5. Pre-marketing Activities

In industrial projects, it is extremely difficult to attain a balance between marketing and full production capacity of the plant simultaneously with the completion of plant construction except in cases where the consumer market is already established, either by imports or by other producers already in operation. On the other hand, fixed costs as a share of total production costs are fixed, irrespective of the volume of sales. Accordingly, the smaller the production, the larger the unit cost and lower the profitability of the project is. It is necessary to take measures to ensure the market simultaneously with construction of the plant.

For example, in the case of fertilizer, it is necessary to expand the market with measures such as setting-up demonstration farms using imported fertilizers of the same kind, etc. In the case of vinyl chloride it is desirable to construct processing plants and to promote the sales of products. The costs of these pre-marketing activities should be reflected in the project cost, depending on the form in which they are financed, i.e., if they are covered by the project cost itself or if they are done under the responsibility of the distributing agent.

6. Financial Arrangements for Projects

The economic feasibility of a project is evaluated in terms of the IRR, which measures the cash generating power of a project itself. However, when the project is undertaken by a private enterprise, it is very important to evaluate the return with respect to the equity and the cash balance during the project life. The conditions of the loan to be used in the project are the most important factor in detailed viability analysis regarding this aspect. It is necessary, therefore, to carry out further detailed analysis for each individual project.

7. Cost Inflation and Finished Product Price Inflation

The inflation related to the selling price of the finished products and the inflation of raw materials are neglected in the economical evaluation carried out here. Generally speaking, inflation has an effect on both selling prices and raw material prices. It has no influence on capital and debt, however. As a consequence, the IRR is improved when inflation exists.

In terms of profitability of the product, however, it is presumed that a more correct evaluation is possible by making a comparison neglecting the escalation. Accordingly, calculations are carried out by fixing prices at 1981 money values. Attention should be paid to the fact that the influence of this escalation cannot be neglected when carrying out detailed analysis of the cash flow of the project, however.

V. Recommendations for Detailed Feasibility Study

1. General

As discussed in the foregoing, the important factors for determination of the feasibility of each project are the investment required to construct the plant, determination of the source and price of raw material supply and the marketable quantity and price of the products. Accordingly, in the detailed feasibility study it will be necessary to carry out a survey on the status quo of these factors both in Paraguay and neighbouring countries, to analyze the collected data and information and to evaluate the feasibility of the projects. The contents of the survey to be carried out in the detailed feasibility studies for each project are outlined in the following sections.

2. Feasibility Study for Fertilizer Project

2-1 Market Survey

The current fertilizer consumption scale in Paraguay is small and does not justify the construction of a plant of economical scale. However, in many countries the stable and economical supply of fertilizer became possible thanks to the start-up of domestic production. Furthermore, the domestic production of fertilizers often triggers a rapid increase in the consumption, which requires an expansion in the production capacity of the plant, which in turn brings a reduction in the cost of the product and further expansion of demand. The survey on the aforesaid potential market should cover the following:

(1) Forecast of current and future planting acreage in Paraguay by type of crop and region.

(2) Survey of yield improvement potential of arable land in the various regions through the use of nitrogenous and phosphatic fertilizers.

(3) Survey of current and future farmers' sales price for crops.

(4) Estimation of farmer's gate price for fertilizers produced domestically (ex-factory price is determined through feedback of the market scale to the estimation of plant construction costs and raw materials costs).

(5) Determination of optimum fertilizer dosage per area and per crop. The estimation is determined by comparing fertilizer input cost and yield improvement output value.

(6) Determination of measures required to expand the market.

2-2 Raw Materials Survey

It will be necessary to confirm the following items related to the raw materials for fertilizer production.

- Nitrogenous fertilizers: Confirmation of the available quantities and prices of hydrocarbon for evaluation of the alternative process of water electrolysis adopted in this study.

- Phosphoric fertilizers: Confirmation of the location of supply sources and prices (factory gate) of phosphate rock, silica, coke or serpentinite, which are the main raw materials. With regard to phosphate rock, the study should be done on the premise that mainly rock produced in the State of Sao Paulo, Brazil is to be used. The execution of simultaneous investigation of domestic resources may be taken into consideration, however, for the time being we consider it best to set forth on the project assuming the import of rock phosphate (from Brazil, Florida or Morocco) in view of the restrictions related to available time. Domestic supply should be considered as future potential.

Survey Items

(1) Rock phosphate, silica, serpentinite

1) When there is commercial production (Imports from Brazil, etc.)

a. Confirmation of supply sources and prices.

b. Selection of optimum means of transportation per supply source and estimation of transportation costs.

2) When there is no commercial production

a. Confirmation of existence of deposits by means of boring, etc.

b. Estimation of exploitation process and production costs.

c. Selection of means of transportation and relevant costs.

With regard to determination of the transportation cost and means of transportation, it is necessary to select the optimum alternative taking into consideration the plant site selected.

(2) Coke

It is recommended that coke be imported from Brazil or Argentina because there are large scale steel-making industries in these countries. However, it is necessary to study the possibility of developing domestic sources of carbon because the coking of residual oil may become justifiable as a consequence of changes in the demand and supply structure for petroleum derivatives in Paraguay and in such a case there is a possibility of obtaining coke at economical prices.

2-3 Plant Site Selection

Considerable differences affect the investment required for construction of production facilities of chemical industries depending on the plant site. In other words, there is a considerable influence of factors such as availability of access routes for transportation of raw materials and products (including roads, railways, and jettys), the necessity for facilities to obtain utilities (electricity, industrial water, etc.), the necessity for auxiliary facilities such as dwellings for plant workers, hospitals, etc. On the other hand, operating costs such as acquisition of raw materials, transportation of products, discarding of waste, etc., are influenced by the location of the plant, source of raw materials and location of consumption centers.

Accordingly, it is necessary to select several alternative sites and analyze the following points concerning each of them.

(1) Soil Conditions

The plant site should have sufficient load bearing capacity. No additional cost should be required for ground improvement, pilings, etc., for construction of the foundations (buildings and equipment). Preliminary drilling should be carried at the plant site.

(2) Availability of Transportation Facilities

It is necessary to use transport means such as ships, freight cars, trucks, etc., for transportation of the raw materials, products, construction materials, etc. Accordingly, it is necessary to verify if it is necessary to construct new jettys, unloading facilities, etc., at the selected plant site and the required costs in case such are necessary. In case construction of railway sidings and branch roads from trunk roads are necessary a comparative study of required investment should be done.

(3) Availability of Utilities

Electricity and industrial water are utilities indispensable for chemical plants. Facilities for their supply may require considerable cost depending on the location of the plant site. Accordingly, it is necessary to confirm the availability of transmission lines, availability industrial water and the costs required to consturct relevant facilities.

(4) Environmental Survey and Environmental Management Cost

If the plant construction site is selected near urban areas with convenient access, it may be necessary to consider measures to reduce plant noise levels, the control of raw materials and industrial wastes and the required costs. Accordingly, it is a survey of conditions prevailing around the plant site is required to assess quantitatively their influence on the project.

(5) Survey of the Infrastructure

Transportation costs can be reduced if the plant site is selected close to source of raw materials (rock phosphate and other minerals). In such a case, however, facilities for the livelihood of the personnel required to operate the plant may not be available. Such being the case, it may be necessary to construct not only dwelling for the workers, but other facilities such as schools, hospitals, garages, etc., which require additional investment. This means an increase in costs. If conditions for the betterment of the livelihood of the workers are not available, it may be necessary to make considerable expenditure to hire manpower of high quality. Therefore, it is necessary to study carefully these aspects to select the plant site.

2-4 Technical Studies (Conceptual Design)

The determine the feasibility of the project it is necessary to decide the scale of the production facilities, the facilities required to receive and store raw materials, basic design of the production facilities, design of the utility facilities, the facilities for processing exhaust gas, waste water and waste materials, the repair shop for maintenance of the plant, design of laboratories, offices, etc., required for operation of the plant, etc., based on information and data obtained from the survey described in sections 2-1 to 2-3 of this report. These decisions, design and planning are required prior to estimation of the investment and period of construction required for the plant. The required raw materials, secondary materials, utilities and manpower can be determined as a result of the aforesaid design. Making it possible as a consequence to decide the data required for estimation of the production cost.

2-5 Financial and Economic Viability Study

All results of the investigations described in sections 2-1 to 2-4 of this report are converted into monetary terms and at the same time the taxation and financial system of Paraguay, conditions of the investors, purchase of raw materials, demand for marketing funds for the products, etc., are scrutinized in order to carry out financial analysis of the project. The contents of the analysis are the same as the Appendix, but sufficient reliability is ensured with regard to the results, thanks to final accurate input data.

3. Feasibility Study for Electrolysis Plant

Feasibility studies for the fertilizer project and this project should have the same contents except for the market survey and raw material survey. Accordingly, only these two items are described here.

3-1 Market Survey

The scale of the electrolysis plant covered by this report is determined by adding a bleaching powder plant of minimum scale to the scale of the plant responsible for supply of the chlorine required to produce polyvinyl chloride described in the above section. On a long-term basis, the bleaching powder produced by this plant can be used in various kinds of products in addition to consumption in paper & pulp plants. There is possibility of demand in other applications in additon to export to the alumina plant planned this time and use for sterilization of potable water, depending on the results of the potential market survey. In such a case it will be possible to expand the scale and improve profitability.

(1) Caustic Soda

The demand for caustic soda is estimated by analyzing the status quo and forecasting future trends for the industries listed below to determine their production and demands.

1) Pulp & Paper
2) Soap
3) Glass
4) Water processing, oil refining and others.

(2) Derivatives of chlorine (calcium hypochlorite)

1) Pulp industry
2) Cotton spinning
3) Water sterilization

3-2 Raw Material Survey (Rock Salt)

(1) Exploitation of Domestic Sources of Brine

It is necessary to confirm brine source currently being exploited in the Lambre area and to estimate exploitation and transportation costs.

(2) Import of Rock Salt

According to statistical data of the United Nations in 1979, the annual production of salt is of the order of 1 million ton in Argentine, 2.8 million tons in Brazil and 600 thousand tons in Chile. We presume that feasibility of the project at the present time can be determined by estimating the means for importing and transporting salt from these sources and the relevant costs.

4. Feasibility Study for Poly Vinyl Chloride Project

A detailed feasibility study for this project can be carried out by the same method as the fertilizer project. The following idea should be adopted in the market survey and raw material survey, however.

4-1 Market Survey

Plastics (such as vinyl chloride) have many applications as building, packing and agricultural materials, miscellaneous goods, etc., and it is very difficult to forecast the demand by focusing on specific applications. The method described below is often used to estimate demand, however. In the first place, the relationship between vinyl chloride demand and demand for alternative materials such as polyethylene, etc., and the evolution of the GNP and industries related to these materials is determined in countries with peculiarities similar to Paraguay. In addition, demand is forecast taking into consideration the influence of other factors such as price, etc., in addition to the GNP. The demand in Paraguay is forecast taking into consideration competition with products imported from foreign countries, based on factors like development of domestic industry, future trends in production cost, etc.

4-2 Raw Materials Survey

The raw materials for production of vinyl chloride are limestone, carbon and rock salt. The existence of limestone has been confirmed in various places in Paraguay and exploitation and transportation costs are estimated by setting optimum exploitation sites corresponding to each possible plant site.

Discussion of carbon (coke) and rock salt is omitted here because they are the same as the cases of the fertilizer project and the electrolysis project.

5. Typical Study Program

Details such as depth, required personnel, etc., of the study program depend on whether the study is carried out on the premise that the decisions related to investment are to be made based on the number of plant sites, quality and quantity of data related to the supply of raw materials, quality and quantity of data required for market study, number of plants covered by the project, number of products and the results of the study itself (in this case there is a clear idea of investors and financial arrangements), whether applications are to be sent to potential investors, etc., but the study program should be as follows, in order to make it comprehensive enough to allow for investment decisions.

(1) Pre-conditions

1) With regard to mineral resources, data required for estimation of deposits are available

2) The plant sites are restricted to several places.

3) Basic data required for market study, demographic trends, economic indexes, status quo and future trends for key industries.

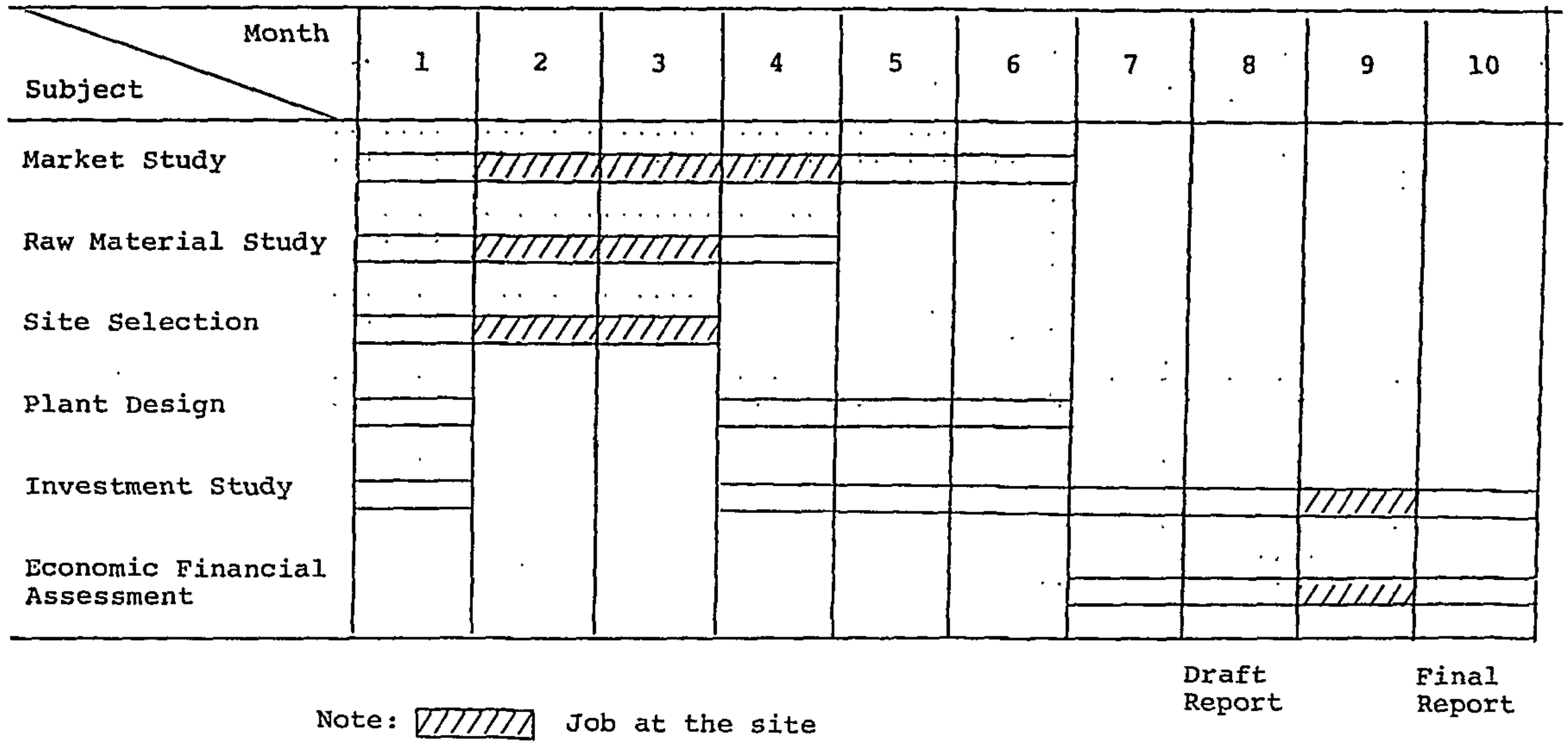
4) Soil and meteorological data, water resource data, etc. related to the plant sites are available, at least at minimum level.

5) Minimum data related to the costs of facilities for transportation of commodities related to Paraguay and neighbouring countries are available.

(2) Experts to be Involved (Preliminary·Typical)

	Function	Number	Working time (months)	
a.	Market study	Two	Six to eight	12-16
b.	Process selection and process engineering	Two	Six to eight	12-16
c.	Investment estimation	Two	Four to six	8-12
d.	Geologist	One	Four	4
e.	Mining engineer	One	Four	4
f.	Civil engineer	One	Six	6
g.	Utility · off-site engineer	Two	Four	8
h.	Transportation expert	One	Four	4
i.	Project manager	One	Eight to ten	8-10
j.	Economist	One	Four	4
	Total	Fourteen	M/M	70-84

Schedule Typical



Appendix I

Study of Fertilizer Market in Paraguay

1. Introduction

The current status of the domestic fertilizer market of Paraguay and the possibility of domestic production of fertilizers from the point of view of potential demand in the country are discussed herein.

Generally speaking, it can be said that there is a market for a certain commodity only when the following conditions are satisfied.

1. There is either existing or potential demand for the commodity in question.
2. The commodity in question has sufficient competitiveness to capture a significant share of the market even when there is a rival product.

Of the two conditions above, only the former one is discussed in this chapter.

2. Current Status of Fertilizer Consumption in Paraguay

(1) Demand for Fertilizers

The supply of fertilizers in Paraguay is dependent completely on import. There is currently a mixed fertilizer plant in Paraguay but details on production are not available. Data on demand are given in Table A-1-1.

(2) Current Status of Fertilizer Consumption

The fertilizer consumption level per unit area in Paraguay is shown in Table A-1-2. It is evident that the consumption is extremely low compared not only with neighbouring Brazil but also with the average for all of South America.

3. Possibility of Expansion of Domestic Demand for Fertilizers in Paraguay

(1) Method of Study

As mentioned above, the fertilizer consumption level in Paraguay is very low compared with other countries. It is not correct, however, to conclude that there is no potential for expansion of consumption in future from the mere fact that the current consumption level is low. The potential maximum consumption level is influenced by factors such as the structure of agricultural operations, conditions of the soil, type and variety of crops, system of irrigation, etc.

At the present time very little data is available on the structure of agriculture operations and the effects of application of fertilizers in Paraguay. It is desirable that this subject be discussed taking into consideration the aforementioned factors existing in Paraguay but in this report the possibility of expansion of demand is discussed with reference to the conditions prevailing in Brazil as it has soil conditions relatively similar to those of Paraguay.

(2) Possibility of Expansion of the Demand

Table A-1-3 gives a forecast of demand for fertilizers on three levels as follows:

Level 1: Maximum potential demand level. This is maximum application of fertilizers for each crop which can be justified by the conditions existing in Brazil (this is the maximum fertilizer application level from the economic point of view and not from the physical point of view).

Level 2: This is the fertilizer application level currently prevailing in Brazil.

Level 3: This is the fertilizer application level expected to exist in 1990 in Paraguay, extrapolated from past fertilizer applications.

For the planted areas of the crops mentioned below a) b), these are determined by choosing the smallest from among the areas estimated for 1990 according to the criteria described below and the area extrapolated for 1990 by linear regression of the planted area expansion tendency for the 1975-1979 period.

a) Soybean: Area regarded as the most appropriate (1,362 million ha) for cultivation of soybeans according to PROGRAMA NACIONAL DE SOJA.

b) Cotton: Area estimated assuming an annual growth rate equivalent to 1/2 that occurring in 1979 (the production expansion plan for the period up to 1979 assumes a growth rate equivalent to 1/2 that of 1979 for 1980 and 1981).

The planted area for all other crops in 1990 is extrapolated by linear regression from the planted area of the 1975-1979 period.

Assuming the incentive policy for the development of agriculture is strengthened as the way currently implemented, the demand for fertilizers is estimated to expand by the Level 3 rate (1990).

It is not clearly known why the fertilizer application level is so low in Paraguay. Generally speaking, however, it can be attributed to the following:

1. Farmers do not have sufficient knowledge of the fertilizer application effect itself.

2. Farmers have sufficient knowledge of fertilizers but no increase in yield can be expected from such application.

3. Yield improves, but the application of fertilizers does not bring a positive financial return because the fertilizer is too expensive or the crop is too cheap.

4. The market for agricultural products is not of sufficient size to absorb increases in production.

5. Fertilizers are not available.

The Paraguayan Government is currently taking measures to increase the production of crops such as soybean, cotton, wheat, etc. but it is not clearly known how effective these measures have been in eliminating the aforementioned obstacles against application of fertilizers.

If the production of fertilizers is started in Paraguay and measures to stimulate use introduced by Paraguayan authorities, it is presumed possible to reach Level 2 construction, however.

Level 1 is the maximum level in terms of possible expansion of demand.

(3) Forms of Fertilizers

1) Tendency in Brazil

There is no information available on the kinds of fertilizers currently used or which are the most appropriate types in Paraguay. In this connection, the consumption shares of the various fertilizers in Brazil are given in Table A-1-4.

With regard to nitrogenous fertilizers, the consumption of urea is increasing in place of ammonium sulfate and fertilizers of the ammonium nitrate family. With phosphatic fertilizers there is a tendency for ammonium phosphate to increase. The principal causes of the aforementioned changes are attributable to the preference for more concentrated fertilizers, which cut down transportation costs rather than for improvements in agricultural techniques.

2) Calcium Cyanamide

Calcium cyanamide is a basic fertilizer which contains approximately 50% calcium in the form of CaO and has a soil conditioning character. On the other hand, the cyanamide contained in it is toxic to animals and plants in general, hinders germination and causes withering of leaves when if it comes in contact, therefore, it is effective when used in acidic soils for soil conditioning, soil sterilization and as a herbicide. In view of these properties the timing for its application should be determined taking into consideration the decomposition period and seed-sowing and transplantation timing. Furthermore, calcium cyanamide should be buried in the soil in order to achieve effective results, therefore, this fertilizer is not suited for extensive type agriculture.

3) Fused Phosphatic Fertilizer

Fused phosphatic fertilizers have rather poor effects in the case of crops with short growing periods and in the case of alkaline and approximately neutral soils because it does not contain water soluble phosphate. It is quite effective in the case of strongly acidic soils with shortages of phosphorus and soils with shortages of magnesium because it neutralizes the acidity and supplies magnesium at the same time.

4) Other Fertilizers

With regard to other fertilizers, currently available information is not sufficient to judge which is the most appropriate form of application. It is presumed, however, that concentrated fertilizers may find their "raison d'etre" in reduction of transportation cost.

4. Possibility of Export to Neighbouring Countries

As can be seen in Table 3, the domestic fertilizer market of Paraguay is very small. Accordingly the production of fertilizers in Paraguay is not feasible if only the present domestic market is taken into consideration as the objective market. Neighbouring Brazil is the largest importer of nitrogenous fertilizers and phosphatic fertilizers in South America, however, and nitrogenous fertilizer plants are currently under construction in Brazil. Nevertheless, it is expected to continue importing large amounts of fertilizer. Accordingly, if the fertilizers turned out in Paraguay are competitive from the point of view of production cost and transportation cost, the southwestern region of Brazil can be taken into consideration as a possible export market.

TABLE A-1-1 FERTILIZER CONSUMPTION IN PARAGUAY (1)

(Unit: Nutrient ton)

Year	1976/77	1977/78	1978/79	1979/80
Nitrogen Fertilizer	500*)	300*)	800*)	1,092
Phosphate Fertilizer	300*)	700*)	1,100*)	915
Potassium Fertilizer	200*)	100*)	900*)	1,400*)

Note: *) Un-official figure

Source: FAO, "FAO Fertilizer Yearbook, 1980"

TABLE A-1-2 CONSUMPTION OF FERTILIZERS PER HA OF ARABLE LAND AND PERMANENT CROPS in 1979

(2)

	Nitrogen Fertilizers (Kg/ha N)	Phosphate Fertilizers (Kg/ha P_2O_5)	Potassium Fertilizers (Kg/ha K_2O)	Total (Kg/ha N, P_2O_5, K_2O)
Paraguay	0.9	0.8	1.2	2.9
Brazil	12.7	27.3	17.6	57.6
Argentina	1.7	1.7	0.3	3.7
USA	54.9	26.0	29.7	110.6
Mexio	35.6	11.0	2.6	49.1
Regional average:				
S. America	10.6	16.6	10.2	37.4
N.C. America	46.5	22.1	23.4	92.0
World	39.5	21.5	16.2	77.1

Source: FAO, "FAO Fertilizer Yearbook, 1980"

TABLE A-1-3 ESTIMATED FERTILIZER DEMAND IN PARAGUAY (3)

Crop	Cultivated Area ('000 ha)		Estimated Fertilizer Demand															
			Level 1 (Future Potential)						Level 2 (likely)						Level 3		
	Futre potential	(1979)	Application level (kg/ha) (a)			Demand ('000 ton) (b)			Application level (a)			('000 ton) (b)			('000 ton) (b)		
			N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Soybean	912	(360.3)	20	100	40	18	91	36	10	50	20	9	46	19	-	-	-
Maize	641	(352.7)	20	75	30	13	48	19	2	8	3	1	5	2	-	-	-
Cotton	464	(312.5)	45	55	40	21	26	19	-	-	-	-	-	-	-	-	-
Cassava	208	(126.4)	40	70	35	8	15	7	-	-	-	-	-	-	-	-	-
Wheat	112	(52.3)	40	100	40	4	11	4	15	40	15	2	4	2	-	-	-
Sugarcane	50	(34.8)	70	100	100	4	5	5	50	70	70	3	4	4	-	-	-
Rice	49	(30.1)	20	100	40	1	5	2	5	25	10	0	1	0	-	-	-
Sorghum	8	(6.9)	45	80	35	-	1	-	-	-	-	-	-	-	-	-	-
Coffee	61	(21.6)	200	50	150	12	3	9	125	30	95	8	2	6	-	-	-
Vegetables 1)	7	(5.7)	140*	120*	60*	1	1	-	60**	55**	25**	-	-	-	-	-	-
Beans	135	(79.1)	40	75	35	5	10	5	-	-	-	-	-	-	-	-	-
Total	2,647	1,382.4				87	216	106				23	62	32	13	16	25

Note: 1) Total of onion, potato, garlic

*) FAO world average

**) rate in colombia

TABLE A-1-4 CONSUMPTION OF FERTILIZER BY TYPE IN BRAZIL (4)

(Unit: %)

Year	1978	1973
Nitrogen Fertilizers		
CAN/AN	15.8	19.3
AS	24.8	32.7
Urea	28.1	19.9
Other straight	3.5	1.9
Ammonium phosphate	23.2	24.6
NPK Compounds	4.6	1.6
Total	100.0	100.0
Phosphate Fertilizers		
Basic slag	0.1	0.6
SSP	16.8	21.2
DSP/TSP	35.1	38.0
Ground rock phosphate	7.2	10.0
Other straight	1.6	2.9
Ammonium phosphate	31.8	27.1
NPK Compounds	7.4	0.2
Total	100.0	100.0

Appendix II

*** PARAGUAY ELECTRICITY INTENSIVE CHEMICAL INDUSTRY ***
LOAN REPAYMENT SCHEDULE FOR LONG TERM DEBT
Electrolysis CHLORINE CAUSTIC COMPLEX (US$1,000)

AMOUNT OF DEBT 25012.

INTEREST RATE 10.00 PER CENT/YEAR

REPAYMENT 8 YEAR-EQUAL-INSTALLMENT-REPAYMENT (ANNUAL REPAYMENT)

YEAR	SER.NO	PRINCIPAL	INTEREST	DEBT SERVICE	BALANCE AFT. PAYMENT
1983	1	0.	0.	0.	25012.
1984	2	0.	0.	0.	25012.
1985	3	0.	0.	0.	25012.
1986	4	0.	2501.	2501.	25012.
1987	5	0.	2501.	2501.	25012.
1988	6	3126.	2501.	5628.	21885.
1989	7	3126.	2189.	5315.	18759.
1990	8	3126.	1876.	5002.	15632.
1991	9	3126.	1563.	4690.	12506.
1992	10	3126.	1251.	4377.	9379.
1993	11	3126.	938.	4064.	6253.
1994	12	3126.	625.	3752.	3126.
1995	13	3126.	313.	3439.	0.
TOTAL		25012.	16257.	41269.	0.

*** PARAGUAY ELECTRICITY INTENSIVE CHEMICAL INDUSTRY ***
INCOME STATEMENTS (FOR YEARS ENDING DECEMBER 31)
Electrolysis CHLORINE CAUSTIC COMPLEX (US$1,000)

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
SALES REVENUE	7295.	8820.	9875.	9875.	9875.	9875.	9875.	9875.	9875.	9875.
COST OF SALES	6202.	6947.	7180.	7154.	7128.	7102.	7076.	7050.	7024.	6998.
VARIABLE COST	1550.	1743.	1937.	1937.	1937.	1937.	1937.	1937.	1937.	1937.
DEPRECIATION & AMORTIZATION	3050.	3050.	3050.	3050.	3050.	3050.	3050.	3050.	3050.	3050.
OTHER FIXED COST	2245.	2219.	2193.	2167.	2141.	2115.	2089.	2063.	2037.	2011.
(INC) IN PRODUCT INVENTORIES	-642.	-65.	0.	0.	0.	0.	0.	0.	0.	0.
GROSS PROFIT OR (LOSS) ON SALES	1093.	1873.	2695.	2721.	2747.	2773.	2799.	2825.	2851.	2877.
LESS. SALES EXPENSES	342.	351.	359.	358.	356.	355.	354.	352.	351.	350.
OPERATING PROFIT OR (LOSS)	751.	1523.	2336.	2364.	2391.	2418.	2445.	2473.	2500.	2527.
LESS. INTEREST										
ON LONG TERM DEBT	2501.	2501.	2501.	2189.	1876.	1563.	1251.	938.	625.	313.
ON SHORT TERM DEBT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
NET PROFIT OR (LOSS) BEFORE TAX	-1751.	-978.	-165.	175.	515.	855.	1195.	1535.	1875.	2215.
LESS. INCOME TAX	0.	0.	0.	0.	0.	0.	26.	767.	937.	1107.
NET PROFIT OR (LOSS) AFTER TAX	-1751.	-978.	-165.	175.	515.	855.	1169.	767.	937.	1107.

*** PARAGUAY ELECTRICITY INTENSIVE CHEMICAL INDUSTRY ***
FUNDS FLOW STATEMENTS (FOR YEARS ENDING DECEMBER 31)
Electrolysis CHLORINE CAUSTIC COMPLEX (US$1,000)

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
SOURCES OF FUNDS	12863.	13220.	9647.	4059.	4605.	5418.	5413.	5441.	5468.	5495.	5523.
CASH GENERATED FROM OPERATION	0.	0.	0.	3800.	4573.	5386.	5413.	5441.	5468.	5495.	5523.
PROFIT BEFORE TAX, INTEREST	0.	0.	0.	751.	1523.	2336.	2364.	2391.	2418.	2445.	2473.
DEPRECIATION & AMORTIZATION	0.	0.	0.	3050.	3050.	3050.	3050.	3050.	3050.	3050.	3050.
FINANCIAL RESOURCES	12863.	13220.	9647.	0.	0.	0.	0.	0.	0.	0.	0.
SHARE CAPITAL	5360.	3216.	2144.	0.	0.	0.	0.	0.	0.	0.	0.
LONG TERM DEBT	7503.	10005.	7503.	0.	0.	0.	0.	0.	0.	0.	0.
SHORT TERM DEBT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
INCREASE IN ACCT PAYABLE	0.	0.	0.	258.	32.	32.	0.	0.	0.	0.	0.
USES OF FUNDS	8192.	16640.	10158.	3850.	2706.	5728.	5315.	5002.	4690.	4377.	4090.
INVESTMENT IN FIXED ASSET	8192.	16640.	10158.	0.	0.	0.	0.	0.	0.	0.	0.
LAND AND SITE IMPROVEMENT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CONSTRUCTED FACILITIES	7616.	15232.	7616.	0.	0.	0.	0.	0.	0.	0.	0.
PRE-INVEST. & START-UP EXP	300.	300.	600.	0.	0.	0.	0.	0.	0.	0.	0.
INTEREST DURING CONSTRUCTN	276.	1107.	1942.	0.	0.	0.	0.	0.	0.	0.	0.
INCREASE IN CURRENT ASSET OTHER THAN CASH	0.	0.	0.	1349.	204.	100.	0.	0.	0.	0.	0.
INCR(DECR) ACC T RECEIVABLE	0.	0.	0.	608.	127.	88.	0.	0.	0.	0.	0.
INCR(DECR) IN INVENTORIES											
PRODUCTS	0.	0.	0.	642.	65.	0.	0.	0.	0.	0.	0.
MATERIALS	0.	0.	0.	100.	12.	12.	0.	0.	0.	0.	0.
DEBT SERVICES	0.	0.	0.	2501.	2501.	5628.	5315.	5002.	4690.	4377.	4064.
REPAYMENT OF LONG TERM DEBT	0.	0.	0.	0.	0.	3126.	3126.	3126.	3126.	3126.	3126.
REPAYMNT OF SHORT TERM DEBT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
INTEREST ON LONG TERM DEBT	0.	0.	0.	2501.	2501.	2501.	2189.	1876.	1563.	1251.	938.
INTEREST ON SHORT TERM DEBT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
INCOME TAX PAYMENT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	26.
DIVIDENDS PAYMENT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CASH INCREASE OR (DECREASE)	4671.	-3419.	-511.	209.	1899.	-309.	98.	438.	778.	1118.	1432.
BEGINNING CASH BALANCE	0.	4671.	1252.	741.	950.	2849.	2539.	2638.	3076.	3855.	4973.
ENDING CASH BALANCE	4671.	1252.	741.	950.	2849.	2539.	2638.	3076.	3855.	4973.	6405.

*** PARAGUAY ELECTRICITY INTENSIVE CHEMICAL INDUSTRY ***
FUNDS FLOW STATEMENTS (FOR YEARS ENDING DECEMBER 31)
Electrolysis CHLORINE CAUSTIC COMPLEX (US$1,000)

	1994	1995
SOURCES OF FUNDS	5550.	5577.
CASH GENERATED FROM OPERATION	5550.	5577.
PROFIT BEFORE TAX, INTEREST	2500.	2527.
DEPRECIATION & AMORTIZATION	3050.	3050.
FINANCIAL RESOURCES	0.	0.
SHARE CAPITAL	0.	0.
LONG TERM DEBT	0.	0.
SHORT TERM DEBT	0.	0.
INCREASE IN ACCT PAYABLE	0.	0.
USES OF FUNDS	5107.	5314.
INVESTMENT IN FIXED ASSET	0.	0.
LAND AND SITE IMPROVEMENT	0.	0.
CONSTRUCTED FACILITIES	0.	0.
PRE-INVEST. & START-UP EXP	0.	0.
INTEREST DURING CONSTRUCTN	0.	0.
INCREASE IN CURRENT ASSET OTHER THAN CASH	0.	0.
INCR(DECR) ACC T RECEIVABLE	0.	0.
INCR(DECR) IN INVENTORIES		
PRODUCTS	0.	0.
MATERIALS	0.	0.
DEBT SERVICES	3752.	3439.
REPAYMENT OF LONG TERM DEBT	3126.	3126.
REPAYMNT OF SHORT TERM DEBT	0.	0.
INTEREST ON LONG TERM DEBT	625.	313.
INTEREST ON SHORT TERM DEBT	0.	0.
INCOME TAX PAYMENT	767.	937.
DIVIDENDS PAYMENT	588.	937.
CASH INCREASE OR (DECREASE)	443.	263.
BEGINNING CASH BALANCE	6405.	6848.
ENDING CASH BALANCE	6848.	7112.

*** PARAGUAY ELECTRICITY INTENSIVE CHEMICAL INDUSTRY ***
BALANCE SHEET (FOR YEARS ENDING DECEMBER 31)
Electrolysis CHLORINE CAUSTIC COMPLEX (US$1,000)

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
ASSETS	12863.	26083.	35731.	34239.	33292.	30033.	27082.	24471.	22199.	20267.	18650.
CURRENT ASSETS	4671.	1252.	741.	2299.	4402.	4193.	4292.	4730.	5508.	6627.	8059.
CASH	4671.	1252.	741.	950.	2849.	2539.	2638.	3076.	3855.	4973.	6405.
ACCOUNTS RECEIVABLE	0.	0.	0.	608.	735.	823.	823.	823.	823.	823.	823.
INVENTORIES											
PRODUCTS	0.	0.	0.	642.	707.	707.	707.	707.	707.	707.	707.
MATERIALS	0.	0.	0.	100.	112.	124.	124.	124.	124.	124.	124.
NET FIXED ASSETS	8192.	24832.	34990.	31940.	28890.	25840.	22790.	19740.	16691.	13641.	10591.
INVESTMENT	8192.	24832.	34990.	34990.	34990.	34990.	34990.	34990.	34990.	34990.	34990.
LAND & SITE IMPROVEMENT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CONSTRUCTED FACILITIES	7616.	22849.	30465.	30465.	30465.	30465.	30465.	30465.	30465.	30465.	30465.
PRE-INVEST. & START-UP EXP	300.	600.	1200.	1200.	1200.	1200.	1200.	1200.	1200.	1200.	1200.
INTEREST DURING CONSTRUCTN	276.	1383.	3325.	3325.	3325.	3325.	3325.	3325.	3325.	3325.	3325.
LESS.DEPRECIATN & AMORTIZTN	0.	0.	0.	3050.	6100.	9149.	12199.	15249.	18299.	21349.	24399.
LIABILITIES	7503.	17508.	25012.	25270.	25302.	22208.	19081.	15955.	12829.	9726.	7931.
CURRENT LIABILITIES	0.	0.	0.	258.	3417.	3449.	3449.	3449.	3449.	3475.	4804.
ACCOUNTS PAYABLE	0.	0.	0.	258.	291.	323.	323.	323.	323.	323.	323.
INCOME TAX PAYABLE	0.	0.	0.	0.	0.	0.	0.	0.	0.	26.	767.
DIVIDENDS PAYABLE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	588.
CURRENT PORTION OF DEBT											
LONG TERM DEBT	0.	0.	0.	0.	3126.	3126.	3126.	3126.	3126.	3126.	3126.
SHORT TERM DEBT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
FIXED LIABILITIES	7503.	17508.	25012.	25012.	21885.	18759.	15632.	12506.	9379.	6253.	3126.
LONG TERM DEBT BALANCE	7503.	17508.	25012.	25012.	21885.	18759.	15632.	12506.	9379.	6253.	3126.
STOCK HOLDERS EQUITY	5360.	8575.	10719.	8969.	7990.	7825.	8001.	8516.	9370.	10539.	10719.
SHARE CAPITAL	5360.	8575.	10719.	10719.	10719.	10719.	10719.	10719.	10719.	10719.	10719.
RETAINED ERNINGS	0.	0.	0.	-1751.	-2729.	-2894.	-2719.	-2204.	-1349.	-180.	0.

*** PARAGUAY ELECTRICITY INTENSIVE CHEMICAL INDUSTRY ***
BALANCE SHEET (FOR YEARS ENDING DECEMBER 31)
Electrolysis CHLORINE CAUSTIC COMPLEX (US$1,000)

	1994	1995
ASSETS	16043.	13257.
CURRENT ASSETS	8502.	8765.
CASH	6848.	7112.
ACCOUNTS RECEIVABLE	823.	823.
INVENTORIES		
PRODUCTS	707.	707.
MATERIALS	124.	124.
NET FIXED ASSETS	7541.	4491.
INVESTMENT	34990.	34990.
LAND & SITE IMPROVEMENT	0.	0.
CONSTRUCTED FACILITIES	30465.	30465.
PRE-INVEST. & START-UP EXP	1200.	1200.
INTEREST DURING CONSTRUCTN	3325.	3325.
LESS.DEPRECIATN & AMORTIZTN	27448.	30498.
LIABILITIES	5324.	2502.
CURRENT LIABILITIES	5324.	2502.
ACCOUNTS PAYABLE	323.	323.
INCOME TAX PAYABLE	937.	1107.
DIVIDENDS PAYABLE	937.	1072.
CURRENT PORTION OF DEBT		
LONG TERM DEBT	3126.	0.
SHORT TERM DEBT	0.	0.
FIXED LIABILITIES	-0.	-0.
LONG TERM DEBT BALANCE	-0.	-0.
STOCK HOLDERS EQUITY	10719.	10755.
SHARE CAPITAL	10719.	10719.
RETAINED ERNINGS	0.	35.

*** PARAGUAY ELECTRICITY INTENSIVE CHEMICAL INDUSTRY ***
PRODUCTION AND SALES PLAN
Electrolysis CHLORINE CAUSTIC COMPLEX (US$1,000)

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
CAPACITY (CHLORINE)	13170.	13170.	13170.	13170.	13170.	13170.	13170.	13170.	13170.	13170.
CAPACITY UTILIZATION	0.800	0.900	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
PRODUCTION	10536.	11853.	13170.	13170.	13170.	13170.	13170.	13170.	13170.	13170.
INCREASE IN INVENTORY	988.	110.	0.	0.	0.	0.	0.	0.	0.	0.
SALES VOLUME	7255.	8162.	9069.	9069.	9069.	9069.	9069.	9069.	9069.	9069.
UNIT PRICE	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
SALES REVENUE	1451.	1632.	1814.	1814.	1814.	1814.	1814.	1814.	1814.	1814.
CAPACITY (CAUSTIC SODA)	11270.	11270.	11270.	11270.	11270.	11270.	11270.	11270.	11270.	11270.
CAPACITY UTILIZATION	0.800	0.900	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
PRODUCTION	9016.	10143.	11270.	11270.	11270.	11270.	11270.	11270.	11270.	11270.
INCREASE IN INVENTORY	845.	94.	0.	0.	0.	0.	0.	0.	0.	0.
SALES VOLUME	8171.	10049.	11270.	11270.	11270.	11270.	11270.	11270.	11270.	11270.
UNIT PRICE	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
SALES REVENUE	2451.	3015.	3381.	3381.	3381.	3381.	3381.	3381.	3381.	3381.
CAPACITY (CA(CLO)2)	3600.	3600.	3600.	3600.	3600.	3600.	3600.	3600.	3600.	3600.
CAPACITY UTILIZATION	0.800	0.900	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
PRODUCTION	2880.	3240.	3600.	3600.	3600.	3600.	3600.	3600.	3600.	3600.
INCREASE IN INVENTORY	270.	30.	0.	0.	0.	0.	0.	0.	0.	0.
SALES VOLUME	2610.	3210.	3600.	3600.	3600.	3600.	3600.	3600.	3600.	3600.
UNIT PRICE	1.3000	1.3000	1.3000	1.3000	1.3000	1.3000	1.3000	1.3000	1.3000	1.3000
SALES REVENUE	3393.	4173.	4680.	4680.	4680.	4680.	4680.	4680.	4680.	4680.
*** TOTAL SALES REVENUE ***	7295.	8820.	9875.	9875.	9875.	9875.	9875.	9875.	9875.	9875.
*** TOTAL SALES VOLUME ***	18036.	21421.	23939.	23939.	23939.	23939.	23939.	23939.	23939.	23939.
*** AVERAGE SALES PRICE ***	0.4045	0.4117	0.4125	0.4125	0.4125	0.4125	0.4125	0.4125	0.4125	0.4125

*** PARAGUAY ELECTRICITY INTENSIVE CHEMICAL INDUSTRY ***
PRODUCTION COST STATEMENTS
Electrolysis CHLORINE CAUSTIC COMPLEX (US$1,000)

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
PRODUCTION	10536.	11853.	13170.	13170.	13170.	13170.	13170.	13170.	13170.	13170.
ROCK SALT	597.	672.	746.	746.	746.	746.	746.	746.	746.	746.
ELECTRICITY	328.	369.	410.	410.	410.	410.	410.	410.	410.	410.
STEAM	145.	163.	182.	182.	182.	182.	182.	182.	182.	182.
PROCESS WATER	12.	13.	15.	15.	15.	15.	15.	15.	15.	15.
UTILITIES COST	485.	545.	606.	606.	606.	606.	606.	606.	606.	606.
CHEMICALS.CONTAINER	468.	526.	585.	585.	585.	585.	585.	585.	585.	585.
VARIABLE COST	1550.	1743.	1937.	1937.	1937.	1937.	1937.	1937.	1937.	1937.
DEP.(PROCESS PLANT)	2308.	2308.	2308.	2308.	2308.	2308.	2308.	2308.	2308.	2308.
DEP.(CIVIL AND BUILDING)	289.	289.	289.	289.	289.	289.	289.	289.	289.	289.
DEPRECIATION	2597.	2597.	2597.	2597.	2597.	2597.	2597.	2597.	2597.	2597.
AMR.(PRE-OPER)	120.	120.	120.	120.	120.	120.	120.	120.	120.	120.
AMR.(INT DRG CONST)	332.	332.	332.	332.	332.	332.	332.	332.	332.	332.
AMORTIZATION	452.	452.	452.	452.	452.	452.	452.	452.	452.	452.
DEPRECIATION & AMORTIZATION	3050.	3050.	3050.	3050.	3050.	3050.	3050.	3050.	3050.	3050.
LABOR COST	513.	513.	513.	513.	513.	513.	513.	513.	513.	513.
OVERHEAD	513.	513.	513.	513.	513.	513.	513.	513.	513.	513.
EMPLOYMENT COST	1026.	1026.	1026.	1026.	1026.	1026.	1026.	1026.	1026.	1026.
MAINTENANCE COST	914.	914.	914.	914.	914.	914.	914.	914.	914.	914.
TAX AND INSURANCE	305.	279.	253.	227.	201.	175.	149.	123.	97.	71.
DIRECT FIXED COST	2245.	2219.	2193.	2167.	2141.	2115.	2089.	2063.	2037.	2011.
EX-FACTORY PRODUCTION COST	6844.	7012.	7180.	7154.	7128.	7102.	7076.	7050.	7024.	6998.
UNIT DIRECT OPERATING COST	0.6496	0.5916	0.5451	0.5432	0.5412	0.5392	0.5373	0.5353	0.5333	0.5313
ADMINISTRATIVE & SALES EXP.	342.	351.	359.	358.	356.	355.	354.	352.	351.	350.
INTEREST ON LONG-TERM DEBT	2501.	2501.	2501.	2189.	1876.	1563.	1251.	938.	625.	313.
INTEREST ON SHORT-TERM DEBT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TOTAL PRODUCTION COST	9687.	9864.	10040.	9700.	9360.	9020.	8680.	8340.	8000.	7660.
UNIT PRODUCTION COST	0.9195	0.8322	0.7623	0.7365	0.7107	0.6849	0.6591	0.6333	0.6075	0.5816

*** PARAGUAY ELECTRICITY INTENSIVE CHEMICAL INDUSTRY ***
IRR CALCULATION ON TOTAL INVESTMENT
Electrolysis CHLORINE CAUSTIC COMPLEX (US$1,000)

YEAR	TOTAL INVESTMENT	PROFIT BEFORE TAX	DEPRECIATN	INTEREST ON L-T DEBT	RETURN BEFORE TAX	DISCOUNT FACTOR	(BEFORE TAX) PRESENT VALUE INVEST.	(BEFORE TAX) PRESENT VALUE RETURN	(LESS) INCOME TAX	RETURN AFTER TAX	DISCOUNT FACTOR	(AFTER TAX) PRESENT VALUE INVEST.	(AFTER TAX) PRESENT VALUE RETURN
1983	7916.	0.	0.	0.	0.	1.0000	7916.	0.	0.	0.	1.0000	7916.	0.
1984	15532.	0.	0.	0.	0.	0.9183	14263.	0.	0.	0.	0.9239	14350.	0.
1985	8216.	0.	0.	0.	0.	0.8432	6928.	0.	0.	0.	0.8535	7013.	0.
1986	741.	-1751.	3050.	2501.	3800.	0.7743	574.	2943.	0.	3800.	0.7885	584.	2997.
1987	0.	-978.	3050.	2501.	4573.	0.7111	0.	3251.	0.	4573.	0.7285	0.	3331.
1988	0.	-165.	3050.	2501.	5386.	0.6529	0.	3517.	0.	5386.	0.6730	0.	3625.
1989	0.	175.	3050.	2189.	5413.	0.5996	0.	3246.	0.	5413.	0.6218	0.	3366.
1990	0.	515.	3050.	1876.	5441.	0.5506	0.	2996.	0.	5441.	0.5744	0.	3125.
1991	0.	855.	3050.	1563.	5468.	0.5056	0.	2765.	0.	5468.	0.5307	0.	2902.
1992	0.	1195.	3050.	1251.	5495.	0.4643	0.	2551.	26.	5469.	0.4903	0.	2682.
1993	0.	1535.	3050.	938.	5523.	0.4263	0.	2354.	767.	4755.	0.4530	0.	2154.
1994	0.	1875.	3050.	625.	5550.	0.3915	0.	2173.	937.	4612.	0.4185	0.	1930.
1995	-5232.	2215.	3050.	313.	5577.	0.3595	-1881.	2005.	1107.	4470.	0.3866	-2023.	1728.
TOTAL	27174.				52226.		27800.	27800.		49388.		27840.	27840.

***** INTERNAL RATE OF RETURN ***** 8.90 PER CENT (BEFORE TAX) 8.24 PER CENT (AFTER TAX)

***** PAY-OUT PERIOD ***** 7.03 YEAR (BEFORE TAX) 7.04 YEAR (AFTER TAX)
(THE YEAR WHEN THE TOTAL CAPITAL COST WILL BE PAID OUT BY ACCUMULATED TOTAL RETURN, FROM THE BEG. OF OPERATION)

CAPITAL REQUIREMENTS

LAND AND SITE IMPROVEMENT	0.
PROCESS PLANT	25649.
CIVIL AND BUILDING	4816.
CONSTRUCTED FACILITIES	30465.
PRE-INVEST AND START-UP EXP	1200.
INTEREST DURING CONSTRUCTION	3325.
TOTAL FIXED CAPITAL	34990.
	642.
	100.
INITIAL WORKING CAPITAL	741.
TOTAL CAPITAL COST	35731.

SOURCE OF FUNDS

PAID-UP SHARE CAPITAL	10719.
LONG TERM DEBT	25012.
SHORT TERM DEBT	0.
FINANCIAL RESOURCES	35731.

*** PARAGUAY ELECTRICITY INTENSIVE CHEMICAL INDUSTRY ***
PROFITABILITY AND FINANCIAL INDICATORS
Electrolysis CHLORINE CAUSTIC COMPLEX (US$1,000)

YEAR	(1) AFT TAX PROFIT -TO- SALES REV (PCT)	(2) AFT TAX PROFIT -TO- S/H EQUITY (PCT)	(3) BFR TAX PROFIT -TO- INVESTMNT (PCT)	(4) AFT TAX PROFIT -TO- S/CAPITAL (PCT)	(5) CURRENT RATIO	(6) QUICK RATIO	(7) DEBT SERVICE RATIO	(8) L/T DEBT -TO- S/H EQUITY	(9)* PROFIT B.E.P. CAPACITY UTILIZE (PCT)	(10)* CASH B.E.P. SALES PRICE (PRICE)	(11)* CASH B.E.P. CAPACITY UTILIZE (PCT)
1986	-24.0	-19.5	-4.9	-16.3	8.90	6.03	1.52	74./ 26.	71.7	914.9	43.6
1987	-11.1	-12.2	-2.7	-9.1	1.29	1.05	1.83	73./ 27.	65.3	834.8	39.6
1988	-1.7	-2.1	-0.5	-1.5	1.22	0.97	0.96	71./ 29.	64.3	1115.5	64.9
1989	1.8	2.2	0.5	1.6	1.24	1.00	1.02	66./ 34.	61.5	1086.4	62.7
1990	5.2	6.0	1.4	4.8	1.37	1.13	1.09	59./ 41.	58.7	1049.0	59.9
1991	8.7	9.1	2.4	8.0	1.60	1.36	1.17	50./ 50.	55.8	1011.5	57.1
1992	11.8	11.1	3.3	10.9	1.91	1.67	1.25	37./ 63.	53.0	974.0	54.3
1993	7.8	7.2	4.3	7.2	1.68	1.50	1.17	23./ 77.	50.2	936.5	51.5
1994	9.5	8.7	5.2	8.7	1.60	1.44	1.23	-0./100.	47.4	899.0	48.7
1995	11.2	10.3	6.2	10.3	3.50	3.17	1.30	-0./100.	44.6	861.6	45.9
AVERAGE1	1.9	2.1	1.5	2.5	2.43	1.93	1.25	45./ 55.	57.2	968.3	52.8
AVERAGE2	2.8	2.8	1.5	2.5	1.71	1.46	1.20	55./ 45.			

(AVERAGE1) : SUM OF ANNUAL FIGURES OF PERCENTAGE AND RATIO IS DIVIDED BY NO. OF YEARS(SIMPLE AVERAGE)
(AVERAGE2) : AVERAGE FIGURES ARE CALCULATED BY ACTUAL VALUES ACCUMULATED OVER THE PROJECT LIFE(WEIGHTED AVERAGE)
* NOTE FOR (9)(10)(11)
WHEN THERE ARE TWO OR MORE PRODUCTS, AND DURING THE YEARS WHEN ALL OF PRODUCTS ARE NOT PRODUCED AT THE SAME RATE OF CAPACITY UTILIZATION, ABOVE BREAK-EVEN-POINTS CANNOT GIVE CORRECT FIGURES.

SECTION III

NON-FERROUS METAL REFINING INDUSTRY

CONTENTS

Page

III. Copper

Non-ferrous Metal Refining Industry

I. Introduction

Non-ferrous metals include a wide variety of materials ranging from such as copper, gold and silver, used since early mankind to new metals such as aluminium, titanium, etc., which are being consumed in increasing amounts concurrently with the development of modern industry. The consumption of non-ferrous metals is growing both in terms of quantity and variety along with modern technological developments and,therefore, the refining industry is continually experiencing growth. In essence, the metal industry, including the iron and steel sectors, is a business dedicated to the concentration, extraction and refining of the metallic elements contained in ores, the metallic mineral deposits found around the world. The refining process is carried out suing either thermochemical reaction equipment or electrochemical reaction equipment.
The metal refining industry is an energy-intensive, installation-intensive and capital-intensive business.

Until the early 20th century, metal refineries were located in regions where the raw material were found. Nowadays, however, siting a plant near the raw material source is not necessarily the most advantageous alternative for many kinds of metals in view of developments in transportation, large-scale production, diversification of energy sources and other technological advances.

In the case of Japan, for example, as one of the most important metal producing countries in the world and also as one of the principal metal consumers, its geographical peculiarities as an insular country have been advantageous in the transport of both raw materials such as ores, petroleum and coal, as well as the resultant products. This has enabled Japan to turn out metals at production costs sufficiently competitive on the international market. However, fundamental changes have been taking place in the production structure of world metal refining industries in recent years. The substantial rises in the prices of petroleum resulting from the oil crisis of 1973 are gradually offsetting the merits of bulk transportation and massive production of the metal refining industries in metal consuming countries, therefore, locating refineries at sites where cheap energy is available increasingly advantageous for certain kinds of metal.

Paraguay is not endowed with metallic minerals that can be used as raw materials for the metal refining industry. As well, the domestic consumption of metals is small. Consequently, common sense suggests that this country is not suitable for establishment of a metal refining industry. This conclusion is not necessarily correct, however. There is an extremely wide variety of non-ferrous metals in the world, and is quite possible to introduce a metal refining industry of a type dedicated exclusively to export of products to the world market utilizing the cheap and abundant electricity generated at Itaipu. In such a case the appropriate kind of metal industry will have to be selected taking into account factors such as unit prices of raw materials, and the product, the transportation cost as a share of the production cost, the volume of electrical energy consumed in the production process, etc. It is indispensable to overcome several major obstacles existing in Paraguay at the present time, however, in order to make such projects feasible. Measures required to remove these barriers include the following:

(1) Improvement of transportation infrastructure to lower the transportation cost of imported raw materials such as ore, etc.

(2) Training of management personnel, engineers and technicians for operation of plants.

(3) Strengthening of fund raising capability.

The aforementioned measures are key points for successful implementation of any metal refining projects in Paraguay. These problems are unavoidable in promoting industrialization of any inland country the economy of which is based principally on the agriculture and the problems should therefore be solved through long range efforts for development of the national economy.

In this study several metal refining industries are selected which can be introduced in Paraguay. Preliminary discussion is presented for each on the assumption that long range efforts to overcome development obstacles will be made by Paraguayan authorities.

The metal refining industries that may be feasible in Paraguay discuss in this study were selected based on the following premises:

(1) Related production techniques are mature and technology transfer is relatively easy.

(2) There is a possibility of importing raw materials from the Latin American region, particularly from countries located near Paraguay for the industry introduced in the country.

(3) The related industry's electricity cost requirement represents a large share of the production cost.

(4) The transportation cost for material movement for the industry represents a small share.

(5) There is a good possibility for export of the products to the Latin American market.

From the standpoint of the order of magnitude of the consumption of metals, particularly non-ferrous metals in the domestic Paraguayan market which is small even in the long term view due to the production structure of the national economy. Metal refining industries introduced in Paraguay should be export-oriented. They should consist of import of raw or intermediate products and export of finished products through use of electric energy.

The 3 projects described below are selected based on the aforementioned criteria.

(1) Aluminum refining industry for production of aluminum ingots by electrolysis of imported alumina, which is an intermediate product.

(2) Copper refining industry for production of electrolytic copper by electrolysis of imported crude copper, which is an intermediate product.

(3) Zinc refining industry for production of electrolytic zinc from imported zinc ore. This is the type of zinc refining industry which has the largest consumption of electricity.

II. Aluminum Smelting Industry

1. General Description of Aluminum

Metals such as iron, copper, etc., have been used by mankind since ancient times. Aluminum, however, is a "young" metal discovered only 170 years ago. Industrial production of aluminum started barely 90 years ago. Both the use of and demand for this metal has expanded remarkably within the 90 year period and nowadays the scales of production and consumption of aluminum exceed those of other metals such as copper, zinc, tin, etc. Aluminum is the second most popularly used metallic material next to iron and steel.

The specific gravity of aluminum is approximately 1/3 that of steel and copper and, in addition, it is strong and easy to work. In the early days of production, aluminum was used mainly for utensils for home use. Nowadays it is widely used as a structural material for airplanes, ships, rolling stock, automobiles and other transportation machinery and equipment. It is also consumed in conductors for high voltage transmission lines, electrical machinery, electronic equipment, etc., owing to its good conductivity of heat and electricity. The demand for aluminum in the fields of construction and packing materials, including cans, has expanded considerably in recent years.

In the 1920s the production of aluminum was barely of the order of 0.02% that of steel but in the 1960s that ratio increased to 1.3 to 1.5%, followed by 1.73% in 1973 and 2.24% in 1980. The average annual growth rate of aluminum demand in the 1970s was 4.3%, larger than the world economic growth rate of 3.2% and higher by far the growth rates of 1.9% for steel, 2.7% for copper and 1.9% for zinc recorded during the same period. The primary aluminum industry attained remarkable growth, supported by the strong increase of demand.

The primary aluminum industry has two processes, namely one which converts bauxite, the raw material, into high purity aluminum oxide (i.e., alumina) by means of chemical reactions and the process which converts alumina into aluminum by means of electrolytic reduction. The production of alumina composing the first step in aluminum smelting is an inorganic chemical process based on chemical equipment such as digesters, kilns, tanks, filters, etc., while the second step where the metallic aluminum is turned out is a pyrometallurgical process with the alumina being dissolved in a moltencryolite bath. While alumina production is of a highly chemical nature, the production scale and price of bauxite have a decisive influence on production costs. On the other hand, the aluminum electrolytic process requires a huge amount of electricity, normally 14,000 to 16,000 KWH per 1 ton of aluminum produced. The cost of electricity is an important factor determining the production cost, therefore for this reason aluminum is called "Packaged Electrical Power."

One of the factors contributing to the development of the aluminum industry is abundant reserves of bauxite, unlike in the case of iron and copper. With iron and copper it is necessary to make major investments to exploit new deposits and to develop new technologies to cope with the impoverishment of the ore grade concurrently with a expansion of production. Such investment is a heavy burden on the copper refining and steelmaking industries. On the other hand, bauxite is widely distributed in the tropical and subtropical zones within 30° to the north and to the south of the equator. Confirmed deposits of this mineral as of 1980 were of the order of 30.7 billion tons. Furthermore, exploitation and mining of these deposits is relatively easy because it is found in the form of conglomerates exposed on the earth's furace.

With regard to the location of alumina and aluminum facilities, alumina plants are located in coastal areas where bauxite can be economically transported by ships constructed exclusively for this purpose. On the other hand, aluminum reduction plants are located in areas where large amounts of electricity are available at low cost. Until 1974, when the price of petroleum was low, fully integrated complexes located in coastal areas, covering all stages ranging from bauxite to aluminum and associated with large scale oil fired-thermoelectric power plants used to be the most advantageous. Most aluminum reduction plants newly constructed at that time in the U.S., Japan and Europe were of this type. Since then, the new tendency taking place in the aluminum industry is toward establishment of alumina plants at or near the bauxitiminesite and smelting plants at or near the area where a supply of cheap hydroelectric power is available.

As a consequence of the substantial rise in the price of petroleum energy following the oil crises and the increased consciousness of the bauxite producing countries regarding the value of their natural resources, the aluminum industry of the former type is being faced with substantial increases in production costs. As a result, plants of the latter type are becoming increasingly advantageous. The aluminum industry was developing quite satisfactorily until recently but since 1980 it has faced an unprecedented reduction in demand as a consequence of the worldwide economic recession. The market prices of this metal suffered a substantial drop, and the world aluminum industry is now in an extremely difficult position. On a long-term basis, however, the demand for aluminum is expected to increase at a rate higher than the growth rate of the world economy. In particular, the Latin American market, where the consumption of aluminum is currently at a low level, is expected to expand very rapidly.

2. Present Market Situation and Price of Aluminum

2-1 Production and Consumption

Aluminum is produced in 34 countries of the free world and in 8 countries of the communist block, totalling 42 countries as of 1980. The world production of aluminum was 10.3 million tons in 1970, but in 1980 it increased to 16.06 million tons, growing therefore by approximately 60% during the decade. In terms of distribution by area, North and South America has 40% share, Europe, 24% the communist block 20%, Asia 10% , Oceania 3% and Africa 3%. In terms of production share by country, the U.S. produces 29%, the Soviet Union 15%, Japan 7% , Canada 7% , West Germany 5%, and Norway 4% . These six countries are the principal aluminum producing countries of the world. In Latin America there are currently 5 countries producing aluminum, with Venezuela leading the group, followed by Brazil, Argentina, Mexico and Surinam. The production of aluminum in Latin America in 1980 was approximately 820,000 tons, or 5% of the world total.

As a consequence of the rise in energy costs after the oil shock of 1974, the production of aluminum in the major traditional producing countries such as the U.S., Canada, Japan, West Germany and Norway is either stagnant or declining. On the other hand, production has been growing remarkably in countries such as Venezuela and Brazil, which are favoured with abundant resources of bauxite in addition to cheap electrical energy.

The world consumption of aluminum was 15.3 million tons in 1980, with a growth of more than 50% compared to the 10.02 million tons produced in 1970. The consumption of this metal has been stagnant since 1974 due to the recession in the world economy caused by the oil crisis. In terms of consumption by country, the 5 leading countries consume 62% of the world total, with the U.S. consuming 29%, the Soviet Union, 12%, Japan, 10%, West Germany, 7% and France, 4%. In Latin America, Brazil has the largest consumption with 280,000 tons, followed by Mexico with 110,000 tons, Venezuela with 80,000 tons and Argentina with 70,000 tons. The total consumption of Latin America is approximately 600,000 tons, representing barely 4% of the world total. The growth rate for consumption of aluminum in the '70s was 11%/year, surpassing by far the world average of 4.3% during the same period, however.

The consumption of aluminum has a close correlation with the income level of the population and the industrial level of the country in question. Statistical data on consumption of aluminum per capita in the industrialized countries as of 1980 show that it was 26 kg. in the U.S., 22 kg. in West Germany, 21 kg. in Japan and 14 kg. in France. Compared with these large consumption figures, those for Latin America are quite modest, with 2.9 kg. in Brazil, which has the largest consumption in the area, followed by Argentina with 2.7 kg.

Currently the consumption of aluminum is stagnant due to the worldwide recession. But considerable growth can be expected on a long-term basis concurrent with the increase in per capita income and the rise in the industrial levels of developing countries.

2-2 Demand Trends

Analysis of the supply and demand balance for aluminum in the world using statistical data shows that production exceeded 100% only in 1970, 1971 and 1975 in the '70s and in 1980. In all other years consumption exceeded the production. The two statistics are not perfectly adjusted but it is presumed that the gaps between supply and demand were compensated for using cushion stocks. With regard to the communist block, the production of aluminum exceeded consumption in 1976 but demand has since been larger than production.

By area, Africa, Oceania and America can be considered supplier areas while Europe and Asia have consumption larger than production. As for Latin America, production of aluminum in 1980 was 820,000 tons while consumption was 600,000 tons, i.e., production is approximately 1.5 times larger than consumption and therefore a large amount of the metal is exported to other areas.

In terms of share per country, in the free world Norway, Canada, Holland, etc., are traditional exporters but recently newcomers such as New Zealand, Bahrain, Spain, Venezuela, etc. have entered the world aluminum export market. As for the U.S., this depends on the economic situation of the country, i.e., when the domestic economy

Table II-2-2

Aluminium (unwrought)

	1975	1976	1977	1978	1979	1980
World exports						
Canada	509	508	655	863	551	785
Norway	452	562	555	630	565	521
USA	169	139	89	102	164	608
Netherlands	264	290	316	294	359	365
Germany, FR	160	281	199	272	248	224
France	164	149	166	166	158	177
UK	88	162	145	160	205	194
Ghana	136	145	148	111	153	132
Australia	77	65	78	80	76	44
Other	649	796	810	858	936	645
WOCA Total	2668	3097	3161	3536	3415	3695
USSR(*e*)	500	520	520	580	560	n.a.
Other non-WOCA(*e*)	160	180	330	290	210	n.a.
World total(*e*)	3328	3797	4011	4406	4185	n.a.
World imports						
Japan	378	430	534	740	748	910
USA	415	517	611	686	517	527
Germany, FR	287	417	440	434	511	589
France	218	251	275	291	315	333
Italy	111	197	196	191	237	295
Belgium	188	258	238	267	253	233(*a*)
Netherlands	121	162	162	146	167	216
UK	160	218	197	186	182	169
Other	369	468	553	551	533	600
WOCA Total	2247	2917	3204	3490	3463	3872
Non-WOCA(*e*)	450	450	500	680	580	n.a.
World total(*e*)	2697	3367	3704	4170	4043	n.a.

Note: (*a*) January to November.
(*e*) estimate.
n.a. not available.
WOCA: World Outside Communist Areas.

Source: World Bureau of Metal Statistics, *World Metal Statistics*, (May 1981) and Department of Trade and Resources estimates.

is booming it is an importer of aluminum but during recession periods such as occurred in 1970 and 1980, production surpasses consumption and the country is an exporter of this commodity. As for West Germany, France, Italy, Great Britain and Japan, these countries are classified as aluminum importing countries.

According to statistical data for 1980, the principal exporters of aluminum in the world are Canada (790,000 tons), the U.S. (610,000 tons), Norway (520,000 tons) and Holland (370,000 tons). These four countries generate 62% of total exports in the free world. The principal importers are Japan (910,000 tons), West Germany (590,000 tons), the U.S. (530,000 tons) and France (330,000 tons). These countries take 61% of all imports in the free world. Definitive 1981 statistical data for individual countries throughout the world are not available yet but the production of aluminum in the free world is estimated to be 12.47 million tons and consumption 11.24 million tons, a drop of 2.3% in production and 6.2% in consumption compared with 1980.

The aforementioned data reflect the declining demand in every major industrial country as a consequence of the serious economic recession. The supply/demand balance indicates a considerable excess of supply causing stocks of aluminum in the free world to increase rapidly. Accordingly to inventory statistics of IPAI (International Primary Aluminum Institute), the stock of aluminum in the free world (excluding Yugoslavia) reached a peak of 3.39 million tons in September of 1975, coinciding with an economic recession, after which it declined gradually, reaching a bottom of 1.39 million tons in April of 1980. Stocks then increased rapidly, reaching 3.11 million tons at the end of 1981 and

3.32 million tons in February of 1982. This is almost equivalent to the peak stock registered in 1975.

The proportion of stock in relation to production corresponds to 3.9 months for all member countries of IPAI, with 8.2 months in Asia, 4.9 months in North America, 3.5 months in South Asia, 2.9 months in Europe, 2.5 months in Africa, 2.1 months in Latin America and 2.0 months in Oceania. The data above indicate extremely large stocks in the first two areas.

The stock of aluminum in free world countries surpassed 3.1 million tons in mid 1982 and there is no sign of substantial improvement. On the other hand, while no accurate data on demand is available there is no indication of change for the better in the form of stock reductions by increases in shipment to cover growth of demand. As a matter of fact, stocks are being adjusted by controlling production.

In Japan, aluminum smelting facilities are being scrapped due to unprofitability caused by soaring energy prices after the oil shock. Production in the U.S. is also undergoing drastic cut backs due to the sharp decline in demand.

Detailed reports on the production cut back situation are carried in trade and economic newspapers and magazines such as the American Metal Market, Metal Bulletin, etc. The information contained therein can be summarized as follows. The rate of operation, expressed in terms of the ratio (operating capacity)/(installation capacity) is low all over the free world, with 31% in Japan, 12% in Taiwan, 58% in the U.S. and 66% in Great Britain, resulting in an estimated average of the order of 75% for the free world as a whole. There are countries with no slow-down at all in operation, however, and the situation varies according to country and individual company.

2-3 Price

There are various aluminum transaction price indexes, namely, the export quotation of Alcan, the U.S. producers quotation, the NY market quotation in the U.S., the London free market quotation and the LME spot market and 3 month futures quotation.

The export quotation of Alcan is called the World Price and is an important reference price for international transactions of aluminum ingot. The Alcan quotation experienced 4 successive rises in 1979 but the current price has remained for more than 2 years, with the latest hike to US$1,750/ton in March, 1980.

On the other hand, the LME quotation is changing bit by bit. Starting from £631/ton in January, 1979, the quotation peaked at £931/ton in February, 1980 (the London Free quotation peaked slightly above US$2,000/ton in the same month) but after this the price slowed down as a consequence of the reduction in demand and the increase of stocks, bottoming at £523/ton in June, 1982 (in June, 1982 the U.S. Market quotation was US$945/ton and the London Free quotation was US$981/ton).

Very recently the transaction volume of aluminum has been increasing and the LME quotation, an index which is sensitive to the supply and demand balance and other relevant factors, is attracting attention and exerting an

Table II-2-3 Overseas Aluminum Ingot Quotation (January, 1978 to March, 1982)

	Alcan Export List US$/ton (Cents/Pound)	London Free Market 99.5% (US$/ton) High Quotation	London Free Market 99.5% (US$/ton) Low Quotation	London Free Market 99.7% (US$/ton) High Quotation	London Free Market 99.7% (US$/ton) Low Quotation	LME Spot (£/ton)	LME 3 month futures Quotation (£/ton)	LME Settlement (£/ton)	Producers List (¢/£)	U.S. Market (¢/£)
1978年 1月	1) 1,124(51.000)	955.625	970.625	–	–	–	–	–	53.000	48.940
2	〃 〃	953.750	968.750	–	–	–	–	–	53.000	48.139
3	〃 〃	950.000	965.000	–	–	–	–	–	53.000	48.033
4	〃 〃	961.250	976.250	–	–	–	–	–	53.000	48.313
5	2) 〃 〃	971.875	985.000	–	–	–	–	–	53.000	49.545
6	1,168(53.000)	1,020.000	1,036.667	–	–	–	–	–	53.000	50.284
7	〃 〃	1,041.250	1,056.875	–	–	–	–	–	53.000	50.925
8	3) 〃 〃	1,057.500	1,079.375	–	–	–	–	–	53.000	51.359
9	1,253(56.019)	1,070.000	1,091.667	–	–	–	–	–	53.000	52.500
10	〃 〃	1,110.000	1,135.000	–	–	–	595.81	–	53.000	53.619
11	〃 〃	1,175.625	1,203.750	–	–	–	606.45	–	53.000	54.850
12	〃 〃	1,170.000	1,185.000	–	–	–	621.54	–	53.900	55.325
1979年 1月	4) 〃 〃	1,225.625	1,240.625	1,240.000	1,260.000	630.78	630.77	631.28	55.000	57.182
2	1,300(58.968)	1,325.750	1,343.125	1,326.250	1,353.750	719.41	718.51	720.55	55.000	63.324
3	5) 〃 〃	1,452.778	1,477.778	1,463.333	1,491.667	756.57	753.16	757.23	55.341	70.432
4	1,400(63.504)	1,475.000	1,500.000	1,490.000	1,530.000	756.87	755.54	757.47	58.000	72.762
5	〃 〃	1,497.500	1,520.000	1,515.000	1,545.500	766.25	772.58	766.83	58.000	73.182
6	〃 〃	1,573.333	1,610.667	1,582.222	1,610.000	756.65	758.60	757.55	58.000	74.393
7	〃 〃	1,521.667	1,548.333	1,532.222	1,557.222	678.93	676.93	679.70	58.000	71.381
8	6) 〃 〃	1,520.00	1,537.50	1,530.00	1,565.00	697.86	690.70	698.80	58.000	71.413
9	1,525(69.174)	1,520.00	1,540.00	1,530.00	1,580.00	735.34	728.43	736.25	60.079	72.526
10	〃 〃	1,588.33	1,608.33	1,653.33	1,683.33	831.93	781.95	835.61	65.318	73.409
11	7) 〃 〃	1,705.00	1,732.22	1,717.78	1,748.89	860.55	805.47	863.18	66.000	72.579
12	1,600(72.576)	〃	1,740.00	1,720.00	1,760.00	869.97	829.26	871.28	66.000	75.875
1980年 1月	〃 〃	1,880.714	1,955.00	1,871.667	1,945.00	907.64	898.13	908.84	66.000	84.068
2	8) 〃 〃	1,960.00	2,040.00	1,970.00	2,050.00	930.33	937.83	931.19	66.000	90.579
3	1,750(794)	1,780.00	1,864.00	1,860.00	1,895.00	896.79	866.75	898.90	66.000	86.387
4	〃 〃	1,827.143	1,887.143	1,871.250	1,907.500	872.35	839.61	874.00	68.000	82.159
5	〃 〃	1,758.333	1,791.667	1,770.000	1,798.889	771.33	761.29	772.15	68.000	74.786
6	〃 〃	1,640.625	1,675.625	1,675.625	1,711.250	714.12	714.62	714.81	68.000	70.476
7	〃 〃	9) nom.	9) nom.	9) nom.	9) nom.	741.12	724.50	741.96	68.000	70.909
8	〃 〃	1,674.286	1,702.857	9) nom.	9) nom.	752.85	735.98	753.78	68.000	72.333
9	〃 〃	1,664.444	1,694.444	1,635.00	1,666.667	689.05	698.78	689.77	69.333	71.429
10	〃 〃	1,630.000	1,660.000	1,630.000	1,660.000	673.07	697.59	673.78	75.455	72.432
11	〃 〃	1,530.000	1,558.333	1,475.000	1,500.000	626.99	651.63	627.65	76.000	70.353
12	〃 〃	1,432.500	1,457.500	1,461.875	1,486.875	610.83	631.14	611.55	76.000	67.398
1981年 1月	〃 〃	1,435.00	1,462.50	1,460.00	1,485.00	594.98	615.13	595.68	76.00	67.595
2	〃 〃	1,430.00	1,455.00	1,460.00	1,485.00	632.54	645.93	633.13	76.00	67.861
3	〃 〃	1,421.11	1,441.67	1,433.33	1,458.33	647.22	656.17	647.89	76.00	68.000
4	〃 〃	1,385.00	1,403.75	1,387.86	1,407.14	628.64	643.49	629.15	76.00	65.977
5	〃 〃	1,295.00	1,310.00	1,300.00	1,315.00	620.58	639.84	621.03	76.00	62.763
6	〃 〃	6) nom.	6) nom.	6) nom.	6) nom.	623.74	644.25	624.20	76.00	60.102
7	〃 〃	6) nom.	6) nom.	6) nom.	6) nom.	626.60	646.88	627.11	76.00	56.696
8	〃 〃	6) nom.	6) nom.	6) nom.	6) nom.	676.56	700.40	677.23	76.00	57.905
9	〃 〃	6) nom.	6) nom.	6) nom.	6) nom.	644.16	670.18	644.61	76.00	56.905
10	〃 〃	6) nom.	6) nom.	6) nom.	6) nom.	618.69	645.98	619.05	76.00	54.786
11	〃 〃	1,100.00	1,132.50	6) nom.	6) nom.	568.75	592.69	569.29	76.00	48.917
12	〃 〃	1,135.00	1,180.00	6) nom.	6) nom.	593.35	616.25	593.69	76.00	50.614
1982年 1月	〃 〃	1,107.50	1,150.00	6) nom.	6) nom.	590.04	614.36	590.45	76.00	51.250
2	〃 〃	1,105.00	1,125.00	6) nom.	6) nom.	588.99	610.61	589.43	76.00	51.500
3	〃 〃	1,045.00	1,067.50	6) nom.	6) nom.	569.29	591.52	569.70	76.00	50.087

Note: 1) Since April 1, 1977 2) Since June 19, 1978 3) Since September 20, 1978
4) Since February 6, 1979 5) Since April 18, 1979
6) Since September 28, 1979 7) Since December 20, 1979
8) Since March 27, 1980
9) Nominal: Discrepancy from actual state due to insufficient amount.

Source: Metal Bulletin, Metals Week

important influence on spot quotations for the metal. Currently the supply and demand balance is slack, stocks are increasing and it is presumed that ingots turned out by producing countries of the communist block and other countries which are keeping high operation rates are flooding the LME, therefore, the LME aluminum business is becoming gradually active.

In view of the fact that the current quotation is under US$1,000/ton, it is said that U.S. aluminum producers are also incurring losses.

A new trend taking place in the world aluminum market is the relatively close correlation between the LME stock fluctuation described earlier and the situation in other markets.

2-4 Form of Transactions

Primary aluminum ingots are ingotiated in the same form as other non-ferrous metals but in addition to the spot transactions and long-term contract transactions there is also the so-called development import where the amount of metal offtake and other conditions are determined in advance between the participants in the projects. The price is determined on a CIF major ports of the world basis.

In spot transactions the prices fluctuate considerably depending on factors such as the LME quotation, interest rates, time of commodity delivery, etc., and there are many uncertainties for the consumer. Negotiation is carried out in relatively small lots in spot transactions. On the other hand, in the case of large consumers and trading companies which require the product in large lots, transactions are carried out on a long-term contract basis. In this case the transaction is stable from the point of view of quantity and there is the merit of planned production for both producer and consumer.

On the other hand, the investment required for construction of new aluminum smelting plants tends to increase and, in particular, additional investment in addition to the plant installation itself is required when the infrastructure is not sufficiently consolidated at the construction site. The tendency recently for construction of new aluminum refining plants is therefore to organize international financing consortia with the participation of local capital and foreign investors, aiming at sharing the fundraising responsibility and dispersing the risk. This form of financing is often adopted in Latin America.

In the case of international joint venture projects of this kind, it is common to determine the share of the produced aluminum ingots commensurate with the investment share and other relevant factors. This type of project has merit for both parties concerned, i.e., the investor has a stable ingot supply source and the producer can engage in planned production on a long-term basis with no concern about marketing.

There are some points which require special attention, however. The aspects following should be carefully discussed by parties investing in the project.

- The transaction prices should be set in such a way as to ensure competitiveness in the international market.

- The price and the quantity of aluminum to be taken should be guaranteed on a long-term basis.

- The supply and price of electricity, which constitutes an important influence on the cost of the product, should be guaranteed on a long-term basis.

- The construction period, time of commissioning, inflation hedge and other aspects should be carefully studied.

In Latin America (only Argentina, Brazil, Surinam and Venezuela) there are 11 projects in operation or in the process of implementation (described later in this report) and in most of them the aluminum ingots seem to be taken according to the investment share.

The construction of an aluminum smelting plant requires the investment of huge capital and a long period of time, therefore, the start and completion of construction may be varied, depending on factors related to market conditions and the economic situation in general. This aspect should be studied with special care in view of the instability of the international economy.

2-5 Major Aluminum Companies

The 6 international major aluminum companies, which are traditional integrated aluminum makers, exert of strong direct and indirect influence on every aspect of the aluminum industry ranging from exploitation of bauxite mines to aluminum production and marketing.

These aluminum companies are ALCOA (U.S.), ALCAN (Canada), Reynolds (U.S.), KAISER (U.S.), PUK (France) and ALUSSUISE (Switzerland).

These major companies have a 40% share of world bauxite production capacity (45% of free world production capacity), 54% of alumina production capacity (63% of free world alumina production capacity) and 43% of aluminum smelting capacity (53% of free world aluminum refining capacity). In recent years the share of the major aluminum companies in the world has been declining due to increases in the alumina and aluminum production capacity of industrialized countries like Japan and the intervention of the governments of bauxite producing countries in the aluminum business and, therefore, their influence on the international aluminum market is also weakening.

3. Future Prospects of the Aluminum Market

3-1 Supply and Demand Prospects

The consumption of aluminum in the free world expanded with high growth rates averaging 9.2%/year in the '50s and '80s, however, it slowed to 4.2%, as a consequence of the oil shock and the world economic recession in 1975, 1980 and 1981. Consumption of aluminum is growing steadily in the fields of transportation, construction and packing materials, however, and on a medium and long-term basis it is expected to show stable growth, supported by demand in these fields.

A quantitative demand forecast for aluminum on a medium and long-term basis is very difficult. Several authoritative survey organizations are carrying out such forecast work though. Such being the case, the Chase Econometric forecast, a typical example, is used as a reference in this study.

So far Chase Econometric has published many medium and long-term forecasts. In the report of February, 1982 it forecasts the consumption of primary aluminum ingot in the free world based on forecasts from the principal countries.

This forecast refers to 2 cases, namely the trend of most probability and the standard cycle.

Growth rates of 2.3% to 3.4% for the 1980 to 1985 period and 3.8% to 4.1% for the 1985 to 1990 period, regarding consumption of primary ingots of aluminum in the free world seem to be rather optimistic. It is presumed possible to maintain a growth rate of approximately 4%/year for the coming decade (1980 to 1990), however.

Production is determined by the installed capacity and the operation rate. Production capacity is expected to reach 15,803,000 ton by 1985, on the basis of the currently existing capacity and the planned ones.

According to the Spector Report of August, 1982, the free world production capacity was revised from the 15,363,000 tons announced in the same report of late 1981 to a more moderate 14,982,000 tons. Accordingly, the aforementioned forecast seems somewhat exaggerated for the present. In any case with respect to the balance between consumption and production, the operation rate is expected to be of the order of 80% in 1985, with a surplus supply capacity.

The same source forecasts future investment costs for aluminum plants of US$6,220 to US$6,450 per ton of capacity in 1985, with an increase of 8% to 9% compared with the investment required in 1980. Accordingly, the direct production cost is expected to rise from US$1,157 ton prevailing in 1980 to the order of US$1,830 to US$1,930 in 1985 and the target marketing price is therefore expected to rise to US$2,660 ton to US$2,790 in 1985 compared with US$1,718 in 1980.

Forecasts by the Spector Report and the IBA are also given as references.

As can be seen from the above, there is considerable fluctuation in the supply and demand prospects, according to the surveying organization, evidencing the difficulty forecasting present. In any case, the various forecasts seem to agree that even in 1985, aluminum smelting facilities will not be required to operate at full capacity.

3-2 Export Market

The supply and demand prospects balance in the free world aluminum market is expected to be loose by 1985 and, therefore, in the case of start up of new smelting facilities, it is expected to be quite difficult to find markets for the products.

In the case of production at relatively low cost, there is a possibility that exist clients in the international market will exist but the situation will be quite unstable.

The economies and industries of South American countries, including Paraguay, are currently in a development stage and there is possibility of creation of new markets in future. On the other hand, competition is expected to be severe and the absorption capacity of aluminum by the market is not expected to be sufficient.

On the other hand, when aluminum is produced by an international consortium and the share of the product for each investor is agreed to in advance, the project stands in an advantageous position becuase a stable market is guaranteed.

In other words, in the case of an aluminum smelting project in Paraguay, it is expected that it will be quite difficult to enter the export market in the near future.

Table III-3-1 Forecast by Chase Econometric

	1980	1985				1990			
1. Demand (1,000 tons, %)		Trend		Standard Cycle		Trend		Standard Cycle	
U.S.	4,473	5,048	(2.5)	4,644	(0.8)	5,863	(3.0)	5,676	(4.1)
Canada	292	414	(7.2)	390	(6.0)	542	(5.5)	522	(6.0)
Japan	1,637	2,184	(5.9)	2,118	(5.3)	3,126	(7.4)	3,123	(8.1)
Europe	3,858	4,435	(2.8)	4,197	(1.7)	5,428	(4.1)	5,318	(4.9)
Brazil	309	365	(3.4)	360	(3.1)	470	(5.2)	470	(5.5)
Others	1,457	1,757	(3.8)	1,734	(3.5)	2,552	(7.8)	2,398	(6.7)
Free World Total	12,025	14,202	(3.4)	13,444	(2.3)	17,981	(4.8)	17,509	(5.4)
80 → 90							(4.1)		(3.8)
2. Production (1,000 tons)									
Free World Total	12,775	14,054		13,558		17,944		17,222	
3. Capacity (1,000 tons)	13,414	15,803		15,803		18,934		18,082	
4. Production (1,000 tons)	12,775	14,054		13,558		17,944		17,222	
5. Rate of Operation	95%	89%		86%		95%		95%	
(Reference)									
Spector (1,000 tons)									
Demand				15,295					
Production				15,127					
Capacity				15,963					
Rate of Operation				94.8%					
(Reference)									
IBA - (1,000 tons)									
Demand = Production				14,919					
Capacity				17,974					
Rate of Operation				83%					
6. Direct Cost Total (US$/ton)	1,157	1,831		1,925		2,695		2,874	
Capital Cost (US$/ton)	4,194	6,217		6,446		8,408		9,106	
Target Price (US$/ton)	1,718	2,663		2,788		3,821		4,093	
7. U.S. Producer List (US$/ton)	1,534	2,782		2,664		4,093		3,822	

4. Aluminum Production Process

4-1 Alumina Refinery

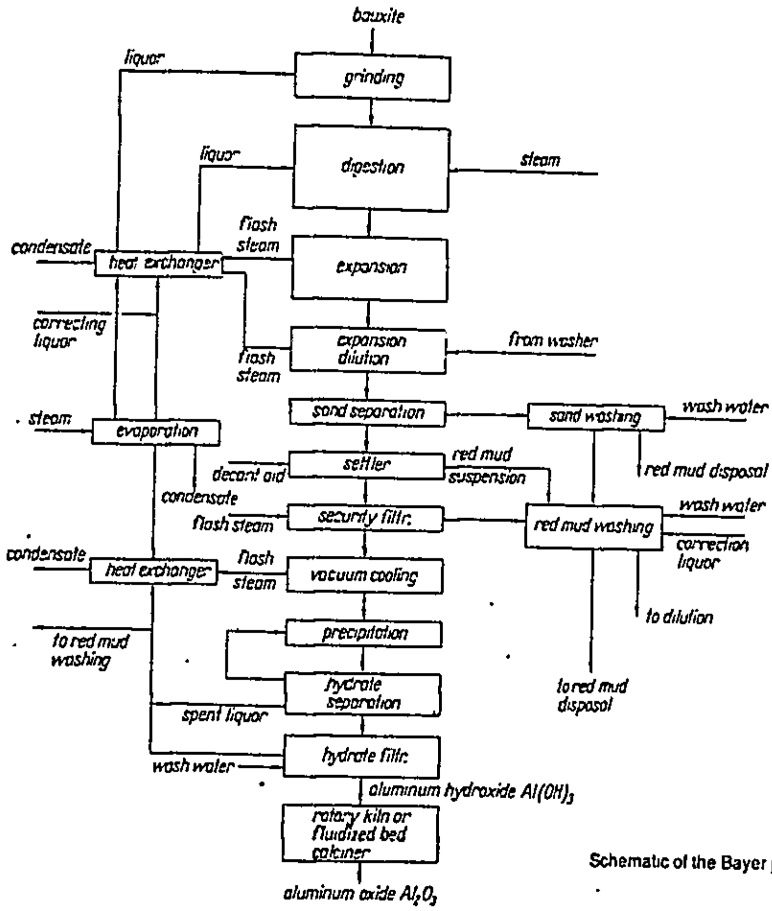
The aluminum production process consists of two parts, described as follows:

- Alumina refining process where bauxite is treated with caustic soda (Bayer process).

- Aluminum smelting process where alumina is electrolytically reduced (Hall-Heroult process)

In the alumina refining process the bauxite is crushed, mixed with caustic soda and digested at a temperature of more than 130°C under a pressure of 5 kg/cm^2 in an autoclave or digester. In this treatment, alumina hydrate present in the bauxite is dissolved in the caustic solution, becoming sodium aluminate. After digestion is completed, the insoluble conponents of the bauxite - primarily iron oxide, silica and titania - remain as a residue known as red mud. The red mud is filtrated and discarded. Next, the sodium aluminate solution is diluted by adding approximately double the amount of water and is sent to a precipitation tank for cooling. The diluted sodium aluminate solution is cooled down to approximately 50 to 60°C and agitated for approximately 100 hours, during which time the alumina hydrate is precipitated out. The aforesaid alumina hydrate is calcined in a kiln at a temperature of approximately 1,200°C becoming calcined alumina.

Figure II-4-1 Alumina Production Process

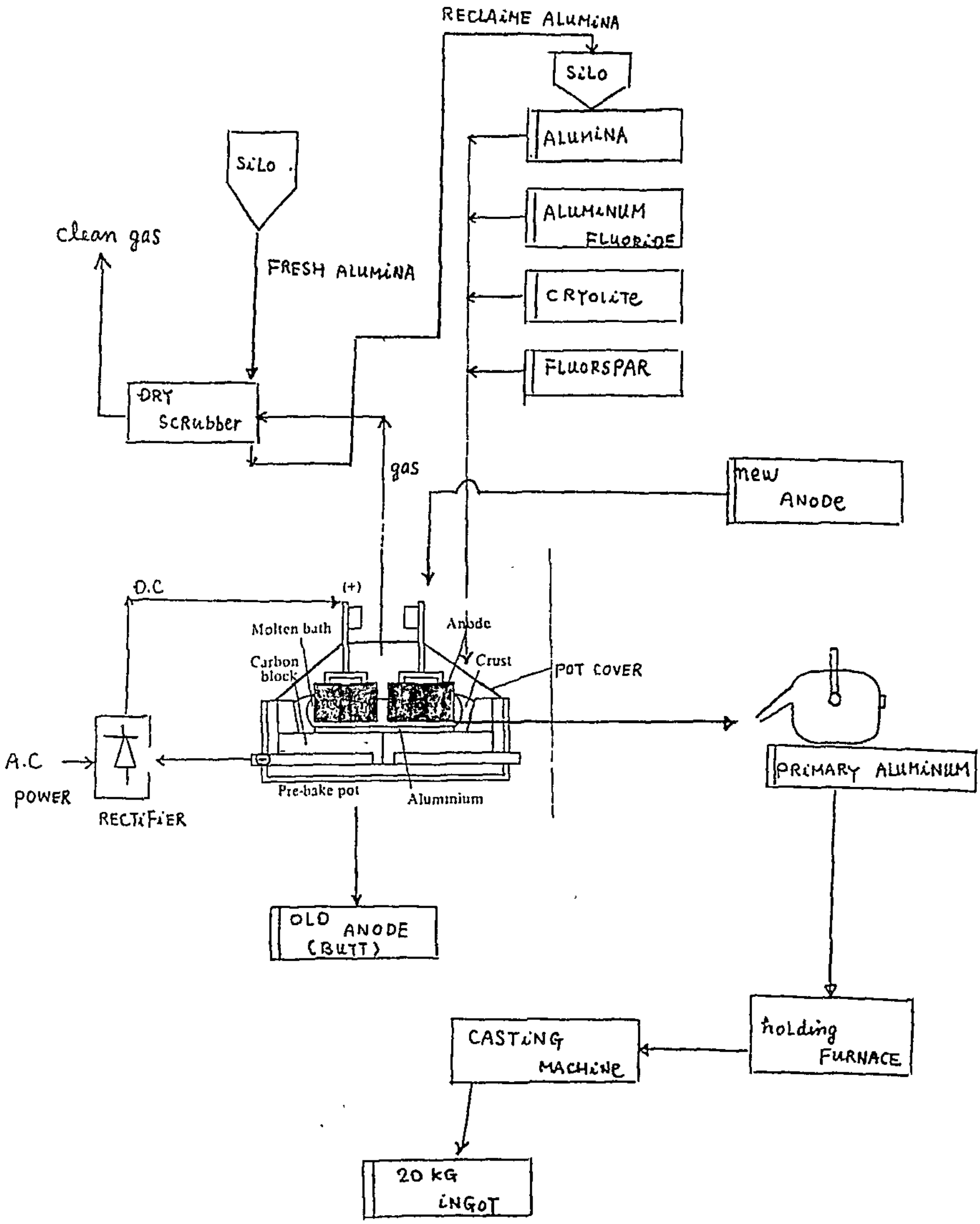


Schematic of the Bayer process.

4-2 Electrolysis of Aluminum

In the electrolytic reduction process, cryolite is initially charged in a reduction cell (or pot) and is melted by introducing direct current. The alumina is then charged in moltencryolite. Alumina itself has a melting point of more than 2,000°C, and is quite hard to melt, however, its melting point can be lowered by adding cryolite and temperatures of the order of 950 to 1,000°C are suffi-

Figure II-4-2 Aluminum Electrolysis and Casting Process



cient. When electrolysis is carried out with a current of the order of $2A/cm^2$, by applying a voltage of 5 to 6V, molten aluminum is deposited on the cathode located at the bottom of the cell. Molten aluminum accumulated at the bottom of the cell is tapped with a vacuum ladle and then transported to the holding furnace. Aluminum contained in the holding furnace is poured in to moulds of the casting machine where it is cooled and solidified to form aluminum ingots, the finished product of the aluminum reduction process.

The electrolytic process consumers large amounts of electrical energy, requiring approximately 14,000 to 15,000 KWH to produce one ton of aluminum.

5. Quality and Market of the Principal Raw Materials

5-1 Bauxite

The confirmed reserves of bauxite existing in the world amount to 30.7 billion tons as of 1980. In terms of the current annual consumption level of bauxite (90 million tons), there is a quantity sufficient to cope with more than 300 years of consumption. Further, confirmed reserve surpassing consumption are discovered frequently. Accordingly, there is no concern about shortage of aluminum resources.

The most important deposits of bauxite are located in New Guinea (37%), Australia (16%), Brazil (1%) and Jamaica (5%). These 4 countries have approximately 70% of the total reserves of the world.

Table II-5-1

World trade ('000 tonnes)

	1975	1976	1977	1978	1979
Bauxite					
World exports					
Total of which:	30 547	32 016	34 884	35 298	34 997
Guinea	6 505	8 576	9 146	10 225	9 338
Jamaica	6 368	7 166	7 447	7 591	7 831
Australia	7 839	6 904	7 314	6 563	6 854
Surinam	1 948	1 817	2 261	2 486	1 771
Guyana	1 119	1 297	1 398	1 716	1 530
Greece	1 035	990	1 119	1 595	1 767
World imports					
USA	11 861	13 111	13 616	15 333	14 506
Japan	4 600	4 275	5 318	4 743	4 596
Germany, FR	4 213	4 087	4 091	3 614	3 694
USSR	3 477	4 140	4 140	3 610	3 612
Italy	1 830	1 824	1 913	1 608	2 169
Canada	2 430	1 231	2 755	2 433	2 149
France	1 458	2 270	1 919	1 955	1 720
Alumina					
World exports					
Total of which:	10 484	11 683	13 029	12 947	13 409
Australia	4 194	5 442	6 153	6 085	6 809
Jamaica	1 831	1 787	1 935	2 148	1 977
Surinam	1 028	811	970	1 159	1 010
USA	397	888	924	873	775
World imports					
USA	3 192	3 288	3 759	3 967	3 767
Norway	1 235	1 312	1 312	998	1 174
Canada	763	909	822	1 057	953
Japan	546	627	940	757	759
UK	558	526	703	740	596

Source: World Bureau of Metal Statistics, *World Metal Statistics*, various issues.
Metallgesellschaft A.G., *Metal Statistics 1969–79*.

In terms of production also, these countries have the largest share. According to statistical data of 1980, five countries, namely Australia (29%), Guinea (14%), Jamaica (13%), Surinam (5%) and Brazil (4%) have 65% of world production totalling 92.6 million tons.

The principal exporters of bauxite as of 1979 are Guinea (9.34 million tons), Jamaica (7.83 million tons), Australia (6.85 million tons) and Surinam (1.77 million tons).

The principal importers of bauxite are the U.S. (14.51 million bons), Japan (4.6 million tons), West Germany (3.7 million tons), and the Soviet Union (3.61 million tons).

For aluminum smelters, principally the major aluminum companies participate directly in the production of bauxite and in most of the cases they have the majority of production. The amount of bauxite sold on the free market is approximately 13% of total bauxite production therefore the quality of the bauxite presents different chemical compositions and physical properties according to the mine and, therefore, it is not uniform. Generally speaking, however, it must contain more than 45% Al_2O_3 and less than 5% of SiO_2.

5-2 Alumina

Alumina is the aluminum oxide (Al_2O_3) extracted from bauxite and is the intermediate product between bauxite and aluminum ingots. Currently, the most common pattern in the aluminum industry is massive production of alumina in bauxite producing countries and export by sea to smelting areas.

Fluctuation in the production of alumina is roughly linked with the production of aluminum ingots. World production is of the order of 35 million tons as of 1980. The principal alumina producing countries are Australia (21%), the U.S. (20%), the Soviet Union (9%), Jamaica (7%) and Japan (6%). Australia exports 90% of its production of alumina, while Jamaica exports 100%.

The principal exporters of alumina as of 1979 are Australia (6.81 million tons), Jamaica (1.98 million tons) and Surinam (1.01 million tons). As can be seen from these figures, Australia has the absolute majority of world exports of alumina, being a supplier to countries all over the world.

Aluminum makers are principally the major aluminum companies participating in the production of alumina, as in the case of the bauxite exploitation. They generate the majority of production. Approximately 80 to 85% of total alumina production is either consumed by these majors or is supplied to their subsidiary companies and the remaining is traded on the free market.

Alumina is normally sold on a long-term contract basis and the prices are reviewed every 1 to 2 years. Alumina traded on the international market is of three types according to grade, namely, metal grade (for smelting), chemical grade and others (for refractories, abrasives, etc.), but the chemical composition is approximately the same, being more than 99.3% alumina.

5-3 Cryolite and Aluminum Fluoride

Cryolite and aluminum fluoride are indispensable materials in the aluminum smelting industry. Aluminum fluoride is added occasionally to adjust the cryolite bath ratio of NaF/AlF_3, because it is dispersed during electrolysis.

Usually, cryolite is recovered by the smelters in the form of synthetic cryolite using the fluorine gas collected during the smelting to meet their own requirement and so smelters purchase from external sources only when it is needed.

In Japan, aluminum fluoride used as an additive is purchased from makers specializing in its production.

Fluorite concentrates (more than 96% of CaF_2) are used as raw material for production of both cryolite and aluminum fluoride in most cases. Recently however, use of the fluorine contained in rock phosphate, extracted during the treatment of this mineral, is becoming.

5-4 Carbon Materials

Anode and cathode are required in the aluminum electrolytic process. There are two types of anode, namely the pre-baked type electrode and the self-baking type electrode. The former type is produced using the same method as other type electrodes, while the latter type, called Sodeberg, is formed by self-baking during the electrolytic process.

Recently, the pre-baked electrode (anode block) is used more commonly in view of soaring electricity costs and increasingly severe environmental pollution control.

The anode is normally produced at a carbon plant constructed together with an aluminum smelting plant. The raw materials required for production of anode are calcined petroleum coke and binder pitch.

Carbon blocks are used as cathode at the bottom of cells.

The U.S. is the leading petroleum coke producing country and it supplies this product to countries all over the world.

As for the quality of the calcined petroleum coke, it must contain more than 98.5% fixed carbon, less than 2.5% sulfur, less than 0.5% volatile mater and less than 0.5% ash.

6. Aluminum Smelter Project Planned for Paraguay

6-1 System of the Smelting Plant

There is a possibility that bauxite exists in Paraguay but no study has been carried out so far with regard to deposits, quality, etc. In the production of alumina, the intermediate product from bauxite, a larger production scale provides better profitability and, therefore, the required investment becomes quite huge.

Discussion of this matter is carried out assuming construction of smelting plant with a minimum economic scale of aluminum plant with imported alumina in the first stage of the project, in order to learn operating techniques and enter the aluminum export market.

Next, it will be necessary to open up new export markets, expand production capacity of the plant and carry out detailed studies of domestic bauxite resources. Once a deposit has proven to the economicaly feasible then construction of an alumina plant with a capacity balanced to the smelting plant can be beguan.

It seems appropriate to establish an integrated aluminum complex ranging from bauxite to aluminum.

6-2 Plant Site

The site for construction of the aluminum plant must meet the following conditions, as in the case of other electricity-intensive industrial plants:

(1) The transportation cost of both raw materials and finished products shall be economical.

(2) The supply of electricity shall be stable and inexpensive.

Further, a rationalized transportation infrastructure is indispensable in order to minimize the transportation cost because the optimum production scale is large and requires the massive movements of both raw materials and products.

Details regarding selection of the plant site should be decided upon completion of the field survey. In this report discussion is set forth assuming construction of the plant in the outskirts of Asuncion, in view of the available data and information.

6-3 Possible Supply Sources of Principal Raw Materials

(1) Alumina

As mentioned in Section 5-2, the principal exporters of alumina are Australia, Jamaica, Guinea, Surinam, Guyana, etc., with Australia having the largest capacity.

Due to the geographical conditions of Paraguay, Jamaica, Surinam and Guyana, located in the Caribbean, seem to be most advantageous in terms of transportation cost. In future it will be possible to take Brazil into consideration as a supply source as it is currently implementing new alumina projects. In any case, the source of supply of this material should be studied with special care from the points of view of supply stability and economy because this is the essential raw material of the project.

(2) Cryolite and Aluminum Fluoride

Exporters of aluminum fluoride are industrial countries which have their own aluminum smelting industries.

The U.S., Japan and West Germany can be taken into consideration as possible suppliers of this material because they have sufficient production experience.

(3) Carbon Material

As for petroleum coke, the U.S., is the most important producer of this material and exports to countries all over the world because it refines the largest amount of petroleum in the world. In the case of Paraguay, it would be most advantageous to import this material from the U.S.A., in view of its geographical location.

6-4 Possible Markets for Products

The consumption of aluminum in the domestic market of Paraguay is extremely small and therefore it is presumed that the entire production of this project will be destined for export. Statistical data on the production and consumption of aluminum in Latin America (described later in this report) indicate that consumption tripled in the 10 year period between 1970 to 1980. On the other hand, production increased by 5.8 times in the same period. It is expected that several large scale alumina and aluminum smelting projects will start operation within the next several years in Brazil and, therefore, this country is expected to become a major exporter not only of bauxite, but of alumina and aluminum ingots.

If this project has sufficient international competitiveness, the U.S., Japan and Europe seem to be promising export markets therefore.

6-5 Production Scale of Plant

Scale merit is a factor of fundamental importance for aluminum smelting operations and therefore the minimum economical scale should be taken into consideration in discussion of this project. Further, the production scale should be determined taking into account the possibility of export of the product. There are many other determinative factors but in this study the discussion is focused on the two points mentioned above.

On the basis of aforementioned consideration, adoption of 160,000 Ampere pre-baked electrode type electrolytic cells has been decided upon.

In this connection, the project should start with one pot line with an 80,000 ton/year production capacity to attain the best current efficiency in systems of this amperage.

Criteria for selection of electrolysis system

(1) The larger the electrolysis current, the larger the production per cell and the better the productivity.

(2) Operations related to anode and anode maintenance are easy in the pre-baked type multiple electrode cell.

(3) The anode voltage is low and therefore the consumption of power in the electrolysis is small in this system.

(4) The environmental conditions at the work place are better in this type of cell, because it uses pre-baked electrode.

7. Estimation of Model Plant Construction Cost

7-1 Principal Facilities

(1) Facilities and scale of the smelting plant

Electrolysis current	160 KA
Number of electrolysis cells	208 cells (With an average of 200 cells in operation)
Current efficiency	87.5%
Required power	143 MW (Including auxiliary power)
Production/year	160 KA x 0.335 kg/KA.H x 24 H/D x 365D x 0.875 x T/1,000 kg x 200 furnaces = 82.267 tons

Assuming that 835 tons/year of aluminum metal is consumed in its own plant for anode coating, the amount of metal turned out as finished product is (82,267 tons - 835 tons) x 0.994 = 80,943 tons/year.

(2) Casting Plant

Three holding furnaces heated either by fuel oil or electrical means are installed in the casting plant. Aluminum is cast in 20 kg ingots with 3 ingot casting machines.

(3) Anode Plant

The anode plant consists of grinding, moulding, baking and rodding processes.

(4) Analysis and Inspection Laboratory

(5) Storage Facilities

7-2 Plant Layout

Refer to the plant layout in Figure II-7-2.

7-3 Estimation of Model Plant Construction Cost

The construction cost of the model plant taken into consideration in this study is estimated on the following premises:

(1) The construction cost is estimated by assuming procurement of the required materials, machinery and equipment in Japan and partially in foreign countries at August 1982 prices on an FOB basis.

(2) Construction materials for buildings, etc., are not included.

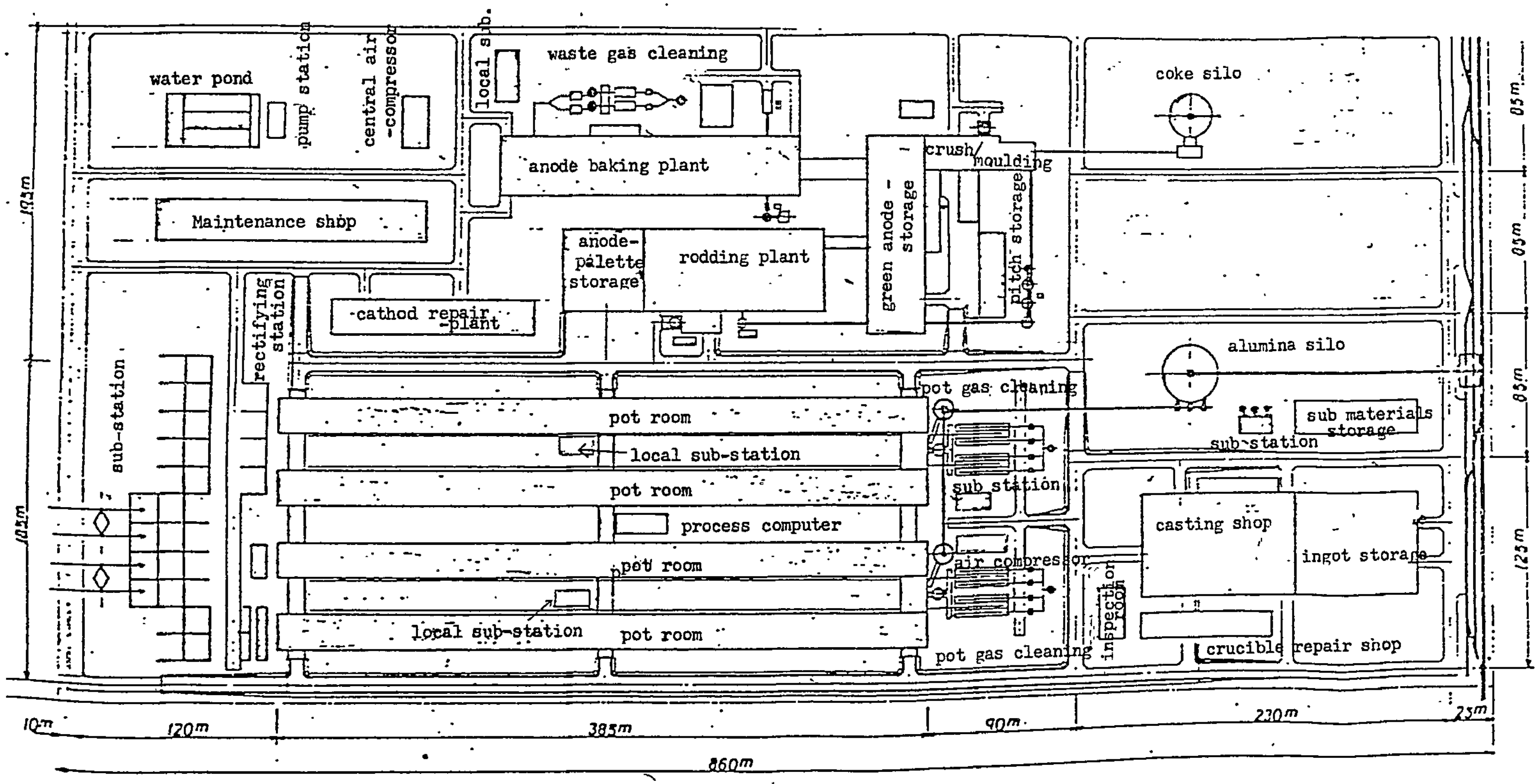
(3) The exchange rate is assumed to be ¥250/US$.

Machinery, equipment and materials

- Substation and power receiving facilities	US$27,600,000
- Anode plant	US$45,600,000
- Electrolytic plant	US$85,600,000
- Casting plant	US$9,200,000
- Service and maintenance facilities	US$10,800,000
- Spare parts	US$8,000,000

Figure II-7-2 Entire layout of an aluminium smelting plant
(80,000 metric ton per year)
(model plant)

Land required: 326,800 m^2



The construction cost of the model plant is estimated as follows, based on the figures listed above.

- Construction work	US$93,400,000
- Machinery, equipment and materials	US$186,800,000
- Erection	US$56,040,000
- Transportation	US$74,720,000
- Engineering and know-how	US$40,000,000
Total	US$450,960,000

Therefore, the construction cost per ton of product is calculated by dividing the total amount above by the annual production of 80,943 tons of aluminum.

US$450,960,000 ÷ 80,942t = US$5,571/T

It is necessary to bear in mind that the construction, erection and transportation costs may be further increased, depending on the location of the plant site.

8. Operation Conditions Expected for Model Plant

8-1 Amounts of Materials Handled (Raw Materials, Secondary Materials and Products)

The principal materials and products to be handled and the respective amounts are as follows:

Name	Basic Unit	Amount/T.Y.
Alumina	1.93t/Al.t	158,800
Aluminum fluoride	0.027t/Al.t	2,200
Cryolite	0.005t/Al.t	400
Fluorite	0.001t/Al.t	80
Calcined petroleum coke	0.707t/Anode.T	33,700
Hard pitch	0.173t/Anode.T	8,200
Cathode carbon blocks	15.9t/furnace	770
Other carbon materials	For cathode	530
Refractories, etc.	For cathode	1,120
Steel materials	For cathode	650
Fuel oil	0.123t	9,800
Aluminum ingot		80,000

8-2 Utilities Requirements

The utilities required by the model plant are as follows:

Electricity:	1,234 billion KWH/Year (15,425 KWH/ton)
Fuel oil:	9,800 tons/year
Industrial water:	Omitted
Land:	327,000 m^2 required for plant only.

8-3 Personnel Requirements

The personnel required by the model plant are as follows (Only for operation of the plant).

Plant Manager 1

	Manager	Foreman	Operator, etc.	Total
Anode plant	1	3	63	67
Electrolytic plant	1	5	148	154
Substation, rectifier, power distribution		1	17	18
Ingot casting plant		1	54	55
Analysis laboratory			20	20
Operation			12	12
Maintenance		1	89	90
Control	1		60	61
Total	3	11	463	477

9. Estimation of Production Costs in the Model Plant

9-1 Estimated Production Cost

The production cost of the model plant is estimated on the following premises, with factors contributing to the composition of the cost being elucidated.

(1) Depreciation cost (Refer to Section 7-3 for details of construction costs)

20-year straight line depreciation is assumed in this study.

(2) Interest

In this stidy it is assumed that 70% of the construction cost is covered by loans, with the principal reimbursed in 15 years.
Interest rate of 10%.

(3) Real estate tax and insurance

Omitted

(4) Personnel expenditures (Refer to Section 8-3 for details of personnel requirements)

Wages per function are assumed as follows:

General manager	US$48,000/Y
Manager	US$40,000/Y
Foreman	US$19,200/Y
Technician/clerk	US$15,000/Y
Operator	US$14,400/Y

(5) Cost of electricity

Calculated on plant receiving end basis.

(6) Maintenance cost

Assumed as 2%/year of the installation cost.

(7) Material cost (refer to Section 8-1 for details of principal materials)

(8) Utility cost (refer to Section 8-2 for details of utilities requirements)

The project is discussed for 3 electricity cost cases:

US¢1/KWH
US¢2/KWH
US¢3/KWH

Fuel oil cost: The project is discussed assuming a fuel oil cost of US$240/KL (FOB)

(9) Transportation cost

The transportation cost depends on the type of raw material handled. This matter is discussed by dividing transportation into ocean transport and fluvial transport. Generally speaking, the cost is assumed to be of the order of US$35 - 70/ton (for details refer to following table).

(10) Infrastructure:

Not included

(11) The project is discussed assuming import of all construction and raw materials on a duty free basis.

(12) Exchange rate

¥250/US$

(13) Prices as of August, 1982

Estimation of Principal Raw and Secondary Materials Prices

(US$)

Product	Unit Price (FOB)/T	Ocean Freight	Fluvial Freight	Total
Alumina	200	35	35	270
Aluminum fluoride	920	35	70	1,025
Cryolite	800	35	70	905
Fluorite	135	35	70	240
Calcined petroleum Coke	200	35	35	270
Hard pitch	260	35	35	330
Cathode carbon	1,320	35	70	1,425
Other carbon materials	840	35	70	945
Fuel oil	264	35	35	334

The smelting cost per ton of aluminum estimated assuming the prices above is as follows:

Aluminum Production Cost (Prices as of 1982)

Cost Item	Amount (x10^3US$/Y)	Cost per Ton of Aluminum (US$)	Share (%)
(Fixed cost)			
Depreciation	20,548	257	14.6
Interest	11,838	148	8.4
(1) Sub-total	32,386	405	23.0
(Variable cost)			
Alumina	42,876	536	30.4
Aluminum fluoride	2,255	28	
Cryolite	362	5	10.3
Calcined petroleum coke	9,099	114	
Hard pitch	2,706	34	
Electricity cost (1¢/KWH)	12,340	154	8.7
Labour cost	7,060	88	5.0
Cathode carbon	1,097	14	1.1
Other carbon	501	6	
Fuel oil	3,273	41	2.3
Maintenance cost	8,272	103	5.8
Contingencies	2,695	34	1.9
(2) Sub-total	92,536	1,157	65.5
(1)+(2) Production cost	124,922	1,562	88.5
Head office cost	3,748	47	2.7
Marketing cost, etc.	12,492	156	8.8
Total cost	141,162	1,765	100

(NOTE): Basic electricity cost: 15,425 KWH/T
Marketing cost: 10% of production cost
Maintenance cost: 2% of installation cost
Contingencies: 3% of variable cost
Head office cost: 3% of production cost

9-2 Influence of Electricity Cost

Aluminum smelting is an industry which consumes large amounts of electricity. The estimated production cost and the percentage represented by the electricity cost are calculated for a model plant with a production capacity of 80,000 T/Y, assuming electricity charges of US1¢/KWH, 2¢/KWH and 3¢/KWH.

Electricity Cost (US¢/KWH)	Estimated Cost (US$/T)	Share of Production Cost (%)
1	1,765	8.7
2	2,073	14.9
3	2,227	20.7

10. International Competitiveness of Estimated Cost

The estimated construction cost of the model plant taken into consideration in this study is US$5,570 per ton of production capacity. This is quite expensive in terms of international competitiveness.

In terms of production cost, the direct production cost is US$1,562/T and it eventually becomes US$1,765, when head office and marketing costs are added. It is important to bear in mind that these costs exclude industrial water, land, infrastructure, etc., however. Further, the plant construction site is inconveniently situated from the point of view of transportation and therefore it will be necessary to maintain stocks of raw material sufficient for at least 10 months of operation. Delays can also be expected in shipping of the aluminum ingots produced, but the interest resulting from these extra expenditures are not taken into consideration in the cost estimation. The revolving capital and its interest are not taken into consideration in cost estimation.

Technicians and operators should be carefully trained with a sufficient lead time before start of plant operations. The relevant costs are not taken into consideration, however, as the local situation is not clearly known.

Such being the case, it is evident that the total production cost, including these expenditures would be quite high. We are regretfully forced to conclude, therefore, that the price of aluminum ingots of this project exceeds by far the Alcan quotation of US$1,750/T, and has no international competitiveness at all.

The principal reasons leading to this lack of international competitiveness are as follows:

- The fluvial transportation routes through the inland rivers are too great and do not allow the use of large ships.

- All construction materials and raw materials required for implementation of the project must be imported.

11. Problems Requiring Further Discussions

In this study the estimated costs are based on 1982 prices on the premise that raw materials are imported from Japan (partially from other countries). This study also assumes construction of a model plant adopting the most economic and modern techniques available in Japan.

Further discussion taking into consideration more concrete conditions and local conditions prevailing in Paraguay are needed, however.

Conditions which require confirmation in future studies are as follows:

(1) Market Survey

The international aluminum market has been fluctuating considerably over the last several years and therefore it does not seem appropriate to rely on data of the past.

Investment timing should be determined through correct judgement based on a careful survey of the supply and demand balance in the international market.

(2) Raw Materials

The cost of raw materials is estimated by adding the ocean and fluvial transportation cost to the acquisition price in Japan. It is necessary to carry out a field survey of this subject, including a study on possible acquisition of construction materials and raw materials from neighbouring countries and a price survey.

(3) Construction Materials and Costs

In this study the construction cost is estimated assuming execution of construction work in Japan for the sake of convenience.

A portion of the required construction materials can be replaced by domestically materials, however. On the other hand, the required construction cost will be increased if carried out by contractors of Japan or other foreign countries staying in Paraguay.

(4) Transportation

Rational means of transportation for the raw materials, secondary materials, operation materials and products should be studied taking into consideration concrete conditions in order to evaluate actual costs.

(5) Process

The most modern processes adopted in similar projects implemented in Japan and other foreign countries is adopted in this study. Further, adjustments are made taking into consideration local conditions. Execution of a field survey is required in order to elucidate further details.

(6) Utility

This study requires the examination of the utility supply plan based on a concrete process design and the corresponding cost evaluation, particularly the electricity cost evaluation. As mentioned before, factors like land cost, industrial water, infrastructure, etc., are not taken into consideration in this study. As for the electricity, the cost is estimated on the premise that the transmission and distribution facilities are provided by third parties up to the gate of the plant.

(7) Fund Rising Plan

It is necessary to study the cash flow plan by taking into consideration the most advantageous way to rise the required funds and the economic conditions of Paraguay.

(8) Infrastructure

The construction of an aluminum smelting plant in a virgin land requires huge investments in public infrastructure like harbour facilities, urban development, road construction, etc. The aforesaid investments are completely neglected in this study, but normally most of them are covered by the government of the country where the plant in question is to be constructed.

As a matter of course, it is indispensable to discuss in detail the infrastructure at the occasion of the feasibility study to be carried out futurely.

12. Research and Development of New Aluminum Smelting Processes

The industrial production of aluminum is carried out by producing alumina from bauxite using the Bayer process, and by producing aluminum with electrolysis of alumina through the Hall-Heroult process. This refining method is a traditional one, having been used for approximately 90 years. In the Hall-Heroult process, however, production per cell is extremely small it therefore has demerits such as low production efficiency and large consumption of electricity. Accordingly, aluminum companies and research institutes in various countries are making efforts to develop new smelting methods.

Many processes have been proposed and tested to date but none are used in commercial production due to inherent technical and/or economic difficulties.

The new smelting methods proposed so far can be classified into two types.

a) Crude aluminum alloy or crude aluminum is produced by carbonic reduction of the ore. Aluminum is refined from the aforementioned crude alloy or crude metal by distillation, electrolysis or by the monochloride process which uses the reaction with aluminum chloride. The monochloride process was intensively tested by Alcan at one time.

b) Aluminum chloride is produced as an intermediate product from either alumina or bauxite. Next, aluminum chloride is either reduced by using manganese (TOTH process) or electrolytically refined in a chloride bath. Alcoa worked actively in the development of this latter process at one time.

The current topic in new aluminum smelting processes is the blast furnace process developed by Mitsui Alumina. In this process aluminum raw materials (bauxite, clay, etc.) are initially pelletized together with coke. Next, the pellets are melted in a blast furnace at a temperature of the order of 2,000°C. Lead is added to this molten material to produce an aluminum-lead alloy. Impurities such as Fe, Si, etc., are separated from the aforesaid alloy and then aluminum is obtained by vacuum distillation. This process is in the test stage and many problems are still to be solved in order to make possible its use for commercial production.

III. Copper

1. General Description of Copper

Copper is a metal characterized by the following properties;

- High electrical conductivity
- High thermal conductivity
- Corrosion resistance
- Excellent workability due to extremely high ductility
- Easy formation into alloys with other metals and excellent castability.

Copper is used either as a pure metal or copper alloy in forming electric wires, rolled copper and copper castings. In particular, more than a half of all copper is used in the electrical industry as pure metal. In spite of the appearance of alternative materials such as aluminum, optical fiber, etc., it is presumed that the demand for copper will expand further through technical innovations, development of new applications, etc.

Copper is negotiated as an international commodity in the form of ore, intermediate products and metal. However, factors such as the energy problem, environmental pollution control in the industrialized countries, etc., exert serious influences which may change the supply mechanism of this product in the international market.

From the technical point of view, on the otherhand, progress in exploration techniques and mineral dressing techniques ensure the required economic ore reserves and progress in smelting and refining techniques have solved problems related to energy, environmental pollution control, etc.

2. Trends in the Copper Market and Price

The consumption of copper has stagnanted at a level not exceeding 10 million tons in the last several years due to stagnation of the world economy. The principal consumers of copper are the U.S., the Soviet Union and Japan, which represent 50% of the total. On a long-term basis, it is expected that the consumption of copper will grow at an annual rate of 2.6%, exceeding 13 million tons by the year 2000.

The production of copper ore is approximately 8 million tons and the principal producers are the U.S., the Soviet Union and Chile, which produce 50% of the total. The principal deposits are located in Chile, the U.S. and the Soviet Union, which represent 50% of the total. The production of metal, on the other hand, is approximately 9 million tons and the principal producing countries are the U.S., the Soviet Union and Japan, which produce approximately 50% of the total.

The principal copper producing countries can be classified into the following types. The U.S. and the Soviet Union have sufficient natural resources, refining capacity and consumption to maintain a relatively even balance while Japan imports ore and some metal. Chile is blessed with abundant natural resources in addition to a sufficient refining capacity and exports ore, intermediate products and copper metal. The European countries are of the Japanese type but they have export a larger percentage of the metal. Korea, Taiwan and other Asian countries are of this type also. On the other hand, Canada, Australia, etc., are of the Chilean type.

Statistical data on production of ore, production of smelters, production of refineries and consumption of copper are indicated in Tables III-2-1, III-2-2, III-2-3 and III-2-4.

Copper refining is carried out in various ways.

- Integrated smelting and refining from concentrate to metal
- Smelting from concentrate to intermediate products such as matte, blister copper, anode, etc.,
- Refining from blister and copper scrap to metal
- Refining from anode to metal

Copper is negotiated on the market in the form of raw materials and intermediate products such as copper concentrate (Cu 20 to 30%), matte (Cu 30 to 50%), blister copper (Cu 98.5 to 99%) and anode (Cu 99.0 to 99.5%), and finished products such as electrolytic copper (Cu 99.99% or more), fire refined copper (Cu 99.9% or more), etc,

In view of the recent stagnation of demand and the low price of metallic copper, some mines have suspended production while other mines have closed. On the other hand, copper refineries, which are typically energy-intensive, have been forced either to suspend activities or to go out of business due to the rise in energy costs, the rise in pollution control installation costs due to the increasingly severe pollution regulations, etc. In any

Table III-2-1 World Mine Production of Copper

Metric Tons

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
United States	1,510.0	1,558.2	1,448.5	1,281.9	1,461.5	1,364.1	1,357.3	1,443.2	1,180.9	1,528.7
Canada	719.5	823.8	821.2	733.7	747.0	759.2	659.3	636.3	716.2	717.9
Mexico	78.7	80.5	82.7	78.2	80.0	89.7	87.2	107.1	175.3	181.4
Cuba *	1.8	2.1	2.9	3.0	3.0	2.6	2.8	2.8	3.3	2.8
Guatemala	-	-	-	-	-	2.5	2.8	2.0	0.8	0.7
Nicaragua	2.5	2.7	2.5	0.6	1.0	2.7	0.1	-	-	-
Argentina	-	-	-	-	-	0.2	0.2	0.1	0.1	-
Bolivia (a)	8.4	8.2	7.9	6.0	4.7	3.2	2.8	1.8	1.9	1.8
Brazil	5.0	4.2	3.5	1.7	-	-	0.1	5.3	1.4	18.0
Chile	716.7	735.2	901.9	828.1	1,005.0	1,056.0	1,035.2	1,060.8	1,067.4	1,080.6
Colombia	-	-	-	-	-	0.7	0.5	1.1	1.4	1.2
Ecuador	-	-	-	-	-	1.0	0.8	1.2	1.2	1.3
Peru	219.0	215.0	213.1	173.8	218.5	329.3	376.3	397.1	365.[illegible]	335.1
Total America	3,261.6	3,429.9	3,484.2	3,107.0	3,520.7	3,611.2	3,525.4	3,658.8	3,515.1	3,869.5
Austria	2.[illegible]	2.7	2.6	1.9	1.1	0.1	-	-	-	-
Finland	37.6	45.4	40.5	39.6	41.7	46.7	46.8	41.1	36.7	38.2
France	0.5	0.4	0.4	0.5	0.5	0.3	0.6	0.4	1.0	1.0
Germany, F.R.	1.3	1.4	1.7	2.0	1.6	1.2	0.8	0.9	1.3	1.4
Greece	-	-	-	-	-	3.5	1.5	-	0.1	-
Ireland	13.7	10.4	12.6	9.8	4.0	4.8	4.8	4.8	4.2	3.5

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Italy	1.2	1.6	0.9	0.8	0.7	0.7	0.5	0.5	0.6	0.6
Norway	26.2	28.4	24.1	28.1	31.5	29.1	29.1	28.7	28.8	28.9
Portugal	5.0	2.5	2.5	2.1	1.4	2.5	3.0	3.6	3.0	2.9
Spain	40.5	43.0	44.5	52.0	47.0	48.3	42.2	43.3	47.5	48.0
Sweden	24.3	44.8	40.6	40.6	47.2	44.8	47.3	45.8	42.8	46.3
United Kingdom	-	-	-	-	-	0.4	0.2	-	0.2	0.4
Yugoslavia	103.1	111.8	112.1	114.9	120.0	116.2	123.3	111.4	116.7	101.3
Total Europe	256.1	292.4	282.5	292.3	296.7	298.6	300.1	280.5	282.9	272.5
Burma	-	-	-	-	-	0.1	0.1	0.1	0.1	-
Cyprus	16.8	14.2	11.0	8.0	9.5	6.8	5.1	1.2	-	-
India	14.6	22.4	20.1	20.0	27.0	30.2	26.6	30.6	26.9	23.0
Indonesia	5.0	37.9	64.6	63.5	68.4	57.1	58.0	57.2	56.6	57.1
Iran	-	-	-	-	-	6.0	6.0	3.0	1.0	1.2
Israel	12.0	10.6	10.1	8.6	-	-	-	-	0.4	4.4
Japan	112.1	91.2	82.1	85.0	81.6	81.4	72.0	59.0	52.5	51.4
Republic of Korea	2.1	2.3	2.8	2.7	2.7	1.7	0.7	0.5	0.4	1.1
Malaysia	-	-	-	-	-	24.0	26.0	24.5	27.0	28.7
Philippines	213.6	221.1	225.4	225.7	224.9	272.7	263.3	300.4	304.5	305.2
Taiwan	-	-	-	-	-	2.0	0.8	0.6	0.5	0.7
Turkey	22.1	30.2	40.7	43.5	45.0	25.8	18.7	30.1	20.8	36.3
Total Asia	398.3	429.9	456.8	457.0	459.1	507.8	477.3	507.2	490.7	509.1

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Algeria	-	-	-	-	-	0.4	0.2	0.2	0.2	0.1
Botswana	-	-	-	-	-	11.7	14.6	14.6	15.6	17.2
Congo	-	-	-	-	-	2.0	1.0	1.0	-	-
Mauritania	14.9	21.8	20.2	6.6	9.2	7.7	2.8	-	-	-
Morocco	-	-	-	-	-	3.4	4.3	8.3	8.4	8.0
Mozambique	-	-	-	-	-	-	0.3	0.2	-	-
Namibia	..	-	-	-	-	50.1	37.7	41.9	39.2	39.6
Republic of Zaire	437.2	487.6	494.5	494.7	442.6	481.5	423.8	399.7	459.6	477.8
Rhodesia	31.7	32.0	32.0	30.0	30.0	-	-	-	-	-
Sough West Africa	21.5	28.3	26.1	25.3	42.4	-	-	-	-	-
Uganda	14.1	14.2	11.5	8.5	9.0	8.3	1.3	-	-	-
Republic of South Africa	161.9	175.8	179.1	178.9	196.8	216.0	209.2	203.2	211.9	207.5
Zambia	717.6	717.8	697.8	676.7	708.7	655.9	642.9	588.2	595.7	589.4
Zimbabwe	-	-	-	-	-	34.8	33.8	29.6	27.0	23.7
Total Africa	1,398.9	1,477.5	1,461.2	1,420.7	1,438.7	1,471.8	1,371.9	1,286.9	1,357.6	1,363.3
Australia	185.8	220.2	251.2	218.9	206.3	221.6	222.0	237.5	243.5	223.3
Repua New Guinea	125.9	182.8	184.0	172.4	176.5	182.3	198.5	170.8	146.8	165.2
Total Oceania	311.7	403.0	435.2	391.3	382.8	403.9	420.5	408.3	390.3	388.5
U.S.S.R. *	1,029.4	1.061.2	1,061.2	1,100.2	1,200.0	1,099.7	1,139.7	1,149.8	1,149.8	1,149.2
Albania *	6.7	7.0	7.0	8.0	8.0	10.0	11.5	9.7	10.5	10.0
Bulgaria *	38.0	48.1	50.0	55.0	54.0	57.0	58.0	60.0	61.9	61.7
Czechoslovakia *	4.7	4.3	4.5	5.0	5.0	7.8	8.2	9.0	8.0	7.7

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Germany, D.R. *	20.0	18.0	18.0	16.5	18.0	17.0	16.0	15.0	15.0	14.5
Hungary *	1.0	1.0	0.4	0.3	0.5	0.2	0.1	0.1	-	-
Mongolia	-	-	-	-	-	-	4.0	12.0	15.0	14.5
Poland *	135.[illegible]	151.9	184.9	229.9	309.9	282.0	311.9	339.9	342.9	315.2
Rumania *	30.0	40.0	40.0	45.0	48.0	27.0	27.0	29.0	28.0	27.7
China	-	-	-	-	-	155.0	160.0	160.0	165.0	164.6
China and Other Aisa *	135.0	140.0	149.9	160.0	162.0	-	-	-	-	-
North Korea	-	-	-	-	-	15.0	15.0	15.0	12.0	11.8
Total	1,399.8	1,471.5	1,515.9	1,619.9	1,805.4	1,670.7	1,751.4	1,799.5	1,808.1	1,776.9
World Total (b)	7,026.4	7,504.2	7,635.8	7,288.2	7,903.4	7,964.0	7,846.6	7,941.2	7,844.7	8,179.8

Source : American Bureau of Metal Statistics Inc., U.S. Bureau of Mines, World Bureau of Metal Statistics and various other sources.

(a) Exports.

(b) In addition, there is production in Algeria, Argentina, Burma, Congo (Brazzaville), Colombia, Dominican Republic, Ecuador, Fiji, Iran Kenya, Malaysia, Morocco, Mozambique, New Zealand, and Taiwan, the total of all these countries is estimated to be about 41,000 tons in 1976.

* Conjectural.

Table III-2-2 World Smelter Production Of Copper

Metric Tons

	197	1973	1974	1975	1976	1977	1978	1979	1980	1981
United States	1,569.0	1,590.3	1,417.2	1,331.6	1,447.5	1,346.5	1,342.4	1,395.5	1,053.0	1,377.4
Canada	463.5	458.9	515.6	493.9	480.8	504.7	413.3	396.5	492.6	486.3
Mexico	66.6	64.4	71.2	61.5	76.0	87.5	87.0	83.9	85.7	61.5
Brazil	4.8	4.2	3.5	1.7	-	-	-	-	-	-
Chile	630 5	589.7	724.1	699.8	856.1	888.2	927.2	946.7	952.9	953.7
Peru	176.1	176.0	177.3	156.2	192.6	321.1	318.9	370.5	348.6	317.0
Total America	2,910.5	2,883.5	2,908.9	2,744.7	3,053.0	3,148.8	3,088.8	3,195.1	2,932.8	3,195.9
Austria	22.7	22.9	26.7	26.9	28.6	21.5	19.8	21.8	31.3	28.4
Belgium	.	-	-	-	-	61.6	55.9	55.4	29.2	36.0
Finland	34.7	40.9	43.1	41.5	45.8	60.8	53.1	54.6	47.2	54.0
France	6 5	8.8	9.3	2.8	3.9	5.3	3.2	5.0	7.3	6.5
Germany, F.R.	203 5	232.4	244.6	215.8	219.9	248.0	221.5	250.6	257.8	240.0
Norway	33 9	34.6	31.7	26.3	23.8	26.6	20.1	27.3	33.6	31.9
Portugal	-	-	-	-	-	3.3	3.0	5.5	6.6	4.7
Spain	88 9	94.4	99.0	109.7	108.5	117.5	112.5	108.3	103.0	107.9
Sweden	55.4	61.8	59.9	57.0	61.9	61.7	67.0	64.5	56.4	62.6
Yugoslavia	104.3	103.8	124.9	119.1	130.5	102.9	117.0	110.0	114.0	102.4
Total Europe	549.9	599.6	639.2	599.1	622.9	709.2	673.1	703.0	686.4	674.4
India	10 3	12.0	11.8	24.0	25.0	23.5	19.5	21.5	28.5	26.3
Iran	.	-	-	-	-	7.0	6.0	0.7	-	-

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Japan	809.8	950.6	995.8	818.7	864.2	915.0	905.7	921.2	929.6	979.9
Republic Of Korea	10.3	18.0	20.9	20.3	29.4	36.8	54.9	48.2	64.1	100.9
Taiwan	-	-	-	-	-	11.5	13.0	14.3	17.0	52.2
Turkey	17.1	25.0	29.6	27.0	24.0	31.7	26.2	22.3	15.9	23.0
Total Asia	847.5	1,005.6	1,058.1	890.0	942.6	1,025.5	1,025.3	1,028.2	1,055.1	1,182.3
Republic Of Zaire	428.1	449.9	453.9	462.5	408.2	450.6	390.9	370.1	425.7	448.9
Rhodesia*	29.9	29.9	29.9	29.9	29.9	-	-	-	-	-
Namibia	-	-	-	-	-	53.4	45.9	42.7	40.0	38.7
Republic Of South Africa	161.4	150.4	147.8	149.7	151.9	188.4	189.4	182.3	185.8	186.2
South West Africa	26.1	36.0	46.6	36.4	36.1	-	-	-	-	-
Uganda	14.1	9.7	8.1	8.3	8.0	8.3	1.3	-	-	-
Zambia	700.4	682.8	709.2	658.8	705.7	658.4	653.8	595.0	601.2	568.9
Zimbabwe	-	-	-	-	-	28.0	34.2	31.4	26.7	23.7
Total Africa	1,360.0	1,358.7	1,395.5	1,345.6	1,339.8	1,387.1	1,315.5	1,221.5	1,279.4	1,266.4
Australia	144.7	162.5	196.1	182.4	160.1	171.8	167.8	173.3	174.9	173.4
U.S.S.R.*	1,088.4	1.088.4	1,179.1	1,099.7	1.199.8	1,099.7	1,169.8	1,169.8	1,149.8	1,149.2
Albania*	6.7	7.0	6.0	7.0	8.0	9.0	9.5	9.7	10.5	10.0
Bulgaria*	48.1	52.6	48.1	60.0	56.0	57.0	57.0	57.0	57.0	57.0
Czechoslovakia*	7.0	7.0	6.0	7.0	6.0	7.0	6.0	7.0	6.0	5.9
Germany, D.R.*	20 0	18.0	18.0	16.5	18.0	18.0	17.0	19.0	18.0	17.7
Hungary*	1.0	1.0	1.0	0.3	0.5	3.8	-	-	-	-

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Poland	134.2	151.9	184.9	229.9	279.9	290.0	319.9	319.9	319.9	290.2
Rumania*	35.0	40.0	40.0	50.0	48.0	41.4	38.9	40.0	40.0	39.9
China	-	-	-	-	-	149.9	149.9	149.9	149.9	149.7
North Korea	-	-	-	-	-	20.0	20.0	18.0	17.0	16.8
China & Other Asia*	135.1	139.7	149.7	160.0	162.0	-	-	-	-	-
Total	1,475.5	1,505.6	1,632.8	1,630.4	1,778.2	1,695.8	1,788.0	1,790.3	1,768.1	1,736.4
World Total (a)	7,288.1	7,515.5	7,830.6	7,392.2	7,896.6	8,137.4	8,058.5	8,111.4	7,896.7	8,228.8

Source: American Bureau of Metal Statistics Inc., U.S. Bureau of Mines, World Bureau of Metal Statistics and various other sources.

(a) In addition there is production in Argentina, Portugal, and Taiwan which was about 9,000 tons in 1976.

* Conjectural.

Table III-2-3 World Refined Production of Copper

Metric Tons

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Unites States	2,048 5	2,097.6	1,939.7	1,609.1	1,721.7	1,676.7	1,831.6	1,975.4	1,685.7	1,958.5
Canada	495 8	497.6	559.6	529.1	510.4	508.7	446.2	397.2	505.1	473.5
Mexico	64.0	61.9	71.1	69.7	83.3	79.0	83.0	100.8	102.4	68.2
Brazil	27.8	29.7	37.3	28.8	31.1	28.6	25.8	33.9	38.9	29.1
Chile	461.3	414.7	538.0	535.1	631.9	675.9	748.9	781.7	810.5	775.5
Peru	39.2	39.0	38.0	53.0	143.6	188.0	185.4	230.3	230.6	207.4
Total America	3,136.6	3,140.5	3,180.1	2,824.8	3,122.0	3,156.9	3,320.9	3,519.3	3,373.2	3,512.2
Austria	22.7	22.8	26.7	26.9	30.5	34.7	32.0	32.8	43.3	39.1
Belgium	314.3	367.4	378.7	331.5	457.6	464.6	388.6	368.7	373.6	219.6
Finland	38.4	42.9	36.3	35.8	38.2	42.8	42.7	43.0	40.5	33.8
France	30.0	33.1	43.9	39.6	39.2	45.0	41.3	45.3	46.5	46.3
Germany, F.R.	398.4	406.6	421.5	422.1	446.5	440.1	404.4	382.4	373.7	387 2
Italy	9.0	12.2	13.7	13.2	10.0	20.0	17.5	15.6	12.2	12.0
Norway	26.4	25.8	24.8	19.7	16.7	21.2	15.6	22.0	25.8	26.0
Portugal	3 4	3.7	3.6	3.2	2.5	3.4	3.0	3.4	4.6	4.7
Spain	87.0	93.8	123.4	130.2	143.7	160.0	146.9	140.4	153.6	151.7
Sweden	51.6	59.5	59.9	56.2	59.4	63.7	64.4	61.7	55.7	61.9
United Kingdom	162.0	170.8	160.1	151.5	137.1	122.2	125.6	121.7	161.3	141.8
Yugoslavia	130.0	137.5	150.0	137.9	130.0	143.5	150.7	137.5	131.2	135.2
Total Europe	1,273.6	1,376.1	1,446.6	1,367.8	1,511.4	1,559.2	1,432.7	1,374.5	1,786.5	1,259.3

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Iran	6.0	7.0	7.0	7.0	7.0	7.0	6.0	3.0	1.0	0.9
India	10.5	11.7	11.8	24.0	38.7	22.8	11.8	14.7	17.0	14.9
Japan	809 9	950.6	995.8	818.7	864.2	933.5	958.9	983.5	1,014.1	1,049.9
Republic of Korea	9.1	9.2	12.4	20.9	29.0	42.9	62.4	76.0	84.9	113.4
Taiwan	4.8	6.6	9.9	7.1	11.0	11.5	14.5	15.3	19.5	52.2
Turkey	17.1	15.0	29.6	21.4	16.0	18.2	14.6	22.3	18.8	23.0
Total Asia	857.4	1,000.1	1,066.5	899.1	965.9	1,035.9	1,068.2	1,114.8	1,155.3	1,254.3
Republic of Zaire	216.1	230.1	254.4	135.1	66.0	98.7	102.5	103.2	144.2	153.6
Egypt	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.4
Rhodesia	30.0	30.0	30.0	30.0	30.0	-	-	-	-	-
Republic of South Africa	79.3	90.6	88.5	86.3	85.0	145.8	152.5	152.3	147.8	144.6
Zambia	615.0	638.3	676.6	629.0	694.8	648.9	627.6	563.5	607.5	560.3
Zimbabwe	-	-	-	-	-	12.0	11.2	8.4	7.5	18.0
Total Africa	942.4	991.0	1,051.5	882.4	877.8	907.4	895.8	829.4	909.0	878.9
Australia	156.1	159.1	194.5	193.3	187.6	183.0	174.5	171.3	182.9	190.8
U.S.S.R. *	1,224.7	1,299.7	1,349.7	1,419.7	1439.7	1,439.7	1,459.7	1,479.7	1,449.7	1,449.4
Albania	-	-	-	-	-	7.0	7.0	7.2	9.0	8.6
Bulgaria *	45.0	48.0	47.0	52.0	54.0	58.0	61.9	61.9	62.9	62.6
Czechoslovakia	-	-	-	-	-	23.1	23.8	24.6	25.6	25.4
Germany, D.R. *	47.0	45.0	45.0	43.0	45.0	51.0	49.0	51.0	51.0	50.8

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Hungary	..	-	-	-	-	12.1	13.1	12.0	12.1	11.8
Poland *	131.0	156.4	194.5	248.5	269.9	306.6	332.0	335.8	357.3	327.2
Rumania	-	-	-	-	-	48.2	66.7	66.3	65.0	64.9
China	..	-	-	-	-	259.9	269.9	269.9	269.9	269.8
China & Other Asia *	200 0	219.9	240.0	250.0	263.9	-	-	-	-	-
North Korea	-	-	-	-	-	25.0	25.0	22.0	19.0	18.6
Other Europe *	65.1	732.9	81.9	88.5	96.6	-	-	-	-	-
Total	1,712.8	2.501.9	1,958.1	2,101.7	879.1	2,230.6	2,308.1	2,330.4	2,321.5	2,289.1
World Total	8,078.9	9.168.7	8,903.3	8,269.1	7,543.8	9.073.0	9,200.2	9,339.7	9,728.4	9,384.6

1972 - 1976 Source : World Bureau of Metal Statistics.

1977 - 1981 Source : American Bureau of Metal Statistics Inc., U.S. Bureau of Mines, Metallgesellschaft AG, World Bureau of Metal Statistics and various other sources.

* Conjectural.

Table III-2-4 World Refined Consumption Of Copper

Metric Tons

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
United States	2029.5	2220.6	1994.5	1396.1	1803.3	1989.2	2196.5	2164.1	1867.3	1889.2
Canada	223.8	248.2	270.0	196.1	215.2	222.1	250.1	243.3	208.5	252.1
Mexico	64.0	65.9	72.5	70.7	82.2	77.3	83.1	103.9	123.2	142.1
Cuba	-	-	-	-	-	1.0	1.0	1.0	1.2	1.2
Argentina	36.5	35.5	47.3	42.7	36.0	32.2	33.0	48.8	43.2	48.0
Brazil	112.4	123.7	173.9	155.2	179.2	213.7	180.8	228.7	246.0	164.3
Chile	36.3	34.2	29.4	26.8	46.3	48.4	51.6	49.0	42.9	39.6
Peru	6.0	6.0	8.1	11.0	9.1	9.7	10.3	19.3	19.2	16.9
Other America	2.0	3.0	4.0	3.1	4.2	12.0	16.4	13.3	12.4	12.0
Total America	2510.5	2737.1	2599.7	1901.7	2375.5	2605.6	2822.8	2871.4	2563.9	2565.4
Austria	46.9	38.9	42.6	34.3	29.2	34.7	19.2	17.7	30.8	32.6
Belgium	153.0	164.3	178.1	177.4	225.0	295.3	289.4	303.0	303.8	275.0
Denmark	4.1	5.5	4.7	3.8	4.1	6.5	5.2	3.4	1.6	1.6
Finland	30 1	32.6	40.3	33.7	36.8	37.0	40.4	50.6	57.5	56.1
France	390 2	407.7	414.1	364.4	377.9	326.1	318.9	358.4	433.3	429.6
Germany, F.R.	672 1	727.1	731.0	634.4	741.8	779.7	779.8	793.9	747.6	744.1
Greece	15 6	18.0	14.4	18.0	18.0	22.2	24.0	29.5	24.7	31.4
Ireland	0.1	0.3	0.4	0.4	0.4	0.4	0.2	0.1	0.2	0.1
Italy	284.0	295.0	307.9	290.0	335.1	326.0	343.9	351.9	387.9	383.8
Netherlands	36.6	38.2	29.6	37.0	50.0	46.6	31.6	27.0	34.8	44.5
Norway	4 8	6.0	5.6	5.3	5.4	5.4	6.1	6.3	6.2	6.3

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Portugal	12.0	13.5	13.7	13.5	12.0	16.0	16.0	12.2	18.4	17.1
Spain	119.4	139.8	143.9	119.4	132.9	135.0	128.4	132.5	132.0	112.3
Sweden	96.9	114.0	108.2	94.4	89.4	81.1	103.5	107.6	105.3	106.1
Switzerland	30.1	25.5	30.2	31.0	32.3	24.1	21.3	24.0	29.7	24.5
United Kingdom	534.5	541.1	496.9	450.4	457.5	511.9	501.5	498.7	409.1	333.1
Yugoslavia	83.1	84.6	108.7	106.1	140.0	118.0	124.8	132.0	148.8	142.9
Total Europe	2513.5	2652.1	2670.3	2413.5	2687.8	2766.0	2754.2	2848.8	2871.7	2741.1
India	59.3	62.9	49.8	44.0	42.0	37.5	57.7	63.3	71.0	68.0
Iran	-	-	-	-	-	7.0	6.0	3.0	1.0	1.0
Japan	951.1	1201.6	880.7	821.7	1050.1	1126.9	1241.1	1329.8	1325.2	1226.4
Philippines	-	-	-	-	-	5.5	5.5	2.9	3.7	3.6
Republic Of Korea	-	-	-	-	-	57.8	73.5	85.3	89.7	143.3
Taiwan	-	-	-	-	-	48.2	47.7	71.3	84.4	96.4
Turkey	15.0	15.0	14.0	20.0	20.0	22.0	26.0	22.1	33.4	30.0
Other Asia	43.0	61.6	68.1	74.1	93.9	5.4	9.0	9.4	28.1	24.0
Total Asia	1068.4	1341.1	1012.6	959.8	1206.0	1310.3	1466.5	1587.1	1636.5	1592.7
Algeria	2.4	2.3	2.5	2.5	2.5	4.8	4.0	4.0	4.0	4.5
Egypt	.	-	-	-	-	7.0	8.5	8.6	7.6	8.1
Republic Of South Africa	47.4	62.7	66.8	65.3	60.0	52.1	60.3	69.3	89.9	90.1
Rhodesia	4.0	5.0	5.0	5.0	5.0	-	-	-	-	-
Zaire	.	-	-	-	-	2.8	2.8	2.4	3.4	2.7
Zambia		-	-	-	-	2.2	2.7	1.6	2.2	2.4

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Zimbabwe	-	-	-	-	-	12.0	11.2	8.4	7.5	6.0
Other Africa	12.5	16.8	17.5	12.2	12.0	3.0	1.9	1.0	2.0	0.9
Total Africa	66.3	86.8	91.8	85.0	79.5	83.9	91.4	95.3	116.6	114.7
Australia	102.0	121.8	121.5	102.8	115.4	112.6	123.8	126.9	128.4	136.7
New Zealand	1.0	2.0	2.4	0.9	1.0	1.9	2.0	1.9	2.3	1.2
Total Australasia	103.0	123.8	123.9	103.7	116.4	114.5	125.8	128.8	130.7	137.9
U.S.S.R. (a)	1,029.8	1,099.7	1,169.8	1,199.8	1,249.8	1,289.8	1,329.8	1,359.7	1,299.7	1,301.5
Albania	-	-	-	-	-	5.5	6.0	6.0	7.0	6.3
Bulgaria	-	-	-	-	-	52.0	58.0	60.0	55.0	54.4
Czechoslovakia	-	-	-	-	-	81.1	79.8	82.6	79.0	78.9
Germany, D.R. (a)	100.0	101.9	104.9	112.0	120.0	115.0	118.0	122.0	120.0	119.7
Hungary	-	-	-	-	-	23.0	24.3	24.1	22.0	21.8
Poland	-	-	-	-	-	187.9	184.9	202.0	213.1	192.3
Rumania	-	-	-	-	-	80.0	83.4	85.0	80.0	79.8
Vietnam	-	-	-	-	-	1.0	1.0	1.0	1.0	1.0
China	-	-	-	-	-	330.0	339.9	339.9	330.0	330.1
North Korea	-	-	-	-	-	15.0	16.0	15.0	15.0	15.4
China & Other Asia	269.9	299.9	299.9	330.0	349.9	-	-	-	-	-
Other E. Europe (a)	299.9	332.3	321.3	362.5	371.4	-	-	-	-	-
Total	1,699.6	1,833.8	1,895.9	2,004.3	2,091.1	2,180.3	2,241.1	2,297.3	2,221.8	2,200.3
World Total	7,961.3	8,774.7	8,394.2	7,468.0	8,556.3	9,060.6	9,501.8	9,828.7	9,541.2	9,352.1

case, a gradual change is taking place in sectors such as mining, smelting and refining, processing, etc., in the world copper market, due to changes in conditions related to the availability of raw materials, transportation of raw materials and finished products, availability of energy, control of environmental pollution, availability of markets, etc.

As for the price of copper metal in the international copper market, there are free prices such as the London Metal Exchange Price (LME Price), the COMEX Price, etc., and producer's prices such as the U.S. P.P., etc. The LME quotation, which has a relatively strong influence on the market, is indicated in Table III-2-5.

Table III-2-5 LME Copper Price

U.S. Cents Per Pound

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
January	48.870	50.765	92.192	54.940	54.113	63.279	57.191	75.264	117.959	84.766
February	50.454	56.379	103.951	57.504	55.310	64.677	55.188	88.191	132.363	81.703
March	52.541	68.468	124.570	60.852	60.283	68.652	56.862	92.973	104.601	82.472
April	51.359	72.001	137.565	60.309	68.526	64.775	58.286	95.237	93.970	82.615
May	50.196	70.402	130.449	56.841	68.595	62.217	59.072	87.373	92.868	79.028
June	48.091	79.322	110.705	54.071	70.279	59.526	60.444	85.181	91.003	77.111
July	46.960	91.611	87.089	55.446	74.686	56.624	60.652	82.283	98.720	76.290
August	47.482	94.794	81.766	57.928	69.751	52.566	64.685	89.650	94.442	81.066
September	48.111	87.781	66.276	54.859	66.219	54.230	65.419	95.067	93.460	77.583
October	46.595	93.681	63.463	53.496	58.324	54.883	68.331	94.145	92.794	75.580
November	45.634	103.006	64.188	53.461	58.000	53.638	66.665	94.805	91.196	74.906
December	46.369	101.039	58.494	52.205	58.432	57.152	69.551	100.427	85.213	75.084
Year	48.545	80.805	93.097	56.110	64.051	59.380	61.826	90.113	99.297	79.488

Source : Metal Bulletin. Electrolytic wirebars. Monthly average settlement price.

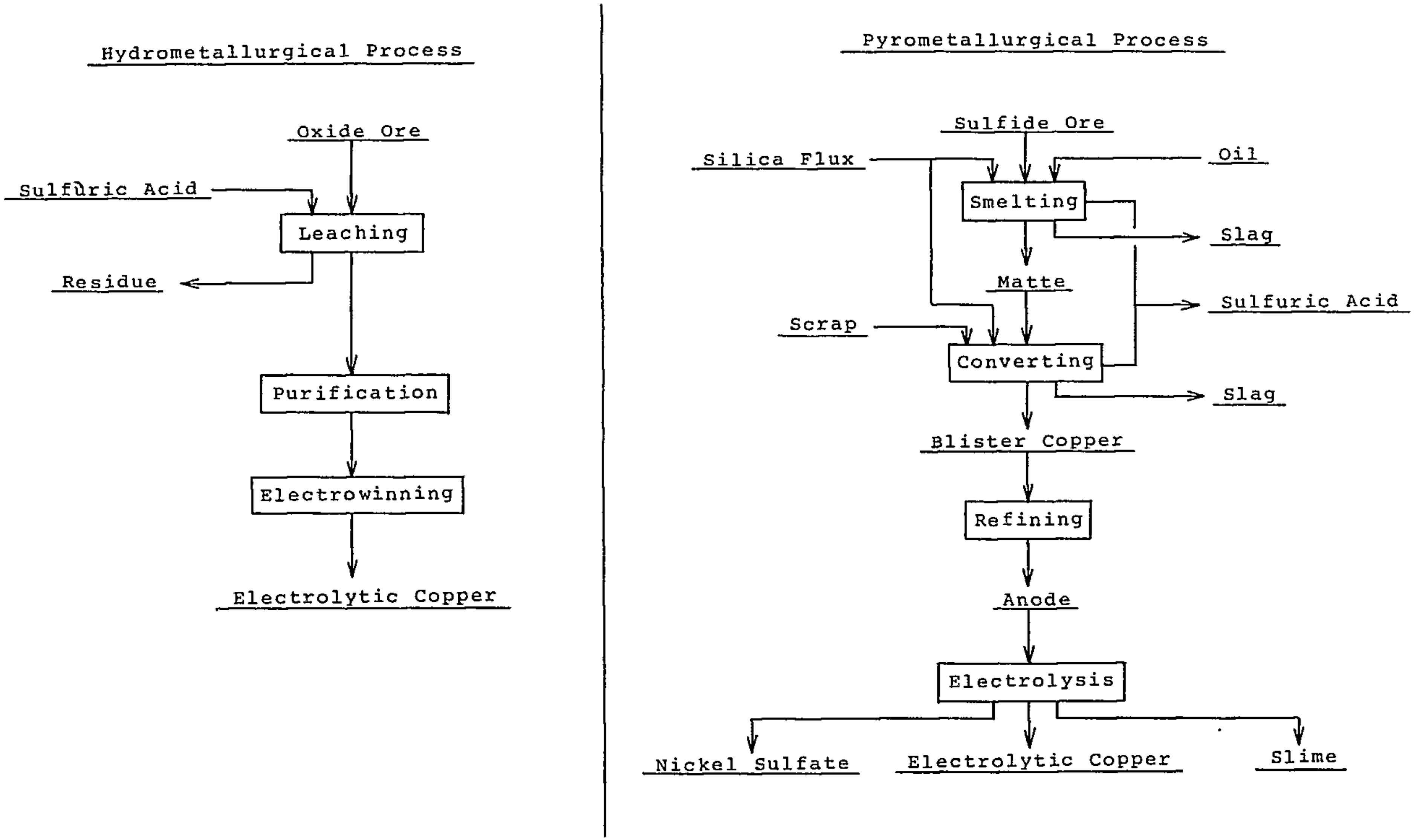
3. Copper Extracting Process

Broadly speaking, there are two copper extracting processes, namely the hydrometallurgical process which turns out copper by means of electrowinning of ore leached with acid, and the pyrometallurgical process, which produces copper by electrolytic refining of anodes obtained by high temperature smelting, oxidation and reduction of copper concentrate. The hydrometallurgical process is suited for refining of oxide ore, while the pyrometallurgical process is suited appropriate for refining of sulphide ore.

Outlines of the aforementioned extracting processes are illustrated in Figure III-3.

Most of copper ore is of the sulphide type and therefore is smelted and refined by means of the pyrometallurgical process. The ore is melted and oxidized together with flux and the Cu is carried to matte (Cu 30 to 50%), Fe and other material are carried to slag and S is converted into gas in the form of SO_2. Matte, together with flux, is submitted to further oxidation in a converter where copper is concentrated in the form of blister (98.5%), other materials are carried by the slag and S is carried by the gas in the form of SO_2. Blister is refined and cast in the form of anodes (99.5%). The cast anode is electrolytically refined by an electrolysis process and is converted into cathode (99.99% or more).

Figure III-3 Copper Extracting Process



4. Copper Ore, Secondary Ingredients and Byproducts

4-1 Copper Ore

Copper ore exists in the form of native copper, sulfide ore and oxide ore, but sulfide ore is the most common.

Normally, ore of a copper grade of the order of 1% is treated by floatation to obtain copper concentrates of the order of 20 to 30%, therefore, copper ore is negotiated on the market in the form of concentrate. Deposits of copper estimated to exist currently in the world total approximately $500x10^6$ tons, and the principal countries favoured with deposits of this metal are Chile with $97x10^6T$ (19.7%), the U.S. with $92x10^6T$ (18.7%) and the Soviet Union with $36x10^6T$ (7.3%), followed by Zambia, Canada, Perú, Zaire, the Philippines, etc. The principal producing countries are the U.S., the Soviet Union, and Chile but other ore exporting countries include Canada, the Philippines and Chile in this order. In addition to the ore itself, copper is negotiated on the market in the form of intermediate products such as matte and blister. Chile and Perú, in South America, export more copper in the form of metal and blister copper than concentrate.

Scrap is an important resource in countries like the USA, etc., which have large consumption of copper and furthermore a consolidated distribution route.

4-2 Secondary Materials

4-2-1 Silica

Silica is used as a flux in the copper smelting process to control the composition of the slag. Silicate ore containing Au and Ag is used in some cases. Cu has the property of absorbing Au and Ag well and these noble metals can be separated out in the form of slime during the electrolysis process.

Silica is added to the ore in proportions of the order of 20 to 30%. Requirements for purity of silica used for copper smelting are quite loose.

Limestone is added to the copper ore and silica in some cases.

4-3 Byproducts

Copper ore contains various metals in addition to the copper itself. The copper smelting and refining process turns out various byproducts when each of these metals are separated out.

4-3-1 Slag

Oxides of Fe and other metals contained in the copper ore form silicates. These silicates compose the slag generated in the copper smelting process. Normally this slag is discarded but in some cases it may be used as a raw material for the production of cement.

4-3-2 Sulfuric Acid, Gypsum and Liquid Sulfuric Acid

Normally the copper ore contains S (sulfur), which is separated out in the form of SO_2 contained in the gas generated during the smelting process. This SO_2 is fixed and collected as H_2SO_4, $CaSO_4 \cdot 2H_2O$, liquid SO_2, etc., which can be marketed, should there be demand.

4-3-3 Slime

Precious metals such as Au, Ag, etc. contained in the copper ore go to the anode mixed with Cu and are separated in the form of slime during the electrolytic process. This slime can be either refined into Au, Ag, etc., or sold as raw material for these noble metals.

4-3-4 Crude Nickel Sulfate

Ni contained in the anode goes to the electrolyte in the electrolytic process, and is cristalized in the form of $NiSO_4 \cdot 6H_2O$ in order to maintain the electrolyte concentration balance. This nickel sulfate can be sold as raw material for nickel plating and other uses.

5. Copper Extracting Project to be Implemented in Paraguay

5-1 Current Status of Copper Market in South America

A portion of the statistical data for 1981 on South America selected from the tables of Section 2 of this report is shown in Table III-5-1.

Table III-5-1 South American Copper Market (1981)

Unit: 10^3T

	Mine Production	Smelter Production	Refinery Production	Consumption
Argentina	-	-	-	48.0
Brazil	18.0	-	29.1	164.1
Chile	1,080.6	953.7	775.5	39.6
Peru	335.1	317.0	207.4	16.9

As mentioned in Section 2 of this report, Chile and Peru export blister copper and metal in addition to copper concentrate. Data given in the table shown that the capacity of the refineries is insufficient compared with the production of concentrate. This tendency is pronounced particularly in Chuquicamata, Chile, largest production mine in the world.

On the other hand, the demand for copper as a basic material is expanding in countries on the eastern side of South American - like Brazil, Argentine, etc. - and according to long-term plans of these countries, it is expected to expand further in the coming years. As for the problem of the copper market within South America, it is naturally indispensable to fill the increasing demand for metal within the region itself. On the other hand, copper produced in this region is exported once in the form of ore and blister copper and then imported again as metal. It is evident that it is more advantageous to export the metal or processed products instead, in order to increase the added value. In particular, Paraguay is located in an advantageous geographical position from the point of view of processing the abundant raw materials found on the west coast of the South American continent and shipping products to consumer centers on the east coast. Furthermore, if the international railway and highway routes will be improved, it will be possible for Paraguay to export refined copper products through ports on the Pacific Coast of South America, by taking into consideration countries in Asian markets such as Japan, Taiwan, etc.

5-2 Form of Copper Extracting Industry in Paraguay

Copper ore is easily available in South America but Paraguay is in a very disadvantageous position from the point of view of access for large-sized ships compared with copper smelters in Japan and Europe. The form of integrated custom sweltering existing in Japan and Europe, which starts from import of concentrate and turns out electrolytic copper, can not be considered advantageous for Paraguay as well.

Currently all factors involved in locating a copper extracting plant in Paraguay are not clearly known. The form of the extracting industry to be introduced in Paraguay is planned based upon the following premises, however.

(1) This project should be planned as a part of an integrated copper production system in the South American region covering "Ore Production" - "Smelting and Refining" - "Metal Consumption" and "Metal Export".

(2) The raw materials should be available under as economical terms as possible and at minimum transportation cost.

(3) Electricity should be used as effectively as possible for production of the finished product.

Such being the case, it is supposed that the most advantageous form of copper extracting for Paraguay is import of blister copper produced in Chile and Peru in view of its relative compactness and transportation advantage. Electrolytic copper can then be produced by electrolysis of the blister copper and the copper exported. The electrolytic process does not require much labour and the process itself is simple and clean, with generation of little industrial waste. Furthermore, there is a possibility of expansion to an integrated process covering all phases from concentrate to metal. The above proposal can be regarded as the most recommendable as a first step for introduction of copper smelting and refining in Paraguay.

5-3 Plant Site

The vicinity of Asuncion is the best place for siting the copper refinery in view of the following:

(1) The traditional fluvial routes can be used for transportation of the raw materials, secondary materials

and finished products between the plant site and the Atlantic coast. Furthermore, land transportation can be used for countries located on the Pacific coast side such as Chile, Peru, etc.

(2) A stable supply of electricity can be ensured at this site.

(3) The required labour can be recruited with relative ease.

The problem of environmental pollution has been technically solved already and so presents no obstacle to construction of the plant.

5-4 Source of Supply for Raw Materials and Market for Products

As mentioned in Section 5-1 of this report, the countries of South America able to supply blister copper are Chile and Peru. At Chuquicamata, the largest copper smelter and refinery complex of Chile, for example, the capacity of the refinery is insufficient compared to the capacity of the mine and smelter and this situation is expected to continue in the future because electricity is not abundantly available in the area. Similar situations are evident in other mines, smelters and refineries of northern Chile and Peru.

From the point of view of the transportation route for the raw materials to be used in this project, import blister copper from Chile by land transportation is recommended. It is expected that improvement of the land transportation routes between Chile and Paraguay will be useful also from the point of view of marketing of the products turned out by this project.

The most important copper metal importers in South America are Brazil and Argentina. It is indispensable to develop new markets on the east coast of North America and in Asia (Japan, Korea, Taiwan, etc.) via Antofagasta, the Chilean port facing of the Pacific Ocean, in addition to the traditional markets of South America, the east coast of North America and Europe via the La Plata River. Therefore, improvement of the land transportation route between Paraguay and Chile is indispensable from the point of view of both import of blister copper the raw material for the refining plant, and export of electrolytic copper. Such being the case, it is necessary to draw up a rational transportation plan and a realistic marketing plan in order to successfully implement this project.

5-5 Production Scale of Plant

The copper electrolysis plants existing in the world at present have varying capacities ranging from 50,000 T/Y to 400,000 T/Y. In South America the Oroya Refinery and the Ilo Refinery of Peru have 50,000 T/Y and 150,000 T/Y capacity, respectively, while the Protrerillos Refinery, Chuquicamata Refinery and Las Ventanas Refinery, all in Chile, have capacities of 79,000 T/Y, 390,000 T/Y and 150,000 T/Y, respectively.

In the case of custom refineries (raw material purchasing type), the larger the production scale the better the economic efficiency. In this case, an annual production capacity exceeding 100,000 T/Y seems to be best. In the case of Paraguay, however, we assume an annual capacity of 60,000 T, which is the minimum scale from the operational point of view, because the required raw materials are available nearby.

6. General Description of Process in the Model Plant

6-1 Production Process

This study is set forth assuming a copper refining plant with an annual production capacity of 60,000 ton of electrolytic copper, using blister copper as the raw material.

- Melting & refining : Cylindrical horizontal rotary furnace system
- Casting: Walker system
- Electrolytic refining: Conventional system

6-2 General Description of the Process

A flow sheet for the process adopted in this project is presented in Figure III-6-2.

The blister copper is melted and refined in the refining furnace and is cast in the form of anodes. The electrolytic refining of copper is carried out by arranging the cast anodes and cathodes consisting of thin plates of electrolytic copper in an electrolytic cell containing ($CuSO_4$ + H_2SO_4) solution and applying direct current between the anodes and cathodes. Electrolytic copper is obtained as a result of the electrochemical transportation of the Cu of the anode to the cathode. The electrodes used in this process are replaced periodically, i.e., the anodes are replaced at intervals of 24 days and the cathodes at intervals of 12 days. Part of the anode left as residual copper is recycled to the refining furnace. The cathode obtained by this electrolytic process is shipped as the finished product after being washed. Crude nickel sulfate is obtained from the electrolyte. Au and Ag are deposited at the bottom of the electrolytic cell in the form of slime. These precious metals can be sold in the form of slime but in the future it is possible to carry out refining of the Au and Ag as well. The anodes and cathodes of the electrolytic cell should be permanently monitored and adjusted in order to prevent short circuits between them. The electrolyte should be kept always at the desired conditions by circulation and purification and by providing the required additive. The electrolytic copper refining process described does not require special skills, the installations are simple and the operation itself is easy to understand.

6-3 Plant Layout

The layout of the model plant is shown in Figure III-6-3.

Figure III-6-2 Process Flow Sheet

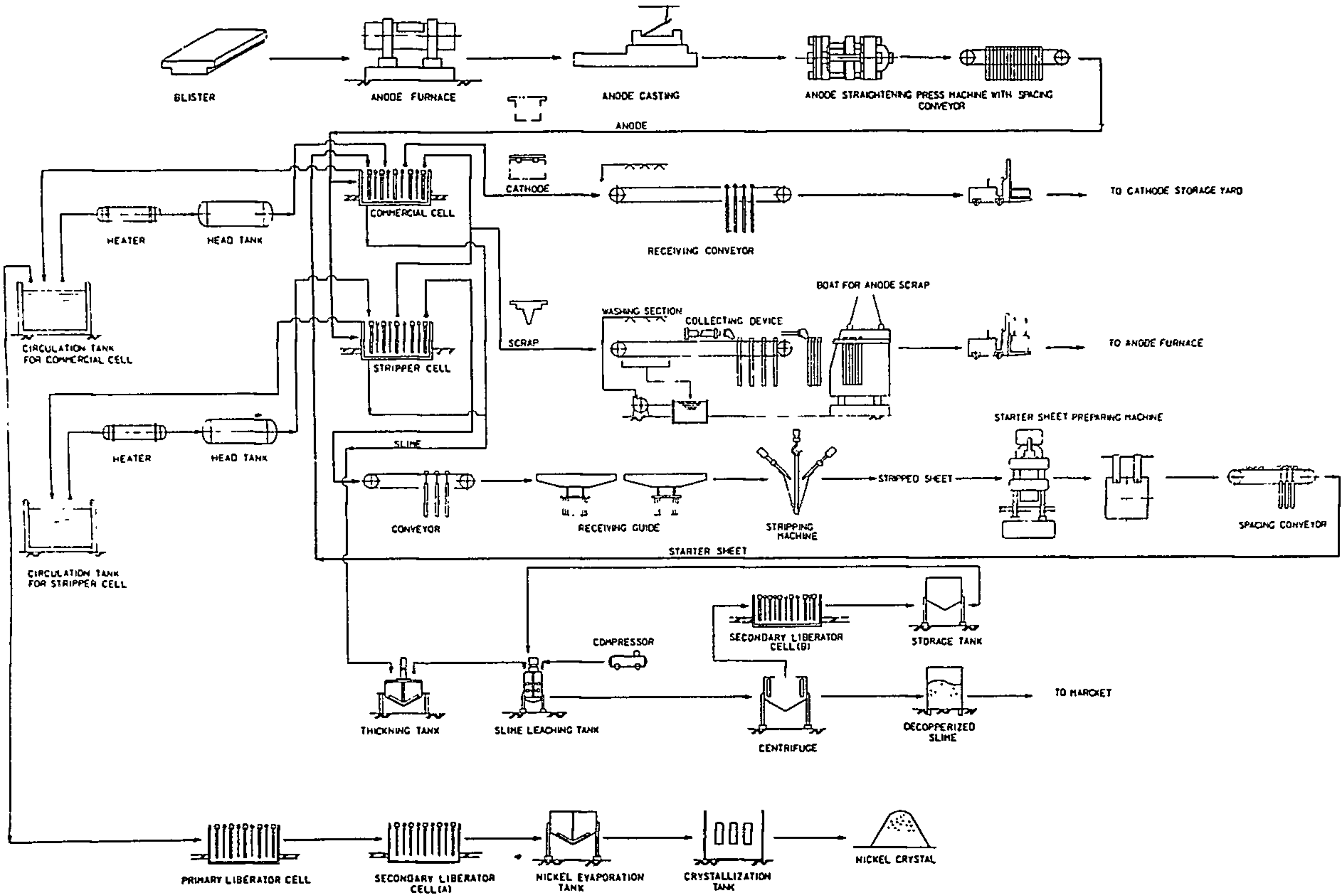
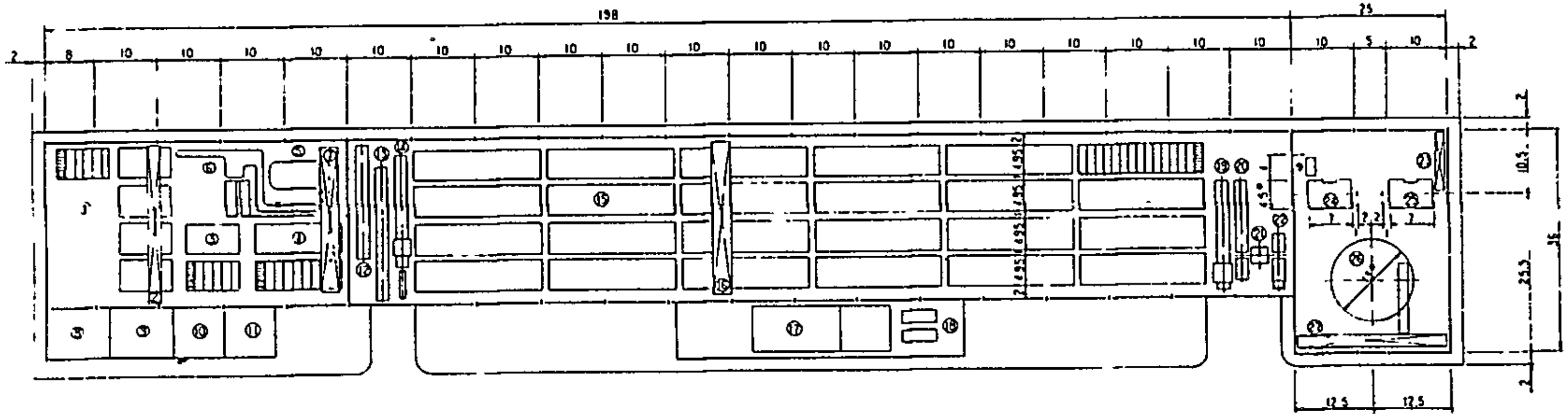


Figure III-6-3 Plant Layout



①	SECONDARY LIBERATOR CELL AREA
②	5 TON CRANE
③	PRIMARY LIBERATOR CELL AREA
④	STRIPPER CELLS
⑤	STARTER SHEET STRIPPING AREA
⑥	STRIPPING CONVEYOR
⑦	20 TON CRANE
⑧	ANODE SLIME LEACHING AREA
⑨	NICKEL SULFATE AREA

⑩	CONTROL ROOM
⑪	ELECTRICAL EQUIPMENT AREA
⑫	STARTER SHEET PREPARING MACHINE
⑬	CROSS BAR CONVEYOR
⑭	CATHODE WASHING AND STACKING MACHINE
⑮	COMMERCIAL SELLS
⑯	20 TON CRANE
⑰	CIRCULATION TANK
⑱	FILTER

⑲	ANODE SCRAP WASHING MACHINE
⑳	ANODE SPACING MACHINE
㉑	ANODE PRESS
㉒	RECEIVING CONVEYOR
㉓	10 TON CRANE
㉔	#2 ANODE F'CE
㉕	#1 ANODE F'CE
㉖	CASTING TABLE
㉗	3 TON CRANE

7. Estimation of Model Plant Construction Cost

The construction cost of the model plant is estimated on the following premises:

(1) The construction cost is based on prices prevailing in Japan in August, 1982, plus 25%. (The aforementioned prices prevailing in Japan are assumed to have an accuracy of ±30%).

(2) The installation cost is included in this estimation.

(3) The land acquisition cost and land preparation cost are not included in the plant construction cost.

(4) The maintenance workshop, office building for management of the plant, warehouses, etc., are not included in the estimation.

The construction cost of each plant of the project is estimated as follows.

Plant	Estimated Construction Cost (US$$10^3$)
Refining & casting	4,500
Electrolysis	27,900
Slime leaching	850
Nickel sulfate	550
Boiler	350
Total	34,150

8. Expected Operation Conditions of the Model Plant

8-1 Materials to be Handled (Raw Materials, Intermediate Products and Finished Products)

The grades and amounts of the principal materials to be handled in the model plant are as follows:

Name	Grade (%)	Amount (T/Y)
Blister copper	Cu 98.5 Ni 0.02	61,000
Anode	Cu 99.5	73,000
Electrolytic copper	Cu 99.99<	60,000
Crude nickel sulfate	Ni 20	60
Slime	Au 0.2 to 1.0 Ag 10 to 20	Depending on the content of these precious metals in the raw material

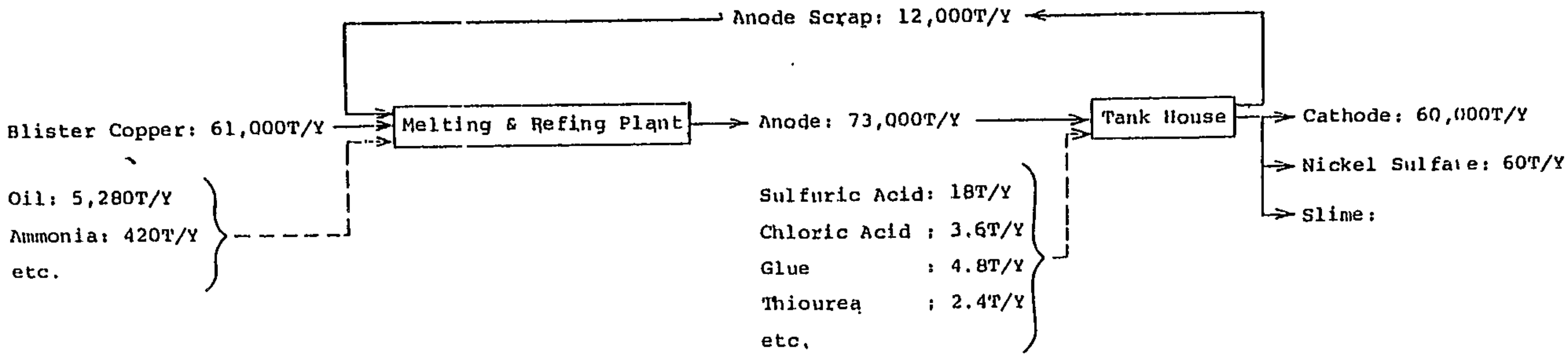
8-2 Principal Materials Required for Operation

The basic units and consumption of the principal materials required for operation of the plant, in addition to spare parts, are as follows:

Sulfuric acid	3 kg/T.Cu	18 T/Y
Hydrochloric acid	0.06 kg/T.Cu	3.6 T/Y
Glue	0.08 kg/T.Cu	4.8 T/Y
Thiourea	0.04 kg/T.Cu	2.4 T/Y
Ammonia	7 kg/T.Cu	420 T/Y (Ammonia can be replaced by LPG)

The material flow of the items mentioned in sections 8-1 and 8-2 are described in Figure III-8-1.

Fig. III-8-1 Material Flow



8-3 Utilities Requirements

The basic units and annual consumption of utilities required for operation of the plant in question are as follows:

Electricity	430 KWH/T	25,870 MWH/Y
Steam	607 Kg/T	36,400 T/Y
Cooling water	22.4 T/T	$1,344 \times 10^6$ T/Y
Fuel oil	88 L/T	5,280 KL/Y

8-4 Personnel Required

The personnel required for operation of the plant are as follows. (Plant personnel only)

Manager 1

	Engineer	Foreman	Operator
Refining	1	1	11
Electrolysis	2	2	
Stripping sheet			8
Current check			9
Replacement			6
Mother blank prepatation			6
Crane operation			2
Others			14
Total	3	3	56

9. Estimation of Production Costs in the Model Plant

9-1 Profitability of Custom Smelters and Refineries

9-1-1 Determination of Purchasing Terms

There are two types of copper smelter, namely, the domestic smelter and the custom smelter. The domestic smelter carries out an integrated process from the mining to the refining and basically is operated on the income generated by sales of the copper metal. On the other hand, the custom smelter and refinery covers only the smelting and refining processes and basically is operated on the income resulting from the treatment charge and refining charge in the purchasing terms.

Broadly speaking, the purchasing terms (CIF basis) at custom smelters and refineries are as follows.

Copper concentrate price (US$/T)

$$= (K-a) \times (x-b) \times 2204.6 - C \times 1/100 \quad (9.1.1)$$

K : Metal price (¢/Lb)
a : Refining charge (R/C) (¢/Lb)
x : Copper grade (%)
b : Unit reduction
2204.6 : 2204.6 lb. = 1T
C : Treatment charge (T/C) (US$/T)

a: R/C is the item corresponding principally to the refining cost for obtaining electrolytic copper from blister copper, c: T/C corresponds to the treatment cost for obtaining blister copper from the concentrate, b: Unit reduction is the recovery, in other words, (Recovery) =

(x-b)/x. When the concentrate contains Au and Ag and their content exceeds a gi-en value, they are evaluated in a form similar to that for Cu, through the recovery and refining charge (R/C).

In addition to the precious metals mentioned above, the copper concentrate also contains various other metals, for example, S, Ni, etc., and these contribute to the earnings of the plant as byproducts. Other materials such as As, Sb, Bi, etc., may be subject to penalty because they have a noxious influence on the electrolysis process.

When the copper concentrate is actually handed over to the smelter and refinery, other expenses such as domestic transportation freight, commission to trading companies involved in the transaction, miscellaneous expenses, etc., are added to the copper concentrate price given by the expression (9.1.1).

In the case of blister copper the price configuration is basically the same as that of for copper concentrate, and is given by the expression (9.1.1) minus item C: the treatment charge.

Blister copper price (US$/T)
= (k-a) x (x-b) x 2204.6 x 1/100 (9.1.2)

K: Metal price (¢/Lb)
a: Refining charge (R/C) (¢/Lb)
x: Copper grade (%)
b: Unit reduction
2204.6: 2204.6 lb. = 1T

a: R/C corresponds to the refining charge for obtaining electrolytic copper from blister copper. b: Unit reduction corresponds to recover.

When blister is handed over to the refinery, other expenses such as domestic transportation, commission to trading companies involved in the transaction, other miscellaneous expenses, etc., are added to the price above.

Now, let us calculate the price of blister copper on the following premises.

Metal price:	80¢/Lb
Refining charge:	10¢/Lb
Copper grade:	98%
Unit yield:	1

Blister copper price (US$/T) =

$$= (80-10) \times (0.98-0.01) \times 2204.6 \times 1/100$$
$$= 70 \times 0.97 \times 2204.6 \times 1/100$$
$$= 1{,}497$$

Electrolytic copper is sold after refining blister purchased at a price of US$1,497/T, therefore, the refining cost should not exceed 10¢/Lb if recovery is assumed to be (0.98-0.01)/0.98 = 0.990, i.e., 99.0%. The project is not commercially profitable if the refining cost is not restricted to less than 6¢/Lb, if the expenses such as domestic transportation, commission to trading companies, miscellaneous expenses, inventory interests, etc., are assumed to total 4¢/Lb.

The actual ore purchasing conditions depend on each individual case and it is very difficult to obtain accurate data on this because it is top secret for the mines, smelters and refineries. This study is carried out assuming a target value of the order of 5 to 6¢/Lb for the refining cost, which is obtained by estimating and deducting the amounts of the CIF prices under conditions equal to those of custom refineries in Europe and Asia, domestic transportation, commission to the trading companies involved in the transaction, other miscellaneous expenses, inventory interest, etc.

In the next step of the study it is indispensable to determine the target value in accordance with the aforesaid purchasing terms, by determining concretely the material to be purchased (e.g. blister copper from Chuquicamata, Chile).

It is particularly important to materialize transportation costs equivalent to those of custom smelters and refineries in Asia and Europe, as assumed in the premises, otherwise, the target refining cost has to be further lowered. Such being the case, a careful study of the transportation methods and routes concrete -ases (alternatives) is also an important point for determination of the ore purchasing terms.

9-1-2 Profitability of Custom Smelters and Refineries

The earnings of custom smelters and refineries are as follows:

(1) Treatment charges and refining charges (T/C and R/C) stipulated in the ore purchasing conditions.

(2) Earnings resulting from the sale of metal obtained in excess of the recovery stipulated in the purchasing terms.

(3) Earnings resulting from the sale of byproducts.

The profit of the smelter and refinery is the difference betwen total earnings and the cost required to carry out the smelting and refining, therefore, profits brought about by the income items mentioned above are independent of the metal price itself, with exception of the recovery mentioned in the item (2). The objective of the operation of the smelter and refinery is how to cut down the apparent refining cost, including the earnings brought in by sales of byproducts, with regard to the T/C and R/C stipulated in the purchasing terms. This is a fundamental difference between copper refining and aluminum refining.

The materials evaluated as byproducts in the copper extracting industry are sulfuric acid in the smelting process and crude nickel sulfate and others in the refining process.

There are impurities contained in the ore which contribute to increasing income as metallic byproducts, but there are also impurities which exert a noxious influence on the process, contributing to a decrease in income, by increasing the costs and/or affecting the purity of the refined product.

In this study, crude nickel sulfate is generated as a byproduct in the process where blister is refined into electrolytic copper.

The amount of metal generated by the difference in recovery between the actual and the purchasing rate depends on the purchasing terms and on the skill of operation of the refining facilities. Particularly at the outset of operations, the recovery rate is low. It is not taken into consideration as an item of earning in this study, therefore. The recovery difference is possible only when the refinery is operating satisfactorily and the raw material is available under advantageous conditions. Accordingly, it should not be taken into consideration in the profitability calculation at the refinery planning stage.

In this study profitability of the refinery is discussed by estimating the refining cost, including the earnings brought about by the byproducts, and comparing it with the target value.

9-2 Estimation of Refining Cost

The refining cost for the model plant is estimated on the following premises, with the purposes of elucidating the elements composing the cost.

(1) Depreciation cost (Refer to the Section 7 for details of construction costs)

A depreciation period of 13 years is applied, assuming a residual book value of 10% and 10 year depreciation for the refining in facilities, 20 years for the sheds and a proportion of 70:30 for the construction costs of the refining facilities and sheds.

(2) Interest

It is assumed that all of the required funds are covered with loans with an annual interest rate of 10%.

(3) Real estate tax and insurance

The real estate tax and the insurance expenses are not taken into consideration in this calculation.

(4) Personnel expenditures (Refer to the Section 8-4 for details on required personnel)

Wages corresponding to each class of function of the required plant operation personnel are assumed to be as follows. (Expenses of auxiliary management sections are included in the overhead costs).

Manager	US$48,000/Y
Engineer	US$24,000/Y
Foreman	US$19,200/Y
Operator	US$14,400/Y

(5) Repair costs

The repair costs are assumed to be 2%/year of the installation cost.

(6) Material costs (Refer to section 8-2 for details on principal materials required for operation of the plant)

(7) Utility costs (Refer to section 8-3 for details on utilities required for operation on the plant)

Electricity cost	Assumed as US¢3KWH
Fuel oil cost	Assumed as US$320/KL

(8) Transportation costs

Transportation costs refer only to the transportation carried out within the plant by means of forklifts, etc.

(9) Overhead costs, etc.

50% of the personnel expenditures

(10) Income from byproducts

Crude nickel sulfate: Assumed as US$600/T.
Au and Ag are not taken into consideration (these are assumed to have the same recovery as the value stipulated in the ore purchasing conditions).

(11) Marketing costs, etc.

10% of the prime cost.

(12) Exchange rate

¥250/US$

The refining cost estimated on the premises listed above is given in Table III-9-2.

Table III-9-2 Estimated Costs for Refining of Electrolytic Copper from Blister

Cost Item	Amount ($x10^6$US$/Y)	Cost of Electrolytic Copper (US¢/Lb)	Share (%)
(Fixed costs)			
Depreciation cost	2.364	1.79	27.7
Interest	0.263	0.20	3.1
Real estate tax, insurance, etc.	-	-	-
(1) Sub-total	2.627	1.99	30.8
(Variable costs)			
Personnel expenditure	0.984	0.74	11.5
Repair cost	0.683	0.52	8.0
Material cost	0.384	0.29	4.5
Utility cost			
- Electricity cost	0.776	0.59	9.1
- Others	1.678	1.27	19.7
Transportation cost	0.163	0.12	1.9
Overhead cost, etc.	0.492	0.37	5.8
(2) Sub-total	5.160	3.90	60.5
(1)+(2) Prime cost total	7.787	5.89	91.3
Byproduct earnings	Δ0.036	Δ0.03	Δ0.4
Direct marketing cost, etc.	0.779	0.59	9.1
Total prime cost	8.530	6.45	100.0