Annex III-1

BASIC DATA FOR CARBON DIOXIDE SUPPLIABILITY CONDITIONS AT CEMENT PLANTS IN NEPAL

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	Hetauda Cement Industries Ltd.		Himal Cement Co. (PVT) Ltd.	
1. Outlines of Cement Plants				
Clinker Production Process	Rotary Kiln, Dry Suspension Heater		Shaft Kiln, Black Meal	
Clinker Production, TPH	31.25		5.25	
TPD	750.00		126.00	
TPY	222,750.00		37,422.00	
Completion of Plant	1985		1976	
Employee	1,200		300	
2. Site Conditions				
Location	Hetauda		Chobar, Kathmandu	
Latitude, North	27°24'		27°39'	
Longitude, East	85°01'		85°17'	
Height, Above Seal Level, m	455		1,260	
Site Area, m^2	600,000		7,200	
Theoretical Standard Pressure, mb	959.8		870.8	
ata	0.9472		0.8594	
Temperature, °C -1980				
Maximum, Absolute	38.8 (April 24)		32.3 (April 25)	
Minimum, Absolute	3.0 (January 1)		(-)1.0 (January 14)	
Monthly Average				
-Maximum	36.1 (April)		29.4 (April)	
-Minimum	5.8 (January)		1.9 (January)	
Annual Average	22.8		18.4	
Precipitation, mm -1980				
Annual	1,948		1,341	
Monthly Maximum	461 (June)		349 (June)	
Monthly Minimum	0 (January)		0 (November)	
Daily Maximum	158 (June 19)		100 (June 9)	
Relative Humidity, % -1980	AM 8:40	PM 5:40	AM 8:40	PM 5:40
Annual Average	74	68	85	65
Monthly Average				
-January	83	74	95	64
-April	43	35	65	41
-June	74	76	82	74
-September	77	79	88	79
Atmospheric Air Condition for Calculation				
Pressure, ata	0.947		0.859	
Temperature, °C	23.0		18.0	
Relative Humidity, %	70.0		75.0	
Composition, kg/kg-Dry Air				
-Nitrogen	0.7670		0.7670	
-Oxygen	0.2330		0.2330	
-Dry Air	1.0000		1.0000	
-Moisture	0.0133		0.0105	
-Total Air	1.0133		1.0105	

3. Raw Materials for Cement Production

(a) Limestone

(Unit: wt%, Dry Basis)

	Hetauda Cement Industries Ltd.		Himal Cement Co. (PVT) Ltd.	
	Average	Range	Average	Range
Chemical Analysis				
Ignition Loss	36.8	39.0 - 36.4	38.4	
SiO_2	13.3	12.3 - 6.5	9.2	
Al_2O_3	2.9	3.7 - 2.1	2.4	
Fe_2O_3	0.6	1.6 - 0.6	2.4	
CaO	44.7	47.6 - 42.8	45.5	
MgO	1.5	3.8 - 1.2	1.7	
SO_3	0.20	-	0.16	
Na_2O	0.14	-	0.01	
K_2O	0.60	-	0.55	
Cl	0.01	-	0.01	
P_2O_5	0.07	-	0.05	
TiO_2	0.12	-	0.08	
Mn_2O_3	0.15	-	0.34	
Total	101.09		100.80	
Composion after Calcination				
CO_2	36.45		37.85	
Ash, Sulfate and Phosphate	63.20		61.40	
Others as Water	0.35		0.75	
Total	100.00		100.00	
Limestone Source	Bhainse Dobhan, Hetauda		Chobar, Kathmandu	
Data Source	HCI, ITB -1977		HCC -1983	

Note: Available CO_2 is calculated assuming that $CaCO_3$ (CO_2/CaO=0.7848) and $MgCO_3$ (CO_2/MgO=1.0915)

(b) Clay

(Unit: wt%, Dry Basis)

	Hetauda Cement Industries Ltd.		Himal Cement Co. (PVT) Ltd.	
	Average	Range	Average	Range
Chemical Analysis				
Ignition Loss	8.8		7.6	
SiO_2	59.5	58 - 62	58.9	
Al_2O_3	19.0	19 - 21	20.5	
Fe_2O_3	8.1	8 - 10	8.2	
CaO	0.3	0.5 - 1.0	1.5	
MgO	0.7	0.75 - 1.25	1.0	
SO_3	0.03		0.19	
Na_2O	0.08		0.18	
K_2O	2.20		3.15	
Cl	-		0.01	
P_2O_5	0.06		0.34	
TiO_2	-		0.92	
Mn_2O_3	-		0.11	
Total	98.77		102.60	
Composion after Calcination				
CO_2	0.00		0.00	
Ash, Sulfate and Phosphate	91.20		90.80	
Others as Water	8.80		9.20	
Total	100.00		100.00	
Clay Source	Lamsure, Hetauda		Kathmandu	
Data Source	HCI, ITB -1977		HCC -1983	

(c) Iron Oxide and Gypsum

(Unit: wt%, Dry Basis)

	Hetauda Cement Industries Ltd.		Himal Cement Co. (PVT) Ltd.	
	Iron Ore	Gypsum	Iron Ore	Gypsum
Chemical Analysis				
Ignition Loss	1.2	16.8	(Not Used	16.8
SiO_2	4.6	9.3	in the Plant)	9.3
Al_2O_3	2.8	1.8	-	1.8
Fe_2O_3	89.3	1.1	-	1.1
CaO	0.8	31.0	-	31.0
MgO	0.7	2.0	-	2.0
SO_3	0.04	32.5	-	32.5
Na_2O	0.10	0.19	-	0.19
K_2O	0.92	0.24	-	0.24
P_2O_5	-	-	-	-
Total	100.46	94.93	-	94.93
Composition after Calcination				
CO_2	0.00	0.00	-	0.00
Ash, Sulfate and Phosphate	98.80	83.20	-	83.20
Others as Water	1.20	16.80	-	16.80
	100.00	100.00	-	100.00
Raw Material Source	Bihar, India or Phulchowki, Nepal	Bikaner, India	-	Bikaner, India
Data Source	HCI, ITB-1977	HCI, ITB-1977	-	HCI, ITB-1977

4. Utility for Cement Production

(a) Fuel

(Unit: wt%, Dry Basis)

	Hetauda Cemant Industries Ltd.			Himal Cement Co. (PVT) Ltd.		
	Fuel Oil	Coal	Mixed Use	Coke Breeze	Special Low Volatile Coal	Mixed Use
Chemical Analysis						
Moisture	0.05	2.4		1.9	2.2	2.1
Ash	0.01	10.0		28.7	19.5	23.8
Volatile Matter	95.0	40.0		6.5	10.7	
Fixed Carbon	4.0	47.0		64.1	67.6	63.3
Carbon	85.0	70.0		63.5	71.6	66.9
Hydrogen	11.0	5.2		0.2	2.3	1.3
Sulfur	3.5	3.5		0.5	0.2	0.4
Nitrogen	0.30	1.1		0.9	0.9	0.9
Oxygen and Others	0.30	7.2		4.4	5.1	4.6
	100.16	99.4		100.1	101.8	100.0
Heating Value, kcal/kg						
Gross (High)	11,152	7,100		5,510	5,417	5,464
Net (Low)	10,558	6,805		5,370	5,390	5,380
Specific Gravity (15/4°C)	0.96					
Chemical Analysis of Ash						
Ignition Loss	0.6	0.60	0.60	-	-	2.42
SiO_2	34.7	58.00	58.00	54.60	52.90	53.75
Al_2O_3	0.1	27.60	27.60	27.43	28.05	27.74
Fe_2O_3	8.7	5.90	5.90	7.72	11.85	9.79
CaO	4.2	2.60	2.60	3.82	5.64	4.73
MgO	1.0	0.80	0.80	3.50	1.27	2.39
SO_3	0.3	0.28	0.28			2.83
Na_2O	0.3	0.11	0.11			0.56
K_2O	0.2	1.70	1.70			2.32
TiO_2/V_2O_3	20.5	-	-			1.51
MnO/NiO	11.3	-	-			0.07
P_2O_5	-	1.25	1.25			0.88
Cl	-	-	-			0.01
	81.9	98.84	98.84	97.07	99.71	109.00
Composition after Combustion or Calcination						
CO_2	318.8	256.5				245.30
H_2O (Including Moisture)	108.2	49.2				11.04
Oxides, Sulfate, Silicate & Phosphate	0.0	10.0				30.00
	427.0	315.7				286.34
Fuel Source	India	Assam, India	-	Durgapur, India	India	India
Data Source	Consultant	HCI-ITB -1977		HCC-1984	HCC-1984	HCC-1984

Notes: 1) HCI will consume a 1/3 of heating value (net) as fuel oil and 2/3 as coal.
2) HCC is consuming a 1/2 of fuel weight as coke and 1/2 as coal.

(b) Raw Water

	Hetauda Cement Industries Ltd.	Himal Cement Co. (PVT) Ltd.
Source	River Bed Well at Kukhureni River (18.0°C, 500m^3/D)	Bagmati River (17.0°C, 30m^3/Day) Plant Well (22.5°C, 3m^3/H) Quarry Well (20.5°C, 5m^3/H) City Water (18.0°C, 0.1m^3/H)

Analysis, ppm	Kukhureni River		Bagmati River	Plant Well
	Record	Measured	Measured	Measured
pH	5.85	5.8	7.2	7.8
Electric Conductivity	-	24	275	450
Total Hardness	12.5	19	97	275
Fe	0.07	0.08	3.1	-
SiO_2	-	-	-	-
Cl	-	3.3	19	18
SO_4	2.5	4	72	16
P	-	-	-	-
N	30.5	-	-	-
COD	-	1	10	-
Suspend Solid	-	1.6	80	6
Disolved Solid	-	38	198	274
Total Alkalinity	-	25	-	-

Notes: 1) Unit of electric conductivity is micromhos/cm.
2) Unit of hardness is in terms of $CaCO_3$.

(c) Electric Power

	Hetauda Cement Industries Ltd.	Himal Cement Co. (PVT) Ltd.
Source	Nepal Electricity Corp.	Nepal Electricity Corp.
Voltage, Volt	10,000	440
Frequency, Hz	50	50
Phase	3	3
Wire	3	3
Location	At Fence	At Fence

5. Raw Materials and Utilities Consumption

(Unit: Ton/Ton-Clinker, Dry Basis)

	Hetauda Cement Industries Ltd.	Himal Cement Co. (PVT) Ltd.
Raw Materials		
Limestone	1.438	1.350
Clay	0.087	0.125
Iron Ore	0.008	-
Sub-Total	1.533	1.475
Fuel		
Fuel Oil	0.0628	-
Coal, Assam	0.0833	-
Coal, Special Low Volatile	-	0.095
Coke, Breeze	-	0.095
Sub-total	0.1101	0.190
Total	1.6430	1.665
Free Moisture		
Black Meal	-	0.249
Raw Meal	0.081	-
Fuel	0.002	-
Sub-Total	0.083	0.254 (13.0%)
Grand-Total	1.726	1.957
Fuel Consumption, 10^3 kcal-LHV	850	1,033
Others		
Atmospheric Air	2.213	3.120
Gypsum	0.05	0.06
Electric Power, kWh	130	100
Process Water, m^3	-	-
Cooling Water Circulation	6.25	3.85
Fuel for Raw Meal Drying		
-Fuel Oil	0.0087	0.0117
-Coal	-	-
Jute Bag, 50kg Net, Sheet	20.1	20.1
Chemicals		
-Alum	-	0.0005
-Bleach Powder	-	-
Lube Oil, and Grease, kg	0.025	0.050
Loss during Production	0.025	0.030

Notes: 1) Clinker production of 1.0 ton is equivalent to 1.05 to 1.06 ton of bagged cement production.

6. Clinker Composition

Chemical Analysis

SiO_2	24.5	22.4
Al_2O_3	6.0	7.1
Fe_2O_3	2.3	4.7
CaO	63.3	62.3
MgO	2.2	2.6
SO_3	0.3	-
Na_2O	0.21	-
K_2O	1.07	-
	99.88	99.1

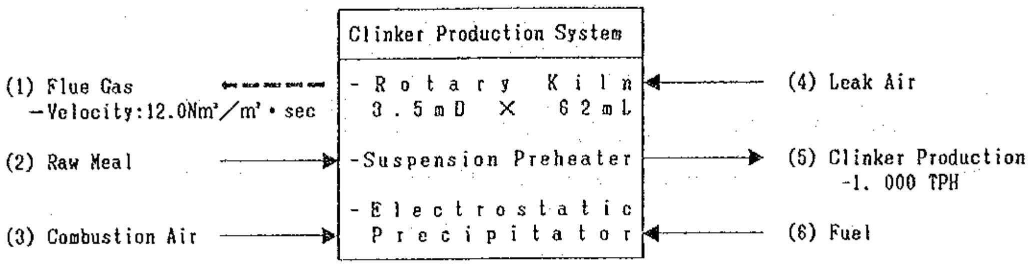
Moduli

HM	1.93	1.82
SM	3.00	1.90
IM	2.60	1.50

7. Carbon Dioxide in Flue Gas

	Hetauda Cement Industries Ltd.		Himal Cement Co. (PVT) Ltd.	
	Base Case	Extreme Case	Base Case	Extreme Case
Physical Conditions				
Temperature, °C	113	102/120	120	100/130
Pressure, ata	0.947		0.859	
Velocity, Nm^3/m^2.sec	15.0		5.7	
Location	Outlet of Electrostatic Precipitator (10m)		Outlet of Stack (33.5m)	
Analysis, Wt%-Wet Gas Basis				
CO	0.10		2.16	
N_2	56.11		58.25	
O_2	8.00		10.40	
CO_2	27.16		20.63	
H_2O	8.72		8.12	
NO_x, ppm	197		51	
SO_x, ppm	600		8	
Dust	0.07		0.31	
Carbon Dioxide Gas in Flue Gas				
Hourly, TPH	25.68		4.42	
Daily, TPD	616.40		105.98	
Annual, TPY	183,069.67		31,475.09	
[24 HPD x (365-35)DPY x 0.9]				
Flow Rate of Flue Gas, Per Ton of Clinker				
Weight, Wet, TPT	3.026		4.077	
Volume, Wet, Nm^3PT	2,274		3,123	

Figure AIII-1 CARBON DIOXIDE BALANCE AT CEMENT PLANTS IN NEPAL (1)

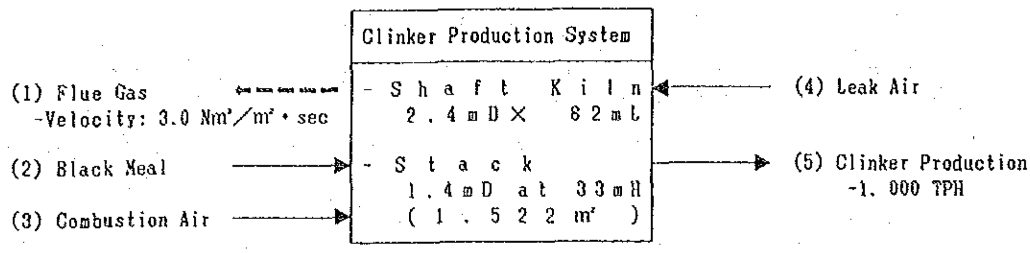


Basis:
Company : Hetauda Cement industries Ltd.
Location: Hetauda, Nepal
Clinker Production: 31.25 TPH
Atmosphere ;
-Pressure: 0.947 ata
-Temperature : 23.0 ℃
-Moisture : 0.0133 kg/kg-dry air

Items	Unit Flow for 1.000 Ton of Clinker Production											
Flow Point,(+) In (-) Out	(1) , (-) Flue Gas		(2) , (+) Raw Meal		(3) , (+) Combustion Air		(4) , (+) Leak Air		(5) , (-) Clinker		(6) , (+) Fuel	
Temperature, ℃	113		200		23		23		100		23	
Pressure, ata	0.947		0.947		0.947		0.947		0.947		0.947	
Material Flow Unit	Ton	Nm³	Ton	Nm³	Ton	Nm³	Ton	Nm³	Ton	Nm³	Ton	Nm³
Metal Oxides 1)	–	–	0.988	–	–	–	–	–	1.000	0.333	0.013	–
H_2	–	–	0.002	–	–	–	–	–	0	0	0.007	–
C	–	–	0.143	–	–	–	–	–	0	0	0.081	–
N_2	–	–	–	–	–	–	–	–	0	0	0.001	–
O_2 (Organics)	–	–	0.400	–	–	–	–	–	0	0	0.006	–
Dry Solid Total	0.002	–	1.533	–	–	–	–	–	1.000	0.333	0.108	–
Moisture	–	–	0.081	–	–	–	–	–	0	0	0.002	–
Wet Solid Total	0.002	–	1.614	–	–	–	–	–	1.000	0.333	0.110	–
CO	0.002	2	–	–	0.000	0	0.000	0	–	–	–	–
N_2	1.698	1,358	–	–	0.899	719	0.799	639	–	–	–	–
O_2	0.242	169	–	–	0.273	191	0.242	169	–	–	–	–
CO_2	0.822	419	–	–	0.000	0	0.000	0	–	–	–	–
Dry Gas Total 2)	2.762	1,946	–	–	1.172	910	1.041	808	–	–	–	–
Moisture 3)	0.264	328	–	–	0.016	19	0.014	17	–	–	–	–
Wet Gas Total	3.026	2,274	–	–	1.188	929	1.055	825	–	–	–	–
Wet Material Total	3.032	2,276	1.614	–	1.188	929	1.055	825	1.000	0.333	0.065	–

NOTES; 1) Metal oxides means metal oxide, sulfate, silicate, phosphate and others which form solid materials in cement production.
2) A small amount of NO_x and SO_x are measured separately.
3) The material balance is calculated at steady state of balanced operation of calcination and raw meal drying. The unbalanced operating condition are considered in extreme case for design purpose of carbon dioxide recovery.

Figure AIII-1 CARBON DIOXIDE BALANCE AT CEMENT PLANTS IN NEPAL (2)



Basis:
Company : Himal Cement Co. (PVT) LTD.
Location: Chobar, Kathmandu, Nepal
Clinker Production: 5.25 TPH
Atmosphere ;
 −Pressure: 0.859 ata
 −Temperature : 18.0 °C
 −Moisture : 0.0105 kg/kg-dry air

Items	Unit Flow for 1.000 Ton of Clinker Production									
Flow Point, (+) In (−) Out	(1), (−) Flue Gas		(2), (+) Black Meal		(3), (+) Combusion Air		(4), (+) Leak Air		(5), (−) Clinker	
Temperature, ℃	120		18		18		18		200	
Pressure, ata	0.859		0.859		0.859		0.859		0.859	
Material Flow Unit	Ton	Nm³	Ton	Nm³	Ton	Nm³	Ton	Nm³	Ton	Nm³
Metal Oxides 1)	–	–	1.004	–	–	–	–	–	1.000	0.333
H_2	–	–	0.005	–	–	–	–	–	0	0
C	–	–	0.287	–	–	–	–	–	0	0
N_2	–	–	0.002	–	–	–	–	–	0	0
O_2 (Organics)	–	–	0.399	–	–	–	–	–	0	0
Dry Solid Total	0.002	–	1.878	–	–	–	–	–	1.000	0.333
Moisture	–	–	0.255	–	–	–	–	–	0	0
Wet Solid Total	0.002	–	1.939	–	–	–	–	–	1.000	0.333
CO	0.088	71	–	–	0	0	0	0	–	–
N_2	2.375	1,916	–	–	1,162	929	1,331	985	–	–
O_2	0.424	297	–	–	0.353	247	374	262	–	–
CO_2	0.841	428	–	–	0	0	0	0	–	–
Dry Gas Total 2)	3.748	2,711	–	–	1.515	1,178	1.805	1,247	–	–
Moisture	0.331	412	–	–	0.016	20	0.017	21	–	–
Wet Gas Total	4.077	3,123	–	–	1.531	1,196	1.622	1,268	–	–
Wet Material Total	4.077	3,123	–	–	1.531	1,198	1.622	1,268	1.000	0.333

NOTES; 1) Metal oxides means metal oxide, sulfate, silicate, phosphate and others which form solid materials in cement production.
2) A small amount of NO, NO_2 and SO_2 are measured separately.

Annex III-2

PRICE INFORMATION IN NEPAL FOR CONSTRUCTION MATERIALS, LABORERS, WORKS, AND INLAND TRANSPORT FROM CALCUTTA

Annex III-2

PRICE INFORMATION IN NEPAL FOR CONSTRUCTION MATERIALS, LABORERS, WORKS, AND INLAND TRANSPORT FROM CALCUTTA

(1) Construction Materrials

Item	Specification	Unit	Price Level RS
Cement	50 kg, Bagged	Ton	2,000 - 2,900
Sand	-	m^3	38 - 45
Gravel	-	m^3	55 - 69
Round Bar	Twisted (8 - 20 mmD)	Ton	8,800 - 9,000
Round Bar	Plain (8 - 20 mmD)	Ton	8,000 - 9,000
Angle	-	Ton	6,700 - 10,000
I Beam (I Type)	-	Ton	7,150 - 11,000
Cannel	-	Ton	7,800 - 10,500
Plate	4 - 12 mm thickness	Ton	10,500 - 11,500
G.I. Plate	-	m^2	100
Pipe	1B - 2 1/2 1.0 - 2.5 Inch	Ton	10,000 - 13,000
G.I. Pipe	12 mmD	ft	3.8 - 7.0
Asbesto Slate		ft^2	7.0
Timber	Square 25 x 50 x 4,000	m^3	3,500 - 3,900
Ordinary Plywood	3 x 1,200 x 2,400	m^2	30 - 100
Planed Plank	12 x 200 x 4,000	ft^3	70 - 150
Brick	Chimney made	1,000 nos.	400 - 475
Brick	Machine made	1,000 nos.	500
Acetylene	Gas	m^3	172
Acetylene	Carbide	kg	22 - 23
Oxygen	-	Cylinder	272 - 292

Notes: 1) Generally observed price level in January, 1984 in Nepal

2) Rs = Nepalese Rupees (Exchange Rate in January, 1984 is Rs 15.65/1.0 US$)

(2) Construction Laborers

Items	Direct Daily Salary, Rs/Day		
	Trained	Experienced	Untrained
Heal Coolie	-	18	-
Coolie (Male)	-	-	16
Coolie (Female)	-	-	14
Coolie (Small)	-	-	10
Head porter	-	18	-
Porter	-	-	16
Mason, Carpenter, Painter, Plumber, Blacksmith	34	32	-
Electrician, Mechanics	32	30	-
Plumber Foreman	35	32	-
Driver (Light vehicle)	25	-	-
Truck driver	30	-	-
Driver cum Junior Mechanics	27	-	-
Truck driver cum mechanics, heavy equipment operator	32	-	-
Timber sawer	-	25	-
Wood carver, Stone carver	32	30	-
Welder, foreman	32	30	-
Security guard	25	22	-
Night watchman	25	22	-
Driller	32	30	-
Helper	-	18	-

Notes: 1) Generally observed wage level in January 1984 in Nepal. The wage level is mostly for governmental project, the wage level is approximately 30% higher in private sector.

2) Rs = Nepalese Rupees (Exchange Rate in January, 1984 is Rs 15.65/1.0 US$)

(3) Construction Works (Labor plus Materials)

Item	Specification	Unit	Price Level Rs
Earth Work - Excavation and Filling	0 - (-)3m (G.L.) Up to lead 100m	m^3	17.25 - 18.30
Earth Work - Excavation and Filling	(-)3 - (-)6m (G.L.) Up to lead 100m	m^3	36.6
Sand Filling Work	Sand	m^3	84.0
Gravel Filling Work	River Gravel	m^3	140.0
Transportation of Soil	Labor only 100-500m	m^3	20
	Labor only 100-1,000m	m^3	30
Concrete Work	(1 : 2 : 4) Plain	m^3	1,200
	(1 : 3 : 6) Plain	m^3	925
Reinforcement Concrete Work	(1 : 2 : 4)	m^3	1,280
Mild Steel Reinforcement Work		Ton	15,660
Form Work		m^2	92
Asbesto Cement Sheet Roofing		m^2	160
Brick Work	Mortar (1 : 4) Chimney-made Brick	m^3	890
Brick Work	Mortar (1 : 4) Machine-made Brick	m^3	790
Course Rubble Masonry	Mortar (1 : 4)	m^3	910

Notes: 1) Generally observed price level in January 1984 in Nepal

2) The price level indicated above is inclusive for labor materials and a 22% of administration charges.

3) Rs = Nepalese Rupees (Exchange Rate in January, 1984 is Rs15.65/1.0 US$)

(4) Inland Transport from Calcutta, India

Transport Route	Road Transport Charge US$/Freight Ton	Days Required Days	Cargo and Weight/ Length Restriction
Calcutta, Raxaul, India /Birganj, Hetauda, Nepal (860 km)	60.0	5.0	Dry Season -30 Ton -4 x 10 Meter Rain Season - 10 Ton - 4 x 10 Meter
Calcutta, Nautunwa, India/Bhairawa, Hetauda, Nepal (1,500 km)	250.0	25.0	Dry Season - 70 Ton - 4.5 x 12 Meter Rain Season - 30 Ton - 4.5 x 12 Meter
Calcutta, Raxaul, India /Birganj, Kathmandu, Nepal (990 km)	90.0	7.0	Dry Season - 15 Ton - 4 x 10 Meter Rain Season - 8 Ton - 4 x 10 Meter

Notes: 1) Rain Season in Nepal is from April to September.

2) Transport charge is not including import tax of 1.0% of CIF value which should be paid by import contractors.

Annex III-3

ELECTRIC POWER CONSUMPTION AND OVERALL LOAD FACTOR INCREASE AT THE UREA FERTILIZER PLANT

Annex III-3

ELECTRIC POWER CONSUMPTION AND OVERALL LOAD FACTOR INCREASE AT THE UREA FERTILIZER PLANT

1. Electric Power Consumption Pattern

The proposed urea fertilizer plant in Nepal will utilize secondary energy electric power as a major input for the production of urea fertilizer. The unit consumption of total electric power in the plant is 6.642 MW/Ton of urea and out of this, a major portion of 5.411 MW(81.5%) will be consumed for hydrogen gas production at water electrolysis plant and the rest of 1.231 MW(18.5%) will be utilized for ammonia synthesis, carbon dioxide recovery, urea synthesis and other facilities in the urea fertilizer plant. The supply of electric power is preferable at 132 kV level at the plant.

It is desirable to operate the whole urea fertilizer plant at the design capacity (275 TPD or 11.458 TPH) continuously throughout a day and a year except during the annual scheduled shut down for maintenance purpose for approximately 30 days a year. Generally such urea fertilizer plant by electrolysis and carbon dioxide recovery schemes would be operable at 90% of capacity utilization if adequate and stable supply of electric power is obtainable.

Therefore, for such continuous operation of urea fertilizer plant, a stable supply of electric power of hourly 76.1 MW or daily 1.827 GWh (monthly 54.8 GWh ... 30 days or annual 542.6 GWh ... 297 days) is required.

However, in Nepal the electric power supply during the dry season, especially in the morning and evening, has been and would be tight and limited, therefore specific provisions in the plant are required in the proposed plant in Nepal, such as to have hydrogen storage facility to keep continuous operation of ammonia and urea plant at technically minimum operable level (50% of design capacity) while closing down the electrolysis plant during a few hours of the peak period of electric power supply shortage to take full advantage of maximum utilization of secondary energy electric power which will be supplied at special tariff.

The highest peak of electric power consumption in Nepal is observed in the evening (from 7:00 PM to 23:00 PM) for four hours and the second peak is in the morning (from 8:00 AM to 10:00 AM) for three hours, therefore the capacity of hydrogen gas storage for two hours full operation use would be adequate to keep operation of ammonia and urea plant at a half load without manufacturing hydrogen gas during such power demand peak hours.

During such half load operation of ammonia and urea plant (5.729 TPH of urea) without water electrolysis operation, the electric power consumption is reduced to 0.6155 MW/Ton of urea. Therefore, the electric power supply of 3.526 MW hourly is the minimum level to sustain such continued operation. The daily production of urea at the plant will be flexible from 275 TPD(100%) to 137.5 TPD(50%) according to the availability of secondary energy. Therefore hourly electric power requirement are from 3.526 to 76.106 MW hourly or 0.913 to 1.827 GWh daily.

Summarizing the above analysis and discussion, the electric power consumption increase for the proposed urea fertilizer plant is calculated and shown as follows;

UREA FERTILIZER PRODUCTION AND ELECTRIC POWER CONSUMPTION

Season	Urea Production			Electric Power Consumption		
	Hourly, TPH			Hourly, MW		
	Peak Hour (3+4 Hours)	Off-Peak Hour (17 Hours)	Daily, TPD (24 Hours)	Peak Hour (3+4 Hours)	Off-Peak Hour (17 Hours)	Daily, GWH (24 Hours)
Rain Season						
-Normal Operation	11.458	11.458	275.0	76.106	76.106	1.826.6
Dry Season						
-Minimum Continuous Operation	5.729	5.729	137.5	3.526	52.272	0.913.3
-Shut Down	0.0	0.0	0.0	0.0	0.0	0.0
-Annual Maintenance	0.0	0.0	0.0	0.0	0.0	0.0

The annual requirement of electric power for the urea production is, therefore calculated in accordance with the annual production schedule which is shown in Table 4-9.

ANNUAL UREA PRODUCTION AND ELECTRIC POWER CONSUMPTION

Year	Urea Production, TPY	Electric Power Consumption, GWh
1991/92	54,500	362.0
92/93	55,340	367.6
93/94	59,320	394.0
94/95	62,480	415.0
95/96	64,610	429.1
⋮	⋮	⋮
2001/02	69,750	463.3
⋮	⋮	⋮
2005/06	72,620	482.3

2. Overall Load Factor

After the completion of the urea fertilizer plant in Nepal, the additional consumption over the firm energy would be added and consequently the overall load factor will be increased. The overall load factor without urea fertilizer plant and with urea fertilizer plant is calculated and shown below;

OVERALL LOAD FACTOR OF ELECTRIC POWER CONSUMPTION

Year	Electric Power Generating, GWh	Consumption, GWh Without Urea Project (Firm Energy)	Consumption, GWh With Urea Project	Load Factor, % Without Urea Project (Firm Energy)	Load Factor, % With Urea Project
1991/92	1,725.7	1,167.8	1,529.8	67.7	88.6
92/93	2,263.9	1,299.4	1,667.0	57.4	73.6
93/94	2,690.8	1,445.6	1,839.6	53.7	68.4
94/95	(2,690.8)	1,608.0	2,023.0	(59.8)	(75.2)
95/96	(2,690.8)	1,788.0	2,217.1	(66.4)	(78.7)
⋮	⋮	⋮	⋮	⋮	⋮
2001/02	(2,690.8)	3,345.5	3,808.8	(124.3)	(141.5)

The electric power generating capability and consumption without the urea fertilizer project are shown in Table 3-5 to Table 3-7. The annual overall load factor for firm energy is 67.7, 57.4, 53.7, 59.8 and 66.4% in 1991/92, 92/93, 93/94, 94/95 and 95/96, respectively, and after the completion of the urea fertilizer plant the overall load factor will be improved up to 88.6, 73.6, 68.4, 75.2 and 78.7%, respectively.

The electric power generating capability increase in Nepal is assumed to be limited up to the completion of Sapta Gandaki plant, therefore the deficit in 2001/02, calculated above is obvious due to such consideration. The deficit would be observed even without urea fertilizer plant in dry season of 1995/96.

Annex III-4

WATER ELECTROLYSIS PROCESSES

Annex III-4

WATER ELECTROLYSIS PROCESSES

1. Introduction

The electrolysis of water to produce hydrogen and oxygen was first discovered by Dr. von Cavendish in 1766. The chemical reaction is shown in accordance with the Faraday's Law as follows,

$$H_2O + 2F = H_2 \text{ (gas)} + 1/2\ O_2 \text{ (gas)}$$

where F is the Faraday's Constant,

$$F = 96{,}484.56 \pm 0.27 \text{ Coulomb}$$

The theoretical electric power requirement in direct current to produce 1.0 $Nm^3 - H_2$ (gas) plus 0.5 $Nm^3 - O_2$ (gas) is calculated as 3.55 kWh/1.0 $Nm^3 - H_2$ with 1.48 Volts potential, however for industrial operations the electric power requirement is much higher according to the process and ranges between 4.00 to 5.00 kWh/1.0 $Nm^3 - H_2$ at 1.6 to 1.9 Voltage.

The theoretical reaction of the ammonia and urea production is described as follows,

$$3H_2 + 2N_2 = 2NH_3 \text{ (Ammonia)}$$

$$2NH_3 + CO_2 = NH_2CONH_2 \text{ (Urea)} + H_2O$$

Therefore the overall reaction in weight basis is summarized,

$$2H_2O + 2N_2 + CO_2 + 6F = NH_2CONH_2 + 3/2\ O_2$$

$$1.5H_2/NH_3 = (3 \times 1.00794)/(14.0067 + 3 \times 1.00794)$$
$$= 0.177553$$

$$2NH_3/NH_2CONH_2 = (2 \times 17.03052)/60.05516 = 0.5671626$$

The consumption of hydrogen is generally quoted in volume as follows,

1,972.93 Nm^3 - H_2 (gas)/1.0 Ton of NH_3

1,118.97 Nm^3 - H_2 (gas)/1.0 Ton of Urea

The electric power loss at the transformer and rectifier is generally 3.0% from alternating current to direct current electric power, therefore the theoretical electric power consumption for the hydrogen production by water electrolysis is calculated as follows,

3,972 kWh/1.0 Ton of Urea (Theoretical)

5,249 kWh/1.0 Ton of Urea (Industrial)

Additional electric power of 1,231 kWh is required for industrial production of ammonia and urea.

2. Industrial Water Electrolysis

Large scale industrial production of hydrogen by electrolysis of water was first done in 1930.

Hydrogen obtained by water electrolysis is utilized at present for nitrogen fertilizer production, metallurgical processes, glass manufacturing, meteorological use, fat hardening, argon purification, chemicals, nuclear power plant and cooling of electric power generators.

Regarding nitrogen fertilizer production from hydrogen obtained by water electrolysis, the major products are nitric acid and ammonium nitrate as final product.

A list of ammonia plants using electrolysis hydrogen from either water or sodium chloride is shown in Table AIII-2-1. Although some of them are now idle or shutdown, the total production capacity is approximately one million tons of ammonia yearly. The largest ammonia plants are in Norway and in Egypt with a 100,000 TPY capacity where low cost electric power is available. It may be noted that none of them are directly producing urea as the final product.

3. Water Electrolysis Processes

Several electrolysis processes are now available as commercially proven technology; the major features of such processes are summarized in Table AIII-2-2. There are basically two types of electrolysis cell, namely Bath Type and Filter Press Type. The operating conditions differ from atmospheric pressure to pressurized up to 30 ata to produce high pressure hydrogen. The electric power consumption is the most important index for the process comparison, the requirement being from 4.22 to 5.5 kWh for the production of 1.0 Nm^3 of hydrogen gas. The reactivity of the electrode is high during the initial year of operation and gradually declines, eventually requiring reactivation treatment. The consumption of electric power similarly increases with each operating year but after the reactivation, the consumption returns to the original minimum level.

Table AIII-4-1 LIST OF AMMONIA PLANTS USING ELECTROLYSIS HYDROGEN AS RAW MATERIAL

Company	Location	Compressor Type	Electrolysis	Ammonia Capacity (Name Plate Capacity x 330 days) - 1984	Final Product
West Europe				(TPY-N)	
- France					
Rhone Poulenc Ind.	Saint Aubar	RCP	H_2O	16,000	
- Iceland					
Arburdarverskmidjan	Gufunes, Reykjavik	RCP	H_2O	8,000	
- Norway					
Norsk Hydro S.A.	Glomfjord	RCP	H_2O	100,000	Ammonia, NA
Norsk Hydro S.A.	Rjukan	RCP	H_2O	95,000	Ammonia, NA, AN, CAN
- Spain					
Energia Ind. Aragonesas. S.A.(ARAGONESAS)	Sabinaningo	RCP	H_2O	8,000	Ammonia, NA, AS
S.A. Cros	Flix	RCP	H_2O	3,000 -Shutdown	Ammonia
- Sweden					
Uddeholm A.B.	Skoghall	RCP	NaCl	2,000	Ammonia
- Switzerland					
Emser Werke A.G.	Ems-Domat	RCP	H_2O	20,000	Ammonia, Urea, AS (Caprolactam)
				252,000	
East Europe				0	
				0	

Company	Location	Compressor Type	Electrolysis	Ammonia Capacity (Name Plate Capacity x 330 days) - 1984	Final Product
North America					
-USA					
Dow Chemical Co.	Freeport	RCP	NaCl	86,000	Ammonia
FMC Corp.	South Charleston	RCP	NaCl	18,000 Closed in 1981	Ammonia
Georgia Pacific	Plaquemine	RCP	NaCl	146,000	Ammonia, (Urea)
Jupiter Chemical	Lake Charles	RCP	NaCl	58,000	Ammonia
Terra					
Occidental Agri. Chem.	Taft	RCP	NaCl	67,000 Idle since 1981	Ammonia
	Tacoma	RCP	NaCl	20,000 Shutdown in 1980	Ammonia
Pennsalt Chemicals	Portland	RCP	NaCl	6,000	Ammonia, Aqua Ammonia
PPG Ind. Inc.	New Martinsville	RCP	NaCl	30,000 Shutdown in 1980	Ammonia
Vulcan Materials Co.	Wichita	RCP	NaCl	32,000 Shutdown in 1981	Ammonia
				463,000	
Latin America					
-Argentine					
Electrochor	Buenos Aires	RCP	NaCl	3,000	Ammonia
-Peru					
Industrial Cachimayo	Cuzco	RCP	H_2O	13,000 16,000	Ammonia, NA, AN
Africa					
-Zimbabwe					
Sable Chemical Ind.	Kwe Kwe	RCP	H_2O	80,000 80,000	Ammonia, NA, AN
Middle East					
-Egypt					
Egyptian Chem. Ind.	Aswan	RCP	H_2O	100,000	Ammonia, NA, AN CAN
(KIMA)				100,000	

Company	Location	Compressor Type	Electrolysis	Ammonia Capacity (Name Plate Capacity x 330 days) - 1984	Final Product
Asia					
-Japan					
Tokuyama Soda Co., Ltd.	Tokuyama	RCP	NaCl	54,000*2)	Ammonia, AC
-India					
Fertilizer Corp. of India Ltd.	Naya Nangal		-	90,000-Closed	Ammonia, NA, CAN
				144,000	
Oceania					
-Australia					
Electrolytic Zinc Co., Australaria Ltd.	Risdon, Tasmania	RCP	-	12,000	Ammonia, AS
				12,000	
WORLD TOTAL				1,067,000	

Notes: AN; Ammonium Nitrate
NA; Nitric Acid
CAN; Calcium Ammonium Nitrate
AC; Ammonium Chloride
RCP; Reciprocating
*1); Ammonial is sold to other company to produe urea.
*2); Raw material has been switched from fuel oil to chlorine cell hydrogen in 1982.

Table AIII-4-2 PROCESS COMPARISON OF WATER ELECTROLYSIS

Process	Electrolyzer				Electrolyte		Operating Conditions		Electric Power Consumption	Hydrogen Purity
	Cell		Electrode		Solution	Circulation	Temperature	Pressure		
	Type	Number	Type	Material	%	°C	°C	ata	DC-kWh/Nm^3-H_2*	%
Process A	Bath	20	Uni-Polar	Ni-Plated	NaOH - 20	Natural	75	1.02	5.5/6.0	99.7
Process B	Filter Press	235	Bi-Polar	Ni-Plated	KOH - 25	Forced	80	1.03	4.22/4.88	99.8
Process C	Filter Press	139	Bi-Polar	Ni-Plated	KOH - 25	Forced	90	30.00	4.3/4.6	99.9

* Nm^3 (Dry gas at 20°C and 1.0 ata)

Annex IV

Annex IV-1

PROJECT COST ESTIMATE

Annex IV-1 PROJECT COST ESTIMATE

Project : Urea Fertilizer Plant
Location: Hetauda, Nepal
Product : Urea, Bagged
Capacity: 275 TPD

Schedule:
-Cost Estimate ; Jan., 1984
-Contract Award ; Jan., 1988
-Mechanical Completion; Jan., 1991
-Commercial Production; July, 1991
-Project Economic Life; July, 2006 (15 years)

Unit: US$,Million

	Item	Investment Cost: Foreign Currency Component	Investment Cost: Local Currency Component	Investment Cost: Total	Note
1.0	Land Acquisition	-	0.59	0.59	Lot (500 x 200 = 100,000 m2) @ US$5.00/m2 (100 x 180 = 18,000 m2)
2.0	Site Preparation	1.35	0.15	1.50	Earth Moving 230,000 m3
3.0	Plant Direct Cost	64.42	8.91	73.33	
3.1	Plant Equipment and Material	52.22	54.47	57.69	
3.1.1	Process Plant	(38.41)	(1.81)	(40.22)	
	- Hydrogen Gas	((21.58))	((0.69))	((22.27))	13,300 Nm3PH
	- Carbon Dioxide Gas	((2.29))	((0.21))	((2.50))	4,380 Nm3PH
	- Nitrogen Gas	((2.00))	((0.02))	((2.02))	4,440 Nm3PH
	- Ammonia	((6.16))	((0.47))	((6.63))	160 TPD
	- Urea	((6.38))	((0.42))	((6.80))	275 TPD
3.1.2	Utility Plant	(10.17)	(0.53)	(10.70)	
	- Raw Water Supply, Water Treatment, and Cooling Water Tower	((1.55))	((0.14))	((1.69))	
	- Waste Water Treatment	((1.42))	((0.12))	((1.54))	
	- Electric Power Generation	((0.35))	((0.01))	((0.36))	
	- Electric Power Receiving	((0.20))	((0.02))	((0.22))	
	- Steam Generation	((4.17))	((0.05))	((4.22))	
	- Inert Gas Generation	((2.26))	((0.16))	((2.42))	
	- Instrument and Plant Air	((0.22))	((0.03))	((0.25))	
3.1.3	Material Handling Facility	(1.74)	(0.59)	(2.33)	
	- Bulk Urea Storage	((0.10))	((0.12))	((0.22))	
	- Urea Bagging and Loading	((1.42))	((0.17))	((1.59))	
	- Bagged Urea Storage	((0.22))	((0.30))	((0.52))	
3.1.4	Auxiliary Facility	((0.20))	((0.23))	((0.43))	
	- Maintenance Shop	((0.19))	((0.21))	((0.40))	
	- Spare Parts and Others Storage	((0.01))	((0.02))	((0.03))	
3.1.5	Offsite Facility	(1.70)	(2.31)	(4.01)	
	- Administration Building and Others	((0.94))	((1.28))	((2.22))	
	- Township	((0.76))	((1.03))	((1.79))	
3.2	Spare Parts	0.85	-	0.85	For two years uses
3.3	Catalyst and Chemicals	1.48	-	1.48	One spare set and two years uses
3.4	Construction and Erection Labor	9.87	3.44	13.31	
3.4.1	Foreign Technician	(9.87)	(2.47)	(12.34)	11,300 Man-Month
3.4.2	Local Labor	(-)	(0.97)	(0.97)	10,400 Man-Month
4.0	Construction and Erection Equipments	7.82	-	7.82	
5.0	Transportation and Insurance	2.00	2.59	4.59	
5.1	Ocean Transport and Insurance	2.00	-	2.00	Net 8,500 Ton, Freight 25,400 Ton
5.2	Custom Clearance, Import Duty and Tax	-	1.11	1.11	1.5% (F.E Portion of 3.1, 3.2, 3.3, 4.0, 5.1)
5.3	Unloading, Inland Transport and Insurance	-	1.48	1.48	Transport mode 860 km
6.0	Indirect Field Expenses	0.33	0.49	0.82	
7.0	Engineering Services Fee	9.31	0.85	10.16	
7.1	Know-How and Basic Engineering	1.34	-	1.34	
7.2	Engineering at Home Office	5.43	-	5.43	480 Man-Month
7.3	Supervisor and Service man	2.54	0.85	3.39	430 Man-Month
8.0	Project Management Services	2.45	0.33	2.78	
8.1	Technical Managerment Advisor	1.45	0.11	1.56	F.E ($9,000 x 150M/M) x 1,075 L.C $50 x 75M/M x 30
8.2	Operation and Maintenance Advisor	1.00	0.22	1.22	F.E ($6,000 x 150M/M) x 1,075 L.C $50 x 150M/M x 30
9.0	Pre-Operational Expenses	0.29	1.90	2.19	
9.1	Personnel Expenses and Overhead	0.05	0.34	0.39	
9.2	Training Expenses	0.23	-	0.23	
9.3	Losses during Start-up	-	1.54	1.54	
9.4	Miscellaneous	0.01	0.02	0.03	5% of 9.1 and 9.2
10.0	Base Project Cost, BPC - at Cost Estimate Date	87.97	15.81	103.78	
11.0	Contingency Combined	22.22	6.79	29.02	
11.1	Physical Contingency	4.41	0.08	5.21	Foreign 5%/Yr, Local 5%
11.2	Price Escalation	17.81	5.99	23.80	Foreign 3.5%/Yr, Local 6%/Yr
12.0	Initial Working Capital	0.40	2.28	2.68	
13.0	Interest during Construction	9.28	-	9.28	Interest Rate; Foreign 5%/Year Local 15%/Year
14.0	Total Financing Required for Completion of Project	119.87	24.92	144.79	Equity/Debt = 30/70

[Attachment (1) to Annex IV-1]

DISBURSEMENT AND INTEREST DURING CONSTRUCTION

TOTAL FINANCING REQUIRED:

DEBT (70.00%)	101.35
EQUITY (30.00%)	43.44
TOTAL	144.79

INTEREST RATE: 5.00% PER YEAR

DISBURSEMENT:

YEAR	%	DISBURSEMENT
1 YEAR	0.0	0.0
2 YEAR	3.00	3.04
3 YEAR	39.00	39.53
4 YEAR	46.00	46.62
5 YEAR	12.00	12.16
		101.35

INTEREST DURING CONSTRUCTION; AT THE END OF YEAR:

	1 YEAR	2 YEAR	3 YEAR	4 YEAR	5 YEAR
A. ALREADY DRAWN	0.0	0.0	3.04	42.57	89.19
B. PREVIOUS YEARS INTEREST	0.0	0.0	0.0	0.0	0.0
C. OPENING DEBT (A+B)	0.0	0.0	3.04	42.57	89.19
D. INTEREST ON OPENING DEBT	0.0	0.0	0.15	2.13	4.46
E. DRAWN DURING YEAR	0.0	3.04	39.53	46.62	12.16
F. INTEREST ON CURRENT DRAW G	0.0	0.08	0.99	1.17	0.30
G. TOTAL INTEREST FOR YEAR(D+F)	0.0	0.08	1.14	3.30	4.76
H. INTEREST PAYMENT	0.0	0.08	1.14	3.30	4.76

INTEREST DURING CONSTRUCTION:

1 YEAR	0.0
2 YEAR	0.08
3 YEAR	1.14
4 YEAR	3.30
5 YEAR	4.76
TOTAL	9.28

[Attachment (2) to Annex IV-1]

CONTINGENCY SCHEDULE BY COST GROUP

NEPAL UREA PROJECT (275 TPD)   (UNIT: US$MIL.)

	MONTHS TO EXPEND DATE (MONTHS)		PHYSICAL CONTINGENCY(PCT)		PRICE CONTINGENCY(PCT)		COMBINED CONTINGENCY(PCT)	
	FOREIGN	LOCAL	FOREIGN	LOCAL	FOREIGN	LOCAL	FOREIGN	LOCAL
A. LAND ACQUISITION	30.00	30.00	0.0	5.00	9.00	15.73	9.00	21.52
B. SITE PREPARATION	42.00	42.00	5.00	5.00	12.81	22.67	18.45	28.81
C. PLANT DIRECT COST								
C-1 PROCESS UNITS	62.00	62.00	5.00	5.00	19.48	35.24	25.46	42.00
C-2 UTILITY FACILITIES	61.00	61.00	5.00	5.00	19.14	34.59	25.10	41.32
C-3 AUXILIARY FACILITIES	60.00	60.00	5.00	5.00	18.80	33.94	24.74	40.63
C-4 OFFSITE FACILITIES	58.00	58.00	5.00	5.00	18.12	32.64	24.03	39.27
D. SPAREPARTS, CATL. & CHEM.	75.00	75.00	5.00	0.0	24.02	44.04	30.22	44.04
E. CONST. & ERECTION LABOR	68.00	68.00	5.00	5.00	21.55	39.22	27.63	46.18
F. CONST. EQUIPMENT	54.00	54.00	5.00	0.0	16.76	30.04	22.60	30.04
G. TRANSPORT,INSURANCE & DUTY	61.00	61.00	5.00	5.00	19.14	34.59	25.10	41.32
H. INDIRECT FIELD EXPENCES	68.00	68.00	5.00	5.00	21.55	39.22	27.63	46.18
I. ENGINEERING SERVICES	59.00	59.00	5.00	5.00	18.46	33.29	24.39	39.95
J. PROJECT MANAGEMENT SERVICES	60.00	60.00	5.00	5.00	18.80	33.94	24.74	40.63
K. PRE-OPERATION EXPENSES	78.00	78.00	5.00	5.00	25.08	46.11	31.33	53.41
M. INITIAL WORKING CAPITAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N. INTEREST DURING CONSTRUCTION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

ESCALATED CAPITAL COST ESTIMATE

NEPAL UREA PROJECT (275 TPD) (UNIT: US$MIL.)

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

Annex IV-2

BACK DATA FOR ESTIMATING ESCALATION

Annex IV-2 (1) PLANT COST INDEX

(Unit: 1980=100)

Year	C.E. PLANT COST INDEX (U.S.A.)	SRI PLANT COST INDEX		
		U.S.A.	JAPAN	W.GERMANY
1980	100	100	100	100
1981	113.7	116.1	104.7	105.2
1982	120.3	120.7	107.4	112.4
1983	122.0	122.4	114.4	113.8
1984	122.9	N.A.	N.A.	N.A.
Av. Ann. (1980-1984) Escalation	5.3%	5.2%	3.4%	3.3%

Source: Chemical Engineering, U.S.A.
SRI, U.S.A.

Annex IV-2 (2) PRICE INDEX IN NEPAL

F.Y.	Average F.E. Rate (Rs. per US $)	National Consumer Price Index for Urban Areas				Kathmandu Consumer Price Index			
		Rupee Terms	Changes to previous year (%)	US Dollar Terms	Changes to previous year (%)	Rupee Terms	Changes to previous year (%)	US Dollar Terms	Changes to previous year (%)
1974/75	10.56	138.0		132.4		134.0		128.54	
1975/76	11.97	137.0	- 0.72	115.9	- 12.46	141.1	+ 5.30	119.41	- 7.11
1976/77	12.50	140.7	+ 2.70	114.0	- 1.64	141.5	+ 0.28	114.67	- 3.97
1977/78	12.36	156.4	+ 11.16	128.2	+ 12.46	155.9	+ 10.18	127.77	+ 11.42
1978/79	12.00	161.8	+ 3.45	136.6	+ 6.55	161.1	+ 3.34	136.00	+ 6.44
1979/80	12.00	177.6	+ 9.77	149.9	+ 9.74	180.8	+ 12.23	152.63	+ 12.23
1980/81	12.00	201.4	+ 13.40	170.0	+ 13.41	207.2	+ 14.60	174.91	+ 14.60
1981/82	12.96	222.4	+ 10.43	173.8	+ 2.24	229.2	+ 10.62	179.15	+ 2.42
1982/83	13.40	250.7	+ 12.72	189.5	+ 9.03	252.4	+ 13.35	196.40	+ 9.63
Average Increase Rate (1977/78 - 1982/83)		10.67%		8.89%		10.75%		8.98%	

Source: Nepal Rastra Bank

Annex IV-3

BREAKDOWN OF PRE-OPERATION EXPENSES AND INITIAL WORKING CAPITAL

Annex IV-3(1)

ESTIMATE OF PRE-OPERATIONAL EXPENSES
(1984 Prices)

1. Personnel Expenses and Overhead

1.1 Initial 3 Years

- General Manager	(1 x Rs. 34,200/yr x 3 yrs)	Rs. 102,600
- Managers	(3 x Rs. 20,520/yr x 3 yrs)	Rs. 184,680
- Senior Engineers, and Senior Officers	(6 x Rs. 15,960/yr x 3 yrs)	Rs. 287,280
- Supervisors, and Officers	(10 x Rs. 13,680/yr x 3 yrs)	Rs. 410,400
- Secretary, and Workers	(10 x Rs. 10,680/yr x 3 yrs)	Rs. 320,400
- General Workers	(5 x Rs. 7,320/yr x 3 yrs)	Rs. 109,800
Total		Rs. 1,415,160

1.2 Last Half Year

50% of full personnel cost (Rs. 3,637,320 1/ x 0.5) — Rs. 1,818,660

1.3 Total Personnel Cost (1.1 + 1.2) — Rs. 3,233,820

1.4 Overhead (1.3 x 70%) — Rs. 2,263,674

Total: (1.3 + 1.4) — Rs. 5,497,494 (US$343,600)

1.5 Overseas Trip Expenses (@US$5,000/trip x 10 trips) — US$50,000

1.6 Personnel Expenses and Overhead: Grand Total — US$393,600

Note: 1/ See Table 2-5, Part IV

2. Training Expenses (Trainings in foreign countries)

2.1 20 persons (2 months training)

- Living expenses (@US$80/diem x 20 persons x 60 days)	US$96,000
- Trip expenses (@US$1,500/trip x 20 trips)	US$30,000
Total	US$126,000

2.2 30 persons (2 months training in India)

- Living expenses (@US$50/diem x 30 persons x 60 days)	US$90,000
- Trip expenses (@US$500/trip x 30 trips)	US$15,000
Total	US$105,000

2.3 Total expenses: (2.1 + 2.2) US$231,000

3. Loss during Start-up

3.1 Utility and supply costs for production of urea

1) Electric power (@US¢3.56/kwh x 6,642 kwh/ton)	US$236.45
2) Coal (@US$40.63/ton x 0.256 tons)	US$10.40
3) Chemicals and catalysts	US$2.72
Total	US$249.57

3.2 Loss (Assuming 50% operation for 3 months and losses for 50% of the production)

US$249.57/ton x 275 tons/day x 0.5 x 90 days US$1,544,214

Annex IV-3(2)

INITIAL WORKING CAPITAL
(1991 Price)

Items	Estimated Cost (US$'000)		
	F.E. Portion	L.C. Portion	Total
1. Product Inventory (Ann. Direct Operating Cost x 20/330)			
- Foreign Exchange Component ($4,496 x 10^3) x 20/330	272	-	272
- Local Currency Component ($35,814 x 10^3) x 20/330	-	2,171	2,171
2. Account Receivable (Ann. Direct Operating Cost x 0.5/12)			
- Foreign Exchange Component ($4,496 x 10^3) x 0.5/12	187	-	187
- Local Currency Components ($35,814 x 10^3) x 0.5/12	-	1,492	1,492
3. Account Payable (15 days usance for electric power, coal, and bags)			
- Coal ($1,416 x 10^3 x 0.5/12)	-)59	-	-)59
- Electric power and bags ($33,259 x 10^3 x 0.5/12)	-	-)1,386	-)1,386
Total	400	2,277	2,677

Annex IV-3(3)

DIRECT OPERATING COST
(1991 Price)

Cost Items	Calculation Basis	Estimated Cost (US$'000)		
		F.E. Portion	L.C. Portion	Total
1. Electric Power	@$0.0356 x 1.5 x 6,642 kwh x 275 t/d x 330 days	-	32,187	32,187
2. Coal	@$40.63 x 1.5 x 0.256 t x 275 t/d x 330 days	1,416	-	1,416
3. Catalyst & Chemicals	@2.72 x 1.5 x 275 t/d x 330 days	370	-	370
4. Bags	@$0.375 x 1.5 x 21 bags x 275 t/d x 330 days	-	1,072	1,072
5. Personnel Cost	$227,333 x 1.407	-	320	320
6. Insurance				
1) Personnel	2% of Item 5	-	6	6
2) Plants	US$117.95 x 10^6 x 1.175%	-	1,327	1,327
		(80%)	(20%)	
7. Maintenance	US$117.95 x 10^6 x 3%	2,710	678	3,388
8. Overhead	70% of Item 5	-	224	224
Total		4,496	35,814	40,310

Annex IV-4

COMPARATIVE STUDY OF ALTERNATIVE PLANT CAPACITIES AND MANUFACTURING PROCESS

Annex IV-4

COMPARATIVE STUDY OF ALTERNATIVE PLANT CAPACITIES AND MANUFACTURING PROCESSES

1. Introduction

This Annex IV presents the results of a comparative study of urea fertilizer production economics, based on alternative plant capacities and alternative manufacturing processes. The objective of this study is to determine the optimum capacity of the proposed urea fertilizer plant, as well as an appropriate manufacturing process to be adopted for the plant. The study is made in the following two steps.

Step 1: Comparison of the production economics of water-electrolysis-based urea fertilizer plants of different size

Step 2: Comparison the production economics of the water-electrolysis-based urea fertilizer plant, with those of alternative manufacturing processes.

2. Production Economics of Water-Electrolysis-Based Urea Fertilizer Plants

The primary objective of this project is to produce urea fertilizer by efficient utilization of indigenous resources -- water and hydropower. In this context analysis of the production economics of urea fertilizer is first made on water-electrolysis-based urea fertilizer plants of different sizes. In view of the future demand for urea fertilizer in Nepal [Part II -- Market Study], the following five cases have been selected for the comparative studies:

Case 1:	100 TPD
Case 2:	200 TPD
Case 3:	250 TPD
Case 4:	275 TPD
Case 5:	300 TPD

Table IV-4(1) tabulates the project costs estimated for these five cases, and Table IV-4(3) tabulates the production costs of urea fertilizer (bagged) estimated for each case. The estimates use the same assumptions as used for the base estimate [Part IV -- Financial Analysis]. Presented in Table IV-4(3) are the production costs in current prices estimated for the year of 1997, the mean year of the 15-years project economic life span, so the given costs show a representative cost structure. They are the production costs estimated by assuming 90% capacity utilization. Figure IV-4(1) illustrates the correlation of the production costs vs. plant capacity which has been derived from the costs estimated for the 90% capacity utilization [Table IV-4(3)]. Figure IV-4(2) illustrates sensitivity of the production costs to changes in capacity utilization. These estimates indicate the characteristics of the production economics as summarized below.

(1) A large size plant can produce urea fertilizer at lower production costs per ton (unit production costs), since capital related costs and other fixed costs per ton of the product are lower for a larger size plant due to scale economy. Hence, the production costs for Case 5 (300 TPD) are lowest among the five alternatives, as far as all cases assume operation at the same capacity utilization rate.

(2) Assuming operation at the same capacity utilization rate, differences in the unit production costs which accrue from differences in plant capacity would be smaller for plants

having larger capacity; assuming operation at 90% capacity utilization rate, the cost differences are US$175.39 per ton between Case 1 (100 TPD) and Case 2 (200 TPD), and US$63.53 per ton between Case 2 (200 TPD) and Case 5 (300 TPD).

(3) The unit production costs will increase if operation in done at lower capacity utilization rates [Figure IV-4(2)]. Even at lower capacity utilization rates, however, there is no change in the relative position of the unit costs due to differences in plant capacity, as far as operation at the same capacity utilization rate is assumed for all cases.

(4) Contrary to the mechanisum of production costs as mentioned in (3) above, the relative position of the unit production costs due to differences in plant capacity would change if the different capacity utilization rates are applied for each case.

Because of the characteristics of the production economics as summarized above, selection of an optimum plant capacity must be made by giving attention to the unit production costs likely to be attained for producing a projected quantity of urea fertilizer.

3. Selection of Optimum Capacity of Water-Electrolysis-Based Urea Fertilizer Plant

Table IV-4(6) tabulates the annual production of urea fertilizer projected for this project, and annual capacity utilization rates for operation which have to be achieved in order to realize the projected production. It is common practice to assume a maximum capacity utilization rate for operation of urea fertilizer plants as 90% of annual production capacity based on 330 on-stream days a year. In addition to that, there is a limited supply of electricity which is another factor limiting the capacity utilization rates [See Part III]. By taking those factors into consideration, the maximum capacity utilization rate for each case is assumed as follows:

	Daily Capacity	Annual Capacity	Max. Capacity Utilization Rate	Maximum Production (tons)
Case 1	100 TPD	33,000 TPA	90%	29,700
Case 2	200 TPD	66,000 TPA	85%	56,100
Case 3	250 TPD	82,500 TPA	83%	68,475
Case 4	275 TPD	90,750 TPA	83%	75,322
Case 5	300 TPD	99,000 TPA	80%	79,200

As in evident from the figures given in Table IV-4(6), Case 1 (100 TPD) and Case 2 (200 TPD) would be too small, while Case 5 (300 TPD) would be too large. Thus Case 3 (250 TPD) or Case 4 (275 TPD) should be an appropriate plant capacity for the project. The unit production costs which are incurred in producing the quantity projected for 1977/78 are as follows [Table IV-4(3) and Figure IV-4(2)]:

	Capacity Utilization Rate	Annual Production (ton)	Daily Costs (US$'000)	Unit Cost per Ton (US$/t)
Case 1	90.00%	29,700	20,960	705.71
Case 2	85.00%	56,100	30,854	549.98
Case 3	80.92%	66,760	35,117	526.02
Case 4	73.56%	66,760	36,165	541.72
Case 5	67.43%	66,760	37,210	557.37

[These figures are indicated with (x) mark in Figure IV-4(2)]

The given figures can use an economic parameter for judging an economic advantage of each case, because they are deemed as those representing the production cost position of each case. These cost figures imply that Case 3 (250 TPD) and Case 4 (275 TPD) are more economical than other cases, due to the following reasons.

(1) The production costs of Case 1 and Case 2, although a least cost level attained by maximum capacity utilization (i.e., 90% for Case 1 and 85% for Case 2), are still higher than those for Case 3, Case 4, and Case 5 due to the former's disadvantage in scale economy compared to others.

(2) The production cost of Case 5 in higher than those for Case 3 and Case 4, because in this case a lower capacity utilization results in cost increases more than offsetting cost advantage compared to Case 3 and Case 4.

Hence, the selection of Case 3 or Case 4 can also be justified from the viewpoint of production economics. Now, further scrutiny is made to select Case 3 or Case 4 specifically. Table IV-4(8) tabulates the unit production costs of Case 3 (250 TPD) and Case 4 (275 TPD) estimated for every year of 1991/92 - 2005/06. These costs have been estimated on the following assumption:

a. Electricity Price: 40% of the present tariff level
b. Equity/Debt Ratio: 30:70
c. Interest on
   Long-Term Loan : 5% p.a.

The estimates indicate that for the initial ten years (1991/92 - 2000/01) the unit production cost of Case 3 (250 TPD) will be slightly lower than than of Case 4 (275 TPD), although the position will reverse after the 12th year (2002/03).

Nevertheless the cost differences of Case 4 will not exceed 3.4% of the cost of Case 3. If the production of Case 4 increases to 80% capacity utilization due to increased demand, its production cost would become lower than that of Case 3. Hence it can be judged that they are close to each other in regard to production costs. The financial returns of those two cases are estimated as follows:

	IRR for 15 years (After Tax)
Case 3	3.79 %
Case 4	3.36 %

These figures reveal that their financial returns would be close in the order of magnitude. If Case 3 is selected, after 1999/2000 annual demand will exceed the domestic production and shortage in the supply therefore would have to be met by imports. On the other hand, if Case 4 is selected, the domestic production would fully satisfy the demand more than 15 years. From these points of view, it is judged that 275 TPD would be the optimum capacity for the project.

4. Comparison with Alternative Manufacutring Processes

Alternative processes for manufacutring urea fertilizer are based on the use of alternative feedstock -- hydrocarbon such as natural gas, naphtha, fuel oil and coal. Table IV-4(8) gives the manufacturing processes based on a variety of hydrocarbons and the consumption of those feedstock materials for manufacutring urea fertilizer, and Figure IV-4(3) illustrates a schematic flow of these processes. Natural gas is transported only through pipeline, and the use of this material therefore is possible in an area where there exist natural gas reserves available of commerical scale. In Nepal there is so far no possibility to establish a natural-gas-based urea fertilizer plant, since a commercially viable natural gas reserves have not been indentified yet. Feedstock materials usable in the country may be naphtha, fuel oil, or coal, although these materials also must be imported from India. India has no surplus of naphtha for supply to other countries, so it seems unrealistic to assume the use of naphtha for this project. In general the production cost of urea fertilizer based on coal is higher than that based on naphtha or fuel oil, because capital related costs required for a coal based urea fertilizer plant are substantially higher than those for a urea fertilizer plant using naphtha or fuel oil. Hence there is no economic advantage for establishing a coal based urea fertilizer plant unless coal is locally available.

Under these circumstances, the manufacutre of urea fertilizer from fuel oil is the only alternative process which can be compared with the water-electrolysis-based urea fertilizer manufacturing process. A urea fertilizer plant based on fuel oil can be operated at 90% capacity utilization, because its electricity consumption is comparatively small compared to that for a water-electrolysis-based plant so that limited supply of electricity will not limit annual operation. Thus a 250 TPD fuel-oil-based urea fertilizer plant would be comparable to a 275 TPD water-electrolysis-based plant. Table IV-4(9) gives capital cost estimates of a 250 TPD fuel-oil-based urea fertilizer plant, and Table IV-4(10) gives the production cost of urea fertilizer estimated for that plant. Comparison of the production cost for a 275 TPD water-electrolysis-based urea fertilizer plant with a 250 TPD fuel-oil-based urea fertilizer plant is summarized below.

ESTIMATED PRODUCTION COST PER TON

[1997: Current Price]

(Unit: US$/ton)

	275 TPD Water-Electrolysis-Based Plant 1/			250 TPD Fuel-Oil Based Plant 2/	
	(90% C.U.)	(80% C.U.)	(70% C.U.)	(90% C.U.)	(80% C.U.)
1. Variable Cost	196.08	196.08	196.08	433.84	433.84
2. Direct Fixed Cost	79.90	89.89	102.73	75.10	84.48
3. Depreciation/ Amortization	161.82	182.05	208.06	149.60	168.30
4. General Admn. Expenses	3.67	4.13	4.72	4.04	4.55
5. Interest on Long-Term Loan	37.12	41.76	47.73	35.85	40.33
Total	478.59	513.91	559.32	698.43	731.50

Notes: 1/ Assuming the electricity price as 30% of the present tariff rate. [See Table IV-4(3)]

2/ Assuming the fuel oil price as US$240/ton in 1984 and US$578.36/ton in 1997 escalated at 7% p.a. [See Table IV-4(10)]

In the variable costs as given above, the feedstock cost for the water-electrolysis-based plant (i.e., electricity cost) is US$151.30 per ton of urea, while that for the fuel-oil-based plant (i.e., fuel oil) is US$390.39 per ton of urea. The cost of a 250 TPD water-electrolysis-based plant at 70% capacity utilization is comparative to that of a 275 TPD fuel-oil-based plant. When these costs are compared, it is found that the former is lower by US$172.18 per ton of urea as compared to the latter. This reveals that the cost of a fuel-oil-based plant is equivalent to the cost of water-electrolysis-based plant for which the electricity price be US¢4.87/kWh is 1997 or US¢2.28/kWh in 1984 (US¢4.87 1.06^{13}), as calculated in the following manner.

	Cost Per Ton of Urea (US$/t)
1) Electricity Cost of Water-Electrolysis-Based Plant assuming 30% of the present tariff rate:	151.30
2) Cost Difference between Water-Electrolysis-Based Plant and Fuel-Oil-Based Plant:	172.18
Total	323.48
3) Electricity Price Equipment: 1997 (US$323.48/t 6,642kWh/t)	US¢4.87/kWh
Electricity Price Equivalent: 1984 (US¢4.87 1.06^{13})	US¢2.28/kWh

This electricity price is equivalent to about 64% of the present tariff rate.

In view of these cost differences, it is judged that the water-electrolysis-based plant can produce urea fertilizer at lower cost than that of a fuel-oil-based plant, as far as electricity can be supplied at a price lower than 64% of the present tariff rate. Further, the urea fertilizer production based on fuel oil requires a foreign exchange outlay of US$390.39 per ton of urea for importation of fuel oil, in addition to foreign exchange outlay for imports of catalyst, chemicals and spare parts, as well as repayment and interest payment for a foreign loan. Thus it is concluded that a water-electrolysis-based process would be appropriate for the project.

Table IV-4(1) CAPITAL COST ESTIMATES

(Urea Fertilizer Plant Based on water Electrolysis)

(Unit: US$ Million)

	100 TPD	200 TPD	250 TPD	275 TPD	300 TPD
A. LAND ACQUISITION	0.72	0.72	0.72	0.72	0.72
B. SITE PREPARATION	1.80	1.80	1.80	1.80	1.80
C. PLANT DIRECT COST	34.36	57.23	67.92	73.13	78.26
C-1 PROCESS UNITS	(21.27)	(38.60)	(46.77)	(50.76)	(54.70)
C-2 UTILITY FACILITIES	(6.00)	(10.44)	(12.48)	(13.47)	(14.44)
C-3 AUXILIARY FACILITIES	(1.76)	(2.86)	(3.34)	(3.57)	(3.79)
C-4 OFFSITE FACILITIES	(5.33)	(5.33)	(5.33)	(5.33)	(5.33)
D. SPAREPARTS, CATL. & CHEM.	1.19	2.26	2.78	3.04	3.30
E. CONST. & ERECTION LABOR	17.62	17.62	17.62	17.62	17.62
F. CONST. EQUIPMENT	9.59	9.59	9.59	9.59	9.59
G. TRANSPORT, INSURANCE & DUTY	3.13	4.98	5.78	6.16	6.53
H. INDIRECT FIELD EXPENSES	1.13	1.13	1.13	1.13	1.13
I. ENGINEERING SERVICES	11.78	12.45	12.67	12.77	12.86
J. PROJECT MANAGEMENT SERVICES	3.57	3.57	3.57	3.57	3.57
K. PRE-OPERATION EXPENSES	2.32	2.95	3.19	3.30	3.40
L. BASE PROJECT COST	87.21	114.30	126.77	132.83	138.78
M. INITIAL WORKING CAPITAL	1.24	2.10	2.49	2.68	2.86
N. INTEREST DURING CONST.	6.09	7.99	8.86	9.28	9.70
O. TOTAL FINANCING REQUIRED	94.54	124.39	138.12	144.79	151.34

Table IV-4(2) BREAKDOWN OF FIXED ASSETS FOR DEPRECIATION
(Buildings and Plant Facilities)

(Unit: US$ Million)

	100 TPD		200 TPD		250 TPD		275 TPD		300 TPD	
	Build-ings	Plants Facil-ity	Build-ings	Plants Facil-ity	Build-ings	Plants Facil-ity	Build-ings	Plants Facil-ity	Build-ings	Plants Facil-ity
- Process Units	-	21.27	-	38.60	-	46.77	-	50.76	-	54.70
- Utility Facilities	0.47	5.53	0.82	9.62	0.98	11.50	1.06	12.41	1.14	13.30
- Auxiliary Facilities	1.24	0.52	2.02	0.84	2.36	0.98	2.52	1.05	2.68	1.11
- Offsite Facilities	5.33	-	5.33	-	5.33	-	5.33	-	5.33	-
- Spareparts, Catalysis & Chemicals	-	1.19	-	2.26	-	2.78	-	3.04	-	3.30
- Construction Equipment	-	9.59	-	9.59	-	9.59	-	9.59	-	9.59
- Construction Labor; Transport, Insurance, Duty; Engineering Service & Management Service	3.32	32.78	3.55	35.07	3.65	35.99	3.69	36.44	3.73	36.85
Total	10.36	70.88	11.72	95.98	12.32	107.61	12.60	113.29	12.88	118.85
	81.24		107.70		119.93		125.89		131.73	

Table IV-4(3) ESTIMATED PRODUCTION COST OF UREA (BAGGED)
(1997: Current Price)

Process: Water Electrolysis
Capacity Utilization: 90%
Interest on Loaned: 5% p.a.

Plant Capacity	100 TPD		200 TPD		250 TPD		275 TPD		300 TPD	
Annual Production (90% Capacity Utilization)	29,700 TPA		59,400 TPA		74,250 TPA		81,675 TPA		89,100 TPA	
	Ann. Cost (US$'000)	Cost Per Ton (US$/ton)	Ann. Cost (US$'000)	Cost Per Ton (US$/ton)	Ann. Cost (US$'000)	Cost Per Ton (US$/ton)	Ann. Cost (US$'000)	Cost Per Ton (US$/ton)	Ann. Cost (US$'000)	Cost Per Ton (US$/ton)
1. Variable Cost										
1.1 Electric Power1/	4,494	151.30	8,987	151.30	11,234	151.30	12,357	151.30	13,481	151.30
1.2 Coal2/	659	22.18	1,317	22.18	1,647	22.18	1,812	22.18	1,976	22.18
1.3 Catalysis and Chemicals3/	172	5.80	345	5.80	431	5.80	474	5.80	517	5.80
1.4 Bags4/	499	16.80	998	16.80	1,247	16.80	1,372	16.80	1,497	16.80
Sub-total	5,824	196.08	11,647	196.08	14,559	196.08	16,015	196.08	17,471	196.08
2. Direct Fixed Cost										
2.1 Personnel Cost5/	429	14.44	429	7.22	429	5.78	429	5.25	429	4.81
2.2 Maintenance Cost6/	3,587	120.78	4,739	79.78	5,270	70.97	5,528	67.68	5,781	64.88
2.3 Insurance7/	388	13.06	496	8.35	545	7.34	569	6.97	593	6.66
Sub-total	4,404	148.28	5,664	95.35	6,244	84.09	6,526	79.90	6,803	76.35
3. Depreciation and Amort.8/										
3.1 Plants and Facilities9/	7,088	238.65	9,598	161.58	10,761	144.93	11,329	138.71	11,885	133.39
3.2 Buildings10/	518	17.44	586	9.87	616	8.30	630	7.71	644	7.23
3.3 Preoperation Expenses11/	232	7.81	295	4.97	319	4.29	330	4.04	340	3.81
3.4 Interest during Const.12/	609	20.51	799	13.45	886	11.93	928	11.36	970	10.89
Sub-total	8,447	284.41	11,278	189.87	12,582	169.45	13,217	161.82	13,839	155.32
4. General Admn. Expenses13/	300	10.10	300	5.05	300	4.04	300	3.67	300	3.37
5. Interest on Long Term Loan14/	1,985	66.84	2,612	43.97	2,901	39.07	3,032	37.12	3,178	35.67
Total Cost	20,960	705.71	31,501	530.32	36,586	492.73	39,090	478.59	41,591	466.79

[EXPLANATORY NOTES TO TABLE IV-4(3)]

1/ 1984: US¢3.56/kWh x 0.3 = US¢1.068/kWh
1997: US¢2.278/kWh (US¢1.068/kWh x 1.06^{13})
US¢2.278/kWh x 6,642 kWh/t = US$151.30/t - urea

2/ 1984: US$40.63/ton - coal
1997: US$86.66/ton - coal (US$40.63 x 1.06^{13})
US$86.66/ton x 0.256 ton/t = US$22.18/t - urea

3/ 1984: US$2.72/t - urea
1977: US$5.80/t - urea (US$2.72 x 1.06^{13})

4/ 1984: US¢37.5/bag
US¢80.0/bag (US¢37.5 x 1.06^{13})
US¢80.0/bag x 21 bags/t = US$16.8/t - urea

5/ 1984: US$227,333/year
1997: US$428,670/year (227,333 x 1.05^{13})

6/ 1991: 3% of Plant Cost (Base Project Cost less: Land Acquisition Cost, Site Preparation Cost, and Part of Indirect Field Expenses - US$0.41 million)
1997: Maintenance Cost (1984) x 1.06^{6}

Plant Capacity	Plant Cost (US$'000)
100 TPD	84,280
200 TPD	111,370
250 TPD	123,840
275 TPD	129,900
300 TPD	135,850

7/ 1.175% of outstanding depreciable asset value [Table IV-4(4)]

8/ Excluding amortization of indirect field expenses because of those expenses amortized out within the initial five years

9/ 10% of the Plant Facilities Value [Table IV-4(2)]

10/ 5% of the Buildings Value [Table IV-4(2)]

11/ 10% of the Pre-operation Expenses [Table IV-4(1)]

12/ 10% of the Interest During Construction [Table IV-4(1)]

13/ 70% of the Personnel Cost

14/ (Total Financing Required) x 0.7 x 9/15 x 0.05

Table IV-4(4) VALUE OF ASSETS FOR INSURANCE (1997)

(Unit: US$'000)

	100 TPD	200 TPD	250 TPD	275 TPD	300 TPD
1. Total Assets					
1.1 Non-depreciable Assets					
1.1.1 Land	720	720	720	720	720
1.1.2 Site Preparation	1,800	1,800	1,800	1,800	1,800
Sub-total	2,520	2,520	2,520	2,520	2,520
1.2 Depreciable Assets					
1.2.1 Plant Facilities	70,880	95,980	107,610	113,290	118,850
1.2.2 Buildings	10,360	11,720	12,320	12,600	12,880
1.2.3 Indirect Field Expenses	713	713	713	713	713
1.2.4 Pre-operation Expenses	2,320	2,950	3,190	3,300	3,400
1.2.5 Interest During Construction	6,090	7,990	8,860	9,280	9,700
Sub-total	90,363	119,353	132,693	139,183	145,543
1.3 Total (1.1 + 1.2)	92,883	121,873	135,213	141,703	148,063
2. Accumulated Depreciation (up to 1996)					
2.1 Plant Facilities (Value x 7/10)	49,616	67,186	75,327	79,303	83,195
2.2 Buildings (Value x 7/20)	3,626	4,102	4,312	4,410	4,508
2.3 Indirect Field Expenses (Value x 5/5)	713	713	713	713	713
2.4 Pre-operation Expenses (Value x 7/10)	1,624	2,065	2,233	2,310	2,380
2.5 Interest During Construction (Value x 7/10)	4,263	5,593	6,202	6,496	6,790
2.6 Total	59,842	79,659	88,787	93,232	97,586
3. Total Assets less Acc. Depreciation	33,041	42,214	46,426	48,471	50,477

Table IV-4(5) ESTIMATED PRODUCTION COST OF UREA (BAGGED) BY CHANGES IN CAPACITY UTILIZATION (1997: Current Price)

(Unit: US$ Per Ton)

Capacity Utilization Rate	100 TPD	200 TPD	250 TPD	275 TPD	300 TPD
100%	654.75	496.90	463.07	450.35	439.72
90%	705.71	530.32	492.73	478.59	466.79
80%	769.41	572.10	529.82	513.92	500.63
70%	851.32	625.82	577.50	559.32	544.13
60%	960.52	697.44	641.07	619.86	602.14
50%	1,113.41	797.72	730.07	704.62	683.35

Table IV-4(6) CAPACITY UTILIZATION RATE BY DIFFERENT PLANT CAPACITY

Year	Projected Production (tons)	Capacity Utilization Rate (%)				
		100 TPD	200 TPD	250 TPD	275 TPD	300 TPD
1991/92	54,500	*	82.58	66.06	60.06	55.05
1992/93	55,340	*	83.85	67.08	60.98	55.90
1993/94	59,320	*	**	71.90	65.37	59.92
1994/95	62,480	*	**	75.73	68.85	63.11
1995/96	64,610	*	**	78.32	71.20	65.26
1996/97	65,660	*	**	79.59	72.35	66.32
1997/98	66,760	*	**	80.92	73.56	67.43
1998/99	67,860	*	**	82.25	74.78	68.55
1999/2000	68,860	*	**	***	75.88	69.56
2000/01	69,750	*	**	***	76.86	70.45
2001/02	70,540	*	**	***	77.73	71.25
2002/03	71,130	*	**	***	78.38	71.85
2003/04	71,730	*	**	***	79.04	72.45
2004/05	72,230	*	**	***	79.59	72.96
2005/06	72,620	*	**	***	80.02	73.35

Notes: Capacity Utilization Rate; Projected Production over Annual Capacity (Daily Capacity x 330 on-stream days)

* Over the maximum capacity utilization rate of 90%; maximum production being 56,700 TPA

** Over the maximum capacity utilization rate of 85%; maximum production being 56,100 TPA

*** Over the maximumm capacity uilization rate of 83%; maximum production being 68,475 TPA

TABLE IV-4(7) ESTIMATED PRODUCTION COST OF UREA FERTILIZER (BAGGED) [CURRENT PRICE]

Unit Cost per Ton (US$/t)

Year	(A) 250 TPD	(B) 275 TPD	(C) B-A	C/A
1991/92	602.3	620.7	+18.4	+3.1
1992/93	605.3	624.8	+19.5	+3.2
1993/94	581.7	601.2	+19.5	+3.4
1994/95	570.8	586.4	+15.6	+2.7
1995/96	568.5	583.4	+14.9	+2.6
1996/97	570.3	586.1	+15.8	+2.8
1997/98	576.6	592.0	+15.4	+2.7
1998/99	584.3	599.4	+15.1	+2.6
1999/2000	595.7	608.7	+13.0	+2.2
2000/01	611.2	619.9	+8.7	+1.4
2001/02	455.4	456.7	+1.3	+0.3
2002/03	475.8	475.9	+0.1	0
2003/04	497.6	496.5	-1.1	-0.2
2004/05	521.1	518.8	-2.3	-0.4
2005/06	546.2	543.1	-3.1	-0.6

TABLE IV-4(8) COMPARISON OF PROCESS AND FEEDSTOCK CONSUMPTION FOR UREA FERTILIZER PRODUCTION

Feedstock	Process Scheme	Feedstock Consumption
		Per Ton of Urea Fertilizer
(1) Electricity	Water Electrolysis Air Fractionation Carbon Dioxide Recovery Ammonia Synthesis Urea Synthesis	6,642.0 kWh
(2) Natural Gas	Steam Reforming Synthesis Gas Preparation Ammonia Synthesis Urea Synthesis	23.5 MMBTU-LHV
(3) Naphtha	Steam Reforming Synthesis Gas Preparation Ammonia Synthesis Urea Synthesis	0.55 Ton (10,600 kcal-LHV/kg)
(4) Fuel Oil	Air Fractionation Partial Oxydation Synthesis Gas Preparation Ammonia Synthesis Urea Synthesis	0.67 Ton (10,300 kcal-LHV/kg)
(5) Coal	Air Fractionation Partial Oxydation (Gasification) Synthesis Gas Preparation Ammonia Synthesis Urea Syntesis	1.25 Ton (6,300 kcal-LHV/kg)

Notes: Synthesis gas preparation refers generally to secondary reforming, shift reaction, carbon dioxide removal, methanation and other synthesis gas purification process.

Table IV-4(9) CAPITAL COST ESTIMATE

(Urea Fertilizer Plant Based on Partial Oxydation of Fuel Oil)

Capacity: 250 TPD

(Unit: US$ Million)

ITEMS	ESTIMATED COST
A. LAND ACQUISITION	0.72
B. SITE PREPARATION	1.80
C. PLANT DIRECT COST	54.37
C-1 PROCESS UNITS	(33.22)
-AMMONIA PLANT	[25.31]
-UREA PLANT	[7.91]
C-2 UTILITY FACILITIES	(12.48)
C-3 AUXILIARY FACILITIES	(3.34)
C-4 OFFSITE FACILITIES	(5.33)
D. SPAREPARTS, CATL. & CHEM.	2.17
E. CONST. & ERECTION LABOR	17.62
F. CONST. EQUIPMENT	9.59
G. TRANSPORT, INSURANCE & DUTY	5.29
H. INDIRECT FIELD EXPENSES	1.13
I. ENGINEERING SERVICES	12.67
J. PROJECT MANAGEMENT SERVICES	3.57
K. PRE-OPERATION EXPENSES	4.04
L. BASE PROJECT COST	112.97
M. INITIAL WORKING CAPITAL	5.89
N. INTEREST DURING CONST.*	7.90
O. TOTAL FIANACING REQUIRED	126.76

Note: * Assuming equity/debt ratio of 30:70 and 5% p.a. loan interest

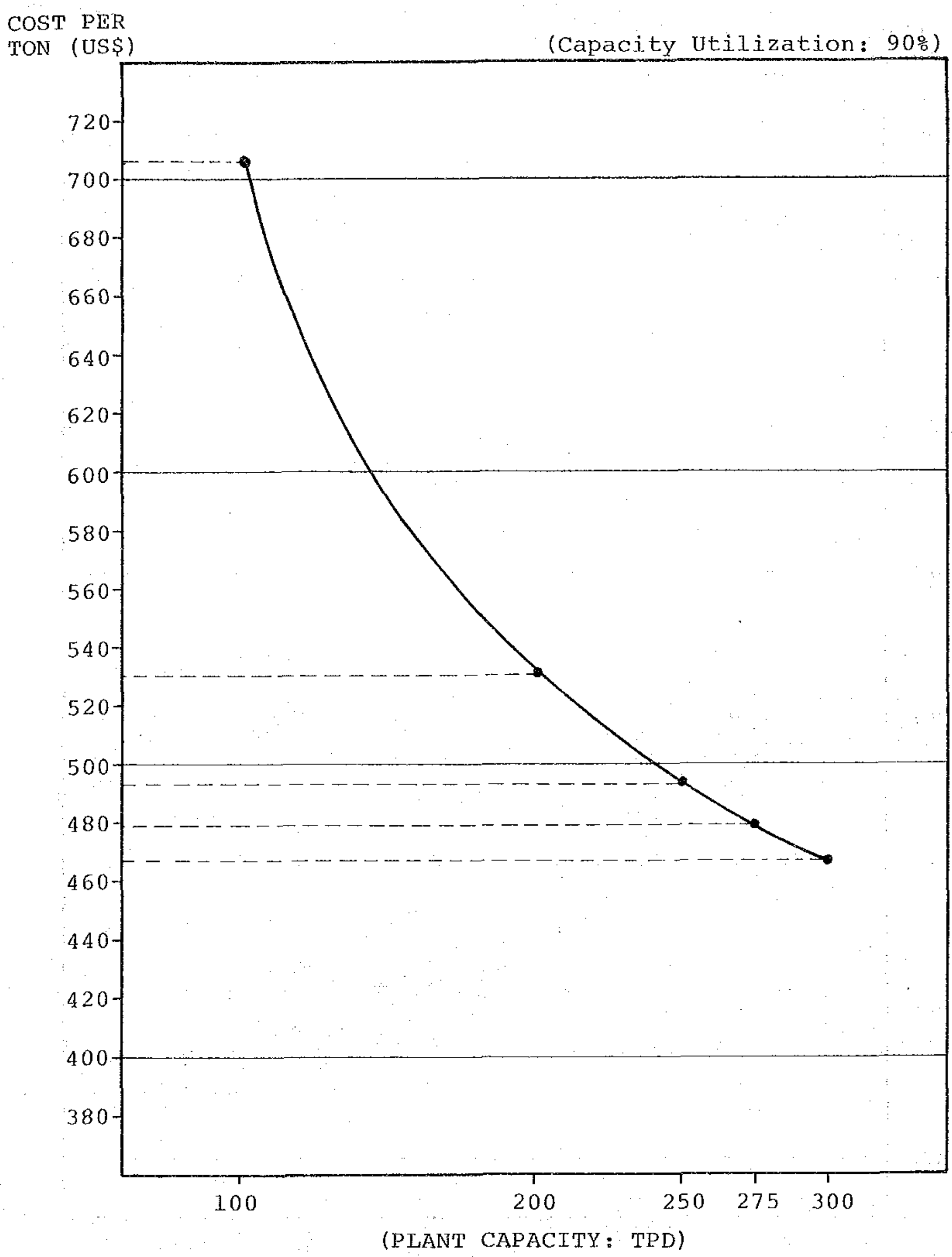
Table IV-4(10) ESTIMATED PRODUCTION COST OF UREA (BAGGED)
(1997: Current Price)

Process: Partial Oxydation of Fuel Oil
Capacity: 250 TPD

Items	Particulars	Annual Costs (US$'000)	Cost Per Ton (US$/ton)
1. Variable Cost			
1.1 Fuel Oil	@US$240/ton 2/ x 1.07^{13} x 0.675ton/t	28,986	390.39
1.2 Electric Power	@US¢3.56/kWh 2/ x 1.06^{13} x 0.3 x 1,055kWh/t	1,786	24.05
1.3 Catalysis & Chemicals	@US$1.22/t 2/ - urea x 1.06^{13}	193	2.60
1.4 Bags	@US¢37.5/bag 2/ x 1.06^{13} x 21bags/t	1,247	16.80
Sub-total		32,212	433.84
2. Direct Fixed Cost			
2.1 Personnel Cost	US$227,333/year x 1.05^{13}	429	5.78
2.2 Maintenance Cost	US$110.04 million x 0.03 x 1.06^{6}	4,683	63.07
2.3 Insurance	(US$118,350 - US$78,886) x 10^{3} x 0.01175	464	6.25
Sub-total		5,576	75.10
3. Depreciation and Amortization			
3.1 Plant and Facilities	US$93.00 million x 1/10	9,300	125.25
3.2 Buildings	US$12.28 million x 1/20	614	8.27
3.3 Preoperation Expenses	US$4.04 million x 1/10	404	5.44
3.4 Interest during Const.	US$7.90 million x 1/10	790	10.64
Sub-total		11,108	149.60
4. General Admn. Expenses	US$429,000 x 0.7	300	4.04
5. Interest on Long Term Loan	US$126,760 x 10^{3} x 0.7 x 9/15 x 0.05	2,662	35.85
Total Cost		51,858	698.43

Notes: 1/ Assuming 90% capacity utilization (i.e., 250 TPD x 300 days x 0.9 = 74,250 TPA)
2/ 1984 prices

Figure IV-4(1) ESTIMATED PRODUCTION COST OF UREA (BAGGED)
(1997: Current Price)



Process: Water Electrolysis
Loan Interest: 5% p.a.

Figure IV-4(2) ESTIMATED PRODUCTION COST OF UREA (BAGGED) BY CHANGES IN CAPACITY UTILIZATION

(1977: Current Price)

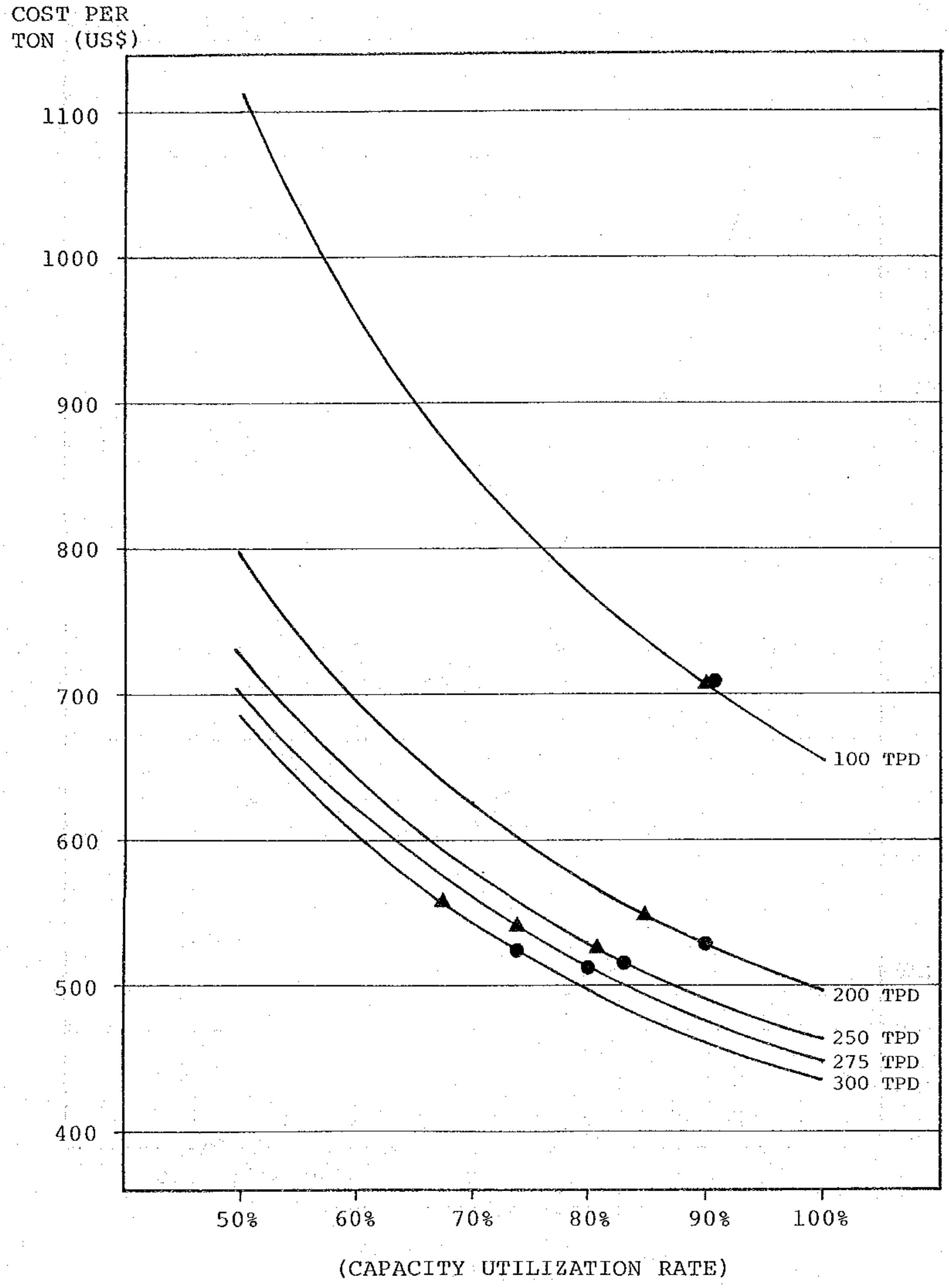


Figure IV-4(3) PROCESS SCHEME AND FEEDSTOCK FOR UREA FERTILIZER PRODUCTION