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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

ALUMINIUM AND COPPER INDUSTRIES IN INDIA
- A CASE STUDY

by

G.D. KALRA*

for

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION
(UNIDO)

September 1986

* Senior Mineralogist, National Council of Applied Economic Research (NCAER),

New Delhi, India.

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Copper and Aluminium Industries In India - A Case Study

Non-ferrous metals constitute a major input in the process of rapid industrialisation. This is particularly the case inrespect of the Indian economy. The successive Five year development plans dating from the early fifties have stressed the role and significance of non-ferrous metals in promoting the growth process. In the initial stages, copper, aluminium, lead zinc, etc. accounted for a large share of India's import bill,* despite the low per capita consumption of these metals by international standards. Obviously the solution was to explore the domestic potential in respect of these metals and to bring their accelerated development. This has been the centre-piece of Indian Government policy almost from the very inception of the process of planned economic development. The result of this policy can be seen in the progress achieved in the identification and proving of reserves relating to major non-ferrous metal ores during the last three decades.

Non-ferrous Metal Ores - Growth in Reserves
(In Million Tonnes)

	1955	19[illegible]5
Bauxite	210.52	[illegible],670
Lead & Zinc Ore (lead marginal)	4.[illegible]7	860
Copper Ore	3.4	56[illegible]

Despite the substantial increase in reserves the per capita consumption of these metals in India is only of the order of 2 to 4% of that in the industrialised countries. An increase of the order of 10-[illegible] times fromthe present day consumption itself - by no means an ambitious target - can be attained only over a longer period of time and that too with a concerted effort atspeeding the pace of development.

Table - 1 Salient Prameters of Progress of Non-ferrous Metals Development In India - 1960 to 1983-84.

		Aluminium		Copper		Lead		Zinc	
		1960	1983-84	1960	1983-84	1960	1983-84	1960	1983-84
1	Production ('000 tonnes)	18	220	9	36	3.7	24	5.4	60
2	Imports ('000 tonnes)	25	19	61	59	51.3	49	7[illegible].6	70
3	Consumption ('000 tonnes)	43	232	70	95	35	73	85	130
4	Domestic Production (as a percent of consumption)	42	95	13	38	11	33	6	46
5	Per capita consumption in India (Kg.)	0.10	0.33	0.16	0.13	0.08	[illegible]	[illegible]	0.18
6	Per capita consumption in industrialised countries (Kg)	-	9.0	-	6.2	-	4.3	-	4.3
7	Per capita consumption in India (as a percentage of that in the industrialised countries).	-	3.7	-	2.0	-	1.9	-	4.[illegible]

Copper Industry

Hindustan Copper Limited (HCL) a public sector undertaking, is the sole producer of primary refind copper in India. Some state Mining Corpoeations viz. Chitradurge Copper Company, Karnatake; Andhra Pradesh Mining Corporation Limited (AMPC); and Sikkim Mining Corporation (SMC) also have developed small mines with matching concentrators for production of copper concentrates. The Copper concentrates produced by these companies are supplied to HCL for both smelting and refining. Another mine at Ambamata (Gujarat) is being developed by Gujarat Mineral Development Corporation (GMDC). The Copper concentrates from the ploy-metallic ore of this mine will not be of the quality required for the domestic smeltor and therefore will have to be toll smelted abroad.

Since its formation in 1967 HCL reported losses every year except in 1978-79. The accumulated losses totalled to Rs. 1,970 million till 1983-84. HCL planned to raise the capacities of the Khetri and Ghatsila smelters from 31,000 and 16,500 tpy to 45,000 and 20.000 tpy respectively. Khetri expansion was to enable it to handle the concentrate from the newly opened Malanjkhand concentrator. Expansion has still not been accomplished; a part of Malanjkhand concentrate is toll smelted abroad. The company intends to enhance capacities through oxygen enrichment of process air.

In addition, there is a possibility of setting up of a 50,000 tpy smelter based on integrated development of the Singhbhum Copper belt in Bihar. In early 1983, the company issued a global tender for preliminary studies to exploit the copper deposits in the region. The first phase of the programme proposes developing a new mine and installing matching concentration capacity. Mosabani, Pathargora, Surda and Rakha mines already exploit some of the deposits of the Singhbhum belt.

HCL expects that planned new refinery capacities at Khetri and Ghatsila will produce enough byproduce trace elements to warrant a new recovery facility. The existing byproduct plant at Ghatsila will be expanded and modernised to handle the load from both the refineries. About 185 tonnes of anode slimes would be treated annually.

The prices of copper in India are determined by the Mineral and Metal Trading Corporation (MMTC), a Government owned canalising agency. The prices are declared on a month to month basis and are related to London Metal Encharge (LME) prices. The imported copper carries 117% customs duty and Rs. 3,500 per tonne as countervailing duty. This is to protect the high cost mining and smelting operations of HCL. HCL has to sell at the price fixed by MMTC.

Copper base industry in India presents a picture of uncoordinated growth. In some areas, installed capacities are far in excess of the existing demand. As a result of idle excess capacity, there is no economic incentive for technological improvement and innovations. The co-existence of large and relatively smaller units has lead to a very unhealthy competition, this phenomenon especially exists in the winding and domestic wire industries.

There are suggestions that the present mining and smelting operations based on lead ore may be suspended and the domestic requirements of copper may be met through imports. This, will save the industry from the burden of duties levied on imported metal to protect the domestc production. The present facilities may however be kept operable to serve the strategic needs. This does not, however, appear to be a viable answer in the light of investments already made in the entire industry and expertise already acquired during two decades.

The copper ore resources are summarised in Table 2.

Table - 2 Summary of Copper Ore and Metal Resources in India as on 31.3.1983.

		In situ Reserves/Resources			No.of deposits/projects.	Average Reserves/Resources per deposit in 000 tonnes	
		Ore (Million Tonnes)	Metal (000 Tonnes)	Grade % Cu		Ore	Metal
I	Working Mines						
	HCL mines	252.12	3,081	1.22	10	25,210	308
	Other mines	7.22	88	1.22	6	1,200	15
	Sub-total	259.34	3,169	1.22	16	16,210	198
II	Project under consideration/ Formulation						
	Rakha Phase-II	46.56	582	1.25	1	46,560	582
	Others	10.04	156	1.55	3	3,350	52
	Sub-total	56.60	738	1.30	4	-	-
III	Deposits apparently Viable						
	Bihar	97.17	1,299	1.34	7	13,880	186
	Rajasthan	12.49	180	1.43	4	3,120	45
	Madhya Pradesh	7.00	105	1.50	1	7,000	105
	Other States	1.03	26	2.52	2	515	13
	Sub-total	117.69	1,610	1.37	14	-	-
IV	Para-marginal and Sub-marginal Prospects						
	a Above 0.60% Cu	47.84	534	1.11	37	1,296	14
	b Below 0.60% Cu	84.79	242	0.29	3	28,263	81
	Sub-total	132.63	776	0.59	40	-	-
V	All India Total						
	a Above 0.60% Cu	481.47	6,051	1.26	71	-	-
	b Below 0.60% Cu	84.79	242	0.29	3	-	-
	TOTAL	566.26	6,293	1.11	74	-	-

The reserves of 6.3 million tonnes of copper in India are not of significance in the global perspective. The reserves of copper in principal countries is given in Table - 3.

Table - 3 World Reserves of Copper (By Principal Countries)

(In '000 tonnes)

Country	Reserve Base
World : Total	505,000
United States	90,000
Australia	16,000
Canada	32,000
Chile	97,000
Papua, New Guinea	14,000
Peru	32,000
Phillipines	16,000
Zaire	30,000
Zambia	34,000
Other Market Economy Countries	77,000
Poland	13,000
U S S R	36,000
Other Central Economy Countries	11,000

Source: Mineral commodity summaries, 1982.

The above figures bear testimony to the fact that the distribution of known reserves of copper metal is widespread and further that no single country possesses copper reserves that gives it a position of world domination.

Technical and Socio-economic Characteristic of Copper Mines in India

Ex-ploited Mines

Copper ore in India is mined exclusively by the public sector undertaking. HCL operates 10 major working mines. Six other relatively smaller mines are operated by the State Government undertakings. The mines exploited by of HCL (Appendix Cu-1) have reserves of 3.081 million tonnes of copper in 252 million tonnes of ore with an average grade of 1.22% Cu. The six other working mines have only 88,000 tonnes of copper metal resources in 7 million tonnes of ore. The location wise distribution of reserves in exploited mines is indicated in Table 4.

Table - 4 Location-wise Distribution of Reserves and Exploited Mines

Location (State)	'No. of Exploited' mines	Resources: ORE (Million tonnes)	Resources: Metal ('000 tonnes)	Distribution %: Ore	Distribution %: Metal
Bihar	5	66.27	975	25.6	30.8
Rajasthan	4	70.22	799	27.1	25.2
Madhya Pradesh (MP)	1	115.63	1,307	44.6	41.2
Others	6	7.22	88	2.7	2.8
Total: Exploited Mines	16	259.34	3,169	100.0	100.0

The mines in Bihar have the richest ore with an average copper of 1.47%. Next in importance is the mechanised large scale open pit in Madhya Pradesh with copper content of 1.22%. The ore in the mines of Rajasthan has a copper content of 1.14%. The operation in mines under 'others' category is limited to concentration of ore. The concentrates from these mines are transferred to HCL for smelting.

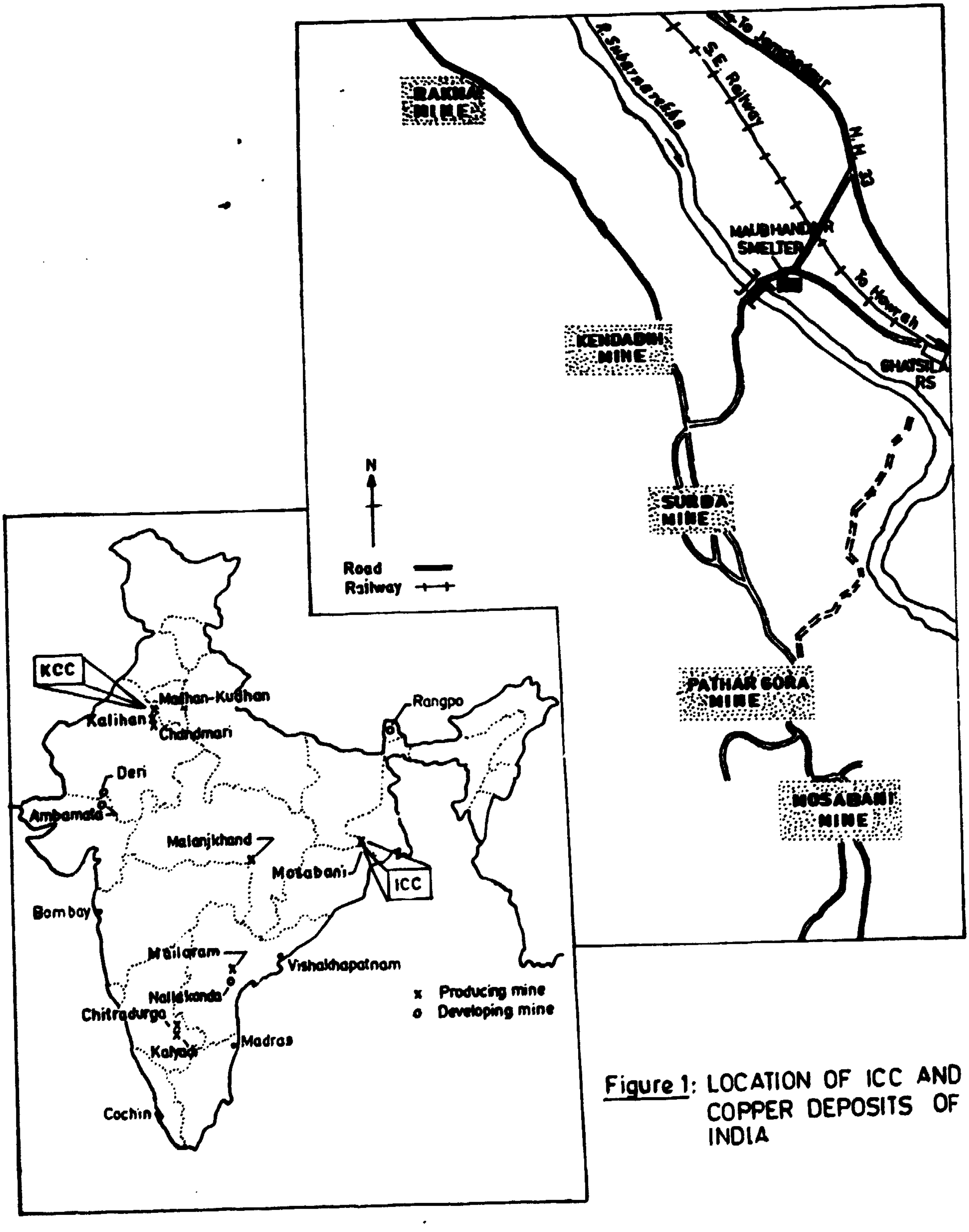

Figure 1: LOCATION OF ICC AND COPPER DEPOSITS OF INDIA

On the basis of 50% insitu reserves as recoverable, the present known reserves in working mines would be exhausted in 24 years at a depletion rate of 65,000 tpy.

Unless supported by comprehensive perspective planning, there might be critical shortages in the domestic supply. The anticipated deple- tion schedules of mines has to be precisely determined to facilitate advance action for new mines or expansion of working mines. Moreover, the new mining activity coming in place of the depleted ones should feed the same mill and/or smelter which received the ore from the depleted mine. An examination of data presented in Appendix Cu-I, for example, brings out some critical periods which have to be watched and monitored carefully. The Mosabani mine is expected to be depleted in 1994. This will mean a shortfall of about 11,500 tonnes of metal product. Other critical periods are, 1996 (closure of Pathargora), 2001 (closure of Rakha), 2009 (closure of Surda) and 2013 (closure of Kendadih). To maintain the production of copper metal at the pre-1994 level, India has to develop a new mine or expand produstion in the Indian copper complex (I.C.C.) by 11,500 tonnes in 1994 and corresponding production levels for the period stated above in respect of other mines. Since development of new mines involve long gestation period, planning for such projects has to be taken up in advance.

The resources data of the exploited mines presented in Appendix Cu-I, are applicable to the extent of depth explored/developed, which varies from 50m (Chandmari) to 1060m (Mosabani) from the surface. If the ore is continuing down to a depth of 1060m in all the areas (where considerable exporation and development have been carried out), 7,200 tonnes of copper would be available per metre depth from 14,400 tonnes, of insitu copper reserves per metre of depth (Appendix Cu-II) from copper ore with an average copper extent of 1.27%. Appendix Cu-II spells out extension of the existing deposits or the deposits in the neighbourhood which can be developed to substitute the mines likely to be depleted.

Mode of Calculation of Royalties and Levies

Royalty : Since the mineral rights rest with the State Governments they collect royalty in lieu of the depletion of their natural assets. The rates of royalties on different minerals are fixed by the Central Government and revised at intervals of every four years. The present rate of royalty is Rs. 4.0 per unit percent of copper metal per tonne of ore on prorata basis. It is fixed (not on a rational foundation) and collected by the State Governments. There is no fixed interval for revision of and the rate of cess varies from State to State. In some states it is as much as 200 to 300 percent of the rate of royalty and is usually a point of controversy between the mine operator and the State Governments.

Besides these explicit duties, the implicit duties are in the form of excise duty, sales tax, octroi etc. on the different inputs consumed in the mining of ore. These duties ultimately result in increasing the cost of production.

Since the mines are operated in the public sector, the profit and loss constitute the assets and liability of the Central Government and the States.

Available Infrastructure

The mines are connected to the benefication plants through roads/ropeways. Developments of infrastructure within the lease area is the responsibility of the lessee which in this case is a public sector undertaking. Investment on infrastructure form part of overall mine project cost.

Intermediary Consumption in 1985 and its Evolution During Recent Years

The mining and milling capacities of HCL in the three geographical regions are as follows :

(Million tpy)

Eastern Sector			
a	Ore raising	-	1.830
b	Milling	-	1.551
Western Sector			
a	Ore raising	-	2.73
b	Milling	-	2.5
Central Sector			
a	Ore raising	-	2.0
b	Milling	-	2.0

The inputs consumed per tonne of copper ore in HCL's Mosabni mines (in Eastern region) is furnished in Appendix Cu-III.

As is evident from the table the salary/wages and benefits account for 62% of the value of one tonne of copper ore raised. This reflects on the extent of mechanisation of mines. These mines can, at best, be called semi-mechanised. Over staffing may be prevelent to some extent.

There is, however, negligible variation in the cost of inputs consumed in the small mines operated by the State Government. In this case the cost of manpower is only 52% of the value of production. This is attributed to the fact that these mines are comparitively newer and the management has been able to keep the wage bill lower through their pragmatic evaluation of the shorter life span of the deposit. The consumption of inputs in smaller mines is presented in Appendix Cu-IV.

Annual capacity of copper concentration plants operated by HCL is as follows :

State	Annual Milling Capacity (Million tonnes)
Bihar	1.551
Rajasthan	2.500
Madhya Pradesh	2.000
TOTAL	6.051

Besides, small benefication plants are operated by the small copper ore mines located in Andhra Pradesh, Karnataka and Sikkim. The inputs consumed per tonne of concentrates vary according to grade of silo-feed and the expected metal recovery in the concentrates. The benefication plant consists of sections : (a) crushing; (b) grinding; (c) flotation; (d) thickening and filteration; and (f) disposal and water reclamation.

The different inputs consumed per tonne of concentrates in the case of HCL are summarised in Table 5.

Table - 5 Inputs Consumed for Production of One Tonne of Copper Concentrates in the Concentrators Operated by HCL During the Period 1979-80 to 1984-85.

	Item	Unit	Quantity per tonne	Cost in Rs. per tonne of concentrates	Cost in Rs/ Rupee value of concentrates
1	Ore	Tonne	19.75	3,443.13	0.90
2	Reagent			43.37	
3	Electricity	KWH	476.00	157.08	
4	Lubricants	Kg	2.35	18.00	
5	Spares			60.83	
6	Grinding media	Kg	11.47	43.11	0.10
7	Liners	Kg	2.29	33.10	
8	Manpower			45.35	
9	Others (not specified) such as)			5.03	
	- Screen cloth	M^2	0.0075		
	- Conveyor belt	M	0.0186		
				3,831.00	1.00

Ore, electricity, reagents and manpower are the main inputs required for concentration of copper ore; ore itself accounts for 90% of the total value of production.

The consumption of inputs in smaller concentrators operated by small mines in Karnataka and Andhra Pradesh is practically the same. However, on account of economies of scale the cost of the ore, reagents and the manpower vary marginally (Appendix Cu-V).

Evolution of Production & Per Unit Cost

Appendix Cu VI gives the production of copper ore during the decade 1975-1984 between 1978 and 1984, the production declined. This was mainly due to the inadequate power supply and the restricted availability of explosives. The production, however, picked up from 1982 with the commissioning of Malanjkhand Project in Madhya Pradesh.

Table - 6 Value of Production of Copper Ore (1975-1984) per Tonne

(Rs./Tonne)

Year	All India	Bihar	Rajasthan	Madhya Pradesh
1975	106.1	106.1	106.8	-
1976	99.4	111.0	88.3	
1977	117.6	114.1	121.4	-
1978	120.9	132.9	109.2	-
1979	137.4	153.2	125.4	-
1980	163.8	173.9	149.7	-
1981	202.5	183.6	233.7	-
1982	182.3	187.8	257.0	73.0
1983	192.7	190.9	254.1	147.0
1984	189.7	192.0	262.0	120.4

Production of copper ore in Bihar comes exclusively from underground mines. In Rajasthan also the production of ore is from underground working except for the small amount contributed by Chandmari open cast mines. And this explains the lowest value of productions per tonne in M.P. as compared to the working mines in Bihar and Rajasthan.

Investment

Based on the various schemes/projects recommended for copper by the Planning Commission for the Sixth Plan Period(1980-85) the investment, as detailed in Table 7 has been made in the copper mining, milling and smelting sub-sectors.

Table - 7 Investment Made in the Mining, Milling and Smelting Sub-Sectors of Copper Industry.

	Item	1980-81	1981-82	1982-83	1983-84	1984-85
1	Continuing scheme	314.5	358.4	264.3	90.0	265.1
2	New scheme covered under sixth five year plan and Mid-term review.	5.0	75.2	119.5	44.4	-
3	Replacement renewals and township	60.0	100.4	145.7	129.6	200.0
4	Science & Technology Scheme	-	-	12.0	15.7	2.9
	TOTAL	379.5	534.0	541.5	279.7	468.0

Source: GOI Department of Mines, various Annual Reports.

The long term programme envisages Rs. 6,713.0 million and Rs. 1,572.1 million to be invested during 1985-90 and 1990-95, as summarised below :

(Rs. million)

		1985-90	1990-95
a	Continuing Scheme	1.4	
b	New Scheme		
i	Mining & Concentrator	2,392.0	1,572.1
ii	Metallurgical Plants	1,469.6	
iii	Industrial Housing	100.0	
iv	Power Generation	1,710.0	
v	Pre-feasibility Studies	80.0	
c	Science & Technology	20.0	
d	Replacement Renewal	1,000.0	
	TOTAL	6,773.0	1,572.1 @

As a result of the investment the following are the salient achievements in the mining and concentration of copper ore.

1 Malanjkhand Copper Project

This is the largest open cast mine in the country with an annual mining capacity of 2 million tonnes of ore equivalent or about 23,000 tonnes of copper metal per year. An investment of Rs. 1,307.5 million has been made on the project. The first stage of one million tonnes of copper ore per annum with matching concentration capacity was completed in July 1982 and the full capacity in 1984.

@ Planning commission, working group on Non Ferrous Metals Copper & Nickel) Seventh Five Year Plan (1985-90), for details see Appendix Cu-XV

2 Nosabani Mine

Expansion of Nosabani mine capacity from 50,000 tonnes per month to 80,000 tonnes per month was completed in April/ May 1985, at an investment of Rs. 81.00 million.

Since the copper ore mining concentration and smelting are vertically integrated, the copper ore and concentrates do not find access to the open market. Small mines and concentrators operated by the State Governments also sell the concentrates to HCL under contractural obligation.

Existing Processing Operations (Smelting, Refining, Production of Semi-finished and Finished Products).

Smelting & Refining of Copper

Presently in India, copper is being produced exclusively by pyromatallurgical operations using flash furnace technology offered by M/s. Outokumpy of Finland. The smelters are located at :

- Khetri in Rajasthan with an installed capacity of 31,000 tpy: and
- Ghatsila in Bihar with an installed capacity of 16,000 tpy.

The smelter at Khetri has a cent percent refining capacity while the refining capacity at Ghatsila is limited to 8,400 tonnes per annum. As against the total refining capacity the production of wirebars registered less than 50% of capacity utilisation except once in the period 1975-84. The low capacity utilisation is attributed to low production from the mines.

Table - 8 Production of Wirebars, Level of Capacity Utilisation and the Value of Production (1975 to 1984).

Year	Production (in tonnes)	Capacity Utilisation (%)	Value of Production (Rs./Tonnes)
1975	12,228	31.03	20,219.6
1976	17,012	43.18	22,737.0
1977	21,069	53.47	23,640.2
1978	11,754	29.83	25,722.2
1979	14,707	37.33	30,136.8
1980	17,021	43.20	32,092.1
1981	14,787	37.53	30.773.3
1982	15,066	38.24	27,252.3
1983	19,585	49.70	36,658.3
1984	18,651	47.34	35,902.0

Source : Government of India, Indian Bureau of Mines, Mineral Statistics of India, April 1985.

Since melting of copper concentrates is through exothermic reactions, no energy is consumed in smelting. Copper concentrates, electricity, manpower, spare parts etc. constitute the major inputs. The consumption of these inputs is furnished in Table 9.

Table - 9 Average of Inputs Consumed for Production of One Tonne of Copper Anode During the Period 1979-85 in Smelters Operated by HCL.

	Item	Unit	Quantity per tonne	Cost in Rs. per tonne	Cost in Rs./ Rupee Value of Anode
1	Concentrates	Tonne	5.17	19,806.27	0.79
2	Power	KWH	1,394.00	460.02	0.02
3	Manpower			710.00	0.03
4	Others (including spare part reagents etc.)			4,028.71	0.16
				25,005.00	1.00

Consumption of inputs in copper refining is presented in Appendix Cu-VII.

Besides cathode copper which is the main end product, some-products are produced as a result of refining. The sub-products obtained per tonne of copper cathode are :

	Quantity per tonne of Refined Copper
- Anode Scrap	199.91 Kg
- Liberator Cathode	4.09 Kg
- Liberator slime	21.77 Kg
- Nickel sulphate solution	0.72 m^3(6.36 Kg Nickel)
- Anode slime	5.00 Kg (14 gm silver, 136 gm selenium, 240 gm gold, 2.4 gm tellarium)

Power is one of the most critical inputs in copper mining and smelting industry. At the current status of production, the requirements of power per tonne of copper metal is as follows :

Operations	Specific Consumption in KWH/Tonne of Refined Copper KCC, Rajasthan	ICC, Bihar
Mining	3,750	6,250
Benefication	2,460	1,910
Smelting	1,060	1,440
Refining	1,130	610
Others	800	700
TOTAL	9,200	10,910

Higher power consumption at ICC compared to KCC is due to the differences in the characteristics of ore, operating technologies particularly in mining and slag cleaning operations and capacity utilisation.

Based on the above input norms the demand of power for the different operating units of HCL works out as follows :

Unit	Energy Demand in MW	
	Present (1984)	Future (1990)
KCC	32.5	40
ICC	34.0	52
MCP	10.0	16

The supply of power from the utilities i.e. respective State Electricity Boards has been inadequate and accompanied with frequent interruptions.

In the Khatri Copper Complex, power shortage has been a major constraint in achieving the desired economic level of capacity utilisation. The level of satisfaction of supply of power by the utility i.e. Rajasthan State Electricity Board for instance, was 57% in 1980-81, 59% in 1981-82 and 68% in 1982-83.

In I.C.C. the major problem had been the frequent load shedding/interruption which destablized operations in almost all sectors of production. As an illustration, the number of interruptions and their durations during the three years are given below :

Year	Power Interruption at I.C.C., Bihar	
	Number	Duration in hours
1980-81	1,800	1,129
1981-82	1,464	817
1982-83	1,622	901

To tide over this uncertain power supply position and also to offer stability to the operating systems, H.C.L. has taken steps to boost up its existing captive generating capability to 75% of demand satisfaction level to achieve 60% overall utilisation of installed capacity. Table 10 shows the split up of captive power generation capacities at the three operating sectors including the mode of generation.

Table - 10 Present and Future Captive Power Generation Capacity at all the Three Sectors of HCL

	Sector	Capitive Generating Capacity in MW		
		Steam/Gas Present 1986	DG Set	Steam/Gas Future 1990
1	KCC, Rajasthan	-	26.4	30
2	ICC, Bihar	4.2	14.0	108.4@
3	MCP, Madhya Pradesh	-	7.0	-

@ includes the proposed 100 MW coal based thermal plant in the joint sector.

The above increase in the installed capacity will dovetail the implementation pattern of expansion/new projects.

Fuel is another critical input, its steady supply is essential for achieving the desired capacity utilisation and for completion of mine construction/explansion within the stipulated time. Recently the demand for distillate fuels and coal has also increased considerably because of the increase in captive power generating capacity. HCL has worked out deman for various fuels to meet its production as well as power generation targets both present as well as future (Table 11).

Table - 11 **Demand of Various Fuels by HCL**

Sector	Type of Fuel	Annual Requirements: Present (1986) For Production	Present (1986) For Power Generation	Future (1990) For Production	Future (1990) For Power Generation
KCC, Rajasthan	Distillate Fuels	5,000 Kl	16,500 Kl	8,000 Kl	46,500 Kl
	Furnace Oil	30,000 Kl	-	45,000 Kl	-
	Coal	600 tonnes	-	1,000 tonnes	-
ICC, Bihar	Distillate Fuels	1,000 Kl	10,000 Kl	1,500 Kl	13,000 Kl
	Furnace Oil	12,000 Kl	-	14,000 Kl	-
	Coal	12,000 tonnes	36,000 tonnes	12,000 tonnes	72,000 tonnes
MCP	Distillate Fuels	4,000 Kl	6,000 Kl	4,500 Kl	12,000 Kl
Others	-	-	-	-	-

Oxygen has lately been introduced in the process cycle of smelter plant to augment the production from existing units and also to control the generation and consumption of reverts. It is used for enrichment of process air. Uninterrupted supply of oxygen is essential for smooth running of smelter. Presently requirement of oxygen is within the range of 280-300 NM^3 per tonne of metal smelted. To cater to the need, particularly in the western sector (where oxygen supply from external agencies is very much vulnerable to power cut and disruption due to transport constraints). HCL has decided to install ultimately a 150 tpd oxygen plant. Already three small oxygen units each of 150 NM^3/hr capacity are presently being installed at Khetri to meet a part of present requirements.

Analysis of the Changes in the Structure of Balance Sheets, Profit and Loss Statement of H.C.L.

The statement of profit and loss and sources of funds and expenditure are furnished in Appendix Cu-VIII and Appendix Cu-IX for the period 1972-73 to 1984-85.

During this period HCL suffered a net loss of Rs. 1,154.5 million. The net income during the period increased 12 fold while expenses in production registered 15 fold increase. This resulted in heavy losses in some of the years such as 1977-78 and 1980-81 to 1982-83. This is inspite of the fact that percentages of materials cost and manpower to the cost of production have not shown significant changes. The value added as percentage of capital employed has shown a remarkable increase from 27.0% in 1978-79 to 51% in 1984-85.

The data on manpower employed, wages and productivity are furnished in Table 12.

Table - 12 Evolution of Wages and Productivity (At Current prices)

	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85
No. of employees (other than casual)	23,638	24,415	25,376	25,846	26,071	26,248	26,634
Productivity per employee (Kg.of wirebar Copper)	497	602	671	572	578	746	695
Average monthly emoluments per employees (Rs.)	583	737	834	941	1,024	1,314	1,566
Value of production per month(Rs)	2,545	3,046	3,979	2,722	3,893	4,905	6,301
Value added per man month (Rs.)	1,512	2,512	1,530	750	1,509	2,478	3,416

Source: Government of India, Bureau of Public Enterprises, Public Enterprises Survey, Volume - 3, various Issues.

The table exhibits increasing wage levels in nominal terms with corresponding increase in value of production per man month. Value added per manmonth dipped very low in 1981-82 but shows a rising trend in nominal terms from 1982-83 onwards.

It is generally argued that prior to the nationalisation the Indian Copper Limited was making profit, with its annual production in the region of 10,000 tonnes. It needs to be mentioned that the parameters adopted prior to nationalisation for ore reserves estimation were minimum stoping width of one metre, cut-off grade of 1% copper and pay limit 1.8% copper which gave rise to narrow lodes, payable zones in patches and low ore reserves of very high grade. The present serving of cut off grade to 0.5% copper diluted the average grade of feed to the concentration down to present 1.09% copper.

The high operating cost of HCL result from :

1 Uneconomic grade of the copper ore in India which average 1.11% copper as against 3% in other copper producing countries. Despite the very low grade of the ore, India set up production facilities purely on strategic grounds;

2 Uneconomic scale in operation which restricts HCL to produce only 6,000 tonnes of ore per day as against 80,000 tonnes in the major mining countries. Besides, the smelters and refineries are dwarfs when compared to the large-scale operations of other producing countries; and

3 Lack of power supplies from the state grid. As a result of this HCL is forced to operate captive diesel-based generating sets which add to its power costs by an additional Rs. 8,000 per tonne of copper produced. If adequate power is supplied from the state grid, it would straight away reduce Rs. 8,000 from HCL's production cost.

A striking feature is that HCL's average cash cost of production still compares favourably with the major world copper producers. Two indepth studies carried out indepenly in 1982, one by the U.S. Bureau of Mines and the other by Commodities Research Unit (CRU-London) covering about 250 copper mining companies found that the average cash cost of production was about 1.2 dollars per lb of copper excluding depreciation and interest and not taking into consideration by-product recovery. This is equivalent to about Rs. 33,000 per tonne at the prevailing prices and dollar parity.and is about the same as HCL's cash cost of production. The main point favouring the world's major producers is that being based on richer copper ore than HCL's they are in a position to recover high quantities of precious metals as by-products from copper ore, such as molybedenum in North America and Chile, Cobalt in Zambia and Zaire, gold in the Phillipines, and so on. These by-product recoveries pay back as much as 40 cents per lb to the producers thus bringing down their net production cost to 80 cents per lb. By product content in India, copper ore on the other hand is very low. For instance through a total copper metal production of say 25,000 tonnes, HCL is able to recover about 60 kg of gold, 350kg of silver, 3,400 kg of selenium and 60 kg of tellurium. All these together pay back hardly 2% of the total cost of production.

Under such circumstances the economics of copper mining in India lies in determining the widths and tonnages of ore bodies with lower cut-off and indentification of the associated minerals and metals which can be extructed in the process to be adopted. Obviously the process selected will be the one which will result in the maximum extraction of dominant mineral or metal. The dimensions of the orebody have to be so delineated as to facilitate adoption of open cast mining method or underground method suited for wide ore bodies.

Evolution of Prices of Copper

Table 13 furnishes the prices of copper wirebars in India vis-a-vis LME prices. The average of official monthly selling prices of copper in 1985 in India was Rs. 44,225 per tonne. On the face of it, this steep increase of about Rs. 5,000 per tonne in just one year can be attributed to some extent to the sudden increase in LME prices. But a rough comparison shows that even the LME's average high price in 1985 equates to much less than Rs. 20,000 per tonne. The balance of the selling price in India is composed of duties as discussed elsewhere.

Table 13 International and Indian Prices of Copper

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
LME Copper (Annual average price in £/ tonne)	556.81	782.40	750.25	710.30	934.04	941.75	865.75	846.14	1,048.84	1,032.60	1,235.00
% change over previous year	-	40.4	(-) 4.1	(-)15.3	31.5	0.8	(-) 8.1	(-)2.2	24.0	(-) 1.6	(+)19.60
LME copper in Rs/Tonne	10,440	12,558	11,369	11,155	15,970	16,550	15,190	14,266	16,580	16,015	19,030
Average of monthly prices of copper wirebars in India in Rs/ Tonne (NMTC)	25,483	26,385	27,583	28,330	34,220	35,169	32,542	29,567	40,167	39,333	44,225

Copper and Copper Alloys and Semis

The downstream industry consists pf units captive to the Ordnance factories, railways, mint and also units manufacturing semis which are entirely owned by private enterprise. The industry has registered a fourfold expansion over the last three and half decades. Notwithstanding the impressive growth, the present semis industry is far behind the other developing economies such as South Korea, Brazil etc. both in terms of scale of operations and technological standards.

Presently 80% of the total copper consumption in India is in the form of wrought products, while the rest is accounted for by other industries such as castings, forgings, chemicals etc..

1 Copper Wire Bars/Continuous Cast Copper Wire Rods (CC Rods)

The share of electrical industry i.e. power generation and utilisation increased from 56% in 1976-77 to 62% in 1982-83. The main problem in this area relates to the production of appropriate type of material employing latest technologies. India is still lagging in producing copper rods by the continuous process. Adequate c.c. rod units need to be installed in different parts of the country to cater to the needs of the electrical sector. However, the Government has decided to produce these rods only in the public sector. The Government is of the opinion that c.c. rod units below 30, 00 tpy capacity are unremunerative. Since c.c. rods are large space occupying items and have to be handled carefully to preserve their properties. Transportation problems would arise in taking the raw material from a single large capacity plant to the widely dispersed user industries. Transporting cathodes to the widely dispersed c.c.rod manufacturing units would be easier than transporting the final product to the consuming units. Even 6,000 tpy units have been found to be economically viable in other countries.

2 Winding Wires and Strips

The electric wire industry in India is now a little over 60 years old but the major expansion and growth in the industry has occurred during the last three decades. At present, there are a dozen large scale manufacturers in this field besides a host of medium-scale and small scale manufacturers. There are a few manufacturers who have developed into integrated units making semis to finished products. Average annual production of strips during the last decade is furnished in Table 14.

Table - 14 Average Annual Production of Winding Wires and Winding Strips During 1975-76 to 1984-85

Region	Organised Sector		Total	S.S. Sector	Grand Total
	Winding Wires	Winding Strips		Winding Wires & Strips	
Western	9,980	4,365	14,345	2,500	16,845
Southern	2,500	800	3,300	1,800	5,100
Northern	2,200	370	2,570	1,500	4,070
Eastern	2,600	1,280	3,880	1,200	5,080
TOTAL	17,280	6,815	24,095	7,000	31,095

Source : Indian Non Ferrous Metals Manufacturers Association, Bombay.

Input/output ratio during this period was :

Copper consumed/tonne	-	1.02 tonnes
Cost of copper consumed per tonne of wire/strip	-	Rs. 33,670
Cost of copper per Rupee Value of wire/Strip	-	Rs. 0.86

It is observed that about 13-17% process scrap is generated by winding wire/strips units. This is recycled and converted into wire bars for wire drawing. Copper oxide, which is generated at an average 2% of metal melted, is sold out.

3 Flat Products

Among the other wrought products manufacture, sheets and strips from a sizeable portion of copper based semis. It meets 80% of the indigenous requirements. Yet, this utilises only 45% of the capacity of installed manufacturing units. Licensed capacity in this area is around 46,000 tonnes but proliferation of units has created an imbalance in supply and demand and the problem is compounded by the fact that many of the units are still to establish their credibility in manufacturing well proven items. To add to this woe, there has been further spurt in licensing which may increase the capacity by 10,000 tonnes and perhaps exceed the requirements considerably. The total requirement is expected to increase to only about 32,000 tonnes by the end of this decade.

Nearly 50% of the production comes from three units in the organised sector located in Bombay. The trade sources estimate the capacity of unorganised sector at about 2,000 tpy. The units in the organised sector generally have more sophisticated rolling mills, electric annealing facilities, apart from general purpose machine shops and auxiliary facilities.

The units in the unorganised sector use operative processes which are normally outdated and consequently concentrate in products which are thicker in gauge and are used by non-industrial sector. More sophisticated products, such as thinner gauge materials or alloys of phosphor bronze, nickel silver etc. are not taken up in such units since these require more sophisticated melting, rolling and annealing facilities.

The total process scrap ranges from 15 to 20% and is recycled.

4 Extruded and Drawn Products of Copper and Copper Alloys

These products have been facing severe competition from imports. This industry is still in its infancy and the installed capacity is about 28,000 tonnes in both the organised and small scale sectors.

Although there is sufficient installed capacity for production of tubes, sections, solide etc. almost 15,000 tonnes of the Indian requirement is met through imports. Electrical power disalination and other tube utilising industries will increase the demand to about 25,000 tonnes by the late eighties and the indigenous production capabilities should match this requirement. The problem is not one of having sufficient capacity but whether the industry is capable of producing the desired quality components such as cupronickel tubes for condensor applications, economically. Another problem which plagues the manufacturers is the variety of specifications which are pinpointed in various collaborations for the manufacture of tube utilising components.

The indigenous production capacity for other types of wrought products including alloy rods and wires, sintered products etc. is indeed very low. They account for a total copper consumption of about 5,000 tpy. Foundry is a major industry which should have made considerable progress in the wake of industrialisation, is lagging behind. It is not yet geared for the manufacture of specialised valves and components for oil exploration, for desalination units, for nuclear power plants etc. There is still uncertainity about availability of satisfactory components for steel plants, such as tuyers, rolling mill components etc. which can be easily manufactured in the country. Here again the quantities and the different specifications seriously affect development of such items. Nevertheless, there are many foundries in the medium and small scale sector which try to fill in the gap and supply castings of high copper alloys, special bronze etc.

The scrap generated in the foundries of organised sector is 1 to 0.2% as rejection scrap and 10-15% as process (machining) scrap. But in well established units like that of Bharat Heavy Electrical Limited (BHEL), the overall process scrap is limited to 5 percent. Small foundries generate a considerable amount of scrap due to lack of proper facilities to control the quality of castings etc. Since the small foundries can always recycle their in-house generated scrap, they are less concious of scrap generation. The melting losses in these foundries are within the range of 2 to 2.5% whereas the maximum average loss is expected to be around 1.0% in an average size foundry. These losses can be brought down by use of electric furnances which allow closer control of metal composition and other parameters such as temperatures. However, due to limited availability of power, only the fired furnaces can be used. Certain fluxes also can help to reduce the losses.

Constraints of Copper Semis Industry

The production base of Indian non-ferrous semis manufacturers is generally small and consequently their production costs are high. Since the installed capacity is more than the demand in each of the semis subsectors, this has brought intense competition and in the process has brought down the profit margin. The profit margin for instance in respect of manufacture of copper strips and wires range from 2% to 5%•. The loss of Rs. 14 per kg. of wire/strips due to rejection contributes significantly to the low profit margin.

The heavy incidence of all sorts of duties and taxes levied by the Central and State Governments only aggravate the high cost operations. Besides the customs and countervailing duties, there are the octroi and Sales tax. For example in Maharashtra, there is 1.5% octroi on semis and a 4% sales tax. There has been a progressive increase in excise duty on copper semis in each budget. For example, in the 1984-85 budget :

• Source: Director National Wire and Metal Industries, Bombay.

- **an excise duty of Rs. 1,300 per tonne was clamped on wire rods of above 6 mm which were earlier exempt from duty;**
- the duty was changed from 10% advalorem to specific one of Rs. 700 per tonne on copper section;
- the duty was doubled to 20% on copper wire upto 6 mm; and
- the duty was raised from 10% to 28% on liners hollow rods and print rolls.

The 1985-86 Budget brought no relief. 1986-87 Budget brought a little relief on some semis but hiked the excise on others.

- Excise on copper pipes and tubes is raised from 9% to 15% ad valorem while the tariff on shells and blanks for pipes and tubes and hollow section of copper has been reduced to 15% from 20% ad valorem.
- Stranded wires, cables, plated bevel and the like (electrically non insulated) will attract an excise levy of 20% ad valorem. Other similar articles have higher excise levy of 15% ad valorem against the previous 12%.
- Copper wires now include bare copper wire of electrical grade attracting an excise levy of 20% ad valorem.

With such sharp increase in levies, the semis industry's production economics have been adversely affected, the mushrooming of small scrap based units in the field has been posing very stiff competition to the organised units.

The other notable impact on economics of semis manufacture is the price quotation of prices on monthly basis by MMTC. The copper processors do not know what their operating cost will be at the time of making deliveries of processed material. The orders are mostly booked on the basis of prevailing raw material prices and margin of five to ten percent to account for unexpected increase in costs. But if the raw material costs increase beyond the calculated extent, the processors run into heavy losses because most of them do not have the advantage of a price variation clause. The industry is of the view that MMTC should revert to its earlier practice of announcing prices on quarterly basis, if not on six monthly basis, so that the processors may book orders at firm prices and commit delivery of goods in two to three months.

Nature and Organisation of the Links Between Copper Industry and the Other Sectors of the Economy

Based on five year grouping, the following average annual consumption of copper is discernible :

Period	Average Consumption ('000 tonnes)
1951-55	24.8
1956-60	51.0
1961-65	70.6
1966-70	41.7
1971-76	51.4
1976-81	71.5
1981-84 (3 years)	102.0●

The consumption of copper exhibits considerable volatility. This was because of several reasons not the least of which was the substitution of copper by aluminium particularly in cables and conductors on grounds of price differential.

Indian economy is largely planned at the macro-economic level. Demand for copper (as for many other metals) is derivative in nature. Growth of demand for copper would be dependent, for example, on the growth prospects of copper using industries which in turn are dependent on the growth of the national economy as a whole or of specific

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● Furnished in detail in Appendix Cu-X

sector therein. On this premise, the behaviour of consumption of copper in India may be chronologically, explained as under :

i . **Period 1961-65 was marked by two wars - one with China and other with Pakistan. This boosted the demand for copper.**

ii This was followed by a period of economic recession owing to sharp deficit in farm output and increased borrowings. This resulted in devaluation of the Rupee and consequently crises in foreign exchange reserves. Consumption of copper fell sharply due to restrictions on imports due to foreign exchange constraints.

iii The period 1971-76 and 1976-81 were characterised by the adverse effects of oil price escalations; inflationary trends and recession in engineering industries.

iv The running four years period i.e. 1982-86 has brought relief to Indian economy due to fall in oil prices in international market resulting in easier foreign exchange for import of other essential industrial inputs, comfortable agricultural output and growth of industrial output ranging from 6 to 10% per annum.

Inspite of the fluctuting circumstances, the resilience of Indian copper industry is clearly brought out by the sustained growth in five yearly averages since the period 1966-70. The average consumption of 1971-76 period was 23% more than the previous period. The 1976-81 period average was 39% higher than that of 1971-76 period.

Table 15 indicates the relationship that exists between the main suppliers of copper and its consuming sectors.

Table - 15 Pattern of Off-Take of Primary Copper in India

	Period	1977-78● Offtake%	1982-83●● Offtake%	Source
a	Winding wires, cables, electrical goods etc.	56.0	62.0	MMTC
	-do-	-	5.0	Private
b	Semis & Alloys	18.0	15.0	HCL
	-do-	-	3.0	Private
c	Railways	11.9	1.6	HCL/MMTC
	Mint	-	1.0	HCL
	Ordinance	-	6.0	HCL
d	Miscellaneous	14.1	3.4	HCL
	-do-	-	3.0	Private
	TOTAL	100.0	100.0	

● Report of the Working Group on Non-Ferrous Metals (Copper & Nickel), 1980

●● Hindustan Copper Limited, Annual Report 1982-83.

It is seen that compared to the 1976-78 period, there has been substantial increase in off-take by the electrical industry sector in the year 1982-83. The consumption in the semis and alloys industry has remained steady i.e. 18% of the total consumption. On the other hand other sectors have shown decline in consumption when considered together. This decline is attributed to larger domestic availability of scrap augmented by ever increasing quantum of imports.

Import of Scrap*

(in tonnes)

	Waste and Scrap of Copper	Waste and Scrap of Brass Bronze and Similar Alloys of Copper
1974-75	NIL	8
1975-76	463	2,377
1976-77	2,478	5,312
1977-78	6,358	11,760
1978-79	9,886	12,378
1979-80	13,521	22,576
1980-81	19,640	20,795
1981-82	19,210	19,674

The import of copper scrap has been further liberalised by the Government by categorising it under Open General Licence (OGL) under the Import Policy 1985-90. Copper base scrap is an alternative or supplementary raw material to concentrates in the production of refined copper, but it is also the first choice of many manufacturers for use in the production of many semis alloys and chemicals. The quality of the products manufactured limits the types of scrap which can be used by different industries.

Government Policies in Respect of Distribution and Pricing

Since the demand far outstrips indigenous production, India has to depend on imports and will continue to do so taking into consideration the limited resources of copper ore. Import of copper is canalised through MMTC. The objectives of canalisation are :

Note :* Copper-base scrap meets 50% of the demand for copper in the non-socialist countries in India, contribution of scrap is roughly estimated at 15% of consumption.

i Procurement of metals at the most competitive prices through economies of bulk order and transport;

ii Distribution of metal at the right time and right place;

iii Keeping the sale prices at the lowest with minimum margins for MMTC; and

iv Customer service/satisfaction through streamlining of distribution centres and procedures.

MMTC has two sources for copper imports. It has entered into long term arrangement with Zambia for supply of wirebars. Zambia because of geographical proximity is a natural source of supply. For copper rods MMTC goes into spot tender from time to time. Limited shelf life of rods, delicate packing, comparitive price situation at a particular point of time vis-a-vis the conversion cost in India, changing duty structure and limitation of handling are some of the important reasons for going for spot purchases of copper rods.

The selling price of imported copper is regulated by a Pricing Committee headed by the Chief Controller of Imports and Exports. The pricing is normally done on cost plus interest on principal. As for instance, if the selling price of copper in India is Rs. 44,500 per tonne, against the international free market price (LME) of about 1,270 pounds or about Rs. 19,570, the difference between the international free market price and the selling price is explained by high import duties which at present are as high as 117% plus countervailing duty @ Rs3300 pt, which on the basis of the c.i.f. cost cited above, works out to about 18%. HCL also sells at the price thus fixed. The high duty structure is aimed at protecting the operations of HCL.

Note: The price paid by MMTC in long contracts may also be said to be the lowest because the premium paid on these contracts over the LME prices are not obtainable in purchases in the International free market (London Metal Exchange). The prices to be paid in any spot purchases are inveriably higher than in the long term contracts with producers.

● (Refer footnote on next page)

Although domestic prices are linked to the international prices, there is a time lag in the formulation of the domestic prices. As a result the domestic prices increasing with the international prices but do not come down immediately when there is a fall in the International prices. This evidently encourages a great deal of speculation. Anyone can guess fairly correctly whether MMTC prices would go up or down, but it is the uncertainty about the extent of change that fires speculation.

From the producer's point of view under such circumstances it means that either the customers would not lift or delay lifting materials specially since the registration policy also does not bind them to lift their committed tonnages, or there could be sudden heavy registration of demand, depending upon which way the speculation predominates. It distorts planning and upsets all calculations.

The distribution policy for copper itself is characterised by a number of supperfluous regulations. Consumers are divided between HCL and MMTC and a consumer cannot shift from one agency to another. Such a policy is partly influenced by the necessity to ensure disposal of domestically produced copper. The consumer, however, would like flexibility inobtaining copper either from HCL or MMTC depending upon where the material is available. In the absence of such flexibility, consumers are left in the lurch if there appointed supplying agency has no copper in stock.

It is sometimes advocated that distribution of both indigenously produced copper and imported copper should be handled by one agency to provide the single window system through MMTC. It is advocated to be advantageous to both the producer and the industry. The advantages to the producer would be : i) MMTC will market the entire output of HCL including even the sub-standard material; ii) MMTC can make 100 percent

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Note: It needs, however, be mentioned that if HCL were to market copper at cost plus principal, its selling prices would be even higher than the domestic selling prices of imported copper because its cost of production is much higher than the internationally competitive levels.

* From 70% ad valorem, import duty went upto 100% in November 1982, then to 105 percent in the next month and 115% in March 1984 and 117% from 1985 onwards.

cash payment which is expected to improve the liquidity position of HCL; and iii) based on MMTC's wide contacts with the consumers, essential feed back can be given to HCL about the consumer's requirements regarding quality, delivery and type of material. Advantages to the industry are also expected to be many such as : i) all industrial customers will be serviced by one agency; ii) MMTC can so arrange the inventory holding that the costs could be brought down considerably; iii) pricing can be arranged so that the unhealthy commercial practices are not followed, iv) the present bitterness of customers who are asked to switch between HCL and MMTC periodically can be eliminated; and v) cross country movement of metals by HCL and also by MMTC can be eliminated. MMTC has about 20 distribution centres, one each in almost every State of the country.

The answer to the distribution problem lies in three major changes:

1 bringing about coordination between the two supplying agencies, just as in the case of another non-ferrous metals;

2 making a realistic assessment of demand which would call for among other things, firm monitoring by the Directorate General of Technical Development (DGTD) and other technical authorities; and

3 introducing a reasonable registration policy which does not throw the producer at the consumer's mercy or the consumer at the producer's

Government Strategy, Policies and Incentives to Develop the Mines and Copper Industries

Unless new deposite of large reserves like Malanjkhand are discovered, the chances of meeting even 50% of the demand (except for short periods when a new mine-smelter complex comes up) are remote. Therefore, the shortfall in demand has to be met by one or combination of alternatives such as :

a Import;

b Increased use of scrap;

c Smelting and refining of imported concentrates at new smelters/ refineries located in suitable areas;

d marine resources development if possible; and

e removing the imbalances between mining, concentration and smelting capacities. This may ease linkages in different regions.

The first two points are receiving adequate attention and both together are taking care of nearly 60-65% of our all demand for copper metal. The third and fourth alternative are of longer gestation and may not be of immediate help. The last alternative needs strategic planning and execution.

A Malanjkhand Copper Project was sanctioned with the idea that the concentrates from Malanjkhand would be treated at Khetri smelter. The project has been commissioned with the output of copper at full capacity as under :

Ore (Million tpy)	Grade (% Cu)	Annual recoverable metal (Tonnes)
2.0	1.3	23,077

The project has been commissioned but the Khetri smelter expansion has not materialised. The gap of 14,000 tpy persists :

Mines of Khetri plus Malanjkhand (Tonnes of Copper)	Smelter (tonnes)	Refinery (tonnes)	Gas between mines Refinery output (Tonnes)
45,000	31,000	31,000	14,000

As a result, the concentrate is being sent abroad for toll smelting. There are four alternatives to bridge the gap :

1 The first alternative would be to set up a smelter at Malanjkhand. Prima-facie it has been observed that the minimum economically viable unit along with by product sulphuric acid facility is 50,000/60,000 tpy. The present capacity of the mine and the additional resources established around Malanjkhand do not warrant that.

2 The second alternative could be to sell concentrate in the world market. The international prices being low HCL would sustain perpetual losses.

3 The third alternative would be to toll smelt excess concentrate in foreign smelter as is being done at present. Toll smelting is a comparatively expensive proposition. The cost of toll smelting presently works out to Rs. 11,500 per tonne of returnable copper. Against this incremental cost of production in the expanded smelting and refining, is estimated to work out to Rs. 4,000 per tonne.

4 The fourth alternative would be to augment the capacity of the Khetri smelter through oxygen enrichment of the process air in the flash furnace. The main investment in the expansion of Khetri smelter would be in setting up an oxygen plant. Alongwith expansion of Khetri smelter. The Khetri refinery has also to be expanded to treat the increased blister copper output from expanded smelter. The present refinery at Khetri does not have a purification section. The proposal to expand the refinery has to include the purification section to ensure that the quality of the final product is acceptable to the electrical sector. Bulk of the requirements of electrical sector at present are imported.

B <u>Ambamata Mine</u> in Gujarat is being developed by Gujarat Mineral Development Corporation (GMDC). The copper concentrate from this polymetallic ore will not be able to meet the quality requirements of the feed of the domestic smelters and, therefore, will have to be toll smelted abroad.

C **Mine Concentration Balance**

As against the ultimate production capacity of 9,000 tpd in Khetri Copper Complex, the designed capacity of the concentrator is 5,000 tpd. Certain modifications to the plant through installation of equipments in crushing and grinding system, would be necessary to augment the capacity of Khetri concentrator. HCL is, however, trying this by setting up of ore sorter prior to the concentrator so that the facilities suffice to handle the quantum of output.

D **Eastern Sector**

There is an imbalance between mining, milling, smelting and refining capacities in the Eastern Sector.

The installed capacities are as follows :

1	a	Ore raising	-	1,85 million tonnes
	b	Contained metal	-	20,160 tonnes
	c	Equivalent refined Cu	-	18,043 tonnes
2	a	Concentrates	-	1.551 million tonnes
	b	Refined copper produced limited by concentrate capacity	-	15,299 tonnes
3	Smelter		-	16,500 tonnes
4	Refinery		-	8,400 tonnes

The capacities in the Western Sector are already tied up with Malanjkhand concentrator. As such there will be no surplus capacity available to treat materials from the Eastern sector. Perusal of the various capacities in the Eastern sector brings out the following imbalances :

i	Between mining and milling	-	0.28 million tpy
ii	Between mining and smelter	-	1,543 tpy
iii	Between smelter and refinery	-	8,100 tpy

To overcome these imbalances, various expansion projects have been conceived by HCL. These are :

- the smelter at Mosabani is being expanded to 20,000 tpy with the help of oxygen enrichment of process air with augmentation of refining capacity;
- a new concentrator plant of 3,000 tpd capacity is being built at Surda to eliminate the mis-match of mines output and concentrator capacity and also as replaement of the old concentrator;
- some minor expansions of mines are being undertaken by employing some additional equipments to fuller use of hoisting capacities; and
- the by-product plant at ICC is being expanded to treat the entire generation of slime from expanded refinery capacities at ICC and KCC. The excess of slime at present is sold out.

E Refinery-Wire Bar Balance

The installed capacities of the wire bar plants of HCL are as follows :

KCC, Rajasthan	-	31,000 tpy
ICC, Bihar	-	8,400 tpy

However, Government of India has decided to install continuous cast copper rod project based on high grade copper cathodes to be imported by MMTC. It may be located somewhere in Western India alongwith the natural gas pipelines. As a result of this development, it is not necessary to augment the capacities of the wire bar plant either at Ghatsila or at Khetri.

Legal and Institutional Aspects

1 Treatment of Foreign Capital

Foreign Exchange Regulation Act (FERA) and provisions of foreign investment and collaborations are not applicable to copper industry since copper mines and smelters are owned by the public sector and copper and copper alloys semis industry is by and large financed indigenously.

2 Protection of Environment

This is governed by : i) Environment (Protection) Act 1986; and ii) Water and Air Pollution Control Act. For strict enforcement of the new Act, an implementing authority has been set up by the Department of Environment & Forest to check further degradation of the environment.

The Act gives sweeping deterrent powers to the Central Government. It provided for prescribed punishment i.e. five years imprisonment or a fine of Rs. 0.1 million and seven years imprisonment for contravention beyond a period of one year after the date of conviction and a fine of Rs. 5,000 for every day of contravention.

The Act also provides for punishment where an offence has been committed by any department of Government public undertakings. In such cases, the head of the department shall be deemed to be guilty of the offence and shall be liable to be prosecuted against and punished.

The implementing authority will have wings for developing standards monitoring and enforcement. These wings will be manned by scientific administrative and legal personnel.

The degradation due to mining projects will be sought to be minimised through a system of environment impact assessment before the start of such projects.

The new Act will not replace the existing Central and State organisations but will only assist them in discharging their functions. The Centre will have the power to intervene if other measures fail.

Measures Taken by HCL for Protection of Environment

There are basically four forms of environmental hazards in various fields of copper mining and smelting operations. These are solid waste, liquid, effluent gaseous discharge and noise. There is presently no legislation in India specifying the upper limits of tolerance of the above agents of environment hazards. The Ministry of Environment and Forest has however, issued guidelines for environment controls in mines as well as smelters.

1 Liquid Effluent

The sources of liquid effluent are from mines, fertiliser plants and other process plants. Generally these effluents are treated to take care of toxicity. Effluents are required to be also treated for eliminating high quality of suspended solids.

2 Gaseous Effluent

The source of gaseous effluent are from the smelter plant, acid plant and fertilizer plants. Further the dust load in the mines are required to be maintained within safety limit. Toxic gases like carbon monoxide and nitrogen oxide are released during blasting. These alongwith diesel engine exhaust gases, are being controlled and maintained below the acceptable limits by adequate ventilation of the mines. The dust in the crushing sections has been contained by proper operation of dust extraction equipment. The sulpher dioxide emitted from the smelter is consumed in by production of sulphuric acid, However, dut to frequent interruptions of sulphuric acid plants at Khetri and Mosabani due to power shortage, atmoshperic pollution is often noticed. During this time, the gasses are let off through sufficiently high chimney to reduce the concentration of sulphur dioxide and other toxic gases below the acceptable levels. However, with captive power generation this problem is not likely to persist.

3 **Solid Waste**

Areas have been located for proper dumping of solid wastes from the mines. The solid waste from fertilizer plants are disposed off on a regular basis. The tailing from concentrator plant is being disposed off in a tailing pond from where the clear water would be recovered for re-use in the plant. Planning is in hand to dispose tailing from concentration at ICC in tailing pond.

4 **Noise**

No specific studies have been conducted by HCL so far for ascertaining the noise pollution. However, ear-muffs have been provided by HCL to the persons working in high noise areas.

HCL has taken steps to augment the laboratory facilities for monitoring the liquid effluent and the mines discharge. Arrangements have also been taken in hand for monitoring the dust borne by the exhaust gases. Both at Khetri and Ghatsila, integrated neutralising system for liquid effluents are being planned. M/s. Dharamsi Morarji Company has been engaged as consultants for anti-pollution measures.

Safety Health and Working Conditions

All production activities whether in a working mine, underground or open cast, or in a plant are attended with many hazards likely to result in the deterioration of health, minor or major accidents and even death. The undesirable results of these hazards are mainly due to human failures, which can be avoided by adoption of correct techniques, design and safety measures. Minimum safety provisions have been indicated by relevant Mines (Amended) Act 1984 and Factories Act and rules and regulations framed therein. These regulations are enforced by the Directorate General of Mines Safety (DGMS) and Inspectorate of Factories under the Ministry of Labour.

Table 16 Occurrences of Major Accidents in the HCL Mines and Plants During 1981 to 1983

Period	No. of Accidents		No. of Persons		Rate per 1,000 persons Employed	
	Fatel	Serious	Killed	Seriously Injured	Death	Serious Injury
A Mines						
1981	5	164	5	164	0.33	11.2
1982	3	128	3	130	0.20	8.7
1983	2	145	2	147	0.10	10.08
B Other than Mines						
1981	1	32	1	32	0.10	3.6
1982	NIL	31	NIL	31	NIL	3.4
1983	4	23	5	25	0.50	2.7

Source: Directorate General of Mines Safety (DGMS) Dhanbad (Bihar).

It is estimated by DGMS that the total direct and indirect cost of fatal accidents works out at about Rs. 0.375 million to HCL.

Steps taken by HCL to improve safety standards are as follows :

- Technological improvements have been introduced in the field of raising, blasting, stoping etc. to reduce hazards in mining operations;
- Monitoring and review of safety practices to identify weaknesses in the system and take corrective action;
- Training programme and safety campaigns are organised to generate safety conciousness and skill in reducing unsafe practices and hazards. Mines safety weeks are organised on an annual basis; and
- A special sub-committee of the Joint Consultative Committee on Safety has been constituted at the highest level of management on matters concerning safety. This provides excellent opportunity for workers participation in safety management. The safety committee has now the statutory backing of the Mines Act(Ammended) 1984.

Wage Levels

1 Wage levels in the public sector enterprises are agreed through long term wage settlements between the management and the workers. Bureau of Public Enterprises (BPE) constituted as an administative unit under that Ministry of Finance is the nodal agency for such settlements. HCL revised its wage structure through such settlement on 1.8.1982.

2 HCL gives 8.33 % of the wages as bonus to the employees under the Payment of Bonus Act (as amended upto 1980). This is irrespective of whether or not the employer has any allocable surplus in the accounting year. The bonus is subject to a maximum of 20% of wages of employee if justified by the availability of allocable surplus.

3 Production incentive Scheme is operated outside the provisions of payment of Bonus Act. It is directly co-related with geniune increase in overall volume of production. It becomes admissible only on attainment of a specified threshold level.

The wages in the semis industries are governed by the settlement arrived between private management and workers unions. Such agreements are usually operated for a period of maximum three years. The provision of payment of Bonus Act are applicable to the private sector as well.

Institutional Organisation

HCL comes under the administrative control of the Department of Mines which controls its functioning through the Chairman appointed by it.

Budgetary support to HCL forms a part of overall financial allocation made to the Department of Mines by the Finance Ministry. Scheme of expansion/new projects and their priorities are approved and fixed by the Department of Mines in consultation with the Planning Commission and within the overall financial allocation accorded by the Finance Ministry.

BPE is a nodal staff agency to provide managerial, advisory and performance monitoring services in various facets of HCL management. During this process, BPE gets actively associated with the Department of Mines as well.

HCL functions through a Board of Directors headed by its Chairman. HCL coordinates with the semis manufacturers through fixed linkages in terms of identification of firms and the quantum of metal to be lifted within the specified time schedule. All this is decided by the Committee comprising of representatives of MMTC, Department of Mines, HCL, Directorate General of Technical Development (Department of Industry) on a half yearly basis.

Stragegies of Development and Cooperation

a Non Exploited Deposits

Details of reserves in respect of non-exploited but known deposits are furnished in Appendixs Cu-XI and Cu-XII. The total reserves in these known deposits are summarised in Table 17.

Table 17 Summery of Reserves in Non-Exploited but Known Deposits

	Insitu Reserves in Million Tonnes and Grade % Cu				Total Metal in '000 Tonnes
	Proved	Probable	Possible	Total	
i Projects under consideration/formulation	27.79 (1.25)	27.52 (1.35)	1.29 (1.55)	56.60 (1.30)	738
ii Deposits apparently viable	18.11 (1.42)	70.42 (1.37)	29.16 (1.53)	117.69 (1.37)	1,610
iii Paramarginal and submarginal prospects					
a) Above 0.6% Cu	-	19.89 (1.26)	27.95 (1.01)	47.84 (1.11)	534
b) Below 0.6% Cu	-	43.57 (0.22)	41.22 (0.35)	84.79 (0.29)	242
Sub Total iii	-	63.46 (0.55)	69.17 (0.63)	132.63 (0.59)	776
Grand Total					
a Above 0.6% Cu	45.90	117.83	58.40	222.13	2,882
b Below 0.6% Cu	-	43.57	41.22	84.79	242
All Deposits and Prospects	45.90	161.40	99.62	306.92	3,124

Of the reserves tabulated above, the deposits categorised as projects under consideration/formulation would be in a stage of exploitation in the VII and VIII Plan period. The projects have been indentified in Appendix Cu-VII and corresponding investment in Appendix Cu-VIII. Important new deposits under consideration are as follows :

1 **Tamapahar - Rakha - Sidheswar** in Singhbhum contains large reserves by undertaking open pit mining together with large underground mining, a larger output as compared to underground mining is apparently feasible. Moreover, open pit mining may permit lowering of both cut-off grade and workable grade enhancing thereby the recoverable reserves by nearby 30%. While it may take 10 years to start full fledged underground operation, it may take 3 to 5 years to start an open pit mine. This provides the option to increase production as well as maximise recovery of metal values from the deposit.

2 **Ambamata Project** is a polymetallic project being developed by the Gujarat Mineral Development Corporation. Since there are no smelting facilities for polymetallic concentrates, the concentrates have to be exported for toll smelting.

3 Dikchu Copper Zinc Deposit has 3.10% copper and 0.99% zinc. The copper recovery in the concentrates is about 90%. The Himalayan base metal deposits are quite attractive as far as their metal content is concerned. However, their structural complexities, hostile terrain conditions and inadequate communications and other infrastructural facilities pose many problems in the way of their economic exploitation.

4 Akwali and Banwas are the two new projects in Western sector that may play a supplementary role in lengthening the life of the overall copper mining. The working mines appear to contain copper at the rate of 2.1 thousand tonnes (Khetri and Kolihan) to 2.5 thousand tonnes (Khetri, Kolihan and Chandmari provided exploration proves continuity of ore in Chandmari) per metre down to a depth of 300 m from the surface. The other five better known deposits together may provide one thousand tonnes of copper per metre depth in-situ reserves down to 200 m depth from the surface. If the annual rate of extraction is 10 m in Khetri and Kolihan mines and in five other mines, the availability of copper metal from Rajasthan for the next 20 years may amount to 14.5 to 16.5 thousand tonnes per year. Apparently it would be difficult to substain an annual production of 20 to 25th.tonnes per year for more than 8 years after which the availability from working mines in Rajathan may sharply decline to a level of only to 10 to 13 thousand tonnes a year. Therefore, three steps are necessary : i) opening of supplementary mines in the known apparently viable deposits (Appendix Cu-XII); ii) depth-exploration in the working and viable deposits; and iii) intensive exploration of paramarginal and sub-marginal deposits of Rajasthan.

Most of 37 paramarginal and sub-marginal prospects (Appendix Cu-XIII) spread all over India are of small dimensions and have not been explored in depth. Any prospect having the potential of yielding atleast 10 thousand tonnes of ore per metre depth over 500 m strike length with an average grade of 1.5% copper or so may be explored in details alongwith exploratory mining and 100 to 200 tpd pilot plant facilities to produce concentrate (4 to 10 tpd). There are only 17 prospects with grade of above 1.2% copper out of which 8 have more then 2.0 million tonnes of ore. Six prospects have an average grade of 1.50% copper or above, out of which three have more than one million tonnes of ore.

The average availability of copper from these 37 prospects is seven thousand tonnes based on 50% recovery from in-situ resources. Assuming the life span of each prospect to be 20 years, the average annual production from each prospect would be of the order of 350 tonnes of metal equivalent or to about 0.5% of the envisaged annual production of 65,000 tonnes from 1988-89. Since it would take atleast five years to set up any mine-concentrator unit into commission, it would be necessary to plan production from 10 such deposits every 5 years to achieve an increase of 5% in production capacity every 5 yaers. Simultaneously, every year, atleast two such deposits have to be explored and proved. If the minimum exploration of a prospect is carried out at 50 m x 50 m grid, the annual drilling rate required would be 80 holes of 300 m depth each when the success ratio is 50%. Thus, atleast 240,000 m of exploratory drilling in 10 prospects every five years will be required to sustain the growth rate of about 5%. This would amount to atleast 80 m of exploratory drilling every day or constant deployment of 30 drilling machines every day (assuming annual drilling of 800 m per rig) for prospecting purposes.

The working mines and better known deposits in India taken together can possibly provide 65,000 to 72,000 tonnes of copper at an extraction rate of 10 m per year (Appendix Cu-XIV). If combined open pit and underground mining system is adopted for Malanjkhand and Rakha-Sidheswar area, the possible increase in production capacity at the same rate of extraction would be 25,000 tonnes at Malanjkhand and 13,000 tonnes at Rakha-Sidheswar area.

Thus a possible increase of mine production capacity from the existing mines in the near future may be of order of 40,000 tonnes.

From the above discussion the following actions are suggested:

- **accelerating exploration and discovering new deposits at the rate of atleast one prospect/deposit with a minimum of 150 tonnes of copper per metre depth over 500 m strike length every year; and**

- **exploring and assessing the possibility of increasing mineral reserves and production capacity in existing mines and minerals deposits by suitably changing the cut - off grade. Reduction of cut-off grade will generally result in increasing mining width and lowering the average grade. The increase in dimensions may be such as to permit open cast mining to be adopted or to introduce bulk underground mining methods. Because the tenor of the ore will be lower, various alternatives available for preconcentration need be examined. Heavy Media Seperation (HMS) and various ore sorters are the techniques now available to reduce the cost of beneficiation of copper ore.**

Main Area for Cooperation of the Sub-regional, Regional and the Countries Outside the Region

Necessary expertise in the field of prospecting and exploration for copper are available in the country. Expertise and facilities for preparation of feasibility reports, development of mines and setting up of beneficiation plants for copper are also available to a large extent but foreign te hnical assistance as a back-up consultancy is still required in certain specialised areas of mine design and planning and beneficiation for polymetallic ores. These specified areas in which the foreign expertise or export of technology may be warranted are spelt out below :

1 Prospecting of Mineral Resources

A Survey and Exploration

The Geological Survey of India (GSI) has the necessary expertise for undertaking geophysical, geochemical and ground surveys. GSI may, however, require assistance from international agencies for airborne regional reconnaissance by way of special equipments for extensive areas such as in Rajasthan and concealed deposits as in Madhya Pradesh.

Systematic investigation over a period of years has brought to light existence of important potential mineralised belts in Rajasthan. A large potential area extending from a little south of Delhi to Ambamata in Gujarat is one of the most important belt in India. The rocks exposed extend well over 700 km in length with a cummulative width of more than 150 km. Within this area of over 100,000 km^2 bulk of the exploration work has been centered in 20 sub-areas in about 90 occurrences of lead, zinc and copper. The aggregate area of 20 sub-areas constitutes very small fraction of the total potential. The pattern of exploration hitherto has been one of concentrating around small areas rather than expanding the potentialities over large mineralised districts. Such investigation of large tracts may involve sophisticated instruments for pinpointing the economic mineralisation in the belt.

Huge deposits of various non-ferrous metals are also reported to occur under the desert cover of Barmer district in Rajasthan stretching over an area of over 28,300 sq. km.

World's copper resources increased from 154 million tonnes in 1960 to 451 million tonnes in 1976 mainly due to contribution of copper metal from Porphyry copper deposits averaging between 0.3% to 1.0% copper in grade. Similar increase took place in India due to the discovery of Malanjkhand copper deposit during the same period. Presently, Porphyry copper deposits comprise nearly 50% of the world's copper resources. But similar deposits of Malanjkhand contributes only 26% of the country's copper resources. It is quite possible that exploration in the vicinity of Malanjkhand may provide more economical deposits. Technical assistance from foreign agencies may prove catalytic in locating the further concealed resources near Malanjkhand in Madhya Pradesh.

B Detailed Exploration

Mineral Exploration Corporation (MEC) is fully equipped to undertake detailed exploration by way of drilling and exploratory mining to prove the ore reserves in mineral deposits facilitating investment decision for exploitation.

2 Exploitation

a Necessary expertise is available with HCL, for preparation of feasibility reports and detailed project report for small and medium scale copper projects. Other agencies such as Indian Bureau of Mines (IBM) also have the requisite experties for preparation of feasibility reports for small and medium scale copper projects. For large projects, foreign assistance is still considered necessary.

b In the area of mine planning and design for non-ferrous metals, appreciable progress has been made in development of indigenous expertise, with the assistance of back-up consultancy from reputed firms of foreign consultants such as Selltrust Engineering, U.K. and Golder Moffitt and Associates, U.K. The Planning wings of HCL are in a position to do detailed mine planning and designing under the overall guidance of foreign consultants. However, association of foreign consultants may still be required for some more time before HCL is in a position to reach the level of self-sufficiency in this area.

c In the area of mine construction, expertise is available with the indigenous agencies such as Cementation Company Limited, Mineral Exploration Corporation (MEC) and Bharat Gold Mines Limited (BGML). However, none of these companies have expertise in high speed shaft sinking and tunneling. Efforts are being made to train BGML personnel in the above area in the foreign countries and also for obtaining foreign technical collaboration for BGML and MEC in execution of high speed shaft sinking and tunneling.

3 Beneficiation

i Laboratory Facilities for Development of Beneficiation Technique for Ores

National Laboratories like National Metallurgical Laboratory (NML), Jamshedpur, IBM, Nagpur, Bhaba Atomic Research Centre (BARC), Hyderabad and Regional Research Laboratory (RRL), Bhubaneshwar have the requisite facilities and capabilities to carry out investigation to develop processes (except for complex multimetal deposits) for production of mineral concentrates. As regards complex multi-metal deposits, where production of clean concentrates has not been possible so far by physical beneficiation alone, the country shall have to obtain from abroad viable process know-how. In fact, Government of India is currently pursuing this matter with the Soviet Union and Poland.

ii Design & Engineering Capability for Beneficiation Plants

In the past decade, the country has developed sufficient expertise to implement beneficiation projects either on a consultancy or on turn-key basis. A number of agencies are capable of executing such projects. However, as in the case of multi-metal ores and other similar critical cases where specific expertise will be necessary, it is desirable to have an open door policy to seek and obtain the necessary expertise from agencies outside the country.

4 Extraction of Metals

a Copper

In the area of smelting of copper, flash smelters have been established both at Khetri and Ghatsila by HCL with the technical assistance/collaboration with foreign parties. Certain technological and operational problems were found at Khetri smelter and these have been, by and large, overcome, with the technical assistance from a foreign consultancy firm. For improving the quality of wire bars also, HCL had obtained technical assistance but winding wire quality is yet to be satisfactorily attained by the company. Efforts in this direction are being continued by HCL with in-houseexpertise.

For expansion of smelters and refineries, necessary expertise is not available in the country. HCL is obtaining the necessary technical assistance/collaboration for Khetri smelter expansion from M/s. Outokumpur Oy, Finland and for ICC/KCC refinery expansion from M/s. Mitsubishi Metal Corporation Limited, Japan.

b Precious and Minor Metals

In the Singhbhum belt, the copper deposits also contain other associated metals like nickel, molybdenum, cobalt, selenium, tellurium, gold, silver and also rhenium in traces of very small percentage. With foreign technical assistance, a plant for recovery of selenium and nickel from anode slimes at ICC, Ghatsila has already been established and has been in operation for the last few years. HCL engineers have themselves designed and set up a precious metal recovery plant for extraction of silver and gold from the anode slimes which has already been operational for more than six years. Recovery of tellurium from the electrolytic refinery slime has been successfully established on pilot plant scale through R&D efforts at Ghatsila. For the extraction of cobalt from converter slag at Ghatsila, technical assistance from Outokumpu Oy, Finland is being obtained. For expansion/setting up of selenium and nickel sulphate plants and precious metal plants also, technical assistance of Outokumpu Oy is being obtained. The plant is under expansion to handle increased availability of slimes from Ghatsila and Khetri refineries.

5 Project Implementation

The level of expertise available in respect of basic engineering, detailed engineering and project engineering, in the country with consultants is adequate to handle all the activities related to project based on indigenous know-how. These consultants are now in a position to under take the preparation of basic engineering package with minimum foreign assistance. Thus, it is now possible to maximise the Indian participation in these important areas. However, in areas like recovery of trace metals where previous experience is not available indigenously it may be necessary to solicit foreign assistance.

6 Research and Development

a Recovery of Copper by Dump Leaching of Low Grade Oxidised and Lean Sulphate Ore.

Large quantity of copper is and will be available from oxide ore with 0.5% to 0.6% copper and lean sulphide with 0.2% to 0.3% copper during the open pit mining of Malanjkhand copper deposit. Preliminary test on leaching of these ores indicated the possibility of recovery of a significant amount of primary copper which may otherwise be lost as waste. Further, tests on developing a suitable process, however, have to be carried out. For this purpose foreign consultants are being appointed to undertake necessary tests and design the entire industrial operation, if the tests are successful.

b Foreign consultancy may be warranted in respect of studies relating to the treatment of slag and reverts (including heat-recovery, optional cooling rate and floatation) reverts, purification of electrolyte and recovery of valuable metals from process waste.

7 Copper Alloy and Semis Industry

There are a number of foundries in the medium and small scale sector which claim to supply castings of special alloys of copper. There are still areas for development with regard to materials using aluminium bronze, nickel - alumirium - bronze and alloys for the heat exchanger and ship building industry. It may be difficult to take advantage of the present proven technology available elsewhere because of factors, such as, non-availability of resources, meagre infrastructural facilities, high cost and high production rates (vis-a-vis demand) of adopted technologies. Of course, overall proven technologies have been successfully adopted in the country, for example, continuous casting of alloy strips and section, adoption of high speed rolling mills with automatic gauge control facility for producing thin gauge sheets and strips of continuous length with precious control, production of c.c. rods etc.

Further technical input may be needed in some areas. For example continuous cast strips could be utilised for the manufacture of tubes by suitable forming and welding operations. Continuous cast rods can be used in some applications where extruded rods can be dispensed with, thus affording reduction in cost and better yield. Continuous cast rods of electrolytic copper can be used for the manufacture of long length magnet wire without breaks, for railway overhead traction cable etc. The radiator industry can also benefit through manufacture of welded tubes for radiator applications. Thin gauge strips produced can be used for radiator applications, cable wrappings, co-axial cable sheaths etc.

The other new areas which may need foreign expertise are the manufacture of fine and ultrafine wires, thin foil by rolling and products made out of some of the alloys such as beryllium copper etc.

The country is self-sufficient in production of forged components which require smaller presses but when it comes to manufacture of larger components for electrical industries, the problem is one of lack of quality. In the extrusion area, economic manufacture of commutator segments of the right quality is still posing a serious problem. The printed circuit board industry has very promising potential and coupled with the employment of powder metallurgy technique the scope could be considerable for components for computer and other electronic industry products.

The other areas relate to manufacture of high conductivity copper items such as chromium copper, zirconim copper, cadmium copper, silver bearing copper for welding tips, continuous cast moulds, switch and segment components etc.

The cost of introduction of modern technology and high production rate vis-a-vis demand may discourage introduction of modern facilities. It may be also worth noting that without modern facilities and capabilities it would be difficult to meet the growing demand of special products and the area calls for special attention.

ALUMINIUM INDUSTRY

INTRODUCTION

In India, primary aluminium is currently produced by four companies, accounting for a total of 362,000 tpy installed capacity. Of these, the Bharat Aluminium Company in the Public Sector (BALCO) has a capacity of 100,000 tpy. The three private sector companies are - (1) Indian Aluminium Company (INDAL) with 117,000 tpy capacity; (2) Hindustan Aluminium Corpn. (HINDALCO) with 120,000 tpy; and (3) Madras Aluminium Company (MALCO) with 25,000 tpy. These entities in the private sector have substantial foreign equity participation. Aluminium Company of Canada (ALCAN) holds 50.6% of INDAL; Kaiser Aluminium and Chemical Corporation of USA holds 26.7% of HINDALCO and Aluminium Italia has 20% of the equity in MALCO.

Despite the large share of private ownership, control of the pricing, production and distribution policy is in the hands of the government. Imported aluminium is made available to consumers at the same price as the domestic metal by suitable fiscal adjustments. This is to protect the interest of local producers while ensuring a fair price to the consumer. Present regulations require 50% of all domestic metal to be electric conductor grade aluminium. The MMTC imports and controls the distribution of imported metal in order to maintain an assured level of supply to industry.

The retention pricing system is the government's method of keeping a tight control on the aluminium industry. Retention prices are fixed for each aluminium producer on the basis of its cost of production and a specified return on capital. A sale price is also fixed by the government. If the retention price for a particular unit is lower than the sale price, the excess amount collected has to be credited to an aluminium regulation account. Similarly, if the retention price is more than the sale price i.e. its cost of production is higher than the controlled price, the difference is reimbursed from the aluminium regulation account. The better managed companies claim that the system penalises efficiency and rewards inefficiency.

Despite the problems with the electric power supply and pricing, the industry has a number of projects under construction or design. These are intended to make India an exporter of both alumina and aluminium. In this context, India was admitted as the 12th member of the International Bauxite Association late in the year 1983. The integrated alumina/aluminium complex being commissioned in Orissa by the National Aluminium Company Limited (NALCO), will result in a major boost to output.

HINDALCO is presently engaged in enhancing its capacity to 150,000 tpy. To feed the increased capacity, the company is presently engaged to increase its alumina capacity to 300,000 tonnes per year under technical collaboration with Hungary. HINDALCO's captive power plant - Renusagar Power Company - is being expanded to 350 MW capacity. HINDALCO is the only company in India with captive electric power, which contributed to its relatively high capacity utilisation. NALCO will also have its captive power in 1987 while BALCO is going ahead with a similar venture.

Ever since NALCO was set up in the public sector and work started on the integrated project in Orissa, the performance, management and growth of the aluminium industry has been subjected to intensive review. Questions of periodic over supplies consequent to the commissioning of NALCO have given rise to the need for a long term perspective on the exploitation and use of Aluminium. However, the potential for its long term growth and utilisation is certainly beyond debate, given the interests of overall economic development.

ANALYSIS OF THE TECHNICAL AND SOCIO-ECONOMIC CHARACTERISTICS OF THE BAUXITE MINES AND ALUMINIUM INDUSTRY

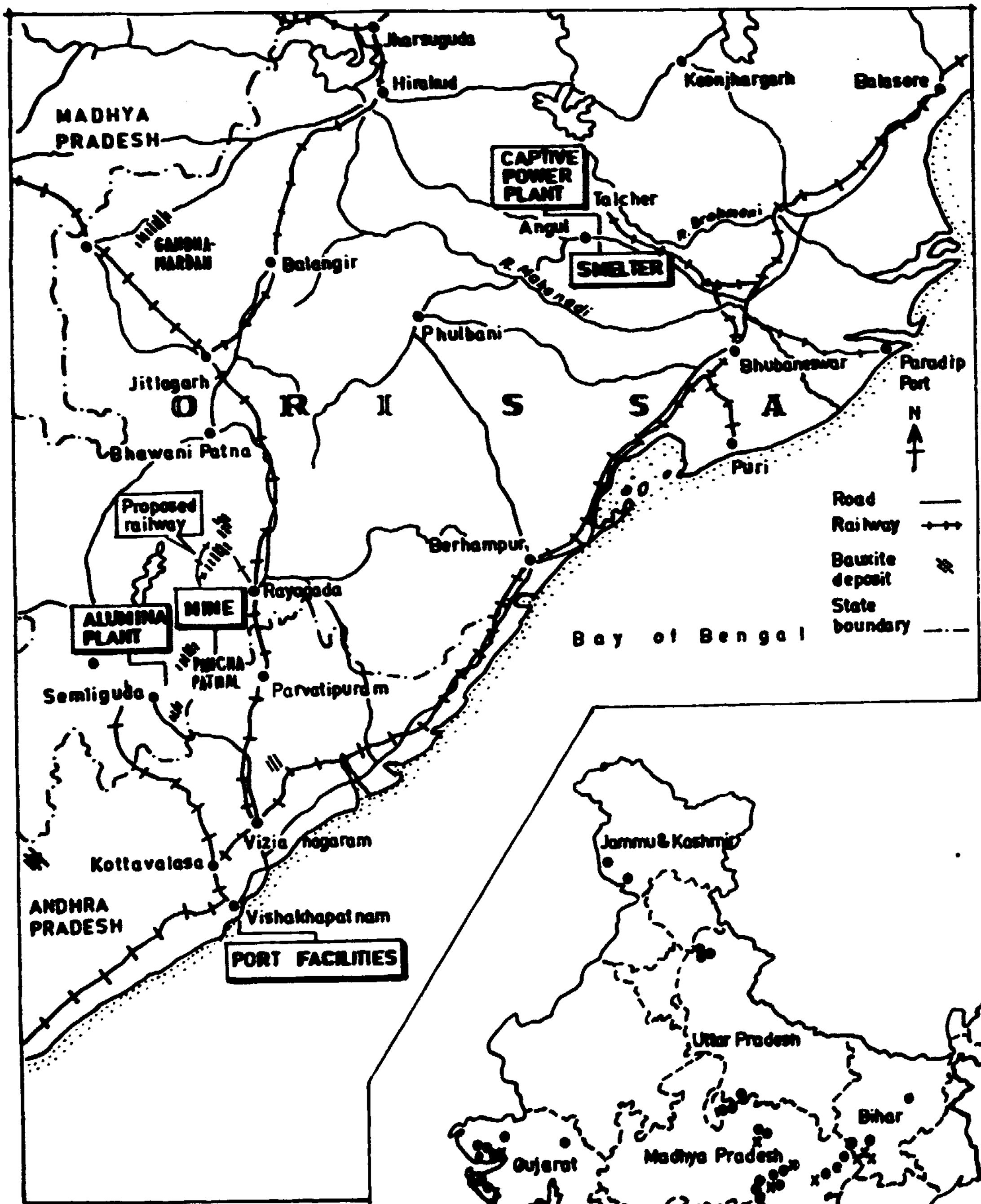
Exploited Mines of Bauxite

In India, there are 95 working mines at present. Nearly $\frac{1}{3}$ of the mines are small mines with annual production of 1,000 tonnes or less while at the other end of the scale, 9 large mines account for 65.48% of production.

Table 18 Percentage Contribution of Bauxite Production - Freque-ncy Groups

Production Group	No. of Mines	Percentage Contribution in Production (%)
Upto 1,000	33	0.56
1,001 - 3,000	18	1.88
3,001 - 5,000	6	1.18
5,001 - 10,000	8	2.71
10,001 - 25,000	12	10.84
25,001 - 50,000	9	17.35
50,001 and above	9	65.48
	95	100.00

Of the 30 mines falling within the last three groups, a significant number are captive mines of aluminium industry.



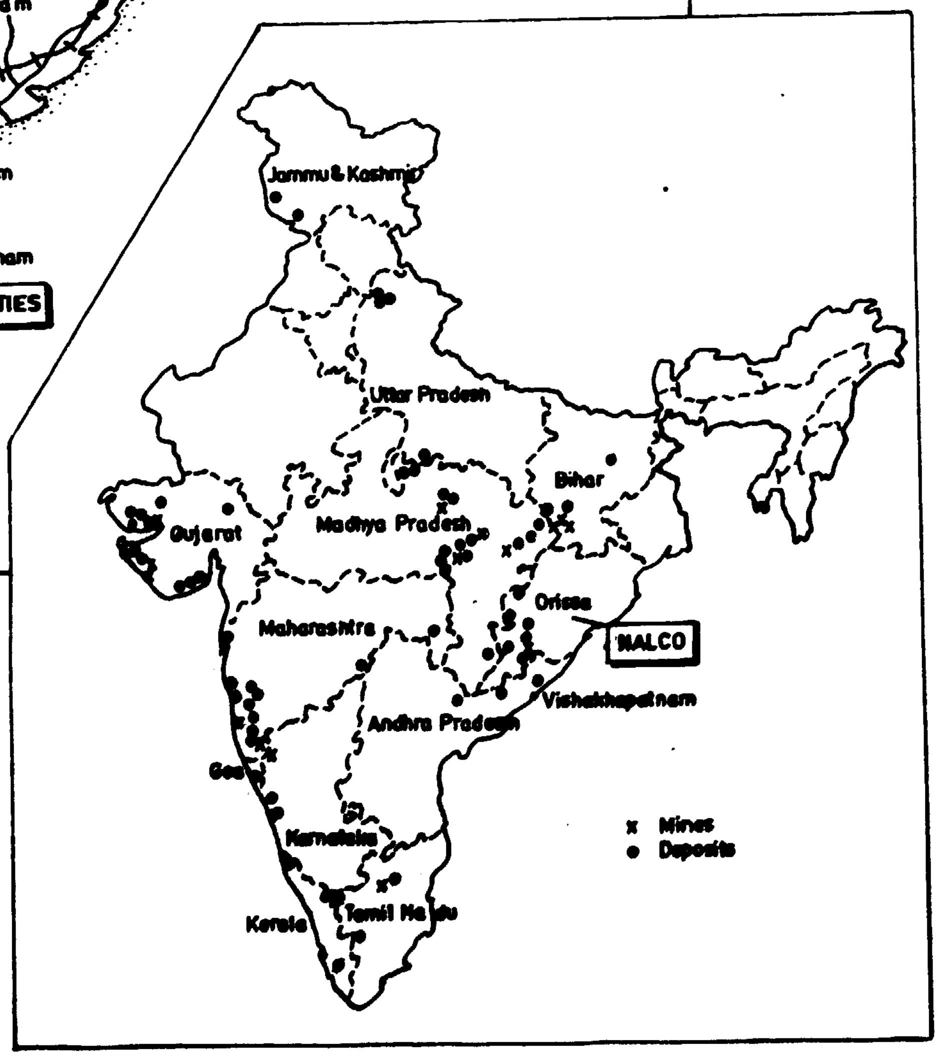


Figure 2. LOCATION OF NALCO AND BAUXITE DEPOSITS OF INDIA

Captive mines contributed about 1.84 million tonnes out of a total of 2.35 million tonnes of bauxite in 1985. The reserves in captive mines and availability of infrastructure are furnished in Appendix Al-I.

The gradewise production of bauxite in India is as follows :

Al_2O_3 (%)	Percentage Contribution
Above 60	0.69
55 - 60	12.06
50 - 55	25.94
45 - 50	59.57
40 - 45	0.23
35 - 40	0.03
Below 35	1.48
	100.00

Nearly 85% of bauxite produced In India falls within the Al_2O_3 of 45 to 55%; production of special high grade with Al_2O_3 content above 60% is negligible.

Bauxite is consumed in aluminium, abrasive, alloy steel, cement, ceramic, chemical, iron and steel, oil and refractory industries. The percentage consumption of bauxite in these industries during 1985 was as indicated below:

Industry	Consumption of Bauxite in 1985 (%)
Abrasives	4.10
Aluminium	78.40
Alloy Steel	0.39
Cement	6.16
Ceramics	0.21
Chemicals	1.54
Iron & Steel	1.10
Oil	-
Refractory	8.10
	100.00

As in obvious, aluminium industry accounts for 78 percent of total consumption in India. This is just below the world average of 90% of bauxite consumption in aluminium industry.

Aluminium plants draw supplies mostly from their captive mines. The supply of chemical grade bauxite is mainly from Saurashtra area in Gujarat State while abrasive grade is largely obtained from deposits in Gujarat, Maharashtra and Tamil Nadu. Lohardaga in Bihar, Katni in Madhya Pradesh and Saurashtra in Gujarat are the principal areas supplying refractory grade.

Aluminium industry generally uses bauxite with Al_2O_3 content from 45 to 55%. However, slightly lower grades with a suitable blend are also used depending upon other characteristics such as freedom from reactive silica.

In steel industry, bauxite is used as slag corrective in place of fluorspar; bauxite should have 45 to 54% Al_2O_3 and SiO_2. Bauxite consumed in the refractory industry generally contains 58 to 60% Al_2O_3, 2 to 3.5% Fe_2O_3 and 3.5% TiO_2 (maximum). In the chemical industry, bauxite having 55 to (plus) 60% Al_2O_3 and Fe_2O_3 less than 2% is consumed.

Labour Force in Bauxite Mines

The average daily labour employed in operating bauxite mines in 1985 was of the order of 5,000. This excludes the labour employed in two mining projects viz. Gandhmardan and Panchpatmali mines in Orissa. The skilled labour constitutes only 15% of the total employment.

Intermediary Consumption in Exploited Mines and its Evolution During Recent Years

The existing aluminium production capacity in the country is 362,000 tpy. The requirement of bauxite for this capacity is around 2.2 million tonnes. A 2.4 million tpy capacity mine is under construction at Panchpatmali to feed NALCO alumina plant of 800,000 tpy capacity.

The nature of deposit determines the selection of mining method and consequently the consumption in inputs. Since the Indian bauxite deposits are near the surface and of a blanket type, the choice is for the opencast method. In the initial years, when the demand was low, manual mining in smaller deposits was adequate. The subsequent expansion of the aluminium industry necessitated development of large mines capable of concentrated production. In view of various geological habitats, the manual semi-mechanised and mechanised bauxite mining operation co-exist.

Transportation

Transportation from the mine to the market or railhead is carried out wholly by truck in case of small tonnages. In all the important and large production mines, material from mine faces is removed by rear-dump trucks to the crushing plant where the material is then crushed and loaded into ropeway buckets. Bi-cable ropeways have also been in use. In the Gandhmardan mine of BALCO, it is proposed to use the train-car system of ropeway upto the mechanised wagon loading plant at railhead. At NALCO, the latest single flight multicurved cable belt conveyor system has been planned for removing bauxite over a 14.5 km. distance from the mine to the alumina plant. The existing ropeways carry annual tonnages ranging from 200,000 to 300,000 tonnes. The Gandhmardan ropeway will carry 600,000 tpy and the cable belt conveyor of NALCO will carry 2.4 million tpy.

The investment on the mode of transport within mine lease area and to the loading point or railhead forms part of overall project cost. This also include the private railway siding for stacking and loading facilities for bauxite.

Consumption of Inputs in Bauxite Mining

Because of the varied geological habitat and the degree of the mechanisation adopted consumption of inputs per tonne of bauxite mined varies appreciably. Consumption of inputs in open-cast mining of bauxite practised in India, is directly related with the stripping ratio, distance of laterite dumping place from the working benches and location of crushing and loading unit. Mechanised/semi mechanised mining of bauxite is carried out in Bihar, Madhya Pradesh and Maharashtra states while in other states the ore is won through manual operations. Consumption of inputs keeping in view the causes of its variations, is reflected in Appendics A1-II to IV.

From the data it is discernible that the manpower component in the value of production of bauxite from the mechanised mines operated by private sector, is about 16% while in the case of mines operated by the public sector, this component rises steeply though the cost of the other inputs (not specified) is bracketed with it. This component alone makes the value of production of bauxite in public sector mine more than twice the value of production of bauxite from the mechanised mine operated by the private sector.

The rate of royalty presently levied in India is Rs. 8.00 per tonne of bauxite irrespective of grade. In the case of Jamaican bauxite, the levies are based on the basis of quality of bauxite as per the details furnished in Table 19.

Table 19 Disaggregated Production Cost for Bauxite Mining in Jamaica (1980)

Item	(In US $ per tonne) Mine A	Mine B
Capacity in tonnes/year	4,100,000	3,500,000
Mining	2.862	3.261
Drying & Storage	2.315	5.183
Depreciation	0.734	0.391
Administrative Expenses	0.825	0.012
	6.736	8.847
Bauxite Levy	13.658	19.642
Royalty	0.276	0.275
	20.670	20.764

Source: Jamaica Bauxite Institute.

Government levies in Jamaica account for 67 to 69% of the total cost of despatch per tonne of bauxite while in case of India these account for 10 to 25%. Other things remaining similar, the large scale mining operations result in lowering the cost of production since the larger-size mining equipments bring in economies of scale.

Evolution of Production of Bauxite and Value of Production During the Last 10 years

During the last ten years, the production of bauxite has remained practically stagnant becaue: (i) there has been no addition to the smelting capacity during this period; (ii) indigenous production was subject to vagaries of power shortages and interruptions and (iii) export of bauxite could not be sustained till 1979-80 due to the development of other sources of supply particularly Australia, which out-priced Indian bauxite because of proximity of its bauxite resources near the ports and the economics accruing due to amenability of its deposits for bulk mining operations.

Table 20 Production of Bauxite in India (1975-1984)

Year	Production in tonnes	Value of Production in '000 Rupees	Value of Production in Rupees/tonne
1975	1,274,432	3,40,60	26.72
1976	1,448,961	4,28,53	29.58
1977	1,518,685	4,59,49	30.26
1978	1,883,251	6,02,53	32.00
1979	1,951,933	7,68,13	39.35
1980	1,784,899	8,72,20	48.86
1981	1,554,650	10,40,25	66.91
1982	1,997,508	12,54,40	62.80
1983	1,576,055	12,21,47	77.50
1984	2,072,197	14,83,40	71.59

Source: GOI, Indian Bureau of Mines (IBM), Mineral Statistics of India, April 1985.

Note: The Value refers to the pits' mouth value furnished by the mine owners to IBM in the Statutory Annual Returns.

The value per tonne of bauxite produced increased approximately three folds during the ten years period. This is attributed to the increase in prices of inputs and revisions of wage structure.

Table 21 Export of Bauxite and Alumina From India

Year	Quantity in tonnes	Value in 'Rs' '000	Value in Rs/ Tonnes	Quantity in tonnes	Value in'Rs' '000	Value in Rs./ Tonne
1976-77	34,531	5,050	146.24	-	-	-
1977-78	42,624	9,586	224.90	4,935	7,225	1,464.0
1978-79	18,536	2,992	161.42	202,554	106,437	525.5
1979-80	45,526	4,844	106.40	100,941	126,027	1,248.5
1980-81	84,624	8,801	104.00	77,380	137,584	1,778.0
1981-82	132,818	16,324	122.90	6,659	17,258	2,591.7
1982-83	387,683	53,163	137.13	37,265	68,450	1,836,8

The per tonne value of export of bauxite hardly covered the average charges per tonne as detailed below :

	Rs./Tonne
Depreciation & Capital Servicing	29.0
Operating Cost	30.0
Rail Head Cost	2.0
Rail Transport from Railhead to Port	34.0
Port Charges	35.0
Total Cost Price FOB Indian Port	130.0

This does not include profit.

India could sell 0.2 million tonnes of alumina in international markets when it brought the prices down to Rs. 525.00 per tonne in 1978-79. The price did not cover even the cash cost, (Appendix Al-V). Except in the year 1981-82, the FOB price of export of alumina has not covered the cost of production plus transport charges from alumina plant to the port.

Alumina Manufacture

The consumption of inputs per tonne of alumina production varies, depending on factors such as :

i quality of bauxite;

ii capacity of the plant;

iii consistency of availability of power;

iv labour efficiency; and

v type of the product whether 'sandy' or 'flour' alumina desired.

Both the economies of scale and the transport cost of bauxite have effect on the overall cost of alumina manufacture. These are well exhibited in the Appendix Al-V to VII. Wages and salaries constitute 54.8% of the total value of production, while fuel and energy account for 31% to 39%.

While comparing the alumina production in Jamaica vis-a-vis Indian operation both manpower and fuel and energy together account for 57 to 75% of the total value of production (Appendix Al-VIII). The efficiency in the use of fuel and raw material weigh more heavily than benefits arising from the economies of scale. To a lesser extent, differences in costs of caustic soda, labour and transportation also account for the variations.

The Evaluation of Existing Processing Operation

The origin of the aluminium industry in India dates back to 1938. Aluminium Production Company of India Limited - which later turned out to be the precursor of the present day INDAL - started with the production of sheets from imported ingots. According to the latest available information INDAL has a smelting capacity of 117,000 tpy spread over three smelters located at Hirakud (Orissa), Alupuram (Kerala) and Belgaum (Karnataka). In addition, the company has downstream facilities in rolled products, extrusions, wire rods and foils, located in Belur (West Bengal), Taloja (Maharashtra), Alupuram Alwaye (Kerala).

The growth performance of HINDALCO has been a landmark in the development of aluminium industry in India. In the year 1959 the company started with a modest smelting capacity of 20,000 tpy at Renukoot (UP). Today HINDALCO has the distinction of being the single largest integrated plant in the country with a smelting capacity of 120,000 tpy and a captive power plant of 270 MW capacity. The company, in addition, has a semi-fabrication capacity of 37,800 tpy in rolled products, extrusions and wire rods. Plans are under way to increase the smelting capacity to 1,50,000 tpy.

The public sector joined the industry in 1965 with the setting up of BALCO. Initially it was proposed to set up the integrated plants - one at Ratnagiri (Maharashtra) and the other at Korba (Madhya Pradesh). The proposed Ratnagiri plant could not go beyond the foetal stage because of the huge reserves discovered in the Eastern Coast and comparative advantage in setting up a plant somewhere in the Eastern Region. This, in fact, is the genesis of the NALCO project. The Korba plant has a smelting capacity of 100,000 tpy and a semi-fabrication capacity of 32,000 tpy. The semi fabrication product mix of the company includes rolled products, extrusions and wire rods. In the early years the performance characteristics of the company were badly hit because of the inadequate availability of power from the public utility system. Plans are under way for setting up of captive power plant of 270 MW.

In the year 1965 MALCO set up a 10,000 tpy plant at Mettur (Tamil Nadu). The company increased the installed capacity to 25,000 tpy but has shown to signs of growth since then. The company is the smallest producer of the metal in the country. The semi-fabrication capacity of the company is 17,500 tpy in the area of rolled products, extrusions and wire rods.

The significance of the public sector in the industry will receive a boost with the commissioning of the NALCO project. The project includes a bauxite mining capacity of 2.4 million tpy, an alumina capacity of 800,000 tpy and a smelting capacity of 218,000 tpy. The project will have a captive power plant of 600 MW capacity. In addition, it would have port facility for the import of 146,000 tpy of caustic soda and export of 325,000 tpy of alumina in the existing berth of Vishakapatnam port. The company proposes setting up semi-fabrication capacity to the tune of 149,000 tpy and the product mix would include rolled products, extrusions, wire rods and foils. With the production at NALCO reaching its full capacity, the public sector's share in the total aluminium smelting at 318,000 tpy would be 55%

Evolution of Capacity and Production

The growth in the installed capacity and production of aluminium in India is given in Table 22.

Table 22 Grwoth in the Installed Capacity and Production of Aluminium inmIndia

Year	Capacity: Quantity ('000 tonnes)	Capacity: Rate of Growth (%)	Production: Quantity ('000 tonnes)	Production: Rate of Growth (%)	Capacity Utilisation (%)
1950	5.0	-	4.0	-	80.00
1960	18.0	16.24	18.0	16.24	100.00
1970	185.0	26.22	169.0	25.00	91.24
1975	241.0	1.21	174.2	0.51	72.28
1976	256.0	6.22	209.8	19.98	81.95
1977	268.0	4.69	196.4	(-) 6.39	73.28
1978	299.0	11.59	204.9	4.33	68.53

1979	321.0	7.36	210.7	2.83	65.64
1980	321.0	-	171.6	(-) 18.51	53.86
1981	341.0	6.23	208.2	21.33	61.06
1982	341.0	-	208.3	-	61.09
1983	362.0	6.16	213.6	2.54	59.01
1984	362.0	-	220.0	2.99	60.77
1985	362.0	-	276.5	25.68	76.38

Till 1970 the industry reported a high capacity utilisation and was marked with rapid strides in development and growth. This was made possible through the adequate availability of power, efficient production management as well as favourable market conditions. The declining trend started in the seventies and became significant in the latter half of the decade. Except for HINDALCO - which established its captive power plant in the mid-seventies - all other plants were badly hit by inadequate power supplies, resulting in the falling capacity utilisation. Appendix A1-IX gives the companywise installed capacity, production and capacity utilisation between 1975 and 1984.

Under the Aluminium (Control) Order of 1970, all primary producers are required to keep aside 50 percent of their metal production as EC grade. The consumption of EC grade after having touched 61% of the total consumption in 1976-77 came down to 34.8% in 1984-85. This trend warrants a careful look at the Aluminium (Control) Order in the perspective of prevailing conditions, In fact, the existing allocation system will have little relevance in the emerging over-supply situation consequent to the commissioning of NALCO in 1987-88. The producers of metal could be left alone to deal with the demand for EC grade aluminium purely on the basis of the market developments.

Pricing Systems

Under the prevailing system, retention prices are fixed for such manufacturing enterprises with the objective of ensuring a stipulated rate of return on net worth, at varying levels of capacity utilisation. The sale price is also administered by the Government. The implications of this approach are that the administered prices have to be changed with the changes in the cost of production. The prices of both EC grade (EC) aluminium and Commercial Grade have been changed from time to time - sometimes 3 to 4 times a year. Appendix Al-X and Appendix Al-XI reflect the average prices prevailing during the period 1975-86.

The prices are influenced by the levy of excise duty (collected by the Central Government) and sales tax (collected by the State Government under whose jurisdiction the unit is located) on an ad-valorem basis. This results in a larger rise in consumer prices, every time the administered prices are increased.

Evolution of Consumption of the Main Inputs

Consumption of inputs in pre-baked furnace in India during 1977-1983, is furnished in Appendix Al-XII. Cost of inputs consumed constituted 96 to 97% of the total cost of production during the period.

The wages component in the total value of production of metal (in percentages at the smelting stage only) works out as follows :

	1977	1980	1983
Wages	1.5%	1.37%	1.39%
Salary	0.6%	0.49%	0.42%

The consumption of inputs per tonne of metal is a function of :

- vintage effect and the technology available at the time of installation;
- plant sizes, as the unit consumption of inputs declines somewhat with increasing plant size;
- relative energy resource endowment and technology choice. This is specifically applicable to consumption of power.

The Indian industry was initially set up when the price of power was below Rs. 0.10 per unit and formed a relatively lower component of overall cost. The energy saving aspect was, therefore, of lesser importance. But since the energy crunch from 1972-73, the industry has been constantly engaged in conservation of energy and other inputs. The backward linkage in the Indian context are quite comparable to the smelters of same vintage and capacity in other parts of the world. The data are presented in Appendix Al-XIII.

There has also been improvement in Indian smelter parameters. Electric current efficiency of the order of 87.1% and electric current density of 0.73 Amp/cm^2 have already been achieved. With the adoption of monolithic carbon lining by the industry the life of the cell lining has improved to 2,200 days. Through in-house R&D efforts the industry is constantly engaged in further improving the technical parameters to save inputs.

Evolution of Price of Main Inputs

Evolution of prices of main inputs and electrical power is shown in Appendix Al-XIV and Appendix Al-XV.

A salient feature of the aluminium industry has been the escalating cost of inputs. The annual rate of growth of the prices of inputs has ranged from 10 to 15%. These cost push-ups had impacts on the cost of productions of the virgin metal. Between 1979 and 1983, the total cost of production exclusive of depreciation and interest charges, went up by 148 percent in case of INDAL, 84% in the case of HINDALCO, 111% in the case of MALCO and 75% for BALCO. And, of the total cost increase around 40 per cent was accounted for by rise in power costs for all the companies. A further 20 to 25 per cent increase was due to the rise in the prices of calcined petroleum coke (CPC) and pitch.

There have been some cost increase on account of other inputs like aluminium flouride, cryolite and caustic soda. However, these do not have the same significance as that of power, CPC and pitch. It is also noteworthy that the latter three inputs are supplied by the public sector enterprises and their price structure has not been rationalised as yet.

Table 23 Comparison Between International and Indian Prices of Inputs During 1984

(Rs./Tonne)

Input	International	India	Ratio = India / International
C.P. Coke	4,400	6,450	1.47
Caustic Soda	1,706	5,483	3.21
Pitch	2,700	5,000	1.83
Power			
Canada	0.04	0.45	
West Europe	0.20	0.45	
U.S.A.	0.22	0.45	
Brazil	0.22	0.45	

It may be instructive to examine the effect of the prices of power, C.P.C. and pitch on the prices of aluminium manufactured in India as compared to situation obtaining in the international market. This is done inthe following Table 24.

Table 24 Significance of Power, CPC and Pitch in Aluminium Price 1984.

(Rs./Tonne)

Input	Indian Price	International Price	Consumption per tonne of Aluminium	Excess of Indian Cost
Power	0.45	0.20	16,500 KWH	4,125
C.P. Coke	6,450	4,400	0.40 tonne	820
Pitch	5,001	2.70	0.20 tonne	460
				5,405

The above illustrative calculations show that the prevailing Indian prices of power, C.P.C. and pitch alone raise the price of aluminium manufacture in India by as much as Rs. 5,405 per tonne as compared to the international market. With this order of price differential the scope for exports of Indian aluminium is virtually non-existent.

Evolution of Profitability

The implications of the prevailing system of retention prices are obvious. First, the administered price can not remain constant over long periods unless, the cost of production also remain unchanged. Second, the changing levels of capacity utilisation - this could be due to factors beyond the control of the manufactur-ing enterprises - will lead to fluctuating rates of return. And most importantly, any failure on the part of the pricing authority to promptly respond to changes in cost of production, would result in uneven financial performance, often to the detriment of the manufacturing enterprise. It should also be noted that since administered prices can not be revised frequently and input prices generally keep on rising as discussed earlier, the net effect could be a rising cost of production, continuously eroding the margin envisaged initially in the administered price.

The administered price for aluminium metal defined as the retention price, specifically provides for a post-tax return on net worth of each enterprise, ranging from 7 percent at 55% utilisation of installed capacity to 12 percent at 90% capacity utilisation. Thus, the maximum feasible return for any enterprise can not exceed 12 per cent of its net worth. In the context of these considerations, objectives and limitations implied in the retention price, the profitability during theperiod 1977-1983 for four aluminium manufacturers is indicated in the following Table 25. The computations are based on balance sheet data and a uniform assumption of corporate tax liability at 57.7 percent.

Table 25 Profitability Performance of Aluminium Companies

(Percentage)

Year	INDAL		HINDALCO		MALCO		BALCO	
	C.U.	P.A.T. as % of N.W.	C.U.	P.A.T. as % of N.W.	C.U.	P.A.T. as % of N.W.	C.U.	P.A.T. as % of N.W.
1977	68	9.51	77	13.10	68	-	32	-
1978	86	10.82	69	9.54	92	4.90	34	-
1979	84	10.90	78	8.45	90	10.73	30	-
1980	60	5.83	75	1.56	90	2.28	30	-
1981	91	4.45	64	6.21	59	-	36	-
1982	73	5.28	76	5.75	57	-	44	-
1983	44	-	78	7.69	20	-	-	-

Source: NCAER - Aluminium Industry - Problems & Prospects, 1985.

Note: C.U. - Capacity utilisation rate.
PAT - Profit after tax.
N.W. - Net Worth

The above analysis brings but a number of conclusions. None of the companies can achieve the maximum return of 12% of net worth after payment of taxes, even when operating at 90 per cent of capacity. For all the companies, profitability falls well below the assumption implied in the formulae for fixing the retention prices with the exception of the three years ending 1979, profitability is seen as lower than 7% after tax return at 55 percent capacity utilisation provided for in the retention price formulae. And all the companies with the exception of BALCO, had operated at well over 55 per cent utilisation of capacity. The evidence supports the view that objectives of the retention price formulae have not been realised in practice.

It is clear that the companies have been gradually approaching a near non-viable state over the years. It is particularly noteworthy that MALCO had become non-profitable even when operating at over 55% of capacity. In the case of BALCO, not only was profitability not attained till 1983, but even the net worth and become negative with recurring levels of very low capacity utilisation.

The poor financial performance of aluminium companies has to be seen in the context of their technical performance. The available evidence - particularly in terms of material consumption - suggest a satisfactory record on this score.

The analysis clearly establishes that poor profitability of the aluminium companies primarily arises from :

- an inadequate retention price mainly on account of its failure to take account of the increasing input costs and the delays in compensating for such increase through an expeditious revision of the retention price; and
- falling capacity utilisation.

While the costs of inputs have escalated rapidly after 1979, retention price increase granted by the Government have not always kept pace with increase in costs.

Retention price of manufacturers (except INDAL) were revised on 4th October 1979 and were fixed on the basis of raw material prices prevailing in early 1979. Retention prices remained fixed all through 1980 while prices of raw materials witnessed large increase between 1979 and 1980. Power, C.P. Coke and pitch alone contributed 60% of increase in cost of production. Consequently, in 1980 all manufacturers were incurring a loss on the sale of metal: Private manufacturers losing around Rs. 2,000 per tonne of metal while BALCO, with its larger interest and depreciation, overheads, lost more that Rs. 10,000 per tonne of metal.

The situation appears to have improved only in terms of lower losses even with the 1983 retention price revised on 3rd December 1981.

The prices were revised upward by 6% in December, 1985 with a corresponding 6% decrease in excise duty so as to keep the consumer price of aluminium ingot unchanged. The prices of R.P.C. were slashed down by Rs. 940 per tonne in 1986. The industry did not get any relief in prices of other inputs. Instead, State Governments have increased power tariff by as much as Rs. 0.08 per Kwh.

Main Suppliers of Inputs and Their Evolution Over the Last Years

Bauxite

The reserves of bauxite in India represent over 11% of the world reserves. In view of the vast bauxite reserves, there should be no difficulty in meeting the requirement for aluminium production in the country for several decades.

Power

Power is the critical input for production of alumina into aluminium and constitute 35 to 40% of the cost of aluminium production. On an average every thousand tpy of aluminium ingot production requires about 2 MW of power. At present, only HINDALCO has a captive thermal generating capacity of 270 MW and this is planned to be augmented to 350 MW. INDAL is also working on various schemes to install captive power plants in Orissa and Karnataka on a consortium basis.

The installation of a captive power plant of 270 MW capacity of BALCO has been sanctioned by the government and it is expected to be in operation towards the end of the Seventh Plan Period.

NALCO with a sanctioned 600 MW captive thermal plant, will commission its power generating facilities to synchronise with the commissioning of its smelter. It appears that MALCO will continue to depend on Tamil Nadu State Electricity Board for power supply.

The power requirements for production of aluminium in 1980-90 are estimated at about 1,000 MW. The corresponding generating capacity that should be directly related to aluminium industry - assuming 75% effective power generation works out to be about 1,350 MW. Any shortfall with reference to this requirement will directly effect the domestic aluminium availability.

Caustic Soda

As worked out earlier, 100 kg of caustic soda is required for digestion of bauxite to produce one tonne of alumina. Hence, a norm of 0.2 tonne of caustic soda per tonne of aluminium may safely be adopted for working out the requirements of this input. For achieving aluminium production estimated during the VII Plan, caustic soda requirement will increase from about 54,000 tonnes in 1984-85 to about 94,200 tonnes in 1989-90.

Table 26 Requirement of Caustic Soda

('000 tonnes/year)

Particulars	1985-86	1986-87	1987-88	1988-89	1989-90
Aluminium Production	280	289	393	483	495
Requirement of Caustic Soda @ 200 Kg.	56	56	78	97	100

At present, there are 34 caustic soda plants in operation in the country and the current production of caustic soda is about 6,25,000 tonnes. The other industrial consumer of caustic soda include other industries like textiles, paper etc. Adequacy of domestic production of caustic soda to meet the growing demand of aluminium industry will depend on the future growth of these industries. Viability of caustic soda depends on economic use of by-product chlorine and assured supply of power. Both of these pre-requisites are doubtful to be accomplished either for further utilisation of installed capacity or for setting up of additional units. For meeting shortage, if any, caustic soda will have to be imported. NALCO will import its entire consumption of caustic soda; infrastructure has already been created for receipt and storage of caustic soda at Vishakapatnam port.

Calcined Petroleum Coke

On the basis of 0.450 tonnes of consumption of C.P.C. per tonne of aluminium as worked out earlier, the requirements of C.P.C. during the period 1985-86 to 1989-90 to meet the projected requirements of aluminium are indicated below:

Table 27 Estimated Requirements and Supply of Calcined Petroleum Coke

('000 tonnes)

Particulars	1985-86	1986-87	1987-88	1988-89	1989-90
Estimated Production of aluminium	280	289	393	483	499
CPC required @ 0.45 tonne	126	126	177	217	225
Raw petroleum coke (RPC) required @ 1.33 tonne per tonne of CPC	168	168	235	289	299

The present installed capacity for production of CPC is 276,000 tonnes distributed among the six suppliers as indicated in Table 28.

Table 28 Capacity for Calcined Petroleum Coke

(Tonnes)

Name of the Unit	Capacity
IOC/Berauni	45,000
Indian Carbon, Guwahati	65,000
Indian Carbon, Budge Budge	16,000
Petro Carbon, Haldia	50,000
Goa Carbon, Goa	50,000
Bongaigon Refinery, Bongaigon	50,000
TOTAL	276,000

The present production of CPC is about 125,000 tpy which matches the requirements. The new units at Haldia and Goa are based on imported RPC and have not as yet achieved full production. The future requirement of CPC for the aluminium industry can be indigenously met by installing new capacity, if required, whilst importing adequate quantity of RPC.

Coal Tar Pitch

As already established a tonne of aluminium requires approximately 150 kg of coal tar pitch. This works out to 47,000 tonnes for the production level of 380,000 tpy during 1985-86. This would increase to 75,000 tonnes by the final year of VII Plan (1985-86 to 1989-90).

Steel Authority of India (SAIL) is the largest producer of coal tar pitch in the country. Apart from SAIL, other producers like Bharat Coking Coal Limited, Durgapur Project Limited and Shalimar Tar Products also produce a small quantity and this does not have much impact on the overall market.

According to the present assessment, demand for pitch for aluminium and graphite industries ranges from 70,000 to 80,000 tpy.

In the immediate future SAIL has no expansion in hand and as such availability of pitch from SAIL may not change in the next few years. About 28,000 tonnes/year of pitch may be available from Vizag Steel Plant during the VII Plan.

It is evident that dependence on imports for pitch may continue for the aluminium industry during the VII Plan. Import of pitch is allowed under Open General Licence (OGL) which is applicable for items not produced/available in the country to the desired extent.

Cryolite

The average norm of consumption of cryolite is about 50 kg per tonne of aluminium. However, aluminium producers recover cryolite from pot skimmings for recycling. They also have or propose to have facilities for recovering cryolite from pot gases. Taking the proposed recovery of cryolite by the producers, it is felt that a norm of about 25 kg per tonne of aluminium may be adopted for working out the net requirements of cryolite for aluminium production during the next five years as furnished in Table 29 below :

Table 29 Requirement of Cryolite for Aluminium Production During the next five years (1985-86 to 1989-90)

	1985-86	1986-87	1987-88	1988-89	1989-90
Estimated Production of aluminium	280	289	393	483	499
Cryolite @ 0.025 tonnes per tonne of aluminium	7	7	10	12	13

The present capacity for production of cryolite in the country is 8,770 tpy. Imports are also effected for blending :

Table 30 Capacity and Production of Cryolite

(tonnes)

	Unit	Installed Capacity	Production 1979	1980	1981	1982
1	Navin Fluorine Ind., Bombay	4,000	4,207	1,281	1,340	1,889
2	FACT, Cochin	1,650	120	95	86	125
3	Dharamsi Morarji Chemicals Limited	1,500	554	500	227	167
4	Phosphate Co. Ltd., Calcutta	360				
5	Adarsh Chem. & Fertiliser, Calcutta	540				
6	Jayshree Chem. & Fertiliser, Calcutta	180				
7	Premier Fertiliser Ind., Madras	540				
	TOTAL	8,770	4,981	1,876	1,643	2,171

To meet the short fall in the future years, additional facilities for the production of cryolite will have to be continued utilising indigenous fluorspar/by product from phosphatic fertiliser industry. However, it is necessary to ensure that they meet the specification especially in respect of P_2O_5, Silica contents.

Aluminium Fluoride

35 kg of aluminium fluoride per tonne of aluminium is the average consumption in Indian smelters. On this basis the requirement of aluminium fluoride works out as shown in the table 31.

Table 31 Requirement of Aluminium Fluoride

Particulars	1985-86	1986-87	1987-88	1988-89	1989-90
Estimated Production of Aluminium	280	289	393	483	499
Aluminium Fluoride @ of 0.035 tonne per tonne of aluminium	10	10	14	17	18

The present installed capacity for production of aluminium fluoride is 11,550 tpy and actual production at present is of the order of 4,000/5,000 tonnes as detailed in Table 32.

Table 32 Capacity & Production of Aluminium Fluoride

(tonnes)

Producer's Name	Capacity	Production				
		1979	1980	1981	1982	1983
Navin Fluoride India	8,000	2,722	2,223	3,219	3,702	4,100
Everest Refrigerents	2,000	302	369	130	4[illegible]3	550
Dharamsi Morarji	1,550	69	123	142	203	350
TOTAL	11,550	3,103	2,715	3,491	4,303	5,000

The units have not yet attained full production. The domestic production of aluminium fluoride is supplemented by imports. Additional capacity that is likely to be implemented will increase the present capacity to 24,550 tpy by 1989-90. Details of new capacity are furnished in Table 33.

Table 33 Additional Capacities for Aluminium Fluoride

(Tonnes)

	Name of the Producer	Capacity
1	Tamilnadu Fluorine & Allied Chem. Limited	7,500
2	Hindustan Copper Limited	3,000
3	SPIC (Tamil Nadu)	2,500
	TOTAL	13,000

Considering that aluminium production from 1987-88 will require over 18,000 tonnes of aluminium fluoride, it is necessary that the new capacity envisaged should go into production from 1985-86. To the extent that these requirements are not met, imports will have to be continued.

Carbon Blocks

Carbon blocks are used in the cathode lining of aluminium pots. Although cathodes are not consumed during metal production, they have a limited life span of 4-5 years, due to thermal and electrical shocks. This material is used by all the producers except HINDALCO (who use monolithic lining).

The present requirement of carbon blocks is about 3,000 tonnes per annum which is being met entirely by imports. The requirements may go upto about 6,000 tonnes by 1986-87. From 1980 INDAL has been meeting a part of its requirement from its unit at Belgaum having a capacity of

2,800 tonnes per annum. Based on the experience of INDAL, it may be worthwhile to augment the capacity for meeting increased demand for carbon blocks in the future.

Semi-Fabricated Products

The present licensing policy stipulates that primary producers of aluminium can have semi-fabrication capacities to the extent of 50% of the installed capacity of primary metal production. The Government generally encourages joint sector companies to go in for semi-fabricated products.

Most of the modern semi-fabrication capacity is with the primary producers of the metal. The distribution of semi-fabrication capacity as between primary and secondary manufacturers in the year 1983-84 was as given in Table 34.

Table 34 Distribution of Semi-Fabrication Capacities

('000 tonnes)

Product	Primary Producers	Secondary Producers	Total
Extrusions	18.7	19.3	38.0
Wire Rods	63.5	92.8	156.3
Rolled Products	93.2	17.4	110.6
Foils	4.0	5.9	9.9

As against these capacities, the production of rolled products and extrusion has been as follows :

	Rolled Products	Extrusion Products
		(tonnes)
1965-66	34,000 (5,908)	6,056
1970-71	62,130 (16,030)	10,535
1975-76	64,200 (17,790)	11,813
1980-81	75,090 (18,910)	45,035
1982-83	88,078 (19,770)	35,432

Figures in bracket indicate production of rolled products obtained by melting of scrap.

Use of scrap in rolled products has been continuously increasing. Since the use of aluminium scrap involves 1/15th of energy used in production of primary metal, the Government has increased the use of scrap by categorising its imports under OGL. To promote extensive use of the metal, the licensing policy has been liberalised. Broad banding of some of the semis has been permitted to be covered under the licensed capacity. The primary producers are at an advantageous position in identifying new areas of use and developing the product. They have got the necessary expertise and resources to go in for development of alloys and their semis. These producers have the technical and financial back-up to develop products having future applications.

Profitability of Semis Manufacture

The impact of the downstream operations on profitability is worth noting. The profit indicated for INDAL, and Hl DALCO especially after 1979, appears to be the result of gains accruing from downstream operations rather than from the production of primary metal. And since neither MALCO nor BALCO had any significant downstream operations during this period, they were inevitably in the red.

Appendix Al-XVI indicates the evolution of relationship between the prices of ingots and semis and the value added per tonne in downstream operations during the period 1975 to 1983. It is evident that the value added per tonne of foil manufactured is the maximum but its demand in the Indian context is very limited. Value added per tonne of extrusions has always been ahead of rolled products, but the bulk operations in respect of rolled products as compared to extrusion have helped in overall quantum of profitability.

Backward Linkages for Semis Production

Properzi Rods

Presently two grades of EC grade aluminium are supplied viz. aluminium with 99.6% purity as Grade I and with 99.5% purity as Grade II. Supply of ingots is in the form of rectangular bars of 800 x 150 x 115 mm weighing about 20 Kg. More than 90% of the EC wire rod production in India is by continuous casting and rolling, popularly known as Properzi process. The rods produced have a nominal diameter of 9.50 plus 0.5 mm (3/8"). Generally the wire rods are supplied in coils of 1 to 1.5 tonnes. However, depending on the specific requirements and handling facilities available to the customer 500 Kg. coils are also supplied. Linkages for properzi rod manufacture are furnished in Table 35.

Table 35 Weighted Average of Inputs Consumed for Production of One Tonne of Properzi Rod During the Period 1975-1983

		Unit	Quantity	Cost in Rs. per tonne	Cost in Rs. per Rupee Value of Properzi Rod
1	EC grade aluminium	tonne	1.03	8,725.33	0.98
2	Electricity			4.16	
3	Fuels & Lubricants			34.68	
4	Stores & Spares			51.71	
5	Manpower				0.20
	- Managerial & Supervisory			16.50	
	- Skilled & Semi-skilled			60.40	
6	Others			34.55	
	TOTAL			8,824.33	1.00

Generation of scrap and in-house processing of scrap is on an average as follows :

		Scrap Generated	Scrap Recycled
1	Melting and Holding Scrap	3% (dross with 25-40% metal content)	Sold Outside
2	End pieces & Starting scrap	5%	100%
3	Inspection Scrap	1%	100%

Extruded Products

The linkages for extruded products are as furnished in Table 36.

Table 36 Weighted Average of Inputs Consumed For Production of One Tonne of Extruded Products of Aluminium During 1975-1983.

		Units	Quantity	Cost in Rs. per tonne	Cost in Rs. per Rupee Value of Extruded Products
1	Aluminium	Tonne	1.07	14,620.00	0.94
2	Electricity	Kwh	1150	230.00	0.01
3	Fuel Oil	Litres	200	266.00	0.02
4	Master Alloy	Kg.	9.33	373.20	0.03
5	Manpower			60.00	
				15,549.20	1.00

The norms of generation of scrap in the aluminium extrusion industry on an average were as follows :

		Scrap generated as percentage of aluminium consumed	Scrap recycled
1	Ingots melting	2% metal loss and 5% dross formation	Dross sold outside
2	Cut ends, machining etc.	6%	100% recycled
3	Final Inspection rejects	12%	100% recycled

Rolled Products

The average operating parameters in Indian rolling mills during the period 1975 to 1984 are furnished in the Table 37.

Table 37 Average Operating Parameters in Indian Aluminium Rolling Mills - 1975 to 1984

Year	Net Recovery (%)	Melt Loss (%)	Power (Kwh/Tonne)	Fuel (Litres/Tonne)	Rolling Oil (Litres/Tonne)
1975	60.2	2.20	1,791	185	3.79
1976	58.3	1.82	1,795	171	4.66
1977	59.9	1.88	1,641	133	4.48
1978	60.7	1.91	1,649	138	4.27
1979	61.0	1.65	1,636	131	5.17
1980	63.2	1.63	1,600	130	4.35
1981	58.5	1.28	1,740	129	4.76
1982	56.9	1.40	1,713	131	2.68
1983	56.8	1.41	1,700	123	3.29
1984	57.19	1.29	1,554	115	2.55

Note: Recovery denoted is average recovery for sheets, circles and strips.

The scrap generated is in house recycled.

The cost of aluminium rolling increased two fold during the period 1975-1984 primarily due to the increase in the wage structure, power tariff and cost of fuel etc. The changes in cost structure are reflected in Appendix A1-XVII.

Aluminium Foils

Foil stocks are used for manufacture of aluminium foils. The linkages on the average are as follows :

Aluminium Stocks consumed/tonne	-	1.35 tonne
Cost of aluminium/tonne	-	Rs. 19,823.57
Cost of aluminium/Rupee value of foil	-	Rs. 0.45

Nature and Organisation of Links between the Aluminium Industry and The Other Sectors of the Economy.

The links between aluminium industry and the other sectors of economy can be defined in terms of consumption of aluminium in different sectors of the economy as shown in Table 38.

Table 38 Consumption of Aluminium in Different Sectors of Indian Economy

('000 tonnes)

	Sector	1950-51	1960-61	1970-71	1980-81
1	Electrical	(2.9 (20)	17.5 (40)	84.0 (48)	164.6 (52)
2	Transport	0.9 (06)	5.7 (13)	14.0 (08)	34.0 (11)
3	Household & Commercial	7.7 (52)	10.5 (24)	49.0 (28)	60.1 (19)
4	Building & Consumption	0.3 (02)	0.9 (02)	3.5 (02)	19.0 (06)
5	Packaging & Container	1.5 (10)	4.8 (11)	14.0 (08)	19.0 (06)
6	Machinery, Equipment & Others	1.5 (10)	4.4 (10)	10.5 (06)	19.0 (06)
	All Sectors	14.8	43.7	175.2	316.6

Source: NCAER, Aluminium Industry in India, Problems & Prospects, 1985.

Note: Figures in paranthesis indicate percentages.

There has been a significant shift towards a larger use of aluminium in the electrical sector. This has come about through the increasing substitution of copper conductors by aluminium and the growth of power sector during the successive Five Year Plans and the consequent increased demand for electrical grade aluminium. However, the increase in aluminium use in electrical sector took place mainly during the fifties and sixties. Among the non-electrical sectors, there has been some improvement in transport and building and construction, but in the case of other categories, the share of aluminium consumption has been either on the decline or tended to remain stagnant.

The use pattern in various sectors observed in India is very much at variance with those prevailing in the developed countries as well as in several other developing countries. A comparative assessment can be made from the proportions shown in Table 39.

Table 39 Comparative use pattern of Aluminium - India And Other Countries

Sector of Economy	India (1980-81)	Developing Countries (1979-80)	Developed Countries (1979-80)
Electrical	52	15	12 to 16
Transport	11	22	17 to 32
Household & Commercial	19	12	10 to 20
Building & Construction	6	23	10 to 30
Packaging & Container	6	10	7 to 15
Machinery Equipment and others	6	18	15 to 28

It is clear that in the developed countries aluminium finds application mainly in transport and building construction sectors. Since aluminium is light and is easy to work with, other countries have taken advantage of use of aluminium to save fuel in transport sector and save timber and consequently forest resources in building and architectural applications. This is the trend in the case of other developing countries also. In the Indian context the share of aluminium consumption in the electrical sector has been more or less stagnant during the period 1970. While this could be partly due to the slow-down of investment in the transmission and distribution facilities during the recent years, a slight increase in the transport and construction uses is discernible. The developed countries having reached an advanced stage of infrastructural development, reflect increasing uses of aluminium in sectors other than electricals. This trend will come about in India also, once the national power grids are fully established.

The consumption of aluminium is sensitive to the general level of economic activity which makes it reliant on derived demand. There is a very close relationship between the growth of GDP (Gross Domestic Product) and growth of consumption aluminium. The elasticity of consumption of aluminium in India is 1.85 i.e. 1% growth in real GDP implies on an average 1.85% increase in consumption of aluminium. This is what may be actually expected in a developing country like India. Since India has extensiveelectrification programme and hasastructure of the industry which existed in developed countries in earlier stages, a higher specific demand for aluminium could be expected to result. The elasticity of consumption of aluminium in developed countries is 1.2 to 1.5.

Effects of Mines, Alumina Plants and Smelters on the National Economy

Aluminium is more a capital-intensive industry. Increase in the scale of operations in aluminium industry do not generate proporationate increase in employment. The total manpower employed presently in bauxite mining, aluminium production, smelting,semi-fabrication and captive power plant (wherever it has been set up) with primary aluminium producers is about 25,000. It needs, however, to be emphasised that downstream employment in further processing the ingots, semi-fabrication and in the manufacture of finished products such as utensils, architectural fittings, furniture etc is serveral times the number ofpersons employed directly in aluminium production. It is particularly discernible that the bulk of secondary and tertiary employment emanates from the small scale sector which accounts for more than 40% of the use of aluminium in utensil production and in conductor cable manufacture.

It has been estimated that additional employment opportunities from on going programmes relating to the aluminium industry would be of the order of 6,000. This will enhance the total direct employment in aluminium production to about 31,000.

Note: Average employment in capitive and as well as non-capitive bauxite mines in India is of the order 5,000 both skilled and unskilled.

Table 40 Job Opportunities In Semi-Fabrication Facilities and Finished Product Manufacture

	Facility	Annual Capacity: Tonnes per year	Annual Capacity: Nos per year	Manpower Requirements: Engineer	Manpower Requirements: Technician	Manpower Requirements: Skilled Workers	Manpower Requirements: Un-Skilled Workers	Total
A	SEMI FABRICATION							
1	Continuous Strip Casting Machines	27,000	-	4	11	35	60	110
2	Rolling Mill	20,000	-	6	10	85	90	201
3	Extruded & Draw Products	15,000	-	5	12	85	88	190
4	Semi-Continous Extrusion billet casting shop	25,000	-	4	10	30	50	94
5	Continous Casting-rolling mill for wirerods	20,000	-	3	7	30	50	90
6	Forgings	1,500	-	1	3	10	10	24
7	Remelting Facilities	2,000	-	11	2	12	13	28
B	FINISHED PRODUCTS							
8	Household Utensils	135	270,000	-	2	17	7	26
9	Milk Cans	600	100,000	-	2	18	20	40
10	LPG Cylinder Plant	8,000	400,000	3	12	50	35	100
11	Beer Barrels	400	40,000 (50 litres)	-	3	18	15	36
12	Soda Water Syphons	350	500,000	-	3	18	15	36
13	Heat Exchangers	750	200,000 M^2	3	6	25	21	55
14	Lamp post & Lamp arms	1,000	35,000	3	9	30	30	72
15	Rain gutters of supported type & hanging form	800	800,000m	-	3	12	21	34
16	Containers, tanks and bankers for food & chemical industries	1,200	36,000 m^3	-	-	40	80	120
17	Pannels for Building & Construction	1,400	200,000 m^3	-	-	2	10	12

Source: UNIDO, Aluminium production and use in Developing countries with special emphasis on the manufacture of aluminium semis and finished products.

- October 1984
- Magyar Aluminium 1984

Aluminium producers are at present fully equipped to train personnel of all categories to handle bauxite mining, alumina production smelter operation and semi-fabrication facilities. However, there might be the necessity of sending, on a selective basis, operating personnel as well as some senior technical experts to foreign collaborators to expose them to the more sophisticated technological practices.

Both the scale of operation and complexity of the plants at different stages of aluminium production and fabrication have been increasing over the periods necessitating specialised management skill. In view of this, it is felt that improved training facilities for management of aluminium plants, need to be taken up for various facets of management.

Protection of Environment, Working Conditions, Health & Safety

Health and Safety

From bauxite mining to production of semi-fabrication, aluminium industry faces safety hazards characteristic of large scale manufacturing including chemical and metallurgical processing. Bauxite mining being open-cast type in India, does not pose serious problem in safety. Nevertheless the mining operations are regulated through Mines Act (Amended) 1983.

The hazards of caustic burn and burns due to splashing of hot electrolyte and metal statutorily require aluminium producers providing safety gadgets such as safety helmets, goggles, face shields, safety boots, gloves and mittens, angle shield etc. to personnel engaged in manufacturing. It is ensured that under the factory act (Amended) special protective safety gadgets, both standard and non-standard to provide adequate safety for working personnel in the industry.

Electrical hazard for operators working in the aluminium smelters is almost eliminated by providing, in addition to special insulated safety boots, multi-stage electrical insulation in civil building and structurals of the cell houses at every possible place of accidental grounding of electrical circuit through the operators.

Environmental Impact of the Aluminium Industry

Bauxite Mining

The principal environmental consideration in mining should be the complete rehabilitation of the mined land to alternative land use. It remains a distant goal in India. The Phutkapahar mines of BALCO have reached exhaustion stage and will be abandoned without specific measures for their rehabilitation. However, it is reported that at the other BALCO mining site at Amarkanatak, care is being taken to raise suitable plantation and cover the land with green vegetation.

Ore extraction in open pit mining produces a large amount of dust; subsequent operations like transportation of mineral ore, grinding etc. raise even bigger amount of dust. The dust raised by mining equipment is arrested by dust collectors while dust raised by movement of dumpers is supressed by water spraying. The muddy water during rainy season is drained away from the quarry into suitable disposal area to avoid any ground pollution.

Alumina Plant

The major pollutants generated in the alumina plant are red mud, waste liquor and boiler emissions. No other industry discards such a huge quantity of waste maintaining 1 : 2.5 ratio between the end product and waste product.

Aluminium Smelting

Table 41 gives the main types of pollutants from primary aluminium smelters.

Table 41 Main Pollutants From Smelters

	Type of Pollution	Material Produced
1	Gaseous emissions	Carbon monoxide, carbon dioxide, Hydrogen flouride, Sulphur dioxide, Carbon disulphide, Silicon tetra-flouride, Carbon tetra-flouride, Hexa-flouroethane, Water vapour.
2	Solid emissions	Alumina, Cryolite, aluminium flouride, Calcium flouride, Carbon, Iron oxide.
3	Liquid effluents	Fluoride compounds, Hydrocarbons (from soderberg plants), entrained water.
4	Smelter wastes	Spent pot linings, anode butts from pre-backed pots, dust from gas cleaning, sludges from cleaning scrubbing water, material from pot skimming, spills.
5	Paste preparation emission and wastes	Coke dust, coal dust fines, hydro-carbon fumes.
6	Anode backing emissions and wastes	Hydro-carbons, fluorides, sulphur.
7	Cast house emissions and waste	Fluxing fumes (primarily aluminium chloride), trace flucrine, sulphur dioxide.
8	Ancillary operations emissions and wastes	Dust from bulk material handling, demolition of old pots, and cleaning of pre-backed anode butts to recover carbon.

Source: The World Aluminium Industry, Vol. 1, Australian Mineral Economics Pty. Limited, Sydney, February 1982.

The concentration of carbon monoxide and sulphur dioxide is low and does not require special measures. The major problem is posed by gaseous and particulate fluoride emission which requires great attention.

Pollution Control Measures Taken by the Industry

Bharat Aluminium Company Limited

1 Alumina Plant

Caustic laden red mud slurry is pumped into specially built red mud pond away from inhabitation and the clear water is pumped back into the process. The waste liquors from different sources are also collected into sump and fed back to the system. The dust raised by boilers of steam plant is collected by dust collectors and the flue gases are vented out into the atmosphere through sufficiently high chimney. The alumina calciners are also equipped with electrostratic precipitators and bag filters to arrest the flying alumina dust during calcination.

2 Smelter

Four gas cleaning units have been installed at Korba Aluminium plant to control the pollution hazards. Tar and dust are arrested by electrostatic precipitators while the fluorides are wet scrubbed before venting it into the atmosphere through 80 m high stacks. The efficiency of gas cleaning plant at Korba aluminium plant is 98% for fluorides, 96.5% for dust and 69% for tar, which are well within the desired norms Cryolite is recovered from the scrubbed solution.

3 Fabrication Complex

The fabrication unit does not pose any serious pollution problems except the emulsified effluents. An emulsion treatment plant has been provided at Korba for treatment of oil laden water before disposal.

Indian Aluminium Company Limited

The entire pot room exhaust system of the 50 KA line at Alupuram was modernised at a cost of Rs. 1.0 million including increase in stack height. This has helped in improving the internal environment.

At Hirakud (Orissa), the pot dust design has been changed to balanced duct design in a section-on experiment basis. This new design has helped in improving the internal atmosphere. It is planned to change over to the duct design in stages in other sections also.

For external environment control INDAL has initiated systematic assessment of fluroine content in foliage around 5 km. radius of the smelter plants. Preliminary results indicate the flurorine level within limits.

Social forestry has also been started to provide green belt around smelter plants.

Note: Approximately 780 m^3 of gases are produced per tonnes of aluminium from the cryolite, aluminium fluoride, calcium flouride and sodium fluoride used in the electrolysis process. In practice, actual quantity released vary considerably depending on such factors as temperature, bath composition method of working the pots, type of anode used and crust breaking technique. Emission level also vary during smelting cycle, primarily as a result of changes in levels during crust breaking and alumina feeding. As for example, routine crust breaking can increase the normal level of fluoride emission to 50 kg/tonne of aluminium temporarily and crust breaking and the addition of alumina, when gas forms at the anode (the anode effect) can increase the emission level to as high as 350 to 400 kg./tonne of aluminium.

Hindustan Aluminium Corporation Limited

1 Effluent Treatment Plant

The effluent treatment plant is being designed and installed to collect all waste products such as oil emulsion, water containing fluorides, caustic soda etc. This scheme which is under implementation will control the liquid and solid effluents.

2 Air Pollution Control

A scheme has been designed to collect all the gases from the pot cells and treat the same with alumina so as to absorb all fluorine The dry scrubbing system-for which know how has already been received from M/s Alasa - Alusuisan Switzerland will ensure clean pollution free atmosphere in the pot room. The scheme was to be installed in 40 pots on trial basis by 1984.

3 Boiler Ash

Earlier HINDALCO had manual ash disposal system which was causing environmental problem. The ash disposal system was mechanised with the installation of a submerged ash conveyor and all the ash is now collected in silo and discharged by means of truck into nearby valleys.

4 Electro-Static Precipitator

The electro-static precipitators installed in the Rotary Kiln in Alumin plant arrests and puts back the alumina dust and prevents it from escaping in the atmosphere. The advantages are two fold viz prevent pollution and save alumina from going waste. The efficiency of the electrostatic precipitator is about 99%.

Madras Aluminium Company Limited

1 Pot Section

The gases emitted from the electrolytic cells are sucked and scrubbed with caustic soda to fix fluorine as sodium fluoride and to regenerate it as cryolite.

2 On the Floor

Bag filters in electrode Paste Plant and electrostatic precipitators in calcination section are installed for prevention of dust pollution.

National Aluminium Company Limited

In smelter division-fume treatment plant will be installed to absorb all the gases and particulates. The holding efficiency in the pot room will be 97% with this system and the cryolite consumption will be reduced considerably.

From the foregoing it is be observed that all the primary producers of aluminium have adopted environmental control measures of varying types. In order to ensure that future plants are set up with comprehensive arrangements for pollution control, it would appear necessary to earmark at least 1 to 2% of the sale realisation exclusively for undertaking pollution control measures.

Strategies of Development and Cooperation

Non-Exploited Deposits

During the last decade and a half, there has been a significant thrust in the direction of establishing new bauxite reserves in India particularly in the Eastern Coast in Andhra Pradesh (AP) and Orissa states. As a result of this, the figure of known bauxite reserves has risen from approximately 345 million tonnes in 1970 to the order of 2,670 million tonnes in 1983.

Of the total reserves of bauxite deposits both exploited and non-exploited tabulated in Appendix A1-XVIII about 1,930 million tonnes of reserves are in the non-exploited deposits. The currently assessed bauxite reserves of the order of 2,670 million tonnes, would be adequate to produce about 1,000 million tonnes of alumina, or about 500 million tonnes of aluminium. These reserves are enough to meet the requirements of aluminium in a country for a considerably long time. Bulk of these deposits may, therefore, be spared for export purposes. The deposits which are suited for development for export purposes are :

1 Saurashtra Bauxite Deposits in Jamnagar District of Gujarat

The deposits lie within 0.5 to 2.0 km from the coast. The quality of bauxite in these deposits compares with the best bauxites of the world and Japan has found that the quality of Indian bauxite surpasses that from Indonesia, Malaysia and Australia. However, in view of transport problems, the Saurashtra bauxites are yet to attract foreign buyers. Gujarat Mineral Development Corporation (GMDC) has been planning to have an alumina plant for export purposes based on these deposits. The details of the proposed facilities alongwith details of investments are furnished under the topic 'New Projects'.

2 Anantagiri and Chintapalle group of deposits in Andhra Pradesh have the distinction of geographical proximity to Visakhapatnam port. The deposits have about 480 million tonnes of reserves. USSR has shown interest in deposits for import of bauxite/alumina, but till date the definite financial and buy-back arrangement have not been arrived at.

Envisaged or Feasible Projects and Volume of Required Investment

On a broad assessment the likely capital investment in the Seventh Plan would be of the order of Rs. 33,146 million. The break-up of investment is furnished in Appendix Al-XIX. A brief description of the projects which are under planning/implementation during the Seventh Plan Period is given hereunder :

1 Aluminium Complex of NALCO

NALCO has been established with the objective of exploiting the bauxite reserves of Panchpatmali in Orissa. About 400,000 tonnes of alumina will be converted into aluminium metal while balance alumina is planned to be exported. Out of the 218,000 tonnes of metal it is proposed to convert 100,000 tonnes as EC grade wire rods and the balance 118,000 tonnes as pigs for production of semis. These are expected to be commissioned in phases from 1987 to 1989. The estimated cost of the project is Rs. 24,400 million.

2 Downstream Facilities for NALCO

Setting up of value added downstream facilities are considered conducive to improve the economic viability of the NALCO complex. The feasibility report for downstream facilities is under preparation. The estimated cost of the projects is Rs. 2,320 million for the production facilities as furnished below :

	Capacity ('000 tpy)
Rolled Products	25
Extrusion Products	10
Foils	5
EC grade wire rods	100

3 **Aluminium-Silicon Plant for BALCO**

A feasibility report for setting up the plant with a capacity of 90,000 tpy was prepared by VAMI of USSR in 1980 in collaboration with Indian Rare Earths (IRE) under UNIDO assistance. Production of the alloy was envisaged through the electrothermic process using sillimanite concentrate available as by-product of mining of ilmenite from beach sand. Subsequently, a techno-economic evaluation was done by VAMI in 1983 for the plant down-scaled to 30,000 tpy. The plant is now slated to be implemented by NALCO at Angul in Orissa by 1988-89. The investment would be of the order of Rs. 390 million.

4 Gandhamardan Bauxite Project of BALCO

Gandhamardan bauxite deposits are located at Sambalpur and Bolangir districts of Orissa. Presently, BALCO is developing a 600,000 tpa mine in this deposit at an estimated cost of Rs. 526 million. The project is scheduled to be completed by October 1986. The bauxite will be transported to Korba alumina plant through ropeway and railways.

5 Captive Power Plant for BALCO

Inadequate power supply from Madhya Pradesh State Electricity Board has hitherto resulted in under utilisation of installed capacity of Korba smelter. BALCO has, therefore, decided to set up a captive power plant of 270 MW capacity. The project is under implementation. The likely cost of the project is of the order of Rs. 4,212 million.

6 Balancing facilities and Replacement Need for BALCO

a Korba Unit

For fuller utilisation of capacity of 100,000 tpy of smelter, 35,000 tonnes of properzi rods, 40,000 tonnes of rolled products, 7,000 tonnes of extruded products and the balance 18,000 tonnes as ingots, the following balancing facilities are needed to be installed at Korba.

i augmentation of facilities to generate steam required for alumina plant

ii modification of leaching process to suit the characteristics of bauxite available from Gandhamardhan mine

iii provision of additional cold rolling unit to match the hot rolling mill

iv installation of slitting-cum-rewinding line to meet the market demand of low weight spoolless coils.

Metallurgical and Engineering Consultants (India) Limited (MECON) is presently engaged in carrying out a comprehensive study of these aspects.

b <u>Bidhan Bagh Unit</u> (Erstwhile ALUCOIN, Jaykaynagar, West Bengal)

It has been decided to activate the semi-fabrication facilities of the unit (which has been closed for the last over 15 years) to improve the financial performance of the unit as a whole, it is proposed to provide facilities like die-shop, homogenising furnace etc. need to be provided in the extrusion plant, to start with. The foil plant which was set up later than the other fabrication facilities is in good condition.

7 <u>Research & Development in BALCO</u>

Augmentation of facilities in the R&D section of Korba are planned for development and testing of sophisticated aluminium alloys and semi-fabricated products for defence and strategic purposes.

Proposals are under consideration for demonstration units for :

i energy conservation in rotary calcinar for alumina;

ii for utilisation of red-mud; and

iii for production of super purity aluminium.

Preliminary action for these proposals have been completed through UNDP and UNIDO assistance.

8 New Scheme of BALCO

a Andhra Aluminium Project

A feasibility report for setting up of an alumina plant in Andhra Pradesh with an annual capacity of 600,000 - 800,000 tonnes was prepared by USSR in 1980. Subsequently in 1982, it was modified to include an export oriented bauxite mine of 2.3 million tpy to supply the required mineral to the alumina plant. The project, emerging on the basis of discussion hitherto envisages development of a 2.3 million tpy bauxite mine in Andhra Pradesh for export of bauxite to USSR on long term basis, later expansion of bauxite mine to 4 million tpy and setting up an export oriented 600,000 tpy alumina plant. The project is yet to be implemented.

The estimated cost for the total project comprising of the export oriented mine and the alumina plant along with railway and port facilities etc. is likely to be of the order of Rs. 8,000 million. This project is considered as a potential Seventh Plan project subject to financing arrangements and agreement on long term export of alumina to USSR at an acceptable pricing formula.

b Expansion of Korba Plant

BALCO plans to initiate action to expand its smelter capacity by 25,000 tpy at a cost of Rs. 550 million.

9 Gujarat Alumina Plant

M/s. ALUTERV-FKI of Hungary prepared feasibility report in 1979 for establishment of alumina plant of 0.3 million tonnes capacity based on Kutch deposits in Gujarat. Location of alumina in the Kandla Free Trade Zone will cost Rs. 1,580 million and at Devpar location about Rs. 1,670 million. GMDC wanted the alumina produced to be toll-smelted by M/s. Hungarian Alumina Corporation. Establishment of the

the project depends on satisfactory foreign financing of the project and buy-back at mutually satisfactory price.

10 Aluminium Research Development & Design Centre

The existing aluminium industry in the country is based almost entirely on foreign know-how. Though certain amount of research and development work on various technological issues is being carried out by the aluminium industry as well as certain research laboratories, a coordinated effort in R&D would be essential to attain self reliance in the alumina and aluminium technology for the development of the aluminium industry.

A preparatory project repott for setting up of a centre has been prepared by ALUTERV FKI assisted by MECON. UNIDO has rendered all assistance for preparation of this report. The estimated cost for the centre may be Rs. 490 million.

11 Ratnagiri Aluminium Project

The Ratnagiri Aluminium Project with a capacity of 50,000 tonnes per annum was sanctioned by Government as early as April 1974, at a total cost of Rs. 743 million. However, because of financial constraints, implementation of Project could not be undertaken.

12 Investment in the Private Sector

Information in respect of future investment in the private primary sector is shown below :

(Rs. million)

	HINDALCO	INDAL	MALCO	Total
New Capacities/ Expansion of Capacities	950	900	-	1,850
Modernisation & Replacements	450	240	10	700
Grand Total	1,400	1,140	10	2,550

The total investment indicated in the Appendix A1-XIX includes the cost of development of infrastructure facilities such as roads, railways, ports etc. These investments are incurred by the concerned project authority. The likely investment for infrastructure development in the state of Andhra Pradesh, Gujarat and Orissa is likely to be of the order of Rs. 2,650 million. The break-up of this investment is furnished below :

Infrastructure Development

The availability of adequate power, water and transportation facilities for raw materials and finished products are important factors to be considered in the infrastructure development for aluminium industry. Since the identified bauxite deposits are located away from the existing rail and road networks, development of new rail and roads needs to be planned along with development of aluminium industry. Development of adequate port facilities is also required for export of value added alumina.

Since the development of these facilities will require considerable time, the areas where such development is required need to be identified and necessary action should be initiated, sufficiently in advance.

Transportation

Railways

a Ahdhra Alumina Project is proposed to be served by a railway track of about 62 km. between the existing rail-head Narsipatnam or Rayyavaram to the proposed plant site at Krishnadevapeta.

b In case of NALCO, a link track of about 174 km. is under construction between Koraput (on Kirundul - Kottavalasa line) and Rayagada (on Raipur - Vijayanagaram line). Another link track of about 170 km. between Sambalpur - Talchar is under construction.

c Gandhamardan Bauxite Project of BALCO under construction, will be served by about 26 km. B.G. Railway track from Lakhna railway station to foothill. This line is presently under construction.

Roads

Andhra Alumina Project is proposed to be located near Krishnadevapeta village in Vishakhapatnam district based on Bauxite deposits of Jarella/Sapparla about 45 km. from plant site. The new road that needs to be developed for the project may be about 40 km. including Sapparla Mines and plant. Existing roads will need widening/back tapping, etc.

Gujarat alumina project which is proposed to be located in Bhuj in Kutch district will require about 2 km. of road from plant site to existing national highway. Some existing roads may require widening to cater to the increased traffic load.

Port Facilities

The export of bulk quantity of alumina will require the development of additional port facilities like installation of alumina silos, provision of pneumatic conveying system for landing alumina directly into the ships, etc.

The facilities at Visakhapatnam port being developed for NALCO will require augmentation for handling additional alumina from Andhra Alumina Project (for export) and import of materials. Kandla port has been considered for the export alumina from Gujarat Alumina Project.

Power

The requirement of power for the existing alumina plant is of the order of 826 MW. The present supply arrangement of power is from State Electricity Board except in the case of HINDALCO.

	Company	Requirement of Power (MW)
1	Bharat Aluminium Co. (BALCO)	235.00
2	Hindustan Aluminium Company (HINDALCO)	250.00
3	Indial Aluminium Company (INDAL)	
i	Alwaye Plant	45.40
ii	Hirakud Plant	50.00
iii	Belgaum Plant	171.20
4	Madras Aluminium Co. (MALCO)	75.00
		826.60

It is reported by the industry that an interruption of 2 hours in supply causes an additional hike in the supply of metal by Rs. 2,800 per tonne, for the metal produced in the two days which follow the interruption. An outage of 4 hours caused a hike in the metal price by Rs. 5,600 per tonne for 5 days that follow the interruption. This is reported due to :

- higher power consumption per tonne of hot metal:
- increased consumption of anode and bath material (cryolite and aluminium fluoride); and
- shorter span of life of cathode lining.

The industry has estimated that for each MW power cut, approximately 5.5 pots have to be shunted. Relining and restarting expenses of each pot come to about Rs. 0.1 million (1984 prices).

Investment for Infrastructure

Investment for infrastructure includes the cost of railway track, road, special type alumina wagons, external power supply, external water supply, port facilities etc. The estimated investment required for development of infrastructure facilities for various projects is given below :

	Description	Investment in Rs. million for Infrastructure
1	Andhra Alumina Project including mine	1,020
2	Gujarat Alumina Project	130
3	Gandhamardan Bauxite Project (under implementation)	150
4	Port Facilities at Vizag and Kandla	1,350
		2,650

Main Areas for Cooperation

The aluminium industry in India has been built with most of the aluminium technologies available in the world during the fifties and sixties.

	Name of Aluminium Plant	Foreign Collaborator
1	Aluminium Corporation of India, Asansol (W. Bengal)	Swiss Aluminium (ALUSUISSE) Switzerland
2	Madras Aluminium Company, Mettur, Tamil Nadu	Aluminium Italia, Italy

	Name of Aluminium Plant	Foreign Collaborator
3	Indian Aluminium Company Hirakud, Alwaye & Belgaum	ALCAN, Canada
4	Hindustan Aluminium Corpn. Renukoot (U.P.)	Kaiser Engineers Overseas Corporation, USA
5	Bharat Aluminium Co. Ltd., Korba, Madhya Pradesh	- ALUTERV - FKI, Hungary for alumina plant - Swetemetpromexport USSR for smelter & fabrication complex
6	National Aluminium Company Limited, Angul, Orissa (under construction)	Aluminium Pechiney France

These technologies were brought some years ago and while they are fully absorbed and considerably Indianised by now, a lot of R&D work would be required to keep them modernised; viable and pollution free. Latest technology to come to India is the Pechiney technology adopted by NALCO.

For the first four units, the know-how and the detailed engineering was carried out by the foreign technical collaborators. The detailed design, engineering and consultancy services for the projects during the last decade has been undertaken by Indian engineering and consultancy organisations. For implementation of future aluminium plants, necessary indigenous expertise for detailed design, consultancy and engineering services has been developed in the country. However, basic know-how for the projects to incorporate latest technology is still required to be imported from foreign sources untill the Aluminium Research, Development and Design Centre is set up in the country.

Considerable developments have taken place in the advanced countries leading to production in operating costs and conservation of energy. BALCO's Alumina plant and aluminium smelter which were commissioned in mid-seventies may also need certain amount of modernisation in specific areas. Revolutionary changes have taken place especially in the downstream areas of rolling, extrusion and casting of aluminium. It would be appropriate to identify specific areas of technical cooperation with the advanced countries and conduct detailed integrated studies for each plant to identify areas where modernisation efforts could be undertaken especially in the context of energy saving.

Various operational stages in the aluminium industry are :

i exploration and mining of bauxite;

ii conversion of bauxite to alumina; and

iii smelting of alumina to aluminium metal and fabrication of metal to various forms for industrial use.

In all these fields lot of progress has been made and improved technology and process introduced in the country, yet there are areas of improvement.

Exploration of Bauxite Reserves

Bauxite deposits being of varied types and non-uniform within a single area need special attention in estimation of reserves and grade. The drilling has changed from wet to dry drilling. Even this has been replaced by vacuum drilling technology abroad. This technology may need equipment manufacturing facilities and training of drilling personnel in the countries where the above technologies are practised.

Another aspect in the matter of bauxite resource appraisal is the application of geo-statistics and computerisation of data for mine planning. This is being adopted in the new bauxite mine of NALCO. The know-how need to be fully transferred and applied in all future mines so that mines could be developed systematically to supply required quality of material to the plants. Central exploration agencies like Geological Survey of India, Mineral Exploration Corporation should get equipped for this and operating mines should have trained personnel for proper application of these techniques.

Mine Planning and Design

Indigenous expertise is well developed to design mine projects with sufficient competence. MECON is already carrying out the detailed engineering, mine planning and development for 600,000 tpy Gandhamardan mine for BALCO. Engineers India Limited (EIL) is rendering detailed engineering services for 2.4 million tpy Panchpatmali mine of NALCO. However, to keep abreast with the latest technological advancement in the world in the field of computerised mine planning, it would be necessary to have interaction with reputed organisations abroad.

Manufacture of Alumina

A beginning in the development of indigenous consultancy and engineering services for the aluminium industry in India was made with Indian Organisations undertaking the detailed engineering assignment for 100,000 tpy integrated aluminium complex at Korba. Detailed engineering for a project of this magnitude was carried out indigenously for the first time within the country.

Presently, Engineers India Limited (EIL) is carrying out the detailed engineering for alumina and aluminium plants of NALCO.

But considerable improvements have been achieved in the advanced countries in order to reduce energy consumption and cost of production as well as to improve the quality. Areas of these developments include :

i fluidised bed calcination which requires 30% less energy than the conventional rotary calciner;

ii dry disposal of red mud as compared to conventional wet impounding method;

iii removal of organic impurities; and

iv process control through microprocessors/ computers etc.

The fluidised bed calcination of alumina has been adopted for NALCO. The recent trend world over is to produce sandy alumina at process parameters achieved in European alumina plants resulting in less energy consumption. NALCO has adopted the same process.

It is understood that HINDALCO has initiated action to change over to fluidised bed calcination in replacement of the existing rotary kiln system and other energy saving features in their expansion of the plant. BALCO is taking up experiments to reduce fuel consumption in its rotary kiln calciner on the lines suggested by UNIDO.

Technical know-how needs to be imported to develop fluidised bed calcination equipment in the country.

Aluminium Smelting

The existing aluminium smelters in the country are based on conventional Hall-Heroult process with current intensity ranging from 50-100 KA with an average power (DC) consumption of 16,500 kwh/tonne. The aluminium smelter under construction by NALCO in Orissa has a current intensity of 175kA and will have power consumption of around 13,600 kwh/tonne.

The present world trend is towards larger cells, higher amperage cell hooding with dry gas cleaning and controlled operation. Cells with a current intensity of upto 225 KA are already in operation in certain countries. For optimum process control mechanisation and automation have been extensively introduced in new plants. In the international field, cell with higher amperage upto 300 KA are under experimentation.

Computerised automatic voltage control systems are adopted to achieve substantial savings in power and raw material consumption besides better production efficiency. Automatic voltage control system has been installed in India by BALCO, MALCO and INDAL. In the NALCO plant a computerised process control system is planned to be installed.

It is suggested that a comprehensive study be carried out for the existing aluminium industry with special reference to incorporation of new technology, in order to reduce energy and raw material consumption and to achieve higher productivity and efficiency. Foreign know-how may be acquired wherever necessary for technological upgradation of the existing plants.

Semis Manufacture

For the proposed downstream facilities for NALCO, MECON has been assigned the task of detailed engineering consultancy and project management services. Sufficient expertise have also been developed for manufacture of different alloys of aluminium and their semis.

R & D Facilities

In the light of pace at which technological development in aluminium abroad are taking place, it is in the interest of aluminium producing companies in India to set up the required R&D facilities which could deal with different phases of development related to aluminium production and application. The research facilities should cover the areas of bauxite beneficiation and mining, bauxite processing and alumina production, smelter and carbon technology, alloy development, casting and fabrication technology including development of new applications. Details of R&D efforts of primary aluminium producers and the areas in which foreign assistance may be warranted are noted below :

a Bharat Aluminium Company (BALCO)

BALCO has established a pilot plant for evaluating bauxite samples for production of alumina; bench scale testing facilities are also in operation. In addition, R&D facilities for development of sophisticated aluminium alloys for eventual fabrication for defence and other strategic purposes and import substitution are being established. A study is under way for the use of lithium carbonate and magnesium carbonate to reduce electrical resistance and energy consumption. It is also proposed to take up the study for enhancing service life of equipment by making more effective use of oils and lubricants, and also for reclaiming valuable oil and additives. Action has been initiated for gainful use of red mud.

b Indian Aluminium Company Limited (INDAL)

The major thrust in the R&D efforts is directed towards energy conservation. The objective is to improve energy consumption to around 14,500 kwh/tonne by 1987. The schemes involve improvement in anode, cathode and busbar design changes, installation of micro-processor devices, improvement of pot room equipment and replacement of old mercury arc rectifier by silicon type rectifiers.

The company is already recovering cryolite from spent pot linings. Its study indicates scope for minimising loss of fluoride in spent lining during its dismantling from pots to its despatch to cryolite recovery plant at Belgaum. A scheme has been worked out and will be implemented within a year or two.

Vanadium recovery from the alumina plant liquor has been implemented.

The company is recovering carbon from spent lining which has been used as a pot lining material as a substitute for anthracite thus saving on foreign exchange.

c Hindustan Aluminium Corporation Limited (HINDALCO)

The company has done considerable work in assimilation and compilation of data on energy consumption and has initiated a number of schemes for energy conservation and increasing current efficiency. The old rotary kiln calciner is to be replaced by 'fluidised bed vertical calciner' which is expected to reduce the fuel oil consumption by about 30% in the alumina plant. Alumina plant is under expansion to 300,000 tonnes annual capacity through Hungarian technology. This includes

- raising plant liquor concentration by adding extra evaporation unit

- liquor purification
- heat transfer of pregnant liquor by spent liquor
- hydrogarnate technology and red mud causticisation

The expansion is expected to becompleted by 1986 and involves an investment of Rs. 500 million. The modification in technology is expected to reduce steam consumption from 5.0 tonnes (1983) to 4.14 tonnes per tonne of alumina, and also result in reduction of consumption of electrical energy.

A scheme has been proposed to replace the existing old small size boilers with a large 80 TPH pulverised coal fired boiler with cogeneration facilities.

The review of the steps taken by the individual units in the field of R&D, lead to the conclusion that though there had been considerable efforts, this has not resulted in the upgradation of the technology on a significant scale. The aluminium industry in India is 40 years old now. There are four existing units and one under implementation and each of these has a different technology. This is a reflection of the fact that India has not been able to substantially absorb any of the technologies imported in the past. In this context, it is imperative that the aluminium industry as a whole should pool expertise to upgrade the technology in their plants with the help of their foreign collaborators to bring them technologically at par with the plants abroad.

Another area is in the application of aluminium. For every tonne of metal produced, it is necessary that it be remelted, cast and fabricated into usable applications - applications which are viable, beneficial to the consumer and national economy. With increasing level of production, the pertinent issue in India is to increase the consumption of aluminium. India has a large potential in the electrical, transport, building and packaging fields. These have to be developed and tapped by R&D and marketing efforts. Creating and satisfying these potential markets, multiplying the uses of aluminium manifold, will be the challenge which not only the R&D men but also the marketing men and entrepreneurs will have to face and solve. India will have to evolve a judicious mix of fabricating technologies to meet its special needs. India will need to expand the highly sophisticated production and capital intensive primary rolling mills which can recycle scrap and satisfy the conventional utensil and household market. India will need high capacity, highly productive and high quality presses which would produce goods of average specifications.

In the casting and diecasting sectors, intensive R&D efferts will be required to satisfy the rather stringent requirements of castings suitable for the newly emerging transport sector. Myriads of techniques involving jointing, brazing, anodizing, painting, surface finishing, gauge control, new alloys etc. will have to be developed by R&D efforts at various centres. India will of course, need the assistance of more developed countries in the form of information, technology exchange and marketing intelligence so that India could learn from their experience, avoid the possible pitfalls and catch up as fast as possible with the more advanced usage of aluminium in these countries.

Aluminium is a good conductor of electricity and India has largly exploited this property in the field ofpower generation and transmission. However, there are areas like aluminium winding wires where further R&D work is required so that the potential of aluminium usage in electrical industry is fully exploited. Assistance from advanced countries in this respect may accelerate the process.

India has still to make a significant begining in the area of substitution of timber (in building and architectural applications) with aluminium and saving of fuel in transport sector. Other countries have taken full advantage of this fuel and forest saving potentialities while India's transport and building sectors consume hardly 15% of aluminium produced; in Japan these sectors consume as much as 50% of the aluminium used.

Appendix Cu - I

Reserves And Other Technical Parameters of Exploited Mines of Copper Ore In India

As on 31st March 1983

Exploited mine	Location	Type of ownership	In-situ ore reserves in million tonnes and grade % Cu. Proved	Probable	Possible	Total	Total Metal ('000 tonnes)	Cut-off grade assumed % Cu.	Vertical depth in metres	Installed/ proposed mine capacity (tpd)	Life of the recoverable reserves in years
I.A Eastern Sector (I.C.C. Group)											
1. Mosabani	Bihar	HCL Public Sector	9.81 (1.70)	3.78 (1.72)	3.98 (1.79)	17.57 (1.71)	300	0.5	1060	3200	11
2. Pathargora	"	"	1.70 (1.47)	0.44 (1.36)	0.39 (1.42)	2.53 (1.44)	36	0.5	347	400	13
3. Surda (Phase I and Phase II)	"	"	10.65 (1.20)	5.37 (1.22)	7.50 (1.22)	23.52 (1.21)	205	0.5	500	1300/1800	26
4. Kendadih (Phase I and Phase II)	"	"	8.79 (1.78)	3.02 (1.72)	3.01 (1.74)	14.82 (1.76)	261	0.5	500	200/1000	30
5. Rakha Phase I	"	"	7.83 (1.19)	-	-	7.83 (1.19)	93	0.5-1.00	206	1000	18
Sub-Total: Eastern Sector (ICC Group)			38.78 (1.47)	12.61 (1.49)	14.88 (1.47)	66.27 (1.47)	975				
B. Western Sector (KCC Group)											
6.[1/] Madhan-Kudan	Rajasthan	HCL	7.92 (0.95)	7.74 (0.91)	23.28 (0.93)	38.94 (0.93)	362	0.5	760	5000	16
7.[2/] Kolihan	"	"	12.99 (1.71)	5.61 (1.15)	10.56 (1.15)	29.16 (1.40)	400	0.5	568	3000	19
8.[3/] Chandmari	"	"	-	1.77 (1.31)	-	1.77 (1.31)	23	0.5	46	500	8
9. Kho-Dariba	"	"	0.28 (1.90)	-	0.07 (1.50)	0.35 (1.82)	6	0.5	60	100	7
Sub-Total: Western Sector (KCC Group)			21.19 (1.43)	15.12 (1.05)	33.91 (1.00)	70.22 (1.14)	799				
C. Central Sector (malanj Khand Group)											
10.[4/] Malanj Khand Copper	M.P.	HCL	24.34	36.08	55.21	115.63	1307	0.4 (0.45 for open-pit)	350 (Upto 300 MRL)	6700	29
Sub-Total: HCL mines			84.31 (1.43)	63.81 (1.19)	104.00 (1.07)	252.12 (1.22)	3081				

Exploited mine	Location	Type of owner-ship	In-situ Ore reserves in million tonnes and grade % Cu. Proved	Probable	Possible	Total	Total Metal ('000 tonnes)	Cut-off grade assumed % Cu.	Vertical depth in metres	Installed/ proposed mine capacity (tpd)	Life of recoverable reserves in years
D. Other Working Mines											
11. 5/ Rangpo	Sikkim	SMC	-	0.47 (1.19)	-	0.47 (1.19)	6	N.A.	N.A.	100	9
12. Ingaldal	Karnataka	CCC	0.19 (2.26)	-	1.04 (1.44)	1.23 (1.54)	19	N.A.	300	250	-
13. Kalyadi	"	"	1.13 (1.03)	1.73 (0.80)	0.17 (0.63)	3.03 (0.88)	27	0.30	250	500	-
14. Mailaram	A.P.	APMC	0.15 (1.90)	0.41 (1.38)	-	0.56 (1.54)	9	1.00	235	N.A.	-
15. 6/ Rajpura-Dariba	Rajasthan	HZL	-	-	0.89 (1.38)	0.89 (1.38)	12	-	-	-	-
16. 6/ Bandalamottu	A.P.	HZL	-	-	1.04 (1.42)	1.04 (1.42)	15	-	-	-	-
Sub-Total: Other working mines			1.47 (1.28)	2.61 (0.96)	3.14 (1.37)	7.22 (1.22)	88				

Note: Life of recoverable reserves is computed on proposed capacity.

1/ The vertical depth comprises of 160 m above valley level and 620 m below it.

2/ The vertical depth comprises of 144 m above valley level and 424 m below it.

3/ Chandmari mine is open cast workings lying between 404 and 340 MRL.

4/ Life is based on open-pit reserves of 57.9 million tonnes.

5/ 60% reserves are recoverable; Besides copper the deposit contains 1.20% Pb. and 2.51% Zn.

6/ Incidental to Pb - Zn ore mining.

Source: GOI, Planning Commission, Report of Working Group on Non-Ferrous Metals (Copper & Nickel), 1984.

Prospective Copper Ore Resources in Exploited Mines and Their Neighbourhood upto A Depth of 1060 Metres From Surface

Appendix Cu-II

Exploited mines/ Deposits in neighbourhood	Moderately explored upto depth (metre)	Expected Grade	Expected availability per metre depth		Additional prospective ore		
			Ore ('000 tonnes)	Metal (tonnes)	Upto depth (Metre)	Ore ('000 tonnes)	Metal ('000 tonnes)
Eastern Sector							
A. Exploited mines							
Mosabani	1060	1.71	40	680	-	-	-
Pathargora	347	1.44	10	140	1060	7100	100
Surda	500	1.21	50	605	1060	28000	340
Kundadih (I+II)	500	1.76	30	530	1060	16800	295
Rakha (I+II)	650	1.20	85	1020	1060	34800	420
Sub-Total A		1.38	215	2975	1060	86700	1155
B. Deposits in neighbourhood							
Siddeswar	500	1.40	75	1050	1060	42000	590
Tamapahar	500	1.11	55	610	1060	30800	340
Turamdih	250	1.57	70	1100	1060	56700	890
Namdup	145	1.29	25	320	1060	22800	290
Ramchandrapahar	130	1.50	13	190	1060	12100	175
Dhadkidih	120	1.42	25	350	1060	23500	330
Sub-Total B		1.38	263	3620	1060	187900	2615
West Sector							
C. Exploited mines							
Khetri	530(350)	0.91(0.91)	75(100)	[illegible]700(910)	1060	34200	310
Kolihan	560(388)	1.15(1.54)	40(78)	460(1200)	1060	19700	225
Chandmari	46	1.31	35	455	1060	35500	460
Sub-Total - C		1.08	150	1615	1060	89400	995
D. Deposits in neighbourhood							
Akwali	150	1.50	10	150	1060	9100	135
Banwas	170	1.90	15	285	1060	13300	250
Dholamula	150	0.95	10	95	1060	9100	85
Bhagoni	250	1.07	20	210	1060	16200	170
Basautgarh	180	1.92	15	285	1060	13200	250
Sub-Total - D		1.46	70	1025	1060	60900	890
Sub-Total (C+D)		1.20	220	2640	1060	150300	1885
Central Sector							
E. Malanjkhand							
Main-lode	300	1.13	385	4350	1060	292600	3306
Main lode hanging wall lode	120	1.50	55	825	1060	51700	775
		1.28	440	5175	1060	344300	4081
Exploited mines		1.19	750	8940	1060	488700	5456
Deposits in neighbourhood		1.14	388	5470	1060	300500	4280
Grand Total		1.27	1138	14410	1060	769200	9736

Appendix Cu-III

Average Consumption of Inputs For Production of One Tonne of Copper Ore at Mosabani Mines of HCL During the Ten Year Period Ending 1984-85

	Items	Unit	Quantity per tonne	Cost in Rs./ tonne	Cost in Rs./per Rupee Value of Ore
A	Consumable Stores				
	- Steel	kg.	1.36	4.68	0.03
	- Cement	kg.	1.97	2.36	0.01
	- Explosives	kg.	0.31	5.07	0.03
	- Timber			6.25	0.04
	- Others			14.38	0.08
B	Maintenance Stores				
	- Spare Parts			9.46	0.06
	- Lubricants			1.86	0.01
C	Fuels			0.85	-
D	Electricity	KWH	40.15	13.25	0.07
E	Manpower			107.08	0.62
F	Others			7.85	0.05
				173.27	1.00

Note: Cost refers to the average cost of input delivered at the plant during the period under consideration.

- Value refers to the exmine value of ore exclusive of the all taxes and duties.

Appendix Cu — IV

Weighted Average of Inputes Consumed For Production of One Tonne of Copper Ore During the Period 1979-80 to 1984-85 at Small Mines Operated by Karnataka Mining Corporation - A State Government Undertaking.

	Items		Unit	Quantity per tonne of Ore	Cost in Rs. per tonne of Ore	Cost in Rs./per Rupees Value of Production of Ore
A	Consumable Stores					
	- Steel		kg.	1.04	5.18	0.03
	- Cement		kg.	2.72	1.40	0.01
	- Explosives		kg.	0.55	7.70	0.05
	- Detonators		Nos	2.20	4.33	0.02
	- Drill Bits		Nos*	11.66	3.33	0.02
	- Timber				1.04	0.01
B	Maintenance Stores					
C	Electricity		KWH	79.31	19.83	0.12
D	Manpower				87.34	0.52
	- Managerial & Supervisory	30	Nos			
	- Skilled & Semi-skilled	291	Nos			
	- Others	414	Nos			
					167.83	1.00

Note: * indicates per '000 tonnes of production of Copper Ore.

Appendix Cu - V

Inputs Consumed For Production of One Tonne of Copper Concentrates In Small Concentrators By The State Government During The Period 1979-80 to 1984-85

	Item	Unit	Quantity per tonne	Cost in Rs. per tonne	Cost in Rs./ Rupee Value of Output
1	Copper Ore	Tonne	21.11	3542.89	0.895
2	Reagents				
	- Lime	Kg	23.28	14.08	-
	- Pineoil	Kg	0.54	18.84	-
	- Xanthate	Kg	0.16	3.79	-
3	Electricity	KWH	633.26	158.36	0.040
4	Lubricants	Litres	1.00	8.00	
5	Spares (Bearings, pump casing, Spares, linings, conveyor, beltings etc.)			134.50	0.035
6	Manpower			121.82	0.030
	- Managerial & Supervisory	14 Nos			
	- Skilled	11 Nos			
	- Semi-skilled	30 Nos			
	- Unskilled	26 Nos			
				4002.28	1.00

Appendix Cu-VI

Production of Copper Ore in India
(1975-1984)

(in Tonnes)

Year	All India	A.P.	Bihar	Karnataka	M.P.	Orissa	Rajasthan	Sikkim
1975	1,838,468	2,739	1,038,086	61,055	-	-	736,588	-
1976	2,395,275	-	1,185,095	71,935	-	-	1,137,445	-
1977	2,551,888	5,050	1,280,669	69,365	-	-	1,196,154	650
1978	2,132,098	939	1,086,031	57,229	-	-	987,870	29
1979	2,156,552	-	988,167	45,744	-	-	1,124,471	170
1980	2,005,436	-	1,145,386	42,981	-	-	816,669	400
1981	2,109,007	1,972	1,247,482	51,662	-	-	807,241	650
1982	2,478,935	1,861	1,347,895	50,007	462,443	-	616,439	290
1983	3,423,555	1,015	1,300,378	61,288	1,110,976	160	949,532	206
1984	3,893,651	1,872	1,298,467	62,928	1,296,427	780	1,232,707	470

Source: Indian Bureau of Mines, Mineral Statistics of India, April 1985.

Appendix Cu-VII

Average of Inputs Consumed for Production of One Tonne of Refined Copper During The Period 1979-80 to 1984-85 at HCL Refineries

	Item	Unit	Quantity per tonne	Cost in Rs. per tonne	Cost in Rs./ Rupee Value of Refined Copper
1	Anode Copper	Tonne	1.22	30,500.00	0.98
2	Electricity*	KWH	750.00	247.50	
3	Reagents**				
	- Sulphuric acid	kg	45.00	18.45	
	- Thio Urea	gm	25.00		
	- Avitone	gm	60.00		
	- Gellatine	gm	120.00	10.25	
	- Hydrochloric acid	gm	70.00		
4	Steam***				0.02
	- at 3 kg/cm^2 pressure	Tonne	1.02	122.40	
	- at 12 kg/cm^2 pressure	Tonne	0.38	30.40	
5	Water****	m^3	1.55	0.43	
6	Mill Scale	kg	7.91	-	
7	Manpower			110.09	
				31,046.52	1.00

* = About 80% of electricity consumption is on account of electrolytic power and 20% on account of motor drive, lighting etc.

** = Sulphuric acid is required for the production of copper sulphate crystals and for dissolving mill scale. The other reagents are added in the electrolyte for smooth and efficient deposition of copper on the cathode.

*** = Steam is used for heating up of electrolyte, cathode washing and stacking machine, slime leaching tank and the copper sulphate section.

**** = Water is mainly required for mill scale dissolver, in the copper sulphate plant cooling tower, as make up water, floor washing of purification section and for slime leaching.

Resources Available, Resources utilised, Working Results and Profit/Loss of Hindustan Copper Ltd.

Appendix Cu - VIII

(Rs. million)

Details	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85
A. Resources Available													
1. Paid up Capital	638.6	713.4	714.3	715.9	797.0	859.1	1000.7	1268.4	1467.4	1606.8	1852.8	2002.8	2196.9
2. Loans	323.5	448.5	658.0	884.5	930.8	964.0	943.7	923.00	1062.9	1430.5	1680.2	1808.5	2243.6
3. Working Capital loans from Central Govt.	-	-	-	-	-	-	70.0	36.7	36.7	57.9	202.6	202.6	-
4. Cash Credit/Advances	35.5	88.2	152.0	179.9	141.5	147.8	132.5	87.1	207.3	214.8	272.7	248.6	192.7
5. Internal Resources	109.7	194.3	279.0	3173.0	425.7	554.5	651.0	675.9	651.0	930.0	1084.2	1288.8	1515.4
Sub-total	1107.3	1444.4	1803.3	2097.6	2295.0	2525.4	2797.9	2991.1	3580.1	4248.0	5092.5	5551.3	6148.6
B. Resources utilised on													
1. Gross Block	374.6	631.0	1012.6	1159.8	1349.6	1545.4	1633.6	1815.6	2011.7	2224.3	[illegible]	2940.8	3217.0
2. Unallocated Expenditure during construction	260.9	262.5	241.4	263.3	273.5	235.7	25.2	35.4	29.3	70.7	51.5	24.2	11.6
3. Capital works in progress	227.7	258.0	119.9	106.2	37.4	54.4	63.6	190.0	303.3	375.7	248.0	256.9	388.6
4. Others	-	-	-	-	-	-	252.1	314.8	433.0	542.6	664.8	855.7	996.4
5. Working capital	244.1	292.9	429.4	567.5	634.5	349.1	434.5	381.6	441.3	250.3	299.9	344.6	374.8
6. Deficit	-	-	-	0.8	-	340.8	388.9	253.7	361.5	784.4	1062.7	1129.6	1160.2
Sub-Total	1107.3	1444.4	1803.3	2097.6	2295.0	2525.4	2797.9	2991.1	3580.1	4248.0	5092.5	5551.3	6148.6
C. Working Results													
1. Net Income	191.3	230.3	312.6	377.7	826.6	825.5	706.4	1031.3	928.9	1016.2	1090.2	1665.3	2308.9
2. Expenses in Production	150.7	154.1	237.4	314.9	707.6	1034.7	644.8	874.7	917.8	1311.2	1189.9	[illegible]	2284.2
3. Gross Profit/Loss	40.6	76.2	75.2	62.8	119.0	(-)209.2	61.6	156.6	11.1	(-)295.0	(-) 99.7	56.5	24.7
4. Interest	15.0	32.4	50.9	85.8	98.9	101.9	109.7	113.2	119.6	130.5	196.6	124.3	56.1
5. Tax Provision	-	-	-	-	-	-	-	-	-	-	-	-	-
6. Net Profit/Loss	25.6	43.8	24.3	(-)23.0	20.1	(-)311.1	(-)48.1	43.4	(-)108.5	(-)425.5	(-) 296.3	(-)67.8	(-) 31.4

Source: Government of India, Bureau of Public Enterprises, Public Enterprises Survey, Volume 3, Various Issues.

Analysis of Changes in Structure of Balance Sheets, Profits and Loss Statements of Hindustan Copper Ltd.

Appendix Cu -

Financial And Management Ratios	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85
A. General							
1. Capital Employed (Rs. Million)	1589.3	1601.8	1728.1	1615.6	2044.3	2061.0	2142.1
2. Value of Production (Rs. million)	722.0	892.3	90.70	844.3	1217.9	1545.1	2013.9
3. Value of Production / Capital Employed (%)	45.4	55.7	52.5	52.3	59.6	75.0	94.0
4. Cost of Production (Rs. Million)	779.3	861.6	1030.1	1291.2	1538.7	1692.6	2136.9
5. Material cost / Cost of production (%)	23.0	26.9	28.1	31.1	30.3	25.0	24.0
6. Man Power Cost / Cost of Production (%)	21.2	25.1	24.6	22.6	20.8	24.4	23.4
7. Value Added (Rs. Million)	429.0	590.4	465.9	232.5	472.1	780.4	1091.7
8. Value Added / Capital Employed (%)	27.0	36.9	27.0	14.4	23.1	37.9	51.0
B. Sales							
9. Cost of Sales (Rs. million)	693.5	892.7	955.1	1347.0	1276.4	1605.8	2208.4
10. Cost of Sales / Net Sales (%)	109.0	96.7	114.8	149.7	133.6	110.1	105.9
11. Net Sales / Capital Employed (%)	40.0	57.6	48.1	55.7	46.7	70.7	98.4
12. Net Sales / Current Assets (%)	77.2	104.5	77.6	84.3	73.6	99.1	136.4
(C) Personnel							
13. No. of employees	23,638	24,415	25,376	25,846	26,071	26,248	26,634
18. Average Capital Employed / Employees (Rs.)	67,235	65,607	68,100	62,509	78,413	78,520	80·427
14. Value of production per man month (Rs.)	2,545	3,046	2,979	2,722	3,893	4,905	6,301
14. Value added per manmonth (Rs.)	1,512	2,015	1,530	750	1,509	2,478	3,416
18. Average monthly sales per employee (Rs.)	2,243	3,152	2,732	2,902	3,054	4,629	6,525
(D) Financial							
16. Gross Margin / Capital employed (%)	10.6	16.5	6.7	Loss	2.0	13.8	13.3
17. Gross Profit / Capital employed (%)	3.9	9.8	0.6	Loss	Loss	2.7	1.2
18. Gross Profit / Net Sales (%)	9.7	17.0	1.3	Loss	Loss	3.9	1.2
19. Profit-before-tax / Net worth (%)	Loss	4.0	Loss	Loss	Loss	Loss	Loss
20. Net Profit / Paid-up-capital (%)	Loss	3.4	Loss	Loss	Loss	Loss	Loss
21. R & D Expenditure / Net Sales (%)	0.5	0.0	0.3	0.3	0.5	1.5	0.2

Appendix Cu - X

Availability of Copper in India - Sourcewise
(Based on Production, Imports & Stocks)

(in tonnes)

	Item	1981	1982	1983	1984
I	Domestic production (wire bars)				
	i HCL, Ghatsila	5,156	7,465	7,989	7,276
	ii HCL, Khetri	9,631	7,601	11,596	11,375
	Total (i+ii)	14,787	15,066	19,585	18,651
II	Sales of Copper Cathodes (HCL, Khetri)	3,252	7,578	3,736	9,117
III	HCL, Ghatsila own use of Copper for Rolled Products	1,374	1,635	1,[illegible]	1,644
IV	Imports by MMTC				
	i Wire bars	34,584	43,465	47,[illegible]3	23,936
	ii Wire rods	6,486	10,533	12,911	3,335
	Total MMTC	41,070	53,998	60,964	27,271
V	Change in Stock	14,796	9,536	6,192	24,992
	Total* (I+II+III+IV)	75,279	87,813	92,297	80,775
	Import under R.P Licences**	15,000	15,000	15,000	15,000
	Total Availability	90,279	102,813	107,297	95,775

Source: * IOI, Indian Bureau of Mines, Consumption of Non-ferrous Metals in India, April-June 1985.

** Estimated on the basis of past imports under RP Licences.

Reserves of Copper Ore In Projects Under Consideration/Formulation

Appendix Cu-XI

Deposit	Location	In-Situ ore reserves in million tonnes and grade % Cu				Total Metal (000 tonnes)	Cut-off grade assumed % Cu	Vertical depth in metre	Installed/proposed mine capacity (tpd)	Life of the recoverable reserves in years
		Prowed	Probable	Possible	Total					
Project under consideration/ Formulation										
A. ICC group of HCL	Bihar									
1. Rakha Phase II	"	27.79 (1.25)	18.77 (1.25)	-	46.56 (1.25)	582	0.5	650	4000	23
2. Surda Phase II	"	Reserves included under exploited mines.								
3. Kendadih Phase II										
B. KCC Group of HCL										
4. Akwali 1/	Rajasthan	-	1.04 (1.60)	0.61 (1.33)	1.65 (1.50)	25	0.4	150	200	8
C. Other Projects										
5. Ambamata of GMDC	Gujarat	-	7.13 (1.59)	0.44 (2.05)	7.57 (1.62)	122	-	-	-	-
6. Deri 3/ of RSMDC	Rajasthan	-	0.58 (1.13)	0.24 (1.13)	0.82 (1.13)	9	-	-	-	-
Total Projects		27.79 (1.25)	27.52 (1.35)	1.29 (1.54)	56.60 (1.30)	738				

Note:-

1/ Life is computed on the basis of feasibility report 0.8 million tonnes of mineable reserves at 60% recovery

2/ This is polymetallic deposit of lead, zinc and copper besides copper the ore analysis 3.23% lead and 5.46% zinc. Feasibility report has been prepared by RTZC.

3/ This is also polymetallic deposit with lead, zinc and copper.

**

GMDC = Gujarat Mineral Development Corporation - A State Undertaking.

RSMDC = Rajasthan State Mineral Development Corporation - A State Undertaking.

Reserves of Copper In Deposits: Apparently Viable

(As on 31-3-1983)

Appendix Cu-XII

Deposit	Location	Lease-hold or Free-hold	In-Situ ore reserves in million tonnes and grad percentage: Proved	Probable	Possible	Total	Total Metal ('000 tonnes)	Cut-off grade assumed % Cu	Vertical depth in metres	Installed/proposed mine capacity	Life of the recoverable reserves in years
1. Turamdih	Bihar	Partly Freehold	-	17.85 (1.57)	-	17.85 (1.57)	280	1.0	250	-	-
2. Siddeswar	"	HCL lease	17.85 (1.40)	20.95 (1.40)	-	38.80 (1.40)	543	0.5	500	-	-
3. Tamapahar 1/	"	"	-	18.87 (1.08)	9.95 (1.16)	28.82 (1.11)	319	0.7	500	-	-
4. Bayawbill	"	Freehold	-	2.82 (1.21)	-	2.82 (1.21)	34	1.00	-	-	-
5. Nandup	"	"	-	-	4.00 (1.29)	4.00 (1.29)	52	-	145	-	-
6. Ramchandra Pahar	"	"	-	-	1.70 (1.50)	1.70 (1.50)	26	-	130	-	-
7. Dhadkidih	"	"	-	-	3.18	3.18	45	1.0	120	-	-
Sub-Total: Bihar			17.85 (1.40)	60.49 (1.34)	18.83 (1.26)	97.17 (1.34)	1299				
8. Dholamala	Rajasthan	Freehold	-	1.44 (1.00)	-	1.44 (1.00)	14	-	150	-	-
9. Banwas	"	HCL leasehold	-	2.64 (1.90)	-	2.64 (1.90)	50	0.50	170	-	-
10. Bhagoni	"	"	-	2.66 (1.07)	2.56 (1.07)	5.22 (1.07)	55	0.65	250	-	-
11. Basantgarh	"	"	-	3.19 (1.92)	-	3.19 (1.92)	61	0.50	180	-	-
Sub-Total: Rajasthan				9.93 (1.53)	2.56 (1.07)	12.49 (1.43)	180				
12. Malanjkhand 2/ (Hanging wall lode)	M.P.	HCL Mkt. leasehold	-	-	7.00	7.00	105	0.45	120	-	-
13. Dikchu 3/	Sikkim	SMC	0.26 (3.20)	-	-	0.26 (3.20)	8	-	75	-	-
14. Askot 4/	U.P.	Freehold	-	-	0.77 (2.32)	0.77 (2.32)	18	-	-	-	-
Total: Apparently viable reserves			18.11 (1.42)	70.42 (1.37)	29.16 (1.33)	117.69 (1.37)	1610				

Note:

1/ At 1% cut-off grade total reserves are 16.12 million tonnes with 1.4% copper

2/ Reserves approximate, exploration is continuing.

3/ Zinc content 1.46%.

4/ Polymetallic deposit Pb : 2.64%, Zinc : 3.95%.

Appendix Cu-XII

Copper Ore Reserves In Para - Marginal and Sub-Marginal Prospects
(As on 31.3.1983)

Deposit	Location	Lease hold(L.H) or Free-hold(F.H)	In-Situ Reserves In Million Tonnes And Grade % Cu				Total Metal ('000 tonnes)	Cut Off grade assumed % Cu	Verti depth metre
			Proved	Probable	Possible	Total			
1. Mainajheria	Bihar	L.H. of HCL	-	-	0.75 (1.00)	0.75 (1.00)	8	-	-
2. Bahargora	"	F.H.	-	-	3.88 (0.90)	3.88 (0.90)	35	0.7	29[illegible]
3. Baragonda	"	F.H.	-	-	0.50 (2.31)	0.50 (2.31)	12	-	-
4. Kesarpur	Orissa	F.H.	-	1.16 (1.59)	0.50 (1.59)	1.66 (1.59)	26	0.80	-
5. Raimal	Orissa	F.H.	-	-	0.70 (1.47)	0.70 (1.47)	10	-	-
6. Tamakhun	W.Bengal	F.H.	-	0.11 (1.85)	-	0.11 (1.85)	2	-	6[illegible]
7. Kolihan North	Rajasthan	L.H of HCL	-	1.03 (0.80)	0.26 (0.80)	1.29 (0.80)	10	-	-
8. Kolihan Intervening	"	L.H of HCL	-	-	0.35 (0.80)	0.35 (0.80)	3	-	27[illegible]
9. Akwali Extension	"	F.H.	-	1.04 (1.60)	0.61 (1.33)	1.65 (1.50)	25	0.40	-
10. Singhana	"	F.H.	-	-	2.95 (0.90)	2.95 (0.90)	26	-	-
11. Muradpur	"	F.H.	-	-	1.11 (0.71)	1.11 (0.71)	8	-	-
12. Satkui	"	F.H.	-	-	3.28 (0.99)	3.28 (0.99)	32	0.40	-
13. Pur-Dariba	"	F.H.	-	1.17 (1.03)	0.47 (1.03)	1.64 (1.03)	17	-	-
14. Banera (Debpura)	"	F.H.	-	1.00 (1.36)	0.51 (1.25)	1.51 (1.31)	20	0.80	17[illegible]
15. Banera Reserve Forest	"	F.H.	-	-	1.50 (0.89)	1.50 (0.89)	13	-	-
16. Chinchroli	"	F.H.	-	-	0.66 (1.15)	0.66 (1.15)	8	-	-
17. Surahari	"	F.H.	-	-	0.50 (1.20)	0.50 (1.20)	6	-	-
18. Balaswar	"	F.H.	-	-	1.00 (1.20)	1.00 (1.20)	12	-	-
19. Tejwala	"	F.H.	-	-	0.50 (0.80)	0.50 (0.80)	4	-	-
20. Satdudhia	"	F.H.	-	-	0.90 (1.35)	0.90 (1.35)	12		
21. Wari	Rajasthan	F.H.	-	0.80 (1.00)	-	0.80 (1.00)	8	0.50	15[illegible]
22. Malwali	"	F.H.	-	-	0.55 (1.35)	0.55 (1.35)	7	0.60	-
23. Golia	"	F.H.	-	-	1.00 (0.90)	1.00 (0.90)	9	-	-
24. Padar-Ki-Pal	"	F.H.	-	0.75 (1.43)	0.34 (1.12)	1.09 (1.33)	15	-	-
25. Khankhera	"	F.H.	-	-	0.22 (1.05)	0.22 (1.05)	2	4	-
26. Imalia	M.P.	F.H.	-	-	0.08 (0.98)	0.08 (0.98)	1	-	-
27. Thanewasna	Maharashtra	F.H.	-	-	3.20 (0.77)	3.20 (0.77)	25	-	2[illegible]
28. Pular-Parsori	"	F.H.	-	-	0.20 (1.95)	0.20 (1.95)	4	-	-
29. Kanchiganahalu	Karnataka	F.H.	-	0.22 (1.46)	-	0.22 (1.46)	3	-	-
30. Aladahalli	"	L.H. of KCCL	-	1.12 (1.24)	-	1.12 (1.24)	14	-	-

(Contd

Deposit	Location	L.H. or F.H.	In Situ Reserves In Million Tonnes And Grade % Cu Proved	Probable	Possible	Total	Total Metal '000 tonnes)	Cut Off grade assumed % Cu	Vertical depth in metres
31. Kallur	Karnataka	F.H.	-	2.48 (0.85)	-	2.48 (0.85)	21	-	90
32. Machanur	"	F.H.	-	1.80 (0.92)	-	1.80 (0.92)	17	-	250
33. Kalaspura	"	F.H.	-	-	1.00 (0.70)	1.00 (0.70)	7	-	-
34. Nallakonda	A.P.	F.H.	-	4.91 (1.48)	-	4.91 (1.48)	73	-	-
35. Dhukonda	"	F.H.	-	2.15 (1.51)	-	2.15 (1.51)	32	-	-
36. Gani-Kalava	"	F.H.	-	-	0.43 (1.37)	0.43 (1.37)	6	-	100
37. Mamandur 1/	Tamil-Nadu	F.H.	-	0.15 (0.68)	-	0.15 (0.68)	1	-	-
Sub-total: Prospects with more than 0.6% Cu. grade			-	19.89 (1.26)	27.95 (1.01)	47.84 (1.11)	534	-	-
38. Malanjkhand 2/ (Oxide ore)	M.P.	HCL	-	-	5.50 (0.58)	5.50 (0.58)	32	-	Upto 376MRL
39. Malanjkhand 3/ (Lean Sulphide Ore)	"	HCL	-	43.57 (0.22)	20.72 (0.33)	64.20 (0.26)	165	0.2to0.40	350(Upto 300 MRL)
40. Golwa Ganguthana 4/ (Mahindragarh)	Haryana	F.H.	-	-	15.00 (0.30)	15.00 (0.30)	45	-	100m
Sub-total: Prospects with less than 0.6% Cu Grade		-	-	43.57 (0.22)	41.22 (0.35)	84.79 (0.29)	242	-	-
Total Para-marginal and Sub-marginal Prospects			-	63.46 (0.55)	69.17 (0.63)	132.63 (0.59)	776	-	-

NOTE :- -

1/ Contains 1.14% Pb., 5.25% Zn and 30gm/tonne Ag.

2/ Within designed pit-limits.

3/ 44.0 million tonnes of ore with 0.22% Cu, within the designed pit-limits.

4/ 30m wide lode traced over 2.0 km. strike length.

Appendix Cu-XIV

Planned Mine & Smelter Production of Copper for Ten Years
(1985-86 to 1994-95)

(In tonnes)

Name of the Project	Ore (Tpd) ultimate capacity	Grade (%)	Annual recoverable metal at ultimate capacity	1985-86 1st year	1986-87 2nd year	1987-88 3rd year	1988-89 4th year	1989-90 5th year	1980-91 6th year	1991-92 7th year	1982-93 8th year	1983-94 9th year	1994-95 10th year
ing/Concentration													
Eastern Sector (Existing Projects)													
i) Mosabani	3200	1.22	10482	10482	10482	10482	10482	10482	10482	10482	10482	10482	10482
Surda	1300	0.90	3141	3141	3141	3141	3141	3141	3141	3141	3143	3141	3141
i) Pathargora	400	1.85	1128	1128	1128	1128	1126	1128	1128	1128	1128	1128	1126
Kendadih	200	1.33	714	714	714	714	714	714	714	714	714	714	714
v) Rakha	1000	0.96	2578	2578	2578	2578	2578	2578	2578	2578	2578	2578	2578
Eastern Sector (New Projects/Expn.)													
Surda Expansion	500	0.90	1208	-	-	-	1208	1208	1208	1208	1208	1208	1208
i) Kudadih	800	1.53	3286	-	-	-	-	-	3286	3286	3286	3286	3286
) Rakha Expansion	400	0.96	1031	-	-	-	1032	1031	1031	1031	1031	1031	1031
v) Integrated development Singhbhum Belt (Roam-Rakh II)	6000	1.05	16915	-	-	-	-	-	-	-	-	-	4230
Surda IIA	2200	0.95	5611	-	-	-	-	-	-	-	-	-	1480
Total I(a) & I(b)			46094	18043	18043	18043	20282	20282	23568	23568	23568	23568	29198
a) Western Sector (Existing Projects)													
i) Khetri	5000	0.70	8715	5230	6000	8715	8715	8715	8715	8715	8715	8715	8715
Kolihan	3000	1.60	11952	1968	9960	11952	11952	11952	11952	11952	11952	11962	11952
i) Chandmari	1000	0.85	2116	1900	2116	2116	2116	1900	-	-	-	-	-
Dariba	100	1.60	400	400	400	400	400	400	400	400	400	400	400
Western Sector (New Projects)													
) Akwali	200	1.36	677	-	-	-	677	677	677	677	677	677	677
Banwas	500	1.57	1955	-	-	-	-	1955	1955	1955	1955	1955	1955
II(a) and II(b)			25815	15498	18476	23183	23860	25599	23699	23699	23699	23699	23699
(a) Central Sector (Malanjkhand)	6700	1.30	23077	23077	23077	23077	23077	23077	23077	23077	23077	23077	23077
(b) Leaching			1300	-	-	-	-	-	1350	1350	1500	1500	1500
III(a) and III(b)			24577	23077	23077	23077	23077	23077	24427	24427	24577	24577	2457
al I, II and III			96486	56618	59596	64303	67219	68958	71694	71694	71844	71844	77474
Projects outside HCL			46837	50956	53634	57872	60497	62062	64525	64525	64660	64660	69727
Sikkim													
Chitradurga/Kalyadi													
Rajpura-Dariba													
Ambamata													
Mailaram													
Jduguda.													

Appendix Cu-XV

Yearwise Investment and Foreign Exchange Requirements for Future Copper Metal Development in the Central Sector
(1985-86 To 1989-90)

(In Rs. million)

	Estimated Cost		1985-86		1986-87		1987-88	
	Total	F.E.	Total	F.E.	Total	F.E.	Total	F.E.
1. Continuing Scheme								
Malanjkhand Project	1363.1	-	1.4	-	-	-	-	-
2. New Schemes								
A. Mining :								
a. Indian Copper Complex								
i. Minor Expansion of Surda	72.3	9.4	20.4	2.6	23.0	2.9	14.8	2.0
ii. Minor Expansion of Rakha	77.4	12.7	34.4	5.6	24.1	3.9	10.5	1.7
iii. Sanagora Vertical Shaft	509.40	127.5	-	-	-	-	63.0	15.5
iv. Integrated Development (Roam-Rakha II)	1300.0	325.0	-	-	-	-	162.5	40.6
v. Surda II	500.0	70.0	-	-	-	-	-	-
vi. Expansion of Kendadih Mine	257.2	15.0	16.0	9.0	57.0	3.3	93.0	5.4
vii. Exploratory Development	10.0	-	2.0	-	2.0	-	2.0	-
b. Khetri Copper Compex								
i. Kolihan Shaft Deepening	145.0	17.7	18.0	3.4	12.5	2.3	14.0	2.6
ii. Banwas Exploration	10.0	-	10.0	-	-	-	-	-
iii. Banwas Mine	104.0	20.8	-	-	-	-	26.0	5.2
iv. Khetri Shaft Deepening	260.0	65.0	-	-	43.0	10.7	50.0	12.5
v. Akwali	36.7	-	21.8	-	6.7	-	5.7	-
vi. Exploratory Development	10.0	-	2.0	-	2.0	-	2.0	-
c. Malanjkhand Copper Project								
i. Exploratory Development	10.1	-	4.0	-	2.0	-	2.0	-
B. Concentrator								
Indian Copper Complex Surda Concentrator	575.3	20.0	28.9	1.0	259.9	9.0	173.3	6.0
C. Metallurgical Projects								
a. Indian Copper Complex								
i. Expansion of Smelter	52.0	5.4	5.4	6.0	16.9	1.7	29.7	3.1
ii. Expansion of Refinery	219.9	59.5	10.2	2.7	37.3	10.0	73.4	19.8
iii. Expansion of by-product Plant	93.0	7.7	11.0	9.0	34.6	2.8	47.4	4.0
iv. Rolling Mill Modernisation	30.0	-	5.0	-	10.0	-	7.5	-
v. Acid Plant Expansion	89.4	6.6	34.0	2.6	55.4	4.0	-	-
vi. Moly Recovery Plant	15.0	-	5.0	-	10.0	-	-	-
b. Khetri Copper Complex								
i. Expansion of Smelter	306.3	22.8	43.3	3.2	105.4	7.8	149.5	11.1
ii. Expansion of Refinery	277.6	76.4	13.1	3.6	44.7	12.3	108.0	29.7
iii. Contop Smelter	125.4	46.4	31.3	11.5	62.7	23.2	31.4	11.7
iv. Expansion of Acid Plant	50.0	12.5	12.5	3.1	25.0	6.2	12.5	3.2
c. Malanjkhand								
i. Leaching Experimental	15.0	7.0	7.5	3.5	7.5	3.5	-	-
ii. Leaching Project	100.0	20.0	-	-	-	-	40.0	8.0
d. Other Metallurgical Projects								
i. Continuous Cast Copper Rod	211.0	62.4	23.0	6.8	58.2	17.2	129.8	38.4
D. Industrial Housing	100.0	-	20.0	-	20.0	-	20.0	-
E. Power Generation								
i. Gas Turbine of KCC (2 x 10 MW)	220.0	130.0	70.0	30.0	-	-	-	-
ii. Replacement of Boiler	70.0	15.0	40.0	5.0	-	-	-	-
iii. Captive Thermal Plant at ICC (3 x 30 MW)	1600.0	-	320.0	-	320.0	-	320.0	-
F. Pre-feasibility Studies	80.0	40.0	16.0	8.0	16.0	8.0	16.0	8.0
G. Science Technology								
i. Continuing Schemes	-	-	-	-	-	-	-	-
ii. New Schemes Mining, Beneficiation & Metallurgy	20.0	10.0	4.0	2.0	4.0	2.0	4.0	2.0
H. Replacement and Renewal	1000.0	10.0	200.0	2.0	200.0	2.0	200.0	2.0
	9915.1	1214.8	1030.2	99.0	1459.9	132.8	1808.0	232.5

Contd.../-

Appendix Cu - XV (Contd.)

(In Rs. million)

	1988-89 Total	1988-89 FE	1989-90 Total	1989-90 FE	Total VII Plan Total	Total VII Plan FE	Spill over to VIII Plan Total	Spill over to VIII Plan FE
Continuing Scheme								
Malanjkhand Project	-	-	-	-	1.40	-	-	-
New Schemes								
Mining								
a. **Indian Copper Complex**								
i. Minor Expansion of Surda	14.1	1.9	-	-	72.3	9.4	-	-
ii. Minor Expansion of Rakha	8.4	1.5	-	-	77.4	12.7	-	-
iii. Sonapura Vertical Shaft	80.0	20.0	80.0	20.0	223.0	55.5	286.4	72.0
iv. Integrated Development (Mosa-Rakha - II)	180.0	45.0	180.0	45.0	522.5	130.6	777.5	194.4
v. Surda II	-	-	100.0	14.0	100.0	14.0	400.0	56.0
vi. Expansion of Kendadih Mine	49.0	42-	42.2	2.5	257.2	15.0	-	-
vii. Exploratory Development	2.0	-	2.0	-	10.0	-	-	-
b. **Khetri Copper Complex**								
i. Kolihan Shaft Deepening	18.5	3.5	30.5	5.9	93.5	17.7	23.2	-
ii. Banwas Exploration	-	-	-	-	10.0	-	-	-
iii. Banwas Mine	30.0	6.0	30.0	6.0	86.0	17.2	18.0	3.6
iv. Khetri Shaft Deepening	50.0	12.5	50.0	12.5	193.0	48.2	67.0	16.8
v. Akwali	2.5	-	-	-	36.7	-	-	-
vi. Exploratory Development	2.0	-	2.0	-	10.0	-	-	-
c. **Malanjkhand Copper Project**								
i. Exploratory Development	2.1	-	-	-	10.1	-	-	-
Concentrator								
Indian Copper Complex Surda Concentrator	113.2	4.0	-	-	575.3	20.0	-	-
Metallurgical Projects								
a. **Indian Copper Complex**								
i. Expansion of Smelter	-	-	-	-	52.0	5.4	-	-
ii. Expansion of Refinery	99.0	27.0	-	-	219.9	59.5	-	-
iii. Expansion of by-product Plant	-	-	-	-	93.0	7.7	-	-
iv. Rolling Mill Modernisation	7.5	-	-	-	30.0	-	-	-
v. Acid Plant Expansion	-	-	-	-	89.4	6.6	-	-
vi. Moly Recovery Plant	-	-	-	-	15.0	-	-	-
b. **Khetri Copper Complex**								
i. Expansion of Smelter	8.1	7.0	-	-	306.3	22.8	-	-
ii. Expansion of Refinery	111.8	30.8	-	-	277.6	76.4	-	-
iii. Contop Smelter	-	-	-	-	125.4	46.4	-	-
iv. Expansion of Acid Plant	-	-	-	-	50.0	12.5	-	-
c. **Malanjkhand**								
i. Leaching Experimental	-	-	-	-	15.0	7.0	-	-
ii. Leaching Project	30.0	6.0	30.0	6.0	100.0	20.0	-	-
d. **Other Metallurgical Projects**								
i. Continuous Cast Copper Rod	-	-	-	-	211.0	62.4	-	-
D. **Industrial Housing**	20.0	-	20.0	-	100.0	-	-	-
Power Generation								
i. Gas Turbine of KCC (2 x 10 MW)	-	-	-	-	70.0	30.0	-	-
ii. Replacement of Boiler	-	-	-	-	40.0	5.0	-	-
iii. Captive Thermal Plant at IBC (3 x 30 MW)	320.0	-	320.0	-	1600.0	-	-	-
F. **Pre-Feasibility Studies**	16.0	8.0	16.0	8.0	80.0	40.0	-	-
G. **Science Technology**								
i. Continuing Schemes	-	-	-	-	-	-	-	-
ii. **New Schemes**								
Mining, Beneficiation and Metallurgy	4.0	2.0	4.0	2.0	20.0	10.0	-	-
H. **Replacement and Renewal**	200.0	2.0	200.0	2.0	1000.0	10.0	-	-
	1368.2	173.8	1106.7	123.9	6773.0	762.0	1572.1	342.6

Appendix AI - I

Resources of Bauxite In Exploited Captive Mines In India (As on 31st March 1983)

Company	Alumina Plant: Location	Alumina Plant: Annual capacity (in tonnes)	Major source of Bauxite Means of Transport and Distance from Alumina Plants: Mine location	Distance & mode of transport to railhead	Distance & mode of transport to alumina plant from railhead	Total distance between mine & alumina plant	Annual capacity of mine in tonnes	Resources in million tonnes	Chemical analysis (%): Al_2O_3	SiO_2	Fe_2O_3	TiO_2
Bharat Aluminium Co. (BALCO)	Korba Bilaspur Dist. M.P.	200,000	(i) Raktidadar & Nanboodadar in Amarkantek Dist. (M.P.)	16.6 km. by 150 tph bicable ropeway to Chuktipani railhead	190 km. by broad gauge	106.6 km.	320,000	On the verge of depliction	49.83	3.24	16.60	7.2
			(ii) Phutkapahar, Bilaspur Dist. M.P.	18.6 km. by 50 tph bicable ropeway to the alumina plant	-	18.6 km.	80,000	On the verge of depliction	49.0	3.17	16.23	7.2
			(iii) Gandhmardan hills in Sambalpur Distt. Orissa (under construction)	3.5 km. by 200 tph bi cable ropeway	366 km. by broad gauge	369.5 km.	600,000	230.0	46.70	2.70		
Hindustan Aluminium Corporation (HINDALCO)	Renukoot Mirzapur Distt. (U.P.)	150,000 under expansion to 300,000	(A) i Maidanpet) ii Birhnipet) of HINDALCO and	62 km. by road	268	330 km.	1,50,000	5.0	49.65	2.46	10.50	9.6
			iii Maidnapet) iv Pakhar) v Banrobar) of Minerals & minerals Ltd.(a subsidiary of HINDALCO) in Ranchi Dist. Bihar	8 km. by tph bicable ropeway to Richigula Railhead	250 by broad gauge	258km.	100,000	5.0	49.00	2.84	16.48	8.4
			(B) Amarkantak Mines Mandla Distt. M.P.	28.96 km. to 48.0 km. to Pendra road Rly station	776 km.	804.92 to 824	1,00,000	30.68	50.16	2.72	16.23	9.
Indian Aluminium Co.Ltd. (INDAL)	(A) Muri, Dhanbad Distt. Bihar	72,000	Lohardaga, Ranchi Dist. Bihar (i) Bagruhill (ii) Hisri (iii) Bhusar (iv) Serangdag	9.6 km. by 40 tph monocable	128 km by narrow gauge & 65 km. by broad gauge	202.6	2,00,000	13.5	49.29	3.59	9.6	12.
	(B) Belgaum, Karnataka	1,54,000	Ngartaswadi Mines in Kolhapur Dist. Maharashtra	58 km. by road		58 km.	450,000	65.5	65.0	0.02	0.15	0.0?7

Contd.........2/-

ompany	Alumina Plants: Location	Alumina Plants: Annual capacity (in tonnes)	Major source of bauxite Means of Transport and Distance from Alumina Plants: Mines location	Distance & mode of transport to railhead	Distance & mode of transport to alumina plant from railead	Total distance between mine & alumina plant	Annual capacity of mine in tonnes	Resource in million tonnes	Chemical Analysis (%): Al_2O_3	SiO_2	Fe_2O_3	TiO_2
Madras Aluminium Co. (MALCO)	Mettur Salem Dist. Tamilnadu	32,600	Shereanoy-hill Salem Dist. Tamilnadu	80 Km by road	-	80 km.	80000	9.657	42.52	5.22	27.60	1.47
National Aluminium Co. Ltd. (NALCO)	Damanjodi Koraput Dist. Orissa	800,000	Panchapatnali, Koraput Dist. Orissa	14 km. by belt conveyor system	-	14 km.	2,400,000	375.0	46.80	2.65		
al of resources of xite in captive mines								734.337				

urces: Based on the information received from Primary Aluminium Producers.

Appendix AI - II

Weighted Average of Inputs Consumed for Production of One Tonne of R.O.M. During the Period 1973-74 to 1984-85 in A Mechanised Bauxite Mine with Annual Capacity of 0.45 Million Tonnes Per Year (Private Sector)

	Item	Unit	Quantity per tonne	Cost in Rs. per tonne	Cost in Rs. per Rupee Value of Bauxite
A	Consumable Store				
	- High Explosives	kg	0.40	3.43	0.14
	- Detonators	Nos	0.06	-	-
	- Drill bits	Nos*	3.00	0.17	0.01
B	Maintenance Store				
	- Spare parts			5.58	0.22
	- Lubricants			0.63	0.03
	- Others			0.27	0.01
C	Fuels	Litres	0.90	1.41	0.06
D	Electricity	KWH	0.70	0.51	0.02
E	Manpower Deployed			4.01	0.16
	- Managerial & Supervisory (22 Nos)			1.25	
	- Skilled (74 Nos)			1.54	
	- Semi-skilled (35 Nos)			0.83	
	- Unskilled (15 Nos)			0.31	
	- Others (10 Nos)			0.08	
F	Others Items (Not specified)			9.01	0.35
				25.02	1.00

Note: * indicates the number consumed per thousand tonnes of Bauxite.

R.O.M. stands for Run-Of-Mine.

Appendix AI - III

Weighted Average of Inputs Consumed For Production of One Tonne of R.O.M. During the Period 1973-74 to 1984-85 in A Mechanised Bauxite Mine with Annual Capacity of 0.20 Million Tonnes Per Year (In Private Sector)

	Item	Unit	Quantity per tonne	** Cost in Rs. per tonne	Cost in Rs.*** per Rupee Value of Bauxite Produced
A	Consumable Store				
	- Cement	kg	0.18	0.12	-
	- Explosive & Detonators			3.21	0.12
	- Drill Bits	Nos*	1.68	0.07	
B	Maintenance Store				
	- Spare Parts			12.54	0.44
	- Lubricants	Litres	0.15	1.41	0.05
C	Fuels	Litres	2.29	4.07	0.14
D	Electricity	KWH	2.62	2.28	0.08
E	Man Power Employed				
	- Managerial & Supervisory	(20 Nos)		4.[illegible]	0.17
	- Skilled	(50 Nos)			
	- Semi-skilled	(27 Nos)			
	- Un-skilled	(80 Nos)			
	- Others	(28 Nos)			
				28.3[illegible]	1.00

Note: * Consumption refers to those per tonne of output.
** Cost refers to the average cost prevailing during the period.
*** Value refers to the Ex-mine value of production excluding duties royalty and cess.

Appendix AI - IV

Weighted Average of Inputs Consumed For Production of One Tonne of R.O.M. During the Period 1973-74 to 1984-85 in A Mechanised Bauxite Mine with Annual Capacity of 0.88 Million Tonnes Per Year (In Private Sector)

	Item	Unit	Quantity per tonne	Cost in Rs. per tonne	Cost in Rs. per Rupee Value of Production
A	Consumable Store				
	- Explosives	kg	1.21	7.11	0.11
B	Maintenance Store				
	- Spare Parts - Lubricants - Others			11.27	0.17
C	Fuels			5.03	0.07
D	Electricity			1.53	0.02
E	Manpower and Other Inputs (not specified)			42.28	0.63
	- Managerial & Supervisory (15 Nos)				
	- Skilled (33 Nos)				
	- Semi-skilled (138 Nos)				
	- Unskilled (1[illegible] Nos)				
				67.22	1.00

Appendix AI - V

Consumption of Inputs per Tonne of Alumina in a Plant with a Capacity of 0.15 Million Tonne Per Year Situated Away From The Mines.

	Particulars	1977 Quantity (tonnes)	1977 Rate (Rs)	1977 Value (Rs)	1980 Quantity (tonnes)	1980 Rate (Rs)	1980 Value (Rs)	1983 Quantity (tonnes)	1983 Rate (Rs)	1983 Value (Rs)
1	Bauxite	2.7775	79.05	219.55	2.7312	98.66	269.47	2.8459	156.79	446.22
2	LD oil/HSD oil ([illegible])	0.0002	1072.64	0.25	0.00036	1990.82	0.72	0.00029	3349.08	0.98
					0.00013	2430.45	0.30			
3	Caustic Soda	0.0907	2035.54	184.59	0.09076	5127.53	465.38	0.0895	5329.83	476.87
4	Lime	0.0378	306.18	11.58	0.05925	472.63	28.00	0.0756	609.14	46.05
5	Starch	0.0023	2581.39	5.99	0.00119	3708.82	4.43	0.0010	5279.64	5.47
6	Filter Cloth (m)	0.6016	15.90	9.59	0.76668	15.06	11.53	0.1454	54.82	7.97
7	Soda Ash	0.0187	1175.82	22.01	0.01659	2335.16	38.74	0.0186	2767.67	51.46
8	Morar Floc	0.0001	8283.80	1.00	0.00037	11034.00	4.07	0.00018	15210.41	2.81
9	Steam Coal	0.9137	107.70	98.42	0.93138	175.84	163.78	1.0804	260.27	281.20
10	Fuel Oil (KL)	0.1341	1007.73	135.10	0.13928	1707.64	237.85	0.1351	2812.93	380.00
11	Electricity (KWH)	387	0.143	55.38	391	0.226	88.54	397	0.3488	138.50
12	Water Charges	-	-	-	-	-	0.91	-	-	1.34
13	Wages			46.98			65.21			91.03
14	Salary			27.68			36.38			46.57
15	Repair & Maintenance			11.12			19.51			2.70
16	Consumable Store			77.31			91.22			110.97
	C[illegible] Cost			906.55			1526.04			2090.14
	Total Cost			992.03			1617.92			2135.28

Appendix AI - VI

Weighted Average of Input Consumed for Production of One Tonne of Alumina During the Period of 1979-80 to 1985-86 at A Plant With Capacity of 0.154 Million Tonnes Per Year and Situated Near The Bauxite Mines.

	Item	Unit	Quantity per tonne	Cost in Rs. per tonne	Cost in Rs. per Rupee of Alumina
1	Bauxite	Tonne	2.89	158.00	0.13
2	Reagents				
	Sodium Carbonate (Na_2CO_3)	kg	121.00	268.46	0.25
	Lime	kg	15.30	6.00	0.01
	Starch	kg	2.00	5.85	0.01
3	Energy				
	Electricity	KWH	238.67	48.26	0.04
	Fuel Oil	Litres	312.33	415.40	0.35
4	Stores				
	Filter Cloth	Metres	0.40	6.93	0.01
	Spares			64.00	0.05
5	Water			3.33	
6	Manpower			62.33	0.05
7	Others			113.00	0.10
				1171.56	1.00

Appendix AI - VII

Weighted Average of Inputs Consumed For Production of One Tonne of Alumina During The Period of 1978-79 to 1985-86 at The Plant With Annual Capacity of 72,000 And At A Medium Distance From The Mines

	Item	Unit	Quantity per tonne	Cost in Rs. per tonne	Cost in Rs. per Rupee Value of Output
1	Bauxite	Tonnes	3.10	185.45	0.17
2	Reagents				
	Na_2CO_3	kg	132.28	364.82	0.33
	Starch	kg	2.48	8.06	0.01
	Lime	kg	22.19	6.70	0.01
3	Energy				
	Coal	kg	1,254.44	19[illegible].87	0.18
	Fuel	Litres	103.71	142.35	0.13
	Electricity	KWH	326.32	35.63	0.03
4	Stores				
	Lubricants			3.33	
	Spares			56.68	0.05
	Filter Cloth	Metres	8.65	10.28	0.01
5	Manpower			101.62	0.08
	i Managerial (31 Nos)				
	ii Supervisory (90 Nos)				
	iii Skilled (162 Nos)				
	iv Unskilled (20[illegible] Nos)				
	v Others (30 Nos)				
				1,113.79	1.00

Appendix AI- VIII

Cost of Production of One Tonne of Alumina In The Integrated Alumina Facilities In Jamaica (1980)

(US$ per tonne)

Capacity of Alumina Plant in Tonne/Year*	Plant A 1,180,000		Plant B (550,000)x2		Plant C 550,000	
	$	%	$	%	$	%
Raw Materials						
Bauxite (excl. levy)	15.17	9.36	13.58	12.44	11.93	10.56
Lime	1.85	1.14	2.79	2.56	1.54	1.36
Caustic Soda	14.75	9.10	10.91	10.00	17.21	15.23
Flocculants	3.34	2.06	2.26	2.07	3.16	2.80
Others	1.47	0.90	0.26	0.24	-	-
Operating Supplies						
Fuel	94.63	58.36	54.62	50.09	51.81	45.85
Others	4.69	2.89	0.75	0.69	1.96	1.73
Utilities						
Steam. Power, Water	-	-	4.35	3.99	-	-
Labour & plant maintenance	26.25	16.19	19.53	17.91	25.39	22.47
Cash Cost	162.15	100.00	109.05	100.00	113.00	100.00
Other Costs	49.85		24.35		35.54	
Bauxite Levies	42.43		41.15		45.69	
	254.43		174.55		194.23	

Source: Jamaican Bauxite Institute.

Appendix AI - IX

Companywise Capacity, Production and Capacity Utilisation

Company	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
INDAL										
I.C ('000 tonnes)	96.00	96.00	96.00	96.00	96.00	96.00	96.00	96.00	117.00	117.00
Production ('000 tonnes)	78.40	84.50	65.90	82.70	81.00	58.10	87.90	70.60	51.70	48.00
Capacity Utilisation (%)	81.87	88.02	68.65	86.15	84.38	60.52	91.56	73.54	44.19	41.00
HINDALCO										
I.C. ('000 tonnes)	95.00	95.00	95.00	95.00	100.00	100.00	120.00	120.00	120.00	120.00
Production ('000 tonnes)	62.40	83.60	73.10	66.00	77.80	75.40	77.30	90.70	93.90	126.00
Capacity Utilisation (%)	65.68	88.00	76.95	69.47	77.80	75.40	64.42	75.58	78.25	105.00
BALCO										
I.C. ('000 tonnes)	25.00	40.00	52.00	83.00	100.00	100.00	100.00	100.00	100.00	100.00
Production ('000 tonnes)	16.30	24.70	38.60	33.50	29.50	16.00	28.80	34.80	61.30	87.00
Capacity Utilisation (%)	68.10	70.00	75.20	91.60	89.60	88.40	56.80	48.80	26.80	60.00
MALCO										
I.C. ('000 tonnes)	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Production ('000 tonnes)	17.10	17.50	18.80	22.90	22.40	22.10	14.20	12.20	6.70	15.00
Cap. utilisation (%)	68.40	70.00	75.20	91.60	89.60	88.40	56.80	48.80	26.80	60.00
TOTAL										
I.C. ('000 tonnes)	241.00	256.00	268.00	299.00	321.00	321.00	341.00	341.00	362.00	362.00
Production ('000 tonnes)	174.20	209.80	196.40	204.90	210.70	171.60	208.20	208.30	213.60	276.00
Cap. utilisation (%)	72.28	81.95	73.28	68.52	65.64	53.46	61.06	61.09	59.01	76.20

Source: Based on information furnished by the primary producers.

Note: I.C. stands for Installed Capacity.

Appendix AI - X

Price of Electrical Grade (EC) Aluminium Ingots In India (1975 to 1986) - Non-Levy

(Rs./tonne)

Year	Ex-Plant	Excise Duty Rate	Excise Duty Amount	Sales Tax Rate	Sale Tax Amount	Total
1975	5,484	40% Adv.	2,193.60	2%	153.55	7,831.15
	8,200	40% + Rs.2000 per tonne	5,280.00	2%	269.60	13,749.60
1976	8,150	40% + Rs.800 per tonne	4,060.00	2%	244.20	12,454.20
1977	8,100	40% + Rs.800 per tonne	4,040.00	2%	242.80	12,382.80
1978	9,050	42% + Rs.840 per tonne	4,641.00	2%	273.82	13,964.82
1979	10,131	42%	4,255.02	2%	287.72	14,673.74
1980	11,497	44%	5,058.68	2%	331.11	16,886.79
1981	12,942	44%	5,694.48	4%	745.46	19,381.94
1982	15,411	Rs.[illegible].50 per tonne	3,39[illegible]	4%	752.18	19,556.68
1983	15,411	Rs.3392.50 per tonne	3,392.50	2%	376.09	19,180.59
1984	18,505	1[illegible].7[illegible] Adv.	3,4[illegible]	2%	439.31	22,404.74
1985	18,505	1[illegible].7[illegible] Adv.	3,460.4[illegible]	2%	439.21	22,404.74
1986	19,615	[illegible] Adv.	2,3[illegible].8[illegible]	2%	4[illegible]9.[illegible]6	22,40[illegible].16

Appendix AI- XI

Prices Of Commercial Grade (99.0%) Aluminium Ingots in India (1975 - 1986)

(Rs./Tonne)

Year	Price	Excise Duty Rates	Excise Duty Amount	Sales Tax Rate	Sales Tax Amount	Total
1975	8,100	40% + Rs2000 per tonne	5,240.00	2%	266.80	13,606.80
1976	7,750	40% + Rs800 per tonne	3,900.00	2%	233.00	11,883.00
1977	8,050	40% + Rs800 per tonne	4,020.00	2%	241.40	12,311.40
1978	8,850	42% + Rs840 per tonne	4,557.00	2%	268.14	13,675.14
1979	9,802	42%	4,116.84	2%	278.39	14,197.22
1980	11,397	44%	5,014.68	2%	328.23	16,739.91
1981	12,842	44%	5,650.48	4%	739.70	19,[illegible].18
1982	15,311	22%	3,368.42	4%	747.18	19,426.60
1983	15,311	22%	3,368.42	4%	747.18	19,426.60
1984	18,405	18.7%	3,441.74	2%	436.93	22,283.60
1985	18,405	18.7%	3,441.74	2%	436.93	22,283.60
1986	19,500	12%	2,3[illegible]	2%	4[illegible]	[illegible],27[illegible]

Appendix AI - XII

Consumption of Inputs For Production of One Tonne of Aluminium Metal In Pre-Baked Pot in India (1977 to 1983)

	Particulars	1977 Quantity (tonnes)	1977 Rate (Rs)	1977 Value (Rs)	1980 Quantity (tonnes)	1980 Rate (Rs)	1980 Value (Rs)	1983 Quantity (tonnes)	1983 Rate (Rs)	1983 Value (Rs)
1	Alumina	1.9778	1005.5	1988.62	2.0033	1617.92	3241.12	2.0227	2045.80	4138.04
2	Cryolite	0.0284	7455.47	211.39	0.00939	10259.67	96.35	0.01405	16374.57	230.02
3	Alu. Flouride	0.0245	8659.67	212.16	0.02895	11773.74	340.86	0.0213	18402.11	392.61
4	Baked Anode	0.4531	3170.59	1436.73	0.45270	5876.65	2660.34	0.4398	7794.08	3428.20
5	Soda Ash	0.0011	1175.82	1.25	0.00287	2335.16	6.70	0.0050	2767.67	13.88
6	Other (Borax etc)	0.0011	3361.12	3.72	0.00118	4857.85	5.75	0.0008	7743.97	6.67
7	Fluor Spar	-	-	-	-	-	-	0.0016	3260.6	5.25
8	Relining Mix	0.0254	-	35.16	0.02525	-	62.85	0.0201	-	60.73
9	Wages	-	-	108.72	-	-	149.26	-	-	215.1
10	Salary	-	-	41.17	-	-	53.26	-	-	65.78
11	Electricity (KWH)	16,706	0.1430	2387.73	16,450	0.2264	3725.01	16,491	0.3487	5751.48
12	Repair & Maintenance	-	-	14.89	-	-	2.22	-	-	5.49
13	Consumable Store	-	-	107.92	-	-	159.25	-	-	170.17
14	Alloys	-	-	-	-	-	9.65	-	-	7.89
15	Relining of Pot other than relining mix.	-	-	28.56	-	-	54.54	-	-	87.97
	A) Cost of Inputs			6578.02			10567.16			14579.29
	B) Total Cost of Production			6907.38			10867.50			15482.98
	A/B x 100 (%)			95.23			97.24			94.16

Appendix AI - XIII

Material Inputs For International and Indian Aluminium Smelters - 1983-84

Inputs	International		Indian Industry			
	RANGE	AVERAGE	INDAL	HINDALCO	BALCO	MALCO
Aluminium Manufacture						
Bauxite (tonnes)	4.0-4.5		5.6-6.0	5.69	5.69	5.56
Caustic Soda (kg)	100-130		180-200	178.94	222.00	166.00
Lime (kg)	45-90		50-60	151.20	260.00	260.00
Starch (kg)	0.9-2.73		5-6	2.06	-	4.00
Aluminium Smelting						
Alumina	1.9-1.95	1.93	2.0	2.02	1.950	1.913
Cryolite (kg)	20-30	30.00	21-36	14.04	45.00	29.00
Calcium Fluoride (kg)	1.8-3.64					
C.P. Coke (kg)	3[illegible]0-432	375.00	500-675	439.80	387.00	527.00
Pitch (kg)	127-136	100.00				
Power (KWH)	Wide range	16,694*	16,000-16,300	16,491	17,637	18,665

Note: * indicates Weighted Average During 198[illegible].

Appendix AI-XIV

Average Delivered Cost of Inputs for Aluminium Industry During the Period 1975-1984 (Rs./Tonne)

Material	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	% Annual Growth Data
Alu. Flouride	8647.31	8111.58	8681.67	9863.61	10623.24	13273.56	16740.99	17705.09	18385.80	18676.70	9.0
Cryolite	7326.27	7604.13	7661.76	8068.39	9297.08	10884.23	13770.17	15004.86	15790.54	16234.86	9.3
Caustic Soda	2134.34	2034.19	2043.74	2450.62	4630.91	5064.99	5714.05	5487.42	5315.98	5483.64	11.1
Furnace Oil(Rs/KL)	823.20	1001.04	1010.08	1013.27	1153.54	1752.81	2310.97	2683.32	2818.14	2950.73	15.2
Steam Coal	93.73	107.82	107.80	113.70	145.68	176.53	216.75	216.75	260.58	265.65	12.3
C.P. Coke	2305.16	2127.44	2095.81	2023.24	2935.05	4942.12	6466.02	6749.51	6139.25	6450.33	12.1
Hard Pitch	1063.20	1747.57	1758.93	1826.38	1994.72	2561.23	3365.65	4766.15	4971.53	5001.70	18.8
Soda Ash	1271.05	1216.59	1177.81	1294.63	1703.55	2469.84	2589.33	2466.67	2791.06	2802.42	9.2
Bauxite	73.03	77.19	79.78	78.37	88.82	100.97	119.77	150.13	138.19	147.84	7.3

Note: Delivered Cost includes basic price, excise duty, sales tax, freight and other incidental charges.

Source: Primary Producers of Aluminium in India.

Appendix AI - XV

Power Rates of Main Supply to Aluminium Smelters By Different State Electricity Boards

(Paise/KWH)

Year	UP	MP	Tamilnadu	Kerala	Karnataka	Orissa
1970-71	2.00					
1971-72	2.00					
1972-73	2.00					
1973-74	2.00		2.00			
1974-75	2.00		5.68			
1975-76	2.00		9.70	7.00	7.00	8.00
1976-77	11.00	12.40	10.70	7.00	7.00	8.00
1977-78	11.00	13.54	10.70	9.50	9.00	10.00
1978-79	11.00	15.41	10.70	9.50	9.00	10.46
1979-80	16.66	20.84	17.50	9.50	9.00	10.46
1980-81	19.57	25.58	17.50	10.86	19.58 - 30.28	10.25
1981-82	28.42	36.40	17.50	10.86	30.18	22.30 to 26.95
1982-83	42.68	39.20	38.50	10.86	30.18	26.95
1983-84	48.59 to 53.15	42.30	44.40	10.86	30.18	26.95
1984-85	58.73 (1.9.84)	45.30	44.40	22.70	41.30	3[illegible].60
Ratio of 1984-85 / 1980-81	3.00	1.77	2.53	2.09	2.10	1.69

Source: Primary Aluminium Producers, Note one paise = 0.01 Rupee

Appendix AI - XVI

Relationship Between Prices of Aluminium Ingot And Semi-Fabricated Products - Value Added in Manufacture of Semis

Year	Sales Value in Rs./tonne				Value Added in Rs./tonne		
	Ingots	Properzi Rod	Extrusions	Rolled Products	Extrusions	Rolled Products	Foils
1975	[illegible]	6,199.24	11,457.75	11,043.69	4,818.60	4,073.34	11,774.04
1976	6,197.67	6,461.83	11,476.41	12,409.10	[illegible]	4,021.73	11,871.85
1977	[illegible]	6,461.08	13,160.40	12,662.89	5,022.83	4,260.93	14,465.27
1978	[illegible]	[illegible]	14,065.00	13,050.97	5,254.54	3,993.54	14,088.91
1979	7,380.33	7,749.76	13,412.86	12,471.34	4,691.00	3,582.17	17,293.91
1980	8,529.43	8,596.43	16,799.52	15,222.09	7,209.88	4,614.87	20,001.92
1981	11,461.08	11,226.76	19,690.98	18,607.51	7,540.10	6,145.77	18,277.97
1982	14,529.97	14,600.62	22,530.75	21,735.09	7,3[illegible]0.90	6,429.00	18,964.04
1983	14,592.24	14,905.76	22,317.87	22,365.12	6,950.07	6,468.82	19,387.76

Note: Sale Value excludes excise duty and all other taxes.

Appendix AI - XVII

Cost Structure of Aluminium Rolling

Year	Fabrication Cost Index 1980	Fabrication Cost Rs./tonne	Employment Rs./tonne	Employment (%)	Power Rs./tonne	Power (%)	Fuel Rs./tonne	Fuel (%)	Repair & Maintenance Rs./tonne	Repair & Maintenance (%)	Op. Supplies Rs./tonne	Op. Supplies (%)	Depreciation Rs./tonne	Depreciation (%)	Others Rs./tonne	Others (%)
1975	315	2,968	1,539	52	399	13	232	8	124	4	247	8	112	4	315	11
1976	333	3,140	1,538	49	457	15	259	8	136	4	265	8	92	3	393	13
1977	323	3,049	1,444	47	445	15	180	6	138	5	260	9	103	3	479	15
1978	336	3,169	1,641	51	493	15	179	6	160	5	276	9	115	4	305	10
1979	382	3,603	1,837	51	516	14	185	5	174	5	308	9	128	4	455	12
1980	427	4,027	2,006	50	677	17	295	7	195	5	334	8	173	4	345	9
1981	545	5,143	2,225	43	874	17	406	8	211	4	390	8	225	4	812	16
1982	544	5,130	2,212	43	1,088	21	413	8	200	4	456	9	319	6	442	9
1983	613	5,788	2,624	45	1,197	21	415	7	219	4	492	9	364	6	477	8
1984	646	6,093	2,590	43	1,222	20	298	7	182	3	478	8	314	5	929	14

Note: Fabrication cost includes packaging and despatch costs but excludes freight charges.

Inventory of Reserves of Bauxite In Exploited and Non-Exploited Deposits In India
(As on 31.3.1983)

State/District	Name of Deposits	Exploited/Non-Exploited	Reserves In Million Tonnes: Measured	Indicated	Inferred	Total	Chemical Analysis (%): Al_2O_3	SiO_2	Fe_2O_3	TiO_2
1. Andhra Pradesh										
i) Visakhapatnam Dist. ii) East Godavari Dist.	Anantagiri Groups of Deposits & Chintapalle Group of Deposits									
	a) Sapparla Blocks 3&2	Non-Exploited	74.600	-	-	74.600	46.04	3.14	16.74	2.56
	b) Jarrela Deposit	Non-Exploited		206.000	-	206.000	47.18	3.34	17.83	2.74
	c) Other Deposits	Non-Exploited	-	..	198.566	198.566				
Sub. total of Andhra Pradesh			74.600	206.000	198.566	479.166				
2. Bihar										
i) Ranchi Dist.	Bagrupat, Seraugdag, Birhnipat, Haidanpat, Baurobar, Pakharpat,	Exploited	17.597	17.681	-	35.278	50.0 to 55.0	2.3 to 4.0	10.0 to 15.0	8.8 to 12.53
	Jamirpat, Khamparpat, Garpat deposits	Non-Exploited	-	-	20.526	20.526				
ii) Palamau Dist.	Netarhat Plateau and Jamirpat area	Non-Exploited	-	-	3.114	3.114				
iii) Santhal Parganas Dist.	Sahibganj Area	Non-Exploited	-	-	12.830	12.830	45.50			
iv) Monghyr Dist.	Kharagpur Hills	Non-Exploited	-	-	1.513	1.513	40-60	2-4		
Sub. total of Bihar			17.597	17.681	37.983	73.261				
3. Gujarat										
i) Jam Nagar Dist.	Known as Saurashtra bauxite-occurs 0.5 to 8 km. from coast	Exploited	13.953	-	-	13.953	55-60	2-4	3-4	2.31-4.30
		Non-Exploited	-	4.831	0.702	5.533				
ii) Kutch Dist.	Abdasa, Anjar, Lakhpat, Mandhvi Nakhatrana deposits	Exploited	24.771	-	-	24.771	55-60	2-4	3-4	2.50-4.50
		Non-Exploited	-	3.041	12.807	15.848				
iii) Other Districts			1.516	0.114	28.604	30.234				
Sub-total of Gujarat			40.240	7.986	42.113	90.339				
4. Goa, Daman & Diu	Eleven Deposits	Exploited	10.036	8.353	9.680	28.069	50-55			
5. Jammu & Kashmir Riasi Dist.	Chakar, Chhaperbara etc.	Non-Exploited	-	3.042	4.238	7.280	55-60			
6. Karnataka										
i) North Kanara Dist.	Swarnagadde, Kumta-plateau, Haldipur, Nittadgi, Bhatkal & Nundalli-Talgod.	Non-Exploited	1.110	2.300	13.014	16.424				
ii) South Kanara Dist.	Guppi plateau, Fadureare, Nagarkalbare, Mudugal, Kallamanduru, Badgamir plateau in Moddibidri-Sampayea area, Kuddarka, Belmane etc.	Partly-Exploited	-	6.500	6.097	12.597	50-55			

(Contd....)

		Non-exploited	Measured	Indicated	Inferred	Total	Al_2O_3	SiO_2	Fe_2O_3	TiO_2
iii) Belgaum & Chick-magalur Districts.	Karle hill, Bailur hill, Boknur-Navge hill, Kiniye, Kiruale Jamboti ridge, Belne and Mandil hill	Exploited	1.019	0.399	0.572	1.990	45-50			
Sub-total of Karnataka			2.129	9.199	19.683	31.011				
7. Kerala										
i) Cannore Dist.	Anantpur Gudda, Perla, Narala and Talakanam,	Non-exploited	0.771	5.769	4.121	10.661				
ii) Quilon Dist.	Cherukad-Vadakkamuri, Chittavatram, Pallikal	Non-exploited	-	0.770	2.015	2.785				
iii) Trivandrum Dist.	Mangalaparam-Chilampil-Mudapraum, Adicchanallur Adikkukulangara, Kudiranakamkunnu	Non-exploited	-	0.930	1.520	2.450				
Sub-total of Kerala			0.771	7.469	7.656	15.896				
8. Madhya Pradesh										
i) Bilaspur, Dist. Shahdol & Mandla Districts	Amarkantak deposits: having Rakti Dadar, Nanhu Dadar, Jammuna Dadar, & Umargobar areas, Kabirdadan, Siria-pondipahar, Gadida-dar-Chhindpani-Dhado-tale, Daikibavelapahar, Pondi baharpahar, Bangla Dadar, Chakmi-Dadar, Bijapahar	Exploited Non-Exploited	31.896 -	- 12.571	- 7.072	31.896 19.643	45-50			
ii) Surguja	Vast cappings of laterite on the plateaus in the northern part of district-Manipat needs special reference	Non-exploited	27.140	-	21.750	48.890				
iii) Balaghat Dist.	Gad Dadar, Dhukri Hill, Kotpahar & Wajiri Dadar.	Exploited Non-exploited	0.730 -	4.550 -	- 13.873	5.280 13.873				
iv) Bastar Dist.	Bailadila range	Non-exploited	0.483	-	9.000	9.483				
v) Raigarh Dist.		Non-exploited	-	-	9.596	9.596				
vi) Rajnandgaon Dist.		Non-exploited	-	-	5.000	5.000				
vii) Rewa & Satna Dist.	Naro Hill area	Exploited	-	47.230	0.712	47 942	55to(+)60			
viii) Other Districts			0.181	0.258	1.272	1.711				
Sub-total of M.P.			60.430	64.609	68.875	193.914				
9. Maharashtra										
i) Kolaba Dist.	Capping of plateaus	Unexploited	18.812	1.256	1.350	21.418				
ii) Kohlapur Dist.	Nagartswadi, Dhangarwadi & Udgiri deposits	Exploited	44.283	2.089	19.060	65.432				
iii) Ratnagiri Dist.	Continuation of deposits of Kolhapur Dist.	Exploited	-	0.066	5.163	5.229				
iv) Satara Dist.	A series of plateaus which run parallel to the Koyna river valley.	Non-exploited	0.364	8.800	-	9.164				
v) Thane Dist.	-	Non-exploited	-	-	0.900	0.900				
			53.[illegible]59	12.[illegible]11	26.473	102.142				

..Contd.

State/District	Name of Deposits	Exploited/ Non-Exploited	Reserves In Million Tonnes				Chemical Analysis			
			Measured	Indicated	Inferred	Total	Al_2O_3	SiO_2	Fe_2O_3	TiO_2
10. Orissa										
i) Bolangir & Sambalpur Districts	Kharier highlands-forming the Western boundary of State-the important occurences are i) Barapet Dongar, ii) Sainipara hill, iii) Kondamal hill, iv) Sand Bahli hill, v) 3095 hill etc. vi) Gandhmardan	Exploited	88.687	118.678	22.640	230.005				
ii) Kalahandi		Non-exploited	-	-	239.314	239.314				
iii) Kalahandi & Koraput		Non-exploited	-	-	167.000	167.000				
iv) Koraput Dist.	Pottangi area having Panchpatmali deposits	Exploited	183.310	179.980	11.71	375.000				
		Non-exploited	-	-	576.02	576.020				
v) Phulbani Dist.		Non-exploited	-	-	18.000	18.000				
vi) Sundargarh Dist.		Non-exploited	-	-	0.065	0.065				
vii) Keonjhar Dist.		Non-exploited	-	5.090	4.910	10.000				
			271.997	303.748	1039.659	1615.404				
11. Rajasthan										
i) Kota		Non-exploited	-	-	1.070	1.070				
12. Tamil Nadu										
i) Maduri Dist.	Palni Hills Near Kodaikanal	Non-exploited	2.230	-	0.020	2.250				
ii) Nilgiris Dist.	Mathorai, Kotagiri, Kerkombai & Iliyada	Exploited	-	1.140	2.966	4.106	45-50	4.58	23.15	1.40
iii) Salem Dist.	Shevroy & Kollaimalai Hills	Exploited	1.987	7.670	-	9.657	45-50	4.24	24.25	1.30
Sub-total of Tamil Nadu			4.217	8.810	4.056	17.083				
13. Uttar Pradesh										
Banda, Lalitpur & Varanasi Districts		Exploited	9.385	0.636	4.000	14.021				
GRAND TOTAL - ALL INDIA			554.861	649.744	1462.982	2667.587				

Appendix AI - XIX

Investment In Aluminium Industry During Seventh Plan

(Rs. Million)

Project Particulars	Estimated/anticipated Total cost	Sixth plan Total	Seventh plan period 1985-86	1986-87	1987-88	1988-89	1989-90	Total	Spill over Eighth plan
Public Sector									
1. Continuing Schemes									
a) **Projects**									
1. National Aluminium Co. (NALCO)									
(i) Alumina-Aluminium Complex	24,400	12,120	8,000	4,000	280	-	-	12,280	
2. Bharat Aluminium Co. (BALCO)	4,738	720	1,140	1,956	700	222	-	4,018	
(i) Gandhamardan Mine	526	270	200	56	-	-	-	256	
(ii) Captive Power Plant	4,212	450	940	1,900	700	222	-	3,762	
Sub-total (a)	29,138	12,840	9,140	5,956	980	222	-	16,298	
Balancing Facilities (Increased productivity & capacity utilisation)									
1. Bharat Aluminium Co.	240	5	42	64	79	20	10	235	
Alumina Plant	65	1	15	35	15	[illegible]	-	65	
(ii) Aluminium plant	[illegible]	4	25	45	60	20	10	160	
(iii) Bidhan Bagh Unit	[illegible]	-	[illegible]	4	4	-	-	10	
Sub-total (b)	[illegible]	5	[illegible]	84	79	20	10	235	
Replacement & Renewals (Maintenance)									
1. Bharat Aluminium Co.	174	4	29	33	42	36	20	170	
(i) Alumina plant (Redmud Pond)	50	4	10	10	10	10	6	46	
(ii) Alumina Plant	71	-	11	18	18	14	10	71	
(iii) Bidhan Bagh Unit	15	-	3	5	4	2	1	15	
(iv) Pollution Control (Measures)	38	-	5	10	10	10	3	38	
Sub-total (c)	174	4	29	43	42	36	20	170	
Total I	29,552	12849	9,211	6,083	1,101	278	30	16,703	
New Schemes									
1. National Aluminium Co.	2,710	-	140	1,010	1,360	200	-	2,710	
(i) Semi-fab. plant	2,320	-	120	870	1,160	170	-	2,320	
(ii) Aluminium-Silicon project	390	-	20	140	200	30	-	390	
2. Bharat Aluminium Co.	8,763	[illegible]	[illegible]	827	1,858	2,500	2,520	7,963	776
(i) Special Grade Alumina Unit	113	-	3	17	28	4	20	113	-
(ii) Bauxite Mine & Alumina Plant (Andhra Project)	8,000	24	250	800	1,800	2,400	2,400	7,650	326
(iii) Expansion of Korba Plant	500	-	-	-	-	100	100	100	450
(iv) LPG Cylinder Unit (Bidhan Bagh)	100	-	-	10	30	60	-	100	-
3. Gujarat Mineral Development Corporation									
(i) Alumina Plant	2,650	-	150	336	720	1,000	450	2,650	-
Total - II	14,123	29	548	2,167	3,938	3,700	2,970	13,323	776

(Contd........

	Estimated/Anticipated Cost	Sixth Plan Total	Seventh Plan period 1985-86	1986-87	1987-88	1988-89	1989-90	Total	Spill over Eighth Plan
III. Science & Technology (Research & Development)									
(a) Continuing Scheme									
1. Bharat Aluminium Co. (Alloy & Product Development, Energy Conservation, waste utilisation etc.)	62	12	14	10	20	6	-	50	-
(b) New Schemes									
1. Bharat Aluminium Co. (Smelter, Input Improvement Pilot Rolling Mill etc.)	30	-	1	7	10	7	5	30	-
2. Aluminium Research, Development & Design Centre	490	-	90	130	90	90	90	490	-
Sub-Total	582	12	105	147	120	103	95	570	-
Total Public Sector	44,257	12,885	9,864	8,397	5,159	4,081	3,095	30,596	776
B. Private Sector									
1. Continuing Schemes									
(a) Balancing Facilities & Modernisation (Power Unit, Calcination plant, Semi-Fab. Plant Etc.)									
1. Hindustan Aluminium Co.	950	-							
2. Indian Aluminium Co.	900	-							
Sub-Total (a)	1,850								
(b) Replacement & Renewals (Maintenance)									
1. Hindustan Aluminium Co.	450								
2. Indian Aluminium Co.	240								
3. Madras Aluminium Co.	10								
Sub-Total (b)	700								
Total Private Sector	2,550	-	195	565	910	715	165	2,550	-
Grand Total	46,807	12,885	10,059	8,962	6,069	4,796	3,260	33,146	776