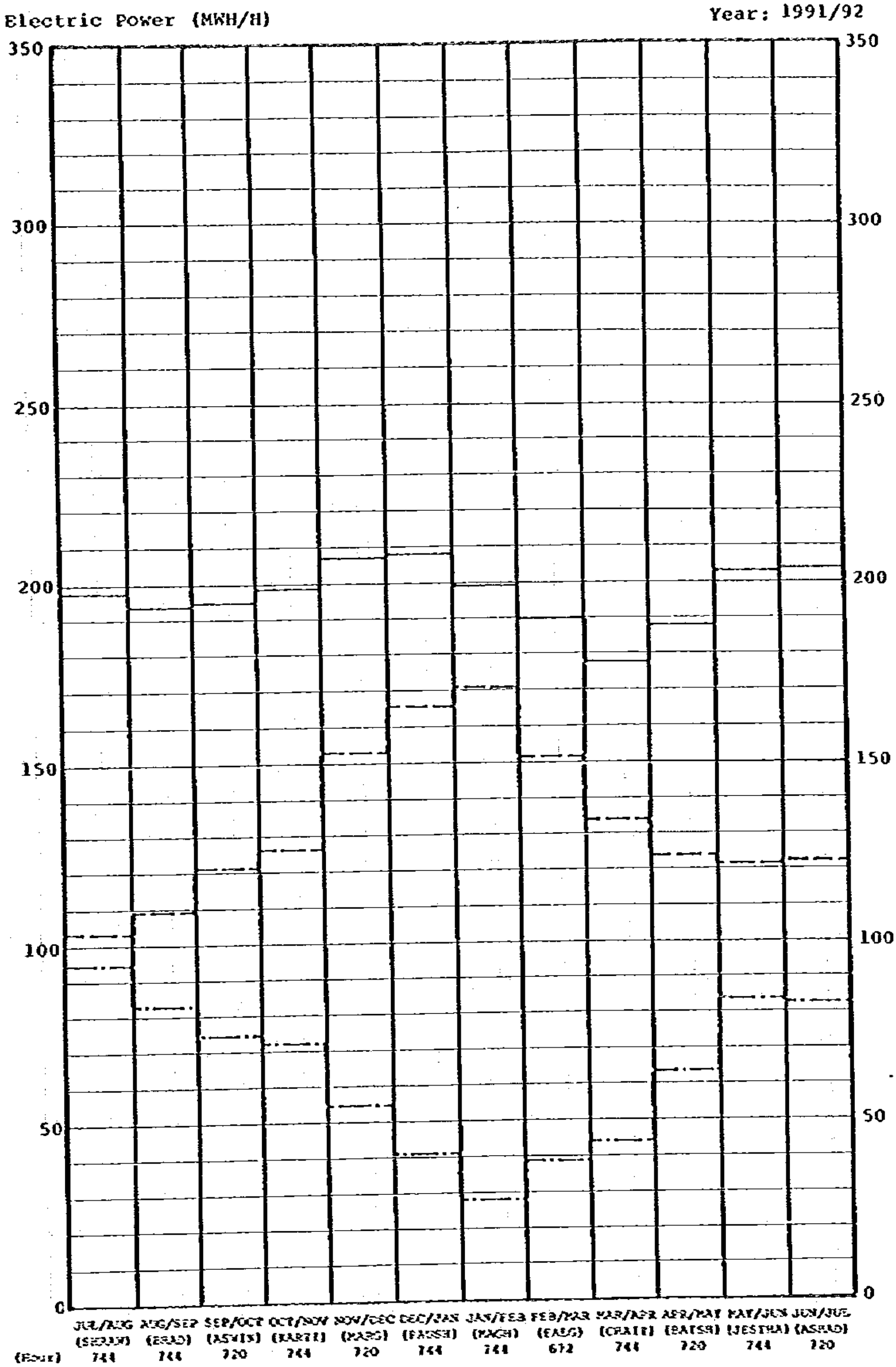
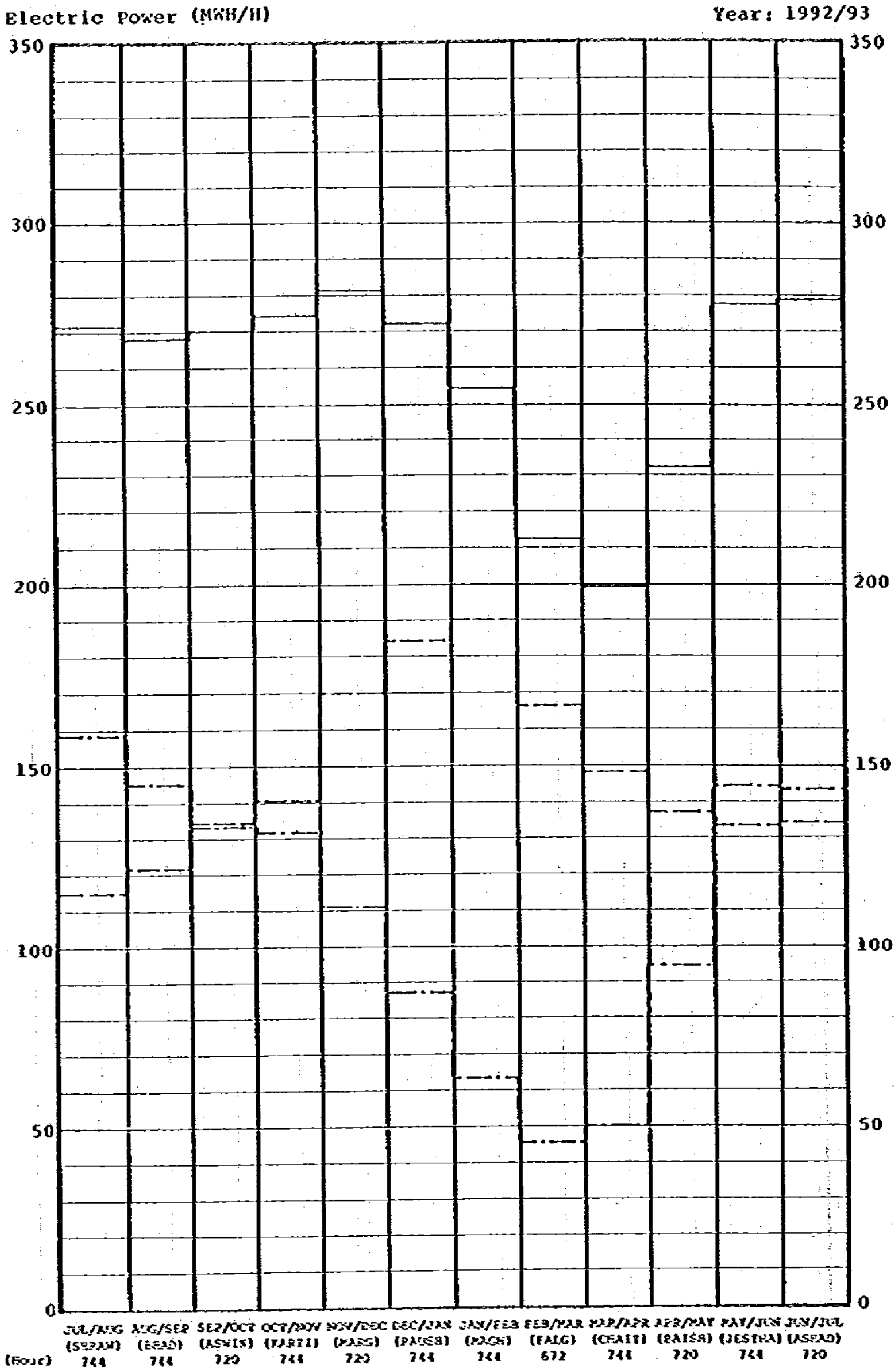


Figure 3-3 PROJECTED ELECTRIC POWER GENERATION CAPABILITY AND CONSUMPTION IN NEPAL (1)



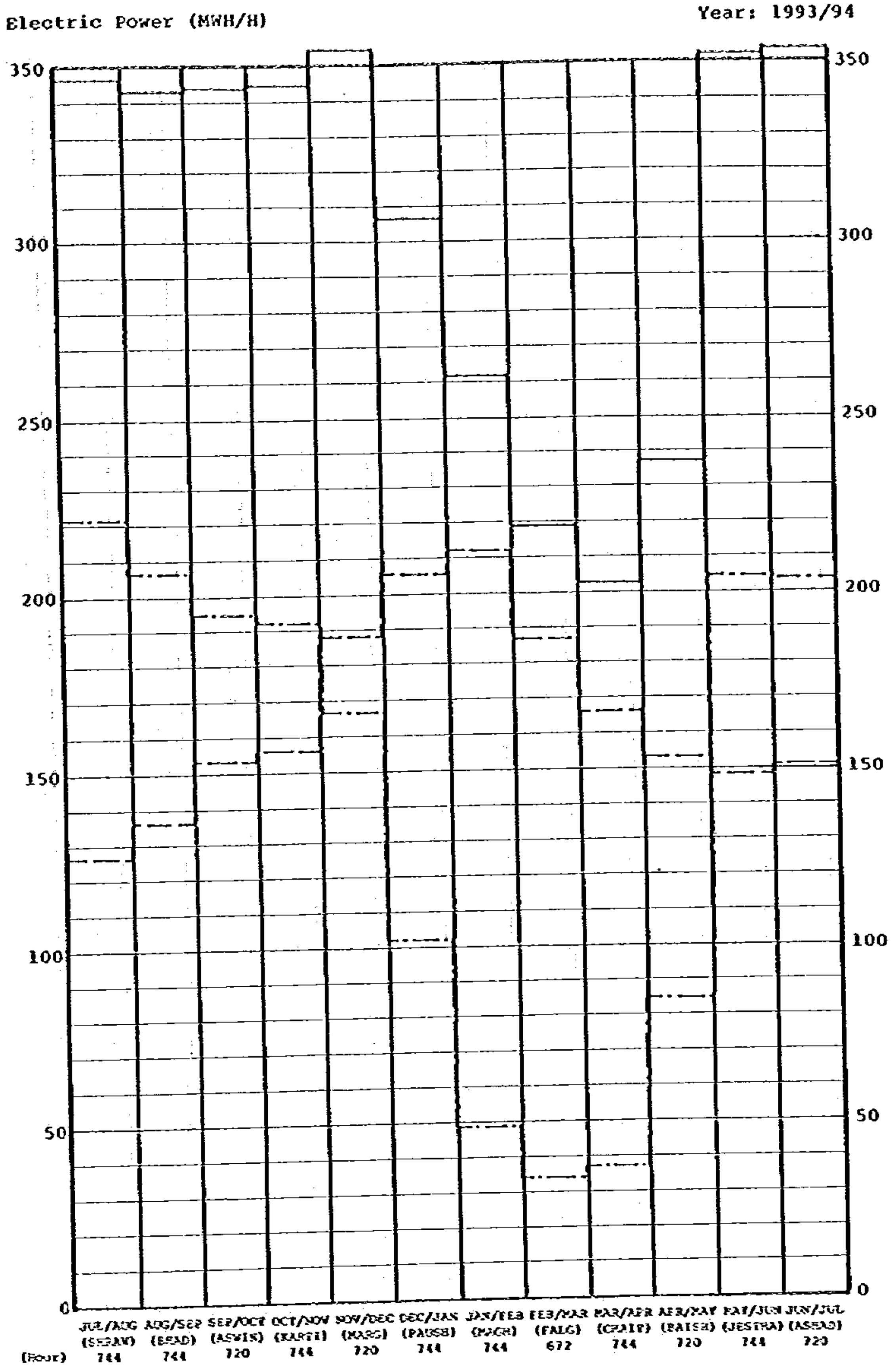
Notes: ——— Generating Capability (MWH/H)
– – – – Consumption (MWH/H)
—·— Surplus (MWH/H)

Figure 3-3 PROJECTED ELECTRIC POWER GENERATION CAPABILITY AND CONSUMPTION IN NEPAL (2)



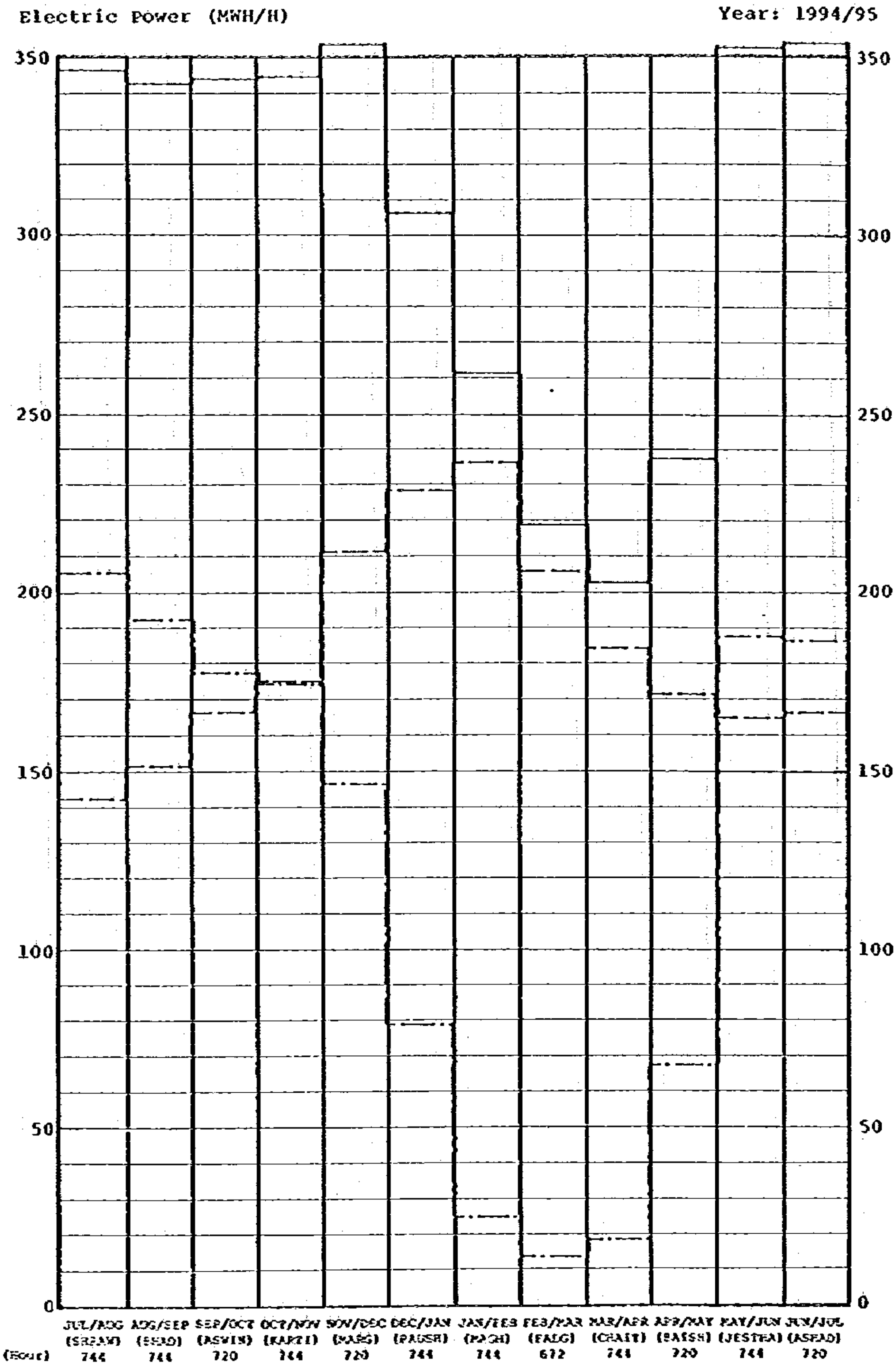
Notes: ——— Generating Capability (MWH/H)
–·–·– Consumption (MWH/H)
—·— Surplus (MWH/H)

Figure 3-3 PROJECTED ELECTRIC POWER GENERATION CAPABILITY AND CONSUMPTION IN NEPAL (3)



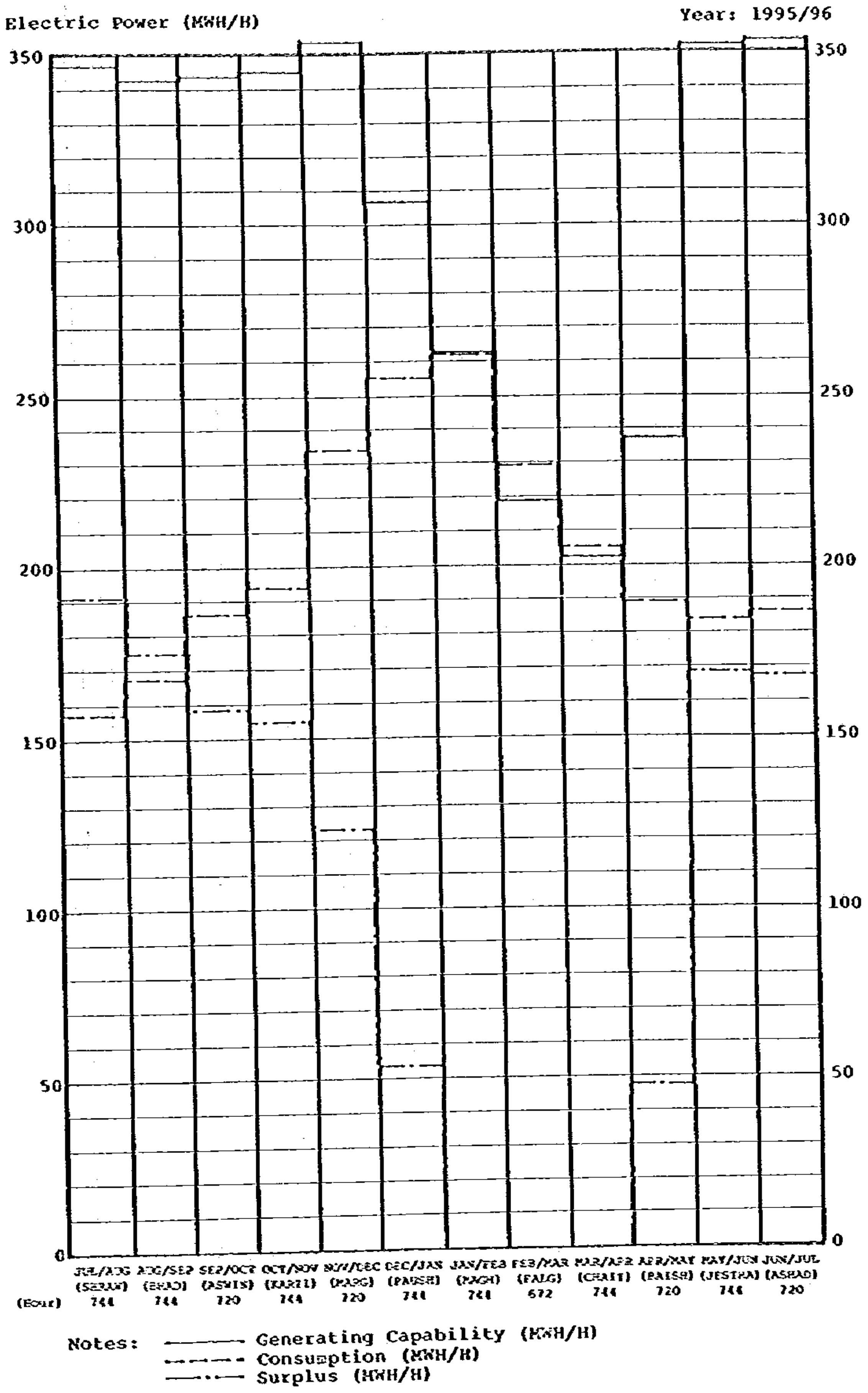
Notes: ——— Generating Capability (MWH/H)
- - - - Consumption (MWH/H)
—·— Surplus (MWH/H)

Figure 3-3 PROJECTED ELECTRIC POWER GENERATION CAPABILITY AND CONSUMPTION IN NEPAL (4)



Notes: ——— Generating Capability (MWH/H)
-·-·- Consumption (MWH/H)
—·— Surplus (MWH/H)

Figure 3-3 PROJECTED ELECTRIC POWER GENERATION CAPABILITY AND CONSUMPTION IN NEPAL (5)



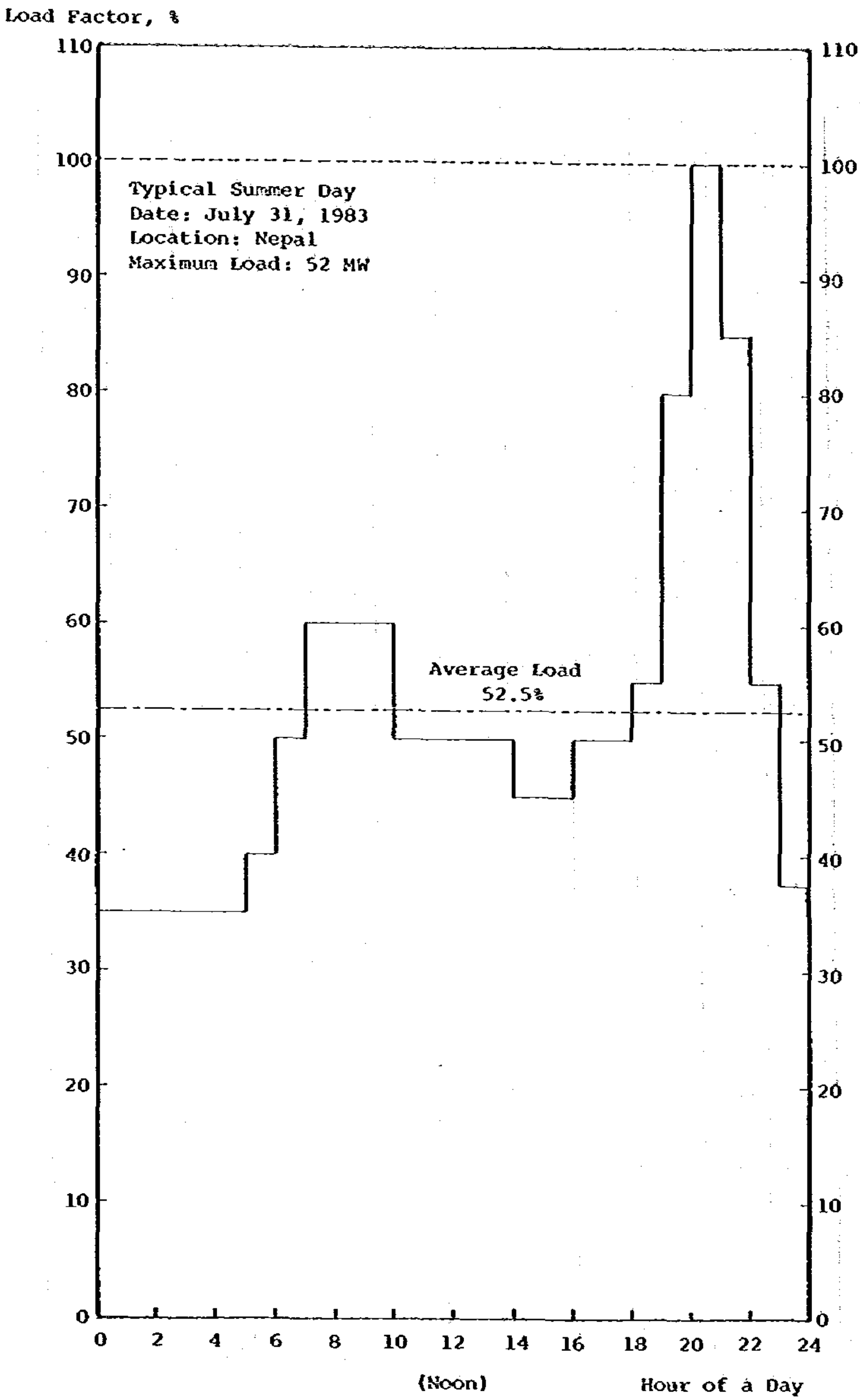


Figure 3-4 HOURLY ELECTRIC POWER CONSUMPTION PATTERN (1)

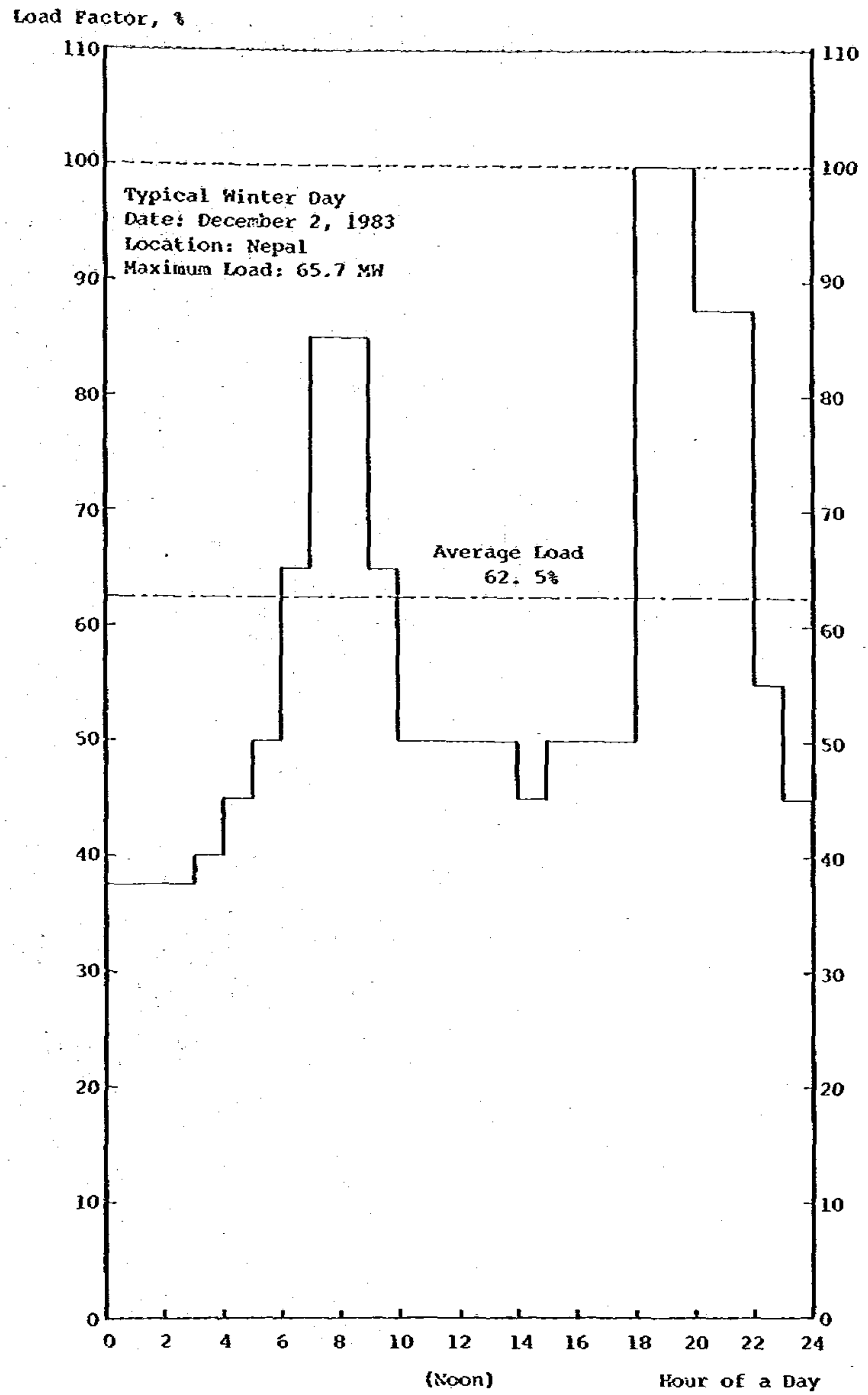
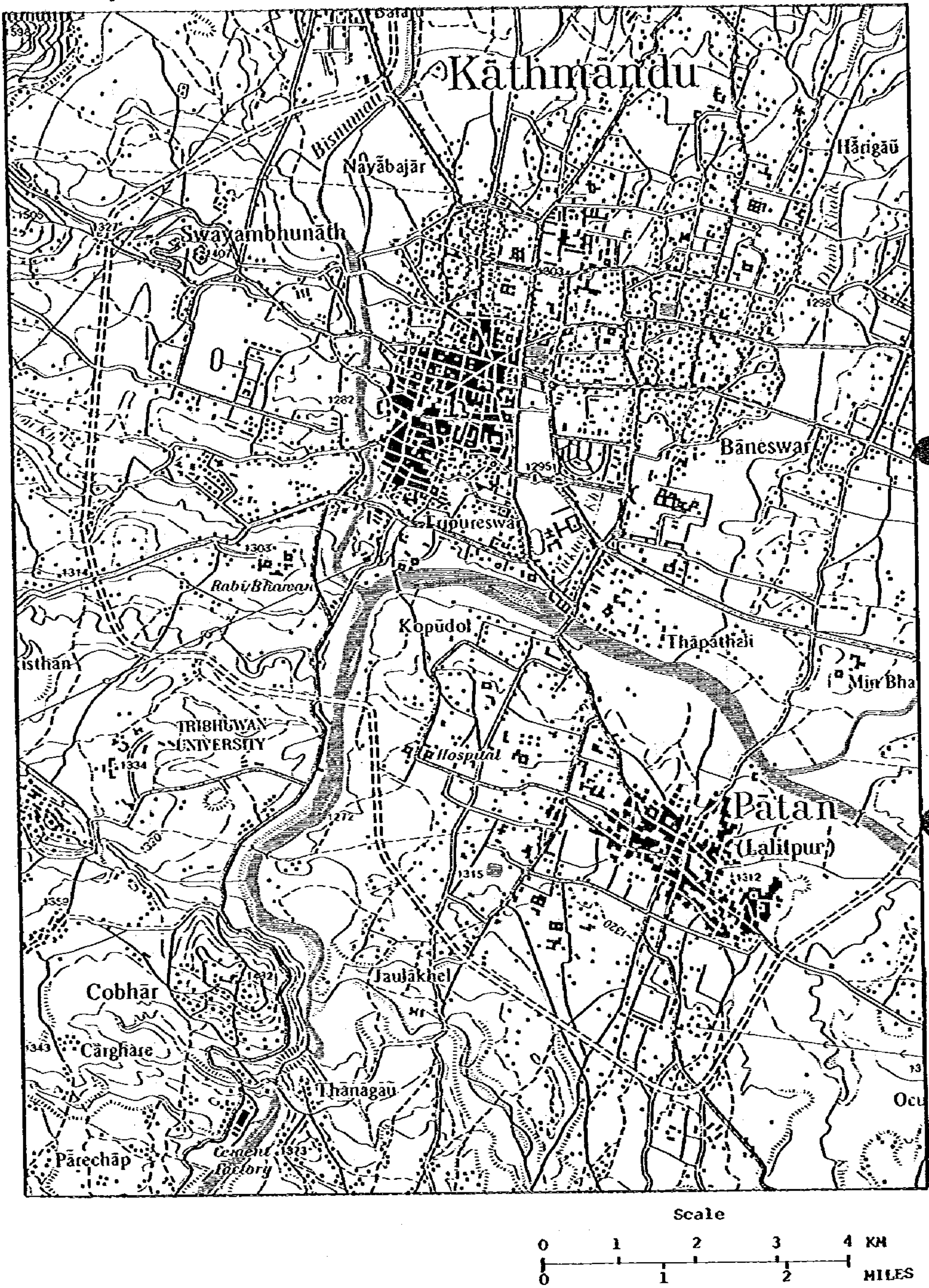


Figure 3-4 HOURLY ELECTRIC POWER CONSUMPTION PATTERN (2)

Figure 3-5 LOCATION MAP OF HIMAL CEMENT CO.(PVT) LTD., CHOBAR, KATHMANDU



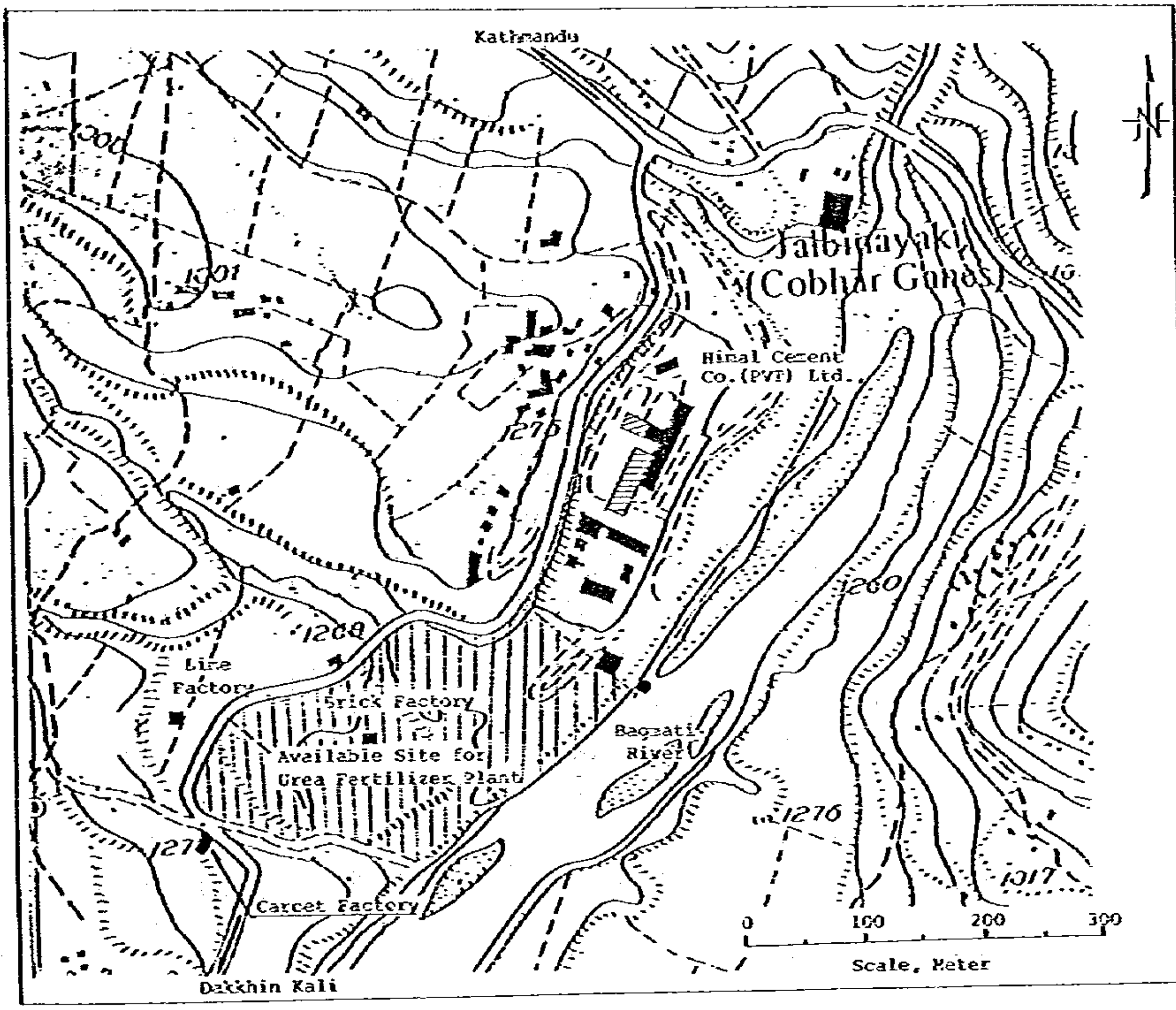


Figure 3-6 AVAILABLE SITE FOR UREA FERTILIZER PLANT AT HIMAL CEMENT CO.(PVT) LTD., CHOBAR, KATHMANDU

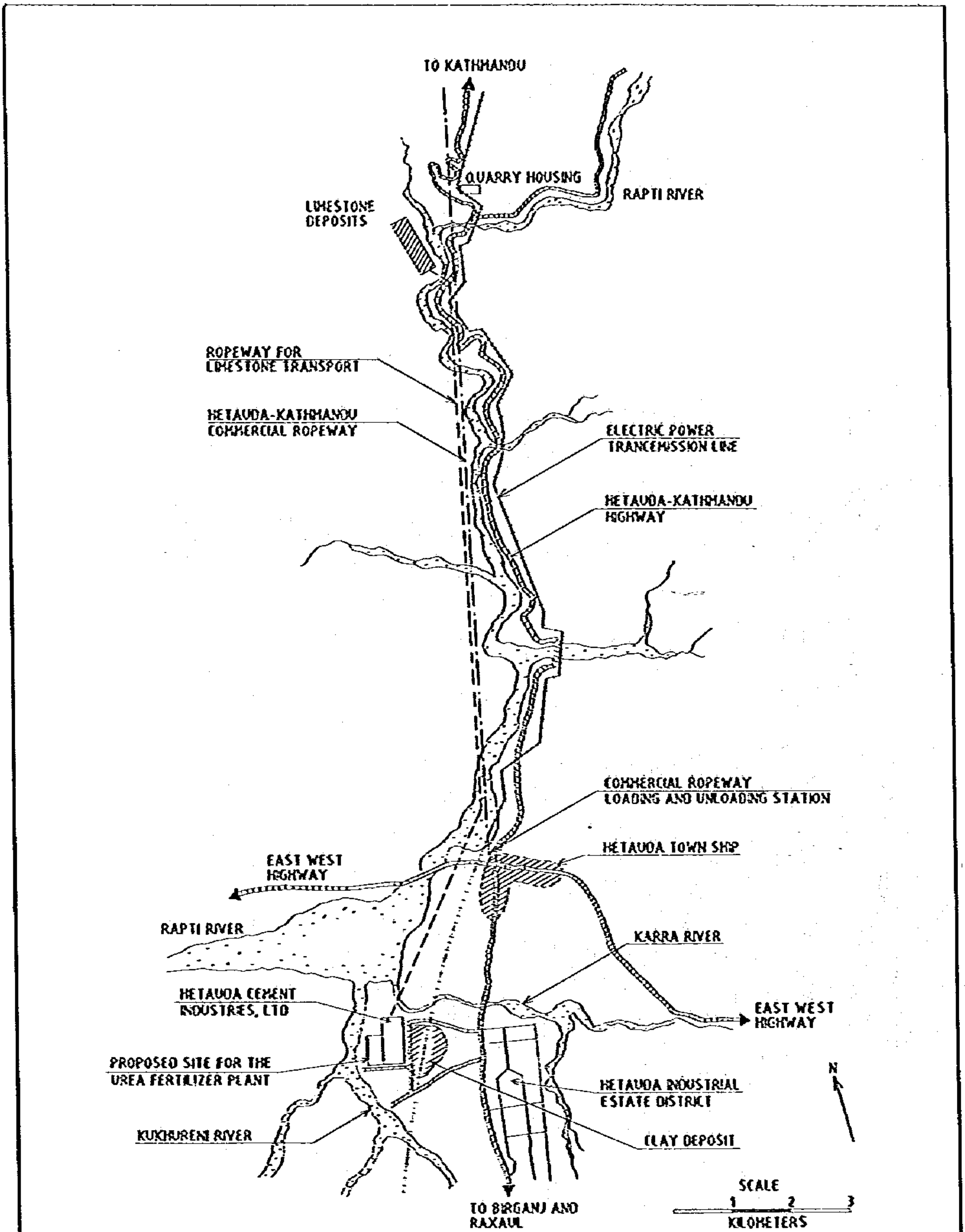
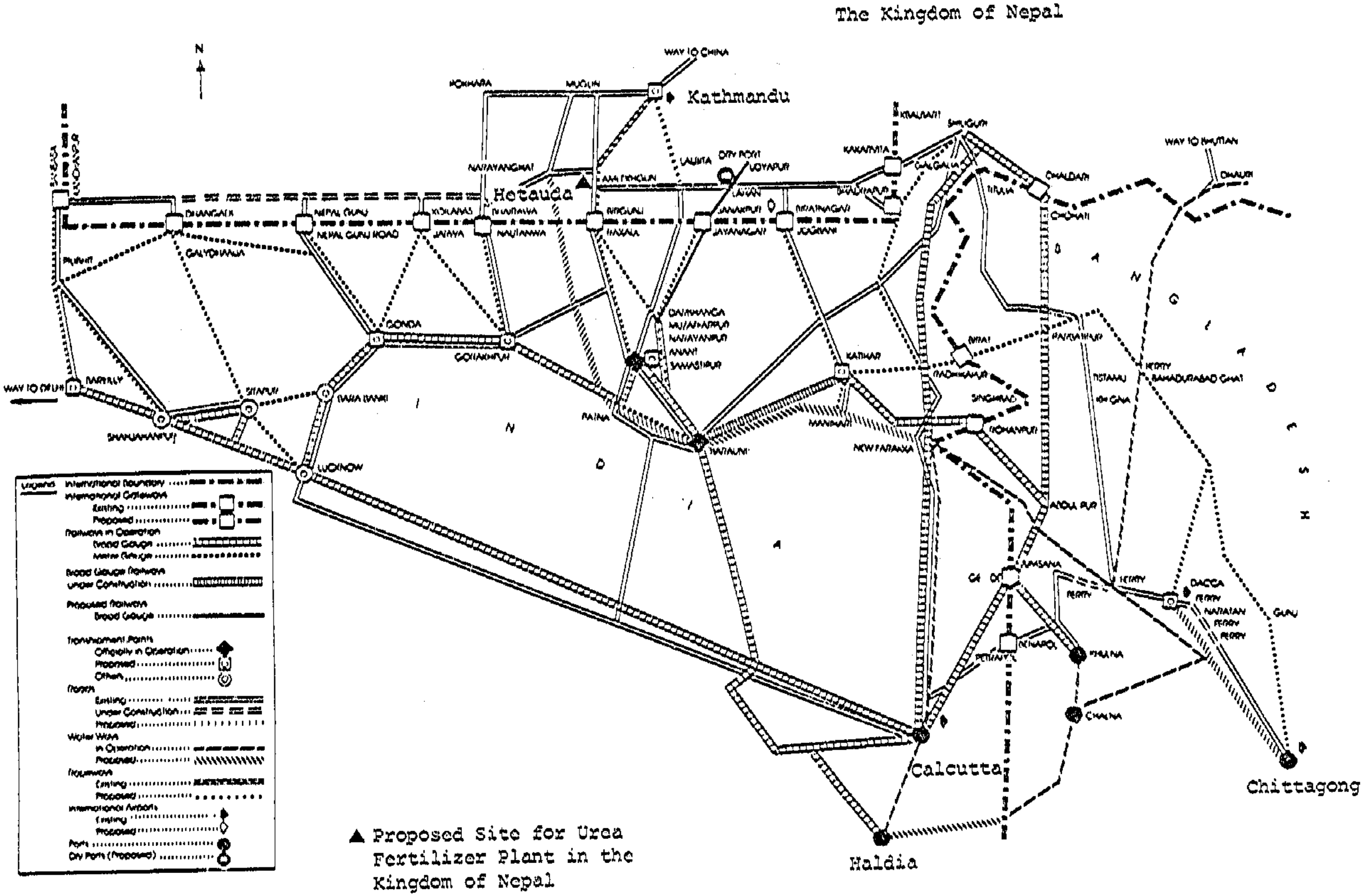


Figure 3-7 GENERAL LOCATION MAP FOR PROPOSED UREA FERTILIZER PLANT IN THE KINGDOM OF NEPAL

Figure 3-8 SCHEMATIC INLAND TRANSPORT ROUTES FOR EQUIPMENT AND MACHINERY FOR UREA FERTILIZER PROJECT IN NEPAL



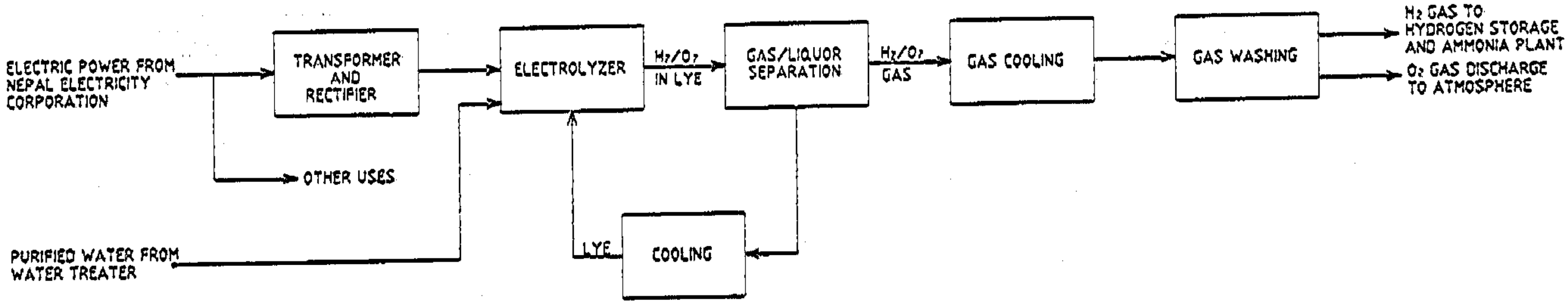


Figure 3-9 BLOCK FLOW DIAGRAM FOR HYDROGEN PLANT

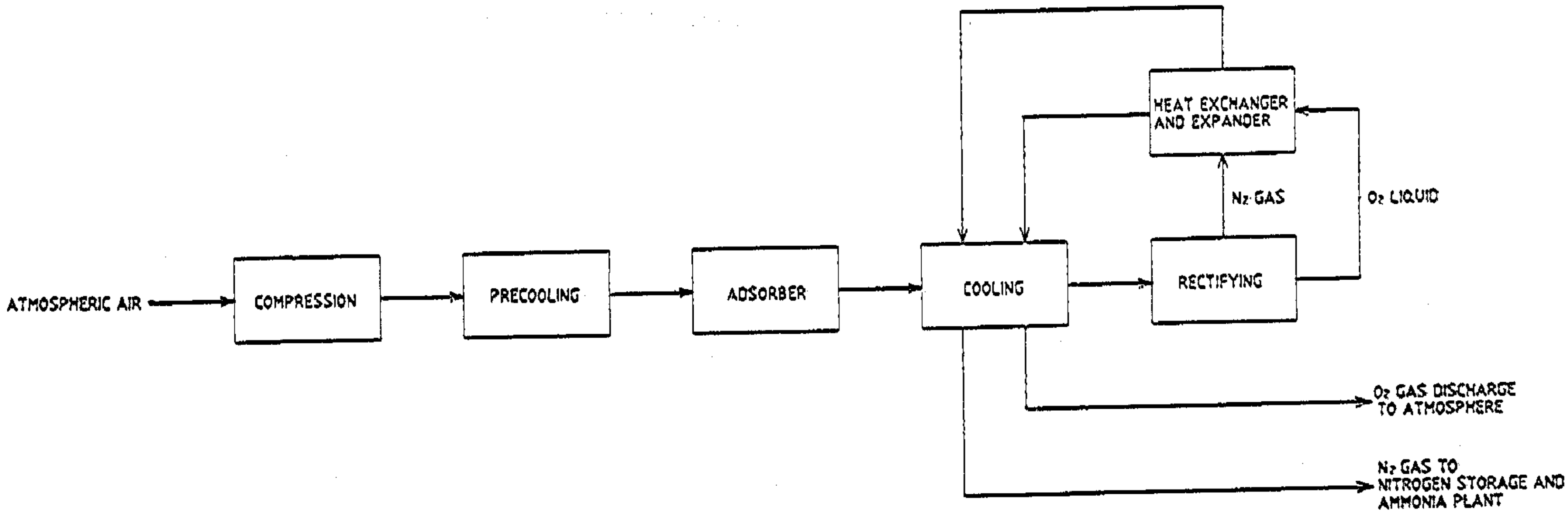


Figure 3-10 BLOCK FLOW DIAGRAM FOR NITROGEN PLANT

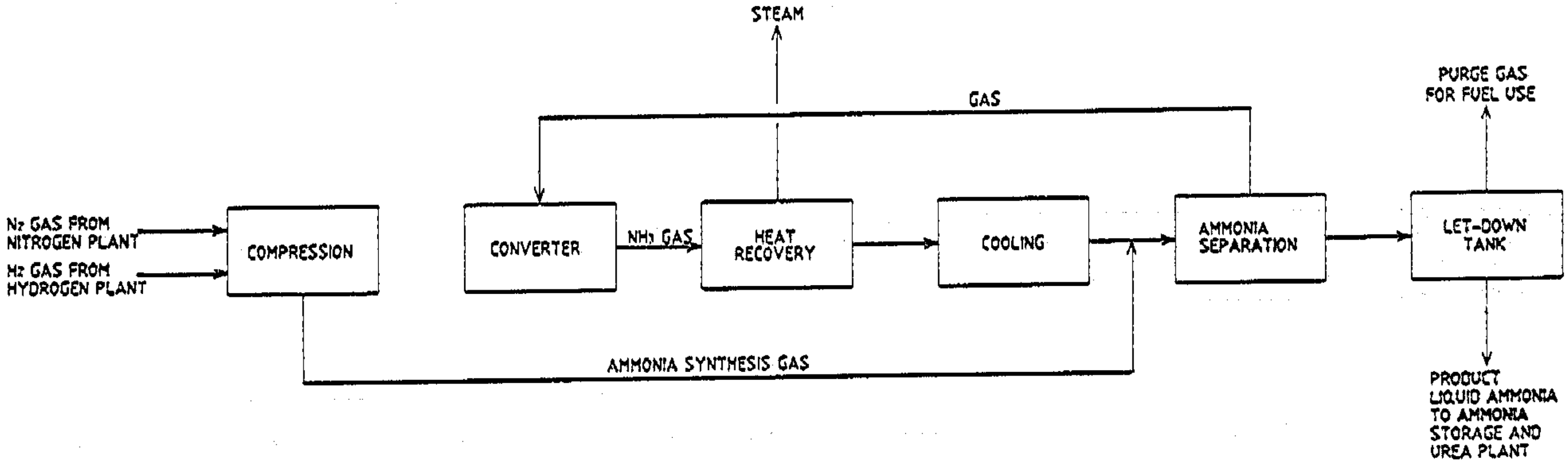


Figure 3-11 BLOCK FLOW DIAGRAM FOR AMMONIA PLANT

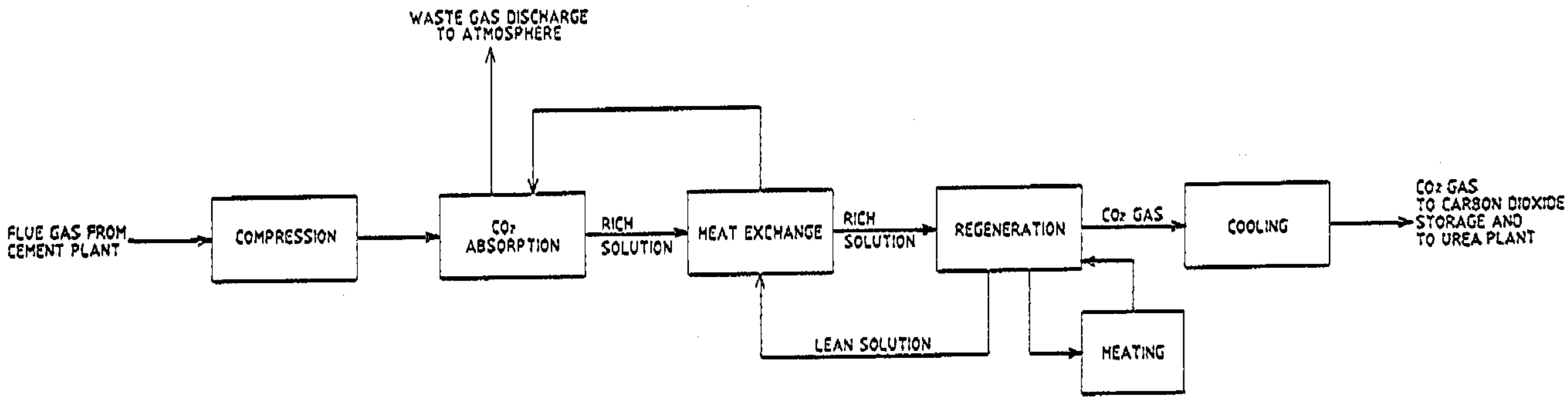


Figure 3-12 BLOCK FLOW DIAGRAM FOR CARBON DIOXIDE GAS PLANT

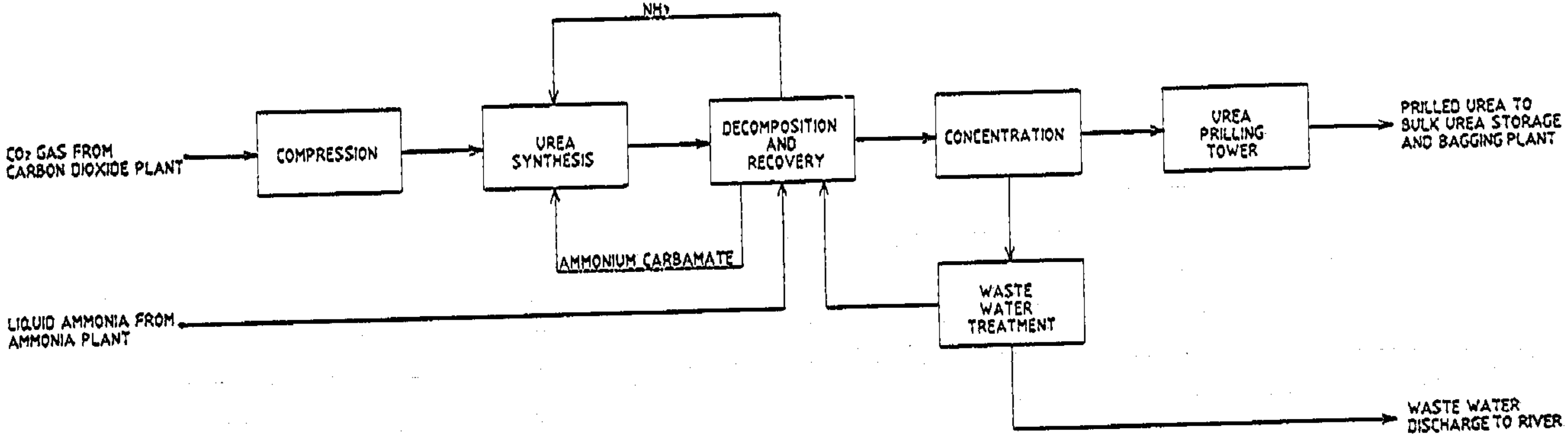
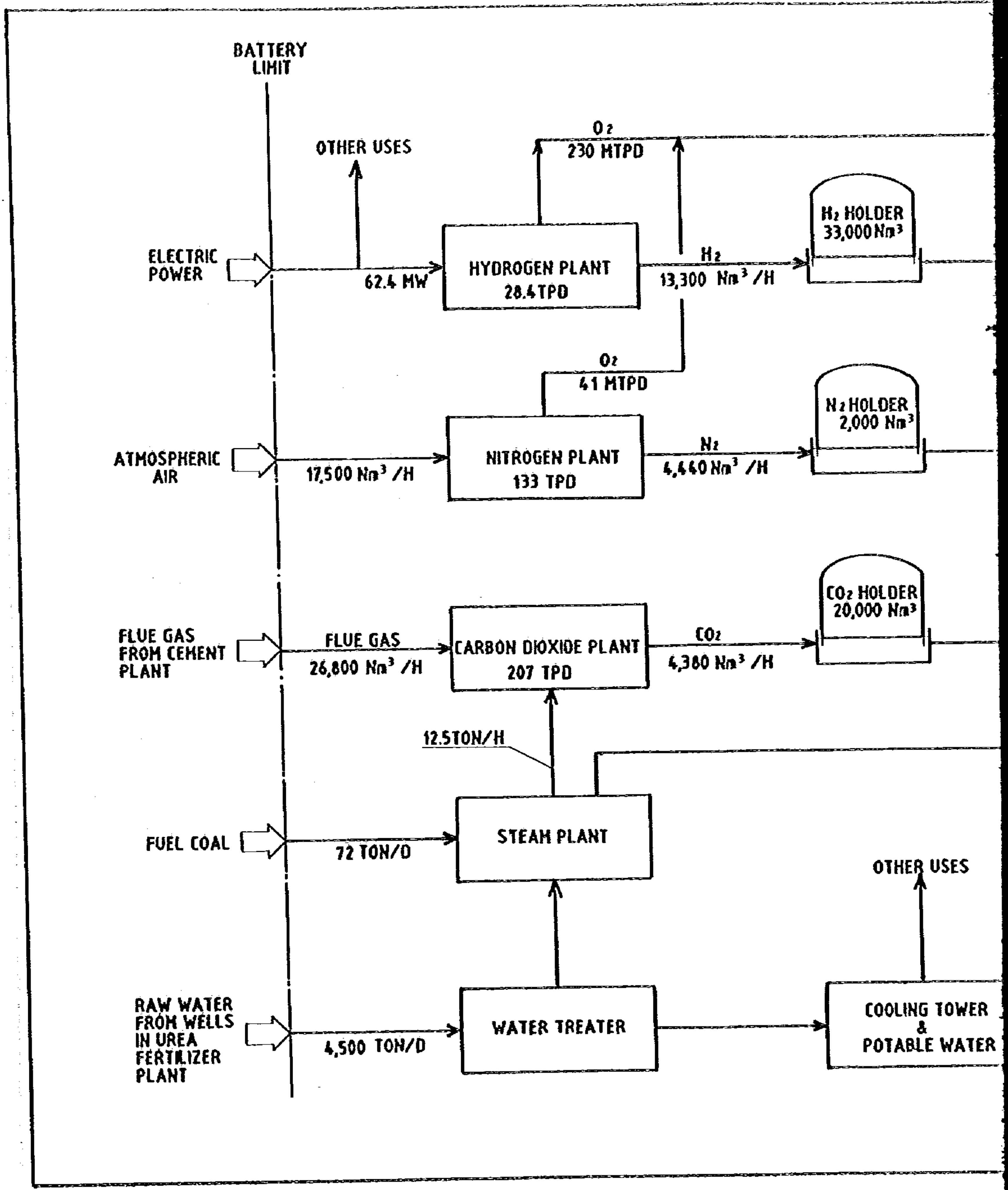
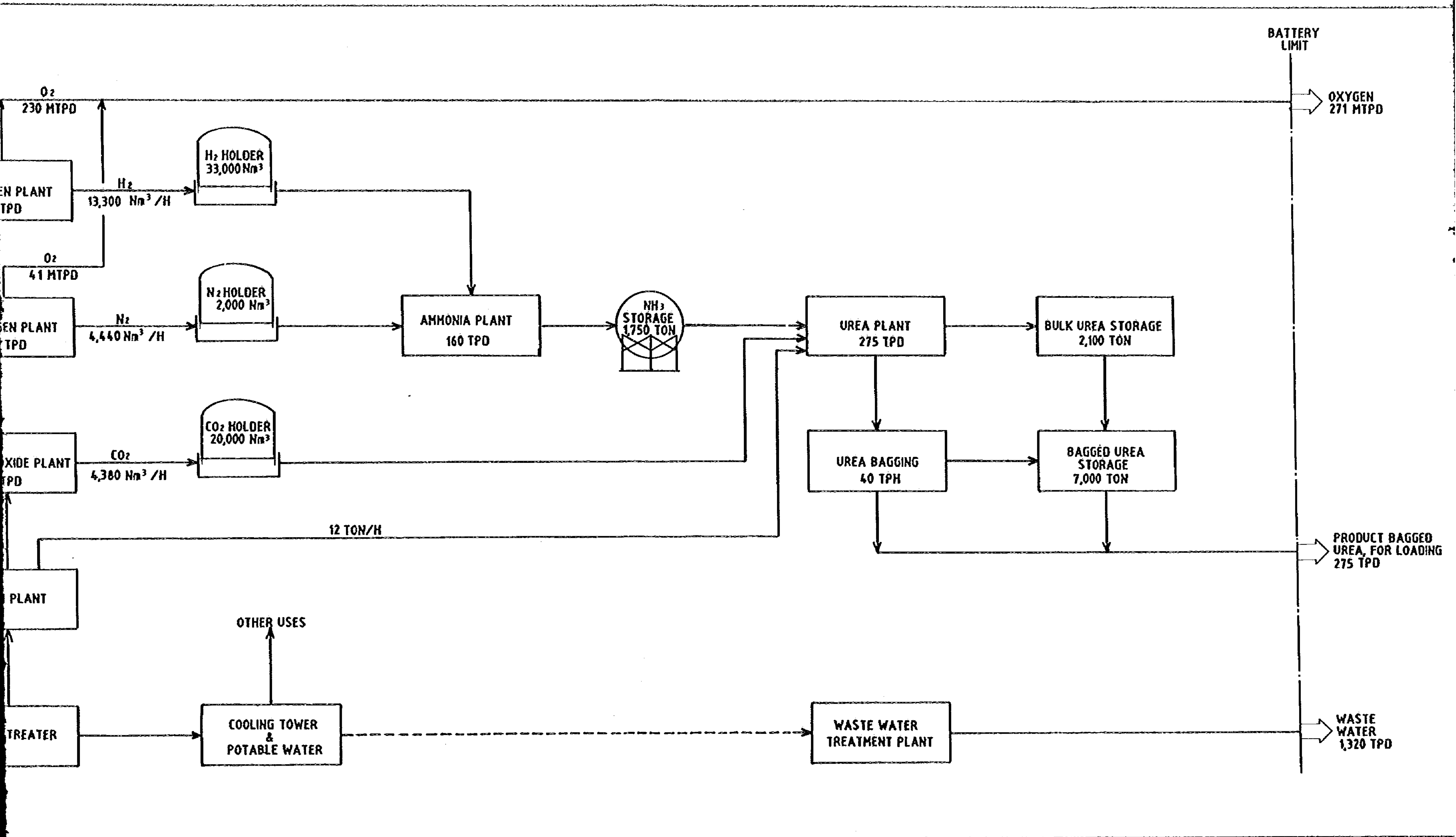
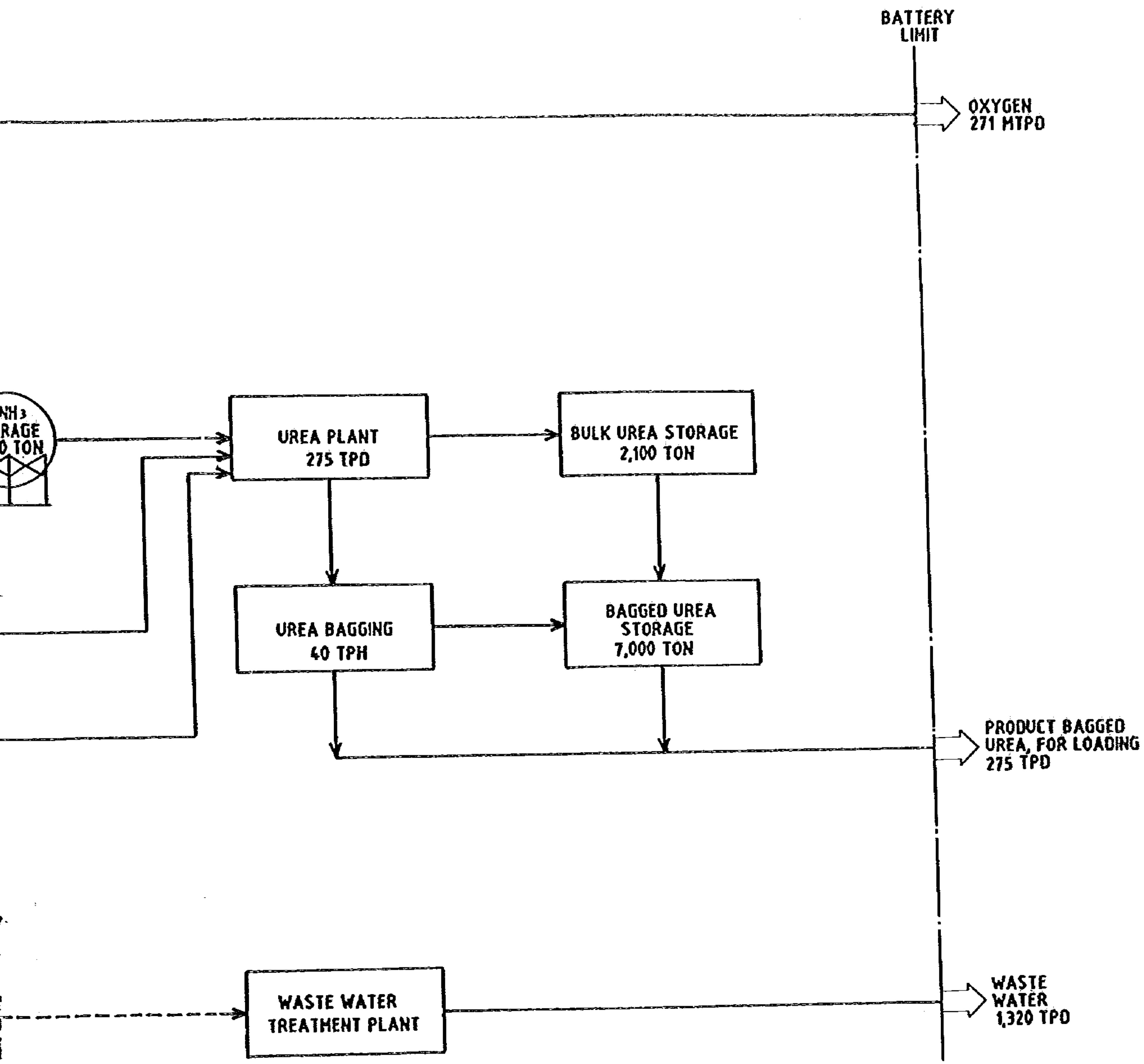


Figure 3-13 BLOCK FLOW DIAGRAM FOR UREA PLANT



BATTERY LIMIT
OTHER USES
O2
230 MTPD
H2 HOLDER
33,000 Nm3
ELECTRIC POWER
62.4 MW
HYDROGEN PLANT
28.4 TPD
H2
13,300 Nm3 /H
O2
41 MTPD
N2 HOLDER
2,000 Nm3
ATMOSPHERIC AIR
17,500 Nm3 /H
NITROGEN PLANT
133 TPD
N2
4,440 Nm3 /H
CO2 HOLDER
20,000 Nm3
FLUE GAS FROM CEMENT PLANT
FLUE GAS
26,800 Nm3 /H
CARBON DIOXIDE PLANT
207 TPD
CO2
4,380 Nm3 /H
12.5 TON/H
FUEL COAL
72 TON/D
STEAM PLANT
OTHER USES
RAW WATER FROM WELLS IN UREA FERTILIZER PLANT
4,500 TON/D
WATER TREATER
COOLING TOWER & POTABLE WATER


BATTERY LIMIT
O2 230 MTPD
OXYGEN 271 MTPD
EN PLANT
TPD
H2 13,300 Nm3 /H
H2 HOLDER 33,000 Nm3
O2 41 MTPD
N2 HOLDER 2,000 Nm3
EN PLANT
TPD
N2 4,440 Nm3 /H
AMMONIA PLANT 160 TPD
NH3 STORAGE 1,750 TON
UREA PLANT 275 TPD
BULK UREA STORAGE 2,100 TON
CO2 HOLDER 20,000 Nm3
XIDE PLANT
TPD
CO2 4,380 Nm3 /H
UREA BAGGING 40 TPH
BAGGED UREA STORAGE 7,000 TON
12 TON/H
PRODUCT BAGGED UREA, FOR LOADING 275 TPD
PLANT
OTHER USES
TREATER
COOLING TOWER & POTABLE WATER
WASTE WATER TREATMENT PLANT
WASTE WATER 1,320 TPD

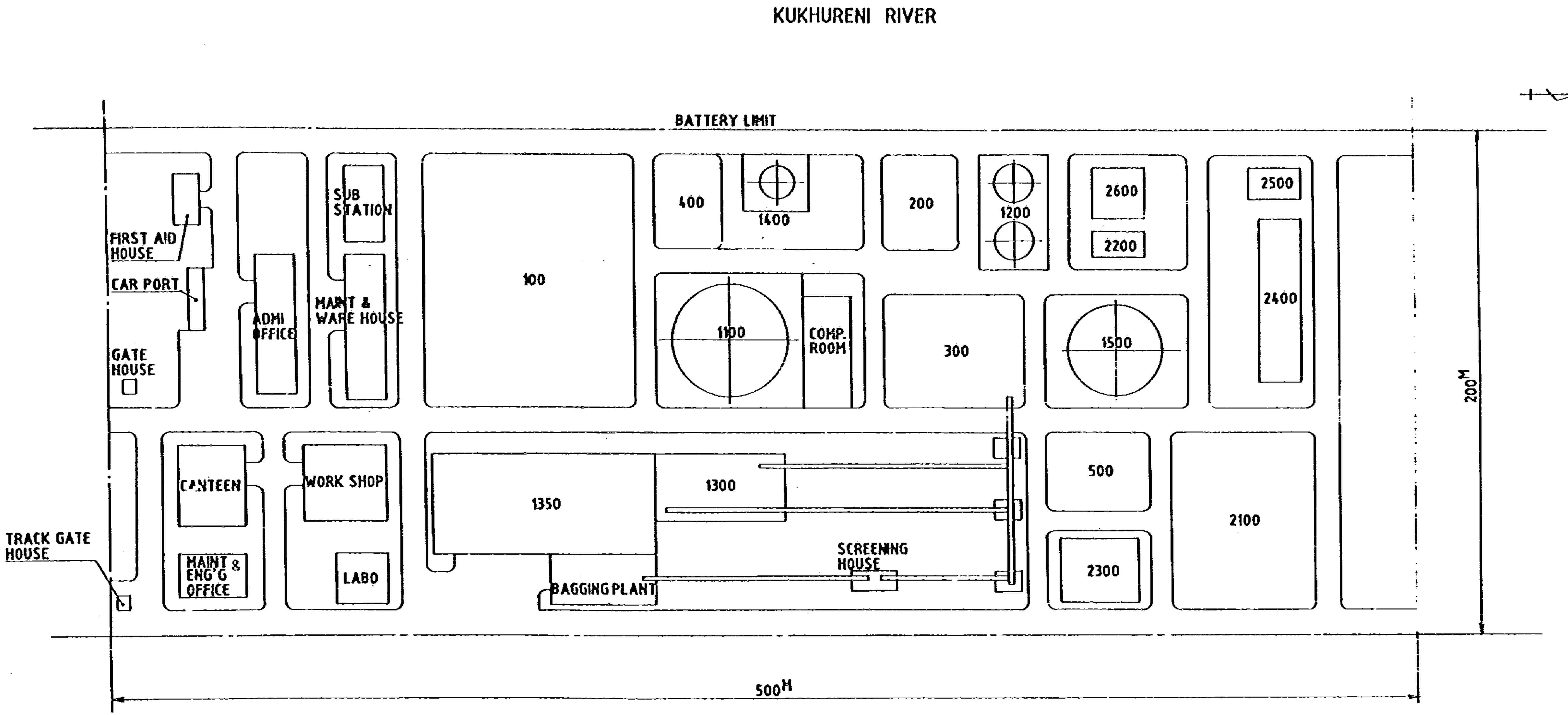


FEASIBILITY STUDY ON THE ESTABLISHMENT OF UREA FERTILIZER PLANT IN THE KINGDOM OF NEPAL

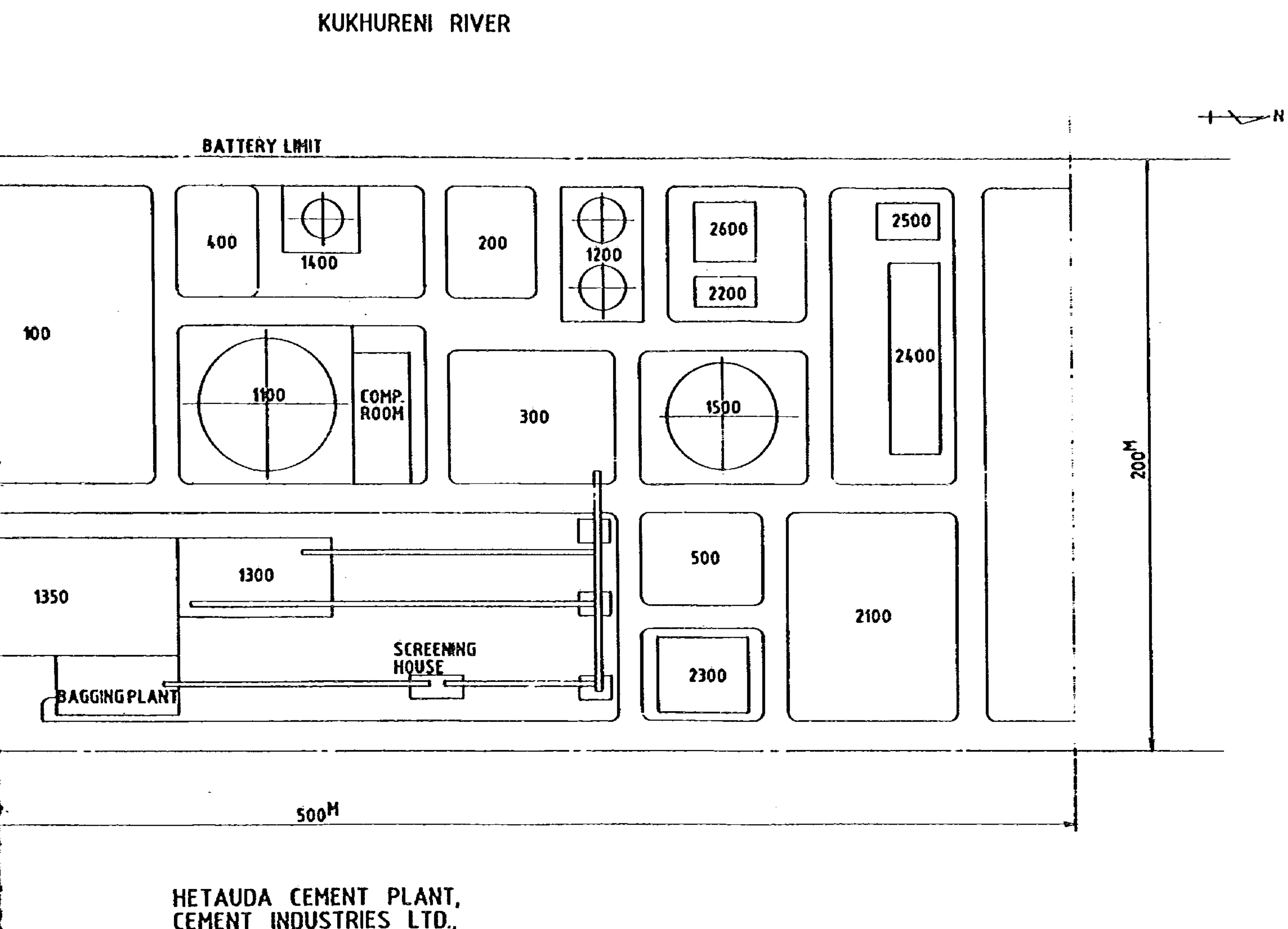
Figure 3-14

UREA FERTILIZER PLANT BLOCK FLOW DIAGRAM

JICA, JUNE, 1984



HETAUDA CEMENT PLANT,
CEMENT INDUSTRIES LTD.,



SECTION NO.	DESIGNATION
100	HYDROGEN PLANT
200	AMMONIA PLANT
300	UREA PLANT
400	NITROGEN PLANT
500	CARBON DIOXIDE PLANT
1100	HYDROGEN STORAGE
1200	AMMONIA STORAGE
1300	BULK UREA STORAGE
1350	BAGGED UREA STORAGE
1400	NITROGEN STORAGE
1500	CARBON DIOXIDE STORAGE
2100	WATER TREATMENT SYSTEM
2200	FUEL SYSTEM
2300	STEAM GENERATOR
2400	COOLING TOWER
2500	AIR COMPRESSOR
2600	EMERGENCY GENERATOR
3000	RESIDENTIAL COLONY OUTSIDE OF BATTERY LIMIT (HOUSING OF 92 RESIDENT EMPLOYEES FOR 6,010 m^2 OF FLOOR SPACE IN 18,000 m^2 OF SITE AREA)

FEASIBILITY STUDY ON THE ESTABLISHMENT OF UREA FERTILIZER PLANT IN THE KINGDOM OF NEPAL

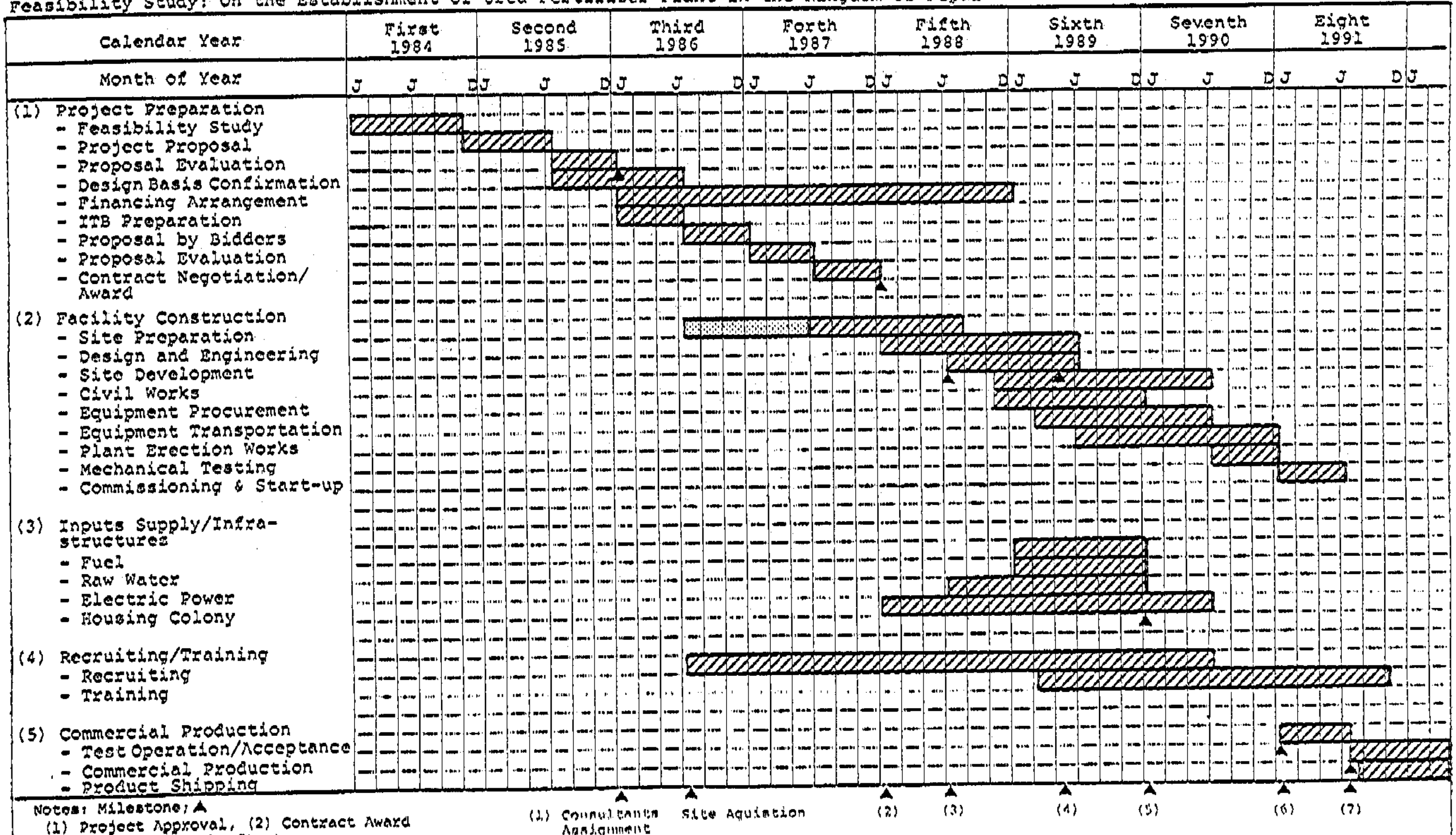
Figure 3-15

UREA FERTILIZER PLANT GENERAL PLOT PLAN

JICA, JUNE, 1984

Fig. 3-16 PROJECT IMPLEMENTATION SCHEDU

Project: Urea Fertilizer Plant
Product: Urea, 275 TPD
Location: Hetauda, Nepal
Feasibility Study: On the Establishment of Urea Fertilizer Plant in the Kingdom of Nepal



Notes: Milestone; ▲
(1) Project Approval, (2) Contract Award
(3) Foundation Works Start
(4) Foundation Works Completion
(5) Utility Supply Start, (6) Mechanical Completion
(7) Plant Acceptance and Commercial Production

Part IV FINANCIAL ANALYSIS AND SOCIO-ECONOMIC EVALUATION OF THE PROJECT