A STUDY
ON
ELECTRICITY-INTENSIVE INDUSTRIES
IN THE
REPUBLIC OF PARAGUAY

DECEMBER 1982

JAPAN INTERNATIONAL COOPERATION AGENCY

CONTENTS

SUMMARY AND RECOMMENDATIONS

1. This study has the basic objective of collecting and accumulation data and information required for planning and implementation of various measures for introduction of electricity-intensive industries in the country. It focuses on industries which show considerable potential for introduction in Paraguay in the near future. Thus, products of four industrial sectors which seem to be typical electricity-intensive industries, namely, the chemistry, ferroalloy, non-ferrous metals and iron and steel industries, are analized. The criterias behind the selection are as follows.

(1) A considerable increase in consumption of the products in question is expected in Paraguay and/or in the Latin America.

(2) The raw materials are easily available at relatively low price in Paraguay and/or in the Latin America.

(3) The production techniques are well developed and the relevant technology is transferable.

(4) The consumption of electricity per unit amount of the product is large.

(5) The transportation cost represents a relatively small portion of the costs of production.

(6) The optimum production scale and the initial investment is relatively small.

2. A total of thirteen products, namely, five of the chemical industry, three of the non-ferrous metal refining industry, four of the ferraolloy industry and one of the iron and steel industry were selected based on the above mentioned criteria. The products selected are as follows;

(1) Chemicals

1) Fused phosphatic fertilizers produced by utilizing rock phosphate and serpentine.

2) Ammonium phosphate produced utilizing ammonia obtained from electrolytic hydrogen and phosphoric acid obtained from elementary phosphorus.

3) Polyvinyl chloride produced utilizing limestone and coke.

4) Clacium Cyanamide produced utilizing limestone and coke.

5) Chlorine and caustic soda produced by electrolysis of salt.

(2) Non-ferrous metals

1) Aluminum produced by fused salt bath electrolysis of alumina.

2) Electrolytic copper refined by electrolysis of blister copper.

3) Electrolytic zinc produced utilizing zinc concentrate as raw material.

(3) Ferroalloys

1) Ferromanganese produced utilizing manganese ore.

2) Silicomanganese produced utilizing manganese ore and silica.

3) Ferrosilicon produced utilizing silica.

4) Ferrochromium produced utilizing chromium ore.

(4) Iron and steel products

1) Small sized steel bar produced in electric furnaces and small sized rolling mills utilizing scrap iron.

3. The results of preliminary discussion of the 5 projects covering the chemicals concerned in this study are as follows;

(1) Fused phosphatic fertilizer

On the premise that the total needs of the Paraguayan market for phosphoric fertilizer can be met with this fused phosphatic fertilizer, the study is carried out assuming a model plant with an annual production of 83,300 t. The result of calculations in this study shows that IRR of this project is 11.07%, i.e., well below the appropriate profitability level in the case of commercial investment, which is of the order of 15 of 20%. This is the most feasible of the 5 projects of the chemical industry sector in this study.
A detailed study of the domestic fertilizer market in

Paraguay and a study of the availability of raw materials (rock phosphate and serpentinite) in the sourthern region of Brazil are very important for execution of the F/S (feasibility study).

(2) Ammonium phosphate fertilizer

Based on the current scale of the Paraguayan fertilizer market, the study of the ammonium phosphate fertilizer project is carried out by calculating the profitability of a model complex plant with a daily production of 60 t of ammonia, 120 t of ammonia phosphate and 50 t of phosphorus, which is aimed at cutting down the production cost. The results of calculations indicate low IRR of around 0% for this project.
The profitability in this case is extremely low because the plant is of extremely small scale for projects of this kind. The capital cost can be cut by expansion of scale if the products can be exported to neighbour countries. Further, the feasibility of the project will be improved if the price of the domestic or Brazilian rock phosphate will be reduced. In any case, it seems recommendable to carry out the fused phosphatic fertilizer production project in the first place, provided that a study can identify the estimated size of the domestic market of Paraguay.

(3) Vinyl chloride

On the premise of supply of large amounts of electricity at low cost and the abundance of limestone in paraguay, the production of poly-vinyl chloride as a derivative of acetylene from carbide can be considered in this project. Vinyl chloride is a product used widely as a building material, agricultural material, packing material and

in other commodities for daily use. Also, the domestic market of Paraguay can be expected to expand considerably in the future. The feasibility of the vinyl chloride project is discussed in this study assuming a model plant with a minimum annual production capacity of 15,000 t. However, data and information related to the domestic market for this material are incomplete.
IRR calculation shows 8.12%. Vinyl chloride sold on the international market is currently produced in large scale petrochemical plants utilizing either natural gas or naphtha. The cost is therefore comparatively low.
In this project, which assumes production utilizing carbide, the ratio of capital costs in the total cost is very large. Therefore, the reduction of plant construction costs and expansion of production scale seem the most important factors in reduction of the production cost.
In order to cut down the cost of the raw material chlorine, the existence of a market for export of the caustic soda obtained as a byproduct, is the key to success in this project.
This project has promising potential as a first step for industrialization of Paraguay, because poly-vinyl chloride is widly used in the form of film, plate, pipe, etc. Therefore, construction of a down-stream vinyl chloride processing industry will be prerequisite.
It is necessary to implement a detailed study concerning prices and other aspects of the market for vinyl chloride and its products in Paraguay and other Latin America.

(4) Calcium Cyanamide

Calcium Cyanamide, which can be produced using limestone - an abundant natural resource in Paraguay - and large amounts of electricity, is a nitrogenous fertilizer

with sterization and germicidal effects.
The profitability of this project is discussed based upon a model plant with an annual production capacity of 10,000 t, but the calcium cyanamide project itself presents a very low rate of return, so feasibility is very poor. This project may become feasible only if this will be a part of the vinyl chloride project in such a way as to produce calcium cyanamide using a portion of the carbide for vinyl chloride. In any case it is very important to carry our further studies to confirm the possibility of selling calcium cyanamide as a fertilizer in the domestic market.

(5) Chlorine and caustic soda

This project is for production of chlorine and caustic soda utilizing either brine or rock salt produced domestically or in Argentina. As mentioned above, chlorine is an indispensable raw material for the vinyl chloride industry. This study emphasizes discussion of feasibility assuming a model plant, (annual production of 13,095 t of chlorine and 11,269 t of caustic soda) which can produce the chlorine required to operate a vinyl chloride pland with an annual capacity of 15,000 t. As for the caustic soda obtained as a byproducts, it is a basic raw material for the chemical industry and there is considerable demand both in Paraguay and in the Latin American countries, where this product has the possibility of being sold at relatively higher price level than international level. The result of profitability calculations, which is carried out on the premise that caustic soda can be exported under satisfactory conditions, indicates a relatively promising IRR of 8.90%. This study assumes construction of a plant for production of bleaching powder, using chlorine with a minimum annual production scale of 3,600 t. Although it depends on the conditions of the bleaching powder market in Paraguay and in neighbouring countries, there is a possibility of cutting the production cost by expanding the scale of the bleaching powder plant and consequent expansion of the production scale of chlorine.

4. Results of the study of non-ferrous metal refining projects

(1) Aluminum

In the Latin America, alumina as an intermediate product is widely available from Caribbean countries. Furthermore, there is a high possibility to import this material from Brazil in the future. Therefore, in this study the aluminum project is discussed assuming a reduction plant equipped with the latest model 160KA electrolytic furnace with an annual production capacity of 80,000 t; the minimum economic scale. The estimated construction cost, assuming exclusion of incidental utilities, transportation and other infrastructure, is US$5,570/t of production capacity, which is high compared with international standards. The direct production cost of aluminum produced by this project is US$1,562/t, and the total cost, including overhead and marketing costs, becomes US$1,765/t, which is more expensive than the current export list price of US$1,750/t quoted by Alcan. Profitability is, therefore, extremely low and the international competitiveness of this project as an export industry cannot help being regarded as quite poor.

Transportation costs for the products and raw materials plays the most important role in the profitability of the project. It has contained disadvantages compared with coastal plants because large sized ships cannot be in the fluvial routes which are the only access to Paraguay.

The above mentioned production cost is calculated on the assumption of an electricity cost of US¢1/KWH, and in this case the electricity cost represents 8.7% in the total production cost. The production cost increases to 154 dollars and to 308 dollars when the calculations are carried out assuming electricity costs of US¢2/KWH and US¢3/KWH, the percentages of the total production cost become 14.9% and 20.7% respectively.

(2) Electrolytic copper

Chile and Perú are the most important copper producing countries in the world. The copper refining capacities which exist currently in there countries are not sufficient, and a considerable amount of the metal produced by these two countries is traded in the international market in the form of copper concentrate and blister copper. On the other hand, Brazil and Argentina are poor in terms of natural resources of copper. Their amounts of imports of electrolytic copper are increasing year by year. Such being the case, the electrolytic copper refining plant comes to the leading electricity-intensive industry in view of the current state of the copper market in Latin America.

The profitability of the project is examined in this study assuming a model plant with a minimum economic production scale of 60,000t/year. This plant assumes the import of blister copper as an intermediate product and the export of refined electrolytic copper. In the discussion of feasibility of an electrolytic copper refining plant, the share of the refining cost in the negotiation price of blister copper becomes the reference for determination of profitability, unlike other industrial products. In the case of operation of the aforementioned model plant, the actual refining cost becomes US¢6.45/t of electrolytic copper when an electricity cost of US¢3/KWH. In this case the project is not feasible because the standard refining cost of the blister copper priced at negotiation price in the world market is of the order of 5 to 6 cents.

The negative principal factor of low profitability is the fixed cost, which represents 30% of the refining cost. Therefore, the refining cost can be considerably improved by expanding production scale.

The electricity cost will be approximately 10% even in the case of US¢3/KWH, so the portion of the electricity cost among the refining cost is not large.

However, it can be said that this cost seems to be an important factor which may contribute to reduce cost.

As for the scale of the plant, it is quite possible to expand by ensuring the stable and long-term supply of raw material blister copper through appropriate purchase contracts. On the other hand, the refining cost, 5 or 6 cents, which prevail currently in transactions of blister copper is quite low even taking into consideration the demand for copper in the world-wide recession. It is therefore quite possible to improve the profitability of the copper electrolysis plant, although it depends on the conditions of purchase of raw material blister copper. On the other hand, cuts in the plant construction cost, introduction of funds under advantageous conditions, improvements in refining and charges in the international market are also factors to be carefully discussed for improvement of profitability.

(3) Electrolytic Zinc

Peru, Bolivia and Mexico are the principal zinc ore producing countries in the would, like producing of copper. Refining capacity in these countries is insufficient, however, and, as a matter of fact, zinc is exported often in the form of ore. On the other hand, Brazil and Argentina are zinc ingot importing countries and the amounts they import are increasing year by year.

In this study the feasibility of construction of an electrolytic zinc refining project using the abundant electricity available in Paraguay is discussed on the assumption of a model plant with a minimum economic production scale of 72,000 t/year.

The profitability of the zinc refining plant is decided by the extent of cutting of the actual refining cost compared with the refining cost stipulated in the conditions for purchase of the ore, as the case of the copper refining project.

In the model plant the electrolytic zinc refining cost becomes US¢11.25/LbZn when an electricity cost is US¢3/KWH. This is rather expensive compared with the refining cost levels of the order of 10¢ to 11¢ prevailing currently in the world market for purchase of zinc ore.

When the fact that the electricity cost represents 50% in the total refining cost is considered,the zinc project becomes quite profitable by reducing the electricity cost, for instance by 1¢/KHW, electricity cost can be cut by 1¢/KHW. On the other hand, there is a possibility of cutting the refining cost by expanding the scale of the plant because fixed costs represents 30% of the total.

In electrolytic zinc refineries of Japan and Europe the

transportation cost is cut by using large ships for transportation of imported ore. However, the present transportation conditions in Paraguay are quite disadvantageous because it is necessary to use fluvial transportation. The cost of electricity, however, does seem to hold the key as to the possibility to make up for this disadvantage.
The key to success in the project is the purchasing condition and the amount of ore imported from the zinc ore producing countries. Another important factor is the possibility of sales of the sulfuric acid, generated in large amounts as a byproduct of the zinc refining process, to the domestic market and neighbouring countries.

5. Summary of the Study of the Ferroalloy Industry

(1) Ferromanganese

There is a high possibility of deposits of manganese ore, which is the raw material for production of ferromanganese, exist in Paraguay. However, this discussion is proceeded on condition of the import of manganese ore from Brazil, because a mineral survey has not been carried out yet. The production cost is estimated based upon two model plants, namely; one with a minimum production scale of 10,000 t/year and the other with an optimum economic production scale of 30,000 t/year. The estimated marketing prices for the aforementioned case are US$750/t and US$633/t, respectively, which exceed by far the feasible export price level of US$328/t (FOB ex-factory).

(2) Silicomanganese

The production of silicomanganese contributes to reduce the production cost of ferromanganese, utilizing the slag generated in the production process of the latter. Therefore, the merits of constructing a silicomanganese plant together with a ferromanganese plant are economically attractive. In this study the profitability of the silicomanganese project is discussed on the basis of two model plants, namely one with an annual production capacity of 8,000 t and the other with an annual capacity of 25,000 t, on the premise of using slag generated as a byproduct of the ferromanganese production process, manganese ore imported from Brazil and silica obtained from domestic sources. The results of cost estimation indicate that the selling prices of silicomanganese becomes US$901/t and US$734/t for the abovementioned model plants, which exceed by far the feasible export price level, which is US$358/t.

(3) Ferrosilicon

Discussion of the feasibility of the ferrosilicon project is carried out on the premise that there is a high possibility of existence of silica in good quality in Paraguay, which is the raw material required for production of this ferroalloy, exists in Paraguay. The discussion assumes two model plants, namely one with an annual production capacity of 6,000 t, which is the minimum scale suited for learning operation techniques, and the other with an annual production capacity of 22,000 t, which is the average world production scale. The estimated production cost becomes US$1,100/t in the case of the minimum scale model plant and US$864/t in the case of the average scale plant, assuming an electricity cost of US¢3/KWH. These costs are very expensive compared with the feasible price for export, which is US$626/t (FOB ex-factory), but the difference is smaller compared with the other ferroalloy projects discussed in this study.

(4) Ferrochromium

Due to the fact because there is little chance of this material can be found in Paraguay, discussion of the ferrochromium project is carried out under the condition of the import of chromium ore from South Africa, which produces chromium ore of the best quality in the world. The discussion assumes two production scales, namely; a minimum annual scale of 8,500 t and an average annual scale of 18,000.t. The estimated selling costs are US$865/t and US$784/t, which are quite expensive compared with the feasible export price of US$537/t prevailing in the international market.
The 4 types of ferroalloy in this study show extremely poor profitability as a result of the abovementioned cost estimation. The causes of the poor profitability are as follows;

1) The expensive fluvial transportation costs for the raw materials and products have a considerable influence on profitability.

2) The ferroalloy industry is installation-intensive, so the depreciation cost of the plant and the cost of interest represent a large percentage, 15 or 20%, even in the case of average production scale.

However, the one of the most important causes is the low level of the feasible price for export to the international market in this study. This is due to the low prices for ferroalloys as a result of low surplus production capacity current in the world ferroalloy industry and recession in the world iron and steel industry.

Of the abovementioned 4 ferroalloys, there is a good possibility quartzite, which is the raw material for production of ferrosilicon, exists in Paraguay. In the case of ferrosilicon, the portion represented by the electricity cost in the total production cost is very high, reaching 27.7% assuming US¢2/KWH, therefore, a considerable cut in the production cost can be expected by reducing the electricity cost.

Should it be possible to cut the plant construction cost and rationalize fluvial transportation, the ferrosilicon project seems to be the most feasible of the various ferroalloys in this study.

Implementation of this project, however, requires a careful study the world ferroalloy market recovery.

6. Currently Paraguay does not have its own iron and steel industry, so total domestic demand for iron and steel products are substituted by imports. The production of reinforced bars as a first step for introduction of an iron and steel industry in Paraguay is discussed in this study, because it is the product with the largest domestic market.

The feasibility of implementation of the project is discussed assuming a mini-mill plant consisting basically of electric furnaces with an annual production capacity of 150,000 t and a small rolling plant.

The steel bar production cost estimated for the model plant is of the order of 284 to 337 dollars/t, which is considerably more expensive than the international price (Europe FOB) of 200 to 220 dollars. The most important factor in the production cost of steel bar is the price of steel scrap, which is the raw material. In the case of developing countries, the quantity of steel scrap generated domestically is small and, therefore, it is unavoidable to depend on imports of this material.

Consequently, the price is high. In the case of Paraguay, the situation is quite vulnerable because the fluvial transportation cost is high. The ratio of the electricity cost in the total cost is relatively small, reaching just 7.2% even in the case of US¢3/KWH. Rather, the portion of cost of secondary materials such as electrodes and refractories are large, so the transportation cost plays an important role.

The results of this preliminary study indicate that a mini-mill plant is not profitable in Paraguay, therefore, implementation of this project appears unfeasible.

7. This study is a preliminary, so further accurate studies, including field surveys, are required in order to confirm the pertinence of the location of these projects in Paraguay.
We suggest that the following with regard to studies should be carried out pertaining to the subject.

(1) Products which may require individual F/S (feasibility study) are fused phosphatic fertilizer and vinyl chloride in the case of chemicals, electrolytic zinc in the case of non-ferrous metal and ferrosilicon in the case of ferroalloys.

(2) Special attention should be paid on the following items F/S for the aforementioned products.

1) Survey of mineral resources available in Paraguay. In particular, a detailed study is required with regard to the availability and cost of non-metallic minerals such as limestone, silica, dolomite, rock salt, brine, etc.

2) As for fluvial transportation, studies should be carried out with regard to the current transportation cost, plans for construction of the most rational transportation system available in the future and the possibility of reducing transportation costs.

3) Execution of domestic market survey, especially domestic demand for products such as fertilizers, vinyl chloride, etc.

4) Survey of conditions related to the supply of raw materials, principally those imported form Latin

America, and the possibility to export products.

Note: This roport will place emphasis directed towards industries which tend to use/require electricity in operation relative to others.
We will use the term electricity intensive industries to describe these types of industries.

Summary of Potential Electricity Intensive Industry Projects

	Main Raw Materials	Raw Material Availability	Potential Markets	Capacity of Model Plant	Construction Cost of Model Plant (U.S. $1,000)	Electricity Consumption Per Unit (kw H/T)	International Market Price (1982) (U.S. $/T)	Technology
[Chemical]								
Fused Phosphate Fertilizer	Phosphate Rock Serpentine	Brazil or domestic domestic	domestic & regional	Mg-P-Fertilizer 83,300 T/Y	14,920	1,700	180	Moderate
Electrolysis Ammonia, Phosphoric Acid, Phosphorous and Fertilizer complex.	Phosphate Rock Silica Cokes	Brazil or domestic domestic U.S.	domestic & regional	Ammonia 18,000 T/Y	52,224	11,700	300	Moderate
				Phosphorous 15,000 T/Y		13,400	1,500	
				Phosphoric Acid 18,000 T/Y		2,900	500	
				D.P.A 35,870 T/Y		-	330	
				Ammonium Sulphate 12,000 T/Y		-	120	
				Calcium Silicate 15,000 T/Y		-	50	
Poly-Vinyl Chloride (P.V.C)	Lime Stone Cokes Chlorine	domestic U.S. domestic	domestic & regional	P.V.C 15,000 T/Y	33,008	5,500	1,300	Rather Complicated
Calcium Cyanamide	Lime Stone Cokes	domestic U.S.	domestic & regional	Calcium Cyanamide 10,000 T/Y	11,026	2,280	300	Moderate
Chlorine & Caustic Soda	Salt	domestic or region	domestic or regional	Chlorine 13,095 T/Y	30,465	2,600	240	Simple
				Caustic Soda 11,269 T/Y			300	
				Bleaching Powder 3,600 T/Y			1,300	
[Non-Ferrous Metals]								
Aluminium	Bauxite Aluminium-Fluoride Cryorite	Caribbean Countries or Brazil U.S. JAPAN U.S. JAPAN	U.S. JAPAN	Aluminium Ingot 80,000 T/Y	450,960	15,425	1.750 (Alcan Export List Price)	Moderate

Summary of Potential Electricity Intensive Industry Projects

	Main Raw Materials	Raw Material Availability	Potential Markets	Capacity of Model Plant	Construction Cost of Model Plant (U.S. $1,000)	Electricity Consumption Per Unit (kw H/T)	International Market Price (1982)	Technology
	Carbon Material	U.S.						
Copper	Blister Copper	Chile, Peru	Regional, U.S., E.C.	Electrolytec Copper Cathud 60,000 T/Y	34,150	430	1,430-1,540	Simple
Zinc	Zinc Concen-trate	Peru, Bolivia	Regional, U.S., E.C.	Electrolytec Zinc 72,000 T/Y Sulfaric Acid· 120,000 T/Y	69,500	4,100 30	800-850	Simple
[Ferroalloy]								
Ferromanganese	Manganese Ore Coke	Brazil U.S.	U.S., E.C., JAPAN	9,500 T/Y (31,000 T/Y)	114,400 (31,200)	2,600 (2,560)	350-610	Moderate
Silicomanganese	Manganese Ore Coke Quartzite	Brazil U.S. domestic	U.S., E.C., JAPAN	7,800 T/Y (24,600 T/Y)	16,000 (34,000)	4,570 (4,570)	400-450	Moderate
Ferrosilicon	Quartzite	domestic	U.S., E.C., JAPAN	6,000 T/Y (19,700 T/Y)	20,000 (36,000)	9,000 (8,700)	350-600	Rather Complicated
Ferrochromium	Chrome Ore Coke Quartzite Serpentine	South Africa U.S. domestic domestic	U.S., E.C., JAPAN	8,500 T/Y (18,000 T/Y)	18,000 (30,400)	4,050 (3,950)	560-1,150	Moderate
[Steel Products]								
Small Steel Bar	Steel Scrap Ferroalloy Electrode	U.S. Brazil U.S.	domestic & regional	150,000 T/Y (300,000 T/Y)	88,000 (148,000)	565	200-220	Simple

SECTION I

INTRODUCTION

CONTENTS

I. Background and Objectives of the Study

Paraguay is currently setting forth on construction of two enormous hydroelectric power generation projects, namely, the Intaipú Hydroelectric Power Station, which will have the largest power generation capacity in the world, in cooperation with Brazil, and the Yacyretá Hydroelectric Power Station in cooperation with Argentina. After completion of these two projects, is expected to be in 1988, Paraguay will be able to generate vast amounts of electricity.

An outline of the two hydroelectric power stations is given below.

(1) Itaipú Hydroelectric Power Station (Joint project by Brazil and Paraguay)

Total power output:	12.6 million KW (18 generators with 700,000 KW capacity each)
Paraguayan share:	700,000 KW × 9 units = 6.3 million KW
Expected start of operations:	1983 or 1984
Estimated total construction cost:	US$12.7 billion

(2) Yacyretá Hydroelectric Power Station (Joint project by Argentina and Paraguay)

Total power output:	2.7 million KW
Paraguayan share:	1.35 million KW
Expected start of operations:	1987 or 1988
Estimated total construction cost:	US$7.2 billion

The current capacity of power supply of Paraguay is approximately 230,000 KW, and principally consists of the Acaray Hydroelectric Power Station, with a capacity of 184,000 KW. After the completion of the aforementioned gigantic power stations in 1988, the power generation capacity of Paraguay will become 34 times as large as that of the present.

The Paraguayan government is promoting domestic electrification by expanding the power distribution network in response to the increase of power generation capacity and is also planning to sell electric surplus to Argentina and Brazil. At the same time on a middle and long term basis, the government is strongly promoting a policy for introduction of the electricity-intensive industries into Paraguay.

However, the Paraguayan government has difficulties in introducing the electricity-intensive industries at present as follows.

(1) The domestic market is small, because the country has a population of only about 3 million, inhabitants and income levels are low.

(2) The potentiality of natural resources of the country, particularly mineral resources, has not been sufficiently studied yet.

(3) The transportation infrastructure has not been sufficiently consolidated because it is an inland country.

(4) The system for supplying industrial labour has not been sufficiently established.

Therefore the government recoguizes the recessity to consolidate foundations for the introduction and development of industries and to provide favorable conditions by various measures from the long-term point of view.

Since Paraguay has developed its economy based on agriculture, the promotion of industrialization, particularly the introduction of electricity-intensive industries, is a new task in its economic policy. Therefore neither the basic data and information nor the system required for planning and implementation of industrial development policies is sufficiently prepared at present.

Accordingly, the consolidation of the foundations of policy planning for the introduction of electricity-intensive industries is of top priority for the Paraguayan government.

This study aims at providing the Paraguayan government with fundamental data and information required for the implementation of industrial development policies. Since enormous amount of basic data and information is required, this study presents a concise summary of concrete data and information collected from those accumulated by the Japanese government and private enterprises by focusing on industrial sectors of highest priority in Paraguay.

II. Method and Contents of Survey

Among the sectors of electricity-intensive industries in Japan, the products fulfilling the following conditions were selected for this study.

(1) There is a possibility of expanding appropriate scale of domestic market in the future or a possibility of exporting from Paraguay to neighbouring countries and/or to the Latin American market.

(2) There is a possibility that raw materials exist in Paraguay or that raw materials are easily available in neighbouring countries or in Latin America.

(3) The relevant production technique is already well developed and the technology is transferable.

(4) The electricity consumptin per unit product is large, or the electricity cost occupies a large share of the production cost.

(5) The transportation cost occupies a relatively small share of the raw material and production costs.

(6) The appropriate production scale and the initial investment scale are relatively small.

After the consideration of above conditions, 5 products of the chemical industry, 3 products of the non-ferrous metal refining industry, 4 products of the ferroalloy industry and 1 product of the iron and steel industry - a total of 13 products - were selected for study.

The products selected for this study are as follows.

(1) Chemicals

1) Fused phosphatic fertilizer produced utilizing rock phosphate and serpentine.

2) Ammonium phosphate produced utilizing ammonia obtained from electrolytic hydrogen and phosphoric acid obtained from rock phosphate.

3) Polyvinyl chloride produced utilizing limestone and coke.

4) Calcium cyanamide produced utilizing limestone and coke.

5) Chlorine and caustic soda obtained by electrolysis of salt.

(2) Non-ferrous Metals

1) Aluminum produced utilizing fused salt bath electrolysis of alumina.

2) Electrolytic copper produced utilizing electrolysis of blister copper.

3) Electrolytic zinc produced utilizing zinc consentrate.

(3) Ferroalloys

1) Ferromanganese produced utilizing manganese ore.

2) Silicomanganese produced utilizing manganese ore and silica.

3) Ferrosilicon produced utilizing silica.

4) Ferrochromium produced utilizing chromium ore.

(4) Iron and Steel Products

1) Small sized steel bar produced in electric furnaces and a small sized rolling mill utilizing scrap iron.

First, the most recent information on the properties, markets, prices, raw materials and techniques related to the selected products, which contribute to studying feasibility of introducing the products in Paraguay, were categorized.

Next, model plants are assumed for each product in order to estimate the investment and cost, and the feasibility of introducing each project was discussed, based on currnt data available in Japan and some conditions peculiar to Paraguay.

It is expected that the data, information and methodology used in the process of implementation of the study will be useful for the staff of the Paraguayan government in charge of planning of industrial development policy as fundamental information for drawing up guidelines for attracting private companies from abroad and for evaluating project proposals presented by interested enterprises.

Furthermore, the results of the study are expected to contribute to selecting products as objects of more detailed feasibility study including field survey.

In this study we faced some difficulties described as follows:

(1) It has become extremely difficult to forecast the structure of future world production of electricity intensive industries. Because the conditions of electricity-intensive industries around the world have changed in the recent years due to rises in the price of petroleum, and the structure of world production by country and the location of new production facilities are entering in an epoch of substantial change.

(2) Forecasting of markets and prices for commodities is difficult, due to the stagnation of the world economy after the oil shock, particularly extreme slump in the markets of manufacturing products in the developed countries.

(3) It is unavoidable that this study includes assumptions regarding many aspects of the conditions prevailing in Paraguay because it is very difficult to obtain accurate information on local conditions in Japan.

Therefore, it is important to bear in mind that this study is a preliminary one. We would like to emphasize the necessity to allocate considerable manpower and time in carrying out the next step of the study, including field surveys.

SECTION II

CHEMICAL INDUSTRY

CONTENTS

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I. General Considerations on Electricity-Intensive Chemical Industries

The history of the development of chemical industry is that of the pursuit of alternative processes to produce the desired product in the most economical way. The evolution of the processes for production of nitrogenous fertilizer is a typical and illustrative example. The first synthetic fertilizer ever produced was ammonium sulfate, obtained from the reaction of ammonia, which is a byproduct of production of coke by carbonization of coal, with sulfuric acid.

The development of various processes for synthesis of ammonia was begun in the early 20th century.

The first process to be developed was the synthesis of ammonia from calcium cyanamide

$$CaO + 3C \xrightarrow{2000°C} CaC_2 + CO$$

$$CaC_2 + N_2 \xrightarrow{1000°C} CaCN_2 + C$$

$$CaCN_2 + 3H_2O \longrightarrow CaCO_3 + NH_3$$

CaO : Caustic Lime
CaC_2 : Calcium Carbide
$CaCO_3$: Calcium Carbonate

The next process to be brought into commercial production was the synthesis of nitric acid (oxidized product from ammonia) by means of an electric arc in the air.

However, by reason of these processes were replaced by the Haber-Bosch process, developed later, which synthesizes ammonia from hydrogen and nitrogen, their large energy consumption.

In the next step, the electrolysis of water, the gasification of coke and the partial oxidation of coal were put into commercial use as methods of production of hydrogen and nitrogen. Afterwards, from about 1950, almost all the ammonia in the world was produced by menas of a process using petroleum and natural gas, in view of its economic advantages. Petroleum, however, lost its advantage as a raw material for synthesis of ammonia as a consequence of the steep rise in the price of crude oil after the oil crisis of 1973, and currently natural gas is considered the most advantageous raw material.

On the other hand, the form of the finished product changed too. In the early stages ammonium sulfate was the most typical synthetic nitrogenous fertilizer but afterwards it changed to ammonium nitrate and urea, which compose the current nitrogenous fertilizer market.

Similar production process evolution and change of raw materials can be observed also in the case of production of nylon and of vinyl chloride.

The considerations above suggest that it is relatively easy to find processes suited to the purpose of consuming the large amounts of electricity to be generated in Paraguay. Table I-1 lists typical examples of such products and processes.

It is, however, indispensable to analyze the competitiveness of electricity-intensive processes, because almost all of the products listed in the aforementioned table can be produced by other processes. In other words, the industry in question may prove economically unfeasible even when the cost of electricity is lowered to zero, depending on the relative difficulty of obtaining raw materials other than electricity, the marketing price of the product and other relevant factors. Therefore, in the first place it is indispensable to confirm the economic feasibility of the possible products and processes.

The following chapters present discussions to determine which projects are of the highest feasibility.

Table I-1 Preliminary Evaluation of the Potential Projects

	Project	Raw Material	Electricity	International Price	Market	Raw Material Availability	Technology	Remarks
I-1)	Adiponitrile ($NC-(CH_2)_4-CN$)	Acryle Nitrile (Toluen Sulphonic acid tetra ethylene ammonia)	3,500 kWH/ton	¥320,000/ton	Not in the region.	From U.S.A. (Brazil)	Complex	The related industries (Raw material and end user) are far away.
I-2)	Calcium Carbide (CaH_2)	Lime Stone, Cokes	3,340 kWH/ton	¥120,000/ton	Potential as raw material.	Available in the region.	Moderate	Good potential depend on electricity cost.
I-3)	Chlorine (Cl_2)	Salt (NaCl)	2,600 kWH/ton	¥66,000/ton	Potential as raw material.	Available in the region.	Simple	Good potential depend on salt availability and electricity cost.
I-4)	Hydrogen (H_2)	Water	5 kWH/M^3	¥60/m^3 (Bomb)	Potential as raw material.	Available.	Simple	Very low cost electricity required.
I-5)	Hydrogen Peroxide (H_2O_2)	Water, Sulphuric Acid, Ammonia	3,800 kWH/ton	¥145,000/ton	Potential for bleaching	Available (Auxiliary material not available.)	Simple	Market and electricity cost is important.
I-6)	Oxygen (O_2)	Water or Air	0.6 kWH/ton (Air Separation)	¥60/m^3 (Bomb)	Limited	Available.	Simple	Market is limited.
I-7)	PNC-Caprolactam ($(CH_2)_5CONH$)	Cyclohexanon	2,000 kWH/ton	¥400,000/ton	Not in the region.	From U.S.A. (Brazil)	Complex	The related industries are far away.
I-8)	Phosphorus (P)	Phosphate Rock, Silca, Cokes	13,400 kWH/ton	¥550,000/ton	Potential as raw material.	Available in the region.	Moderate	Good potential depend on electricity cost.
I-9)	Fused Phosphate	Phosphate Rock Serpentine	1,700 kWH/ton	¥50,000/ton	Potential.	Available in the region.	Moderate	Good potential if market exist.
I-10)	Silicon Carbide	Silica, Cokes	10,000 kWH/ton		Not in the region.	Available in the region.	(Rather complex.)	
I-11)	Sodium Hydroxide	Salt	2,300 kWH/ton	¥70,000/ton	Potential	Available in the region.	Simple	
I-12)	Chlorinated Hydrocarbon	Chlorine, Ethylene			Not in the region	From U.S.A. (Brazil)	Complex	

(Cont'd)

Table I-1 Preliminary Evaluation of the Potential Projects (con'd)

	Project	Raw Material	Electricity	International Price	Market	Raw Material Availability	Technology	Remarks
II-1)	Acetylene	Calcium Carbide	10,500 kWH/ton	¥640/m^3 (Bomb)	Limited. Potential as raw material.	Can be produced.	Simple	
II-2)	Ammonia	Hydrogen, Nitrogen	11,700 kWH/ton	(Bomb) ¥90,000/ton (Fertilizer ¥40,000/ton)	Potential.	Can be produced.	Moderate	Cost can be high unless low price. Power is available.
II-3)	Ammonium Nitrate	Ammonia, Nitric Acid	5,150 kWH/ton	¥50,000/ton	Potential.	Can be produced.	Moderate	As above.
II-4)	Calcium Cyanamide	Carbide, Nitrogen	2,600 kWH/ton	¥66,000/ton	Potential.	Can be produced.	Moderate	Market size may be limited.
II-5)	Calcium Hypochlorite	Lime, Chlorine	1,060 kWH/ton	¥30,000/ton (33% Cl_2)	Potential as bleaching agent.	Can be produced.	Simple	Market may be small.
II-6)	Hydrochloric Acid	Hydrogen, Chlorine	2,700 kWH/ton	¥24,000/ton	Limited. Potential as raw material.	Can be produced.	Simple	Depend on vinylchloride production.
II-7)	Nitric Acid	Ammonia	2,600 kWH/ton	¥60,000/ton (67%)	Limited. Potential as raw material.	Can be produced.	Moderate	Depend on ammonia cost.
II-8)	Nitro Phosphate Fertilizer	Nitric Acid, Phosphate Rock, Ammonia, etc.	5,150 kWH/ton	¥40,000/ton (20-20-0)	Potential.	Can be produced.	Moderate	As above.
II-9)	Phosphoric Acid	Phosphorus	2,900 kWH/ton	¥190,000/ton	Potential as raw material.	Can be produced.	Moderate	Depend on the cost of elementary phosphorus.
II-10)	Soda Ash	Caustic Soda, Carbon Dioxide	1,800 kWH/ton	¥70,000/ton	Potential.	Available in the region.	Moderate	Market and cost are keys.
II-11)	Vinyl Chloride	Acetylene, Hydrogen Chloride	6,700 kWH/ton	¥180,000/ton	Potential.	Can be produced.	Rather complicated.	As above.
II-12)	Vinyl Acetate	Acetylene, Acetic Acid	3,700 kWH/ton (exclude acid)	¥160,000/ton	Not in the region.	Acetic acid may not be in the region.	Rather complicated.	Market is limited.

II. Factors to be Taken into Consideration in the study of the locations of Chemical Industry Projects in Paraguay

1. Selection Criteria

If a project is considered to turn out a sufficient margin of profit corresponding to the capital invested, its implementation might be easier. However, there may be other conflicting factors. For example even when timber production project is deemed feasible, if the project in question is set forth with a cutting speed exceeding the level which allows normal reforestation, sacial losses are taking place outside of the project. Therefore, such a project should be assessed as infeasible from the point of view of the national economy, analyzing its profitability by taking into consideration the costs required for the maintenance and recovery of the forest resources, in addition to the apparent cost of timber production. On the other hand, even when a project has low profitability, it can be judged highly feasible from the point of view of national economy if it contributes to the effective utilization of the domestically available resources (e.g. human resources, mineral resources, etc.). In any case, it is necessary to choose projects which are ranked at relatively higher positions from the point of view of economic rationality. Protection by import tariff barrier and other similar factors are not taken into consideration in this discussion.

2. Advantages and disadvantages of a Location of Chemical Industry in Paraguay

Generally speaking, the following factors should be taken into consideration in the discussion of the location of a factory.

(1) Proximity to the market of the product.

(2) Possibility of obtaining raw materials and secondary materials at low prices.

(3) Availability of high quality labour.

(4) Availability of land suited for construction of a factory.

(5) Availability of infrastructure and utilities such as transportation of raw materials and products, water, electricity etc.

When considering the construction of a new industrial plant with the purpose of producing chemical products utilizing power generated in ITAIPU, followed by the marketing of the said product, it is necessary to assess the cost competitiveness with the product manifactured by similar plants in foreign countries. Now let us think about the projects to be taken into consideration and their superiority or inferiority in terms of competitiveness compared with the rivals.

Assessment of feasibility may need to consider the chemicals in three different types

(1) Fine chemicals group, represented by dyestuffs and medicines.

(2) Group represented by acids, alkalis, fertilizers, etc.

(3) General-purpose petrochemical products represented by polyethylene, vinyl chloride, etc.

2-1 Fine Chemicals Group

Characteristics of the products of this group are as follows:

- High unit price per weight
- Small quantitywise consumption
- Requirement of a wide variety of raw materials and secondary materials
- Requirement of many qualified technical personnel for both production and marketing.

In view of the characteristics listed above, it is evident that Paraguay has too many disadvantages in the establishment of industries of this group. Therefore, it is very difficult to set up industries of this kind in Paraguay.

2-2 Group of Fertilizers, Acids, Alkalis, etc.

The characteristics of this group are as follows:

- The products are consumed in large quantities.
- The price per unit weight of the product is low.
- The transportation cost of the raw materials and products between the production centers and consumption centers has a decisive influence on the economic feasibility of the project.
- The transfer of production technology is relatively easy.

The establishment of industries of this group seems to be feasible if the raw materials are available at low cost and the market is located nearby.

2-3 Group of General-Purpose Petroleum Chemicals

The characteristics of this group are at a median position between the two groups described above. Therefore, if the raw materials and utilities (cost of electricity, etc.) are available under advantageous conditions compared with the industrial countries and the conditions for marketing cónditions and circumustances of the products are favourable, it seems possible to set up industries of this group in Paraguay. However, the recruiting and training of technical personnel indispensable for implementation of the project requires the investment of considerable amount of money. Accordingly, it is necessary to take into consideration these technology transfer costs from the national point of view.

3. Market Scale and Economic Scale of Production Facilities

In addition to the discussion in preceeding chapter on whether or not the market exists in studing the feasibility of the project, the scale of production is another fundamental factor which contributes to the determination of the price competitiveness of the project. The larger the share of capital cost in the price of the product, the more important the scale of production in the determination of the competitiveness of a project.

If the ammonia plant is considered independently in the present case, the cost of construction (capital cost) becomes approximately US$150 per ton of ammonia. This cost alone is close to the international market price of ammonia. If the scale of the project is tripled, it is possible to reduce the capital cost to approximately US$90/ton. In this case, however, it is necessary to export surplus ammonia which cannot be consumed in Paraguay and nearby areas. The transportation of liquid ammonia is very costly unless it is transported in large quantity using large-sized ships. Accordingly, if the scale of the project is expanded, it becomes necessary to reduce the marketing prices (ex-factory) for export and this offsets the merits brought about by scale-up.

It is presumed that the expansion of scale of the plant will be possible and the profitability of the fertilizer project will improve with the future diffusion and expansion of the use of chemical fertilizers. However, it is indispensable to start domestic production of chemical fertilizers with the purpose of ensuring a stable supply of the product at low cost in order to trigger the build-up of a solid domestic market.

Therefore, we consider it indispensable to provide support from the national point of view to pioneer projects of this kind.

4. Natural Resources Available in Paraguay

According to mineral resources surveys carried out so far, the existence of limestone, silica and magnesium salt as raw materials for industrial use has been confirmed. In addition, there is a possibility of the existence of rock phosphate and rock salt. In any case there is a little hope of finding raw materials which would contribute to the development of export-oriented large scale industries. It is thought that a phosphorus complex and a calcium carbide complex have advantages in terms of the availability of raw materials such as calcium carbonate, phosphate rock and silica.

5. Problems Related to Infrastructure

In the projects of industrial countries infrastructure such as land for construction of the plant, facilities for loading and unloading of raw materials and finished products, transportation facilities, etc., are either available or are provided by public institutions. Accordingly, the industrial project itself is not required to bear costs for these. In contrast, in Paraguay the costs of these elements have often to be included in projects, and as a result they contribute to impoverishment of profitability. This is another point which suggests that implementation of an industry of very large scale from the beginning is accompanied by many difficulties.

In addition to the physical infrastructure described above, the social infrastructure represented by the supply of management personnel, chemical engineers, mechanical engineers and operation and maintenance personnel required for successful accomplishment of the project, the supply of materials and technical personnel for repair of the machinery, etc., should be taken into consideration in assessing the feasibility of the project.

III. Preliminary Feasibility Study of Projects which could be Located in Paraguay

1. Selected Project Scheme

As described in the preceeding chapters, the chemical industry to be set up in the first place in Paraguay should fulfill the following conditions:

- The product(s) of the industry in question should be consumed in considerable quantities in the domestic market and in neighbouring areas
- The raw materials should be available economically
- The transfer of required technology should be relatively easy
- The economical and financial profitability should exceed the required levels, etc.

The following industries come to the front as a result of analysis of the historical development process of industrial projects in Latin American and Asian countries as well as of consideration of the aforementioned factors.

(1) Fertilizer industry
(2) Vinyl chloride industry
(3) Salt electrolysis industry

1-1 Fertilizer Industry

Generally speaking, the agriculture in the various countries of the world can be classified into two types, namely, the intensive type carried out in Japan, European and North American countries, etc., which is characterized by the use of large quantities of fertilizers and insecticides and high yield per unit area, and the extensive type carried out in countries like Paraguay, Argentina, etc. The latter type of agriculture relies on the natural production capacity of the soil and not to much capital investment is made in fertilizers and insecticides. When the land has lost it's fertility in extensive agriculture, virgin land is cultivated and the arable land used before is generally abandoned.

There is, however, a gradual conversion from the extensive type of agriculture to the intensive type in various countries of the world, as a consequence of the demographic multiplication and consequent diminishment of arable land (Further discussions on the perspective of fertilizer use in Paraguayan agriculture are presented in this report).

There is a possibility of further improvement in the irrigation of Paraguayan farmland as a consequence of the construction of the ITAIPU Dam and YACIRETA Dam and this is a factor expected to make considerable contribution to the expansion of intensive type agriculture.

On the other hand, it is normally believed that in order to make possible massive use of chemical fertilizers in agricultural production, the cost for acquisition of chemical fertilizers should not exceed approx. 1/3 of the improvement of yield of the crop and consequent increase of income brought to farmers as a result of application of the fertilizer. An analysis of the status quo of Argentinean and other Latin American agricultures shows that the farmer's gate price is very high compared with international prices, and this factor contributes to obstruction of increases in the consumption of fertilizers in these countries.

Accordingly, it is expected that the domestic market will expand gradually if a stable supply is ensured at proper price levels.

However it is presumed that a considerably long period of time will be required until the materialization of the said process. Therefore, it is necessary to assess the feasibility of the fertilizer project assuming a small scale plant for the initial stage. No scale merit can be expected at the beginning. Such being the case, the production cost will be inevitably expensive compared with the large-scale plants of industrialized countries. However, this higher production cost can be well set off by the freight, import clearance and other relevant costs brought about in case of imports, in view of the very special geographical peculiarities of Paraguay. As a consequence, the products can be supplied at price levels at only slightly different levels compared with imported commodities. In particular, this project may become quite attractive if rock phosphate, which is the raw material, can be obtained at economically advantageous price levels from Paraguayan sources or from other sources located in the neighbouring southwest region of Brazil. The production of fused phosphate is in an advantageous position from the point of view of cost but there are doubts about the adequacy of this kind of fertilizer for Paraguayan agriculture.

1-2 Vinyl Chloride Industry

Plastics are today materials indispensable for our daily life and their consumption is increasing year after year to such an extent that we are said to be living in the "plastic age".

Vinyl chloride is consumed in large quantities in agriculture and as a building material, and it is produced in many countries in the world.

Currently vinyl chloride is produced as a derivative of ethylene, obtained by thermal cracking of naphtha or ethane. However, it can also be produced from acetylene through carbide obtained from limestone, coke and electricity. In other words, vinyl chloride can be produced from raw materials easily available in Paraguay. Furthermore, considerable consumption can be expected both in the Paraguayan domestic market and in neighbouring areas. In addition, the difference in price between large-scale production and small-scale production is not so significant as other projects and therefore it is presumed that price competitiveness can be maintained.

In particular, the demand for vinyl chloride is expected to increase considerably when water of the ITAIPU and YACIRETA Dams is utilized for irrigation purposes.

1-3 Salt Electrolysis Industry (Caustic Soda and Chlorine Complex)

In the case of vinyl chloride production, it is indispensable to produce either chlorine or hydrogen chloride because these are most important raw materials of the former. In this case, salt which is the raw material required in addition to electricity can be acquired with ease from neighbouring countries. It is desirable to expand the scale of the plant (salt electrolysis) in order to lower the chlorine production cost to the levels competitive with imports from foreign countries. Aluminum refining can be taken into consideration as an industry to be developed in Paraguay as an electricity utilization project, and in this case it is necessary to either import or produce alumina.

Caustic soda is indispensable for the production of alumina, being consumed at the rate of approximately 0.1 ton per each 1.0 ton of alumina. In the case of imported alumina, the transport means used to send it to Paraguay can be used to transport caustic soda to the alumina plant. Accordingly, the international competitiveness of the electrolysis plant can be strengthened by exporting caustic soda, as described above. The production of bleaching powder (calcium hypochlorite), used for potable water sterilization, bleaching of pulp and other applications, is planned as an alternative for effective use of caustic soda, chlorine and limestone - the raw materials domestically available in Paraguay. In this case, it is necessary to carry out a study on the future demand for bleaching powder in Paraguay and neighbouring countries.

Note: The principal products of the projects herein analyzed are DAP, elementary phosphorus, ammonia, PVC, chlorine, caustic soda and bleaching powder. It is also possible to sell intermediate products such as carbide, acetylene, hydrogen chloride, etc. obtained in the production processes for the aforementioned products.

2. Material Balance

2-1 Fertilizer Industry

In this case it is proposed to produce di-ammonium phosphate, ammonium sulphate and ammonia (or fused phosphate), which are expected to become important inputs of the Paraguayan agriculture in the future, using rock phosphate, which is expected to be available with ease in Sao Paulo State, Brazil, silica, coke and by making use of the advantages offered by the cheap electricity available in Paraguay. The project relies on rock phosphate as the key raw material. Production is destined mostly for the domestic market of Paraguay. The export of a portion of the elementary phsophor obtained as an intermediate product in this process is also taken into consideration. The material balance of the process starting from the raw materials, passing through the intermediate products and ending with the finished products is shown in Figure III-2-1.

This balance assumes simultaneous implementation of the DAP and fused phosphate projects. However, this alternative becomes feasible only when exports to neighbouring countries (Brazil, Uruguay, Argentine and Bolivia) are as large as domestic consumption of the products in the Paraguayan market. In case of immediate implementation of the project, it seems more realistic to set forth on either the DAP project or the fused phosphate project first.

As can be seen in Appendix I, the scale of the P205 fertilizer market expected to be realized in the near future is of the order of 16,000 t/Y and the scale of the fused phsophate plant is therefore assumed to be of the order of 16,000 t/Y. It is, however, difficult to consume the total porduction in the Paraguayan domestic market very soon and therefore it is necessary to export more than a half of production to Brazil, Uruguay and other neighbouring countries. As for the ammonia plant, a scale corresponding to a demand for 13,000 t/Y or nitrogen expected by 1990 is assumed as a basis. On the other hand, the production scale of phsophor, which uses rock phsophate and silica available in Paraguay and in neighbouring areas (Brazil), is increased more than the required amount to produce 16,000 ton P_2O_5 with the purpose of cutting down the production cost and part it is assumed that a portion of the phosphor production will be exported.

Ammonia plant	60 tons/day	(Nitrogen 14,800 t/Y)
DAP plant	120 tons/day	(P_2O_5 16,500 t/Y)
Phosphorus plant	50 tons/day	(P 15,000 t/Y, including export).

It is assumed that ammonium sulphate is produced using sulfuric acid obtained as a byproduct of sulfide ore refining. However, it is possible to cope with this by increasing the quantity of ammonia sold in the market if sulfuric acid is not available.

Fig. III-2-1 (a) Fertilizer Complex Material Balance

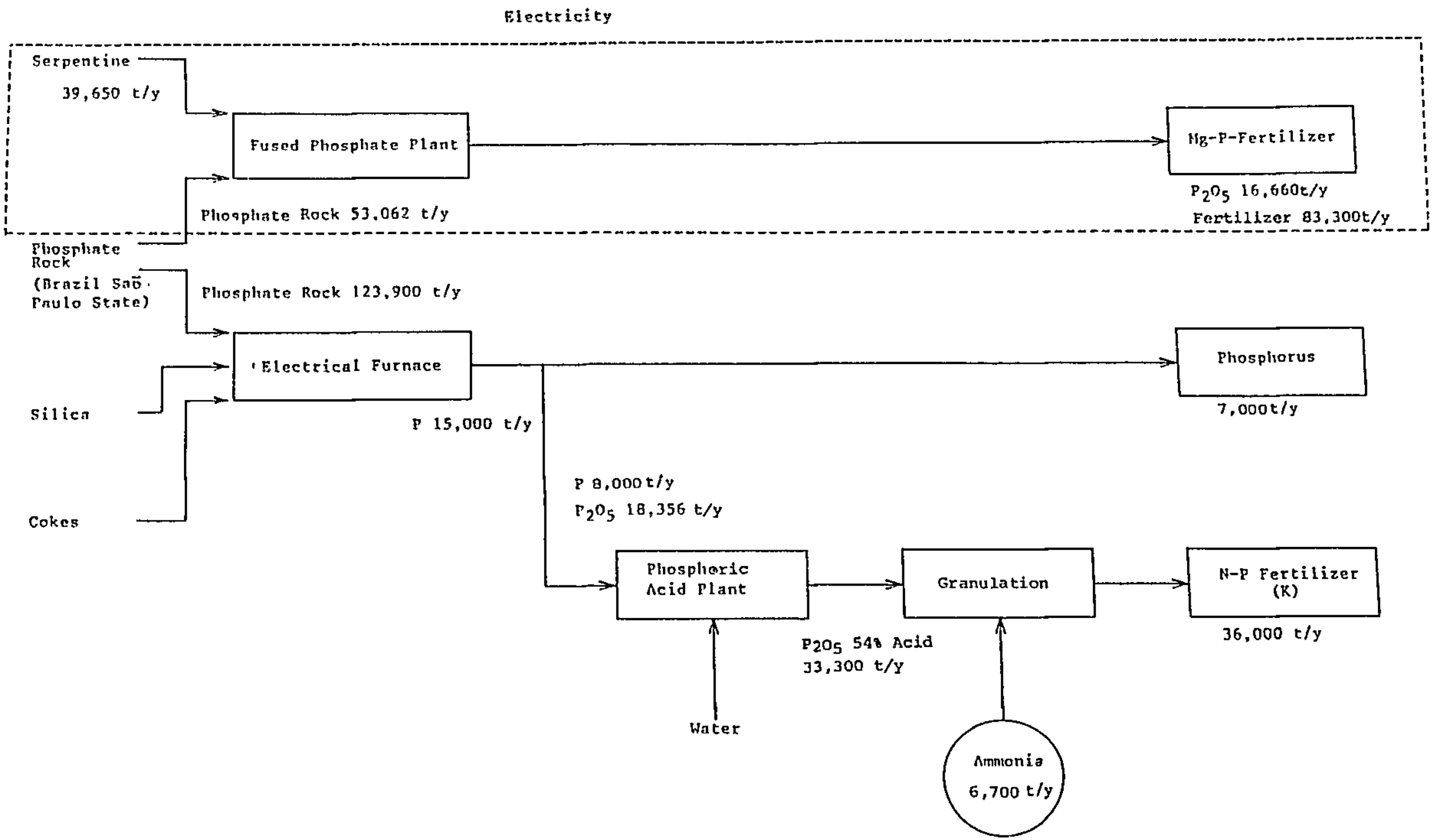
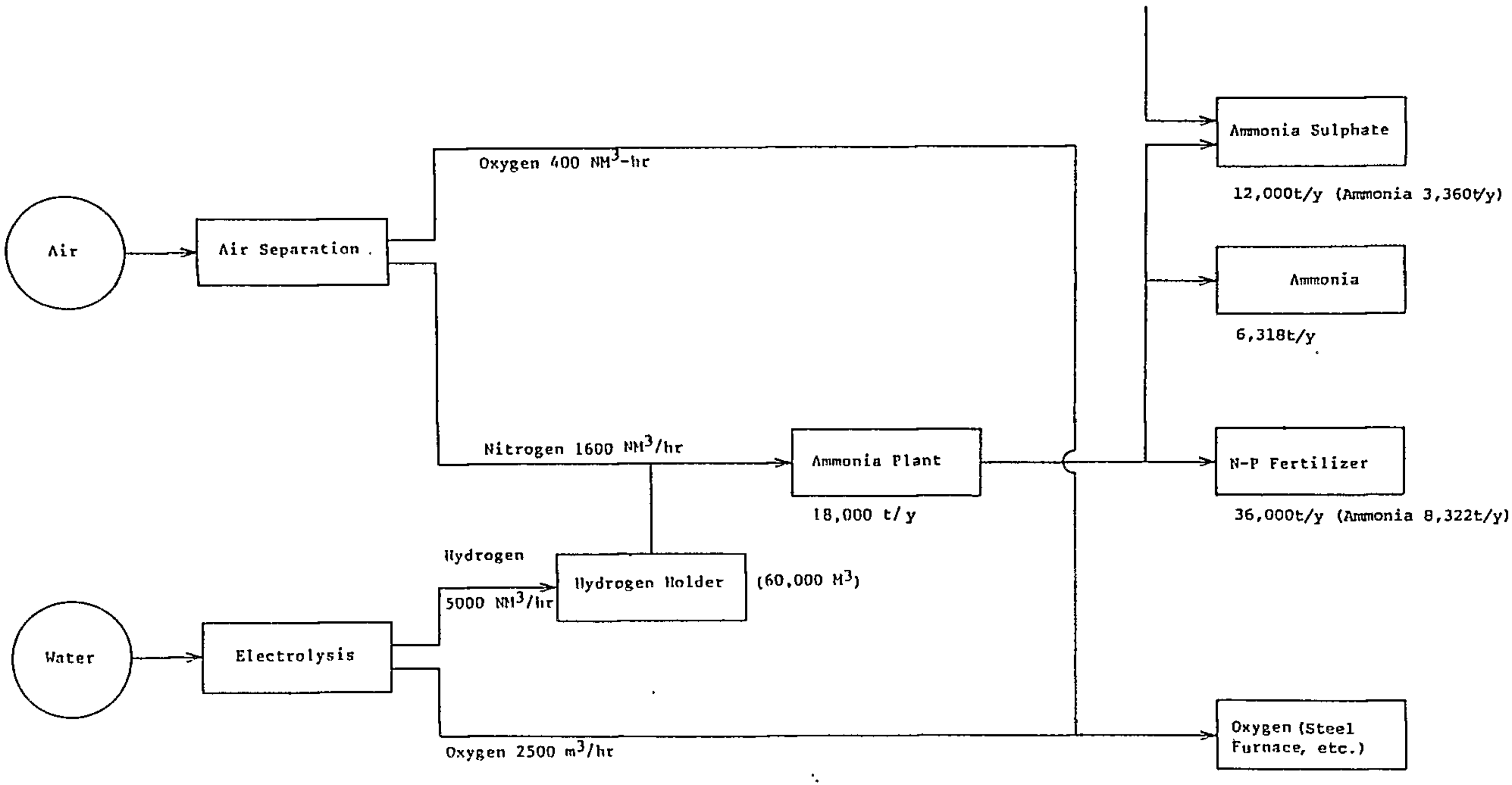


Fig. III-2-1 (b) Fertilizer Complex Material Balance



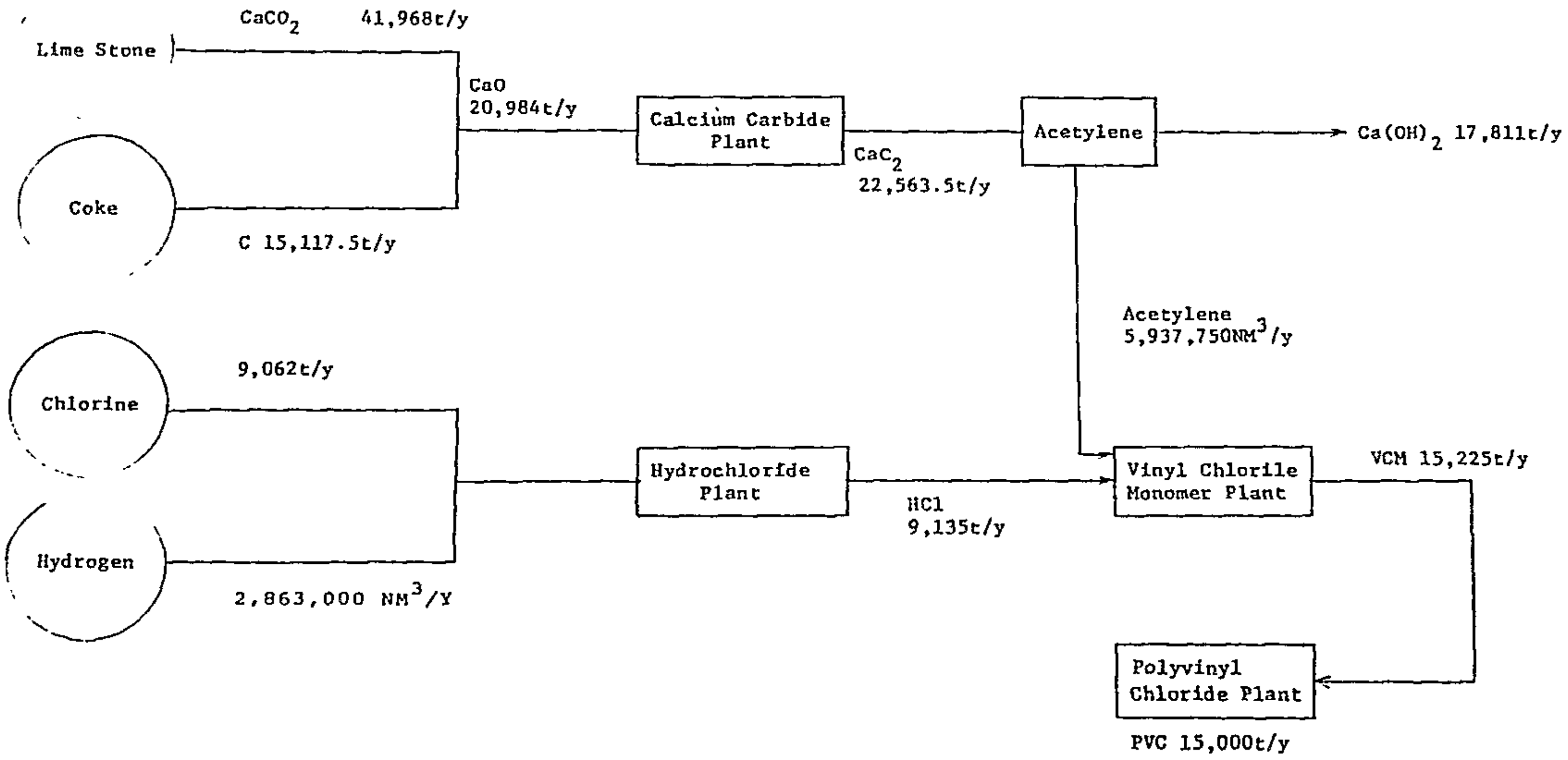
2-2 Vinyl Chloride Industry

The production of carbide can be taken into consideration as a chemical industry to be implanted in Paraguay. Both limestone and electricity are available in abundant quantities. Further steps are related to the production of derivatives of acetylene, which is obtained from carbide. Among such derivatives, vinyl chloride is a product which can be consumed in Paraguay and in neighbouring areas. Vinyl chloride has a wide range of applications in the building materials industry, in agriculture, in the miscellaneous goods industries, etc. Although the market survey is incomplete, the plant taken into consideration in this study is assumed to be of minimum scale. There are, therefore, problems which will be encountered from the aspect of price compared with current international market levels (products turned out by large-scale plants). There is a possibility of strengthening the economic competitiveness if it is possible to sell the products to the markets of neighbouring countries like Brazil, Argentine, etc. We consider it possible to reduce the cost by expanding production capacity should the demand in the Paraguayan domestic market expand futurely.

The following factors are taken into consideration in determination of production scale (15,000 t/Y) of vinyl chloride.

Generally speaking, the consumption per capita of PVC is of the order of 2 kg/Y in countries in the development stage with per capita GNPs of the order of US$1,000. Furthermore, there is consumption of polyethylene (both soft and hard types), belonging to the class of thermoplastic resins, of the order of 3 kg/Y and consumption of polypropylene of the order of 1.5 kg/Y. Should domestic production of PVC start in Paraguay, it is presumed that it will not be so difficult to attain a per capita consumption of the order of 4 to 5 kg/Y because, in addition to the traditional uses of PVC, there is possibility of replacing part of the polyethylene market with PVC. A production scale of 50 t/day (150,000 t/Y), the minimum economically feasible, is assumed for the first stage, taking into consideration the demand of neighbouring areas of Paraguay. Should the domestic market expand and exports to neighbouring areas increase, there is possibility of cutting down production costs by expanding production scale. The key to economic feasibility of this project is the marketing of caustic soda to cut down the cost of chlorine used as raw material. The material balance of process to produce 15,000 t of PVC is shown in Figure III-2-2.

Fig. III-2-2 Poly Vinyl Chloride Complex Material Balance



2-3 Salt Electrolysis Industry

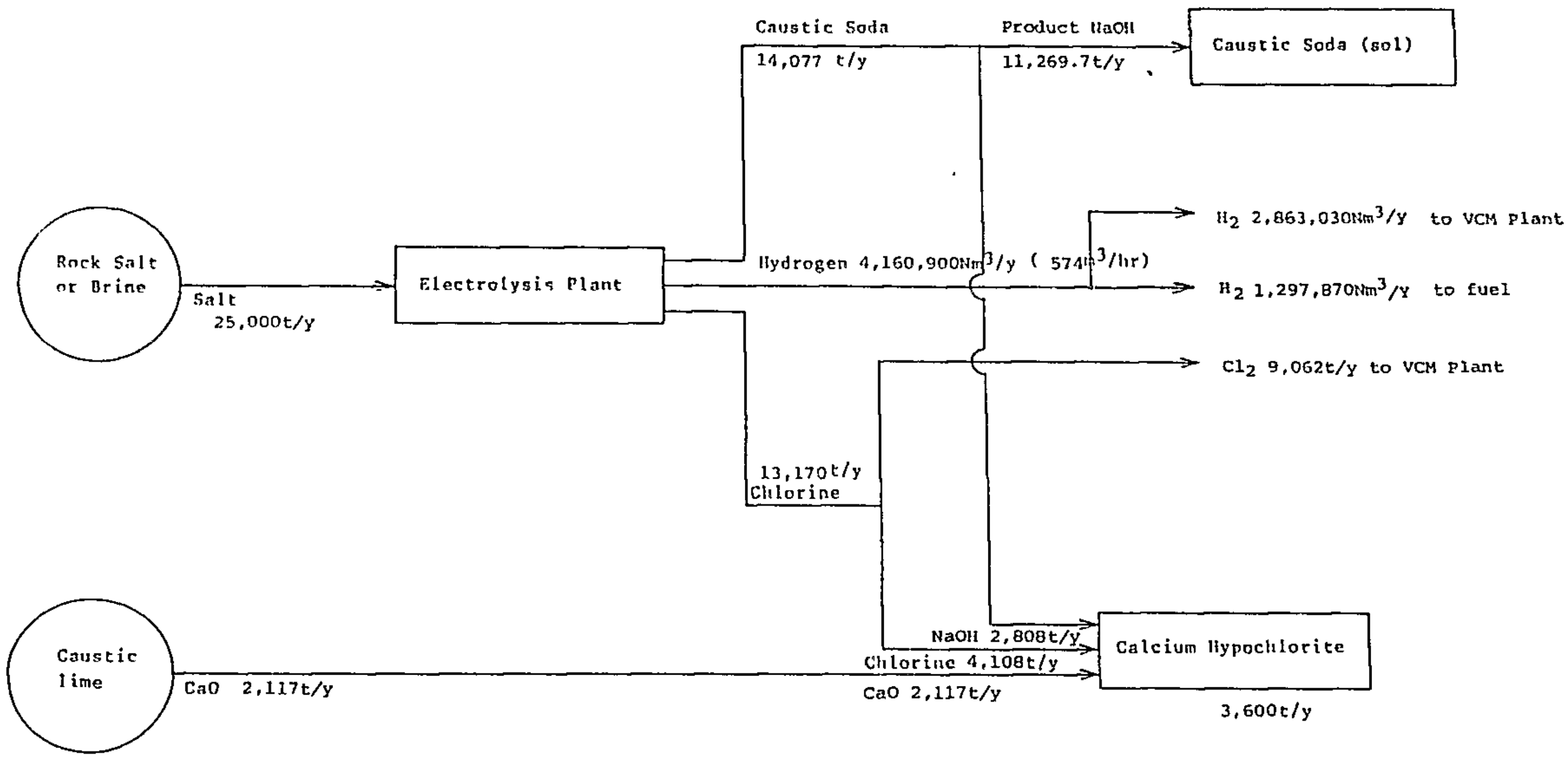
The production of chlorine by electrolysis of salt is indispensable for producing vinyl chloride. Caustic soda is obtained as a byproduct of the electrolysis. The production of high grade bleaching powder using part of the aforesaid chlorine and caustic soda is taken into consideration in this study. The intermediate products and final products of this process are as follows.

(1) Chlorine
(2) Caustic soda
(3) Bleaching powder

The material balance of this process is shown in Figure III-2-3.

The production scale is determined in terms of availability of raw materials for production of vinyl chloride. The production of bleaching powder is limited to the minimum scale. It is, however, possible to attain further cost reduction by increasing the scale of production, depending on the conditions prevailing in the markets of Paraguay and neighbouring countries. The marketing of caustic soda obtained as a byproduct should be studied thoroughly by taking into consideration the aluminum refining, the demand for alkaline materials in neighbouring countries and, if necessary, the production of soda ash used as raw material for production of glass, and other relevant factors.

Fig. III-2-3 Electrolysis Complex Material Balance



3. Analysis of Marketing Prices

The prices of chemical industry products are subject to considerable fluctuation over the short term, depending on the demand-supply balance. On a long-term basis, however, the production cost of the country which plays the leading role in terms of supply to the international market is the predominant factor in determination of the international price. The prices of the following products are determined by the aforementioned mechanism.

In the case of fertilizers:	DAP (Diammonium Phosphate) *1)
In the case of electrolysis projects:	NaOH (Caustic soda)
In the case of vinyl chloride:	PVC (Poly-Vinyl Chloride)
In the case of phosphate complex:	Phosphorus

On the other hand, in the case of commodities like ammonium sulphate, which is produced primarily as a byproduct of the processes for production of other goods, the production cost is not the principal factor in determination of the price. Rather, the prices of products of this kind are determined by the prices of other alternative products in terms of application (e.g., in the case of ammonium sulphate, the alternative products are urea and ammonium nitrate).

NOTE: *1) The price of NaOH is not determined exclusively by the production cost. It is a byproduct of chlorine production, and furthermore faces price competition from natural soda ash.

3-1 Trends in Fertilizer Prices

Projections of various kinds have been carried out with regard to trends in fertilizer prices. In this study the prices of urea, as a representative of nitrogenous fertilizers, and DAP are plotted in a graph based on records of prices in the past and data announced by the World Bank and other organizations. (Refer to Figure II-3-1-1 and Table III-3-1-1). Normally the prices of ammonium sulphate and urea are related by 1:2.2 - approximately 1/1:2 - in view of the proportion of the effective component.

The aforementioned data covers prices prevailing in massive transactions on the international market. The price actually paid by farmers for acquisition of chemical fertilizers is much higher because other costs such as freight, interest accompanying the import transactions, etc. are added to the aforesaid figures. According to recent studies, the price of DAP reaches US$400 to US$460/ton (Latin America) and Urea US$280 to US$350/ton. Ammonium sulphate is presumed to be of the level US$120 to US$220/ton (refer to Table III-3-1-2). In this study it is assumed that DAP can be marketed at US$330/ton and ammonium sulphate at US$120/ton in Paraguay.

The marketing price of US$300/ton - the same level as for urea - is assumed for ahydrous ammonia.

These price levels is assumed by taking into consideration the following factors:

- Price level adequate to develop the fertilizer market on a long-term basis
- Compatibility between the fertilizer prices, increases in yield and consequent increase in income of farmers resulting from its use.

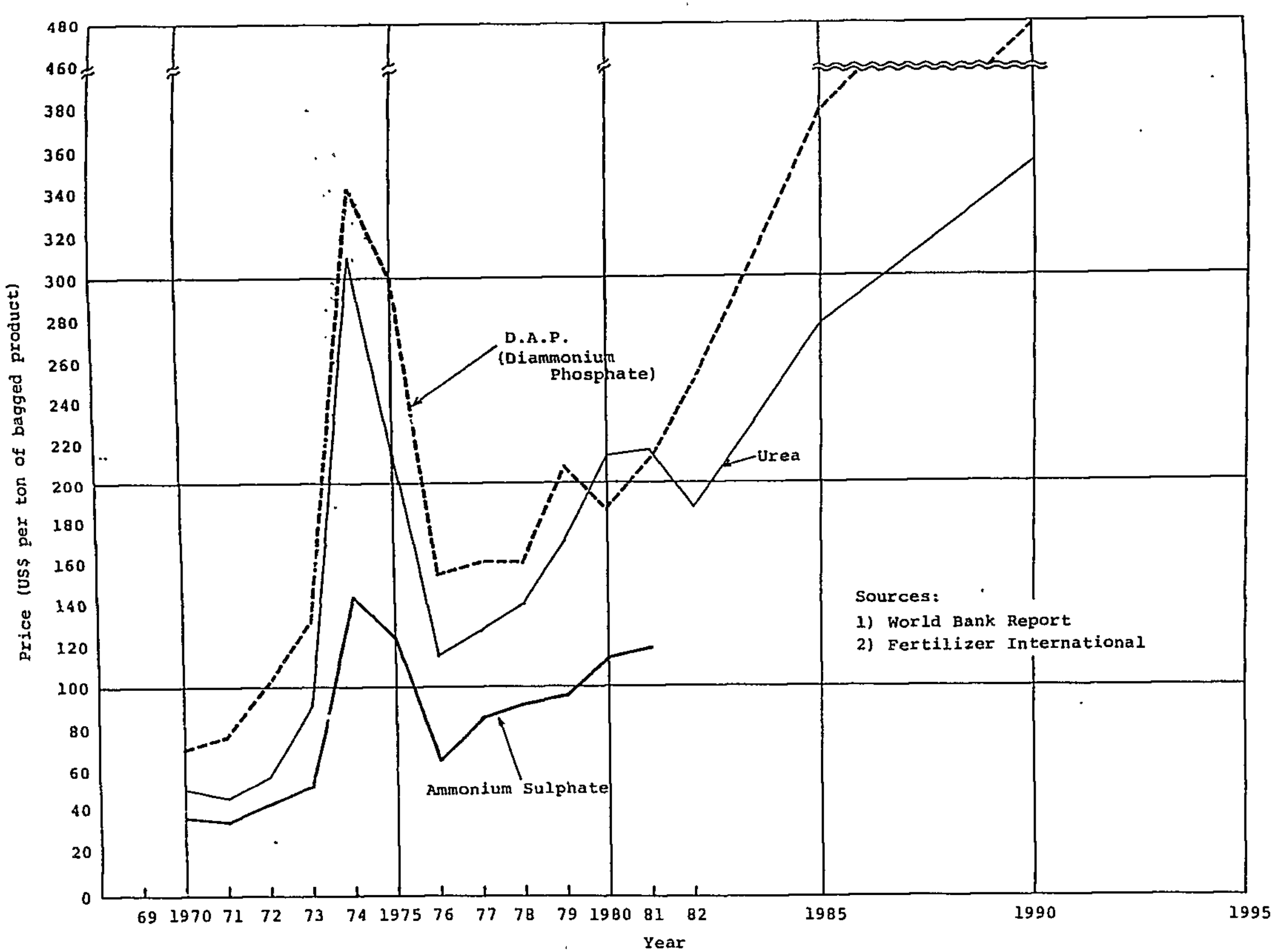


Fig. III-3-1-1 Price Trend/Forecast of Fertilizer

Tab. III-3-1-1 Annual Statistics of World Fertilizer Production and Consumption

Unit: 10^3tons nutrient

SUMMARY OF WORLD NITROGEN FERTILIZER PRODUCTION AND CONSUMPTION

	1977/78		1978/79		1979/80	
	Production	Consumption	Production	Consumption	Production	Consumption
West Europe	10,183	8,977	10,923	9,844	11,382	10,337
East Europe	15,196	12,058	15,686	12,947	15,509	12,444
North America	11,089	9,688	11,772	10,555	12,846	11,136
Central America	791	1,325	737	1,282	914	1,312
South America	606	1,260	613	1,215	657	1,298
Africa	768	1,297	839	1,387	849	1,548
Asia	13,202	14,921	15,241	16,333	17,236	18,632
Oceania	215	237	199	238	217	273
WORLD TOTAL	**51,960**	**49,763**	**56,010**	**53,801**	**59,610**	**56,980**
Less losses of 3%*	50,401		54,330		57,822	
Net difference		+ 638		+ 529		+ 842

SUMMARY OF WORLD PHOSPHATE FERTILIZER PRODUCTION AND CONSUMPTION

	1977/78		1978/79		1979/80	
	Production	Consumption	Production	Consumption	Production	Consumption
West Europe	5,846	5,988	5,919	6,600	5,966	6,675
East Europe	8,639	8,381	9,079	8,714	9,127	8,831
North America	8,034	5,198	8,546	5717	9,339	5,505
Central America	303	403	256	433	237	426
South America	1,227	1,826	1,285	1,837	1,387	2,068
Africa	1,033	901	1,103	921	1,202	1,008
Asia	3,236	3,985	3,593	4,396	4,453	5,354
Oceania	1,152	1,194	1,173	1,250	1,367	1,287
WORLD TOTAL	**29,470**	**27,876**	**30,954**	**29,868**	**33,078**	**31,154**
Less losses of 3%*	28,586		30,025		32,086	
Net difference		+ 710		+ 157		+ 932

SUMMARY OF WORLD POTASH FERTILIZER PRODUCTION AND CONSUMPTION

	1977/78		1978/79		1979/80	
	Production	Consumption	Production	Consumption	Production	Consumption
West Europe	4,765	4,977	5,314	5,284	5,678	5,482
East Europe	11,576	8,818	11,516	8,786	10,031	7,423
North America	8,463	5,276	8,626	6,010	9,397	5,971
Central America	—	287	—	335	—	288
South America	12	1,076	15	1,157	22	1,275
Africa	81	378	—	336	—	348
Asia	727	1,900	700	2,286	776	2,430
Oceania	—	252	—	274	—	263
WORLD TOTAL	**25,624**	**22,964**	**26,171**	**24,468**	**25,904**	**23,480**
Less loss of 5%*	24,343		24,862		24,508	
Less industrial sales	23,684		24,143		23,844	
Net difference		+ 720		-325		+ 364

* This represents an estimate of losses incurred by transport, bagging and handling operations, i.e between the production and consumption stages

Source: British Sulphur

Tab. III-3-1-2

Information on Fertilizer Price at Farmer's Gate, (W.B.)
COUNTRY SOUTH · CENTRAL AMERICA

					Exchange rate
UREA	Brazil	1980	291-353	US$/ton	39-61
		1981	347-452	"	65-125
	EL Salvador	1981	291-352	"	2.5
	Argentine	1980	334-343	"	1,730
	Venezuera	1980	102	"	4.3
	Chile	1980	280-306	"	39
	Colombia	1980-82	324-344	"	45-50
DAP	Brazil	1981	479-581	"	
	Argentine	1980	456-460	"	
	Venezuera	1980	140-140	"	
TSP	Colombia	1982	319-401	"	
	Argentine	1980	306-328	"	
	Chile	1980	268-296	"	
Ammonia Sulphate	Dominica	1980	130-174	"	
	Brazil	1981	198-260	"	
	EL Salvador	1981	178-232	"	
	Argentine	1980	226-227	"	
	Venezuela	1980	63	"	
Product Price, Farmer's Gate					
Wheat	Argentine	1980	133-134	"	
	Chile	1980	200-237	"	
Maize	Brazil	1981-82	112-189	"	
	Argentine	1980	133-135	"	
Soya	Brazil	1981	160-209	"	

3-2 Trends in (Elementary) Phosphor Prices

It can be said that the international price of elementary phosphor is determined by the price of the product supplied by the U.S. The costs of rock phosphate, electricity and coke are the major factors in determination of the price of the product supplied from by the U.S. The price trend/forecast of elementary phosphor is as follows:

Table III-3-2

(Unit: US$/ton)

	Phosphate Rock	Coke	Electricity	Fuel	Miscellaneous (incl. Capital Cost)	Phosphorus (Estimated)
1975	223.08	119.0	138.97	19.05	321.40	821.44
1979	318.01	169.0	351.7	20.91	410.01	1,269.63
1980	318.01	189.8	(3¢) 426.6	20.9	478.2	1,433.5
1985	496.4	251.1	(5¢) 711.0	29.38	683.6	2,171.8
1990	633.5	368.9	(6¢) 852.2	43.16	1,004.8	2,902.6
1995	812.6	542.0	(7.2¢) 1,023.8	63.40	1,447.0	3,888.8

The foregoing is an estimation of the production costs. Data collected so far shows that the prices of the past are practically equivalent or exceed by 10 to 15% the costs calculated by the method presented above. Accordingly, it is estimated that the future price levels will be equivalent to the estimated costs. The marketing price is assumed to be US$1,500/ton, considering that the freight from Paraguay to the various export markets is the same.

3-3 Trends in High Purity Bleaching Powder (Calcium Hypochloride) Prices

Currently, high purity bleaching powder (calcium hypochloride) is exported in large quantities from Japan to the U.S. and Latin American countries for sterilization of potable water, swimming pools, etc. Accordingly, it is presumed that the export price of Japan is the standard international market price.

It is quite difficult to make a forecast of future price trends because most of the production cost is composed of the depreciation of facilities and of labour costs. However, the price forecasted assuming an annual escalation of the order of 4% in view of the trends occurring in the past is as shown in table III-3-3-1.

Table III-3-3-1 Calcium Hypochlorite Price Trend

Unit: US$/ton

Year	Price	Note
1972	463 (Exfactory)	Chemical Industry Statistics (Exfactory)
73	472 "	"
74	595 "	"
75	732 "	"
76	709 "	"
77	959 "	"
78	945 "	"
79	904 " (1,040 (FOB))	(Export Statistics)
80	1,127 (Exfactory) (1,200 (FOB))	"
81	1,159 (Exfactory) (1,236 (FOB))	"
85	1,359 (Exfactory)	(Estimate)
90	1,650 (Exfactory)	(Estimate)

The FOB price for Japan is US$1,200/ton in 1981 prices. It is presumed possible to market high purity calcium hypochlorite in Paraguay and the vicinity at US$1,300/ton taking the differences in freight and other relevant costs into consideration.

3-4 Trends in Caustic Soda Prices

Generally speaking, caustic soda has the characteristic of being a byproduct of the chlorine industry. It is also an alternative product of natural soda ash, a natural alkaline product (caustic soda can also be produced from soda ash). Its price suffers from considerable fluctuation as a result. Such being the case, the estimation of price based on the cost of the raw materials does not have much significance. Extrapolation from trends in the past indicates that in the U.S. there is no increase in price (US$276/ton), while for Europe we have the data shown in the table below.

Table III-3-4-1 Trends in Caustic Soda Prices in Europe.

(Unit: US$/ton)

Europe Price (Trend Extraporation)		Cost Base Estimate			
		Salt	Elect.	Others	Total
1975	224				
76	309				
77	266				
78	306				
79	309				
80	310				
81	320	40.9	86.4 (3¢)	122.7	250
82	330				
83	339				
84	349				
85	358	46.0	144.1 (5¢)	166.9	357
~	~				
90	407	53.4	158.4 (6¢)	245.5	457
~					
95		61.9	201.6 (7¢)	360.7	624

On the other hand, the margin of profit plays a predominant role in analysis of rock salt, electricity and other relevant factors from the cost side (USA). Prices reach the order of US$300/ton, assuming a profit margin of 20% of the ex-factory cost. A price of US$300/ton is assumed in this study. It is presumed that this price level can be maintained in future in view of the availability and price competitiveness of natural soda ash. (Refer to Table III-3-4-2 for details of current supply).

3-5 Trends in Fused Phosphate Prices

Currently fused phosphate is produced and consumed in only a few countries such as Japan, Brazil, Korea, Taiwan, etc. International price have not hardened yet. Generally speaking, this fertilizer is used in soils with MgO and Sio deficiencies. Accordingly, MgO and SiO_2 are evaluated as effective components, in addition to P205 itself. Such being the case, this product is marketed in Japan at prices 20 to 30% higher than for single super phosphate.

Table III-3-5-1 Wholesale Price Trend in Fused Phosphate.

	US$/20kg bag	US$/ton
1975	2.84	142.2
76	3.73	186.4
77	3.82	190.9
78	3.66	183.0
79	3.68	184.1

Tab. III-3-4-2 Production of Caustic Soda

Unit: 10^3 tons

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Africa	29	26	21	17	33	39	29	28	31	37
North America	10,228	9,811	10,366	10,913	11,595	9,466	10,432	11,197	11,034	12,573
South America	318	359	453	464	463	479	544	550	532	573
Asia	4,758	4,999	5,102	5,357	5,360	5,176	5,222	4,971	5,170	5,636
Europe (excl. USSR)	6,759	7,071	7,569	8,660	9,099	8,313	9,515	9,593	9,844	10,378
USSR	1,783	1,866	1,899	2,020	2,174	2,395	2,604	2,658	2,763	2,680
Oceania	112	120	128	123	141	139	137	135	131	132
Total	23,987	24,252	25,538	27,554	28,865	26,007	28,483	29,132	29,505	32,009

Generally speaking, acidic soil is frequently found in areas of Northern Argentine and Southern Brazil having relatively abundant rainfall. In these cases, MgO contained in the fused phosphate brings about effective results. Accordingly, it is thought possible that this product can be marketed at price levels of the order of US$180 to US$200/ton.

3-6 Trends in PVC Prices

The price of raw materials and the investment costs play predominant roles in determination of the price of PVC. Currently, there is a wide variety of processes for production of PVC throughout the world. It can be produced from naphtha decomposition, ethylene, natural gas, fractionation of ethane, production from ethylene-acetylene resulting from decomposition of fuel oil, etc., and therefore it is difficult to estimate the price from the cost calculations for a single process. Such being the case, a method generally used is to estimate the price by calculating the correlation between the factor with most pronounced influence on production cost (e.g., naphtha price, etc.) and the product price and assuming that this relation prevails also in the future. The results of price estimation by the aforesaid method are shown in Table III-4-6-1. It is estimated that this product can easily be marketed in Paraguay at US$1,200/ton, taking into consideration export costs, freight, etc., if the average ex-factory price in the industrialized countries is US$1,040/ton in 1981.

Table III-3-6-1 PVC (General Purpose) (UNICO Estimate)

Unit: $/ton

Year	Price
1976	590
77	543
78	530
79	650
80	962
81	1,040
82	1,127
83	1,221
84	1,325
85	1,438
~	~
90	2,202

(Refer to Figure III-3-6-2 and Table III-3-6-2 for details of cost prices and world supply).

3-7 Trends in Calcium Cyanamide Prices

Data related to prices for calcium cyanamide are scarce because currently it is used as a special fertilizer possessing simultaneously the functions of a germicide and an insecticide rather than simply a nitrogenous fertilizer in view of its expensive production cost. In Japan, calcium cyanamide is marketed at approximately US$300/ton.

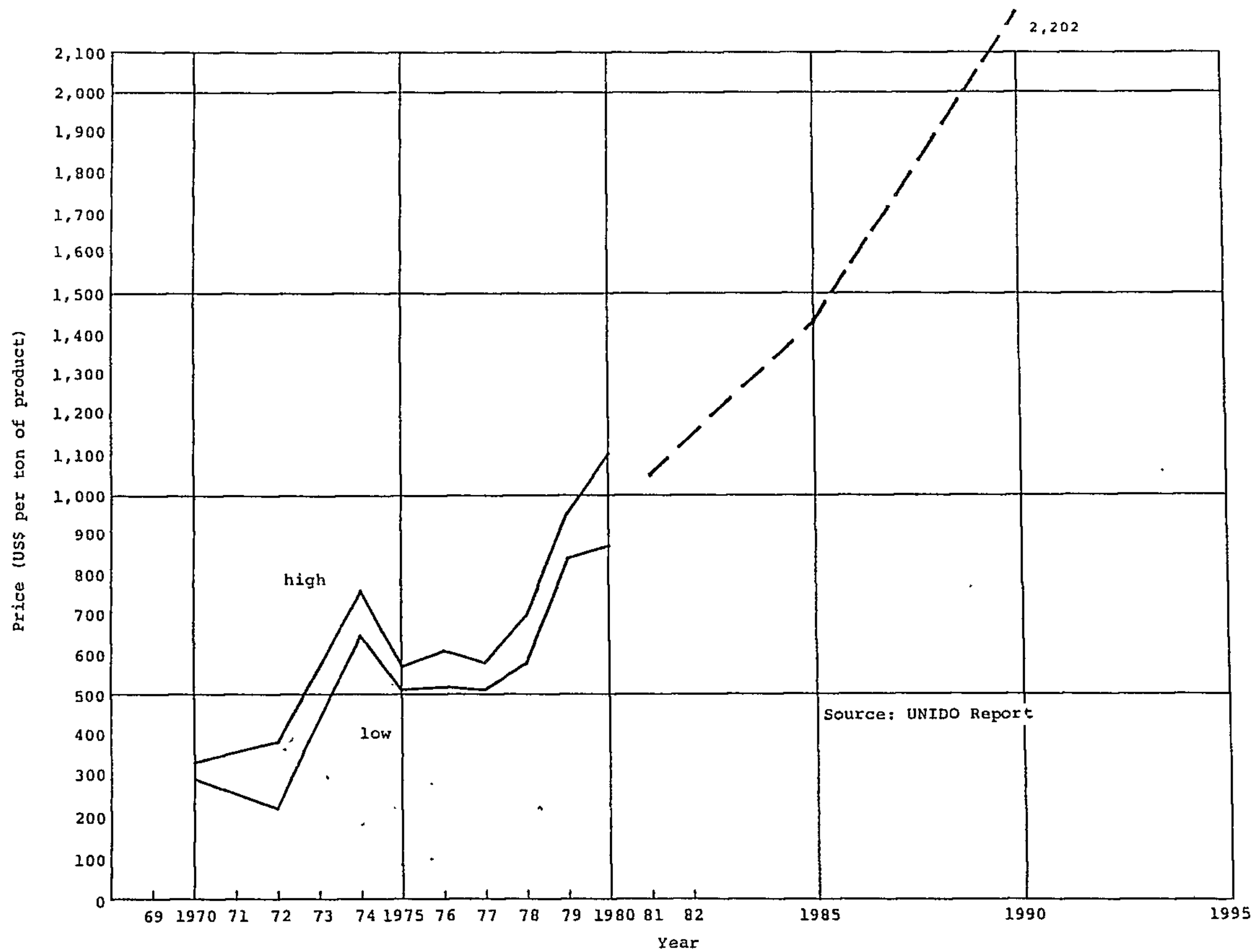


Fig. III-3-6-1 Price Trend/Forecast of Polyvinyl Chloride

Tab. III-3-6-2 Production Trend/Forecast of PVC

(Unit: 1,000 ton)

AREA	Actual										Forecast		
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1985	1990
North America	1485.5	1636.9	2058.7	2196.1	2265.7	1704.4	2158.1	2488.9	2688.9	2973	4124	4124	4124
Central South America	*222.5	*230.5	*232.2	*232.9	*273.2	*242.3	290.7	295.9	276.5	292	344	683	683
Asia (Excl.USSR)	*1542.7	*1434.3	*1512.8	*1777.1	*1932.6	*1578.3	*1536.7	*1504.8	*1777.8	*2310.4	2868	3629	3629
West Europe	2486.1	2598.7	2903	3426.8	3375	2801.7	3376.1	3288.3	3500.7	3763.9	4390	5293	5293
East Europe	233.8	263.1	299.8	326.6	359.9	402.3	534.8	640.1	751.1	792.7	1366	1799	1799
Others											272	272	272
World Total	5970.6	6163.5	7006.5	7959.5	8206.4	6729.0	7896.4	8218.0	8995.0	10132.0	13364	15800	15800

Table III-3-7-1 Wholesale Prices Trends in Calcium Cyanamide Prices

	$/20Kg Bag	$/ton
1975	5.65	282
76	6.17	309
77	6.49	324
78	6.52	326
79	6.47	324 (320 285 $/ton)

In terms of the effective fertilizer component it has only 1/2 that of urea, equivalent to approximately US$150/ton. It is actually negociated at prices of the order of US$300/ton, however, in view of its germicidal and insecticidal character. It is presumed that in Paraguay calcium cyanamide prices can be negociated at the same level.

3-8 Trends in Industrial Phosphoric Acid Prices

Industrial phosphoric acid obtained from elementary phosphorus is used in such applications as raw material for chemicals of various kinds, food grade phosphoric acid, raw material for calcium phosphate of food grade, etc. Considerable demand can be expected in Brazil and in Argentina. It is necessary to wait for the results of the relevant market survey, however. This study is set forth assuming the marketing of 1,500 t/Y. The market prices of industrial phosphoric acid in Japan in recent years are given in the table below.

Table III-3-8-1

Unit: $/ton

Year	Price
1976	650
1977	586
1978	554
1979	531

It is not known if the price decline tendency will continue in future but it is presumed quite possible that the price of US$500/ton will continue for P205.

4. Analysis of Profitability

It is presumed that most of the materials and equipment required to construct the planned plants are available in Brazil and Argentine. However, no reliable data on the cost of equipment and materials from those countries is available at this time. Data available in Japan is so used as the basis for plant cost, and accordingly, there is possibility of some differences between the actual construction costs at the project site and those estimated in this study. Data available in Japan is used as a reference and figures increased by 25% are adopted for this study. Furthermore, the calculations are set forth assuming the raw material prices prevailing in Japan because the status quo at the project site is not clearly known.

Particularly in the case of fertilizer complex, product prices are determined by prices prevailing in the international market place rather than production costs. Accordingly, the estimation of product prices is carried out based on data obtained by adding to the international market price, importation expenses and freight required to bring the product in question to Paraguay and taking into consideration the status quo of the farmer's gate price in Latin America.

The market price of the product, the construction costs (interest) and the price of raw materials have considerable influence on the profitability of the project. Accordingly, the influence of these factors is analyzed in this study.

Calculations related to the influence of electricity cost on profitability of the project are also carried out in this project.

4-1 Basis for Profitability Analysis

4-1-1 Product Prices used in Profitability Analysis

The prices of products used for profitability analysis presented in the attached sheets are as follows.

	Unit: US$/ton	
Ammonia	300	
Phosphorus	1,500	
D.A.P.	330	
Ammonium Sulphate	120	
Phosphoric Acid (Chemical Grade)	500	(for Export)
P.V.C.	1,300	
Bleaching Powder	1,300	
Calcium Silicate	50	
Fused Phosphate	180	

The pertinency of these prices should be confirmed from two points of view in detailed studies to be carried out in future.

- The competition with products imported from foreign countries and the influence of price on the future evolution of the market.

- With regard to elemental phosphorus which must be exported to foreign countries, the ex-factory price should be determined taking into consideration the transportation cost up to the export destination.

In principle, the international price mentioned in Section III-3 and the status quo prevailing in Japan are adopted as bases for determination of the price (Refer to Tables III-4-1-1 to III-4-1-5).

4-1-2 Investment and Cost Data used in Profitability Analysis

Tab. III-4-1-1(a) Cost Data of Phosphoric Acid Plant

	Phosphoric Acid Plant (111 ton 54% Acid) P_2O_5 (18,000 t/y)	Phosphorus (15,000 t/y)
	10^6\$	10^6\$
Investment		
Whole Plant	4.628	32.906
Process plant	2.248	20.117
Building and foundation	0.480	3.938
Engineering and license	0.620	2.200
Spare parts	0.124	1.400
Auxiliary off site	1.156	5.251

Variable Cost

Phosphoric Acid Plant		Phosphorus		
Phosphorus	0.447 t/t (P_2O_5)	Phosphate rock	8.26 t/t (P_2O_5 3 %)	
Chemicals	2.0\$/t (P_2O_5)	Silica stone	2.50t/t	
Electricity	200 KWH/t (P_2O_5)	Cokes	1.46 t/t	
Water (filtered)	12.2/P_2C_5	Fuel oil	75 l/ton	
		Electricity	14,220 KWH/t	
		Kerosene	22 l/t	
		Electrode	18 x 10^{-3} t/t	
		Chemical and lubricant	94.8\$/t	
		By-product	Slug	7.2
			Ironphosphide	0.07

Tab. III-4-1-1(b) Cost Data of DAP Granulation Plant, Ammonia Plant, Ammonium Sulphate Plant

	DAP (18-46) Granulation (35,870t/y) (P_2O_5 16,500t/y)		Ammonia Plant (18,000 t/y)		Ammonium Sulphate (12,000 t/y) (Sulphuric acid 9,380t/y)	
Investment	10^6\$		10^6\$		10^6\$	
Whole plant	6.583		13.575		1.129	
Process plant	3.107		6.928		0.806	
Building and Foundation	0.823		1.222		0.079	
Engineering and license	0.880		1.760		0.172	
Spare parts	0.220		0.395		0.032	
Auxiliary	1.553		3.270		0.040	
Variable Cost						
Ammonia	0.232 t/t				Ammonia	0.28 t/t
Phosphoric acid	0.484 t/t				Sulphuric acid	0.78 t/t
Sulphuric acid	0.045 t/t					
Steam	0.05 t/t	Process water	2.0 t/t		Electricity	90 KWH/t
Electricity	54 KWH/t	C.W. make up	6.0 t/t		Steam	1.0 t/t
Fuel oil	17 liter/t	Electricity	11,940 KWH/t		Chemical and lubricant	2.0\$/t
Process water	0.4 t/t	Catalyst and lubricant	2.4\$/ton		Bags	24.0\$ /t
Chemicals	2.0\$/t					
Bags	24.0\$ /t					

Tab. III-4-1-2 Cost Data of Fused Phosphate Plant

Fused Phosphate 83,300 ton/year

P_2O_5 20% MgO 18%

Investment	10^6\$
Whole Plant	14.921
Process plant	9.552
Building and foundation	2.674
Engineering and license	1.009
Spare parts	0.390
Auxiliary off site	1.296

Variable Cost

Phosphate Rock	0.637 t/t
Serpentine	0.476 t/t
Electrode	5.0×10^{-3} t/t
Fuel oil	8 l/ton
Bags	24.0$ /ton
Electricity	1,400 KWH/ton
Water (filtered)	8 M^3/ton

Tab. III-4-1-3 Cost Data of PVO Complex

PVC (from $Cl_2 \cdot CaCO_2 \cdot C$) 15,000 t/y

	Total Complex	CaC_2 (22,563t/y)	VCM (15,225t/y)	PVC (15,000t/y)
Investment	10^6\$	10^6\$	10^6\$	10^6\$
Whole Plant	43.009	14.567	16.887	11.555
Process Plant	23.290	8.106	9.036	6.148
Building Foundation	4.260	1.482	1.653	1.125
License, Eng., Sup,	5.248	1.426	2.236	1.586
Spare Parts, Mat.	0.851	0.296	0.330	0.225
Auxiliary facility	0.360	3.257	3.632	2.471

Variable Cost

	Total Complex	CaC_2		VCM		PVC	
Lime Stone	2.8t/tPVC	Lime Stone	1.9t/t	Carbide	1.482t/t	VCM	1.015t/t
Coke	1.0t/t	Coke	0.67t/t	Chlorine	0.60t/t		
Chlorine	0.604t/t			Hydrogen	190m^3/t		
Electricity	5,560KwH/t	Electricity	3,200KwH/t				
Steam, Water	36.0\$/t						
Chemicals, Lubricant	71.6\$/t						

Tab. III-4-1-4 Cost Data of Calcium Cyanamide Plant

Calcium Cynamid (preliminary)

Say 10,000 t/y $CaCN_2$ (As N21%)

Investment	Calcium Carbide (6,500t/y) 10^6\$	Cyanamide (10,000t/y) 10^6\$
Whole Plant	8.770	2.256
Process Plant	3.953	1.240
Building Foundation	0.942	0.240
License, Eng., Sup	1.200	0.480
Spare Part	1.884	0.048
Auxiliary Facility	0.791	0.248

Variable Cost	
Lime Stone	1.21 t/t
Coke	0.436 t/t
Electricity	2,280 Kwh/t
Utility	7.6$/t
Auxiliary	50.9$/t

Tab. III-4-1-5 Cost Data of Electrolysis Plant

Electrolysis Plant

	Chlorine (13,176t/y)		Calcium Hypochlorite (2,600t/y)
Investment	$10^6$$		$10^6$$
Whole plant	24.376	Whole plant	6.089
Process plant	15.511	Process plant	3.864
Building and foundation	2.737	Engineering	0.579
Engineering and license	1.600	Building and fundation	0.500
Spare parts	0.558	Spare part	0.116
Auxiliary facility	3.970	Auxiliary facility	1.030
Variable Cost		Variable cost	
Rock salt	1.90 t/t	Chlorine	1.14 t/t
Caustic soda	(1.08 by product)	NaOH	0.78 t/t
Hcl by-pro.		CaO	0.588 t/t
Electricity	2,880KwH/t	Electricity	900 kWh/t
Steam	0.4 t/t	Steam	2.75 t/t
Process water	2.3 t/t	C.W. make up	12.0 t/t
Chemicals	28.0$/t	Packing	60.0$/t

4-2 Expected Man Power Cost

Function	$/Y/person	Fertilizer (I)		Fertilizer (II)		Fertilizer (III)		PVC		Electrolysis	
Engineer	25,560	5	127,800	2	51,120	2	51,120	5	127,800	2	51,120
Supervisor	17,040	7	119,280	2	34,080	2	34,080	6	102,240	3	51,120
Foreman	14,484	20	289,680	5	72,420	10	144,840	15	217,260	10	144,840
Silled Labour	6,816	61	415,776	40	272,640	30	204,480	80	545,280	32	218,112
Semi-skilled Labour	5,964	20	119,280	20	119,280	12	71,568	24	143,136	8	47,712
Total			$1,071 \times 10^3$		548×10^3		506×10^3		$1,136 \times 10^3$		513×10^3

4-3 Manning Plan

Function	$/Y/person	Fertilizer (I)	Fertilizer (II)	Fertilizer (III)	PVC	Electrolysis
Engineer	25,560	5	2	2	5	2
Supervisor	17,040	7	2	2	6	3
Foreman	14,484	20	5	10	15	10
Skilled Labour	6,816	61	40	30	80	32
Sime-skilled Labour	5,964	20	20	12	24	8

4-4 Raw Material Costs

The chemical industries taken into consideration in this report are characterized by relatively easy availability of raw materials. In the case of phosphatic fertilizer complex, the acquisition price of rock phosphate is an important factor in project feasibility. Furthermore, coke, which is used as a secondary raw material for production of phosphorus and as carbonic material for production of carbide, which generates acetylene for the raw material for production of PVC, is another important raw material. As for NaCl, the raw material for production of caustic soda and chlorine, there is a possibility of obtaining it domestically. In case importation is necessary, sources are Brazil and Argentina. Limestone, silica and serpentine are also used as raw materials in addition to those mentioned above. Fortunately, they are available with relative ease and at economic prices in Paraguay or from neighbouring areas.

(1) Rock Phosphate

Currently the rock phosphate international market price is determined by U.S. and Moroccan quotations. These countries are the major exporters of this commodity. The price quoted by Morocco in 1981-1982 for BPL 68% product is US$ 50 - 52/ton and the price quoted by the U.S. is 39 - 40/ton.

According to a long-term forecast made by the World Bank, the rock phosphate price for the 1985-1990 period will be US$39/ton (1980 U.S. Dollars).

Accordingly, the price of international market phosphatic fertilizer is proportional to the rock phosphate price of either Morocco or the U.S. used as raw material. The feasibility of the phosphor and phosphatic fertilizer project in Paraguay is conditional on acquisition of rock phosphate at price levels close to the international market price of this product.

The most desirable alternative is to discover rock phosphate deposits in Paraguay and to use these in the project. Unfortunately no such deposits have been confirmed so far. In the State of Sao Paulo, Brazil, some deposits of rock phosphate have been confirmed and are being commercially exploited in Jacupiranga. There is a possibility of finding rock phosphate deposits at places located at distances of the order of several hundred kilometers from Paraguay. In such a case it is quite possible to acquire the product at price levels of the order of US$50 to US$60 at the plant gate, using railway or the Parana River waterway for transportation.

(2) Coke

Next to rock phosphate, coke has the most important influence on the production cost of carbide (PVC) and phosphor. Currently, Japan imports coke from Australia, Canada and other countries. The price is US$130/ton. The State of Santa Catarina in neighbouring Brazil produces coal of coking quality, although not the best in terms of quality. There is a possibility of price reduction if transportation of this coke is economically feasible, but this is an aspect requiring confirmation through field investigation. Accordingly, in the cost calculations carried out here we adopt a price of US$170/ton which is obtained by adding the freight to Paraguay to the U.S. Breeze price (freight US$70/ton + US$20/ton miscellaneous).

Table III-4-4-1 World Phosphate Rock Production and Consumption

Unit: 10^3 ton

	1977		1978		1979	
	Production	Consumption (apparent)	Production	Consumption (apparent)	Production	Consumption (apparent)
West Europe	215	21,786	137	22,019	126	23,270
East Europe	23,612	30,282	23,595	30,573	24,473	31,639
Africa	29,626	6,777	32,141	7,456	33,978	8,354
North America	47,256	37,233	50,037	40,144	51,611	43,000
Central America	366	1,719	402	1,867	324	1,451
South America	651	2,405	1,126	2,414	1,700	2,746
Asia	9,392	11,750	11,243	12,813	14,918	16,438
Oceania	2,060	2,652	2,702	3,666	2,291	3,857
WORLD TOTAL	**113,178**	**114,606**	**121,382**	**120,951**	**129,421**	**130,754**

Table III-4-4-2 World Salt Production and Consumption (1975)

	Production A (1000 ton)		Consumption B (1000 ton)	Self Subte-nance Rate A/B (%)
France	(3.4)	5,347	5,371	99.6
West Germany	(5.4)	8,440	8,693	97.1
Italy		4,411	4,396	100.3
Netherlands		2,690	814	330.5
Spain		2,646	2,615	101.2
Great Britain	(4.9)	7,630	7,130	107.0
East Germany		2,430	2,242	108.4
Poland		3,513	3,280	107.1
Rumania		3,831	3,152	121.5
U.S.S.R.	(8.3)	13,000	12,918	100.6
Canada	(3.1)	4,836	5,146	94.0
United States	(23.7)	37,222	38,933	95.6
Mexico	(4.0)	6,350	2,440	260.2
Brazil		2,145	2,145	100.0
China	(19.1)	30,000	29,605	101.3
India	(4.5)	7,000	6,738	103.9
Japan		1,068	7,367	14.5
Australia	(2.9)	4,568	712	641.6
World Total	(100)	156,892		

NOTE: Figures in parenthesis in production column indicate share (%) of world total.

Production (1979)

Argentine	997,000 ton
Brazil	2,812,000 ton
Chile	590,000 ton

Tab. III-4-4-3 Production of Coke-Oven Coke

Unit: 10^3 tons

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Africa	4,310	4,493	4,477	4,483	4,964	5,248	5,781	6,350	6,032	6,500
North America	71,099	61,998	65,189	70,106	68,001	63,160	64,335	59,958	55,539	59,750
South America	3,060	3,108	2,880	3,030	3,182	3,660	4,271	4,755	5,144	5,290
Asia	66,647	71,069	72,566	82,360	82,271	84,421	86,126	89,110	89,984	99,945
Europe (Excl. USSR)	125,959	121,034	118,223	122,563	123,245	121,221	119,746	113,360	109,671	112,341
USSR	75,404	78,329	79,773	81,401	82,641	83,543	84,400	86,000	86,400	86,500
Oceania	4,983	4,410	4,594	4,945	5,114	5,239	5,310	4,701	5,228	5,330
Total	351,462	344,441	347,702	368,888	369,418	366,492	369,969	364,234	357,998	375,656

(3) Rock Salt

Approximately 26,000 t/Y of salt is required as raw material for electrolysis (caustic soda and chlorine plant). The transportation cost is a serious problem if all of the aforesaid quantity is imported from abroad. Originally, the price of salt at the production center is of the order of US$10/ton but at the consumption point it often exceeds US$20/ton due to the addition of transportation costs.

In this study the price of salt is assumed to be US$30/ton at the factory gate. In this case it is thought possible a cost of approximately US$30/ton can be maintained using brine domestically available in Paraguay in addition to imported salt.

4-5 Financial Assessment of Each Project Scheme

4-5-1 General Considerations and Premises

(1) General

The financial feasibility of each one of the selected schemes is analyzed using the Internal Rate of Return as an index. The basis for this analysis is the idea of calculating the discount rate required to attain equivalence between the invested capital (investment for plant construction) and the cash generated by the project (in the Income Statement Table this is the amount obtained by adding the depreciation and the interest of the long-term capital to the net profit) within the project life. This method makes possible determination of the cash generating power of the project, irrespective of its capital cost and other relevant factors.

Let us explain the aforesaid analysis by referring to Table III-4-5-1 (IRR calculation on total investment). The amounts of the capital invested annually in the project are indicated in the second column from the left. The figure "-1,677" for 1995 corresponds to the part of the plant cost not yet depreciated and the remainder of the initial working capital, which are handled with a minus sign in the investment column. On the other hand, the 6th column from the left indicates the annual evolution of generated cash (Profit before tax + Depreciation + Interest on long-term debt) during the 10 year period following start-up of the project. The discount rate for conversion cash corresponding to the period ranging from the start of capital investment to 10 years after the start of the plant for 1983 money is shown in the 7th column. The idea of the discount factor is the inverse of interest. If capital of 100 is deposited in a bank account in 1983 instead of being invested in the project, it generates interest. The amount of the generated interest becomes $100 \times (1 + \frac{\alpha}{100})^5$, assuming an annual interest rate of α%. Accordingly, in collecting in 1988 capital of 100 dollars invested in 1983, it is necessary to have $100 \times (1 + \frac{\alpha}{100})^5$ instead of 100 dollars. In other words, the amount of 100 in 1988 corresponds to $1/(1 + \alpha/100)^5$ in 1983 according to this idea. Therefore, the capital invested in 1984 and 1985 have discount values discounted in comparison with the capital invested in 1983. The result of application of this discount factor to the generated cash is the before tax present value of the 8th and 9th columns, and data contained therein are equivalent. The discount factor is given by $(1/(1 + \frac{11.07}{100})) = 0.9003$, and 11.07% of the expression above is called the Internal Rate of Return. This parameter means that the project is not profitable if the required funds are not raised at capital costs below this interest rate. The IRR of each project scheme corresponding to the base case (electricity cost 1¢/KWH) is as follows.

	Before Tax
Fertilizer (I)	0 %
Fertilizer (II)	11.07%
Fertilizer (III)	0 %
PVC	8.12%
Electrolysis	8.90%

In any case the IRR is far below the level of 15 to 20% required by ordinary private investors.

The IRR of the various project schemes are low because the study is set forth on the premise of restricting the market to Paraguay and neighbouring areas. This results in small plant scale, which means large fixed costs in unit cost of product.

Furthermore, the plant construction cost in Paraguay is assumed to be 25% larger compared with that of Japan. This is another factor which contributes to increasing the production cost. On the other hand, profitability is not so high because the marketing price is determined using international prices as reference.

Depending on each project in particular, however, it is presumed that there is a possibility for cutting construction costs by cutting raw material costs and purchasing equipment from Brazil and Argentine.

Conclusions about projects which remain justifiable even by increasing the electricity cost to 2¢/KWH depend on the results of studies related to polyvinyl chloride and electrolysis. Further details about these matter are presented below.

(2) Premises for Profitability Analysis

1. General

1) Project name:

Fertilizer (I)	Electrolysis Ammonia and Dry Process Phosphate Acid
Fertilizer (II)	Fused Phosphate Fertilizer
Fertilizer (III)	Calcium Cyanamide (Preliminary)
PVC	PVC (From Cl_2, $CaCO_2$, C)
Electrolysis	Chlorine, Caustic Soda

2) Plant construction start year: January 1, 1983

3) Operation start year: January 1, 1986

4) Project life after start of operations: 10 years

5) Currency unit: US$1,000.-

6) Salvage value:

The following amounts are assumed as collectable in the last year of the project life for the sake of calculation of the IRR.

(1) Land acquisition price
(2) Residual book value of plant
(3) Initial investment amount of working capital

7) IRR calculation is carried out with regard to the paid up capital and loans.

8) Working capital is included in total investment amount.

9) Financial year: January 1 to December 31

2. Production and marketing plan

1) Annual production capacity

Fertilizer (I)

(1) Ammonia:	18,000 ton/Y
(2) White phosphorus:	15,000 ton/Y
(3) Phsophoric acid:	18,000 ton/Y
(4) Ammonium phosphate:	35,870 ton/Y
(5) Ammonium sulphate:	12,000 ton/Y
(6) Calcium silicate:	15,000 ton/Y

Fertilizer (II)

- 83,300 ton/Y

Fertilizer (III)

- 10,000 ton/Y

PVC

- 15,000 ton/Y

Electrolysis

(1) Chlorine:	13,095 ton/Y
(2) Caustic soda:	11,269 ton/Y
(3) High purity bleaching powder:	3,600 ton/Y

2) Operation rate

- 1st year of operation	80%
- 2nd year of operation	90%
- 3rd year of operation and after	100%

3) Inventory

Fertilizer (I)

- 1st year of operation:	Quantity to be marketed per month.
- 2nd year of operation and after:	Quantity to be marketed per month.

Fertilizer (II), Fertilizer (III), PVC, Electrolysis

- Equivalent to 2 months of production of the following year

4) Quantity to be marketed

Fertilizer (I)

(1) (6,300 ton/Y) - (increase in stock)

(2) (6,954 ton/Y) - (increase in stock)

(3) (1,500 ton/Y) - (increase in stock)

(4) (35,870 ton/Y) - (increase in stock)

(5) (12,000 ton/Y) - (increase in stock)

(6) (60,000 ton/Y) - (increase in stock)

Fertilizer (II)

(Production) - (stock)

Fertilizer III and PVC

(Production) - (stock)

Electrolysis

(1) 8,987 ton/Y

(2)
(3) (Production) - (stock)

5) Marketing prices

Fertilizer (I)	(II)	(III)	PVC	Electrolysis
(1) US$300	US$180	US$300	US$1,300	(1) US$240
(2) US$1,500				(2) US$300
(3) US$500				(3) US$1,300
(4) US$330				
(5) US$120				
(6) US$50				

3. Required capital

1) Land acquisition and land preparation costs: 0

2) Investment for construction of facilities

Plant office, maintenance facilities, warehouse, etc., are taken into consideration in investment analyzed here, in addition to production and service facilities. Roads, railway sidings, jetty, dwellings, etc., are excluded, however. As for service and maintenance facilities, these are discussed on the premise that they are used in common by several plants.
The construction costs are calculated on a 1981 contract basis, because all data such as production cost at the plant, marketing price of the product, etc., used to analyze profitability are for 1981.

(US$1,000)	Fertilizer (I)	(II)	(III)	PVC	Electrolysis
Process plant cost	50,025.2	11,858.0	9,532.4	35,940.0	25,648.8
Accessory facilities cost (Civil & Building)	2,199.2	3,062.8	1,494.0	7,068.0	4,816.0

3) Pre-operation cost (US$1,000)

Fertilizer (I)	(II)	(III)	PVC	Electrolysis
2,400	1,200	1,200	2,400	1,200

4) Interest during construction period:

Interest corresponding to a 1.5 year period at an annual rate of 10% for the loan of the total amount of 1), 2) and 3).

5) Fixed capital: Total of 1), 2), 3) and 4).

6) Initial working capital:

Equivalent to 2 months of finished product stock and raw material stock.

4. Fund raising program

1) The total of fixed capital and working capital is covered by paid-up capital and long-term loans.

2) Proportion of paid-up capital and long-term

3) Long-term loan:

- Repayment period: 8 years
- Start of repayment of principal from the 3rd year after the start of commercial operation.
- Method of repayment:
  Principal paid in even annual installments.
- Annual interest: 10%
  The payment of interest is started from the year of start-up of plant operation.

4) Short-term loan:

In case of shortage of funds after start of operation shortage will be covered by short-term loans with 10% annual interest.

5. Investment and fund raising schedule

1) Operation preparation funds:

To be invested in the operation start year.

2) Payment of funds on hand

1st year	50%
2nd year	30%
3rd year	20%

Payment of long-term loan

1st year	30%
2nd year	40%
3rd year	30%

6. Inventory cost, accounts receivable and accounts payable

1) Product stock: Quantity equivalent to 1 month of production of the following year. Costs are included in production cost.

2) Raw material stock: Quantity equivalent to 2 months of raw material expenses. The total of expenses is included in the first year of operation.

3) Accounts receivable: Amount equivalent to 1 month of turnover.

4) Accounts payable: Amount equivalent to 2 months of variable cost.

7. Variable cost

1) Raw material cost

Fertilizer (I)	Production	Unit Price
Rock Phosphate:	123,900 ton/Y	US$50/ton
Silica:	37,500 ton/Y	US$40/ton
Coke:	21,900 ton/Y	US$170/ton

Fertilizer (II)	Basic Unit	Unit Price
Rock phosphate:	0.637 ton/ton	US$60/ton
Serpentinite:	0.476 ton/ton	US$30/ton

Fertilizer (III)		
Limestone:	1.21 ton/ton	US$12/ton
Coke:	0.436 ton/ton	US$170/ton

PVC	Basic Unit	Unit Price
Limestone:	2.8 ton/ton	US$12/ton
Coke:	1.0 ton/ton	US$170/ton
Chlorine:	0.604 ton/ton	US$200/ton

Electrolysis	Production	Unit Price
Rock salt:	24,880.5 ton/Y	US$30/ton

2) Secondary materials and utilities

Fertilizer		
Electricity:	433.82x10^6KWH/Y	US¢1/KWH
Industrial water:	470.3x10^3 ton/Y	US¢8/ton
Fuel:	2,110 KL/year	US$320/ton
Electrodes:	270 ton/year	US$3,600/ton
Others:	US$2,668x$10^3$/year	

Fertilizer (II)

Electricity:	1,400 KWH/ton	US¢1/KWH
Reagents, etc.:		US$20/ton
Bags:		US$24/ton

Fertilizer (III)

Electricity:	2,280 KWH/ton	US¢1/KWH
Steam, industrial water, etc.		US$7.6/ton
Secondary materials, etc.		US$50.9/ton

PVC

Electricity:	5,560 KWH/ton	US¢1/KWH
Steam, industrial water, etc.		US$36/ton
Reagents and lubricants:		US$71.6/ton

Electrolysis

Electricity:	40,953,600KWH/year	US¢1/KWH
Steam:	15,138 ton/year	US$12/ton
Industrial water:	73,318.5 ton/year	US$0.2/ton
Reagents, packing materials:	13,095 ton/year	US$28/ton
	3,600 ton/year	US$60/ton

8. Fixed costs

1) Direct labour costs (1 year)

Fertilizer (I)	US$1,071,000
Fertilizer (II)	US$548,000
Fertilizer (III)	US$506,000
PVC	US$1,136,000
Electrolysis	US$513,000

2) Overhead costs

Fertilizer (I)	50% of Direct Labour Costs
Fertilizer (II), (III), PVC, Electrolysis	100% of Direct Labour Costs

3) Repair and maintenance costs

3% of facilities cost

4) Tax and insurance

1% of the amount obtained by subtracting "amount depreciated up to the preceeding year" from the total amount of assets to be depreciated and land cost specified in "DEP".

9. Depreciation cost and annual repayment expenses

1) Process plant

Straight line depreciation:
Depreciation period of 10 years, salvage value 10%.

2) Auxiliary facilities cost

Straight line depreciation:
Depreciation period of 15 years, salvage value 15%.

3) Preoperation costs

Straight line annual installment repayment:
Period of repayment of 10 years, salvage value 0.

4) Interest during construction

Straight line annual installment repayment:
Period of repayment of 10 years, salvage value 0.

10. Marketing and administration costs

5% of production cost

11. Others

1) Minimum funds on hand: 0

2) Corporate profit tax:
Loss carry forward period: 5 years
Tax rate: 50%,
Tax exemption period: 3 years

3) Dividend: 10% of paid-up capital

Case Study

Fertilizer (I)

(Case A)
Electricity cost: US¢2/KWH

(Case B)
Investment amount: 5% down

(Case C)
Investment amount: 10% down

(Case D)
Investment amount: 10% up

(Case E)
Marketing unit price: 5% up

(Case F)
Marketing unit price: 10% up

(Case G)
Raw material cost: 5% down

(Case H)
Raw material cost: 10% down

Fertilizer (II), (III), PVC
Electrolysis

(Case A)
Electricity cost: US¢2/KWH

(Case B)
Investment amount: 5% down

(Case C)
Investment amount: 10% down

(Case D)
Marketing unit price: 5% up

(Case E)
Marketing unit price: 10% up

(Case F)
Raw material cost: 5% down

(Case G)
Raw material cost: 10% down

NOTE: Refer to pages 124 to 139 for details of calculation results.

4.5.2 Profitability of Projects

(1) Fertilizer (I)

The profitability of this project is kept at a low level due for the following reasons.

- The plant is small in scale because scale is determined based on the current Paraguayan fertilizer market size.
- The price of rock phosphate is assumed to be US$50/ton.

Profitability can be imporved considerably if the scale of the plant is increased, taking into consideration the markets of Brazil, Argentina and Bolivia in addition to Paraguay. For example, if the production scale is doubled, the capital cost per ton of product is reduced by 20%. Accordingly, the project becomes quite profitable even assuming an electricity cost of 2 cents per KWH. The cost of rock phosphate at the mine is normally of the order of US$20 to US$30 per ton and the price at the plant gate is assumed to be US$50/ton, taking into consideration the transportation cost from the mine to the plant. Regarding this aspect, it is expected that there is the possibility of development of rock phosphate deposits in areas of Brazil close to Paraguay, or in areas which make possible the fluvial transportation route of the Rio Uruguay and other large rivers of the region. In such a case it is possible to acquire rock phosphate at prices of the order of US$40/ton at the plant site.

It is indispensable to make simultaneous improvements regarding two or more elements among the conditions taken into consideration in this study in order to make the fertilizer complex feasible from the point of view of profitability, otherwise it is difficult to make the project financially justifiable. In any case, we consider it necessary to carry out a detailed feasibility study of the fertilizer project for the following reasons.

- This project is useful for the future of Paraguayan agriculture
- There is a possibility of cutting the construction costs
- There is a possibility of further cutting raw material and utility costs.

In particular, we consider it necessary to carry out analysis from the point of view of the national economy, taking into consideration the impact of the project on agricultural production. We presume it possible to achieve financial feasibility if it is possible to materialize the following:

- Improve the operation rate at the start of operation
- Cut operation costs by 10%
- Raise funds at low costs.

(2) Fertilizer (II)

This project has the best profitability among those taken into consideration in this study. One of the reasons leading to the favorable profitability of the project is the assumption we made that total consumption of P2O5 fertilizer in Paraguay can be covered by this type of product. This assumption leads to a fused phosphate plant of sufficiently large scale. We consider it necessary to confirm product demand by means of a detailed market survey. On the other hand, it is known that this kind of fertilizer is very effective in the arable lands of Paraguay and neighbouring areas of Brazil and Argentina (acid soil with a shortage of MgO and SiO_2), and therefore the profitability of the project can be further improved if there is a possibility of marketing the products in such foreign markets.

The operation rate is assumed to be low (60% in the 1st year and 80% in the 2nd year) in the profitability analysis carried out here, because difficulties related to marketing of the products are expected in this project.

(3) Fertilizer (III)

The independent production of calcium cyanamide using the plant size taken into consideration in this study is not financially feasible.

As mentioned before, this fertilizer is used for special applications, in view of its germicidal and insecticidal character. Accordingly, it has a limited market. Independent production of this fertilizer at an economic scale is not financially feasible, hence, the feasibility of this project is conditioned on its inclusion as part of the PVC project. In other words, it can be materialized only when the scheme for expansion of carbide production facilities of the PVC project, with production of calcium cyanamide from carbide, becomes feasible. In any case, confirmation of the existence of a sizable market in Paraguay is the most important condition for this project.

If the market is available and the carbide is produced by the capacity - up of the carbide plant handling the cyanamide project as a part of the PVC complex, cost of installation becomes approximately 40% of the case of independent project. In the case of combination with the PVC project, labour costs of carbide plant operation become unnecessary and, therefore, production costs becomes:

Unit: US$/ton

	Combination with the PVC project	Independent production of calcium cyanamide
Variable Cost	169.9	169.9
Capital Cost	47.8	119.6
Fixed Cost	43.0*	143.4
Interest	38.0	95.1
Sales Administration	21.6	21.6
Total	320.3	584.4

* 30% of Independent

The production cost of US$584.4/ton in the case of independent production is cut to US$320/ton in the case of combined production and the latter figure is close to the sales price. In other words, if construction of the PVC complex proves feasible, related chemical industries such as calcium cyanamide become feasible as well.

This example suggests that even when a project is not financially feasible alone, it may have potential feasibility with respect to future development of related industries. It is therefore necessary to take into consideration this kind of merit in addition to financial feasibility itself.

(4) PVC Complex

The IRR of this project in the base case is 8.12%. There is, however, a possibility of considerable improvement depending on the results of detailed analysis of the plant construction costs in Paraguay because the capital cost represents a considerable proportion of the total cost of the project. This study is set forth assuming the production of PVC chips as the final product. However, if further processing steps are taken into consideration, this project has extremely promising potential as a first stage for the industrialization of Paraguay. It is possible to expect cost reductions by expansion of the market on a long-term basis.

In the sensititivy study there is a pronounced influence of the sales price but the marketing price of US$1,300/ton assumed in this study is higher than the international price and there is little possibility of a further rise in the domestic market price in Paraguay.

(5) Electrolysis Complex

As a matter of fact, materialization of this scheme is conditioned on materialization of the PVC project. Independent implementation is not feasible. Caustic soda is a basic raw material of the chemical industry and even at present there is a possibility of further increases in latent demand in Paraguay and in neighbouring countries. Furthermore, with regard to the price itself, there is a possibility of selling this product at better conditions that that of the international market.

We intend to carry out a sufficiently detailed study on demand for chlorine and caustic soda in the paper industry of Uruguay, Brazil and Argentina.

In the base case, the IRR of the electrolysis complex is 8.90%, but there is a possibility for further improvements in profitability, if it is possible to sell the products to neighbouring countries under satisfactory conditions.

Tab. III-4-5-1 (1)

*** PARAGUAY ELECTRICITY INTENSIVE CHEMICAL INDUSTRY ***
IRR CALCULATION ON TOTAL INVESTMENT
FERTILIZER (I) AMMONIA, DAP (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.	RETURN	(LESS) INCOME TAX	RETURN AFTER TAX	DISCOUNT FACTOR	(AFTER TAX) PRESENT-VALUE INVEST.	RETURN
1983	15305.	0.	0.	0.	0.	0.0	0.	0.	0.	0.	0.0	0.	0.
1984	30611.	0.	0.	0.	0.	0.0	0.	0.	0.	0.	0.0	0.	0.
1985	15305.	0.	0.	0.	0.	0.0	0.	0.	0.	0.	0.0	0.	0.
1986	395.	-9756.	5913.	4763.	921.	0.0	0.	0.	0.	921.	0.0	0.	0.
1987	0.	-8169.	5913.	4763.	2507.	0.0	0.	0.	0.	2507.	0.0	0.	0.
1988	0.	-7383.	5913.	4763.	3293.	0.0	0.	0.	0.	3293.	0.0	0.	0.
1989	0.	-7489.	5913.	4168.	2592.	0.0	0.	0.	0.	2592.	0.0	0.	0.
1990	0.	-7594.	5913.	3572.	1891.	0.0	0.	0.	0.	1891.	0.0	0.	0.
1991	0.	-7709.	5913.	2977.	1181.	0.0	0.	0.	0.	1181.	0.0	0.	0.
1992	0.	-7836.	5913.	2382.	459.	0.0	0.	0.	0.	459.	0.0	0.	0.
1993	0.	-7975.	5913.	1786.	-276.	0.0	0.	0.	0.	-276.	0.0	0.	0.
1994	0.	-8129.	5913.	1191.	-1025.	0.0	0.	0.	0.	-1025.	0.0	0.	0.
1995	-8917.	-8298.	5913.	595.	-1789.	0.0	0.	0.	0.	-1789.	0.0	0.	0.
TOTAL	52701.				9753.		0.	0.		9753.		0.	0.

***** INTERNAL RATE OF RETURN ***** 0.0 PER CENT (BEFORE TAX) 0.0 PER CENT (AFTER TAX)

SUM OF THE COST IS LARGER THAN THE ACCUMULATED RETURN, SO THAT IRR WILL BE GOT IN NEGATIVE QUANTITY (BEFORE TAX)

SUM OF THE COST IS LARGER THAN THE ACCUMULATED RETURN, SO THAT IRR WILL BE GOT IN NEGATIVE QUANTITY (AFTER TAX)

***** PAY-OUT PERIOD (YEARS) **** THE INVESTMENT CAN NOT BE PAID OUT WITHIN THE PROJECT LIFE (AFTER TAX BASE)
***** PAY-OUT PERIOD (YEARS) **** THE INVESTMENT CAN NOT BE PAID OUT WITHIN THE PROJECT LIFE (BEFORE TAX BASE)

CAPITAL REQUIREMENTS

LAND AND SITE IMPROVEMENT	0.
PROCESS PLANT	50025.
CIVIL AND BUILDING	8797.
CONSTRUCTED FACILITIES	58822.
PRE-INVEST AND START-UP EXP	2400.
INTEREST DURING CONSTRUCTION	6428.
TOTAL FIXED CAPITAL	67650.
	142.
	254.
INITIAL WORKING CAPITAL	395.
TOTAL CAPITAL COST	68046.

SOURCE OF FUNDS

PAID-UP SHARE CAPITAL	20414.
LONG TERM DEBT	47632.
SHORT TERM DEBT	0.
FINANCIAL RESOURCES	68046.

Tab. III-4-5-1 (2)

*** PARAGUAY ELECTRICITY INTENSIVE CHEMICAL INDUSTRY ***
IRR CALCULATION ON TOTAL INVESTMENT

FERTILIZER (I) INVESTMENT 10% DOWN

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	13775.	0.	0.	0.	0.	0.0	0.	0.	0.	0.	0.0	0.	0.
1984	27550.	0.	0.	0.	0.	0.0	0.	0.	0.	0.	0.0	0.	0.
1985	13775.	0.	0.	0.	0.	0.0	0.	0.	0.	0.	0.0	0.	0.
1986	352.	-8438.	5322.	4287.	1170.	0.0	0.	0.	0.	1170.	0.0	0.	0.
1987	0.	-6761.	5322.	4287.	2848.	0.0	0.	0.	0.	2848.	0.0	0.	0.
1988	0.	-5895.	5322.	4287.	3714.	0.0	0.	0.	0.	3714.	0.0	0.	0.
1989	0.	-5917.	5322.	3751.	3156.	0.0	0.	0.	0.	3156.	0.0	0.	0.
1990	0.	-5929.	5322.	3215.	2608.	0.0	0.	0.	0.	2608.	0.0	0.	0.
1991	0.	-5942.	5322.	2679.	2059.	0.0	0.	0.	0.	2059.	0.0	0.	0.
1992	0.	-5956.	5322.	2143.	1509.	0.0	0.	0.	0.	1509.	0.0	0.	0.
1993	0.	-5972.	5322.	1607.	957.	0.0	0.	0.	0.	957.	0.0	0.	0.
1994	0.	-5950.	5322.	1072.	403.	0.0	0.	0.	0.	403.	0.0	0.	0.
1995	-8021.	-6009.	5322.	536.	-152.	0.0	0.	0.	0.	-152.	0.0	0.	0.
TOTAL	47431.				18271.		0.	0.		18271.		0.	0.

***** INTERNAL RATE OF RETURN ***** 0.0 PER CENT (BEFORE TAX) 0.0 PER CENT (AFTER TAX)

SUM OF THE COST IS LARGER THAN THE ACCUMULATED RETURN, SO THAT IRR WILL BE GOT IN NEGATIVE QUANTITY (BEFORE TAX)

SUM OF THE COST IS LARGER THAN THE ACCUMULATED RETURN, SO THAT IRR WILL BE GOT IN NEGATIVE QUANTITY (AFTER TAX)

***** PAY-OUT PERIOD (YEARS) **** THE INVESTMENT CAN NOT BE PAID OUT WITHIN THE PROJECT LIFE (AFTER TAX BASE)
***** PAY-OUT PERIOD (YEARS) **** THE INVESTMENT CAN NOT BE PAID OUT WITHIN THE PROJECT LIFE (BEFORE TAX BASE)

CAPITAL REQUIREMENTS	
LAND AND SITE IMPROVEMENT	0.
PROCESS PLANT	45023.
CIVIL AND BUILDING	7917.
CONSTRUCTED FACILITIES	52940.
PRE-INVEST AND START-UP EXP	2160.
INTEREST DURING CONSTRUCTION	5785.
TOTAL FIXED CAPITAL	60885.
	123.
	228.
INITIAL WORKING CAPITAL	352.
TOTAL CAPITAL COST	61237.

SOURCE OF FUNDS	
PAID-UP SHARE CAPITAL	18371.
LONG TERM DEBT	42866.
SHORT TERM DEBT	0.
FINANCIAL RESOURCES	61237.

Tab. III-4-5-1 (3)

*** PARAGUAY ELECTRICITY INTENSIVE CHEMICAL INDUSTRY ***
IRR CALCULATION ON TOTAL INVESTMENT

FERTILIZER (I) SALES PRICE 10% UP

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	15305.	0.	0.	0.	0.	1.0000	15305.	0.	0.	0.	1.0000	15305.	0.
1984	30611.	0.	0.	0.	0.	0.9979	30546.	0.	0.	0.	0.9979	30546.	0.
1985	15305.	0.	0.	0.	0.	0.9958	15241.	0.	0.	0.	0.9958	15241.	0.
1986	395.	-7627.	5913.	4763.	3049.	0.9937	393.	3030.	0.	3049.	0.9937	393.	3030.
1987	0.	-5357.	5913.	4763.	5319.	0.9916	0.	5275.	0.	5319.	0.9916	0.	5275.
1988	0.	-3975.	5913.	4763.	6701.	0.9895	0.	6631.	0.	6701.	0.9895	0.	6631.
1989	0.	-3743.	5913.	4168.	6337.	0.9874	0.	6258.	0.	6337.	0.9874	0.	6258.
1990	0.	-3473.	5913.	3572.	6012.	0.9853	0.	5924.	0.	6012.	0.9853	0.	5924.
1991	0.	-3177.	5913.	2977.	5713.	0.9832	0.	5617.	0.	5713.	0.9832	0.	5617.
1992	0.	-2850.	5913.	2382.	5444.	0.9812	0.	5342.	0.	5444.	0.9812	0.	5342.
1993	0.	-2451.	5913.	1786.	5208.	0.9791	0.	5099.	0.	5208.	0.9791	0.	5099.
1994	0.	-2096.	5913.	1191.	5007.	0.9770	0.	4892.	0.	5007.	0.9770	0.	4892.
1995	-8917.	-1662.	5913.	595.	4847.	0.9750	-8694.	4725.	0.	4847.	0.9750	-8694.	4725.
TOTAL	52701.				53638.		52792.	52792.		53638.		52792.	52792.

***** INTERNAL RATE OF RETURN ***** 0.21 PER CENT (BEFORE TAX) 0.21 PER CENT (AFTER TAX)

***** PAY-OUT PERIOD (YEARS) **** THE INVESTMENT CAN NOT BE PAID OUT WITHIN THE PROJECT LIFE (AFTER TAX BASE)
***** PAY-OUT PERIOD (YEARS) **** THE INVESTMENT CAN NOT BE PAID OUT WITHIN THE PROJECT LIFE (BEFORE TAX BASE)

CAPITAL REQUIREMENTS	
LAND AND SITE IMPROVEMENT	0.
PROCESS PLANT	50025.
CIVIL AND BUILDING	8797.
CONSTRUCTED FACILITIES	58822.
PRE-INVEST AND START-UP EXP	2400.
INTEREST DURING CONSTRUCTION	6428.
TOTAL FIXED CAPITAL	67650.
	142.
	254.
INITIAL WORKING CAPITAL	395.
TOTAL CAPITAL COST	68046.

SOURCE OF FUNDS	
PAID-UP SHARE CAPITAL	20414.
LONG TERM DEBT	47632.
SHORT TERM DEBT	0.
FINANCIAL RESOURCES	68046.

Tab. III-4-5-1 (4)

*** PARAGUAY ELECTRICITY INTENSIVE CHEMICAL INDUSTRY ***
IRR CALCULATION ON TOTAL INVESTMENT

FERTILIZER (I) RAW MATERIAL COST 10% DOWN

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	15305.	0.	0.	0.	0.	0.0	0.	0.	0.	0.	0.0	0.	0.
1984	30611.	0.	0.	0.	0.	0.0	0.	0.	0.	0.	0.0	0.	0.
1985	15305.	0.	0.	0.	0.	0.0	0.	0.	0.	0.	0.0	0.	0.
1986	365.	-8824.	5913.	4761.	1850.	0.0	0.	0.	0.	1850.	0.0	0.	0.
1987	0.	-6998.	5913.	4761.	3675.	0.0	0.	0.	0.	3675.	0.0	0.	0.
1988	0.	-5971.	5913.	4761.	4703.	0.0	0.	0.	0.	4703.	0.0	0.	0.
1989	0.	-5937.	5913.	4166.	4142.	0.0	0.	0.	0.	4142.	0.0	0.	0.
1990	0.	-5886.	5913.	3571.	3598.	0.0	0.	0.	0.	3598.	0.0	0.	0.
1991	0.	-5831.	5913.	2976.	3058.	0.0	0.	0.	0.	3058.	0.0	0.	0.
1992	0.	-5770.	5913.	2381.	2524.	0.0	0.	0.	0.	2524.	0.0	0.	0.
1993	0.	-5703.	5913.	1785.	1996.	0.0	0.	0.	0.	1996.	0.0	0.	0.
1994	0.	-5629.	5913.	1190.	1474.	0.0	0.	0.	0.	1474.	0.0	0.	0.
1995	-8886.	-5547.	5913.	595.	961.	0.0	0.	0.	0.	961.	0.0	0.	0.
TOTAL	52701.				27980.		0.	0.		27980.		0.	0.

***** INTERNAL RATE OF RETURN ***** 0.0 PER CENT (BEFORE TAX) 0.0 PER CENT (AFTER TAX)

SUM OF THE COST IS LARGER THAN THE ACCUMULATED RETURN, SO THAT IRR WILL BE GOT IN NEGATIVE QUANTITY (BEFORE TAX)

SUM OF THE COST IS LARGER THAN THE ACCUMULATED RETURN, SO THAT IRR WILL BE GOT IN NEGATIVE QUANTITY (AFTER TAX)

***** PAY-OUT PERIOD (YEARS) **** THE INVESTMENT CAN NOT BE PAID OUT WITHIN THE PROJECT LIFE (AFTER TAX BASE)
***** PAY-OUT PERIOD (YEARS) **** THE INVESTMENT CAN NOT BE PAID OUT WITHIN THE PROJECT LIFE (BEFORE TAX BASE)

CAPITAL REQUIREMENTS	
LAND AND SITE IMPROVEMENT	0.
PROCESS PLANT	50025.
CIVIL AND BUILDING	8797.
CONSTRUCTED FACILITIES	58822.
PRE-INVEST AND START-UP EXP	2400.
INTEREST DURING CONSTRUCTION	6428.
TOTAL FIXED CAPITAL	67650.
	137.
	228.
INITIAL WORKING CAPITAL	365.
TOTAL CAPITAL COST	68015.

SOURCE OF FUNDS	
PAID-UP SHARE CAPITAL	20405.
LONG TERM DEBT	47611.
SHORT TERM DEBT	0.
FINANCIAL RESOURCES	68015.

Tab. III-4-5-1 (5)

*** PARAGUAY ELECTRICITY INTENSIVE CHEMICAL INDUSTRY ***
IRR CALCULATION ON TOTAL INVESTMENT

FERTILIZER (II) FUSED PHOSPHATE (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	4030.	0.	0.	0.	0.	1.0000	4030.	0.	0.	0.	1.0000	4030.	0.
1984	7760.	0.	0.	0.	0.	0.9003	6987.	0.	0.	0.	0.9139	7092.	0.
1985	4330.	0.	0.	0.	0.	0.8106	3510.	0.	0.	0.	0.8352	3616.	0.
1986	1410.	-1570.	1540.	1346.	1316.	0.7293	1029.	961.	0.	1316.	0.7632	1076.	1005.
1987	0.	-493.	1540.	1346.	2393.	0.6571	0.	1572.	0.	2393.	0.6975	0.	1669.
1988	0.	615.	1540.	1346.	3501.	0.5916	0.	2071.	0.	3501.	0.6374	0.	2232.
1989	0.	796.	1540.	1177.	3514.	0.5326	0.	1872.	0.	3514.	0.5825	0.	2047.
1990	0.	978.	1540.	1009.	3527.	0.4796	0.	1691.	163.	3364.	0.5324	0.	1791.
1991	0.	1159.	1540.	841.	3540.	0.4318	0.	1529.	580.	2961.	0.4865	0.	1441.
1992	0.	1340.	1540.	673.	3553.	0.3887	0.	1381.	670.	2883.	0.4446	0.	1282.
1993	0.	1522.	1540.	505.	3567.	0.3500	0.	1248.	761.	2806.	0.4063	0.	1140.
1994	0.	1704.	1540.	336.	3580.	0.3151	0.	1128.	852.	2728.	0.3713	0.	1013.
1995	-3821.	1884.	1540.	168.	3593.	0.2837	-1084.	1019.	942.	2651.	0.3394	-1297.	900.
TOTAL	13710.				32084.		14472.	14472.		28117.		14518.	14518.

***** INTERNAL RATE OF RETURN ***** 11.07 PER CENT (BEFORE TAX) 9.42 PER CENT (AFTER TAX)

***** PAY-OUT PERIOD ***** 6.40 YEAR (BEFORE TAX) 6.75 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	11858.
CIVIL AND BUILDING	3063.
CONSTRUCTED FACILITIES	14921.
PRE-INVEST AND START-UP EXP	1200.
INTEREST DURING CONSTRUCTION	1693.
TOTAL FIXED CAPITAL	17813.
	973.
	437.
INITIAL WORKING CAPITAL	1410.
TOTAL CAPITAL COST	19224.

SOURCE OF FUNDS

PAID-UP SHARE CAPITAL	5767.
LONG TERM DEBT	13457.
SHORT TERM DEBT	0.
FINANCIAL RESOURCES	19224.

Tab. III-4-5-1 (6)

*** PARAGUAY ELECTRICITY INTENSIVE CHEMICAL INDUSTRY ***
IRR CALCULATION ON TOTAL INVESTMENT

FERTILIZER (II) INVESTMENT 10% DOWN

YEAR	TOTAL INVESTMENT	PROFIT BEFORE TAX	DEPRECIATN	INTEREST ON L-T DEBT	RETURN BEFORE TAX	DISCOUNT FACTOR	(BEFORE TAX) PRESENT VALUE INVEST.	RETURN	(LESS) INCOME TAX	RETURN AFTER TAX	DISCOUNT FACTOR	(AFTER TAX) PRESENT VALUE INVEST.	RETURN
1983	3527.	0.	0.	0.	0.	1.0000	3527.	0.	0.	0.	1.0000	3527.	0.
1984	6984.	0.	0.	0.	0.	0.8837	6172.	0.	0.	0.	0.9036	6311.	0.
1985	3897.	0.	0.	0.	0.	0.7810	3044.	0.	0.	0.	0.8165	3182.	0.
1986	1248.	-1233.	1386.	1210.	1363.	0.6902	861.	941.	0.	1363.	0.7378	921.	1006.
1987	0.	-139.	1385.	1210.	2457.	0.6100	0.	1499.	0.	2457.	0.6667	0.	1638.
1988	0.	971.	1386.	1210.	3569.	0.5391	0.	1924.	0.	3569.	0.6025	0.	2150.
1989	0.	1136.	1386.	1058.	3580.	0.4764	0.	1706.	369.	3212.	0.5444	0.	1749.
1990	0.	1299.	1385.	907.	3592.	0.4210	0.	1512.	649.	2943.	0.4919	0.	1448.
1991	0.	1462.	1386.	756.	3604.	0.3721	0.	1341.	731.	2873.	0.4445	0.	1277.
1992	0.	1625.	1386.	605.	3616.	0.3288	0.	1189.	812.	2803.	0.4017	0.	1126.
1993	0.	1789.	1386.	454.	3628.	0.2906	0.	1054.	894.	2734.	0.3630	0.	992.
1994	0.	1951.	1386.	302.	3640.	0.2568	0.	935.	975.	2664.	0.3280	0.	874.
1995	-3419.	2114.	1386.	151.	3651.	0.2270	-776.	829.	1057.	2594.	0.2964	-1013.	769.
TOTAL	12339.				32700.		12929.	12929.		27212.		13028.	13028.

***** INTERNAL RATE OF RETURN ***** 13.15 PER CENT (BEFORE TAX) 10.67 PER CENT (AFTER TAX)

***** PAY-OUT PERIOD ***** 5.75 YEAR (BEFORE TAX) 6.31 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		SOURCE OF FUNDS	
LAND AND SITE IMPROVEMENT	0.	PAID-UP SHARE CAPITAL	5184.
PROCESS PLANT	10672.	LONG TERM DEBT	12096.
CIVIL AND BUILDING	2757.	SHORT TERM DEBT	0.
CONSTRUCTED FACILITIES	13429.	FINANCIAL RESOURCES	17280.
PRE-INVEST AND START-UP EXP	1080.		
INTEREST DURING CONSTRUCTION	1523.		
TOTAL FIXED CAPITAL	16032.		
	854.		
	394.		
INITIAL WORKING CAPITAL	1248.		
TOTAL CAPITAL COST	17280.		

Tab. III-4-5-I (7)

*** PARAGUAY ELECTRICITY INTENSIVE CHEMICAL INDUSTRY ***
IRR CALCULATION ON TOTAL INVESTMENT

FERTILIZER (II) SALES PRICE 10% UP

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	4030.	0.	0.	0.	0.	1.0000	4030.	0.	0.	0.	1.0000	4030.	0.
1984	7760.	0.	0.	0.	0.	0.8508	6602.	0.	0.	0.	0.8773	6808.	0.
1985	4330.	0.	0.	0.	0.	0.7238	3134.	0.	0.	0.	0.7697	3333.	0.
1986	1410.	-770.	1540.	1346.	2116.	0.6159	868.	1303.	0.	2116.	0.6752	952.	1429.
1987	0.	631.	1540.	1346.	3567.	0.5240	0.	1869.	0.	3567.	0.5924	0.	2113.
1988	0.	2114.	1540.	1346.	5000.	0.4458	0.	2229.	0.	5000.	0.5197	0.	2599.
1989	0.	2296.	1540.	1177.	5013.	0.3793	0.	1901.	1148.	3866.	0.4559	0.	1762.
1990	0.	2477.	1540.	1009.	5027.	0.3227	0.	1622.	1239.	3788.	0.4000	0.	1515.
1991	0.	2659.	1540.	841.	5040.	0.2745	0.	1384.	1329.	3711.	0.3599	0.	1302.
1992	0.	2840.	1540.	673.	5053.	0.2336	0.	1180.	1420.	3633.	0.3078	0.	1118.
1993	0.	3021.	1540.	505.	5066.	0.1987	0.	1007.	1511.	3555.	0.2701	0.	960.
1994	0.	3202.	1540.	336.	5079.	0.1691	0.	859.	1601.	3478.	0.2369	0.	824.
1995	-3821.	3384.	1540.	168.	5092.	0.1438	-550.	732.	1692.	3400.	0.2079	-794.	707.
TOTAL	13710.				46053.		14086.	14086.		36114.		14329.	14329.

***** INTERNAL RATE OF RETURN ***** 17.54 PER CENT (BEFORE TAX) 13.99 PER CENT (AFTER TAX)

***** PAY-OUT PERIOD ***** 4.70 YEAR (BEFORE TAX) 5.24 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		SOURCE OF FUNDS	
LAND AND SITE IMPROVEMENT	0.	PAID-UP SHARE CAPITAL	5767.
PROCESS PLANT	11858.	LONG TERM DEBT	13457.
CIVIL AND BUILDING	3063.	SHORT TERM DEBT	0.
CONSTRUCTED FACILITIES	14921.	FINANCIAL RESOURCES	19224.
PRE-INVEST AND START-UP EXP	1200.		
INTEREST DURING CONSTRUCTION	1693.		
TOTAL FIXED CAPITAL	17813.		
	973.		
	437.		
INITIAL WORKING CAPITAL	1410.		
TOTAL CAPITAL COST	19224.		

Tab. III-4-5-1 (8)

*** PARAGUAY ELECTRICITY INTENSIVE CHEMICAL INDUSTRY ***
IRR CALCULATION ON TOTAL INVESTMENT

FERTILIZER (II) RAW MATERIAL COST 10% DOWN

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	4030.	0.	0.	0.	0.	1.0000	4030.	0.	0.	0.	1.0000	4030.	0.
1984	7760.	0.	0.	0.	0.	0.8832	6854.	0.	0.	0.	0.9033	7010.	0.
1985	4330.	0.	0.	0.	0.	0.7801	3378.	0.	0.	0.	0.8159	3533.	0.
1986	1337.	-1318.	1540.	1341.	1563.	0.6890	921.	1077.	0.	1563.	0.7369	986.	1152.
1987	0.	-128.	1540.	1341.	2753.	0.6086	0.	1675.	0.	2753.	0.6657	0.	1832.
1988	0.	1077.	1543.	1341.	3960.	0.5375	0.	2129.	0.	3960.	0.6013	0.	2381.
1989	0.	1260.	1540.	1173.	3973.	0.4747	0.	1886.	446.	3527.	0.5431	0.	1915.
1990	0.	1441.	1540.	1005.	3986.	0.4193	0.	1672.	720.	3266.	0.4906	0.	1602.
1991	0.	1621.	1540.	838.	3999.	0.3704	0.	1481.	911.	3189.	0.4431	0.	1413.
1992	0.	1802.	1540.	670.	4013.	0.3271	0.	1313.	901.	3112.	0.4002	0.	1245.
1993	0.	1983.	1540.	503.	4026.	0.2889	0.	1163.	991.	3034.	0.3615	0.	1097.
1994	0.	2164.	1540.	335.	4039.	0.2552	0.	1031.	1082.	2957.	0.3265	0.	966.
1995	-3748.	2344.	1540.	168.	4052.	0.2254	-845.	913.	1172.	2880.	0.2949	-1106.	849.
TOTAL	13710.				36364.		14339.	14339.		30240.		14453.	14453.

***** INTERNAL RATE OF RETURN ***** 13.22 PER CENT (BEFORE TAX) 10.71 PER CENT (AFTER TAX)

***** PAY-OUT PERIOD ***** 5.73 YEAR (BEFORE TAX) 6.29 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		SOURCE OF FUNDS	
LAND AND SITE IMPROVEMENT	0.	PAID-UP SHARE CAPITAL	5745.
PROCESS PLANT	11858.	LONG TERM DEBT	13406.
CIVIL AND BUILDING	3063.	SHORT TERM DEBT	0.
CONSTRUCTED FACILITIES	14921.	FINANCIAL RESOURCES	19151.
PRE-INVEST AND START-UP EXP	1200.		
INTEREST DURING CONSTRUCTION	1693.		
TOTAL FIXED CAPITAL	17813.		
	944.		
	394.		
INITIAL WORKING CAPITAL	1337.		
TOTAL CAPITAL COST	19151.		

Tab. III-4-5-1 (9)

*** PARAGUAY ELECTRICITY INTENSIVE CHEMICAL INDUSTRY ***
IRR CALCULATION ON TOTAL INVESTMENT
PVC PVC (FROM CL2.CACO3.C) (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	11352.	0.	0.	0.	0.	1.0000	11352.	0.	0.	0.	1.0000	11352.	0.
1984	22104.	0.	0.	0.	0.	0.9249	20444.	0.	0.	0.	0.9296	20549.	0.
1985	11952.	0.	0.	0.	0.	0.8554	10224.	0.	0.	0.	0.8642	10329.	0.
1986	1982.	-3110.	4375.	3651.	4916.	0.7912	1568.	3890.	0.	4916.	0.8034	1592.	3950.
1987	0.	-1785.	4375.	3651.	6242.	0.7318	0.	4568.	0.	6242.	0.7469	0.	4662.
1988	0.	-540.	4375.	3651.	7486.	0.6768	0.	5067.	0.	7486.	0.6943	0.	5198.
1989	0.	-45.	4375.	3195.	7525.	0.6260	0.	4711.	0.	7525.	0.6455	0.	4857.
1990	0.	450.	4375.	2738.	7563.	0.5790	0.	4377.	0.	7563.	0.6001	0.	4538.
1991	0.	944.	4375.	2282.	7602.	0.5355	0.	4071.	0.	7602.	0.5578	0.	4241.
1992	0.	1439.	4375.	1826.	7640.	0.4953	0.	3784.	0.	7640.	0.5186	0.	3962.
1993	0.	1934.	4375.	1369.	7679.	0.4581	0.	3518.	674.	7004.	0.4821	0.	3377.
1994	0.	2429.	4375.	913.	7717.	0.4237	0.	3270.	1214.	6503.	0.4482	0.	2914.
1995	-8403.	2923.	4375.	456.	7755.	0.3919	-3293.	3039.	1462.	6294.	0.4166	-3501.	2622.
TOTAL	38987.				72125.		40295.	40295.		68774.		40321.	40321.

***** INTERNAL RATE OF RETURN ***** 8.12 PER CENT (BEFORE TAX) 7.57 PER CENT (AFTER TAX)

***** PAY-OUT PERIOD ***** 7.41 YEAR (BEFORE TAX) 7.45 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		SOURCE OF FUNDS	
LAND AND SITE IMPROVEMENT	0.	PAID-UP SHARE CAPITAL	15647.
PROCESS PLANT	35940.	LONG TERM DEBT	36510.
CIVIL AND BUILDING	7068.	SHORT TERM DEBT	0.
CONSTRUCTED FACILITIES	43008.	FINANCIAL RESOURCES	52158.
PRE-INVEST AND START-UP EXP	2400.		
INTEREST DURING CONSTRUCTION	4768.		
TOTAL FIXED CAPITAL	50176.		
	1333.		
	649.		
INITIAL WORKING CAPITAL	1982.		
TOTAL CAPITAL COST	52158.		

Tab. III-4-5-1 (10)

*** PARAGUAY ELECTRICITY INTENSIVE CHEMICAL INDUSTRY ***
IRR CALCULATION ON TOTAL INVESTMENT

PVC INVESTMENT 10% DOWN

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	10217.	0.	0.	0.	0.	1.0000	10217.	0.	0.	0.	1.0000	10217.	0.
1984	19994.	0.	0.	0.	0.	0.9074	18051.	0.	0.	0.	0.9171	18244.	0.
1985	10757.	0.	0.	0.	0.	0.8233	8856.	0.	0.	0.	0.8410	9047.	0.
1986	1732.	-2159.	3938.	3282.	5061.	0.7470	1294.	3781.	0.	5061.	0.7713	1336.	3904.
1987	0.	-786.	3938.	3282.	6435.	0.6778	0.	4361.	0.	6435.	0.7073	0.	4552.
1988	0.	461.	3938.	3282.	7681.	0.6150	0.	4724.	0.	7681.	0.6487	0.	4983.
1989	0.	906.	3938.	2872.	7716.	0.5580	0.	4306.	0.	7716.	0.5949	0.	4590.
1990	0.	1351.	3938.	2462.	7750.	0.5063	0.	3924.	0.	7750.	0.5456	0.	4228.
1991	0.	1796.	3938.	2051.	7785.	0.4594	0.	3577.	784.	7001.	0.5003	0.	3503.
1992	0.	2240.	3938.	1641.	7820.	0.4169	0.	3260.	1120.	6699.	0.4589	0.	3074.
1993	0.	2685.	3938.	1231.	7854.	0.3782	0.	2971.	1343.	6511.	0.4208	0.	2740.
1994	0.	3130.	3938.	821.	7889.	0.3432	0.	2707.	1565.	6324.	0.3859	0.	2440.
1995	-7511.	3575.	3938.	410.	7923.	0.3114	-2339.	2467.	1788.	6136.	0.3539	-2658.	2172.
TOTAL	35088.				73914.		36078.	36078.		67314.		36185.	36185.

***** INTERNAL RATE OF RETURN ***** 10.21 PER CENT (BEFORE TAX) 9.04 PER CENT (AFTER TAX)

***** PAY-OUT PERIOD ***** 6.57 YEAR (BEFORE TAX) 6.78 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		SOURCE OF FUNDS	
LAND AND SITE IMPROVEMENT	0.	PAID-UP SHARE CAPITAL	14067.
PROCESS PLANT	32346.	LONG TERM DEBT	32823.
CIVIL AND BUILDING	6361.	SHORT TERM DEBT	0.
CONSTRUCTED FACILITIES	38707.	FINANCIAL RESOURCES	46890.
PRE-INVEST AND START-UP EXP	2160.		
INTEREST DURING CONSTRUCTION	4291.		
TOTAL FIXED CAPITAL	45158.		
	1149.		
	584.		
INITIAL WORKING CAPITAL	1732.		
TOTAL CAPITAL COST	46890.		

Tab. III-4-5-1 (11)

*** PARAGUAY ELECTRICITY INTENSIVE CHEMICAL INDUSTRY ***

IRR CALCULATION ON TOTAL INVESTMENT

PVC SALES PRICE 10% UP

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	11352.	0.	0.	0.	0.	1.0000	11352.	0.	0.	0.	1.0000	11352.	0.
1984	22104.	0.	0.	0.	0.	0.8934	19747.	0.	0.	0.	0.9086	20084.	0.
1985	11952.	0.	0.	0.	0.	0.7981	9539.	0.	0.	0.	0.8256	9868.	0.
1986	1982.	-1697.	4375.	3651.	6330.	0.7130	1413.	4513.	0.	6330.	0.7502	1487.	4748.
1987	0.	-46.	4375.	3651.	7980.	0.6370	0.	5083.	0.	7980.	0.6816	0.	5440.
1988	0.	1410.	4375.	3651.	9436.	0.5691	0.	5370.	0.	9436.	0.6194	0.	5845.
1989	0.	1905.	4375.	3195.	9475.	0.5084	0.	4817.	786.	8687.	0.5628	0.	4890.
1990	0.	2400.	4375.	2738.	9513.	0.4542	0.	4321.	1200.	9314.	0.5113	0.	4251.
1991	0.	2895.	4375.	2282.	9552.	0.4058	0.	3876.	1447.	8105.	0.4645	0.	3766.
1992	0.	3389.	4375.	1826.	9590.	0.3625	0.	3476.	1695.	7896.	0.4222	0.	3333.
1993	0.	3884.	4375.	1369.	9629.	0.3238	0.	3118.	1942.	7687.	0.3836	0.	2949.
1994	0.	4379.	4375.	913.	9667.	0.2893	0.	2797.	2189.	7478.	0.3496	0.	2606.
1995	-8493.	4873.	4375.	456.	9705.	0.2585	-2172.	2508.	2437.	7269.	0.3167	-2661.	2302.
TOTAL	38897.				90977.		39879.	39879.		79192.		40130.	40130.

***** INTERNAL RATE OF RETURN ***** 11.94 PER CENT (BEFORE TAX) 10.06 PER CENT (AFTER TAX)

***** PAY-OUT PERIOD ***** 5.99 YEAR (BEFORE TAX) 6.42 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	35740.
CIVIL AND BUILDING	7068.
CONSTRUCTED FACILITIES	43008.
PRE-INVEST AND START-UP EXP	2400.
INTEREST DURING CONSTRUCTION	4768.
TOTAL FIXED CAPITAL	50176.
	1333.
	649.
INITIAL WORKING CAPITAL	1982.
TOTAL CAPITAL COST	52158.

SOURCE OF FUNDS

PAID-UP SHARE CAPITAL	15647.
LONG TERM DEBT	36510.
SHORT TERM DEBT	0.
FINANCIAL RESOURCES	52158.

Tab. III-4-5-1 (12)

*** PARAGUAY ELECTRICITY INTENSIVE CHEMICAL INDUSTRY ***
IRR CALCULATION ON TOTAL INVESTMENT

PVC RAW MATERIAL COST 10% DOWN

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	11352.	0.	0.	0.	0.	1.0000	11352.	0.	0.	0.	1.0000	11352.	0.
1984	22104.	0.	0.	0.	0.	0.9159	20246.	0.	0.	0.	0.9224	20398.	0.
1985	11952.	0.	0.	0.	0.	0.8389	10027.	0.	0.	0.	0.8508	10168.	0.
1986	1880.	-2721.	4375.	3644.	5298.	0.7684	1445.	4063.	0.	5298.	0.7847	1476.	4150.
1987	0.	-1322.	4375.	3644.	6697.	0.7038	0.	4714.	0.	6697.	0.7238	0.	4847.
1988	0.	-22.	4375.	3644.	7997.	0.6446	0.	5155.	0.	7997.	0.6676	0.	5339.
1989	0.	477.	4375.	3180.	8036.	0.5904	0.	4744.	0.	8036.	0.6158	0.	4948.
1990	0.	966.	4375.	2733.	8074.	0.5408	0.	4365.	0.	8074.	0.5680	0.	4586.
1991	0.	1460.	4375.	2277.	8113.	0.4953	0.	4018.	0.	8113.	0.5239	0.	4250.
1992	0.	1854.	4375.	1922.	8151.	0.4537	0.	3698.	388.	7763.	0.4832	0.	3751.
1993	0.	2447.	4375.	1366.	8189.	0.4155	0.	3403.	1224.	6966.	0.4457	0.	3104.
1994	0.	2941.	4375.	911.	8229.	0.3806	0.	3131.	1471.	6757.	0.4111	0.	2778.
1995	-8302.	3435.	4375.	455.	8266.	0.3486	-2894.	2882.	1718.	6549.	0.3792	-3148.	2483.
TOTAL	38987.				77040.		40175.	40175.		72240.		40236.	40236.

***** INTERNAL RATE OF RETURN ***** 9.18 PER CENT (BEFORE TAX) 8.42 PER CENT (AFTER TAX)

***** PAY-OUT PERIOD ***** 6.96 YEAR (BEFORE TAX) 7.01 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	35940.
CIVIL AND BUILDING	7068.
CONSTRUCTED FACILITIES	43008.
PRE-INVEST AND START-UP EXP	2400.
INTEREST DURING CONSTRUCTION	4768.
TOTAL FIXED CAPITAL	50176.
	1297.
	584.
INITIAL WORKING CAPITAL	1880.
TOTAL CAPITAL COST	52056.

SOURCE OF FUNDS	
PAID-UP SHARE CAPITAL	15617.
LONG TERM DEBT	36439.
SHORT TERM DEBT	0.
FINANCIAL RESOURCES	52056.

Tab. III-4-5-1 (13)

*** 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.	-778.	3050.	2501.	4573.	0.7111	0.	3251.	0.	4573.	0.7285	0.	3331.
1988	0.	-155.	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.	955.	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.	939.	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	-2073.	1728.
TOTAL	27174.				52226.		27800.	27800.		49388.		27840.	27840.

***** INTERNAL RATE OF RETURN ***** 9.90 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.

Tab. III-4-5-1 (14)

*** PARAGUAY ELECTRICITY INTENSIVE CHEMICAL INDUSTRY ***
IRR CALCULATION ON TOTAL INVESTMENT

ELECTROLYSIS INVESTMENT 10% DOWN

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	7125.	0.	0.	0.	0.	1.0000	7125.	0.	0.	0.	1.0000	7125.	0.
1984	13979.	0.	0.	0.	0.	0.9004	12587.	0.	0.	0.	0.9127	12758.	0.
1985	7395.	0.	0.	0.	0.	0.8108	5996.	0.	0.	0.	0.8330	6159.	0.
1986	431.	-1090.	2745.	2249.	3904.	0.7301	461.	2850.	0.	3904.	0.7602	490.	2968.
1987	0.	-284.	2745.	2249.	4709.	0.6574	0.	3096.	0.	4709.	0.6938	0.	3267.
1988	0.	531.	2745.	2249.	5524.	0.5919	0.	3270.	0.	5524.	0.6332	0.	3498.
1989	0.	836.	2745.	1967.	5548.	0.5330	0.	2957.	0.	5548.	0.5779	0.	3207.
1990	0.	1142.	2745.	1686.	5573.	0.4799	0.	2675.	567.	5005.	0.5274	0.	2640.
1991	0.	1447.	2745.	1405.	5598.	0.4322	0.	2419.	724.	4874.	0.4814	0.	2346.
1992	0.	1753.	2745.	1124.	5622.	0.3891	0.	2188.	876.	4746.	0.4393	0.	2085.
1993	0.	2059.	2745.	843.	5647.	0.3504	0.	1979.	1029.	4617.	0.4010	0.	1851.
1994	0.	2364.	2745.	562.	5671.	0.3155	0.	1789.	1182.	4489.	0.3659	0.	1643.
1995	-4673.	2670.	2745.	281.	5696.	0.2841	-1328.	1618.	1335.	4361.	0.3340	-1561.	1456.
TOTAL	24456.				53491.		24841.	24941.		47778.		24961.	24961.

***** INTERNAL RATE OF RETURN ***** 11.06 PER CENT (BEFORE TAX) 9.57 PER CENT (AFTER TAX)

***** PAY-OUT PERIOD ***** 6.23 YEAR (BEFORE TAX) 6.54 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		SOURCE OF FUNDS	
LAND AND SITE IMPROVEMENT	0.	PAID-UP SHARE CAPITAL	9636.
PROCESS PLANT	23084.	LONG TERM DEBT	22485.
CIVIL AND BUILDING	4334.	SHORT TERM DEBT	0.
CONSTRUCTED FACILITIES	27418.	FINANCIAL RESOURCES	32122.
PRE-INVEST AND START-UP EXP	1080.		
INTEREST DURING CONSTRUCTION	2992.		
TOTAL FIXED CAPITAL	31491.		
	541.		
	90.		
INITIAL WORKING CAPITAL	631.		
TOTAL CAPITAL COST	32122.		

Tab. III-4-5-1 (15)

*** PARAGUAY ELECTRICITY INTENSIVE CHEMICAL INDUSTRY ***
FOR CALCULATION ON TOTAL INVESTMENT

ELECTROLYSIS SALES PRICE 10% UP

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.	0.8952	13904.	0.	0.	0.	0.9075	14127.	0.
1985	8216.	0.	0.	0.	0.	0.8014	6584.	0.	0.	0.	0.8272	6797.	0.
1986	741.	-1021.	3050.	2501.	4530.	0.7174	532.	3250.	0.	4530.	0.7524	558.	3408.
1987	0.	-96.	3050.	2501.	5455.	0.6422	0.	3503.	0.	5455.	0.6843	0.	3733.
1988	0.	823.	3050.	2501.	6374.	0.5749	0.	3664.	0.	6374.	0.6274	0.	3967.
1989	0.	1163.	3050.	2189.	6401.	0.5146	0.	3294.	434.	5957.	0.5661	0.	3378.
1990	0.	1502.	3050.	1876.	6428.	0.4607	0.	2961.	751.	5677.	0.5149	0.	2923.
1991	0.	1842.	3050.	1563.	6455.	0.4124	0.	2662.	921.	5534.	0.4693	0.	2592.
1992	0.	2182.	3050.	1251.	6483.	0.3692	0.	2393.	1091.	5392.	0.4259	0.	2297.
1993	0.	2522.	3050.	938.	6510.	0.3305	0.	2151.	1261.	5249.	0.3874	0.	2033.
1994	0.	2862.	3050.	625.	6537.	0.2958	0.	1934.	1431.	5106.	0.3524	0.	1799.
1995	-5232.	3202.	3050.	313.	6565.	0.2648	-1386.	1738.	1601.	4964.	0.3205	-1677.	1591.
TOTAL	27174.				61737.		27551.	27551.		54247.		27721.	27721.

***** INTERNAL RATE OF RETURN ***** 11.71 PER CENT (BEFORE TAX) 9.95 PER CENT (AFTER TAX)

***** PAY-OUT PERIOD ***** 6.01 YEAR (BEFORE TAX) 6.41 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.

Tab. III-4-5-1 (16)

*** PARAGUAY ELECTRICITY INTENSIVE CHEMICAL INDUSTRY ***
IRR CALCULATION ON TOTAL INVESTMENT

ELECTROLYSIS RAW MATERIAL COST 10% DOWN

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.	0.9163	14232.	0.	0.	0.	0.9224	14327.	0.
1985	8216.	0.	0.	0.	0.	0.8396	6898.	0.	0.	0.	0.8508	6990.	0.
1986	726.	-1692.	3050.	2500.	3858.	0.7693	558.	2968.	0.	3858.	0.7848	569.	3027.
1987	0.	-907.	3050.	2500.	4642.	0.7049	0.	3273.	0.	4642.	0.7239	0.	3361.
1988	0.	-85.	3050.	2500.	5465.	0.6459	0.	3530.	0.	5465.	0.6677	0.	3649.
1989	0.	254.	3050.	2188.	5492.	0.5919	0.	3250.	0.	5492.	0.6159	0.	3382.
1990	0.	594.	3050.	1875.	5519.	0.5423	0.	2993.	0.	5519.	0.5681	0.	3135.
1991	0.	934.	3050.	1563.	5546.	0.4969	0.	2756.	0.	5546.	0.5240	0.	2906.
1992	0.	1274.	3050.	1250.	5574.	0.4553	0.	2538.	186.	5388.	0.4833	0.	2604.
1993	0.	1614.	3050.	938.	5601.	0.4172	0.	2337.	807.	4794.	0.4458	0.	2137.
1994	0.	1953.	3050.	625.	5628.	0.3823	0.	2152.	977.	4652.	0.4112	0.	1913.
1995	-5217.	2293.	3050.	313.	5655.	0.3503	-1828.	1981.	1147.	4509.	0.3793	-1979.	1710.
TOTAL	27174.				52980.		27778.	27778.		49864.		27824.	27824.

***** INTERNAL RATE OF RETURN ***** 9.13 PER CENT (BEFORE TAX) 8.41 PER CENT (AFTER TAX)

***** PAY-OUT PERIOD ***** 6.93 YEAR (BEFORE TAX) 6.96 YEAR (AFTER TAX)
(THE YEAR WHEN THE TOTAL CAPITAL COST WILL BE PAID OUT BY ACCUMULATED TOTAL RETURN, FROM THE BEG. OF OPERATION)

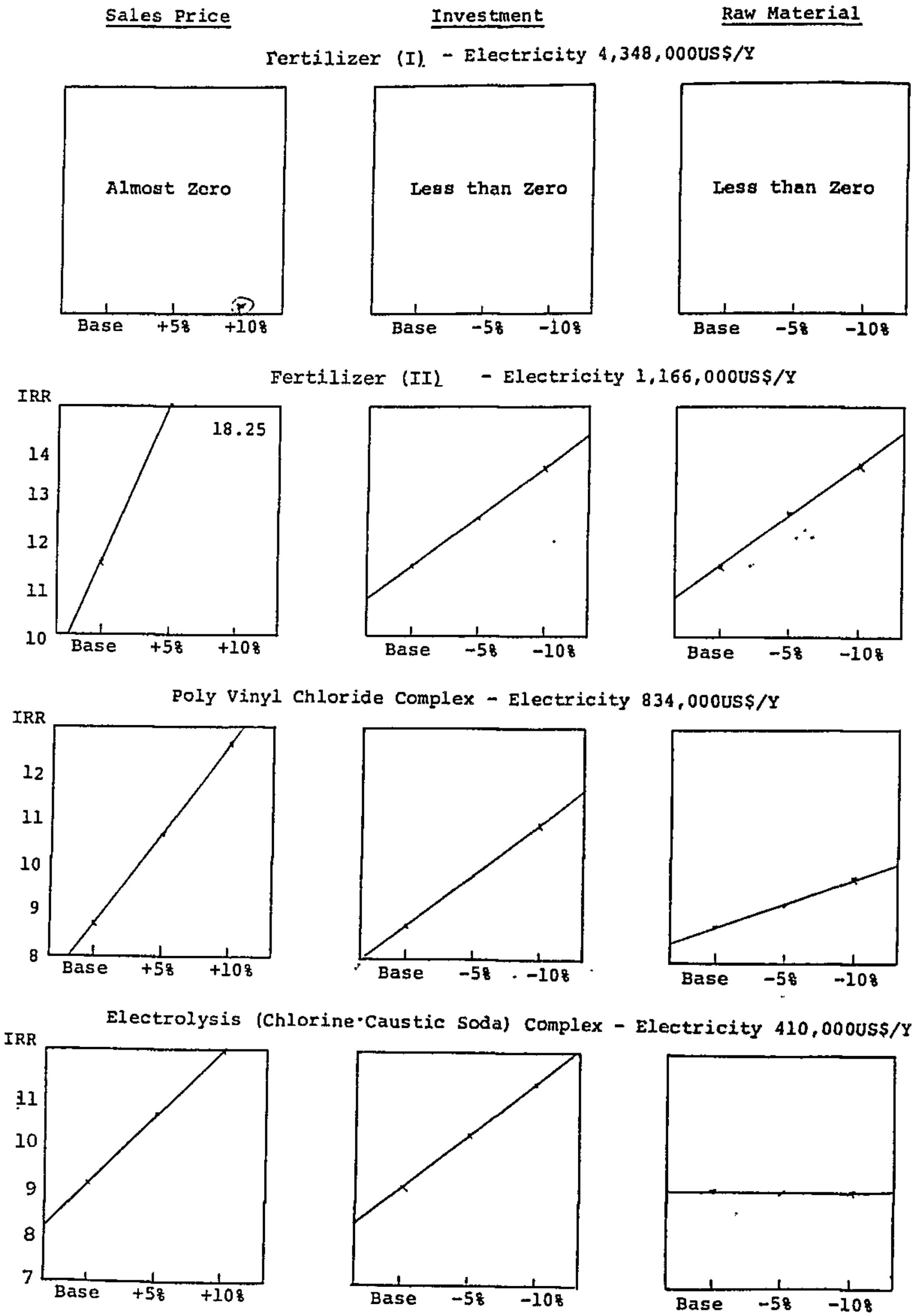
CAPITAL REQUIREMENTS

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.
	636.
	90.
INITIAL WORKING CAPITAL	726.
TOTAL CAPITAL COST	35715.

SOURCE OF FUNDS

PAID-UP SHARE CAPITAL	10715.
LONG TERM DEBT	25001.
SHORT TERM DEBT	0.
FINANCIAL RESOURCES	35715.

Fig. III-4-5-1 Internal Rate of Return of the Projects



4-6 Alternative Processes for the Selected Electricity-Intensive Processes

Of the projects taken into consideration in this study, the processes for production of elementary phosphorus, caustic soda and chlorine are the same as those used currently in various countries around the world. The price competitiveness of these projects is determined by the cost of secondary raw materials such as rock phosphate, rock salt, coke, etc., transportation cost to the consumption center and production scale merit, in addition to the electricity cost. Project feasibility is conditioned on confirmation of these factors.

On the other hand, ammonia as a nitrogenous fertilizer, DAP as a phosphatic fertilizer and PVC as a synthetic resin are produced using other processes in most countries of the world. Accordingly, it is necessary to analyze other factors in order to make a comparison of the price competitiveness of processes proposed here. A comparison of general character is carried out in this study.

4-6-1 Production of Ammonia

The production facilities considered for Paraguay are of relatively small scale, in view of the distance from large markets, and therefore it is not possible to make use of the scale merit as in the case of plants many other countries. This results in relatively high cost. Even when large scale production taking into consideration the possibility of export is considered, there is still the competition of the electricity cost with the natural gas cost (cost element of rival process).

Currently, the raw material for production of ammonia is dominating the world market is natural gas. Cost analysis for an economic scale ammonia plant using natural gas as raw material is as follows:

Production cost: US$260/ton (metric ton of ammonia)

Capital cost (interest, depreciation, etc.:	US$100/ton
Manpower cost (incl. overhead) and others:	US$40/ton
Feed stock (natural gas) 30MMBTU x 4* =	US$120/ton

Of the aforementioned cost items, the first two items are practically common to all countries of the world. In addition, the gas cost in advanced industrial regions is of the order of US$4* to 5/MMBTU. On the other hand, in the case of plants where feed stock is economically available (e.g. feed stock US$1.0/MMBTU) such as in oil producing regions with surplus natural gas, there is extremely high competitiveness be cause the feed stock cost becomes 30 US$ which means 170 US$/ton must product.

The consumption of electricity in the case of production of ammonia by electrolysis of water is approximately 12,000KWH/ton. Accordingly, electricity should be available at (*MMBTU 1.0$) 3,000¢/12,000 = 0.25¢/KWH, in order to make the aforementioned feedstock cost of 30$/ton equivalent to the electricity cost, even when the capital cost and manpower cost are lowered to the same level as the alternative process by means of a plant sufficiently large in scale. Competition is impossible even with an electricity cost of 1.0¢/KWH unless a rise in the natural gas price reaches 4.0$/MMBTU instead of the current 1.0$/MMBTU through measures such as export of LNG by natural gas producing nations. It is necessary bear in mind that the transportation cost is not taken into consideration in this discussion, however. With regard to ammonia consumed in Paraguay and neighbouring areas, the aforementioned cost difference can be bridged by adding the transportation cost to the international market price. As a consequence, competition with an electricity cost of 1.0¢ becomes possible. When the merits of production in Paraguay and the merits of a ammonia-phosphorus-DAP complex take into consideration together the natural gas price rise and the necessity of production of phosphatic fertilizer in Paraguay, the production of ammonia by means of the electrolysis of water may become feasible.

Particularly in the case of inland countries like Paraguay, which do not have access to the ocean, transshipment, storage in warehouses, etc., require considerable costs in the case of import commodities like fertilizer and therefore, there is the possibility of an extremely expensive farmer's gate price for the imported product. Such being the case, there is a possibility of pertinency of production of ammonia by electrolysis of water or by coal gasfication when natural gas is not available.

The following factors should be taken into consideration when discussing the production of ammonia by electrolysis of water in Paraguay.

- Opportunity price of electricity (price in case of alternative use)
- Availability and price of natural gas from Bolivia or Argentina
- Production of ammonia from natural gas in areas neighbouring Paraguay.

4-6-2 Production of Phosphorous Fertilizers

The most popular method for production of phosphatic fertilizers from rock phosphate currently in use is the decomposition of rock phosphate with sulfuric acid for production of phosphoric acid, followed by the reaction of the phosphoric acid with ammonia. In this case the cost of sulfuric acid is one of the most important factors. On the other hand, there is also another method whereby rock phosphate is decomposed by nitric acid to produce phosphoric acid, followed by reaction of the phosphoric acid with ammonia. In the latter case the market for calcium nitrate (CAN) obtained as a byproduct of the process and the economical availability of ammonia, which is the raw material for production of nitric acid, are key factors.

The process by which phosphorus is produced by the reduction of rock phosphate with an electric furnace is considered pertinent in case of utilization of rock phosphate in the form of either phosphorus or phosphoric acid when the rock phosphate deposit is located in an inland area (in this case the export of rock phosphate as is requires too high a transportation cost) and electricity is economically available.

As a matter of fact, the world phosphatic fertilizer market is currently dominated by exports from the U.S., Morocco, Jordan, etc. In Paraguay the farmer's gate price for phosphatic fertilizer is too expensive due to import and transportation costs from these international sources, and it is presumed that this is one of the factors contributing restriction its consumption. Accordingly, should rock phosphate be available at the international price level, i.e., 50 to 60$/ton, the phosphatic fertilizer production project becomes quite feasible from the economic point of view with an electricity cost of 1¢/KWH. On the other hand, with regard to the phosphoric acid project using the decomposition of rock phosphate with sulfuric acid method, there is a possibility for production of phosphoric acid at considerably low cost if it is combined with a Cu and Zn smelter project using sulfide ores as raw materials, and evaluating the sulfuric acid obtained as a byproduct at low cost. We, therefore, consider it necessary to study carefully the possibility of materialization of projects of this kind in neighbouring countries before deciding on implementation of phosphor route phosphatic fertilizer project.

Comparison of DAP Cost

Unit: US$/ton

	Standard Cost Prevailing Currently in the World	Cost in Paraguay (Inferred)
Capital	46.1	132
Phosphate Rock	80.0	80
Sulphur	54.0	-
Ammonia	23.0	60 (excluded KWH)
Electricity	2.0	58
Others	35	10
	238	340

The high cost compared with the international price is due to the small scale of the plant considered here, which results in a large proportion of fixed cost. The cost of electricity (including ammonia and phosphor) should be 1¢/KWH, otherwise the electricity cost can not equal the sulfur cost for production of sulfuric acid. We presume that it is possible to attain sufficient competitiveness compared with the international market price plus freight in case of reduction of the fixed cost through future expansion of scale, provided the phosphate rock cost and electricity cost are maintained at the above level.

4-6-3 Production of PVC

Polyvinyl chloride is popular for a wide variety of applications such as construction materials, etc., as a representative of the thermoplastic resin family. In most countries of the world, PVC is produced from ethylene obtained by decomposing the hydrocarbon contained in naphtha or natural gas.

In other words, VCM (vinyl chloride monomer) is obtained from ethylene and chlorine by means of the oxychlorination process (reaction of the expression below) and PVC is obtained by further polymerization of the monomer.

$$4C_2H_4 + 2Cl_2 + O_2 \rightarrow 4C_2H_3Cl + 2H_2O$$

In this process the cost of ethylene represents 25% of the total cost. The key point is how to obtain ethylene at low cost. The prices of naphtha and ethane, which are the raw materials for production of ethylene, are showing a rising tendency. Accordingly, we consider it possible to produce PVC at the same price levels as imports should electricity and coke be available at advantageous prices in Paraguay provided that a plant of economical scale is built. However, the PVC market which exists currently in Paraguay and in neighbouring areas may not be able to ensure a consumption sufficient to justify the construction of a plant of economical scale. Accordingly, it is necessary to improve the viability of the project by measures such as the introduction of low interest rate funds for construction of the plant.

If ethane obtained from natural gas from Bolivia and Argentina is abundantly available at low cost, it is necessary to carry out a comparative study of the production of PVC by integrating the chlorine project utilizing electricity generated in Paraguay and the project aimed at making use of ethylene obtained by decomposition of ethane, as in the case of the ammonia production project.

The cost for production of PVC from ethylene in various countries of the world is presumed to be as follows:

(1979)	U.S.A.	Japan	West Germany
Variable Cost (US$/ton PVC)			
Ethylene	248.6	354.4	344.0
Chlorine	100.8	127.9	98.3
Cat. Chem.	24.2	24.2	24.2
Sub-total	373.6	506.2	466.2
Utility			
Electricity (3¢/KWH)	22.4	(assume same as U.S.A.)	
Fuel Steam CW	23.9		
Sub-total	46.3		

	U.S.A.	Japan	West Germany
Manpower	18.9		
Capital Cost	103.7	(assume same as U.S.A.)	
Miscellaneous	76.0		
Sub-total	198.6	751.9	711.8
Sales Expense (5%)	28.3		
Return (20%)	129.0		
Total (1980 US$/ton)	776.3	909.2	869.1

The price above is ex-factory for 1980 and is of the order of 900$/ton in 1981. It is presumed that it will reach approximately 1,100 to 1,200$/ton in Paraguay. Currently the world market is influenced by the cheap prices quoted by the U.S. due to the worldwide recession but on a long-term basis it is possible to assume prices of the order of 1,300$/ton in Paraguay. After the reduction of capital cost is attained as depreciation proceeds, it is presumed that the product turned out domestically in Paraguay will acquire competitiveness compared with imports. It is indispensable to raise funds at low interest in order to improve the financial viability of the project.

IV. Subjects to be Scrutinized during Detailed Feasibility Studies

1. Detailed Revision of Plant Construction Costs

The construction costs taken into consideration here cover only the auxiliary facilities normally required in cases such as those studied here. The cost of infrastructures such as the construction of harbour facilities exclusive for the project, railway sidings, roads, townships, etc., are not taken into consideration. Also with regard to preparation of the land required for construction of plant, it is assumed that a sufficient area of flat land of high bearing capacity is available at low cost. Investments related to infrastructure are closely related with selection of the project site as they have an important influence on the economical feasibility of the project. A detailed field survey will therefore be required.

2. Revision of Prices for Acquisition of Raw and Auxiliary Materials

The plant gate price of rock phosphate is an important element in determination of the production cost of phosphor and fertilizers of the phosphoric acid family. Furthermore, the price of carbonic materials, which are used to produce carbide and phosphor is another element which will influence the cost of production. This study is carried out on the assumption that these materials will be imported. It is, however, possible to reduce considerably the cost of acquisition of carbon sources should coke be available in Paraguay or in the Southwestern part of Brazil, and in particular, should there be any plans for construction of coking facilities for processing of residue to increase light product at a petroleum refinery.

3. Transportation System to be Developed for Export of Phosphorus

Phosphorus is a product which may have international competitiveness should there be low cost rock phosphate available in Paraguay or in Southwestern Brazil, in addition to cheap electricity, because its production consumes large amounts of electricity.

However, its handling and transportation requires special care because it catches fire when exposed to air. Accordingly, the system for transportation of phosphor to consumption centers in neighbouring countries requires careful study from both the technical and economic points of view.

4. Training of Personnel for Industrial Projects

Various engineers and experts are needed for building a chemical industry project from the ground-up. It is possible to hire experienced foreign personnel in order to carry out the work and provide training for the Paraguayan personnel but this alternative would require considerable expense (several US$ million). Accordingly, it may have a negative influences on project profitability, particularly in the case of a small scale project. On the other hand, it is indispensable to hire highly qualified technical personnel in order to assure efficient operation of the plant. It is desirable to obtain some technical assistance by the government in order to attain the required transfer of technology without excessive cost to the project itself.