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SF Project SYR .. 34

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Caustic Soda & Chlorine Project

in

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A Prefeasibility Study Report.

Damascus, August 1972

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

SF Project SYR - 34

Caustic Soda & Chlorine Project

in

The Syrian Arab Republic

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This report is presented to the Government without prior approval of either U N D P or U N I D O and, therefore, does not necessarily represent the views of either Organisations.

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SUMMARY

There is a promising investment opportunity to establish an electrolytic caustic soda and chlorine plant in the Syrian Arab Republic based on indigenous rock salt and hydroelectric power from Euphrates Dam. The country can become self-sufficient in caustic soda and chlorine by the construction of the proposed plant to produce 12225 tons of chlorine and 13700 tons of caustic soda per year. Although these two industrial chemicals are used in different fields, they are considered together because both are produced simultaneously by the electrolytic process.

According to recently conducted market surveys for caustic soda and chlorine, domestic consumption of both products will reach 12138 and 12225 tons respectively in 1980. Caustic soda in excess of local consumption is to be solidified and exported to neighbouring countries. The 12225 tons of chlorine produced are fully utilized; 983 tons for sanitation purposes, 8890 tons for polyvinyl chloride production, 2052 tons for the manufacture of 6400 tons hydrochloric acid and 300 tons for the production of 4300 tons of calcium hypochlorite solution containing 70 grams per litre available chlorine.

Plant investment amounts to 26.5 million Syrian Pounds of which 17.9 million pounds are needed in foreign currency. This investment is based on the use of mercury cell and includes also the cost of hydrochloric acid and calcium hypochlorite plants.

For the realization of the project a total period of four years is considered necessary, in other words the project can start production by the end of 1976. However, the hydroelectric power from Euphrates Dam power station will not be available for use by the project before that date.

Plant locational studies proved that the direct vicinity of Aleppo or Homs has economic advantages over other sites. The choice between these two towns needs further information concerning the availability of water in Aleppo and the possibilities of supplying the plant with rock salt from Gabol area.

1. INTRODUCTION

This preliminary selection stage study of the caustic soda and chlorine project in the Syrian Arab Republic was carried out by the experts of the Special Fund Project SYR-34 in accordance with the detailed work programme of SYR-34 which was approved by both the Government and U N I D O.

The study was intended to find out the possibilities for manufacturing caustic soda and chlorine which could lead to a degree of foreign exchange saving, and at the same time serve as a basis for gradual extension and diversification of the Syrian chemical industry.

In order to be able to make a decision on the soundness of the project, the study was classified to cover:

(i) a description of the market outlining an estimation of consumption, trends, present supplies and prices;

(ii) brief description of the alternative technologies and information on the availability of major technical inputs;

(iii) tentative estimation of the investment and operation expenditure;

(iv) preliminary estimate of the commercial profitability.

The study of item (i) was carried out by the Industrial Economist Mr. B. Jovanovic assisted by his counterpart Mr. Farid Roumani. Two reports were presented covering this item, namely:

(a) Caustic soda and chlorine domestic market in Syria and prospective demand, submitted in July 1972;

and (b) Polyvinyl Chloride domestic market in Syria and prospective demand, submitted in August 1972.

Engineer E. Francis participated also in the preparation of the second report on

The study of items (ii), (iii) and (iv) was made by the Project Manager of SYR-34 Mr. F. Abdel Sayed. Material assistance was given by the Syrian Project Co-Manager Engineer Z. Kasaballi and Engineer N. Khayat who was assigned to work on the caustic soda and chlorine project.

2. MARKET STUDY

Caustic soda is an important basic chemical. A basic chemical may be defined as a chemical manufactured in big quantities at low cost and serves as raw material or treating agent for other manufacturing industries.

Caustic soda has many uses, particularly in the manufacture of viscose rayon, soap, pulp, paper, vegetable oils, chemicals, textiles, refined petroleum, reclaimed rubber, and other products.

Chlorine which is obtained as a co-product with caustic soda manufactured by the electrolytic process has various utilizations. Chlorine is commonly used as a bleaching agent and in sanitary applications, such as the purification of public water supplies. In the developed countries it is widely used in chlorinated compounds for insecticides, plastics, refrigerants, chlorinated hydrocarbons and other applications.

2.1 Consumption Trend of Caustic Soda in Syria(1963-1971):

At present there is no local production of caustic soda, all consumers' requirements are supplied through importation.

According to the official foreign trade statistical publications, for the period (1963-1971), the total Syrian import and re-export of caustic soda were as follows:

Tab. 1 Total Syrian Import and Re-export of Caustic Soda, 1963-1971

Years	Import	Re-Export	Net Import
		kilograms	
1963	3,516,189	48,525	3,467,664
1964	3,853,685	400	3,853,286
1965	4,994,020	-	4,994,020
1966	4,405,755	112,816	4,292,939
1967	3,605,084	111,585	3,493,499
1968	7,636,997	245,510	7,391,487
1969	5,092,600	65,350	5,027,250
1970	6,074,802	28,700	6,046,102
1971	7,418,853	30,400	7,388,453

Source: Central Bureau of Statistics - S A R, Foreign Trade Statistics, 1963-1971

Since there is no local production of caustic soda in Syria, one can conclude that the above presented figures for the net import represent simultaneously the so called "Apparent consumption" (production plus import minus export). On the other hand, knowing that the apparent consumption does not include the total quantities of consumed caustic soda (i.e., without that consumption which comes from decreasing of caustic soda stocks at producers and traders), necessary steps were undertaken to contact directly the local consumers and to collect consumption data of caustic soda. The results of these direct contacts give the following picture:

Tab. 2 Total Consumption of Caustic Soda by Consumers in Syria, 1969-1971

Consumers	1969	1970	1971
	in metric tons		
- Union of Textile Industries	1,310	1,780	1,883
- Union of Food Industries	1,000	1,000	1,500
- Petroleum Refinery at Homs	457	423	600
- Union of Engineering & Chemical Industries	114	130	157
- Private Sector's Soap Production	4,449	4,569	3,959
Total:	7,330	7,902	8,101
- 1969 = 100 percent	100.0	107.8	110.5
- Chain Index (percentage)	100.0	107.8	102.5
- Average consumption of caustic soda in 1969-1971, in tons	--	---	7,778.--
- Average annual growth of caustic soda consumption 1969-1971 (percentage)	--	--	5.1

Source: Official letters received from Unions and Petroleum Refinery at Homs.
Soap production in private sector - Central Bureau of Statistics.

On the other hand, the consumption of caustic soda by end-use products in 1971 has the following structure:

Tab. 3 Caustic Soda Consumption by End-Use Products in 1971
(metric tons)

End-Use Products	Consumption of Caustic Soda	
	Quantity	Percentage %
Textile	1,885	23.3
Public Sector's Soap production	840	10.4
Refining of vegetable oil from cotton seed	660	8.1
Petroleum products	600	7.4
Chemicals including synthetic detergents	157	1.9
Private Sector's soap production	3,959	48.9
Total:	8,101	100.0

Source: The data derived from Tab. 2 and details given by consumers

It is evident from the above table that nearly 60 percent of the total caustic soda consumption belongs at present to the soap production in private and public sector.

2.2. Consumption Trend of Chlorine in Syria (1963-1971)

As in the case of caustic soda, there is no local production of chlorine and all consumers' requirements are supplied through importation.

According to the official data of the Syrian Foreign Trade Statistics, the following quantities of chlorine were imported during the period 1963-1971:

Table 4 - Total Syrian Import and Re-Export of Chlorine, 1963-1971

Year	Import	Re-Export	Net Import
	kilograms		
1963	841	1000	- 159
1964	-	45	- 45
1965	6,971	-	6,971
1966	7,669	-	7,669
1967	28,875	-	28,875
1968	52,221	-	52,221
1969	90,593	-	90,593
1970	102,751	-	102,751
1971	132,243	-	132,243

Source: Central Bureau of Statistics - S A R, Foreign Trade Statistics, 1963-1971

The net import given in the above table represents simultaneously the apparent consumption of chlorine for the same reasons mentioned earlier in this context for caustic soda. However, the negative items of net-import in 1963 and 1964 resulted from deliveries of re-exportation from available stocks in the previous period.

However, if one includes in calculation of chlorine consumption the quantities of imported chlorine in the form of hydrochloric acid and calcium hypochlorite, the following figures are obtained:

Table 6 - Conversion of Imported Hydrochloric Acid and Calcium Hypochlorite into Chlorine (kilograms)

Year	Net Importation 1)		Conversion into Chlorine 2)		
	Hydrochloric Acid	Calcium Hypo-chlorite	Hydrochloric Acid	Calcium Hypo-chlorite	Total
1963	678,506	127,411	217,122	82,817	299,939
1964	533,187	246,763	170,620	160,396	331,016
1965	649,437	145,827	207,820	94,788	320,608
1966	1,033,468	357,645	330,710	232,469	563,179
1967	193,656	25,000	61,971	16,250	78,221
1968	607,204	268,680	194,305	174,642	368,947
1969	1,648,968	307,720	527,670	200,018	727,688
1970	1,750,132	78,045	560,042	50,729	610,771
1971	1,955,917	108,826	625,893	70,737	696,630

1) Source for Net Importation: Central Bureau of Statistics - SAR, Foreign Trade Statistics, 1963-1971
2) Conversion factor for hydrochloric acid is 0.32 and for calcium hypochlorite 0.65

Then the total chlorine imported into the S A R can be summarized in the following table:

Tab. 7 Total Imported Chlorine into SAR 1963 - 1971
(Kilograms)

Year	Directly imported chlorine (data from Tab.4, net import)	Chlorine imported into the form of hydrochloric acid and calcium hypochlorite (Tab.6)	Total
1963	- 159	299,939	299,780
1964	- 45	331,016	330,971
1965	6,971	320,608	327,579
1966	7.669	563,179	570,848
1967	28,875	78,221	107,096
1968	52,221	368,947	421,168
1969	90,593	727,688	818,281
1970	102,751	610,771	713,522
1971	132,243	696,630	828,873

Source: Data from Tab. 4 and 6

2.3 Prices of Caustic Soda and Chlorine on the Domestic Market

The price of solid caustic soda 97-98 per cent, up to the stores of consumers in Syria, has the following structure:

Tab. 8 - Domestic Price of Caustic Soda in Syria, end of 1971

	Dollars per ton	Syrian Pounds per ton
FOB (producer) price	110.6 - 114.66	475.58 - 493.03
C & F Lattakia	150	645
Local Costs:		
Customs duty (1 percent)		6.45
Transportation		
- Lattakia - Damascus		23 - 25
- Lattakia - Homs		20
- Lattakia - Aleppo		20
All other costs in domestic currency (loading, harbour demurrage, etc.)		28.55 - 31.45
	Total	ca.705

Source: Chemical Marketing Reporters, Schnell Publishing Company, New York, and consumers' information.

The above cost per ton of caustic soda does not include the costs for containers, i.e. drums.

Concerning chlorine, the price has the following structure on the domestic market at the end of 1971:

Tab. 9 Domestic Price of Chlorine in Syria, End of 1971

	Price of Chlorine - without container - cylinder	
	Dollars per ton	Syrian Pounds per ton
FOB (rpducer) price	80.25 - 162.64	345.08 - 699.35
[illegible] Lattakia	230.76	992.27
Local costs:		
Customs duty (7 percent)		69.46
Transportation		
- Lattakia - Damascus		24.
- Lattakia - Homs		20.
- Lattakia - Aleppo		20.
All other costs in domestic currency (loading, harbour demurrage, etc.) ca.		30.
Total:		ca: 1,150

Source: Chemical Marketing Reporters, Schnell Publishing Company, New York and consumers' information.

It should be underlined that the FOB prices of chlorine have big differences within the range of $ 80.25 - 162.64, which result from the size of the purchase orders.

2.4 Projection of Caustic Soda and Chlorine Future Consumption in Syria (1971-1980):

2.4.1 Market Prospects for Caustic Soda:

The estimation of future consumption of caustic soda is based on the following assumptions:

(i) Consumption of caustic soda in Syria in basic year (1971) amounts to 8101 tons. The breakdown of consumption by consumers is shown in table 2.

(ii) Expected future consumption of caustic soda in textile production as estimated by the Union of Textile Industries[1] is 2350 tons in 1975 and 3173 in 1980. This gives a respective compound growth rate (1971-1980) of 5.3 per cent annually, which is higher than the expected population growth rate (3 percent for the same period). The above estimation can be accepted taking into consideration that the planned growth of the textile sector during the Third Five Year Plan (1971-1975) is as follows:

(a) the production capacity of cotton yarn will be increased by 28,000 tons per annum, with the aim of gradually processing fifty percent of Syria's cotton production;

(b) the production of cotton fabrics will be raised by fifty percent of the 1970 level;

(c) two thousand tons of local wool will be washed instead of exporting them in the crude state.

Moreover, textile exports amount to 400 million Syrian Pounds representing a significant portion of textile industry gross output. Besides, these exports are steadily increasing.

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1) Union of Textile Industries letter No. 12125 dated 13 November 197[illegible]

(iii) The Union of Food Industries used in 19 1 nearly 840 tons of caustic soda for soap production (4,207 tons of soap in 1971) and some 660 tons of caustic soda in refining processes of vegetable oil from cotton seeds (i.e. 30,000 tons of vegetable oil in 1971). The estimation of the Union [1] is that the soap production within the Union will increase in average annually up to 1980 by 10 percent (up to the full use of the available production capacity - i.e., up to 8,000 - 8,500 tons of soap) and vegetable oil from cotton seeds respectively by 5 percent. However, this estimation is rather optimistic and it is more realistic to suppose a growth rate of 3 percent annually during the period 1971-1980 in both cases. Therefore, future consumption of caustic soda for soap production and for vegetable oil refining in public sector may be estimated in 1980 at 1095 and 860 tons respectively.

The above supposed growth rate of caustic soda consumption in 1980 is within the rank of the expected population growth rate in Syria.

(iv) The Petroleum Refinery at Homs [2] estimates future consumption of caustic soda in the refinery at 1,000 tons in 1980. This estimation is based on the requirements of the projects included in the Third Five Year Plan (1971-1975) and on the expectations of the Fourth Plan.

(v) The Union of Engineering & Chemical Industries [3] estimates the total cumulative

1) Union of Food Industries letter No. 2100/12473 dated 12 December 1971.

2) Letter of the Refinery No. 13672 dated 17 November 1971.

3) Letter of Union of Engineering and Chemical Industries No. 2100/719 dated 10 January 1972.

consumption of caustic soda in the period (1971-1980) at 4,173 tons, of which the overwhelming share belongs to the Arabian Co., S A R, Damascus (for detergents' production some 4,115 tons respectively in the period 1971-1980 as a whole). It gives an average growth rate of 20.5 percent annually, and the expected future consumption of caustic soda is therefore estimated at 842 tons in 1980. Although the estimated figure by the Union is rather on the high side, yet it can be accepted as the demand on detergents is sharply rising and as the estimated figure has a relatively small effect on the total projection of caustic soda demand.

(vi) As far as the caustic soda consumption (1971-1980) in soap production by the private sector is concerned, the total soap production (in public and private sector) in the same period was calculated on the basis of the growth rate which is the same for the development of population (3 percent in the period 1971-1980), and then, after deduction of future soap production in public sector (see above item iii) the balance was taken as the future soap production in private sector. The respective needs of caustic soda for the future soap production in private sector is, therefore, estimated at 51681 tons in 1980.

In the light of the foregoing, caustic soda's future demand in Syria can be summarized as shown in the following table:

	1971	1980
	Metric Tons	
- Union of Textile Industries	1,885	3,173
- Union of Food Industries	1,500	1,955
- Petroleum Refinery at Homs	600	1,000
- Union of Engineering & Chemical Industries	157	842
- Private Sector Soap's Production	3,959	5,168
Total:	8,101	12,138

The future demand for caustic soda given above shows a cumulative increase of 49.9 per cent in 1980 over 1971 figure, or an average growth rate during this period of 4.6 percent annually.

2.4.2 Market Prospects for Chlorine:

The estimation of future consumption of chlorine in the Syrian Arab Republic is calculated on the following basis:

(i) Consumption of chlorine in basic year 1971 is 132 tons as shown in table (4). This figure is taken to represent approximately the non-industrial consumption or in other words the sanitation uses of chlorine in Syria.

(ii) The future sanitation consumption of chlorine is estimated by the Ministry of Rural and Municipal Affairs[1] at 983 tons in 1980, out of which 253 tons will be used for purification of drinking water and 730 tons for treatment of sewage water.

(iii) The future needs of the General Company of Petroleum[2] from hydrochloric acid for the reactivation of crude oil wells is estimated at 4500 tons (33-35%) in 1980. This is equivalent to 1440 tons of chlorine.

(iv) The Union of Textile Industries [3] estimates its future requirements from hydrochloric acid in 1980 at 715 tons (33-35%). This quantity is equivalent to 229 tons of chlorine.

(v) The requirements of a Third Five Year Plan project for the production of citric acid from molasses amount to 405 tons of hydrochloric acid (33-35%) equivalent to approximately 130 tons of chlorine.

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1) Letter of Ministry No. 6113/S dated 25 June 1972.

2) Company's cable No. 21[illegible]3 dated 13 November 1971.

3) Letter of Union of Textile Industries No. 2165 dated 13 November 1971.

(vi) The Electricity Corporation[1] estimates its future demand from hydrochloric acid in 1980 at 695 tons equivalent to 222 tons of chlorine.

(vii) The Union of Engineering and Chemical Industries[2] estimates its future needs from hydrochloric acid in 1980 at 17.3 tons equivalent to about 5.5 tons of chlorine.

(viii) The Union of Food Industries[3] estimates its future need from hydrochloric acid in 1980 at 11 tons equivalent to 3.5 tons of chlorine.

(ix) A recent market survey for polyvinil chloride (P. V. C.), its domestic market and prospective demand in Syria[4] has shown that the estimated future consumption of P. V. C. in 1980 amounts to 13900 tons, the breakdown of which is given in the following table:

1) Letter of Electricity Corporation No. 3087 dated 12 June 72.

2) Letter of Union No. T/21/6705 dated 4 August 1971.

3) Letter of Union of Food Industries No. T/2100/6897 dated 14 July 1971.

4) A preliminary selection stage report dated July 1972 prepared by SF Project SYR-34 and submitted to UNIDO and Government of Syria in August 1972.

Table 10 - Estimated Future Consumption of P V C in Syria

(metric tons)

End Products	Type of P V C	Actual consumption of P V C in 1 9 7 2	Estimated Consumption of P V C 1975	1980
A. Existing domestic market				
A.1. Cables	flexible	670	1500	1800
A.2 Flexible extrusion and blowing products, such as profiles, pipes, ropes, packing mat., sheets, synthetic leather, etc.	flexible	1105	4200	5000
A.3 Injection products, such as shoes, heels, soles, boots and others	flexible	4300	5800	6700
Total (A.1) to (A.3)		6075	11500	13500
Total (A.1) to (A.3) converted into rigid PVC		3645	6900	8100
A.4 Containers for vegetable oil and others made of rigid P V C	-rigid	175	600	1100
Total (A.1) to (A.4) converted into rigid P V C		3820	7500	9200
B. Potential domestic new market				
B.1 Building mat., such as floor covering and profiles	rigid	-	500	1400
B.2 Irrigation pipes	rigid	-	-	300
B.3 Exports	rigid	-	-	3000
Total (B.1) to (B.3)		-	500	13900
Grand total (A + B) in rigid form of P V C		3820	8000	13900

The above consumption of P V C would justify the installation of a 15,000 tons polyvinil chloride plant starting from naphtha as a raw material and using the combined acetylene and ethylene process for naphtha cracking. A contact made with a Japanese firm which possesses a licence for such process revealed that a plant of such capacity would be economically feasible.

For the production of 13900 tons of P V C about 14,460 tons of monovinyl chloride (M V C) are required which in turn would need 8890 tons of chlorine.

(x) Foreign trade statistics show that calcium hypochlorite (65 percent available chlorine) is imported in various amounts in Syria. Some 357 and 307 tons were imported in 1966 and 1969 respectively as shown in Table 6. The country's requirements from calcium hypochlorite can be met by installing a simple unit for the production of dissolved calcium hypochlorite (70 grams per litre) which also serves to absorb the chlorine obtained as "sniff" or "vent" gas from other units processing chlorine in the plant. Up to 300 tons (100% available chlorine basis) can be produced in the form of 4300 tons of solution containing 70 grams per litre (i.e. 7% available chlorine) for this purpose. This quantity of calcium hypochlorite bleach liquor need 300 tons of chlorine for its manufacture.

(xi) Other prospective uses of chlorine in the Syrian Arab Republic were investigated. In particular the uses of chlorine as a bleaching agent in the pulp and paper industry, in the manufacture of insecticides, refrigerants, chlorinated hydrocarbons and other applications were thoroughly studied. It was concluded that these utilisations cannot be applied in Syria due to the very limited or rather non-existing demand for such products.

The recapitulation of items (i) to (x) above shows that the estimated future demand for chlorine in 1980 amounts to 12203 tons, the breakdown of which is given in the following table.

Table 11 - Estimated Future Demand for Chlorine in 1980

(metric tons)

End Use	Estimated demand for chlorine
Sanitation Purposes	983
Hydrochloric Acid (6343 tons 32-33%)	2030
Polyvinil chloride (13990 tons)	8890
Calcium hypochlorite (4300 tons 70 g/litre)	300
Total	12203

In the light of the foregoing one can conclude that a future demand for caustic soda and chlorine amounting to 12138 and 12203 tons respectively will exist in Syria in 1980.

The estimated future demand for chlorine and caustic soda year by year starting from 1975 till 1980 can be summarised in the following table:

Table 12 - Estimated demand for chlorine and Caustic Soda during the period 1975 - 1980

(metric tons)

Product	1975	1976	1977	1978	1979	1980
1. Chlorine						
1.1 Total	6799	7627	8565	9632	10845	12203
1.2 for PVC manufacture	5117	5715	6383	7129	7963	8890
1.3 for sanitation purposes	322	403	503	629	787	983
1.4 for hydrochloric acid manufacture	1060	1209	1379	1574	1795	2030
1.5 for cal. hypochlorite manufacture	300	300	300	300	300	300
2. Caustic soda (100 percent NaOH basis)	7615	8542	9593	10788	11604	12138

3. TECHNICAL STUDY

3.1 Processes of Caustic Soda manufacture:

Two types of processes, chemical and electrolytic are used in the manufacture of caustic soda.

3.1.1 Chemical Process:

The chemical process is based on the caustification of sodium carbonate using milk of lime in accordance with the following equation:

$$Na_2\,CO_3 + Ca(OH)_2 \text{ -- } CaCo_3 + 2\,NaOH \text{ ..... (1)}$$

The sodium hydroxide solution (11 percent) is then evaporated and the concentrated solution is solidified to obtain solid caustic.

Sodium carbonate is manufactured chiefly by the "Solvay" or ammonia soda process using salt, limestone, coke and ammonia as raw materials, according to the following reactions:

$$CaCO_3 \longrightarrow CaO + CO_2 \text{ ....(2)}$$

$$C + C_2 \longrightarrow CO_2 \text{ ....(3)}$$

$$CaO + H_2O \longrightarrow Ca\,(OH)_2 \text{ .... (4)}$$

$$NH_3 + H_2O \longrightarrow NH_4\,OH \text{ .... (5)}$$

$$2NH_4OH + CO_2 \longrightarrow (NH_4)\ CO_3 + H_2O \text{ .... (6)}$$

$$(NH_4)_2\ CO_3 + CO_2 + H_2O \longrightarrow 2NH_4\ HCO_3 \text{ .... (7)}$$

$$NH_4\ HCO_3 + NaCl \longrightarrow NH_4Cl + NaHCO_3 \text{ .... (8)}$$

$$2NaHCO_3 \longrightarrow Na_2CO_3 + CO_2 + H_2O \text{ .... (9)}$$

$$2NH_4Cl + Ca(OH)_2 \longrightarrow 2NH_3 + CaCl_2 + 2\,H_2O \text{ ....(10)}$$

The chemical process for the production of caustic soda is no longer used in the developed countries and is replaced by the electrolytic process which produces chlorine together with caustic soda as co-product. In developed countries the demand for chlorine far exceeds that for caustic and therefore chlorine is considered the primary product. This situation does not prevail in most developing countries where chlorine does not find the same uses. Therefore, it is indispensable that practical uses for chlorine must be found to justify the selection of the electrolytic process.

Although the chemical process does not give co-product chlorine and its raw materials - with the exception of coke - do exist locally; yet the chemical process cannot be adopted in Syria. This is due to the fact that the chemical process to be economically feasible requires a very large scale plant. Such a plant for producing sodium carbonate and caustic soda from salt and limestone would be far too large for the 12,138 tons of caustic per year plus the 12,000 tons of sodium carbonate which appear to be the limit of the country's demand in 1980. Moreover, the capital investment needed for the chemical process is much higher than that for the electrolytic process.

3.1.2 Electrolytic Process:

In this process sodium chloride solution is decomposed in electrolytic cells with the production of caustic soda, chlorine and hydrogen.

$$NaCl \longrightarrow Na^+ + Cl^- \ldots\ldots\ldots\ldots (7)$$

$$Na + H_2O \longrightarrow NaOH + 1/2\ H_2 \ldots\ldots\ldots (8)$$

Two types of cells are used in the electrolysis of sodium chloride brine, namely, the diaphragm and the mercury cells.

In case of diaphragm cell, a diaphragm made of asbestos separates the graphite anode from the steel cathode. The direct current causes chlorine to be liberated at the anodes whilst caustic soda and hydrogen gas are formed at the cathodes. The liquid leaving the cell contains approximately 11 percent sodium hydroxide and 15 percent sodium chloride. This liquid is then evaporated in multiple effect evapourators to obtain a 50 percent solution of caustic soda. Sodium chloride crystallises out during evaporation and the 50 percent caustic solution is left with about 1.1 percent sodium chloride and other impurities.

The mercury cell has graphite anodes and mercury cathode. Purified saturated brine is fed to the cell where it flows between the graphite anodes and the mercury cathode. This results in the formation of gaseous chlorine which is liberated at the anode and sodium amalgam which is formed at the cathode. The sodium amalgam flows from the cell to the decomposer whereby it reacts with water to produce mercury, 50 percent caustic soda solution and hydrogen gas. Mercury flows back to the electrolytic cell. The 50 percent caustic soda solution obtained from mercury cells is of high purity with a sodium chloride content of 0.006 percent or less. This high grade caustic soda is suitable for viscose rayon industry and it has a distinctive advantage over caustic soda obtained from diaphragm cells since it does not require further purification to comply with the rayon industry specifications.

3.1.3 Choice of Cell Type:

Both types of cell, the diaphragm and mercury cell have their specific advantages and disadvantages. Caustic soda obtained from mercury cell does not require further concentration or purification as in the case of diaphragm cell.

The consumption of electric power per ton chlorine gas is slightly higher in the mercury cell (3,000 - 3,200 kW-hr direct current) than in the diaphragm cell (2,600 - 2,800 kW-hr); this leads to 12-15 percent higher power costs in case of mercury cell. On the other hand, mercury cell produces concentrated caustic soda solutions (50 to 73 percent N OH) without the use of external heat, while in case of diaphragm cell an 11 percent caustic solution is obtained which is further concentrated by the use of steam. The amount of steam required for concentration of caustic soda solution obtained from diaphragm cell ranges from 4.5 to 7.8 tons per ton of chlorine depending on concentration required. It can be said, therefore, that mercury cell is preferred to diaphragm cell where electric power is cheaper and steam is more expensive.

Other advantages of the mercury cell are that it is simpler in design and operates at high current densities. Besides, the current efficiency in case of mercury cell (96 percent) is higher than that of diaphragm cell (90-92 percent); however, up to 4 percent higher current efficiency is obtained in new diaphragm cell, of the Hooker type, having central circulation space for brine. Complete brine purification for the mercury cell is not necessary as for the diaphragm cell; mercury cells are designed to operate efficiently with salt that has been treated in a relatively simple manner without removal of sulphates and compounds of calcium and magnesium. On the other hand, diaphragm cell is sensitive to changes in brine concentrations and calcium sulphate must be removed before the brine enters the cell otherwise clogging of the diaphragm takes place.

The chief disadvantages of the mercury cell other than the high consumption of electric power are the high cost of mercury inventory, the inevitable mercury make up, the effect of small quantities of heavy metals (e.g. iron, chromium and vanadium) in the brine which cause excessive hydrogen discharge in the cell, and finally more floor space is occupied by mercury cell than some types of diaphragm cell

It can be emphasized, however, that mercury make up in mercury cell is rather small amounting to 0.4 - 0.5 lb per ton of caustic only. The mercury inventory raises the capital investment of the plant but has little effect on the production cost of caustic soda since mercury for the initial filling of cells is considered as a non-depreciable asset.

It is evident from the foregoing that mercury cell has several advantages over diaphragm cell; as a result mercury cell has held the predominant position in Europe whereby it is responsible for more than 95 percent of the total chlorine production in Germany and Italy. In the United States of America there used to be a predominance of diaphragm cell which was largely due to the availability of asbestos as well as of natural brines. Besides, the mercury cell technology has only been available in America for about the last thirty years due to the strict secrecy that for many years surrounded the development of mercury cells in Europe. Mercury cell has been gaining in favour in the U.S.A. accounting for about 20 percent of the total chlorine production in 1960. It is believed that mercury cell will continue to take the lead since for the United States, capital investment and production costs are about the same for both types of cells.

Hence, mercury cell is recommended for use in Syria following the general trend of chlorine industry in developed countries. It is, however, intended to carry out an elaborate economic comparison between the two types of cell based on local conditions in the feasibility study to be prepared during the formulation stage of the caustic soda and chlorine project.

3.2 Description of Mercury Cells:

The mercury cell consists of two parts : (i) the cell or the electrolyzer in which purified saturated brine flows between graphite anodes and a mercury cathode resulting in the formation of chlorine gas and sodium amalgam, (ii) the decomposer or the denuder in which the sodium amalgam reacts with water whereby 50 percent caustic solution, hydrogen gas and mercury are produced.

The electrolyzer consists of a box-like vessel constructed of standard structural steel with sides and top lined with hard rubber. In one particular type of cell (de Nora cell) the electrolyzer is lined with natural syenite rock. A number of graphite anodes extend down through the cell cover which can be easily and accurately adjusted to maintain maximum cell efficiency.

Saturated brine and mercury enter the cell through the inlet end box which closes one end of the cell and has a mercury distributor as well as a brine inlet and chlorine outlet. The moist chlorine gas is under a slight vacuum and leaves the cell through the inlet end box. The brine is fed at a rate which can be easily metered and controlled. The vacuum can be noted on the manometer connected to each electrolyzer. The electrolyzer is sloped (slope of 4 cm approximately) and the brine and mercury flow to the outlet end box which is an intermediate section between the electrolyzer and decomposer. Under the action of direct current, the bottom of the electrolyser is wetted with mercury as it runs down to the outlet end box. Chlorine gas produced on the anodes is vented through suitable perforations in the anodes.

The sodium amalgam formed in the electrolyser flows by gravity to the decomposer which is located below the electrolyser and is made of steel tank packed with graphite lumps. There is a mercury distributor in the top of the decomposer and a water distributor in the bottom. The amalgam enters the top of the decomposer through a seal and pure water is introduced near the bottom. Mercury is pumped back to the inlet end box from the bottom of the decomposer by means of a centrifugal pump. The caustic soda and hydrogen produced in the decomposer leave through separate pipes. Although the decomposer is made of steel or iron, the caustic produced has an extremely low iron content because the steel surfaces become amalgamated very quickly preventing iron from going into solution.

3.3 Brine Treatment

Rock or solar salt is transferred to a conveyor by suitable means and then conveyed to a salt feed hopper by means of a salt elevator. Salt is then fed from the hopper to a saturator. Dechlorinated brine from the electrolyzer is pumped through the saturator. Insoluble impurities are periodically discharged from the bottom of the saturator into a sludge pump. Saturated brine discharges into a weir box where a controlled quantity of dilute caustic soda is continuously added. The caustic precipitates certain impurities such as magnesium and iron, as hydroxides. The brine flows to a flocculator where precipitation continues, then flows by gravity to a brine settler. The precipitates settle to the bottom, and clear liquor overflows to a brine storage tank. From the tank, brine is pumped at a controlled rate through a brine filter and the clarified liquor is discharged to a filtered brine storage tank. Filtered brine is then pumped to a head tank which maintains a constant hydrostatic head for the feed to the cells. The brine dechlorination unit is operated continuously. The dilute brine from the electrolyzer, containing chlorine in solution at about 70°C, flows to a brine surge tank. The dilute brine is acidified with hydrochloric acid and fed at a controlled rate to a flash chamber operated under vacuum. A large portion of the dissolved chlorine is flashed from the brine. The small amount of chlorine remaining is blown out with air in a seal tank. The brine from the flash chamber flows to the seal tank from which it is continuously fed to the saturator for re-use. The chlorine gas leaving the flash chamber passes to a vacuum pump, which discharges to a chlorine collecting main.

A typical analysis of the inlet brine to the mercury cell is as follows:

Table 13 - Typical Analysis of Brine Feed to Cell

$NaCl$	310 grams per litre
Fe	Less than 0.0001 grams per litre
Mg	Less than 0.01 grams per litre
$CaSO_4$	Tolerated up to saturation
$NaClO_3$	Allowed up to 10 grams per litre

Calcium sulphate, magnesium, and iron are among the common impurities present in brine. Hypochlorous acid and sodium chlorate are also present in the brine of an operating cell. Magnesium in brine has a decided effect on the amount of hydrogen in chlorine cell gas and should be kept below 0.01 grams per litre. Iron is bad if it is present as flocs of $Fe(OH)_3$ and it is important to filter the brine before use. Iron can be maintained at a low concentration if the pH of the brine is kept above 4.0

Calcium can be tolerated almost to the solubility of gypsum in brine which is 4.0 - 5.0 grams per litre. When brine is saturated with calcium sulphate (equivalent to 4.0 - 5.0 per litre Na_2SO_4) the graphite loss through anode corrosion is about 5.5 lbs. per ton of caustic produced. This is only about 1.3 lbs. greater than when using sulphate-free brine. The increase in graphite loss is only a few cents compared with several dollars per ton for the chemical removal of sulphate and calcium.

3.4 Caustic treatment:

Mercury amalgam leaving the electrolyser has sodium concentration of 0.1 - 0.15 per cent. It flows to a single stage decomposer whereby it is decomposed with soft water to 50 per cent sodium hydroxide and mercury. If a two stage decomposer with steam jacketed lower stage is used caustic soda with a concentration up to 73 per cent can be produced.

Caustic soda leaves the decomposer near the top. It is filtered to remove the carbon powder carried over from the decomposer and is then stored in rubber lined storage tanks. Liquid caustic soda is normally shipped in drums, tank trucks, or tank cars.

3.5 Chlorine treatment:

The normal composition of chlorine gas leaving the electrolyzer is given in the following table:

Table 14 - Analysis of Chlorine Cell Gas

Cl_2	97%
H_2	0.5 - 1.0%
CO_2	0.5%
Air & moisture	remainder

However, under certain circumstances, particularly on starting up the hydrogen content of the cell gas is increased. In order to keep its concentration below the explosive limit (more than 5 per cent hydrogen), air must be introduced and provision must be made to absorb chlorine cell gas during such short periods. Absorption in milk of lime or dry lime to produce liquid bleach or bleaching powder are convenient methods for accomplishing this result.

Chlorine gas which is to be marketed for sale in liquid form is withdrawn from the electrolyzer containing substantial quantities of moisture at 70 - 90°C. Chlorine under these conditions is highly corrosive and must be handled in corrosion resistant materials, e.g. ceramic, plastic or rubber lined equipment. Chlorine is cooled by a countercurrent spray of cold water in a rubber lined steel scrubber and is then dried with sulphuric acid in drying towers. The dry gas is compressed to 25-60 psig using either sulphuric acid ring compressors or centrifugal compressors, liquified by refrigeration and is finally stored in insulated steel tanks.

Liquid chlorine is shipped in 100-150 lbs steel cylinders, in one ton containers, in tank cars up to 55 tons and in tank barges from 550-1100 tons capacity.

3.6 Hydrogen treatment:

Hydrogen gas of 99.5 per cent purity leaves the decomposer. It is scrubbed with water and sent to a mercury condenser to lower its content from traces of mercury vapour. Part of the hydrogen obtained can be consumed in the hydrochloric acid unit for the manufacture of HCl acid and the remaining part may be compressed in hydrogen cylinders for use by outside consumers.

3.7 Hydrochloric Acid Manufacture:

Hydrochloric acid is required for treating the brine used in the mercury cell as well as for other purposes, in particular, as an acidulator in Syrian oil wells to increase the flow of crude petroleum. Since the hydrogen and chlorine required for its production are available from the electrolytic cell, a hydrochloric acid unit can be installed in the caustic soda and chlorine plant.

Hydrogen from the mercury condenser flows to a hydrogen exhauster and is pumped to a burner at a controlled rate. A controlled amount of chlorine gas is also pumped to the burner whereby the gas mixture is burnt in a brick-lined or silica furnace forming hydrochloric acid gas. The gas leaving the furnace passes to a water cooler where its temperature is reduced. The cooled gases flow to an absorber (often using a tantalum absorber), then to an acid scrubber. Unabsorbed gases are vented to the atmosphere. The acid leaving the absorber flows to a surge tank from which it is pumped to the hydrochloric acid storage tank.

3.8 Calcium hypochlorite manufacture:

A calcium hypochlorite unit may be installed in the caustic soda and chlorine plant to supply the local market with its requirement from bleaching agents. The unit will absorb chlorine obtained as "sniff" or "vent" gas for other units processing chlorine in the plant.

In the usual procedure for producing dissolved calcium hypochlorite, milk of lime is put into a concrete tank and then circulated by an outside centrifugal pump. Chlorine is introduced into the suction side of the pump at a controlled rate to prevent overchlorination. Sweep agitators are used to keep the lime in suspension, and lead cooling coils are used to minimize decomposition from overheating. When completed, the suspension is settled, the clear bleach liquor is pumped off, and the sludge washed with water before being discarded. The concentration of calcium hypochlorite bleach made by this method is normally between 60 and 80 grams per litre of available chlorine.

3.9 Capacity of Proposed Plant:

For the realization of the caustic soda and chlorine project a total period of 40 months was considered necessary, i.e. the project can be completed by the end of 1976. This coincides with the time fixed by the Electricity Corporation for supplying the plant with electric power from the Euphrates hydroelectric power station which is scheduled to be completed in that year.

Hence, it is thought plausible to fix the capacity of the proposed caustic soda and chlorine plant so as to meet the estimated demand of the Syrian market for chlorine in 1980. As stated previously under the market study the local demand for chlorine in 1980 is estimated at 12203 tons. The capacity of the plant is planned at 12225 tons of chlorine per annum so as to allow for the production of part of hydrochloric acid needed in the plant for the acidification of the brine solution. This capacity of chlorine gives 13692 tons of caustic soda (100 percent NaOH basis) as co-product.

The capacities of the various plant sections are planned for convenience in terms of tons of chlorine per 24 hours as follows:

Name of Plant	Capacity in terms of tons of chlorine per 24 hours
Rectifier plant	38
Cell plant	36
Brine saturation and purification plant	36
Chlorine drying plant	36
Chlorine compressing station	36
Chlorine liquefaction plant	5
Hydrochloric acid plant	7
Calcium hypochlorite plant (100 percent available chlorine basis)	3

3.10 Production Programme:

In accordance with the capacity of the proposed plant and on the basis of the estimated local demand for chlorine and caustic soda shown in Table 12, the anticipated output of the plant broken down by years and type of products can be summarized in the following table:

Table 15 - Annual Production of Plant (metric tons)

Product	1977	1978	1979	1980
1. Chlorine				
1.1 Chlorine gas for PVC manufacture	6383	7129	7963	8890
1.2 Liquid chlorine for sanitation purposes	503	629	787	983
2. Hydrochloric acid (32-33 percent)	4310	4918	5610	6400
3. Calcium hypochlorite (70 grams per litre)	4300	4300	4300	4300
4. Sodium hydroxide (100 percent basis)				
4.1 For local consumption	9593	10788	11604	12138
4.2 For export	-	-	542	1554

It must be stated that sodium hydroxide is produced in the form of solution containing 50 percent NaOH; and, therefore, it would be necessary to install a dowtherm solidification plant for the surplus caustic soda in excess of local demand so that it can be exported to neighbouring countries in a solid form.

According to the proposed production programme the plant will operate at about 70 percent of its chlorine capacity in 1977, 79 percent in 1978, 89 percent in 1979, and will reach its full chlorine capacity in 1980.

3.11 Major Input Materials:

The main inputs needed for caustic soda manufactured by the mercury cell process are electric power and sodium chloride. Both items represent approximately 40 per cent of the manufacturing cost of caustic soda. The following table shows the various raw materials consumed per ton of chlorine as cell gas. About 1.12 ton of sodium hydroxide and 11,000 cubic feet (STP) of hydrogen are co-produced per one ton gaseous chlorine:

Table 16 - Consumption of Raw Materials and Power

Raw Material	Unit	Unit per ton of chlorine gas
Sodium chloride	t.	1.70
Graphite	kg.	4.00
Mercury (Make up)	kg.	0.25
Electric current for electrolysis	kW-hr	3300
Other electric power	kW-hr	75
Water	cu.m.	40
Chemicals for brine treatment	Sy.p.	16

3.11.1 Sodium chloride:

Sodium chloride is available locally from rock salt mines that exist at Der-es-sor. About 30 to 70 thousand tons can be supplied to the project starting from 1976. The analysis of rock salt furnished by the Government Agency concerned is in average as follows:

Table 17 - Analysis of Rock Salt

Loss in weight at 105°C		0.05%	
Water insoluble matter		0.08%	
Total siliceous matter	(cal. as SiO_2)		(n.a.)
Iron, aluminium, etc.	(Cal. as R_2O_3)		(n.a.)
Calcium content	(Cal. as CaO)	0.10%	
Magnesium content	(Cal. as MgO)	0.01%	
Sulphate content	(Cal. as SO_3)	0.26%	
Phosphate content	(Cal. as P_2O_5)		(n.a.)
Alkalinity content	(Cal. as $NaHCO_3$)		(n.a.)
Sodium chloride content	(Cal. as NaCl)	99.50%	

The price per ton of rock salt ex-mines has been estimated by the authorities at 48 Syrian Pounds (equivalent to 11.16 dollars). The cost of transport (about 32 s.p.) is to be added to the ex-mines price. This price is extremely high compared with the cost of salt used for industrial purposes in other countries. For instance, solar salt was delivered to the electrolytic caustic soda plant at Alexandria, Egypt, at a price of 0.95 Egyptian Pounds per ton during the period 1961-1965. The price was afterwards raised to 2.4 pounds (equivalent to 5.8 dollars), which price is much lower than that estimated for Syrian rock salt. In the present study, however, the cost of rock salt is estimated at 61.7 Syrian Pounds per ton, broken into 30 pounds as ex-mine's price and 31.7 pounds as the cost of transport to plant site.

It is recommended that the Government take certain measures to ensure special rates for salt used for industrial purposes. It is further recommended to study the possibilities of exploiting rock salt deposits at the Gabol area which is 320 kilometers nearer to plant site than Deir-ez-zor.

3.11.2 Electric Power:

Electric power will be available from the hydro-electric power station of Euphrates Dam starting from 1976. The Syrian Electricity Corporation expressed its readiness to supply the caustic soda and chlorine project with electric power in the range of 5 to 10 Megawatts at a voltage of 66 K.V. provided the project is installed in the vicinity of

Damascus, Aleppo, Homs, Hama or El-Nabk. The cost of kw-hr as fixed by the said corporation is 0.06 Syrian Pounds equivalent to 0.014 dollars. This rate is considered to be extremely high for electrolytic caustic soda industry. Because power is a large factor in the cost of the process, it can be operated economically only when low cost power is available. The following table gives typical power costs from water power (hydroelectric) in some countries as compared with Syria:

Table 18 - Typical Power Costs from Water Power

Country	Cent per kw-hr	Remarks
Norway	0.1 - 1.50	
Sweden	0.1 - 1.50	
England	0.4 - 0.50	
Germany	0.38	From brown coal
Niagara Falls	0.30 up	
Ontario, Canada	0.15 - 0.4	
Egypt	0.27	From Aswan Dam delivered to Kima Works.
	0.54	From High Dam delivered to Aluminium Works.
Syria	1.40	Proposed cost by Electricity Corp.

Measures should be taken by the Syrian Government to grant a special rate for the electric power supplied to the project. A cost of 0.04 Syrian Pounds per kw-hr was assumed in the operating costs of the project. It must be emphasised that the project would not be economically feasible in case electric power is supplied at 0.06 pounds per kw-hr.

3.11.3 Water:

The source of supply of water depends mainly on plant location. Two possible alternatives for plant site are in the vicinity of Homs and Aleppo. In case the plant is installed at Homs, water is obtained from Oronto river. No reliable analysis could be obtained for Oronto river water. However, it can be said from the submitted analysis that this water is suitable for use as process water after treatment. The source of water supply, whether river water or artesian well water, is not yet known for Aleppo site and needs further investigations. The cost of water was estimated at 0.04 pounds per cubic meter.

3.11.4 Other Input Materials:

Other input materials including graphite, mercury, and chemicals for brine treatment are to be imported from abroad since they are not available locally. The value of these materials is rather small and does not exceed 6.4 percent of the total manufacturing cost of caustic soda and chlorine.

3.12 Plant Location:

Five alternative plant sites are considered. The choice of these sites was dictated by the condition imposed by the Electricity Corporation that electric power from Euphrates hydroelectric power station can be supplied to the plant provided it is located in the vicinity of Aleppo, Hama, Homs, El-Nabk or Damascus.

The major controlling factors and possible aspects of cost have been studied for each alternative location as follows:

(a) Utilities:

(i) Water supply: an adequate water supply is available for Homs and Hama sites from the Oronto River. The source of water supply in Damascus area is Barada River. In Aleppo artesian well water is to be used. In El-Nabk area the nearest adequate water supply is at Karena 13 kilometers away.

(ii) Electricity: A reliable and ample supply of electricity is available from the Euphrates hydroelectric power station in the range of 5 to 10 Megawatts at a voltage of 66 K.V. in all proposed sites.

(iii) Waste disposal: All proposed plant sites have no particular difficulty with the problem of waste disposal whereby an effluent neutralisation plant can be installed.

(b) Fuel:

Fuel oil is delivered from the petroleum refinery at Homs to the proposed locations.

(c) Labour:

Labour supply is considered the same in all five locations with the exception of El-Nabk in which industry is less developed. Furthermore, housing, transportation, hospitals, schools and recreation facilities are more available in Damascus, Aleppo and Homs.

(d) Geographical features:

The cost of site development, the availability of nearby good roads and climatic conditions are more or less similar in all five sites.

(e) Raw Materials:

The main raw material is sodium chloride which is obtained from rock salt mines at Deir-ez-zor. About 20783 tons of salt are needed annually for the plant when operating at full capacity. The cost of transportation is taken as 0.10 pound per ton-kilometer and it is assumed that the cost of the return journey should be included in the total transportation cost of salt since the lorries will go back to the mines unloaded. Other raw materials including graphite, mercury (make up) and chemicals for brine treatment (about 970 tons per annum) are imported through Lattakia and transported to proposed site at a cost of 0.1 pounds per ton-kilometer. The following table gives the cost of transportation of raw materials to the proposed locations:

Table 19 - Cost of transportation of raw materials (000 L.S.)

	Aleppo	Damascus	Homs	Hama	El-Nabk
Cost of transportation of salt including return journey	1318	2793	2120	1924	2456
Cost of transportation of other raw materials	18	33	18	14	26
Total	1336	2826	2138	1938	2482

(f) Markets:

The annual production of the plant when operating at full capacity and the share of consumption centres from each product calculated on the basis of installed capacities of consuming industries (e.g. soap, detergents, vegetable oils, sugar, textiles) and/or other facilities (water treatment stations, sewage treatment, oil fields, citric acid project and other purposes) is shown in Table 20.

The cost of transportation of the products to the consumption centres is taken as 0.1 pounds per ton kilometer. In the case of caustic soda, hydrochloric acid, hypochlorite and chlorine for P V C manufacture, the cost of return journey is added to the total transport cost because the special tank lorries used for shipping these products are not loaded on their back journey to the plant. In case of the chlorine for sanitation use the cost of returning the empty chlorine cylinders to the plant is included in the total cost. Table 21 gives the cost of transportation of the products from the proposed plant site to the consumption centres.

Table 20 - Distribution of Annual Production according to Consumption Centres.
(metric tons)

	Caustic Soda (50% solution)	Hydrochloric acid (32-33%)	Chlorine for sanitation		Chlorine for P V C	Calcium hypochlorite 70 g./1 litre
			net	gross packed in 1-ton cylinders		
Total Annual Production	27,384	6400	983	1622	8890	4300
Consumption Centres:						
Aleppo	8406	322	400	665		1935
Damascus	11264	1098	433	712		2279
Homs	2868	423	25	40	8890	86
Hama	796		20	32		
Lattakia	786		18	30		
Hasaka	154		12	20		
Tal Kojek		4500				
Deir-ez-zor			12	20		
Idleb			18	30		
Tartous			15	25		
Others	3108 (for export)	57 (in-plant use)	30	48		
Total	27384	6400	983	1622	8890	4300

Table 21 - Cost of Transportation of Products
(000 L.S.)

	Aleppo	Damascus	Homs	Hama	El-Nabk
Caustic Soda	1007	859	776	808	817
Hydrochloric Acid	711	972	838	807	905
Chlorine for San.use	42	44	41	66	42
Chlorine for P V C	343	288	-	84	144
Calcium Hypochlorite	165	140	148	151	144
Total	2268	2303	1803	1916	2052

(g) Increase in capital investment:

It is assumed that the P V C plant will be installed near the petroleum refinery at Homs as most petrochemical plants invariably are located near refineries or other sources of hydrocarbons. Therefore, chlorine for the manufacture of P V C can be transported in the gaseous form through a pipe line in case the caustic soda and chlorine plant is built at Homs near the petroleum refinery.

The other four locations need a liquefaction plant for chlorine 30 tons per day capacity and four tank lorries ten ton each for transportation of liquid chlorine from caustic soda plant to the P V C plant at Homs. This leads to an increase in plant investment by 80,000 dollars for the tank lorries, and 145,000 dollars for the chlorine liquefaction plant. The annual capital charges (depreciation and interest) for the increase in plant investment in case the plant is installed in one of the four locations other than Homs amounts to 39,800 dollars equivalent to 171,140 Syrian Pounds.

Table 22 shows a summary of the study of the factors controlling plant location as outlined above.

Table 22 - Factors controlling Plant location

Item:	Aleppo	Damas-cus	Homs	Hama	El-Nabk
1.Utilities:					
(i) Water supply	Artesian Water	Barada River	Oronto River	Oronto River	From Karena area
(ii) Water disposal	Possible	Possible	Possi-ble	Possi-ble	Possible
(iii) Electricity	Available	avail-able	avail-able	avail-able	avail-able
2.Fuel	available	avail-able	avail-able	avail-able	available
3.Labour	■	■	■	·	less availabl
4.Housing, schools,) recreation and transportation	■	■	■	less avail-able	less availabl
5.Geographical features ·	same	same	same	same	same
6.Cost aspects(000 L.S.)					
(i)Transportation of raw mat.	1336	2826	2138	1938	2482
(ii)Transportation of products	2268	2303	1803	1916	2052
(iii)Annual capital charges due to increase in plant investment	171	171	-	171	171
Total cost aspects	3775	5300	3941	4025	4705

It can be seen from table 22 that Aleppo site may be considered as the best location for the caustic soda plant followed by Homs site. However, further study is needed to investigate the effect of use of artesian well water in Aleppo from the technical and cost aspects as well as to determine how far the results obtained from the present location study are affected if salt can be supplied regularly from Gabol area instead of Deir-ez-zor salt mines.

3.13 Land and Buildings:

Land area needed for the caustic soda and chlorine project amounts to 20,000 square meters. A preliminary layout of the plant is shown in Fig. (1).

Buildings and civil works required for the plant, their dimensions and estimated cost are given in the following table. These dimensions allow for future expansion of the plant.

Table 23 - Buildings and Civil Works

Building	Dimensions	Estimated Cost (000 LS)
1. Rectifier and cell house	2000 sq.m. x 12 m.high	1200
2. Chlorine drying, compression & liquefaction	450 " x 8 m. "	135
3. Brine house (shed type)	600 " x 9 m. "	108
4. Chlorine storage & filling (shed type)	300 " x 8 m. "	45
5. Hydrochloric acid plant (shed type)	200 " x 8 m. "	30
6. Hypochlorite plant (shed type)	300 " x 8 m. "	45
7. Buildings for auxiliary plants:		
(i) Substation	150 " x 8 m. "	390
(ii) Workshop	300 " x 8 m. "	
(iii) Rubber lining shop	100 " x 8 m. "	
(iv) Graphite shop	200 " x 8 m. "	
(v) Garage	300 " x 8 m. "	
(vi) Laboratory	250 " x 8 m. "	
8. Warehouse	600 " x 5 m. "	150
9. Raw material store (shed type)	650 " x 6 m. "	97
10. Administration building	300 " x 8 m. " (2 storyes)	150
11. Fences	567 meters x 3 m. "	60
12. Reinforced concrete tanks		250
13. Foundations	2500 cu.m.	500
14. Sewers, sanitary, dining room, changing room and shower baths		350
15. Boiler house (shed type)	50 sq.m.x 8 m. high	8
16. Evapouration & Solidification Plant (shed type)	150 " x 8 m. "	22
Total cost of buildings & civil works		3540

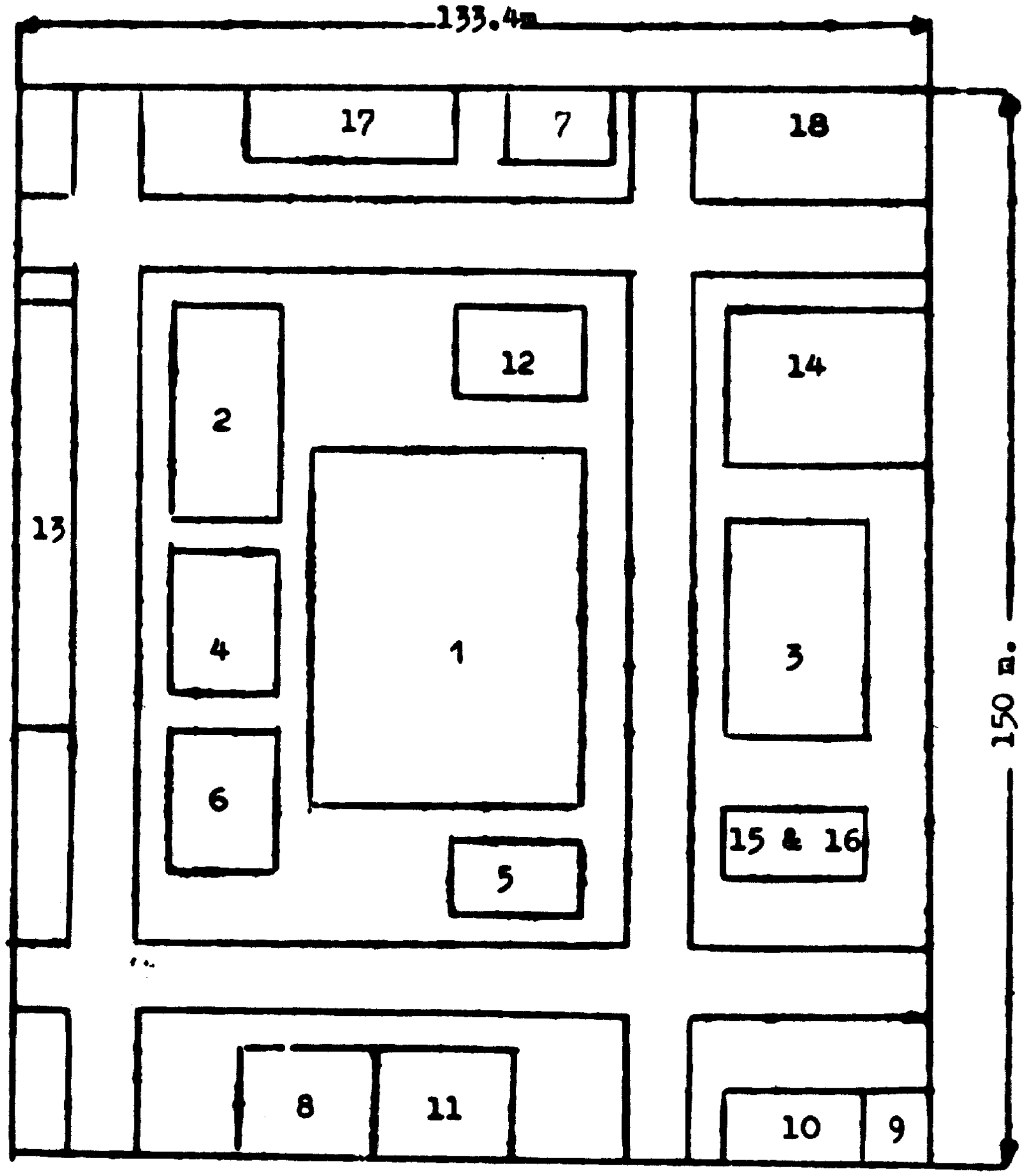

Fig.(1) - Preliminary layout of plant

1. Rectifier and cell house
2. Chlorine drying compression & liquefaction
3. Brine house
4. Chlorine storage & filling
5. Hydrochloric acid plant
6. Hypochlorite plant
7. Substation
8. Workshop
9. Rubber lining shop
10. Graphite shop
11. Garage
12. Laboratory
13. Warehouse
14. Raw material store
15. Boiler house
16. Evapouration & solid. plant
17. Administration building
18. Water treatment plant

N.B. Civil work for water treatment plant costs 120 thousand pounds and is included under facilities.

3.14 Machinery and equipment:

The daily production capacity of the various units of the plant in terms of tons of chlorine per 24 hours is as follows:

Table 24 - Capacity of various units of plant

Name of Unit	Capacity in terms of tons of chlorine per 24 hours
Rectifier plant	38
Cell plant	36
Brine saturation and purification plant	36
Chlorine drying plant	36
Chlorine compressing station	36
Chlorine liquefaction plant	5
Hydrochloric acid plant	7
Calcium hypochlorite plant (100 percent chlorine basis)	3

A caustic soda dowtherm solidification plant with a capacity of 10 tons per day (100 percent NaOH basis) is also needed for the solidification of caustic soda in excess of local requirements so that it can be exported to neighbouring countries.

Table 25 lists all machinery and equipment required for the plant and their FOB value in U.S. dollars.

Table 25 - Machinery and equipment and their FOB value

Machinery and Equipment		FOB Price (U.S.$)
(1)	Cell Room	1 081 000
(2)	Brine treatment plant	300 000
(3)	Electrical rectifiers	390 000
(4)	Chlorine cooling, drying and compression	180 000
(5)	Chlorine liquefaction plant	55 000
(6)	Hydrochloric acid plant	97 500
(7)	Calcium hypochlorite plant	80 000
(8)	Salt transport equipment	47 000
(9)	Storage tanks	
	(i) Caustic Soda tanks 2 tanks 350 cu.m. each	30 000
	(ii) Liquid chlorine storage tank for 200 tons	84 500
	(iii) Other storage tanks	70 000
(10)	Substation and power distribution to motors (6000 kW)	250 000
(11)	Workshop equipment	60 000
(12)	Rubber lining equipment	50 000
(13)	Lighting	40 000
(14)	Steam boiler and piping	30 000
(15)	Dowtherm plant	120 000
(16)	Chlorine cylinders; ninety cylinders one ton capacity	46 800
	Total	3 011 800

equivalent to L.S. 12,950,000

N.B. (i) A water treatment plant 100 cu.m. per hour is included under plant utilities.

(ii) External transport equipment include:

- Seven tank lorries ten tons capacity each for transportation of products costing 140,000 dollars
- Tow buses for transportation of workers costing 30,000 dollars.

3.15 Plant Utilities:

Utility requirements of the plant are as follows:

(i)	Process and cooling water:	about 567600 cu.mt. per annum
(ii)	Electric power	: about 41624 x 10^6 kw-hr
(iii)	Process steam	: about 4 tons per hour at a pressure of 9 atm.

A water treatment plant having a capacity of 100 cu.m. per hour is included under plant utilities. An electric substation with a capacity of 6000 KW is included in the scope of delivery of machinery and equipment. A steam boiler 5 ton steam per hour at a working pressure of 12 atmosphere is also included under machinery and equipment.

3.16 Manning table:

The total number of persons employed in the plant amounts to 160 including two foreign experts: a chemical engineer in charge of production and a mechanical engineer in charge of repair and maintenance. The annual wages and salaries including fringe benefits (at 30 percent) are estimated at 1,020,520 Syrian Pounds. Table 26 shows the categories of persons employed, their salaries and wages.

Table 26 - Categories of Persons employed and their wages.

Categories of persons employed	Domestic No. of Persons	Domestic Annual Wages and Salaries (L S)	Foreign No. of Persons	Foreign Annual wages and Salaries (L S)	Foreign Currency Component (L S)
1. Top managers -	2	28 000			
2. Senior Engineers and Chemists	4	38 000			
3. Engineers	6	45 000	2	84 000	60 000
4. Administrative director	1	8 000			
5. Financial director	1	8 000			
6. Commercial staff	5	35 000			
7. Accountants	4	28 000			
8. Clerks	15	63 000			
9. Typists	5	18 000			
10. Foremen	8	43 200			
11. Skilled operatives	68	326 400			
12. Semi-skilled operatives	8	24 000			
13. Un-skilled operatives	31	55 800			
Total	158	720 400	2	84 000	60 000
Fringe benefits (30%)		216 120			
Grand total	158	936 520	2	84 000	60 000

The breakdown of operatives according to the various plant units and per shift is given in table 27. It is to be noted that a fourth shift was taken into consideration to compensate for absentees on sick and ordinary leave and to account for any future reduction in working hours to 42 hours per week.

Table 27 - Distribution of Operatives

Plant Section	Per shift	Total	Skilled	Semi skilled	un-skilled
Cell room	4	16	16		
Electricity	1	4	4		
Hydrochloric acid plant	1	4	4		
Chlorine plant	3	12	12		
Hypochlorite plant	1	4	2	2	
Brine treatment plant	2	8	4	4	
	4	4			4
Hydrochloric acid storage and filling	2	2			2
Chlorine storage and filling	1	1			1
Hypochlorite storage and filling,	2	2			2
Workshop	8	8	6		2
Rubber lining	1	1	1		
Graphite shop	2	2		2	
Garage	1	4			4
Laboratory	2	8	4		4
Drivers	15	15	15		
General services	3	12			12
Total		107	68	8	31

The manpower, salaries and wages required during construction of the caustic soda and chlorine plant (construction period amounts to 3 years) are given in table 28.

Table 28 - Manpower needed during construction period

	Total		1st Year		2nd Year		3rd year	
	m/m	Salaries & Wages	m/m	Salaries) Wages L.S.	m/m	Salaries & Wages L.S.	m/m	Salaries & Wages. L.S.
Project Manager	1/36	45000	1/12	15000	1/12	15000	1/12	15000
Civil Engineer	1/36	30000	1/12	10000	1/12	10000	1/12	10000
Mechanical Eng.	1/36	30000	1/12	10000	1/12	10000	1/12	10000
Electrical Eng.	1/36	30000	1/12	10000	1/12	10000	1/12	10000
Chemical Eng.	1/36	30000	1/12	10000	1/12	10000	1/12	10000
Chemist	1/12	8000	-	-	-	-	1/12	8000
Engineers	6/156	97500	1/12	7500	6/72	45000	6/72	45000
Administrative Director	1/[illegible]	24000	1/12	8000	1/12	8000	1/12	8000
Financial Director	1/36	24000	1/12	8000	1/12	8000	1/12	8000
Transport & Shipment Clerk	1/24	10000	-	-	1/12	5000	1/12	5000
Accountants	2/60	35000	1/12	7000	2/24	14000	2/24	14000
Clerks	10/300	105000	5/60	21000	10/120	42000	10/120	42000
Typists	4/120	36000	2/24	7200	4/48	14400	4/48	14400
Storekeepers	2/48	16800	-	-	2/[illegible]	8400	2/24	8400
Messengers	5/180	37500	5/60	12500	5/60	12500	5/60	12500
Drivers	1/36	13500	1/12	4500	1/12	4500	1/12	4500
Sub total		572300		130700		216800		224800
Fringe benefits (30%)		171690		39210		65040		67440
Grand total		743990		169910		281840		292240

3.17 Time Schedule for Implementation:

Time schedule proposed for major implementation activities covering contracting and other pre-construction activities, construction schedules, start up and normal operation of the plant is shown in Fig. (2). The total time necessary for the realization of the project amounts to 40 months starting from September 1972, which is the date of submission of this report, till December 1976 the time of completion of the test runs and start of normal operations. The breakdown of the various implementation stages of the project and the time needed for their execution is as follows:

Activity	Duration	Beginning	End
- 1. Preparation of complete feasibility study	4 mon.	Sept.1972	Dec.1972
- 2. Preparation of tender specifications	3 "	Jan.1973	March '73
- 3. Evaluation of bids & conclusion of contract	4 "	July 1973	Nov.1973
- 4. Preparation of tender specifications of civil works	2 "	Dec. 1973	Jan.1974
- 5. Evaluation of bids and conclusion of contracts for civil works.	2 "	Mar. 1974	May 1974
- 6. Completion of civil works	24 "	June 1974	May 1976
- 7. Delivery of equipment	15 "	Dec.1974	Apr.1976
- 8. Erection of equipment	16 "	May 1975	August '76
- 9. Start up & guarantee tests	4 "	Sep.1976	Dec.1976
- 10. Normal operation of plant		Jan.1977	

3.18 Selling Price of Products:

The following table shows the average prices per ton of the project products CIF Syrian Ports compared with the average market prices of those products in developed countries.

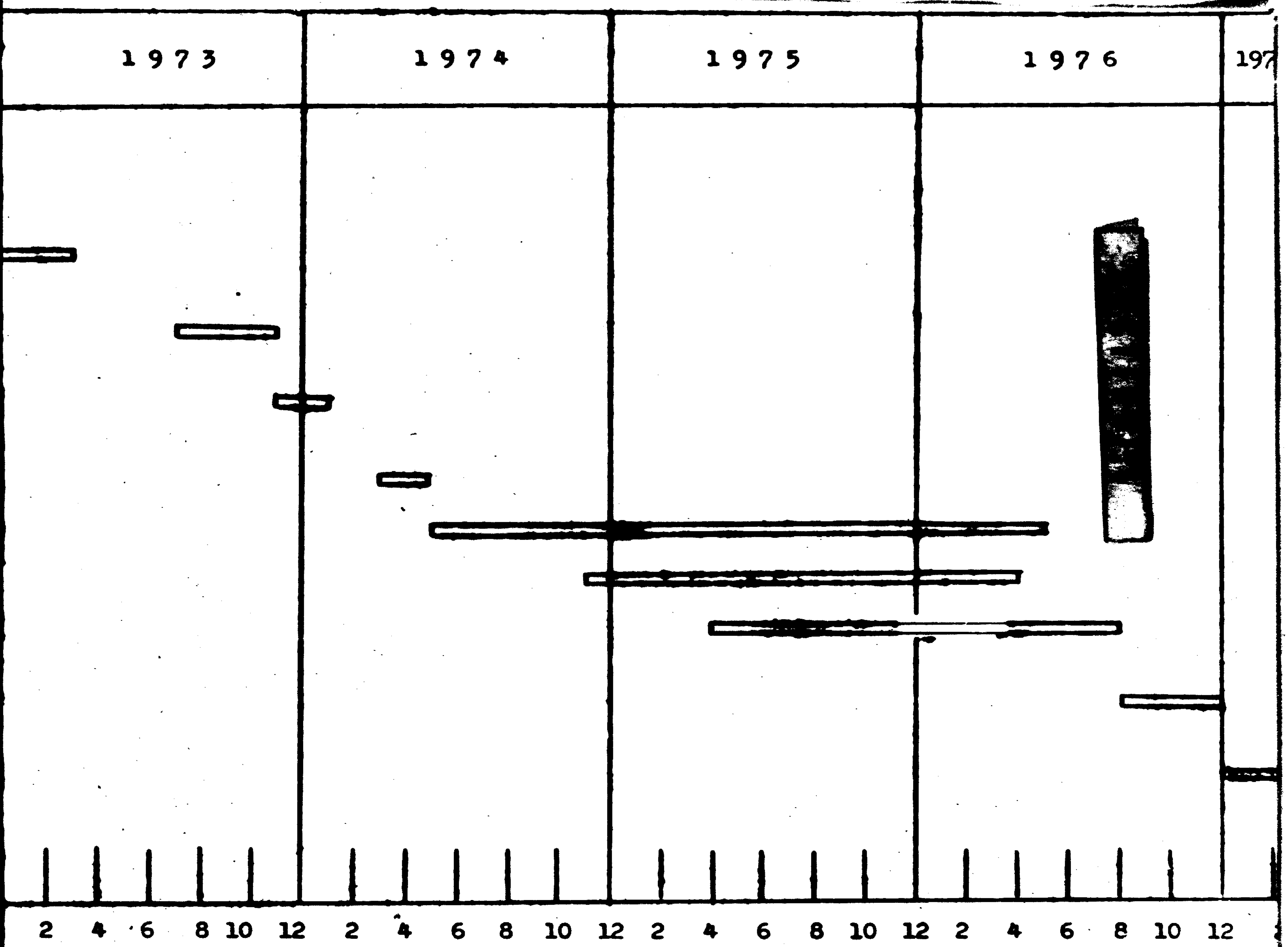

Fig. (2) - Time Schedule for Implementation

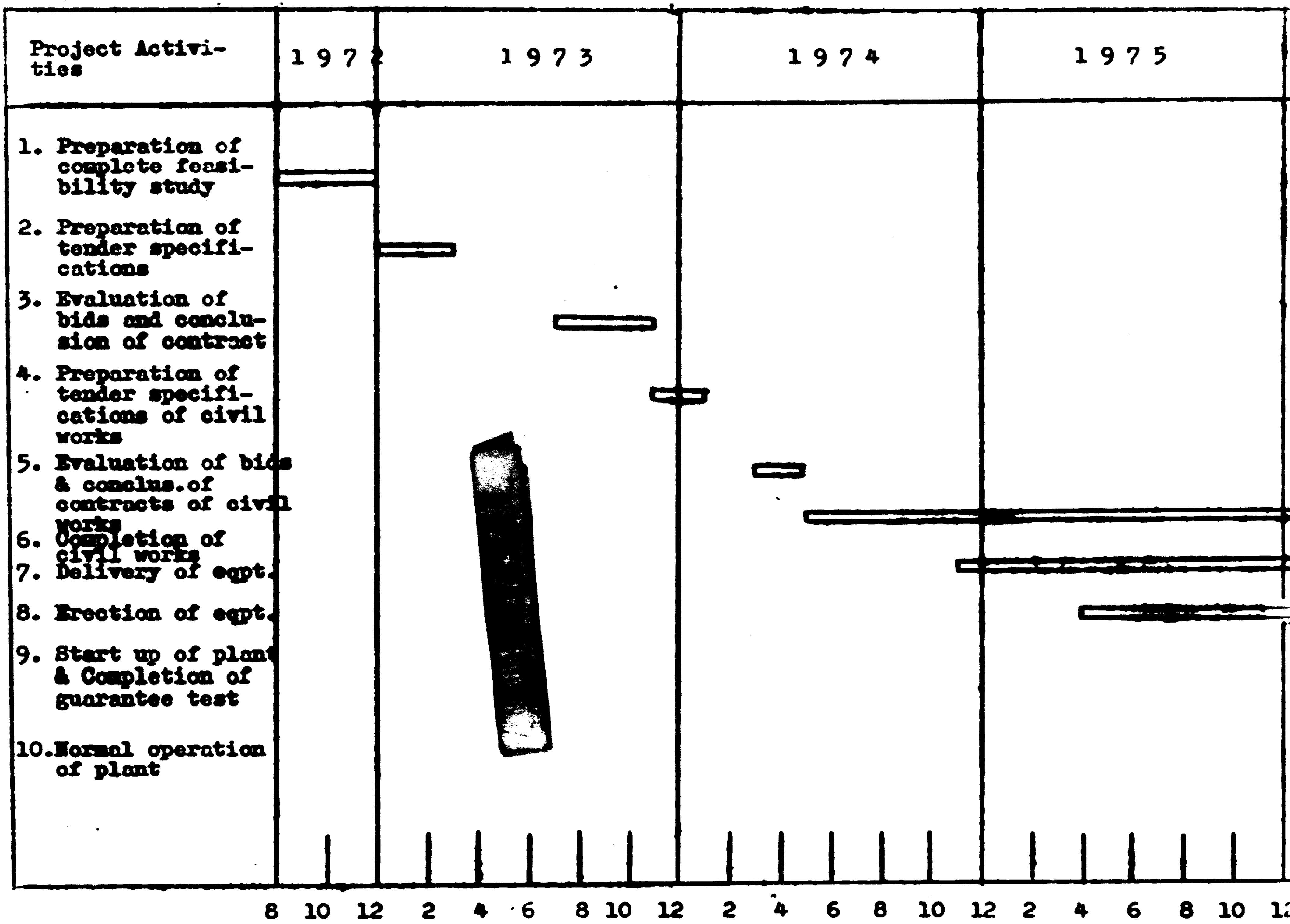

Fig. (2) - Time Schedule for Implementation

Table 29 - Products C&F Prices compared with market prices in developed countries
(L. S.)

Product	C&F Prices: Average during the period 1968-1970	C&F Prices: 1971	Market Price in developed countries	Remarks
Caustic Soda	231	593 to 645	500 - 540	1) Price of caustic soda in developed countries used to range from 230-300 L.S. It has gone up to about 540 L.S. in 1971 and it is expected to come down gradually.
Chlorine	1000	969	250 - 300	
Hydrochloric acid	344	350	140 - 200	
Calcium hypochlorite (65%)	687	685	560 - 590	

Since the products of the caustic soda project are used as raw materials or treating agents in other industries, it is therefore necessary to fix their prices on the basis of market prices in developed countries in order that manufacturing industries based on caustic soda and chlorine may be competitive in foreign markets and that industrialisation may not have an adverse effect on the cost of living in the Syrian Arab Republic.

In the light of the foregoing the ex-factory selling price of the products are fixed on the basis of the market prices in developed countries and not according the CIF prices. However, the caustic soda price was further lowered than its present market price in developed countries since the latter is considered abnormal and is expected to go down gradually in the near future. Table 30 gives the selling price of products ex-factory as well as the total value of annual production during the period 1977 till 1980; the plant reaching its full chlorine capacity during 1980.

Table 30 - Ex-factory prices and value of annual production

Product	Ex-factory price per ton (L.S.)	Annual Production							
		1977		1978		1979		1980	
		Q t	000 L S	Q t	000 L S	Q t	000 L S	Q t	000 L S
Caustic Soda (100% NaOH basis)	400	9593	3837.2	10788	4315.2	12146	4858.4	13692	5476.8
Liquid Chlorine	300	503	150.9	629	188.7	787	236.1	983	294.9
Chlorine for P V C	300	6383	1914.9	7129	2138.7	7963	2388.9	8890	2667.0
Hydrochloric acid (32-33%)	200	4310	862.0	4918	983.6	5610	1122.0	6400	1280.0
Calcium hypochlorite 70 g/litre	75	4300	322.5	4300	322.5	4300	322.5	4300	322.5
Total			7087.5		7948.7		8927.9		10041.2

4. ECONOMIC STUDY

4.1 Investment:

The total investment of the plant is estimated at 26,513,000 Syrian Pounds as shown in the following table.

Table 31 - Plant Investment

(000 L.S.)

Item	Local Currency Component	Foreign Currency Component	Total
1. Fixed assets:			
1.1 Land: 20,000 sq.m. x 5 L.S. per sq.m.	100		100
- Site development 20,000 sq.m. x 2 L.S. per sq.m.	40		40
Sub total	140		140
1.2 Buildings, Facilities and housing:			
- Buildings (see table 23)	3540		3540
- Engineering fees for buildings (included in cost of buildings)	-		-
- Facilities (water treatment plant; capacity 100 cu.m. per hour)	120	280	400
- Roads internal (4 roads 567 m. x 10 m. width)	45		45
- Artesian wells	-	-	-
- Outside drainage	-	-	-
- Railway connections	-	-	-
- High tension power supply line (1.2 km)	100		100
- Contingency 10 percent of above items	381	28	409
- Other expenses	-	-	-
- External utilities	-	-	-
- Housing estate	-	-	-
Sub total	4186	308	4494
1.3 Machinery and equipment:			
- Machinery and equipment FOB (see table 25)	-	12950	12950
- Freight, transport and insurance	225	648	873
- Custom duties	-	-	-
- Transport of equipment from harbour to factory site	60		60
- Engineering and design (included in FOB value)	-	-	-
- Local machinery and equipment	70		70
- Expert fees for supervision of erection	220	430	650
- Local erection expenses	650		650
- Other expenses	-	-	-
Sub total	1225	14028	15253
1.4 Furniture	340		340
1.5 Vehicles & internal transport eqpt.	-	-	-
1.6 External Transport equipment		731	731
Total fixed assets	5091	15067	20958

Table 31 - Plant Investment (Contd.)
(000 L.S.)

Item	Local Currency Component	Foreign Currency Component	Total
2. Other investment costs (deferred payments)			
- Salaries and wages during construction (see table 28)	744		744
- Transport and travelling expenses for training	14.8	34.2	49
- Research and experimental work	20		20
- Expert fees for start up of plant,	25	200	225
- Office expenses during construction	65		65
- Licences, insurances & Government taxes	25		25
- Interest on loans during construction	1141		1141
- Start up expenses	70		70
- Miscellaneous expenses	50		50
Total deferred payments	2154.8	234.2	2389
3. Working capital:			
3.1 Inventories			
- Spare parts (for 3 years operation)	15	650	665
- Production materials including initial filling of mercury (about 65 tons)	292	1965	2257
- Work in process	-	-	-
- Finished products	-	-	-
3.2 Liquid capital			
Annual operating costs minus depreciation and interest divided by capital turn over	1385		1385
Total working capital	1692	2615	4307
Total investment (1+2+3) including interest during construction	9737.8	17916.2	27654.
Total ivvestment (1+2+3) without interest during construction	8596.8	17916.2	26513

It is to be noted that no custom duties are levied on machinery and equipment contracted for industrial projects. Erection expenses including supervision and local expenses are estimated at ten percent of the FOB value of machinery and equipment.

Furniture needed for offices, laboratory, dining room, changing rooms and cabinets for workers has been estimated at 340 thousand Syrian Pounds.

External transport equipment includes seven tank lorries, ten ton capacity each for transportation of products and two buses for workers and employees Training expenses cover the transport and travelling expenses of three engineers, one chemist, two foremen and six skilled workers. They include also the wages of the foremen and workers since their wages are not shown under the salaries and wages during construction. The training period for the engineers and chemist is four months and for the foremen and workers is two months. The expert fees for the supervision of start up is calculated on the basis of a start up team of five engineers and nine foremen and workers for four months period. The remunerations for the start up team are based on East European salary scales as it is likely to include this project within one of the technical and economic co-operation agreements concluded with those countries.

The inventory of production materials is taken for six months for imported materials and one month for indigenous materials.

4.2 Annual operating costs:

The annual operating costs when the plant operates at its full chlorine capacity, i.e. in 1980, is shown in the following table.

Cost item				Annual Cost (L.S.)	Foreign Currency Component (L.S.)
1. Material cost					
Raw material	Unit	Unit Price	Quantity		
1.1 Salt (sodium chloride)	t	61.70	20782	1282250	
1.2 Graphite	kg	4.33	48900	211737	194290
1.3 Mercury (make up)	kg	29.08	3056	88868	82787
1.4 Chemicals for brine treatment per ton of chlorine gas	L.S	16.00		195600	132030
1.5 Electric power	kw-hr	0.04	41624 x 10^6	1664960	
1.6 Process & cooling water	cu.m.	0.04	567600	22704	
1.7 Calcium oxide for hypo.	t	20.00	500	10000	
1.8 Fuel oil	t	63.00	2200	138600	
		Sub total		3614719	409107
2. Personnel cost					
2.1 Wages & salaries (see table 26)				804400	60000
2.2 Contributions to social securities and fringe benefits (30%)				216120	
		Sub total		1020520	60000
3. Maintenance and supplies					
3.1 Maintenance of equipment (1% of equipment FOB)				129500	
3.2 Maintenance of buildings & facilities (1% of 4,494,000)				44940	
3.2 Maintenance of vehicles (5% of 731,000)				36550	
3.3 Spare parts for one year operation				221700	217000
		Sub total		432690	217000
4. Administrative expenses and sales costs				230000	
5. Depreciation (Linear method)					
5.1 Equipment (10% of 15,253,000)				1525300	1402800
5.2 Buildings & Facilities 4% of 4,494,000)				179760	12520
5.3 Vehicles (20% of 731,000)				146200	146200
5.4 Furniture (10% of 340,000)				34000	
5.5 Deferred payment (20% of 2,389,000)				477800	46840
		Sub total		2363060	1608160
6. Packing drums for caustic soda for export				155400	124300
		Total annual operating costs		7816389	2418567

The cost of imported raw materials include custom duties (6.5% of CIF value), port charges and transportation to plant site.

The administrative expenses and sales costs include office supplies, advertisements, insurance fees, communication, staff travel and other business services. They do not include wages and salaries for the enterprise's employees.

The annual operating costs of the first three years of operation during which the plant operates at partial chlorine capacity are shown in table 33.

Table 33 - Annual operating costs at partial chlorine capacity

Cost item	Annual Costs (L.S.) 1st year	2nd year	3rd year
1. Material cost			
1.1 Salt (sodium chloride)	898383	1010300	1137532
1.2 Graphite	148346	166826	187835
1.3 Mercury (make up)	62267	70025	78843
1.4 Chemicals for brine treatm.	137040	154112	173520
1.5 Electric power	1165458	1310907	1476418
1.6 Process and cooling water	16277	18123	20226
1.7 Calcium oxide	10000	10000	10000
1.8 Fuel oil			48340
Sub total	2437771	2740293	3132714
2. Personnel costs			
2.1 Wages and salaries including fringe benefits	752330	843590	920420
3. Maintenance & Supplies	316365	355140	393915
4. Administrative expenses and sales cost	230000	230000	230000
5. Depreciation	2363060	2363060	2363060
6. Packing drums for solid caustic for export	-	-	54200
Total annual operating costs	6099526	6532083	7094309

4.3 Annual Profits:

The annual profits (before taxes) during the first three years and in the fourth year when the full chlorine capacity of the plant is reached are thus calculated as follows:

Table 34 - Annual Profits before taxes
(000 L.S.)

	1st year	2nd year	3rd year	4th year
Sales Revenue (Table 30)	7087	7949	8928	10041
Annual operating costs (Tables 32 and 33)	6099	6532	7094	7816
Profit before taxes	988	1417	1834	2225

4.4 Return on Investment:

The return on investment during the first fifteen years of production may be calculated as follows:

Table 35 - Return on investment during estimated life of plant.
(000 L.S.)

Year	Sales Revenue	Production Expenditure	Profit	Return on investment percent
1	7087	6099	988	3.7 %
2	7949	6532	1417	5.3 %
3	8928	7094	1834	6.9 %
4	10041	7816	2225	8.4 %
5	10041	7816	2225	8.4 %
6	10041	7192	2849	10.7 %
7	10041	7192	2849	10.7 %
8	10041	7192	2849	10.7 %
9	10041	7192	2849	10.7 %
10	10041	7192	2849	10.7 %
11	10041	5633	4408	16.6 %
12	10041	5633	4408	16.6 %
13	10041	5633	4408	16.6 %
14	10041	5633	4408	16.6 %
15	10041	5633	4408	16.6 %

It can be seen from the above table that the return on investment gradually increases till it reaches 8.4% when the chlorine full capacity is attained in the fourth year. It reaches 10.7% in the sixth year after all the deferred payments are depreciated and 16.6% in the eleventh year when the depreciation of the plant equipment is completed.

4.5 Payout time:

The payout time of the project calculated in years from start up amounts to 5.37 years. Table 36 is used to determine the payout time of the project.

Table 36 - Accumulated profits and depreciation (000 L.S.)

Year	Profit	Depreciation	Profit and depreciation	Accumulated profits and depreciation
1	988	2363	3351	3351
2	1417	2363	3780	7131
3	1834	2363	4197	11328
4	2225	2363	4588	15916
5	2225	2363	4588	20504
6	2849	1739	4588	25092
7	2849	1739	4588	29680
8	2849	1739	4588	34268
9	2849	1739	4588	38856
10	2849	1739	4588	43444
11	4408	180	4588	48032
12	4408	180	4588	52620
13	4408	180	4588	57208
14	4408	180	4588	61796
15	4408	180	4588	66384

It is evident from the above table that the total of profits and depreciation exceeds the amount of the original depreciable investment (total investment minus working capital i.e. 22206 thousand Syrian Pounds) sometime between the fifth and sixth year of operation; approximately after 5.37 years from start up.

4.6 Break-even point:

Break-even point is calculated from the break-even chart given in fig. 3 which shows sales income and total production costs plotted as functions of rate of operation of plant in terms of total chlorine production. The following data has been used in drawing the break-even chart.

Production Year	Rate of operation in terms of chlorine production: tons	%	Total Production Cost (L.S.): Fixed costs	Variable costs	Depreciation	Total	Sales income (000 LS)
1	8565	70	519	3217	2363	6099	7087
2	9632	79	519	3650	2363	6532	7949
3	10645	89	519	4212	2363	7094	8920
4	12225	100	519	4934	2363	7816	10041
5	12225	100	519	4934	2363	7816	10041

It can be seen from the chart that the sales income of the project equals all fixed and variable costs at a rate of operation of 6550 tons chlorine.

4.7 Direct value added and employment effects:

The direct net value added is given in table 37. When the full chlorine capacity of the plant is reached in the fourth year of operation the net value added amounts to 3245 thousand pounds of which wages and salaries and profit before tax are 1020 and 2225 thousand pounds respectively. The net value added increased to 3869 thousand pounds in the sixth year and to 5428 thousand pounds in the eleventh year because of increase in profits due to decrease in depreciation installments.

The project provides jobs for 158 domestic employees, 31 of which can be unskilled. Twelve members of the technical staff will be trained in Europe. The project offers training possibilities for domestic students of chemistry and chemical engineering.

It is emphasised that the caustic soda and chlorine industry is a capital intensive industry. More than $ 39,000 would have to be invested for each job created. Thus the direct employment effect may be considered comparatively small.

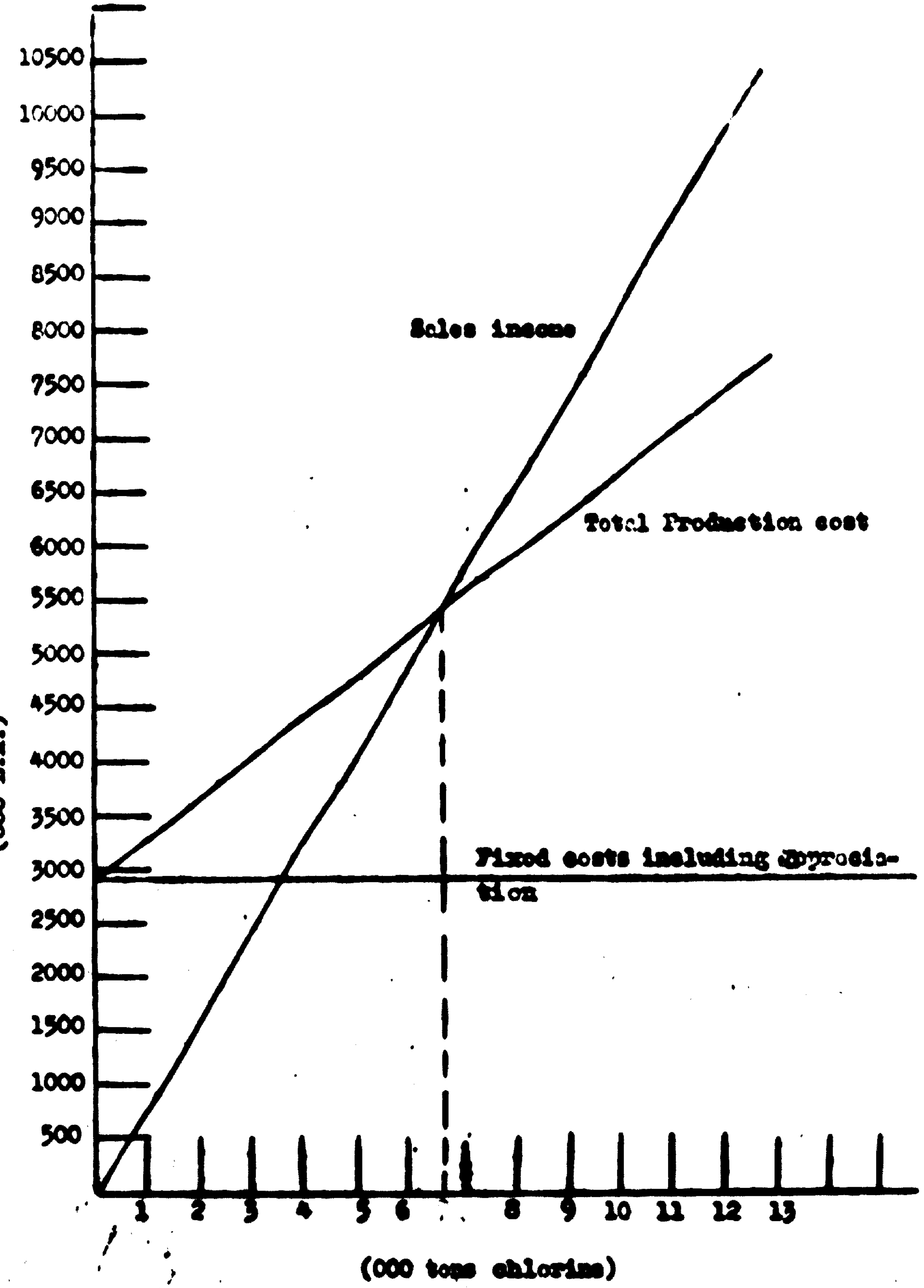

Fig. 3 - Break-even point

4.8 Balance of payment effect:

During the construction years, there will be mainly foreign exchange expenditure in form of capital expenditure. Upon start of production annual net savings of foreign currency are obtained as can be seen from table 38. For instance in the fourth year of production when the full chlorine capacity is attained the annual foreign exchange expenditures will amount to 3940 thousand pounds of which: imports of raw materials (533), spare parts (217), depreciation of imported assets (1608), the salaries of foreign personnel in foreign currency (60) and debt service (1522). The annual foreign exchange savings from import substitution and earnings from exported production amount to 10041 thousand pounds. The net foreign exchange savings in the fourth year thus amount to 6101 thousand pounds. These will increase to 9219 thousand pounds after repayment of supplier's credit.

4.9 Backward and forward effects:

The project will give an impulse to the salt mining industry. More than twenty thousand tons of rock salt will be consumed by the caustic soda and chlorine plant.

The products will serve as raw materials and/or treating agents for many existing industries, e.g. soap and detergents, textiles, vegetable oils, and some chemical products. The utilisation of chlorine in the production of monovinyl and polyvinyl chloride will provide the existing as well as future plastic forming industries with an essential raw material.

Also the production of pure caustic soda may stimulate the establishment of the viscose rayon industry in the Syrian Arab Republic.

4.10 Cash flow table:

The cash flow table (table 39) is prepared on the basis of the following suppositions:

(i) The total capital investment of the project amounts to 26513 thousand Syrian Pounds.

(ii) The machinery and equipment at a FOB value of 12950 thousand Syrian Pounds will be procured on credit from an East European country within the framework of the technical and economic agreement concluded between Syria and that country. The interest rate is 2.5 percent and is due upon completion of delivery of machinery and equipment. The credit is to be repaid on ten equal installments, the first installment being due one year after the start up of the plant.

(iii) The balance of the investment (13563 thousand Syrian Pounds) is financed by the Syrian Government from the National Debt Fund in accordance with the construction schedule of the plant at an interest rate of 6 percent calculated on the utilized funds. Since the annual profits of the enterprise will be collected by the Government, the repayment of the investment financed by same is not contemplated. However, in case it is demanded by Government Authorities to refund the 13563 thousand Syrian Pounds, the enterprise will be able to fulfill this demand fully in the seventh year of operation as can be seen from the cash flow table.

4.11 <u>Present Worth:</u>

All cash flows are discounted to their equivalent value at time zero using minimum acceptable rate of return as the interest rate. Time zero has been chosen as the start of operations and the interest rate is fixed at 8 percent which is the prevailing rate at present.

The excess of the present value of incomes (table 45) over the present value of the investments amounts to 7663 thousand pounds representing 35.14 percent of the present value of investments.

Table 37 - **VALUE ADDED** (000 L.S.)

Item		PRODUCTION YEARS 1st	2nd	3rd	4th	5th	6th	7th	8th	9th
A	Value of Annual Production Total	7087	7949	8928	10041	10041	10041	10041	10041	10041
B	Value of Technical Inputs Total	2983	3325	3810	4433	4433	4433	4433	4433	4433
1.	Material costs Total	2437	2740	3186	3770	3770	3770	3770	3770	3770
1.1	Salt (Sodium chloride)	898	1010	1137	1282	1282	1282	1282	1282	1282
1.2	Graphite	148	157	188	212	212	212	212	212	212
1.3	Mercury (make up)	62	70	79	89	89	89	89	89	89
1.4	Chemicals for brine treatment	137	154	174	196	196	196	196	196	196
1.5	Electric power	1166	1311	1476	1665	1665	1665	1665	1665	1665
1.6	Process and Cooling Water	16	18	20	23	23	23	23	23	23
1.7	Calcium oxide	10	10	10	10	10	10	10	10	10
1.8	Fuel oil	-	-	48	138	138	138	138	138	138
1.9	Drums for packing solid caustic soda			54	155	155	155	155	155	155
2.	Maintenance and Supplies Total	315	355	394	433	433	433	433	433	433
2.1	Maintenance of equipment	91	104	117	129	129	129	129	129	129
2.2	Maintenance of buildings & facilities	45	45	45	45	45	45	45	45	45
2.3	Maintenance of Vehicles	25	29	33	37	37	37	37	37	37
2.4	Spare parts for one year operation	155	177	199	222	222	222	222	222	222
3.	Administrative Expenses and Sales Costs (excluding salaries & wages)	230	230	230	230	230	230	230	230	230
C.	Depreciation Total	2363	2363	2363	2363	2363	1739	1739	1739	1739
1.1	Depreciation of equipment	1525	1525	1525	1525	1525	1525	1525	1525	1525
1.2	Depreciation of buildings & facilities	180	180	180	180	180	180	180	180	180
1.3	Depreciation of vehicles	146	146	146	146	146	-	-	-	-
1.4	Depreciation of Furniture	34	34	34	34	34	34	34	34	34
1.5	Depreciation of deferred payment	478	478	478	478	478	-	-	-	-
	NET VALUE ADDED A - (B + C)	1741	2261	2755	3245	3245	3869	3869	3869	3869

Tabl. 37 - **VALUE ADDED** (000 L.S.)

	PRODUCTION YEARS														
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th
...on	7087	7949	8928	10041	10041	10041	10041	10041	10041	10041	10041	10041	10041	10041	10041
...s	2983	3325	3810	4433	4433	4433	4433	4433	4433	4433	4433	4433	4433	4433	4433
	2437	2740	3186	3770	3770	3770	3770	3770	3770	3770	3770	3770	3770	3770	3770
	898	1010	1137	1282	1282	1282	1282	1282	1282	1282	1282	1282	1282	1282	1282
	148	137	188	212	212	212	212	212	212	212	212	212	212	212	212
	62	70	79	89	89	89	89	89	89	89	89	89	89	89	89
...tment	137	154	174	196	196	196	196	196	196	196	196	196	196	196	196
	1166	1311	1476	1665	1665	1665	1665	1665	1665	1665	1665	1665	1665	1665	1665
...r	1[illegible]	1[illegible]	20	23	23	23	23	23	23	23	23	23	23	23	23
	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	-	-	40	138	138	138	138	138	138	138	138	138	138	138	138
...caustic soda			54	155	155	155	155	155	155	155	155	155	155	155	155
	312	355	324	433	433	433	433	433	433	433	433	433	433	433	433
	91	104	117	129	129	129	129	129	129	129	129	129	129	129	129
...& facilities	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45
	2[illegible]	29	33	37	37	37	37	37	37	37	37	37	37	37	37
...operation	155	177	199	222	222	222	222	222	222	222	222	222	222	222	222
...nd Sales ... & wages)	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230
	2363	2363	2363	2363	2363	1739	1739	1739	1739	1739	180	180	180	180	180
...nt	1525	1525	1525	1525	1525	1525	1525	1525	1525	1525	-	-	-	-	-
...s & facilities	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180
	146	146	146	146	146	-	-	-	-	-	-	-	-	-	-
	34	34	34	34	34	34	34	34	34	34	-	-	-	-	-
...payment	478	478	478	478	478	-	-	-	-	-	-	-	-	-	-
... + C)	1741	22[illegible]1	2755	[illegible]245	3245	3869	3869	38[illegible]9	3869	3869	5428	5428	5428	5428	5428

Table 38 - Effects on the Balanc

Item	Construction Years							
	1st	2nd	3rd	1st	2nd	3rd	4th	5th
1. Capital Expenditure: (foreign component)								
1.1 Facilities (water treatment plant)	-	200	108					
1.2 Machinery & Equipment -(supplied on credit)	-	-	-					
1.3 Transport, insurance and Freight	-	324	324					
1.4 Expert fees for supervision of erection (included under item 3)								
1.5 External transport eqpt.	-	65	666					
1.6 Transport & travelling expenses for trainees	-	17	17					
1.7 Expert fees for start up (included under item 3)								
1.8 Minimum inventory(including spare parts, initial filling of mercury & raw materials)	-	-	2615					
2. Production Expenditure: (foreign component)								
2.1 Material costs				287	322	362	409	409
2.2 Drums for packing solid caustic soda						43	124	124
2.3 Personnel costs(included under item 3)								
2.4 Spare Parts				152	174	195	217	217
2.5 Depreciation of imported assets, (foreign compon.)				1608	1608	1608	1608	1608
3. Expert fees								
3.1 Expert fees for supervision of erection	-	140	290					
3.2 Expert fees for supervision of start up	-	-	200					
3.3 Experts for technical mgmt	-	-	-	60	60	60	60	60
4. Debt Service								
4.1 Interest on Supplier's credit	-	-	-	324	291	259	227	194
4.2 Repayment of Supplier's credit					1295	1295	1295	1295
Total Foreign Currency Expenditure	-	746	4220	2431	3750	3822	3940	3907
6. Sales Revenue Total	-	-	-	7087	7949	8928	10041	10041
6.1 Revenue from exported production				-	-	217	622	622
6.2 Savings from import substitution				7087	7949	8711	9419	9419
7. Effect on the balance of payments due to exportation and import substitution(6-5)		-746	-4220	4656	4199	5106	[illegible]	6134

N.B.: 1. Machinery and equipment replacement is not taken into consideration dur maintained and parts and supplies for repairs and maintenance are adequ

2. Machinery and equipment are procured on credit from an East European co The credit is repaid on ten equal installments beginning one year after

able 38 - Effects on the Balance of Payments

[redacted]

Production Years														
1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th
287	322	362	409	409	409	409	409	409	409	409	409	409	409	409
		43	124	124	124	124	124	124	124	124	124	124	124	124
152	174	195	217	217	217	217	217	217	217	217	217	217	217	217
608	1608	1608	1608	1608	1415	1415	1415	1415	1415	12	12	12	12	12
60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
24	291	259	227	194	162	129	97	65	32	-	-	-	-	-
	1295	1295	1295	1295	1295	1295	1295	1295	1295	1295	-	-	-	-
31	3750	3822	3940	3907	3682	3649	3617	358[illegible]	3552	2117	822	822	822	822
87	7949	8928	10041	10041	10041	10041	0041	10041	10041	10041	10041	10041	10041	10041
	-	217	622	622	622	622	622	622	622	622	622	622	622	622
87	7949	8711	9419	9419	9419	9419	9419	9419	9419	9419	9419	9419	9419	9419
56	4199	5106	62[illegible]	6134	6359	6392	6424	6456	6489	7924	9219	9219	9219	9219

taken into consideration during the estimated project life since the plant is properly
irs and maintenance are adequately furnished.

edit from an East European country at 2.5 percent interest due upon completion of delivery.
ents beginning one year after start of production.

Table 39 - CASH FLOW TABLE (000 L.S.)

		Construction Years								
		1st	2nd	3rd	1st	2nd	3rd	4th	5th	6th
A	Source of Cash	725	10452	15336	7087	7949	8928	10041	10041	10041
1.	Financial resources Total	725	10452	15336						
1.1	Loan	725	3982	8856						
1.2	Equity									
1.3	Supplier's Credits		6470	6480						
1.4	Subsidies									
2.	Sales revenues: (see table 40)	-	-	-	7087	7949	8928	10041	10041	10041
B	Uses of Cash	769	10735	16150	4874	6569	7099	7789	7756	7724
1	Fixed Capital Expenditure: (see table 41) Total	505	10090	10363						
1.1	Land, site improvement and Buildings	455	2594	1585						
1.2	Machinery & Equipment (new installations including furniture & external transport eqpt	50	7496	8778						
1.3	Machinery & Equipment (replacement)*									
2.	Net Working Capital: Total	-	-	4307						
2.1	Stocks of material	-	-	2922						
2.2	Work in process									
2.3	Stocks of finished droducts									
2.4	Liquid Capital	-	-	1385						
3.	Pre-investment & start up expenses (not including interest during construction)	220	362	666						
4.	Production expenditure: (See table 42) Total	-	-	-	3736	4169	4731	5453	5453	545
4.1	Personnel expenditure				752	844	920	1020	1020	102
4.2	Materials				2438	2740	3187	3770	3770	377
4.3	Administrative Expenditure and Sales Costs				230	230	230	230	230	23
4.4	Other Expenditure (excluding depreciation)				316	355	394	433	433	43
4.5	Indirect taxes & royalties				-	-	-	-	-	
5.	Debt Service: (see table 44) Total	44	283	814	1138	2400	2368	2336	2303	227
5.1	Interest on loans	44	283	814	1138	1105	1073	1041	1008	97
5.2	Repayment of loans & credits	-	-	-	-	1295	1295	1295	1295	129
6.	Dividends & Profit taxes paid:	-	-	-	-	-	-	-	-	-
C	Surplus/Deficit (A - B)	-44	- 283	- 814	2213	1380	1829	2252	2285	231
	Surplus/Deficit Accumulated	- 44	- 327	-1141	1072	2452	4281	6533	8818	1113

(*) Machinery and equipment replacement is not considered since the plant is properly maintained and parts and supplies for repairs and maintenance are adequately furnished.

[redacted]

CASH FLOW TABLE (000 L.S.)

	PRODUCTION YEARS														
	1st	2nd	3rd	4th	5th	6th	th	8th	9th	10th	11th	12th	13th	14th	15th
6	7087	7949	8928	10041	10041	10041	10041	10041	10041	10041	10041	10041	10041	10041	10041
6															
6															
0															
	7087	7949	8928	10041	10041	10041	10041	10041	10041	10041	10041	10041	10041	10041	10041
0	4874	6569	7099	7789	7756	7724	7691	7659	7627	7594	7562	6267	6267	6267	6267
3															
5															
8															
7															
2															
5															
2															
	3736	4169	4731	5453	5453	5453	5453	5453	5453	5453	5453	5453	5453	5453	5453
	752	844	920	1020	1020	1020	1020	1020	1020	1020	1020	1020	1020	1020	1020
	2438	2740	3187	3770	3770	3770	3770	3770	3770	3770	3770	3770	3770	3770	3770
	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230
	316	355	394	433	433	433	433	433	433	433	433	433	433	433	433
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1138	2400	2368	2336	2303	2271	2238	2206	2174	2141	2109	814	814	814	814
	1138	1105	1073	1041	1008	976	943	911	879	846	814	814	814	814	814
	-	1295	1295	1295	1295	1295	1295	1295	1295	1295	1295	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2213	1380	1829	2252	2285	2317	2350	2382	2414	2447	2479	3774	3774	3774	3774
	1072	2452	4281	6533	8818	11135	13485	15867	18281	20728	23207	26981	30755	34529	38303

nsidered since the plant is
r repairs and maintenance are

[redacted]

Table 40 - SALES REVENUE (000 L.S.)

Year		Capacity %	Value of annual sales
Construction			
Years	1	-	-
	2	-	-
	3	-	-
Production			
Years	1	70%	7087
	2	79%	7949
	3	89%	8928
	4	100%	10041
	5	100%	10041
	6	100%	10041
	7	100%	10041
	8	100%	10041
	9	100%	10041
	10	100%	10041
	11	100%	10041
	12	100%	10041
	13	100%	10041
	14	100%	10041
	15	100%	10041
Total			144456

Table 41 - Uses of cash for capital expenditure during construction period

(000 L.S.)

Item	1st year	2nd year	3rd year	Total
1. Land	120	20		140
2. Buildings, facilities & housing	335	2574	1585	4494
3. Machinery & equipment		7371	7882	15253
4. Furniture	50	60	230	340
5. External transport equipment		65	666	731
6. Other investment cost	220	362	666	1248
Total	725	10452	11029	22206
7. Minimum Inventory			2922	2922
8. Liquid capital			1385	1385
Total Investment	725	10452	15336	26513

Table 42 - Production Expenditure

(000 L.S.)

Year	Production Expenditure Excluding depreciation					Production Expenditure including depreciation	
	Materials	Personnel	Admin. & Sales	Other Expen.	Total	Depreciation*	Total
1	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-
1	2438	752	230	316	3736	2363	6099
2	2740	844	230	355	4169	2363	6532
3	3187	920	230	394	4731	2363	7094
4	3770	1020	230	433	5453	2363	7816
5	3770	1020	230	433	5453	2363	7816
6	3770	1020	230	433	5453	1739	7192
7	3770	1020	230	433	5453	1739	7192
8	3770	1020	230	433	5453	1739	7192
9	3770	1020	230	433	5453	1739	7192
10	3770	1020	230	433	5453	1739	7192
11	3770	1020	230	433	5453	180	5633
12	3770	1020	230	433	5453	180	5633
13	3770	1020	230	433	5453	180	5633
14	3770	1020	230	433	5453	180	5633
15	3770	1020	230	433	5453	180	5633

* See table 43.

Table 43 - Depreciation During Lifetime of Project

(000 L.S.)

Asset		Machinery & Equipment	Buildings & Facilities	Vehicles	Furniture	Other Investment Costs -	Total
Depreciation rate		10%	4%	20%	10%	20%	-
Production Year	1	1525.3	179.7	146.2	34	477.8	2363
	2	1525.3	179.7	146.2	34	477.8	2363
	3	1525.3	179.7	146.2	34	477.8	2363
	4	1525.3	179.7	146.2	34	477.8	2363
	5	1525.3	179.7	146.2	34	477.8	2363
	6	1525.3	179.7		34		1739
	7	1525.3	179.7		34		1739
	8	1525.3	179.7		34		1739
	9	1525.3	179.7		34		1739
	10	1525.3	179.7		34		1739
	11		179.7				179.7
	12		179.7				179.7
	13		179.7				179.7
	14		179.7				179.7
	15		179.7				179.7
Total		15253	2695.5	731	340	2389	21408.5

Table 44 - Uses of Cash for Capital Expenditure and Debt Service

(000 L.S.)

Year		Uses of cash for capital expenditure	Interest on Loans Local 6%	Interest on Loans Foreign 2.5%	Repayment of Supplier's Credit	Total
Construction	1	725	44	-		769
	2	10452	283	-		10735
	3	15336	814	-		16150
Production	1		814	324		1138
	2		814	291	1295	2400
	3		814	259	1295	2368
	4		814	227	1295	2336
	5		814	194	1295	2303
	6		814	162	1295	2271
	7		814	129	1295	2238
	8		814	97	1295	2206
	9		814	65	1295	2174
	10		814	32	1295	2141
	11		814	-	1295	2109
	12		814			814
	13		814			814
	14		814			814
	15		814			814

Table 45 - Present Worth Value (000 L.S.)

Year	Cash Flow (1)	Debt Service (2)	Total Incomes (1+2) (3)	Single payment present worth interest factor i = 8% (4)	Present worth value of incomes (3) x (4)	Investment (5)	Single pay. Present Worth Interest factor (4)	Present Worth Value of Investments (4)x(5)
Construction 1	(-) 44	44	000	0.9259	00000	725	0.9259	671.28
Construction 2	(-) 283	283	000	0.8573	00000	10452	0.8573	8960.50
Construction 3	(-) 814	814	000	0.7938	00000	15336	0.7938	12173.72
1	2213	1138	3351	0.7350	2462.98			
2	1380	2400	3780	0.6806	2572.67			
3	1829	2368	4197	0.6302	2644.95			
4	2252	2336	4588	0.5835	2677.10			
5	2285	2303	4588	0.5403	2478.89			
6	2317	2271	4588	0.5002	2294.92			
7	2350	2238	4588	0.4632	2125.16			
8	2382	2206	4588	0.4289	1967.79			
9	2414	2174	4588	0.3971	1821.89			
10	2447	2141	4588	0.3677	1687.01			
11	2479	2109	4588	0.3405	1562.21			
12	3774	814	4588	0.3152	1446.14			
13	3774	814	4588	0.2919	1339.24			
14	3774	814	4588	0.2703	1240.14			
15	3774	814	4588	0.2502	1147.92			
				Total	29469.01	Total		21805.50

$$\text{Present worth} = \frac{\text{P.V. of incomes} - \text{P.V. of investments}}{\text{P.V. of investments}} \times 100$$

$$= \frac{29469.01 - 21805.50}{21805.50} \times 100$$

$$= 35.14\%$$

5. Conclusions and Recommendations

It is evident from the market studies that there will be a ready market for 12225 tons of chlorine and 12138 tons of caustic soda in the Syrian Arab Republic in 1980. These requirements can be met by installing a 36 tons per day electrolytic chlorine plant based on mercury cell technique and using local rock salt and hydroelectric power from Euphrates Dam.

The technical and economic studies carried out so far indicate that this plant is feasible and has a positive impact on the national economy.

To achieve the objectives of the project successfully it is recommended that some measures be taken by the Government to ensure that:

(i) Electric power is supplied to the plant at a price not exceeding 0.04 pounds per kw-hr. The project can be operated economically only if cheap power is available as power is a large factor in the cost of the process.

(ii) Rock salt is furnished at a price not more than 30 pounds per ton ex-mines. The possibilities of exploiting salt mines in Gabel should be investigated because Gabol mines are nearer to the proposed plant site than Deir-ez-zor.

It is also recommended that the question of availability of water in Aleppo is investigated with a view to settle the problem of plant location either at Homs or Aleppo.

Further technical assistance should be sought to conduct a complete feasibility study for the caustic soda and chlorine project in accordance with the time schedule proposed for the project. A similar study for the P V C project should be carried out so that the implementation of both projects may be effected simultaneously to ensure the full utilisation of chlorine.

The rate of return on investment amounts to 8.4 percent when full chlorine capacity of plant is attained in the fourth year of operation. The payout time of the project calculated in years from start up amounts to 5.37 years. The net value added at full chlorine capacity is estimated at 3.2 million pounds per annum. The project provides jobs for 158 domestic employees. The net foreign exchange savings amount to 6.1 million pounds per annum increasing to 9.2 millions after repayment of supplier's credit for machinery and equipment.

The project will give an impulse to the salt mining industry and will furnish several existing and prospective manufacturing industries with their requirements from caustic soda, chlorine and their products.

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