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

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GHANA

Technical report comprising opportunity studies on a caustic soda/chlorine plant and on cassava starch processing *

Prepared for the Government of Ghana
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of Michael Nowak, chemical engineer

Backstopping officer: U. Loeser, Feasibility Studies Branch

United Nations Industrial Development Organization
Vienna

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* This document has not been edited.

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1. FINDINGS

During the mission, two opportunity studies were prepared by me, i.e.:

- "Opportunity Study for the Establishment of Caustic Soda\Chlorine Plant in Ghana" (Appendix I)
- "Opportunity Study for the Manufacture of Industrial & Pharmaceutical Cassava Starch" (Appendix II)

Both projects appeared to be feasible for Ghana.

2. RECOMMENDATIONS

2.1 As to the Caustic Soda\Chlorine Plant:

2.1.1 In my opinion, the most appropriate production programme of this plant, will be the manufacturing of caustic soda along with liquefied chlorine and two other chlorine-derivatives i.e.: hydrochloric acid and sodium hypochlorite.

The recommended capacities are as follows:

15,000 tons caustic soda p.a., and processing of gaseous chlorine into the following products:

hydrochloric acid - 1,000 tons p.a., and

sodium hypochlorite - 500 tons (as active Cl_2) p.a.

Remaining chlorine in quantity of 11,650 tons p.a., ought to be liquefied and mostly exported.

2.1.2 In a follow-up, the effort ought to be made to estimate the international market potential for absorbing the above quantity of liquid chlorine (especially in neighboured countries), as well as possibility of increasing its consumption on the local market.

2.1.3 In case, the export potential of chlorine would fall far short of the above quantity, the manufacturing of other chlorine - derivative products, (specified additionally in the study), can be considered, subject to a market study. Then preparation of the second, integral part of the pre-feasibility study on manufacture of other chlorine-derivative products would be necessary.

2.2 As to Cassava Starch Plant:

It is recocommended to divide the project implementation into two phases, i.e.

2.2.1 In the First Phase of the project implementation, only processing cassava into starch (as the final product) will take place. The starch ought to be produced from dried cassava chips, which constitute the most appropriate raw material, with a long shelf life, and thereby securing regular supply of cassava for starch production.

2.2.2 The Second Phase of the project implementation, (processing starch into glucose), ought to be considered later on, however provisions in the original plant layout for this production, ought to be made at present.

Opportunity Study

for

the Establishment of a Caustic Soda/Chlorine Plant

1. INTRODUCTION

The purpose of this study was twofold:

(a) prepare the appropriate and up-dated opportunity Study for the Establishment of Caustic Soda\Chlorine Plant in Ghana.

(b) propose possible methods of utilization of the generated chlorine (listing the most appropriate chlorine-based products and elaborating their technologies).

2. THE PROJECT

2.1 SUMMARY

2.1.1 The proposed Caustic Soda Plant is composed of Caustic Soda Unit and Chlorine Processing Unit. Caustic soda production is based on electrolytic, ion exchange membrane process.

2.1.2 Basic data on the proposed Caustic Soda Plant:

2.1.2.1 Production figures:

Caustic Soda (calculated as 100%)	- 15,000 tons per annum
Chlorine (gas)	- 13,125 tons per annum

Chlorine gas will be processed in the following units:

Chlorine Liquefaction Plant	- 11,650 tons per annum
Hydrochloric Acid Plant	- 1,000 tons (as 100% HCl) per annum
Sodium Hypochlorite Plant	- 500 tons active chlorine per annum

2.1.2.2 Production Period - 300 days a year

Operation Time - 3 shifts of 8 hour each

2.1.2.3 Employment : 120 persons

2.1.2.4 Total Investment Cost : US$ 22,595,000

2.1.2.5 Project Construction Period : 24 months

2.1.2.6 Financial Structure:

- Equity	US$ 4,430,000
- Long Term Loans	US$ 18,165,000
	US$ 22,595,000

2.1.2.7 Profitability:

- Rate of Return : 22%
- Payback Period : 4.5 years (including 2 years of construction)

2.3 RECOMMENDATIONS:

Market study on prospective users of chlorine derivative products ought to be prepared. Estimation of the demand for chlorine-derivative products in Ghana and in other countries (particularly in West Africa), would allow for preparation of the second, integral part of this opportunity study.

3. MARKET ANALYSIS

3.1 Main users of caustic soda in Ghana are: detergent and soap industry, pulp and paper industry, textile industry and man-made fibre industry. Main users of chlorine and its derivatives are: detergent and textiles industries. At present, the country's requirement for caustic soda, chlorine and its derivatives are met entirely through the importation.

3.2 According to NIB's "Market Study Report on Caustic Soda" (March 1990) (1), the caustic soda consumption and projections up to 1992 in Ghana are as follows:

Industry	1987	1988	1989	1990	1991	1992
Detergent & soap, t\y	2,810	3,737	4,235	4,940	5,520	6,280
Textile, t\y	806	775	937	1,400	1,600	1,730
Total: (t\y)	3.616	4,512	5,172	6,340	7,120	8,010

(caustic soda calculated as 100% NaOH)

Previous study (3) revealed, that apart from the above two industries, there are a host of other industries (like: paper, plastics, petroleum refining etc.), where the alkaline properties of caustic soda are exploited to the extent of about 20% of the total demand. Correction of the above figures, and assumption of the same increasing trend in demand in coming years, gives the following projection of caustic soda consumption:

Industry	Quantity tons per annum					
	1990	1991	1992	1993	1994	1995
Detergent & soap	4,940	5,520	6,280	7,065	7,948	8,942
Textile	1,400	1,600	1,730	1,943	2,189	2,458
Others	1,585	1,780	2,002	2,252	2,533	2,850
Total	7,925	8,900	10,012	11,260	12,670	14,250

(caustic soda calculated as 100% NaOH)

3.3 As to chlorine derivatives, the Daewoo's Feasibility Study (2) prepared in 1986, estimated the potential annual demand in Ghana for hydrochloric acid at 460 tons (33% solution HCl). The NIB's Market Study Report (1) presents the following figures concerning consumption and projections of hydrochloric acid in two basic consuming industries in Ghana:

Industry	1987	1988	1989	1990	1991	1992
Detergent & soap, t\y	58	103	324	411	531	596
Textile, t\y	26	31	25	30	36	42
Total: t\y	84	134	349	441	567	638

The above studies clearly show that if the caustic soda project would be realized, the bulk of the production of hydrochloric acid should be <u>either</u> processed into other chemicals <u>and\or</u> exported to neighbouring African countries who rely on the importation.

3.4 Data on the consumption of chlorine in Ghana are not readily available, however, some idea on its demand can be drawn from the consumption figures of some users of bleaching agents (bleaching powder, bleaching liquor and calcium hypochlorite) and chlorine.

Consumption of bleaching agents in textile industry, and water & sewerage treatment was estimated (1) for the second half of 80's on 822 t\y.

Consumption of chlorine gas in sewenage & water treatment was estimated (1) for the second half of 80's on approx. 300 t\y.

3.5 Data on the consumption and\or projections of other chlorine - derivatives like: aluminium chloride, calcium chloride, ammonium chloride, zinc chloride, chlorinated paraffin wax, and chloroacetic acid were not available.

3.6 As the result of market analysis, capacity of the plant at 15,000 t\y caustic soda (calculated as 100%) can be proposed. This production capacity can satisfy requirements of the local industry for caustic soda, at present and in the nearest future. The above plant capacity require however the establishment of a variety of accompanying units, able to process apporoximately 13,000 t\y of chlorine into chlorine-derivative saleable products. The local demand for chlorine and its derivatives stands at present at approx. 700 t\y (calculated as 100% Cl_2).

3.7 Market analysis performed by the Daewoo Corp. (2) confirmed that the proposed plant capacity of 5,500 t\y of caustic soda (calculated as 100% NaOH) will fall far short of the local industry requirements (page 22), however, the whole study was based on the plant capacity equal to 4,950 t\y of caustic soda (calculated as 100% NaOH) (page 17). In fact, the above capacity will be too small to satisfy local demand for caustic soda, and simultaneously too large in comparison with the local demand for chlorine and its derivatives. It means, that after establishment of a such plant, necessity of further importation of caustic soda and exportation of excess chlorine and its derivatives will remain.

3.8 For the purpose of this study, plant capacity at 15,000 t\y of caustic soda (calculated as 100% NaOH) has only been taken into consideration.

4. **PRODUCTION PROGRAMME**

4.1 The production programme proposed in this study is as follows:

(all products are calculated as 100%)

Caustic Soda	-	15,000 tons p.a.
Chlorine (liquid)	-	11,650 tons p.a.
Hydrochloric Acid	-	1,000 tons p.a.
Sodium Hypochlorite	-	500 tons of active Cl_2 p.a.

The above production programme seems the most appropriate for the local conditions.

4.2 It is worth to say, that the production programme for caustic soda\chlorine plant, proposed in 1984 for Bangladesh by Intercontinental Project Developers, USA (6) was as follows:

Caustic Soda (as 100%)	-	9,000 tons p.a.
Chlorine (liquid) (as 100%)	-	6,900 tons p.a.
Hydrochloric Acid (as 100%)	-	600 tons p.a.
Sodium Hypochlorite	-	300 tons of active Cl_2 p.a.

The production programme of caustic soda\chlorine plant being implemented in 1990 in Brazil by OXY, USA (5) is reported to be as follows:

Caustic Soda	-	112,000 tons p.a.
Chlorine	-	100,000 tons p.a.
Hydrochloric Acid	-	27,600 tons p.a.
Sodium Hypochlorite	-	7,200 tons p.a.

4.3 Daewoo Corporation in its Feasibility Study (2) suggested importation of calcium hydroxide for bleaching powder and lime bleach production. The value of the required amount of imported calcium hydroxide constituted about 80% of the total cost of raw materials.

4.4 Through the structure of the production programme proposed in this study, the cost of raw materials will be considerably reduced, in comparison to that suggested by Daewoo (2).

5. MATERIALS

5.1 RAW MATERIALS INPUT

5.1.1 Salt

Common salt (sodium chlorine) is the basic raw material for caustic soda-chlorine production by the electrolytic process. The consumption of the raw materials depends on the common salt quality. The raw material for salt production in Ghana is sea-water, from which the salt is produced by solar evaporation method.

The approximate average composition of seawater around Accra is (3):

Water	95.85%
Sodium Chloride	2.29%
Potassium Chloride	0.08%
Magnesium Chloride	0.37%
Magnesium Sulphate	0.22%
Calcium Sulphate	0.10%
Calcium Carbonate	0.01%

There are local firms producing crude salt, which as a table salt is sold locally and partly exported to other African countries. According to the analysis results of salt by Astek Laboratory, percentage composition of salt on wet basis is as follows (2):

Moisture	7.7%
Water Soluble Matters	0.09%
Total Chlorides (NaCl)	94.9%
Calcium (as $CaSO_4$)	0.18%
Magnesium (as Mg)	0.34%
Magnesium (as $MgCl_2$)	1.13%
Soluble Sulphate	0.59%
Alkalinity (as $CaCO_3$)	0.02%

Salt is produced in abundance in the costal areas of Ghana throughout the year, except 4 months in the rainy season. The total annual salt production of Ghana was estimated at 130,000 to 150,000 tons in 1976, and reached level of about 360,000 tons in 1979 (3). The above facts show that besides domestic consumption, a large quantity of common salt is available for industrial users in Ghana. The quantity of available common salt is much above the requirement of the proposed caustic soda plant.

5.1.2 **Raw Materials Requirement.**

Annual consumption of major raw materials for the manufacturing of 15,000 tons of caustic soda p.a., is estimated as follows:

Common Salt (as 100% NaCl.)	-	25,500 tons
$Na_2 CO_3$	-	165 tons
NaSH	-	3 tons
NaOH	-	450 tons
HCl	-	375 tons
H_2SO_4	-	300 tons

Common salt produced in Ghana is of rather poor quality and therefore, if the crude salt is to be used, the consumption figures of raw materials will be higher than that mentioned above.

The following raw materials will be supplied locally:

- Common salt,
- NaOH,) from the proposed plant
- HCl)

The following raw materials will be imported:

- $Na_2 Co_3$,
- NaSH
- H_2SO_4

5.1.3 The current prices of raw materials required for caustic soda manufacturing are as follows:

		Local Price in US$ per ton	International Price (4) in US$ per ton
-	Common Salt	48	
-	Na_2CO_3 (Soda Ash)		150
-	NaSH		676
-	NaOH (as 100%)		560
-	HCl (as 100%)		300
-	H_2SO_4 (as 100%)		75

5.2 **UTILITIES**

The Caustic Soda Plant annual requirements for major utility supplies are as follows:

		Quantity	Price
-	Electric Power	40,500,000 kWh	US$ 0.0155 per kWh
-	Fuel Oil	1,640 tons	US$ 356 per ton
-	Processing & Cooling Water	286,000 m^3	US$ 0.38 per m^3

All utilities are locally available.

6. **LOCATION**

The proposed Caustic Soda Plant is to be located in Tema, close to salt supply, good traffic network and harbour facilities. Other factors are. approximity to utility sources like water and electric power, as well as availability of skilled and semi-skilled workers, as Tema is one of the biggest industrial areas in Ghana. The site has remarkable marketing advantage i.e. there are many demand sources such as soap production plants, textile mills, petroleum refinery, pulp and paper mills and other users of caustic soda and chlorine products located as well in Tema, as in nearby Accra.

7. PROCESS DESCRIPTION

7.1 Manufacturing of caustic soda, chlorine and some chlorine derivatives (according to the proposed production programme).

7.1.1 Brine Treatment System.

Salt is added to the dissolvers by elevator e.g. twice a day during 2-3 hours. From the dissolvers the saturated brine outflows to a combined precipitation and sedimentation tank. Here the precipitation chemicals (Na_2CO_3 + $NaOH$) are added. When using ion exchange for brine purification, a small amount of sodium bisulphide ($NaSH$) is also added, that eliminates efficiently all residual traces of active chlorine in the brine.

In the lower part of the cylinder the turbulence in the brine is efficiently stopped and sedimentation and agglomeration begin. The agglomeration is completed after approx. 10 hours. The sludge from the bottom of the sedimentation tank is removed regularly to a sludge tank. The brine is then filtered in a filter. to get a entirely pure solution. The purified brine is then stored in a storage tank, before sending it to the electrolyzers.

7.1.2 Membrane Cell Products Treatment (Electrolysis).

Chlorine and hydrogen are released from the cells at a pressure slightly above atmospheric one. In order to ensure that the chlorine gas pressure is always maintained between certain limits, the chlorine main header is connected to a water seal pot. Approx. half the amount of chlorides in brine feed to cells, are converted to chlorine. As there is a considerable water transport through the membranes from anolyte to catholyte side, the resulting concentration of spent brine will be about 200 g NaCl\l. Spent brine is dechlorinated with air in a stripping tower. From here the brine recirculates to one of the dissolvers and the chlorine containing air is transferred to the hypochlorite tower.

Caustic soda produced directly in membrane cell electrolyzers is of about 30% NaOH concentration.

7.1.3 Caustic Soda Evaporation System.

This evaporation system consists of a single stage rising film evaporator unit. Feed liquor enters the heat exchanger, using hot condensate followed by steam. The liquor is then heated in the steam chest of the rising film evaporator before passing to the vapour body, where the concentrated liquor is separated from the vapour. The concentrated 50% NaOH product is pumped to the product cooler, where it is cooled by cooling water to the required outlet temperature.

7.1.4 Hydrochloric Acid Production.

Combustion of hydrogen and chlorine to produce hydrogen chloride gas takes place in the burner section of the synthesis unit. The gas is then contacted with absorption water to produce hydrochloric acid, as a 33% HCl solution. A packed tail gas scrubber is mounted above the absorber. Absorption water is used to eliminate any traces of gaseous hydrogen chloride, before venting to the atmosphere. Hydrochloric acid received from the absorber is fed by gravity to the collection tank and then pumped to the storage tank.

7.1.5 Compression, Drying and Liquefaction of Chlorine.

Cooled chlorine gas is compressed to about 3 bar in the liquid ring compressor. The gaseous chlorine is dried in a sulphuric acid tower. Dry gaseous chlorine is then liquefied in the condenser, and flows by gravity down to one of the storage tanks. Refrigeration system with freon compressors cools the chlorine condenser. The residual gas that remains from the condensation, contains some chlorine. That residual gas can be further used for sodium hypochlorite or hydrochloric acid production.

7.1.6 Sodium Hypochlorite Production.

Sodium hypochlorite is obtained by the reaction of gaseous chlorine with 20% solution of caustic soda at a temperature of 30°C. The product contains 150g Cl_2 per liter of solution. Stabilization of sodium hypochlorite solution so received, can be maintained for a long time, through addition of a little amount of caustic soda to the product. On the other side, small amount of contaminations like iron and it salts can decompose sodium hypochlorite. Therefore glass containers or rubber-lined tankers must be used for the transportation of sodium hypochlorite solution.

7.2 <u>Manufacturing of other alternative chlorine derivatives (not included in the proposed production programme)</u>

7.2.1 Aluminium Chloride ($AlCl_3$).

It is prepared from technical grade aluminium or a good quality aluminium scrap.

Major applications of aluminium chloride are:

- petroleum refining,
- butyl - rubber,
- detergent alkylate,
- pharmaceuticals,
- dyestuff intermediate.

One of the two processes commercially used for $AlCl_3$ production is the process based on reaction between aluminium scrap and chlorine. Aluminium scrap is melt in a refractory furnace at a temperature of 660°C and dry chlorine gas is passed through it. Aluminium chloride is formed, which next vapourizes and leaves the furnace. These vapours are passed through air-cooled condensers, where aluminium chloride sublimes at 175-178°C. Flue gases are scrubbed with water to dissolve traces of aluminium chloride. The finished product is finally packed in polyethylene bags or metal drums.

Equipment required:
- refractory furnace,
- condenser,
- scrubber,.
- auxiliary equipment.

7.2.2 Calcium Chloride ($CaCl_2$).

Major applications of calcium chloride are:

- refrigeration,
- concrete conditioning,
- some soaps and pigments.

One of the two processes of its manufacture is synthetic process. The process consists the following steps:

- reaction of calcium carbonate (limestone) with hydrochloric acid,
- neutralizing and filtering,
- evaporation and crystallization,
- centrifuging and drying,
- packing.

Equipment required:

- reactor (rubber lined),
- neutralizer,
- filter press,
- open pan evaporator,
- tray dryer,
- boiler,
- crystallizer,
- centrifuge,
- auxiliary equipment.

7.2.3 Zinc Chloride (Z_nCl_2).

Major applications of zinc chloride are:

- as a flux (with ammonium chloride) for soldering etching metals, galvanizing,
- as a component of disinfecting fluids and deodorants,
- as a mordant in printing and dyeing textiles,
- in the marcerizing cotton, vulcanizing rubber, and in chemical synthesis as a dehydrating agent.

One of the several methods of Z_nCl_2 production is that zinc dross is treated directly with hydrochloric acid with an insufficient amount to dissolve all the metal, and clear liquor is filtered off. The oxide dross-residue nearly dry is then heated with chlorine. The zinc chloride formed is leached with water and added to the first filtrate. The clear liquor is evaporated to a concentrated solution of zinc chloride.

Zinc chloride can also be prepared by treating zinc metal with hydrochloric acid and concentrating the zinc chloride solution by evaporation.

Equipment required:

- mixing and storage tanks,
- heat exchangers,
- filter presses,
- evaporator,
- crystaliizer,
- auxiliary equipment.

7.2.4 Ammonium Chloride (NH_4Cl)

Major applications of ammonium chloride are:

- as a flux in the soldering and tinning operations,
- in the manufacture of dry cells,
- in pharmaceutical preparations.

Ammonium chloride can be manufactured, among others, by the direct neutralization of hydrochloric acid with ammonia.

Equipment required:

- reactor,
- vacuum filter,
- crystallizer,
- dryer,
- auxiliary equipment.

7.2.5 Chlorinated Paraffin Wax.

Chlorinated paraffin wax of the range 40-45% chlorine content have its most important application as a plasticizer, because of its compatibility with a large variety of resins and plastics.

Chlorinated paraffin wax has a large applications in industries like paper, tannery, plastics, printing, electrical and textile industries.

Its major applications are:

- as plasticizer (in vinyl polymers and other plastics),
- as additive in industrial gear oil,
- in corrossion - resistant and fire-proof paints,
- in electrical insulating materials.

The manufacturing process consists of the following steps:

- melting of wax,
- chlorination of wax (by chlorine gas),
- scrubbing of hydrochloric acid,
- neutralization,
- filtration,
- stabilization,
- packing.

Equipment required:

- melter,
- reaction vessel,
- drier,
- compressor,
- HCl absorption tower,
- filter press,
- tanks.

7.2.6 Monochloro-Acetic Acid ($CH_2ClCOOH$).

Major applications of monochloro-acetic acid are:

- in herbicides,
- dyes,
- pharmaceuticals,
- thiocynate insecticides.

Monochloro-acetic acid is manufactured by passing chlorine into acetic acid in the presence of sulphur or red phosphorus as a catalyst. During the chlorination, hydrogen chloride is evolved and directed to a scrubber for acid recovery. The chlorination step may be carried out continuously in a series of stirred reactors. In any case all equipments must be acid resistant.

Equipment required:

- reactor,
- HCl absorption tower,
- distillation columns,
- mixing and storage tanks,
- auxiliary equipment.

7.2.7 Bleaching Powder [$Ca(OCl)_2.CaCl_2.Ca(OH)_2.2H_2O$]

Major applications of bleaching powder are:

- in paper industry as a bleaching agent,
- in textile industry,
- in water treatment as a disinfectant.

To produce bleaching powder, lime slurry is to be chlorinated under pressure at a temperature 30-40°C. During the chlorination, calcium hypochlorite dihydrate is precipitated from the solution. The precipitate is filtered off and dried up to contain about 2% water. Then an equivalent amount of lime and caustic soda are added. At the temperature below 16°C, the stable solid phase forms, known as triple salt. The solution is then crystallized by cooling to 10°C. These solid crystals are then reacted with chlorinated lime slurry. The lime slurry contains just sufficient calcium chloride to react with the sodium hypochlorite available in triple salt. This slurry is filtered and then spray dried to form powder.

8. MANPOWER

8.1 The manpower requirements for the proposed Caustic Soda Plant are estimated as follows:

	Number	Average cost (US$) p.a.
Managing Director	1	3,550
Divisional Managers	3	2,840
Supervisors	12	2,490
Operators	36	2,130
Other Skilled Workers	48	1,780
Accountants	4	1,600
Sales	5	1,600
Administration	8	1,600
Unskilled Workers	3	1,240

8.2 The manpower requirement will be met from the local sources.

8.3 Three persons in the managerial position (production and maintenance) and five persons in the supervisor position - require technical training abroad. Remaining supervisors and all operators and skilled workers require on spot in-plant training.

8.4 The total cost of manpower stands at US$ 234,990 p.a.

9. IMPLEMENTATION SCHEDULING

9.1 Implementation of the plant, training and start up will take 24 months (2 years).

The project time schedule is as follows:

Item	Month
- Contract Signature	0
- Delivery of Preliminary Layout	1
- Delivery of Process Flow Sheet	2
- Delivery of Specifications of Utility Inputs	3
- Delivery of Connection Points for Sewers, Pipe Bridges, Power Supply	4
- Delivery of Plant Layout with Loads	5
- Delivery of Detailed Equipment Foundation Drawings	8
- Delivery of First Shipment of Machinery	12
- Completion of Shipment of Equipment	16
- Completion of Operating and Maintenance Manuals	17
- Completion of Construction and Erection	22
- Completion of Training	23
- Commissioning & Start-up	24
- Commercial Operation	25

9.2 The plant is expected to operate at 80% capacity in the first year, at 90% capacity in the second year, and at 100% capacity in the third year and thereafter.

10. **INVESTMENT COST**

The total investment cost of the Caustic Soda Plant is estimated at US$ 22,595,000.

(US$ 1,000)

	Local Currency	Foreign Currency	Total
Land	187	-	187
Buildings	1,874	-	1,874
Equipment & Machinery	-	14,613	14,613
Erection Works	1,237	824	2,061
Pre-operational Expenses (incl. training, commissioning, start-up)	422	140	562
Contingencies	-	937	937
Working Capital	710	-	710
Interest during Construction	1,651	-	1,651
TOTAL:	6,081	16,514	22,595

Fixed investment costs of four caustic soda\chlorine plants were compared, namely:

(a) the plant of capacity 4,950 t NaOH p.a., proposed for Ghana by Daewoo Corp. Korea, in 1986 (2),

(b) the plant of capacity 9,000 t NaOH p.a., proposed for Bangladesh by Intercontinental Project Developers, USA in 1984 (6),

(c) the plant of capacity 112,000 t NaOH p.a., being implemented in Carboclorc Company, Brazil by OXY, USA, in 1990 (5).

(d) the plant of capacity 40,000 t NaOH p.a., being implemented in Panamericana Company, Brazil in 1990 (5)

The comparison of the ratios of the caustic soda plant's fixed investment cost per ton of the annual capacity for these three plants, are as follows;

	Ghana (plant proposed by Daewoo, Korea) (2)	Bangladesh (plant proposed by I.P.D. (USA) (6)	Brazil (plant under implementation in Carbocloro Co. by OXY, USA) (5)	Brazil (plant under implementation in Panamericana Co. (5)
fixed investment cost per ton of annual capacity	3,191 $\t	1,404 $\t	1,500 $\t	1,363 $\t

(all fixed investment costs were up-dated to 1990 level).

The relations between output and investment costs of small electrolysis plants are as follows (3):

Output in tons NaOH p.a.	Investment costs per ton of plant capacity (in %)
2,000	100
4,000	80
8,000	62
12,000	58
15,000	56

For higher capacities, the relationship between fixed investment cost and annual production capacity are described by the following exponential equation (3):

$$\left(\frac{C_1}{C_2}\right) = \left(\frac{S_1}{S_2}\right)^{0.77}$$

where:

- C_1 and C_2 are fixed investment cost at two scales of annual output S_1 and S_2
- Exponent for caustic soda\chlorine is 0.77 for the range of outputs between 6,000 t\y and 35,000t\y.

To calculate the fixed investment cost for the proposed plant capacity of 15,000 t NaOH p.a. in Ghana, the above relationships were used. The calculations were based then on fixed investment costs proposed by Daewoo (2) and Intercontinental Project Developers (6). The ratios of fixed investment cost per ton of annual capacity for the same proposed plant are as follows:

	the plant with capacity 15,000 t NaOH p.a. based on Daewoo Study (2)	the plant with capacity 15,000 t NaOH p.a. based on I.P.D.' offer (6)
fixed investment cost per ton of annual capacity	2,383 $\t	1,249 $\t

(both fixed investment costs up-dated to 1990 level).

Conclusion that can be drawn from the above comparisons is that fixed investment cost assumed in Daewoo's Feasibility Study was about 2 times higher than the comparable costs of other international partners, and therefore can't be taken into further consideration. For purpose of this study, the available data on fixed investment cost structure drawn from the I.P.D.' offer (6), were only used.
It has been assumed, that the time of delivery and assembling of machinery and equipment will be 12 months, and the total construction period will be 24 months.

11. **SOURCES OF FINANCE**

The Caustic Soda Plant is expected to be financed as follows:

(US$ 1,000)

	Local Currency	Foreign Currency	Total
Equity	4,430	-	4,430
Loan	1,651	16,514	18,165
TOTAL:	6,081	16,514	22,595

12. COMMERCIAL PROFITABILITY

12.1 The following commercial profitability estimates are made for 4th year of operation, assuming that the Caustic Soda Plant will operate at 100% capacity:

		(US$ 1,000)
Sales		12,800
Costs		
Raw Materials	1,638	
Utilities	1,320	
Labour	198	
Maintenance	73	
Spare Parts	219	
Factory Overhead	49	
Sales Cost	384	
Administrative Overhead	37	
Depreciation	1,555	
	-----	5,473
Profit before Interest & Taxes		7,327
Interest		1,654
Profit before Taxes		5,673

12.2 Profit before Taxes as % of Turnover 44%

12.3 Profit before Taxes as % of Investment 25%

12.4 Profit before Taxes as % of Equity 128%

12.5 Rate of Return 32%

12.6 Payback period 4.5 years including 2 years of construction

12.7 Breakeven point at 20% capacity.

13. **REFERENCES**

1. "Market Study Report, Caustic Soda" prepared by the National Investment Bank, Accra, March 1990.

2. "Feasibility Study for the Establishment of Caustic Soda Manufacturing Plant in Ghana", prepared by Daewoo Corporation, Seoul, Korea, July 1986.

3. "A Study on the Establishment of Caustic Soda and Soda Ash Industry in Ghana", prepared by M. Nowak, Accra, July 1979.

4. "Chemical Marketing Reporter", USA, July 16, 1990.

5. "European Chemical News", UK, March 19, 1990.

6. "Pre-feasibility Study on Caustic Soda Complex Project", UNIDO Project (BGD\80\014), Dacca, 1984.

7. "Manual for the Preparation of Industrial Feasibility Studies", UNIDO, 1978.

14. **EXCHANGE RATE**

Rate : US$1 = ¢ 338

Date : 16.10.1990

Annexure - I

ESTIMATED FINANCIAL EXPENSES

(US $)

Item	Year of Operation			
	1st	2nd	3rd	4th
Interest on Long-Term Loans /1/ + /2/	2,059,197	1,974,986	1,808,205	1,600,139
Interest on Commercial Bank Borrowing (3)	47,783	50,918	54,053	54,053
TOTAL:	2,106,980	2,025,904	1,862,258	1,654,192
1. Foreign Currency Long - Term Loan: Principal	16,514,000	16,514,000	15,688,300	14,036,900
Instalments	-	825,700	1,651,400	1,651,400
	16,514,000	15,688,300	14,036,900	12,385,500
Interest 10% p.a. (on average balance)	1,651,400	1,610,115	1,486,260	1,321,120
2. Local Currency Long-Term Loan: Principal	1,651,000	1,485,900	1,320,800	1,155,700
Instalments	165,100	165,100	165,100	165,100
	1,485,900	1,320,800	1,155,700	990,600
Interest 26% p.a. (on average balance)	407,797	364,871	321,945	279,019
3. Commercial Bank Borrowing:	159,276	169,727	180,178	180,178
Interest 30% p.a.	47,783	50,918	54,053	54,053

Annexure - II

ANNUAL PRODUCTION COST ESTIMATION

(US $)

	Year of Operation			
	1st	2nd	3rd	4th
	80%	90%	100%	100%
I) Manufacturing Cost:				
A) Raw Materials:				
a) local	1,270,800	1,429,650	1,588,500	1,588,500
b) imported	39,422	44,350	49,278	49,278
B) Utilities	1,056,216	1,188,243	1,320,270	1,320,270
C) Direct Labour	158,144	177,912	197,680	197,680
D) Maintenance	14,613	43,839	73,065	73,065
E) Spare Parts	219,195	219,195	219,195	219,195
F) Factory Overhead	49,133	49,133	49,133	49,133
Manufacturing Cost (I) Sub-Total:	2,807,523	3,152,322	3,497,121	3,497,121
II) Sales & Admin. Costs:				
A) Admin. Overhead Cost	37,310	37,310	37,310	37,310
B) Sales Cost	307,202	345,603	384,003	384,003
Operating Cost (I + II) Sub-Total	3,152,035	3,535,235	3,918,434	3,918,434
III) Depreciation	1,555,000	1,555,000	1,555,000	1,555,000
IV) Financial Costs (interests)	2,106,980	2,025,904	1,862,258	1,654,192
Production Cost (I + II + III + IV) Total:	6,814,015	7,116,139	7,335,692	7,127,626

CALCULATION OF WORKING CAPITAL

(US $)

Item	Minimum days of coverage	Year of Operation			
		1st	2nd	3rd	[illegible]
		60%	90%	100%	100%
I) Current Assets:					
A) Accounts Receivable	20	171,767	193,238	214,709	214,709
B) Inventory:					
a) Raw Materials	30	107,690	121,151	134,612	134,612
b) Spare Parts	180	108,096	108,096	108,096	108,096
c) Finished Products	15	116,201	130,726	145,251	145,251
C) Cash in Hand	10	49,987	56,236	62,484	62,484
TOTAL (I):		553,741	609,447	665,152	665,152
II. Current Liabilities:					
A) Accounts Payable	10	35,897	40,384	44,871	44,871
III. Working Capital (I) + (II) TOTAL:		589,638	649,831	710,023	710,023

SALES ESTIMATE

(US $)

Item	Year of Operation			
	1st	2nd	3rd	4th
	80%	90%	100%	100%
Caustic Soda (solid)	6,720,000	7,560,000	8,400,000	8,400,000
Chlorine (liquid)	1,770,800	1,992,150	2,213,500	2,213,500
Hydrochloric Acid	168,000	189,000	210,000	210,000
Sodium Hypochlorite	1,581,280	1,778,940	1,976,600	1,976,600
Sales Total:	10,240,080	11,520,090	12,800,100	12,800,100

Remarks: Prices and sales of all products calculated as 100%.

Selling Prices (4):

Caustic Soda (solid) = US$ 560 per ton

Chlorine (liquid) = US$ 190 per ton

Hydrochloric Acid = US$ 210 per ton

Sodium Hypochlorite = US$ 1,870 per ton

Assumptions:

Production Period - 300 days a year

Operation Time - 3 shifts of 8 hours each (Caustic Soda Plant).

Annexure - V

CASH-FLOW STATEMENT
FOR THE CAUSTIC SODA PROJECT

(US $)

Item	Year of Operation			
	1st	2nd	3rd	4th
	80%	90%	100%	100%
A) CASH INFLOW:	10,240,080	11,520,090	12,800,100	12,800,100
1) Sales Revenue	10,240,080	11,520,090	12,800,100	12,800,100
B) CASH OUTFLOW:	5,930,073	6,556,727	7,598,844	7,335,073
1) Current Assets Increase	553,741	55,706	55,705	-
2) Operating Cost	3,152,035	3,535,235	3,918,434	3,918,434
3) Debt Service:				
a) Repayment of Long-Term Loans	165,100	990,800	1,816,500	1,816,500
b) Payment of interest on Long-Term Loans	2,059,197	1,974,986	1,808,205	1,600,139
C) CASH SURPLUS\ DEFICIT (A) - (B)	4,310,007	4,963,363	5,201,256	5,465,027
D) CUMULATIVE CASH BALANCE	4,310,007	9,273,370	14,474,626	19,939,653

FORMULAS USED FOR CALCULATIONS IN THIS STUDY

* Accounts Receivable = Annual Operating Cost x $\frac{20\ D}{365\ D}$

* Cash-in-Hand = (Annual Operating Cost - Annual Direct Cost) x $\frac{10\ D}{365\ D}$

* Accounts Payable = Annual Direct Material Cost x $\frac{10\ D}{365\ D}$

* Finished Products = (Manufacturing Cost + Admin. Cost) x $\frac{15\ D}{365\ D}$

* Cost of Maintenance & Spare Parts = 2% of Cost of Equipment & Machinery

* Cost of Factory Overhead = 3% of Cost of Materials

* Sales Cost = 3% of Sales

* Commercial Bank Borrowing - 70% of imported raw materials, spare parts and finished products.

* Rate of Return = $\frac{\text{net profit + interest}}{\text{total investment outlay}} \times 100\%$ (7)

* Payback Period = $\frac{\text{total investment outlay}}{\text{net profit + interest + depreciation}}$ (7)

* Breakeven Point = $\frac{\text{fixed production costs}}{\text{sales revenue - variable production costs}} \times 100\%$

(Fixed Production Costs: spare parts, factory overhead, administrative overhead, depreciation;

Variable Production Costs: raw materials, utilities, labour, maintenance, sales costs).

LIST OF INTERNATIONAL SELLING PRICES OF CHLORINE DERIVATIVES IN JULY 1990 (4)

- Aluminium Chloride	-	US$ 1,600 per ton
- Calcium Chloride	-	US$ 165 per ton
- Zinc Chloride	-	US$ 589 per ton
- Ammonium Chloride	-	US$ 400 per ton
- Chlorinated Paraffin Wax (40% chlorine)	-	US$ 1,000 per ton
- Monochloro - Acetic Acid	-	US$ 1,133 per ton

Appendix II

Opportunity Study
for
the Manufacture of Industrial & Pharmaceutical Cassava Starch

1. INTRODUCTION

1.1 Name of Sponsors & Promoters of the Project:

Rowland K. Noamesi

Ayerh E. Moncar

Eric Otubuah

Victor C. Larbi

I.A. Conti Adjei

Main sponsor and promoter of the project is GLUCOSET (GHANA) LTD., Dyson House, Kwame Nkrumah Avenue, P.O. Box 056, Accra.

- Rowland K. Noamesi, the Principal Sponsor\Promoter. An Industrialist\Engineer involved extensively in the manufacture of drugs and farming on a commercial scale in Ghana.

- Mr. Ayerh E. Moncar, the Production Pharmacist. Presently, he is the Production Manager\Consultant Pharmacist in charge of PHARMADEX (GHANA) LTD., a Pharmaceutical Factory in Ghana.

- Mr. Eric Otubuah, the Spare Parts Manager in MacDonnell Douglas Aircraft Corp., (Southern California Facility), USA

- Mr. Victor C. Larbi, an Investment Consultant, of CIBEX (GHANA) LTD.

- Mr. I.A. Conti Adjei, the Pharmacist, presently in private business in Ghana.

1.2 Proposed Foreign Partner for the Project.

TECH-VANCE, Engineering and Construction Corp.,
4/6 Soi 5 Sukhumvit Road, Bangkok 10110, Thailand.

2. **THE PROJECT**

2.1 **SUMMARY:**

2.1.1 The proposed Industrial & Pharmaceutical Cassava Starch Plant ought to be implemented in two phases. The First Phase will comprise production of starch (industrial and pharmaceutical grades) from cassava chips. The Second Phase will comprise processing of part of the above starch into glucose. Only First Phase of the Project was considered in this study.

2.1.2 Basic data on the proposed Cassava Starch Plant (1st Phase) are as follows:

Product: Starch	-	18,000 tons p.a.,
Production Period	-	300 days a year
Operation Time:	-	3 shifts of 8 hour each
Employment	-	42 persons
Total Investment Cost	-	US$ 4,296,000
Project Construction Period:	-	18 months
Rate of Return:	-	162%
Payback Period:	-	2.1 years (including 1.5 years of construction)

2.2 **RECOMMENDATIONS**

2.2.1 The establishment of "Company Cassava Farms" as it is proposed by the Promoters (1) is not recommended. The reasons are as follows (2):

(a) It takes about 5 years to turn a crude land into farm able to provide the adequate yield of cassava

(b) As yield of fresh cassava roots is about 25 tons\ha, the required land for the farms would be 2,880 ha i.e. more than 1,000 to 2,000 ha as assumed by the Promoters.

(c) Clearing of land stands at present at minimum 250,000 ¢\ha, cost of fertilizers 90,000 ¢\ha, cost of herbicides 15,000 ¢\ha. These three costs only give together minimum 355,000 ¢\ha i.e. 1,050 $\ha in comparison to 108 $\ha assumed by the Promoters in 1988. Cost of establishment of the farms would be 10 times higher than that foreseen by the Promoters.

(d) There is already the potential to double the present production of cassava on the existing farms in Ghana up to 7 million tons a year in a medium-term, securing the industrial needs for producing starch from cassava.

2.2.2 Dried cassava chips ought to be used as raw material for the plant. Due to its storability, cassava chips can secure regular supplying the plant with starch raw material.

2.2.3 The detailed market study on present and future demand of the local users for industrial & pharmaceutical starch has to be made, before any decision on the project implementation will be undertaken. Similar study ought to be made on utilization of by-products as an animal feed.

2.2.4 The analysis of starch produced on technology & equipment offered by TECH-VANCE ought to be made. The quality ought to be compared then with the requirements of local users both in industry and in pharmaceuticals. The quality ought to be guaranteed by the Supplier.

2.2.5 The plant would not be built up, until the system of buying of cassava chips was well established.

2.2.6 The potential equipment suppliers ought to be provided with a sample amount of the local cassava chips to check it against the requirements of technologies & equipment offered by them, as well as quality of starch produced.

2.2.7 Price of starch in Ghana, as provided by the Promoter, requires re-confirmation as it seems too high.

2.2.8 Data on tax on profit were not readily available, and tax is to be taken into consideration when further profitability analysis will be made.

3. **MARKET ANALYSIS**

3.1 Industrial starch in Ghana are used mainly in (1): tapioca & other food preparations, bakery & confectionery industries, textiles industry, laundary soap manufacturing, dry cell batteries manufacturing, and in chemicals preparation. Pharmaceutical starch in Ghana are used mainly in (1): various pharmaceutical preparations, and in incense mosquito coil manufacturing.

3.2 Presently, in Ghana, industrial or pharmaceutical starch used by any branch of industry is being imported.

3.3 Attempts to use locally made cassava starch has not been successful because of the low grade of starch.

3.4 According to the Promoters (1), usage of starch in the country in 1988 was about 8,000 tons to 10,000 tons, and in 1995 can reach level of about 16,000 tons to 19,000 tons. This is the estimation only, and the detailed market study is recommended before any decision on implementation of this project will be undertaken.

3.5 For purpose of this study, the plant capacity at 18,000 t\y of starch has been taken into consideration. With this capacity, the produced starch will be entirely absorbed by the local users.

4. PRODUCTION PROGRAMME

4.1 It is proposed to implement the project into two phases.

Production programme for the First Phase:

Starch - 18,000 tons p.a.

Production programme for the Second Phase:

Glucose - 5,000 tons p.a.

The above production programme will be the most appropriate for the local conditions.

This study is only concerned with the First Phase. As soon as starch production is well established, the implementation of the Second Phase can be considered.

4.2 The above production ought to be based on processing of dry cassava chips, as the most appropriate, storable raw material.

4.3 The production programme is import substitution oriented.

5. MATERIAL INPUTS

5.1 RAW MATERIAL

5.1.1 The fundamental food processing concept, that quality of product is directly related to the quality of raw material, is especially true of cassava processing. The factory which relies on the supply of dried chips as its raw material will therefore be most concerned that its supply is of the highest quality possible. The availability and quality of raw materials for cassava starch is a key issue. The factory's main criteria for buying chips will be that they are:

- thoroughly dry,
- free from foreign matters (sand, dirt, insects),
- free from mould or bacterial deterioration,
- white in colour,
- derived from plants of the right maturity.

It is worth to say, that the deterioration of cassava chips will not take place if the moisture content is below 12% i.e. below the level to support the micro-organisms. Therefore the size of the chip is important to ensure thorough drying, (the smaller the better). The recommended size of the chip is usually 5 mm wide by 50-80 mm long.

5.1.2 Cassava is the most important crop in Ghana with the current production of 3.5 million tons and with potential to double the present production to 7 million tons over the medium term (4). According to recent informations received from the Ministry of Agriculture, there is even some overproduction of cassava in some regions of the country, and a factory processing excess of cassava is very desireable solution able to absorb this excess of the crop. It can be said, that the quantity of available cassava, is much above the requirement of the proposed starch plant for this raw material.

5.1.3 A typical analysis of the constituents of fresh cassava root is as follows (3).

25% starch and other carbohydrates
2% cellulose
3% protein
5% others
65% water

100%

5.1.4 The yield of starch from fresh roots is only 1\3 of that from dried chips, and it can be the basis for the price that should be offered farmers for cassava chips. They incur at least as much cost in producing roots as in soaking, peeling and drying them into chips, and a price based on starch yield would be a disincentive to sell fresh roots.
Therefore assumption was made that the price of cassava chips will be 3 times higher than that of fresh cassava roots.

5.1.5 Prices of fresh cassava roots recorded in different districts of Ghana on 20 October 1990, were as follows (5):

(US$\ton)

Ho	Sunyani	Kumasi	Techiman	Accra	Tema
117	55	109	89	273	341

For purpose of this study, the price of fresh cassava roots from Ho District (as suggested by the Promoters), were only taken into consideration. (Hohoe, the proposed location of the plant is in Ho District).

5.1.6 Raw Materials Requirement:

- Annual consumption of cassava chips for the manufacturing of 19,000 tons of starch p.a., is estimated as at 24,000 tons.
- Price of cassava chips (in Hc District) were assumed in this study as 251 $\ton.
- Sulphur for SO_2, in quantity of 3.3 kg per ton of cassava chips is to be imported.
- To secure regular supply of raw material, additional storage facilities able to store cassava chips required for at least 4 months production - ought to be foreseen. These storage facilities will also allow to buy cassava chips in the after harvesting period i.e. when prices are lowest, and ensure stability of raw material cost in periods when the prices are higher.

5.2 **UTILITIES**

The Cassava Starch Plant annual requirement for major utility supplies are as follows:

	Quantity	Price
- Electric Power	4,428,000 kWh	US$ 0.0155 per kWh
- Fuel Oil	900,000 liters	US$ 0.25 per liter
- Processing & Cooling Water	576,000 m^3	US$ 0.38 per m^3

All utilities are locally available (6).

6. **LOCATION**

6.1 The proposed "Industrial and Pharmaceutical Cassava Starch Plant" will be set up at a selected site at Hohoe, as suggested by the Promoters (1). The farms located in the Ho District will be the main suppliers of raw materials i.e. cassava roots/chips. There is electricity and water supply at Hohoe. The area has reasonably good road connections that will be of advantage during the implementation and operation of the Cassava Starch Plant.

Land for the plant is owned by the Promoters. No provision is made for housing of the staff and workers in Hohoe, as they will be drawn from local resources.

6.2 The alternative location of the plant in Sunyani District ought to be also analysed, before final decision on the location will be undertaken. The reason of such suggestion is that prices of cassava roots in Sunyani are the lowest in Ghana, and stand at about 50% of that in Ho and 20% of that in Accra.

7. **PROCESS DESCRIPTION**

7.1 Raw Materials Supply

There are two sources of the raw material i.e. fresh cassava roots and cassava chips. The process of manufacturing starch from cassava is adjusted alternatively to the form of cassava raw material.

7.2 Manufacturing of Starch Slurry:

7.2.1 From Cassava Fresh Roots (Alternative 1)

The extraction of starch from fresh roots is done on standard equipment designed for the extraction of starch from potatoes. The process relies on the use of centrifugal force to separate the starch granules from a water suspension. Process Flow Diagram for Processing of Fresh Cassava Roots into Starch Slurry, is shown in Annexure - 1.

7.2.2 From Cassava Chips (Alternative 2)

At this stage of manufacturing, the slurry from the cassava chips is the same as that for fresh cassava roots. Process Flow Diagram for Processing of Cassava Chips into Starch Slurry, is shown in Annexure - 2.

7.3 Starch Extraction from the Slurry

This stage of manufacturing process is the same for starch slurry obtained in one of the two above methods.

The starch produced at this stage is of 12% moisture content and is stable, and can be stored for considerable period. In this state it may be bagged or kept in bulk for sale and\or for further processing. Process Flow Diagram for Processing Starch Slurry into Starch, is shown in Annexure - 3.

7.4 Glucose from Starch

The conversion of starch to glucose is a standard process used all over the world. This is done by the action of acids, or enzymes or a combination of the two. The most widely used glucose (known as confectioners glucose) has a moisture content of 16 - 20%. Glucose 100% pure is known chemically as dextrose, and the production of dextrose is more elaborate and costly than that of glucose. Process Flow Diagram for Processing Starch into Glucose is shown in Annexure - 4.

7.5 Dextrin from Starch

Dextrin is the term used for the products obtained by treating starch in a number of ways. They may be prepared by a wet or dry process either by acid or enzymes or under carefully controlled heating conditions. Standard equipment is available for dextrin manufacture. One of the method is shown in Process Flow Diagram for Processing Starch into Dextrin (Annexure - 5).

7.6 Effluent Disposal

Considerable quantities of water are used in the process. Where possible this is recirculated and reused by starch plant. The final waste water will contain suspended solids of soil, sand and carbohydrates, plus other organic matters from the process. The resultant waste will need some form of pretreatment before it is discharged into local rivers. Alternatively discharging the waste into a pit\lagoon can be considered.

9. MANPOWER

9.1 The manpower requirements for the proposed Cassava Starch Plant are estimated as follows:

	Number	Average cost (US$) p.a.
Managing Director	1	3,550
Supervisors	3	2,490
Operators	21	2,130
Other Skilled Workers	5	1,780
Unskilled Workers	6	1,240
Accountants	2	1,600
Administration	4	1,600

9.2 The manpower requirement will be met from the local resources.

9.3 In-plant training will be provided by the consultant suggested by TECH-VANCE (1).

9.4 The total cost of manpower stands at US$81,690 p.a.

9. IMPLEMENTATION SCHEDULING

9.1 Implementation of the plant, training and start-up will take 18 months (1.5 year)

Item	Month
- Contract Signature	0
- Delivery of Preliminary Layout	1
- Delivery of Specifications of Utility Inputs	2
- Delivery of Connection Points for Sewers, Pipe Bridges, Power Supply	2
- Delivery of Plant Layout with Loads	3
- Delivery of Detailed Equipment Foundation Drawings	6
- Delivery of First Shipment of Machinery	11
- Completion of Shipment of Equipment	13
- Completion of Construction and Erection Works	17
- Commissioning & Start-up	18
- Commercial Operation	19

9.2 The plant is expected to operate at 80% capacity in the first year, at 90% in the second year, and at 100% capacity in the third year and thereafter.

10. INVESTMENT COST

The total investment cost of "Cassava Starch Plant" is estimated at US$ 4,296,000.

(US$ 1,000)

	Local Currency	Foreign Currency	Total
Land (5 acres)	20	-	20
Buildings (*)	310	-	310
Equipment & Machinery (**)	-	1,431	1,431
Erection Works	172	114	286
Pre-operational Expenses (incl. training, commissioning, start-up)	32	79	111
Contingencies	-	81	81
Working Capital	1,886	-	1,886
Interest during Construction	171	-	171
	2,591	1,705	4,296

(*) Based on up-dated Bill of Quantities of March 1989 by Boateng, Krampa & Associates, Consultant Quantity Surveyors, Accra.

(**) Including additional US$ 100,000 for storage facilities able to store cassava chips required for minimum 4 months production. Equipment & Machinery cost based on the Proforma Invoice of 1988 provided by TECH-VANCE (Thailand), and up-dated to 1990 level.

11. **SOURCES OF FINANCE**

The Cassava Starch Plant is expected to be financed as follows:

(US$ 1,000)

	Local Currency	Foreign Currency	Total
Equity (*)	2,178	242	2,420
Loan	171	1,705	1,876
	2,349	1,947	4,296

(*) TECH-VANCE offered to acquire about 10% equity shares in the project (7).

12. COMMERCIAL PROFITABILITY

12.1 The following commercial profitability estimates are made for 4th year of operation, assuming that the Cassava Starch Plant will operate at 100% capacity:

		(US$ 1,000)
Sales		16,776
Costs		
Raw Materials	8,455	
Utilities	513	
Labour	57	
Maintenance	11	
Spare Parts	43	
Factory Overhead	61	
Sales Cost	503	
Administrative Overhead	13	
Depreciation	159	

		9,815
Profit before Interest & Taxes		6,961
Interest		181
Profit before Taxes		6,780

12.2 Profit before Taxes as % of Turnover 40%

12.3 Profit before Taxes as % of Investment 158%

12.4 Profit before Taxes as % of Equity 280%

12.5 Rate of Return 162%

12.6 Payback Period 2.1 years, (including 1.5 years of construction)

12.7 Breakeven point at 4% capacity.

13. REFERENCES

(1) "Project Proposal for the Manufacture of Integrated Industrial & Pharmaceutical Cassava Starch", Ghana, May 1988.

(2) Data provided by the Management of SCOA Farms Ltd., Accra, on 24 October 1990.

(3) "A Factory Concept for Integrated Cassava Processing Operations", UNIDO, 1983.

(4) Letter ref. M\A-02\12\V-II of 12 March 1990 from Ministry of Agriculture of Ghana to ECOWAS, Togo.

(5) "Weekly Market Price Information as on Week Ending 20 October 1990", Ministry of Agriculture, Accra.

(6) Data provided by the Principal Promoter. (October 1990)

(7) Letter ref. TVEC\CI8 of 13 March 1989 from TECH-VANCE (Thailand) to CIBEX (GHANA) Ltd.

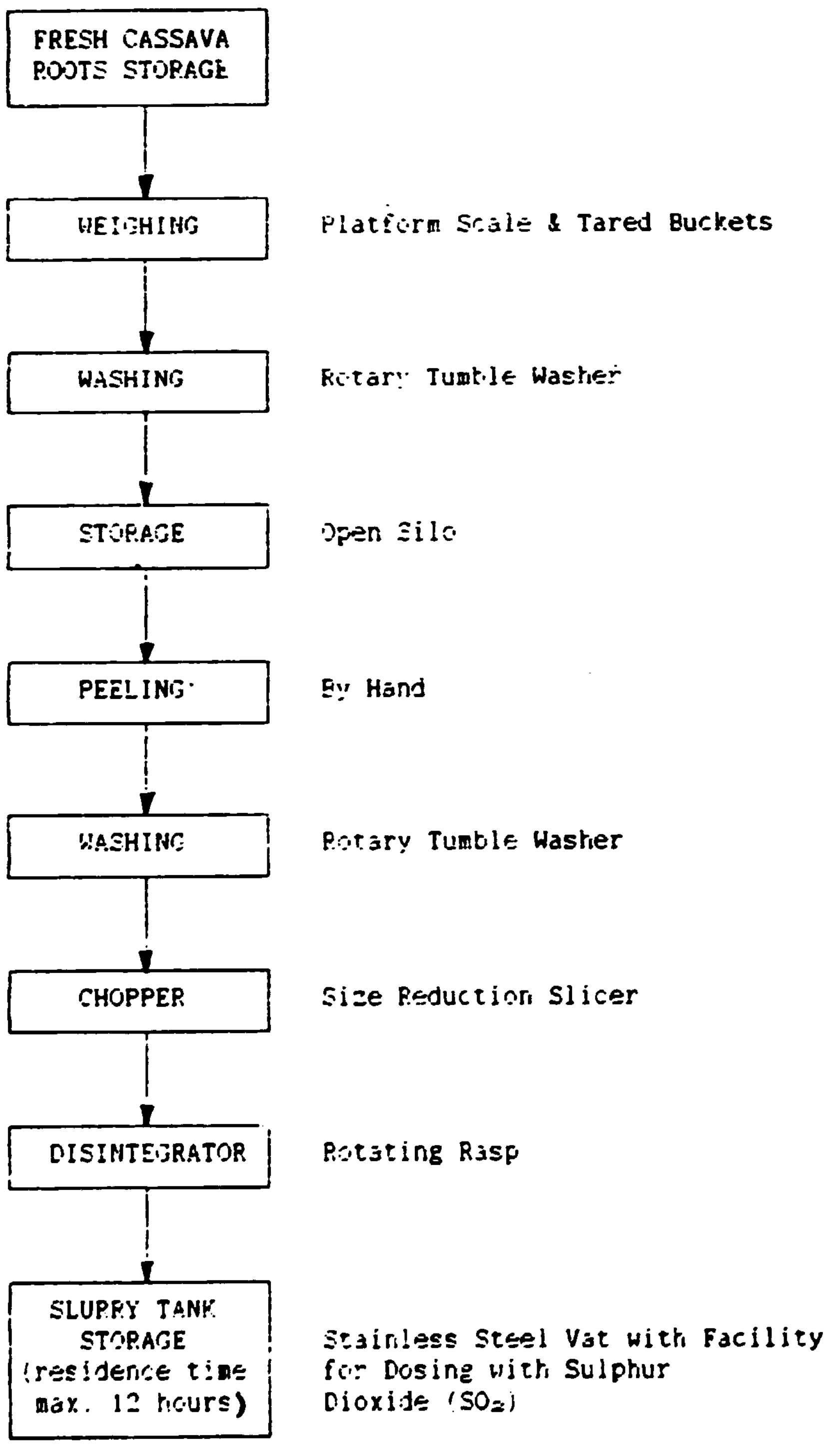
14. EXCHANGE RATE

Rate: US$ 1 = ¢ 329

Date: 25.10.1990

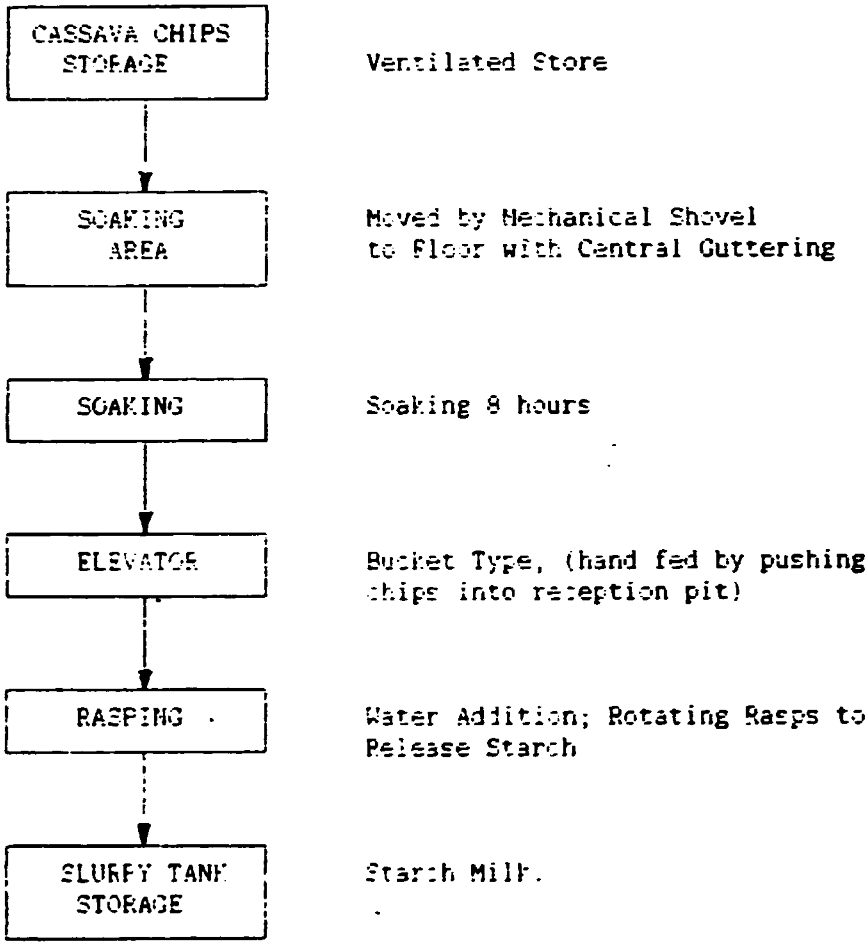
Annexure - 1

PROCESS FLOW DIAGRAM
FOR PROCESSING OF FRESH CASSAVA ROOTS
INTO STARCH SLURRY



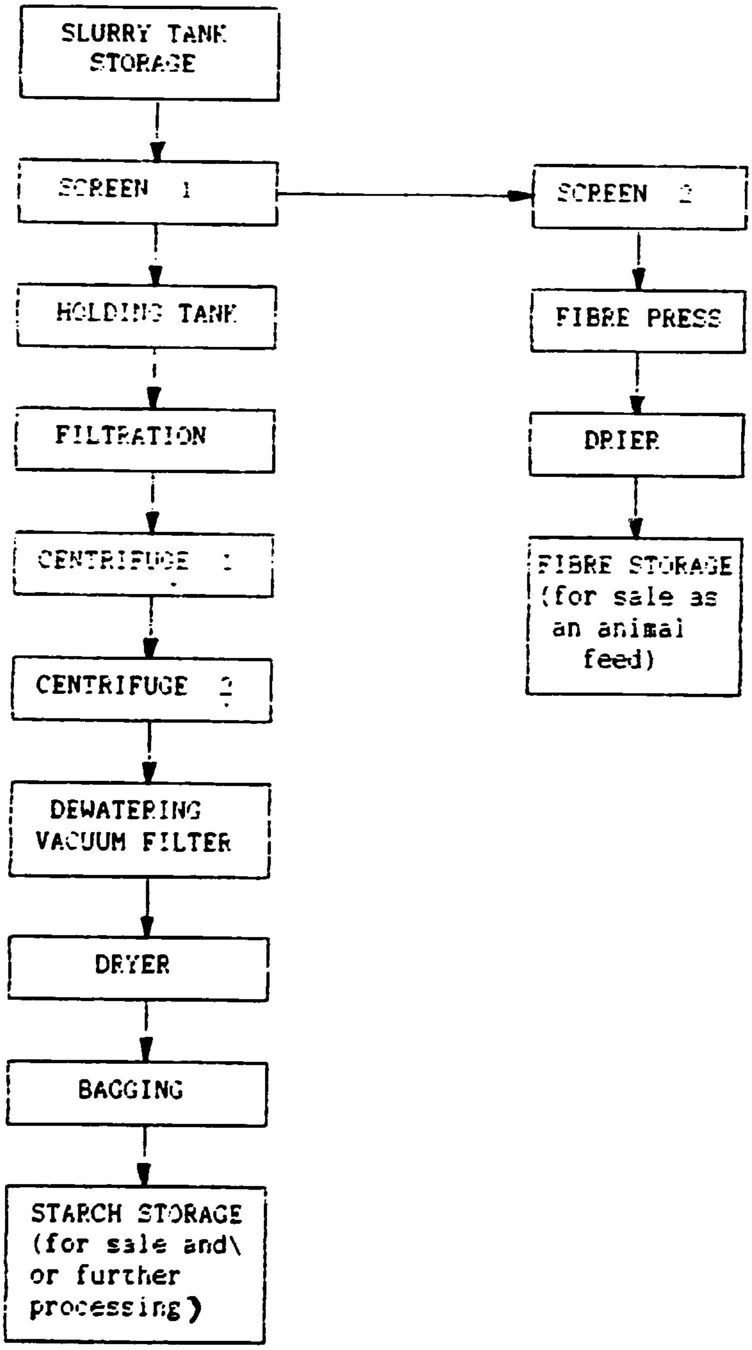
Annexure - 2

PROCESS FLOW DIAGRAM
FOR PROCESSINC OF CASSAVA CHIPS
INTO STARCH SLURRY

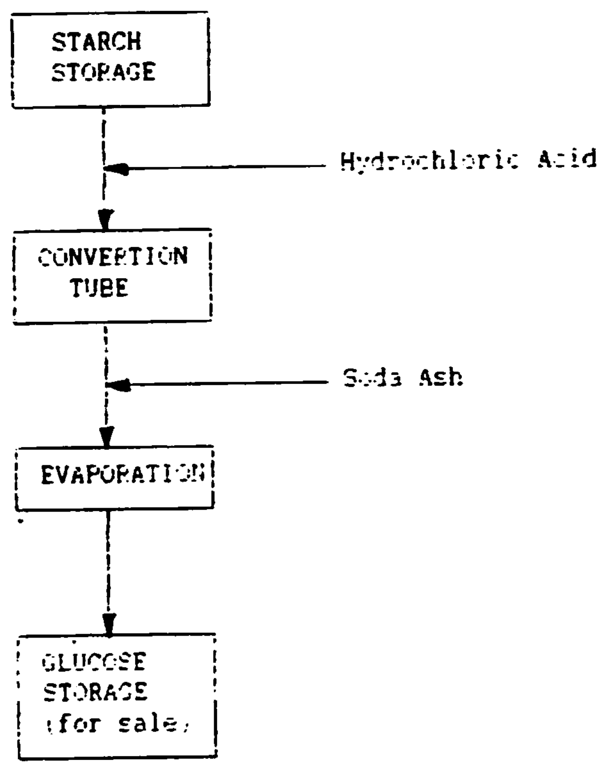


Annexure - 3

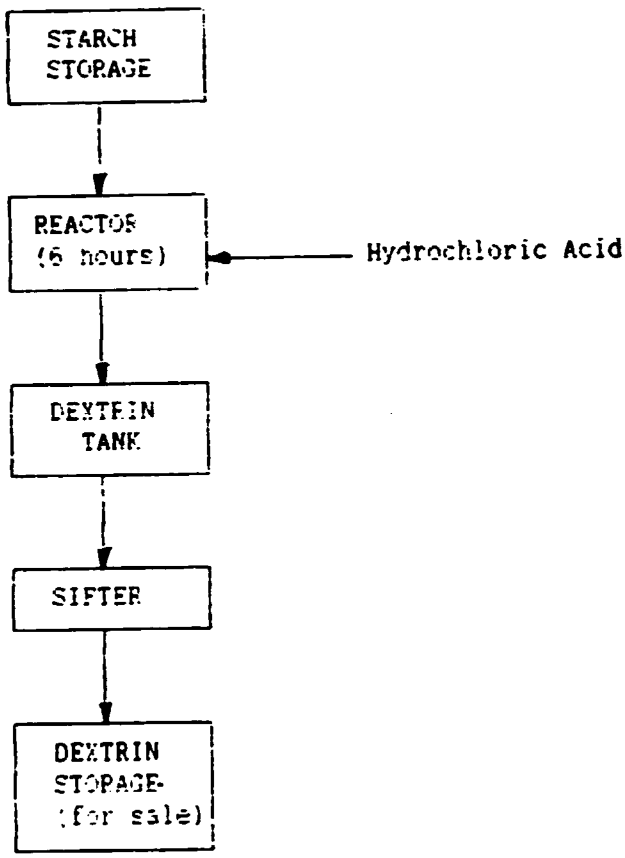
PROCESS FLOW DIAGRAM
FOR PROCESSING STARCH SLURRY
INTO STARCH



PROCESS FLOW DIAGRAM
FOR PROCESSING STARCH
INTO GLUCOSE



PROCESS FLOW DIAGRAM
FOR PROCESSING STARCH
INTO DEXTRIN



Annexure - 6

ESTIMATED FINANCIAL EXPENSES

(US $)

Item	Year of Operation			
	1st	2nd	3rd	4th
Interest on Long-Term Loans /1/ + /2/	212,737	204,029	186,795	165,299
Interest on Commercial Bank Borrowing /3/	14,204	14,853	15,502	15,502
TOTAL:	226,941	218,882	202,297	180,801
1. Foreign Currency Long - Term Loan:				
Principal	1,705,000	1,705,000	1,619,750	1,449,250
Instalments	-	85,250	170,500	170,500
Interest 10% p.a. (on average balance)	170,500	166,238	153,450	136,400
2. Local Currency Long-Term Loan:				
Principal	171,000	153,900	136,800	119,700
Instalments	17,100	17,100	17,100	17,100
	153,900	136,800	119,700	102,600
Interest 26% p.a. (on average balance)	42,237	37,791	33,345	28,899
3. Commercial Bank Borrowing:	47,348	49,510	51,673	51,673
Interest 30% p.a.	14,204	14,853	15,502	15,502

Annexure - 7

ANNUAL PRODUCTION COST ESTIMATION

(US-$)

Item	Year of Operation			
	1st	2nd	3rd	4th
	80%	90%	100%	100%
I) Manufacturing Cost:				
A) Raw Materials:				
a) local	6,739,200	7,581,600	8,424,000	8,424,000
b) imported	24,710	27,799	30,888	30,888
B) Utilities	410,011	461,263	512,514	512,514
C) Direct Labour	45,720	51,435	57,150	57,150
D) Maintenance	9,112	10,251	11,390	11,390
E) Spare Parts	42,930	42,930	42,930	42,930
F) Factory Overhead	61,268	61,268	61,268	61,268
Manufacturing Cost (I) Sub-Total:	7,332,951	8,236,546	9,140,140	9,140,140
II) Sales & Admin. Costs:				
A) Admin. Overhead Cost	13,150	13,150	13,150	13,150
B) Sales Cost	402,624	452,952	503,280	503,280
Operating Cost (I + II) Sub-Total	7,749,725	8,702,648	9,656,570	9,656,570
III) Depreciation	158,600	158,600	158,600	158,600
IV) Financial Costs (interests)	226,941	218,882	202,297	180,801
Production Cost (I + II + III + IV) Total:	8,134,266	9,080,130	10,017,467	9,995,971

Annexure - 6

CALCULATION OF WORKING CAPITAL

(US $)

Item	Minimum days of Coverage	Year of Operation			
		1st	2nd	3rd	4th
		80%	90%	100%	100%
I) Current Assets:					
A) Accounts Receivable	20	424,588	476,857	529,127	529,127
B) Inventory:					
a) Raw Materials	30	555,938	625,430	694,922	694,922
b) Spare Parts	180	21,171	21,171	21,171	21,171
c) Finished Products	15	301,895	339,029	376,163	376,163
C) Cash in Hand	10	26,981	29,952	32,923	32,923
TOTAL (I):		1,330,573	1,492,439	1,654,306	1,654,306
II. Current Liabilities:					
A) Accounts Payable	10	185,313	208,477	231,641	231,641
III. Working Capital (I) + (II) TOTAL:		1,515,886	1,700,916	1,885,947	1,885,947

Annexure - 9

SALES ESTIMATE

(US $)

Item	Year of Operation			
	1st	2nd	3rd	4th
	80%	90%	100%	100%
Starch	13,420,800	15,098,400	16,776,000	16,776,000

Price (import CIF Ghana) (6):

Dry Starch = US$ 932 per ton

Assumptions

Production Period - 300 days a year

Operation Time - 3 shifts of 8 hours each.

Annexure - 10

CASH-FLOW STATEMENT FOR THE CASSAVA STARCH PLANT

(US $)

Item	Year of Operation			
	1st	2nd	3rd	4th
	80%	90%	100%	100%
A) CASH INFLOW:	13,420,800	15,098,400	16,776,000	16,776,000
1) Sales Revenue	13,420,800	15,098,400	16,776,000	16,776,000
B) CASH OUTFLOW:	9,309,135	9,170,893	10,192,832	10,009,469
1) Current Assets Increase	1,330,573	161,866	161,867	-
2) Operating Cost	7,748,725	8,702,648	9,656,570	9,656,570
3) Debt Service:				
a) Repayment of Long-Term Loans	17,100	102,350	187,600	187,600
b) Payment of Interest on Long-Term Loans	212,737	204,029	186,795	165,299
C) CASH SURPLUS\ DEFICIT (A) - (B)	4,111,665	5,927,507	6,583,168	6,766,531
D) CUMULATIVE CASH BALANCE	4,111,665	10,039,172	16,622,340	23,388,871