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ESMAP

Energy Sector Management Assistance Program

JUNE, 1990

Syria

Energy Efficiency Improvement in the Fertilizer Sector

Report No. 115/90

ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAM

PURPOSE

The World Bank/UNDP/Bilateral Aid Energy Sector Management Assistance Program (ESMAP) was launched in 1983 to complement the Energy Assessment Program which had been established three years earlier. The Assessment Program was designed to identify the most serious energy problems facing some 70 developing countries and to propose remedial action. ESMAP was conceived, in part, as a preinvestment facility to help implement recommendations made during the course of assessment. Today ESMAP is carrying out preinvestment and prefeasibility activities in about 60 countries and is providing a wide range of institutional and policy advice. The program plays a significant role in the overall international effort to provide technical assistance to the energy sector of developing countries. It attempts to strengthen the impact of bilateral and multilateral resources and private sector investment. The findings and recommendations emerging from ESMAP country activities provide governments, donors, and potential investors with the information needed to identify economically and environmentally sound energy projects and to accelerate their preparation and implementation. ESMAP's policy and research work analyzing cross-country trends and issues in specific energy subsectors make an important contribution in highlighting critical problems and suggesting solutions.

ESMAP's operational activities are managed by three units within the Energy Strategy Management and Assessment Division of the Industry and Energy Department at the World Bank.

- The Energy Efficiency and Strategy Unit engages in energy assessments addressing institutional, financial, and policy issues, design of sector strategies, the strengthening of energy sector enterprises and sector management, the defining of investment programs, efficiency improvements in energy supply, and energy use, training and research.

- The Household and Renewable Energy Unit addresses technical, economic, financial, institutional and policy issues in the areas of energy use by urban and rural households and small industries, and includes traditional and modern fuel supplies, prefeasibility studies, pilot activities, technology assessments, seminars and workshops, and policy and research work.

- The Natural Gas Development Unit addresses gas issues and promotes the development and use of natural gas in developing countries through preinvestment work, formulating natural gas development and related environmental strategies, and research.

FUNDING

The ESMAP Program is a major international effort supported by the World Bank, the United Nations Development Programme, and Bilateral Aid from a number of countries including Australia, Belgium, Canada, Denmark, Finland, France, Iceland, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Sweden, Switzerland, the United Kingdom, and the United States.

FURTHER INFORMATION

For further information or copies of the completed ESMAP reports listed at the end of this document, contact:

Energy Strategy Management
and Assessment Division
Industry and Energy Department
The World Bank
1818 H Street N.W.
Washington, D.C. USA 20433

OR

Division for Global and Interregional
Programmes
United Nations Development Programme
One United Nations Plaza
New York, NY 10017
USA

SYRIA

ENERGY EFFICIENCY IN THE FERTILIZER SECTOR

JUNE 1990

Energy Efficiency and Strategy Unit
Industry and Energy Department
The World Bank
Washington, D.C. 20433

FOREWORD

The Energy Assessment report on Syria 1/ provided Syria's Government with a series of recommendations on appropriate energy policy measures aimed at increasing Syria's energy supply and slowing down the growth of energy demand.

The report identified energy efficiency improvement in the fertilizer industry as a priority area requiring further analytical and pre-investment studies. Following the recommendations in the report, the Syrian authorities requested assistance from the Joint UNDP/World Bank Energy Sector Management and Assistance Program (ESMAP) to carry out an energy efficiency improvement study of the fertilizer industry. ESMAP agreed to execute the study, and the UNDP provided IPF funding under the project "Energy Efficiency Improvement in the Fertilizer Sector" (SYR/86/016).

The objectives of the project were to (a) examine in more detail the scope for energy efficiency improvements in existing fertilizer industries, and (b) develop proposals for economically viable measures and investments, in sufficient detail to permit appraisal by interested funding agencies. James Chemical Engineering, Inc. (JCE), a consulting firm contracted by ESMAP, carried out the analytical work for the project in Syria (including field visits to the General Fertilizer Company's fertilizer plant at Homs) and in the U.S., under ESMAP's supervision. Their findings, results and technical recommendations have been reported in two documents: an intermediate report prepared in 1988 and a final report prepared in 1989.

The present Activity Completion Report, prepared by ESMAP with assistance from a consultant, 2/ presents JCE's findings and summarizes the measures proposed to the Syrian authorities for improving energy efficiency in the fertilizer industry.

The main conclusion of the JCE study is that both institutional and technical changes are needed to address the serious problems found at the GFC fertilizer plant. A number of technical measures are proposed to increase energy efficiency and raise actual production to a level close

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1/ "Syria : Issues and Options in the Energy Sector," Report No. SYR-5822 of the Joint UNDP/World Bank Energy Sector Assessment Program, May 1986, hereinafter referred to as "Syria: Issues and Options."

2/ The ESMAP activity was initiated by Messrs. Jivat N. Thadani, Senior Economist, and Abderrahmane Megateli, Energy Planner. This report was prepared by Djamal Mostefai, Industrial Energy Conservation Specialist, with the assistance of John Mulckhuyse, Consultant.

to design capacity, in order to meet Syria's increased demand for fertilizers. But these technical measures should only be implemented as part of a rehabilitation program, comprising the following:

- institutional rehabilitation
- physical rehabilitation and improvement of existing production lines and utilities
- an intensive training program
- a safety audit
- an environmental audit

We acknowledge with thanks the cordial cooperation of the management and staff of the General Fertilizer Company, without which it would have been impossible to develop the recommendations and action program outlined in this report.

ABBREVIATIONS

AN	Ammonium nitrate, a reaction product of nitric acid and ammonia
AS	Ammonium sulfate, a reaction product of sulfuric acid and ammonia
BFW	Boiler feed water
BPL	Quality rating for phosphate rock based on the amount of tricalcium phosphate in the rock
CAN	Calcium ammonium nitrate; this nitrogen fertilizer is a mixture of ammonium nitrate and ground limestone (calcium carbonate)
K_2O	Potassium oxide, the chemical unit in which potash plant food content is expressed, normally in kgs or tons
N	Nitrogen, the chemical unit in which the nitrogen plant food content is expressed, normally in kgs or tons
NH_3	Chemical formula for ammonia
NO_x	Nitrous oxides
P_2O_5	Phosphorpentoxide, the chemical unit in which phosphate plant food content is expressed, normally in kgs or tons
PA	Phosphoric acid, a reaction product of sulfuric acid and phosphate rock, generating large amounts of gypsum as a by-product
SA	Sulfuric acid, a reaction product of sulfur, oxygen and water
SSP	Single super phosphate, a reaction product of sulfuric acid and ground phosphate rock
TSP	Triple super phosphate, a reaction product of phosphoric acid and ground phosphate rock
tpd	Metric tons per day
tpy	Metric tons per year

ACRONYMS

GCPM	General Company for Phosphate Mining
GECI	General Establishment of Chemical Industries, a grouping of public industries which reports to the Ministry of Industry
GFC	General Fertilizer Company, a public enterprise supervised and monitored by GECI
PEE	Public Establishment of Electricity, the sole power generating company in Syria

ENERGY MEASURES

kg	kilogram
ton	1000 kg
GJ	Gigajoule or one billion joules
MJ	Megajoule or one million joules
Gcal	Gigacalorie or one billion calories
Mcal	Megacalorie or one million calories

CONVERSION FACTORS

1 MBtu	=	1.05 GJ	=	0.25 Gcal
1 GJ	=	0.95 Mbtu	=	0.24 Mcal
1 Gcal	=	4.19 GJ	=	3.97 MBtu

CURRENCY EQUIVALENTS

US $1.00 = Syrian Pound (LS) 11.25 -- 1987

TABLE OF CONTENTS

TABLES

FIGURES

ANNEXES

SUMMARY AND RECOMMENDATIONS

Objectives

1. The objectives of this report are to present (a) the scope for improving the overall operability, reliability and safety as well as the energy efficiency of the production facilities of the Syrian Fertilizer Industry; and (b) recommendations to the Syrian authorities to achieve potential improvements identified through the ESMAP activity.

Background

2. The Syrian Fertilizer Production Industry. Fertilizer is produced in three separate complexes grouped together at Homs under the management of the General Fertilizer Company (GFC), a publicly owned enterprise responsible for all fertilizer production in Syria. The main products of these complexes are: Calcium-ammonium nitrate (CAN), ammonia, urea and triple superphosphate (TSP). All fertilizers, whether produced by GFC or imported, are sold by the Government-controlled Agricultural Cooperative Bank, supervised by the Ministry of Economy and Foreign Trade. Fertilizer prices are established by the government at a uniform level throughout Syria, regardless of origin (domestic production or import).

3. Confronting a sharply increasing demand for food products stemming from a population growth whose annual rate is averaging 3.4%, Syria is actively promoting the use of fertilizers. However, at the time of the mission's visit, fertilizer use in Syria was still well below the average for developing countries. Domestic production is not always sufficient to meet local demand: for nitrogen fertilizers, imports have always been necessary to complement local production while for phosphate fertilizers, consumption and production have roughly balanced in the 1980s. Because of increased demand for fertilizers, Syria may become a net importer in all fertilizer groups in the next decade if production conditions are not improved.

4. Study approach. The ESMAP study was undertaken following an Energy Assessment report on Syria 3/ that identified the fertilizer industry (which accounted, in 1983, for 19% of Syria's industrial energy consumption) as one whose energy efficiency improvement potential was particularly high. The initial approach of the study was to identify constraints to energy efficiency within the GFC complexes as well as in the offsites and utilities and define economically viable improvements. However, during their site visits in October 1987 and February-March 1988, mission members discussed serious operability, reliability and

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3/ "Syria: Issues and Options."

safety problems as well as some major environmental hazards and concluded that:

(a) energy efficiency improvement would largely derive from improvement of the operability, reliability, safety and environmental conditions of the Homs complexes;

(b) since the main concern for Syrian authorities was improvement of these conditions, any program of action should not be restricted to energy efficiency but should address the overall issues facing the GFC complexes.

Consequently, it was agreed with the Syrian authorities that the scope of the study would be enlarged to encompass, at least on a preliminary basis, the operability, reliability, safety and environmental aspects of GFC's productive activities.

Main Findings

5. The overall situation of the fertilizer production industry. The industry is facing several critical problems. The main problems of the industry are listed below:

(a) Safety. Dangerous situations have developed in the complexes, particularly in the ammonia plant (with explosion and fire hazards) and in connection with the foundation of several plants and buildings (due to spillage of acids). Furthermore, as evidenced by the lack of many so called housekeeping safety measures, safety awareness, discipline, training and enforcement are insufficient.

(b) Environmental problems. Effluents from the complexes containing gypsum, phosphoric acid and fluorine compounds (poisonous to humans, animals and plants in high concentration) are disposed into a lake serving the city of Homs. This lake flows into the Orontes River, which discharges into the Mediterranean Sea.

(c) Overall plant efficiency. Production performance, except to some extent for CAN production, has been well below nameplate standards as summarized in Table 1. (Table 1 summarizes the main performance indicators).

Table 1: PRODUCTION PERFORMANCE INDICATORS

Production line	Operating rates a/ Average	Lowest	Highest	Period
Calcium ammonium nitrate	68	34.5	96.8	1977/87 b/
Ammonia c/	48	41.3	57.9	1983/87 b/
Urea	45	20.3	57.[illegible]	1982/87 b
Triple super phosphate	32	23.3	38.9	1982/87 b/

Source: Mission estimates.

a/ Defined as actual production over annual nameplate capacity (in %)
b/ Based on 6 months records for 1987
c/ Provided in Complex No. 2.

This situation stems from several, often interacting, causes, summarized as follows:

(i) Organization, management and human resources. The organization of GFC is based on decentralization of technical operations into three complexes, and centralization of commercial, planning, administrative and financial functions under one management, with the result that:

- Too many high level managers (10 currently) report to the General Manager.

- Technical resources (particularly in maintenance) are duplicated.

- Management of the utility systems is not unified and does not allow for rational decisionmaking in allocating common utility resources over the three complexes. The most striking example relates to the steam systems, which are not connected: in the past, some plants had to be shut down due to lack of steam even though steam from an adjacent system could have been made available.

- Management of human resources is not optimal. Some of the issues GFC faces are: overstaffing, high turnover, low salaries, no formal training and development program, little or no authority given to GFC's management to make key decisions on staff (hiring, firing, promotion) and develop incentive systems.

(ii) Technical processes and equipment. Production performance has also been limited by several technical constraints related either to production processes or to poor equipment condition. The technical factors limiting production (described in Chapter III of this report and in the consultant's report 4/ generally originate in an inadequate initial plant design or in equipment deterioration due to poor maintenance and operation procedures. Two important factors are:

- the lack of reliability of the water and steam systems which, through chain effects (aggravated by GFC's polluting its own feed water), has caused the most severe problems in the ammonia-urea complex; and

- the poor quality of phosphate rock, for which no satisfactory processing methods have yet been implemented, and which is largely at the origin of the inadequate performance of the TSP complex.

(d) Production capacity imbalances. Several production capacity imbalances are described in this report (Chapter III) and in the consultant's report. The principal imbalance is in ammonia production. The operational production capacity for ammonia is 330,000 tpy 5/ while current GFC operations would require only a maximum of 250,000 tpy. It was originally planned to export the surplus ammonia but the necessary infrastructure has not yet been installed.

The scope for improving the efficiency of fertilizer production

6. Given the present demand for fertilizer in Syria and its expected growth, any additional fertilizer produced within the existing facilities would be consumed locally. For urea, even if nameplate capacity were reached, imports would still be necessary. A preliminary analysis based on estimated economic prices of inputs and foreign exchange suggests that production costs would be significantly lower than world market prices 6/ if production levels of about 80% of installed nameplate capacity were obtained, and that production of fertilizer would be economically profitable for Syria.

4/ "General Fertilizer Company (Homs, Syria): Efficiency Improvement Project," by James Chemical Engineering, Inc.

5/ This is the capacity of Ammonia plant No. 2. It does not take into account the capacity of the ammonia plant in the CAN complex, which was mothballed in 1981.

6/ Except for CAN, for which there is no international market price.

7. While it is technically possible to achieve such a level of production and improve safety and environmental protection, major efforts from both the Syrian authorities and GFC as well as substantial financial resources will be needed to implement a comprehensive rehabilitation program. The ESMAP study identifies the various components of this program and specifies for several of them the options to be considered or actions to be taken by Syrian authorities. The rehabilitation program as identified by ESMAP covers the following categories:

(a) Safety and environmental protection.

(b) Institutional improvements, including increased decisionmaking authority for GFC, and improved organization and human resources;

(c) Operability, reliability and efficiency improvements through the development of adequate operations and maintenance procedures and the implementation of an investment program; and

(d) Options for balancing production capacities within the Homs complexes.

Recommendations

8. It is recommended that Syrian authorities undertake the following actions:

(a) Safety and environmental protection

(i) Carry out full safety and environmental audits.

(ii) Enforce existing "housekeeping" safety measures.

(b) Institutional improvements

(i) Give GFC greater decisionmaking autonomy, particularly in the procurement of spare parts and raw materials and in management and motivation of its personnel.

(ii) Streamline GFC's organization into production, maintenance, administration, technical and engineering departments.

(iii) Develop and implement an improved salaries and incentives system.

(iv) Develop and implement a comprehensive training program for maintenance and production staff.

To implement these actions, ESMAP recommends that GFC obtain the support of a management consulting firm (Management Consultants).

(c) Operability, reliability and efficiency improvements

(i) Develop a technical assistance program with foreign partners (Technical Consultants) to implement effective maintenance, operation and quality control procedures.

(ii) Procure critically needed spare parts and calibration and measurement instruments and improve facilities for spare parts storage.

(iii) Prepare and implement a priority investment program mainly aimed at:

- rehabilitating the water and steam systems as well as the general utilities of the ammonia-urea plant;

- integrating all GFC utilities, particularly the 40 bar steam systems.

- revamping the urea plant and the Stamicarbon process within the ammonia-urea complex; and extending the capacity of the urea plant in line with projected ammonia production capacity.

- rehabilitating the utilities, the effluent treatment system and the phosacid plant of the TSP complex.

The identified investment program is reviewed in Chapter V of this report and the complete list of projects is presented in the consultant's report and duplicated in Annex 1 of this report.

Expected Results

9. Procedure and cost reduction targets. Dramatic results on production and cost levels can be achieved through the implementation of a rehabilitation program as identified by the consultant and ESMAP.

Table 2 summarizes the improvements which can be expected from a program of actions 7/ aimed at:

(a) first, improving the operability and reliability of GFC's complexes ("reliability improvement program") in order to run the plants at around 80% of their nameplate capacity; and

(b) then, further ameliorating the efficiency of GFC's operations ("efficiency improvement program").

Table 2: PRODUCTION AND COST IMPROVEMENT TARGETS

		Investment Programs			
	Initial Situation a/	Reliability	%	Efficiency	%
Urea					
• Production (mty)	171,109	311,850	+82	311,850	-
• Variable financial cost (LS)	870	481	-44	425	-12
• Variable economic cost (LS)	2,821	1,550	-45	1,352	-13
CAN					
• Production (mty)	109,919	111,600	+1.5	111,600	-
• Variable financial cost (LS)	583	374	-36	336	-10
• Variable economic cost (LS)	1,855	1,068	-42	968	-9
TSP					
• Production (mty)	192,720	445,500	+131	445,500	-
• Variable financial cost (LS)	1,243	1,013	-18	1,008	-
• Variable economic cost	3,565	2,656	-25	2,620	-1

Source: Consultant and mission estimates.

a/ Based on 1986 data.

The above expected results are based on a substantial improvement of ammonia production conditions in order to meet increased demand for urea and CAN production and on a reduction of 32% of the variable costs of ammonia production through a reliability improvement program and 7% through an efficiency improvement program.

7/ These actions do not include expansion of production capacities above what has already been installed.

10. Costs of the rehabilitation program. The total cost of the reliability and efficiency programs designed through the study is about US$ 50 million, including local costs and a 25% contingency provision. Implementation of the program would require about five years.

Table 3: BREAKDOWN OF THE REHABILITATION PROGRAM

	Program for Reliability (US$ '000)	Improving Efficiency (US$ '000)	Total (US$ '000)
Managerial and technical assistance	13,800	-	13,800
Safety and maintenance	7,200	-	7,200
Common utilities and offsites	7,800	270	8,070
CAN complex	1,500	3,000	4,500
Urea complex	400	9,000	9,400
TSP complex	7,500	730	8,230
Total	38,200	13,000	51,200

Source: Consultant and mission estimates.

11. Financial results. Based on the nominal prices at which GFC is selling its production, the rehabilitation reliability and efficiency improvements program would lead to a substantial increase in GFC's cash flow; therefore, this program would prove highly profitable. After the implementation phase, expected to last around five years, the annual cash flow increase (in reference to the situation prevailing in 1986-1987) would be about US $46 million. About half of this increase would derive from reduction in costs (90% of which would be achieved as a result of reliability improvement). The Internal Rate of Return of the program would be around 69%.

Table 4: CONSOLIDATED FINANCIAL RESULTS
OF THE RELIABILITY AND EFFICIENCY IMPROVEMENT PROGRAMS

	Improvement Programs		
	Reliability (US$ '000)	Efficiency (US$ '000)	Total (US$ '000)
Annual cash flow increase			
due to: • production increase	22,647	-	22,647
• cost reduction	21,965	2,121	24,086
Subtotal	44,612	2,121	46,733
Discounted net cash flow a/	160,646	-374	160,272
IRR	77	11	69

Source: Mission estimates.

a/ Based on a 12% annual discounting rate and a 6-year period to achieve the final production and cost targets.

12. Economic results. The price system under which GFC is operating is highly distorted. This is particularly true for the foreign exchange rates, energy prices and fertilizer prices. Economic results have been computed based on a reference price system to reflect more accurately the opportunity cost and economic values of products traded by GFC. With an IRR of about 100% the rehabilitation program is also highly profitable on an economic basis: the IRR for the reliability improvement program is about 111%, while the IRR for the efficiency improvement program is around 24%. Due to price distorsions, the financial results markedly underestimate the economic benefits from the rehabilitaton program, particularly for efficiency improvement measures.

I. THE FERTILIZER INDUSTRY IN SYRIA

Sector Institutions and Policies

1.1 Fertilizer supply in Syria is supervised and monitored by the General Establishment for Chemical Industries (GECI) which, as a statutory entity, reports to the Ministry of Industry. Fertilizer demand is monitored and controlled by the Ministry of Agriculture.

1.2 The production of fertilizer is concentrated in the General Fertilizer Company (GFC), a publicly owned enterprise at Homs. GFC is supervised and monitored on a daily basis by GECI.

1.3 The Government puts great emphasis on increasing agricultural production in order to achieve self-sufficiency in food production and feed a population that is growing at 3.4% annually. To achieve the increased crop yields needed to realize this objective, the Ministry of Agriculture plans to substantially increase the use of fertilizers. However, it is doubtful that GFC will be able to meet this increased demand in the short term due to low production efficiency in the existing fertilizer complexes.

Fertilizer Demand

Nitrogen Consumption

1.4 The consumption of nitrogen fertilizers has increased over the past four years at 15% annually, and current production of nitrogen fertilizer is insufficient to meet current demand; the deficit is made by by imports. However, current production of nitrofen fertilizers is well below installed capacity; if full capacity were reached, local production would cover present domestic demand. Nevertheless, the rapidly increasing demand would outstrip potential nitrogen fertilizer production within a few years.

Table 1.1: NITROGEN FERTILIZER PRODUCTION AND CONSUMPTION IN SYRIA
1981/82 - 1986/87
('000 tons N)

Crop Year	Production	Consumption	(Deficit)
81/82	36.9	83.1	(46.2)
82/83	80.0	95.9	(15.9)
83/84	104.3	109.5	(5.2)
84/85	117.0	126.7	(9.7)
85/86	112.2	143.6	(31.4)
86/87	103.3	NA	NA

Sources: FAO, Ministry of Agriculture, GFC.

NA = Not available.

Phosphate Consumption

1.5 The consumption of phosphate fertilizers has grown at almost the same rate (14.5% annually) as that of nitrogen fertilizers. However, the balance between demand and supply is better for phosphate than for nitrogen. For the 1985/86 crop year, a slight surplus of 3,100 ton was produced. (Table 1.2).

Table 1.2: PHOSPHATE FERTILIZER PRODUCTION AND CONSUMPTION IN SYRIA
1981/82 - 1986/87
('000 tons of P_2O_5)

Crop Year	Production	Consumption	Surplus/(Deficit)
81/82	26.3	50.1	(23.8)
82/83	53.8	53.5	0.3
83/84	57.5	63.7	(6.2)
84/85	87.9	74.2	(13.7)
85/86	88.7	85.6	3.1
86/87	72.9	NA	NA

Source: FAO, Ministry of Agriculture, GFC.

Demand Projections

1.6 In recent years Syria has become a net importer of food and livestock feed products. The Government recognizes this problem and continues to put great emphasis on increasing agricultural production in order to meet the demand.

1.7 As shown in Table 1.3, Syria's consumption of fertilizers per hectare of arable land for permanent crops is lower than that of most of its neighboring countries, and well below the average for all developing countries.

Table 1.3: CONSUMPTION OF FERTILIZERS PER HECTARE OF ARABLE LAND FOR PERMANENT CROPS - 1984
(kg/ha)

Country	N	P_2O_5	K_2O	Total
Syria	19.5	11.4	1.0	31.9
Cyprus	24.5	16.9	4.9	46.3
Egypt	292.3	64.6	7.1	363.9
Iran	40.2	28.8	0.9	69.9
Iraq	11.2	4.8	0.5	16.5
Jordan	21.2	15.6	2.6	39.4
Lebanon	60.4	21.8	36.9	119.1
Saudi Arabia	99.8	77.3	12.5	189.6
Turkey	38.4	23.2	0.9	62.5
Average - Middle Eastern Countries	34.2	18.1	1.2	53.6
All Developed Countries	56.6	33.3	31.9	121.8
All Developing Countries	36.5	13.1	4.9	54.5

Source: FAO Fertilizer Yearbook - 1985

Table 1.4 compares Syria's 1985/86 applications per hectare of nitrogen, phosphates and potash with the Ministry of Agriculture's projected applications for 1989/1990, and the application rates recommended by the FAO.

Table 1.4: FERTILIZER APPLICATION RATES
(plant nutrients in kg/ha)

	1985/86 Actual	1989/90 Planned Consumption Ministry of Agriculture	Recommended by FAO
Nitrogen	25.6	42.9	62.5
Phosphate	15.3	35.7	35.7
Potash	1.2	2.9	5.4
Total	42.1	81.5	103.6

Source: FAO, Ministry of Agriculture.

Fertilizer Supply

1.8 GFC is the sole domestic supplier of fertilizers in Syria. When production is insufficient to meet demand, the balance is covered by imports. Currently, the supply of calcium ammonium nitrate (CAN) is sufficient to meet demand, and no shortage is anticipated for the 1989/90 crop year. However, as shown in Table 1.5, the anticipated production of urea and phosphate will fall short of demand by 165,000 tons and 138,000 tons respectively. If the measures proposed in this report are implemented, the production of phosphate fertilizer (TSP) should be adequate to meet current demand, and GFC should be able to produce a slight surplus of CAN. There would still be a shortfall in urea as the expected production of the urea plant after implementation of corrective actions is 346,000 tons and the projected demand for urea is 450,000 tons. After 1992, if the targets for fertilizer consumption set by the Syrian authorities are achieved, GFC will not be able to meet demand using its existing facilities even if the plants are run at the higher production rates expected after rehabilitation. Based on current international fertilizer prices the amount of foreign exchange required to import fertilizer would be reduced by about US $50 million annually if corrective actions recommended in this report were successfully implemented.

Table 1.5: FERTILIZER DEMAND/SUPPLY
('000 ton)

	1	2		3		4		5
	Demand (89/90)	Planned Production (89/90) Production/Balance		Mission Estimate of Production without Corrective Actions Production/Balance		Mission Estimate of Expected Production after implementation of Corrective Actions Production/Balance		Nameplate Capacity
CAN	100	100	-	100	-	112	12	124
UREA	450	285	(165)	200	(250)	312	(138)	346
TSP	445	307	(138)	200	(245)	446	1	495

Source: Ministry of Agriculture, GFC, ESMAP mission.

Fertilizer Sales and Distribution.

1.9 All fertilizers produced by the General Fertilizer Company and all imports are sold by the government-controlled Agricultural Cooperative Bank (supervised by the Ministry of Economy and Foreign Trade). The Bank has 62 branches throughout Syria and also handles distribution to the farmers.

1.10 All fertilizers produced at Homs are packed in 50 kg polyethylene-lined, woven polypropylene bags, and are delivered to the brancnes either by rail or truck. Imports of potassium as well as imports of required nitrogen and phosphate fertilizers (under the jurisdiction of the Foreign Trade Organization for Chemical Foodstuffs) are distributed by the Agricultural Cooperative Bank in a manner similar to that of domestic production.

Pricing of Raw Materials and Fertilizers

Foreign Exchange Availability and Exchange Rate

1.11 Foreign currency for importing raw materials and equipment is only sparingly available on special import permits. By mid-1987 eight official exchange rates were applicable for different international transactions. The lowest is the official selling rate of LS 3.95 to US $1.00, which was the long-standing official rate and is now only used for a limited number of special cases. Most often transactions of the Government and the public sector occur at the rates of LS 5.40, 9.75 or 11.25 to US$ 1.00. Over and above the official exchange rates there is an unrestricted promotion rate which is set by the Government and is based on conditions in the unofficial foreign exchange market. This rate was set at LS 27/US$ at the time of the mission. It is used in this report as the nearest proxy to the shadow rate of exchange, and is applied to the economic analysis.

Supply and Prices of Raw Materials and Commodities

1.12 Raw material and commodities needed by GFC. GFC has been using naphtha as a raw material for producing ammonia. As natural gas has recently become available in Syria, GFC intends to change from naphtha to natural gas. Because ammonia production until 1989 was based on naphtha, historical ammonia cost price calculations are based on naphtha prices. Other commodities consumed are fuel oil for boiler operations, electricity, phosphate rock for phosphoric acid and triple superphosphate production and sulfur for sulfuric acid. Except for natural gas and phosphate rock, all raw materials for fertilizer production have to be imported.

1.13 Raw Material and Commodity Prices. Due to administrative setting of nominal prices of raw materials and commodities purchased by GFC and the strong distinction between the official foreign exchange rate and the economic exchange rate (as estimated by the mission), actual prices of raw materials and commodities used by GFC do not reflect their economic costs and, as indicated in Table 1.6, are generally well below these costs.

Table 1.6: PRICES TO GFC FOR ENERGY, RAW MATERIALS AND UTILITIES, 1987
(In Syrian pounds and in US$ at the official and shadow exchange rates)

	Unit	In LS/Unit	In $/Unit converted at LS 11.25/US$ (nominal price)	In $/unit converted at LS 27/US$ (shadow price)	In $/Unit world market Cost
Naphtha	t	1,160	103.11	42.96	126.00
Fuel Oil	t	786	69.87	29.11	64.00
Phosphate rock	t	100	8.89	3.70	23.50
Sulfur a/	t	1,920	170.67	71.11	120.00
Steam	t	100	8.89	3.70	-
Electricity	kWh	0.36	0.032	0.0133	0.0711

Source: GFC.

a/ This is the most recent price for imported sulfur. Minor quantities are purchased from the Homs refinery at LS 655/t.

Prices of Fertilizers

1.14 Urea. In March 1988 the Middle East bulk FOB price for urea was US$ 107/ton. Adjusting for transport and bagging, the local price would be US$ 140/ton. The economic price of urea would be equivalent to LS 3780/ton at the shadow cost of foreign exchange (LS 27/US$).

1.15 Triple Superphosphate (TSP). In March 1988, the Moroccan bulk FOB price of TSP was about US$ 161/ton. Adjusting for transportation and bagging, the local price would be about US$ 190/ton. The economic price of TSP would bc equivalent to LS 5130/ton at the shadow cost of foreign exchange.

II. THE GENERAL FERTILIZER COMPANY (GFC)

Production Facilities

2.1 The General Fertilizer Company (GFC) produces nitrogen and phosphate fertilizers for the Syrian market at its facilities in Homs. GFC operates three fertilizer complexes, producing three end products: calcium-ammonium nitrate (CAN), urea, and triple super phosphate (TSP).

Complex No. 1 (CAN)

2.2 This complex consists of three production units: (i) a naphtha based ammonia plant with a nameplate capacity of 150 tpd (equivalent to 49,500 tpy at 330 onstream days); (ii) a nitric acid plant with a nameplate capacity of 265 tpd of 47-49% acid (or 87,500 tpy at 330 onstream days); and (iii) a CAN unit with a nameplate capacity of 424 tpd CAN with 25.5% N or 375 tpd CAN with 30% N (respectively 140,000 or 124,000 tpy at 330 onstream days).

2.3 SNAM PROGETTI was the contractor for the ammonia plant, which was commissioned in 1968. This plant was mothballed in 1981 when a new ammonia plant came on stream in Complex No. 2. The nitric acid and CAN plants are a USSR design and supplied and constructed by USSR/Czechoslovak contractors. CAN production peaked in 1986 as shown in Table 2.1.

Table 2.1: CAN - ACTUAL PRODUCTION AND ANNUAL UTILIZATION RATE, 1977-87 a/

Year	Operating Rate: Production '000 Ton	Operating Rate: Annual Utilization Rate (Percentage of Installed Capacity)
1977	84.8	60.6
1978	76.9	54.9
1979	75.9	54.2
1980	48.3	34.5
1981	59.6	42.6
1982	112.8	80.6
1983	116.4	83.1
1984	110.0	79.7
1985	90.5	73.0
1986	109.9	88.6
1987 (6 mos)	60.0	96.8

Source: GFC.

a/ In October 1984 the product specifications were changed from 26.5% N to 30% N.

Complex No. 2 (Ammonia/Urea)

2.4 In 1981 a world-scale ammonia and urea plant came on stream. The ammonia plant of 1000 tpd nameplate capacity was designed by Kellogg. The urea plant of 1050 tpd uses the Stamicarbon process. Both plants were constructed by the French firm Creusot-Loire. Their annual capacity for 330 on-stream days is 330,000 t ammonia and 345,500 t urea respectively. The urea and nitric acid/CAN plants require a total of 250,000 tpy of ammonia, thus the ammonia plant has a design overcapacity of 80,000 tpy ammonia. The original project plan included export of ammonia but the necessary infrastructure was never installed. As a result the ammonia plant has never operated at capacity. If properly rehabilitated and correctly operated, the ammonia plant could produce extra ammonia for export. Table 2.2 gives the ammonia plant's actual production from 1983 to 1987, and its annual utilization rate.

Table 2.2: AMMONIA PLANT - ACTUAL PRODUCTION AND ANNUAL UTILIZATION RATE, 1983-87

Year	Operating Rate	
	Production '000 Ton	Annual Utilization Rate (Percentage of Installed Capacity)
1983	138.0	41.8
1984	136.2	41.3
1985	160.6	48.7
1986	166.5	50.5
1987 (6 mos)	95.6	57.9

Source: GFC.

Table 2.3 gives the annual production of the urea plant from 1982 to 1987, and its annual utilization rate. it should be noted that the urea plant gets its carbon dioxide feedstock from the ammonia plant and thus, if the ammonia plant is shut down, the urea plant has to stop operating.

Table 2.3: UREA PLANT - ACTUAL PRODUCTION AND ANNUAL UTILIZATION RATE, 1982-87

	Operating Rate	
Year	Production '000 Ton	Annual Utilization Rate (Percentage of Installed Capacity)
1982	70.2	20.3
1983	141.8	40.9
1984	164.5	47.5
1985	199.9	57.7
1986	171.1	49.4
1987 (6 mos)	90.6	52.3

Source: GFC.

Complex No. 3 (TSP)

2.5 The TSP complex, commissioned in 1981, consists of the following five production units:

- two sulfuric acid units;
- two phosphoric acid units; and
- one triple super phosphate granulation unit.

The nameplate capacities of these units are: sulfuric acid, 495,000 t; phosphoric acid, 198,000 t; TSP, 495,000 t; and aluminum fluoride, 3,000 t. All units were built by Industrial Export of Roumania. The sulfuric acid units were designed by Lurgi.

The TSP complex has an extremely poor production history. As shown in Table 2.4, it has never surpassed 40% of nameplate capacity (based on 330 onstream days).

Table 2.4: TSP PLANT - ACTUAL PRODUCTION AND ANNUAL UTILIZATION RATE, 1982-87

Year	Operating Rate	
	Production '000 Ton	Annual Utilization Rate (Percentage of Installed Capacity)
1982	115.8	23.3
1983	115.5	23.3
1984	191.2	38.6
1985	162.2	32.8
1986	192.7	38.9
1987 (6 mos)	91.6	37.0

Source: GFC.

The aluminum fluoride plant never ran properly and was closed down in 1982. It should be noted that the production of aluminum fluoride is an excellent way to solve a difficult waste product problem caused by the fluorine solution from the phosphoric acid plant. 8/

Utilities

2.6 The most important utilities are the boiler systems. One system is installed in the TSP complex with 4 boilers in addition to the waste heat boilers in the sulfuric acid plants. A second boiler/steam system is in the ammonia/urea complex with 2 boilers in addition to the waste heat boiler in the ammonia plant. A third system in the CAN complex is based only on waste heat boilers in the ammonia and nitric acid plants.

Raw Material Supply

Naphtha and Fuel Oil

2.7 Naphtha and fuel oil are available from two sources, the Banias and the Homs refineries. Both refineries are owned and operated by the Ministry of Petroleum and charge uniform prices for their products.

8/ Technically mainly a solution of $H_2 Si F_6$ which can cause serious pollution problems if not properly disposed of.

Domestic naphtha and fuel oil demand is met and a surplus is exported. Ex-refinery price of naphtha and fuel oil is fixed within the controlled petroleum prices. A petroleum products sales and distribution company, also under the Ministry of Petroleum, is the sole supplier of naphtha and fuel oil to the Homs fertilizer plant.

Electricity

2.8 Electricity is supplied to the Homs fertilizer plant from PEE's power generating facility at Homs. The sulfuric acid plant, which is part of the TSP complex, has a 6.4 MW power-steam generating unit for its own requirements. However, the generating unit has been inoperative for some time.

2.9 The reliability of electric supply in Syria has declined in recent years due to high electricity demand and insufficient generation capacity. Due to this shortage, PEE has had to manage electricity consumption by load shedding for large sections of the country on a rotating basis every workday. The planned blackouts do not include the fertilizer complex. Nonetheless the complex suffers from electricity shortages through sporadic cuts.

Energy Consumption of the Homs Enterprise

2.10 Table 2.5 shows the fertilizer production and energy consumption of GFC's major fertilizer units for 1986.

Table 2.5 FERTILIZER PRODUCTION AND ENERGY CONSUMPTION OF MAJOR GFC FERTILIZER UNITS, 1986

Product	Production	Consumption of Energy		
		Naphtha	Electricity	Fuel Oil
	(ton)	(ton)	(1000 kWh)	(ton)
Ammonia	166,500	193,979	31,874	-
Urea	171,109	-	16,065	47,718
CAN	109,919	-	18,857	-
TSP	192,720	-	56,424	34,917

Source: GFC.

2.11 In 1983 GFC accounted for 19% of Syria's industrial energy consumption and about 5% of total energy consumption. The ammonia/urea plant is the main consumer of energy, mostly in the form of naphtha and fuel oil. As shown in Table 2.6, in terms of tons of oil equivalent (toe) in 1986 it accounted for more than three quarters of the energy consumed by GFC.

Table 2.6: ENERGY CONSUMPTION OF MAJOR GFC FERTILIZER UNITS, 1986
('000 TOE)

Product	Naphtha	Electricity	Fuel Oil	Total	Percent
Ammonia	199.7	8.0	-	207.7	67.5
Urea	-	4.0	45.8	49.8	16.2
CAN	-	4.7	-	4.7	1.5
TSP	-	14.1	31.4	45.5	14.8
Total	199.7	30.8	77.2	307.7	100.0

Source: GFC and the mission.

Note: toe conversions/metric ton of product
Naphtha = 1.0294
Fuel oil = 0.96
Electricity = 4,000 kWh on a thermal replacement basis

Table 2.7 shows actual and design specific energy use for the GFC plants, and indicates the energy that would be saved if the plants were running properly at design performance rates.

Table 2.7: GFC ACTUAL AND DESIGN SPECIFIC ENERGY USE
PER PRODUCT LINE, 1986
(toe/t)

	Actual 1986	Design	Excess consumption (%)
Ammonia (Complex No. 2)	1,247.0	1,025.0	+17.8
Urea a/	0.3	0.1	+200
CAN	0.0428	0.0095	+4,100
TSP	0.236	0.038	+620

Source: Mission estimates.

a/ Without ammonia input.

2.12 Although the percentage of the ammonia plant's excess energy consumption is rather small compared with the other values, the ammonia plant consumes considerably more energy in absolute terms than any other plant. This is evident when the energy consumption is calculated based on design specifications for the quantities produced in 1986 (Table 2.8).

Table 2.8: GFC ACTUAL AND DESIGN ENERGY CONSUMPTION PER PRODUCT LINE, 1986 ('000 toe)

	Actual	Design ('000 toe)	Excess Consumption
Ammonia	207.7	170.7	37.0
Urea	49.8	17.1	32.7
CAN	4.7	1.04	3.66
TSP	45.5	7.3	38.2

Source: Mission estimates.

2.13 Improving the energy efficiency of the ammonia plant would reduce GFC's energy consumption considerably. However, as discussed in Chapter III, because the ammonia plant feedstock will shortly be changed from naphtha to natural gas, the mission recommends delaying an in-depth energy audit of the plant until the plant has run continuously for some time after the conversion. The first priority for the ammonia plant is to achieve reliable operation.

III. DETAILED ANALYSIS AND RECOMMENDATIONS

3.1 Although GFC's management has put great effort into increasing the reliability and efficiency of the plants, many issues have still to be resolved and many technical problems need to be solved. The main issue of the Homs fertilizer complex is not energy efficiency improvement but improvement of the reliability of all plants and improvement of management and technical efficiency. GFC needs to:

(a) increase production to acceptable levels by removing bottlenecks in organization, maintenance, spare parts procurement, operational knowledge and skill;

(b) improve efficiency (including energy efficiency) of production facilities, and improve utilities;

(c) introduce, manage and monitor a strong operational safety policy; and

(d) solve severe environmental problems.

Organization and Human Resources

Organization

3.2 The organization of GFC has three main shortcomings (see GFC organization chart, Figure 3.1). These are:

(a) Too many high-level managers report to the General Director. At the time of the mission's visit in 1988, GFC had a management team of 36 directors and 10 top managers reported directly to the General Director. Such a centralized management system is generally inefficient and cumbersome as the General Director must pay too much attention to coordination, conflict solving, and operational details, often to the detriment of policymaking and key decisionmaking;

(b) Production operations cannot be easily coordinated. The present organizational structure has evolved from the establishment of the Homs complexes as three essentially separate and rather independent plant groups, with practically no interaction between the groups, and with each plant manager reporting directly to the General Director. This lack of coordination is a fundamental cause of some of GFC's major problems, such as the discharge by one complex of highly polluted effluents into a lake from which the other complexes take their boiler feed water, or the shutdown of one plant due to lack of steam while steam is available in an adjacent complex; and

(c) Maintenance cannot be easily coordinated and managed. Under the present organization, there are four maintenance divisions whose managers report to different top-level directors. The resulting lack of coordination between the maintenance divisions has repercussions on maintenance planning and scheduling. Under present conditions, only emergencies receive attention and preventive maintenance is almost inexistent. The existence of four separate maintenance divisions does not provide an optimal solution to the dramatic shortage of skilled maintenance staff.

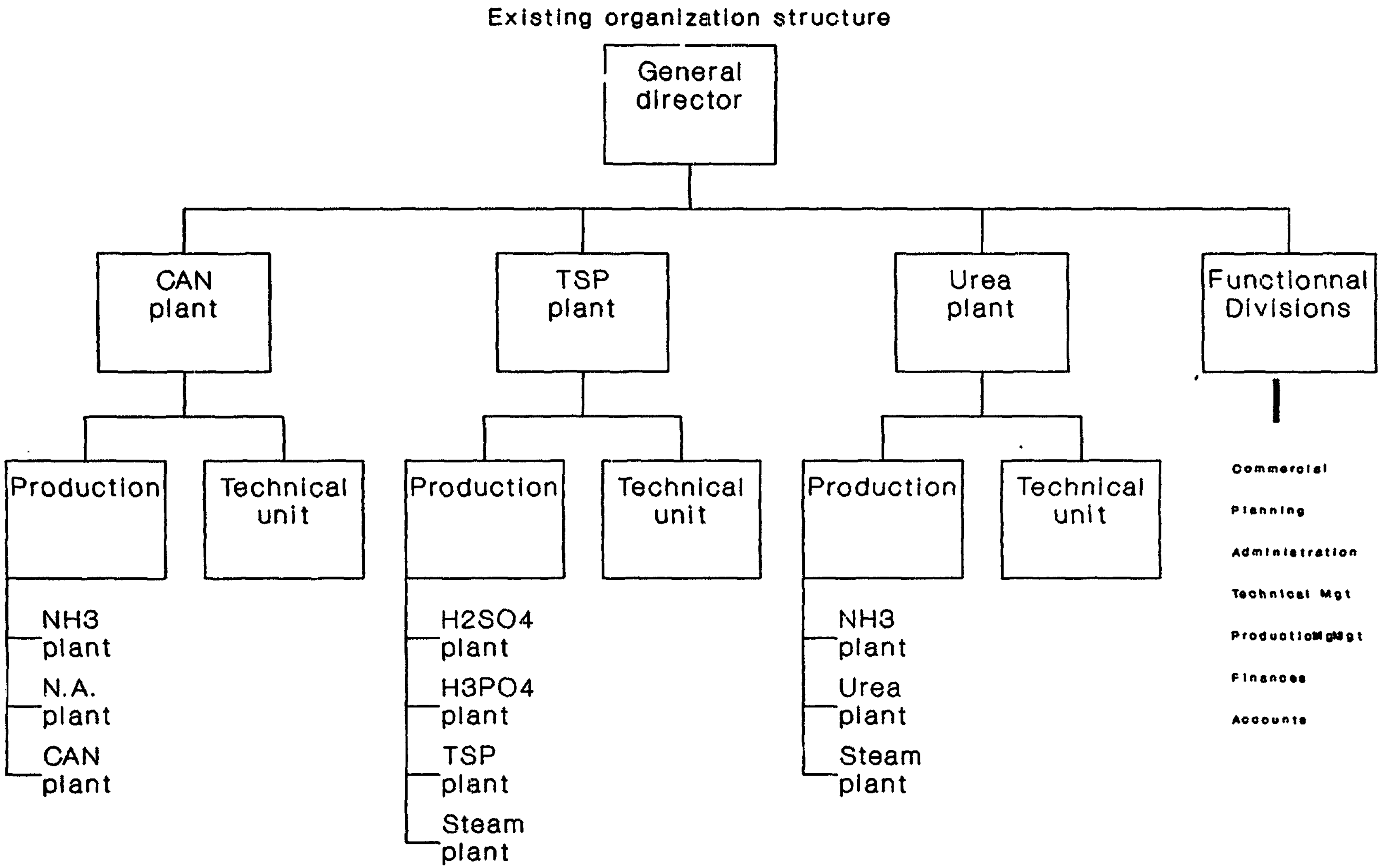

Figure 3.1

GFC ORGANIZATION CHART

Human Resources

3.3 GFC is facing severe personnel problems. While such problems are in no way unique to GFC, they have a pronounced effect on the efficiency of operations and maintenance in an industry that must make use of complicated processes and equipment.

3.4 Wages and Salaries. Wages and salaries are controlled by the Government. They are set too low when compared with those in other industries in the private sector. Consequently, there is an exodus of good people to the private sector or to higher paid public sectors. Many of the employees who remain with GFC hold a second job.

3.5 Personnel Turnover. Employee turnover is high (an estimated 10%) and good employees leave to be replaced by a larger number of less experienced staff. Fewer qualified personnel are available to educate new recruits. The consequence is that the work load is increasingly shifting to the remaining good workers, which is an extra incentive for them to leave the company.

3.6 Overstaffing. Overstaffing is a severe problem. The numbers of employees in the four GFC departments as of January 1988 are given in table 3.1 and compared with employee numbers in same-size complexes in the USA and in other developing countries.

Table 3.1: GFC EMPLOYEE NUMBERS AS OF JANUARY 1988
COMPARED WITH SAME-SIZE COMPLEX IN USA AND OTHER DEVELOPING COUNTRIES

	Actual	Planned	USA	Other developing countries
Central Dept.	1,016	1,434	30	100
Complex 1 (CAN)	599	621	200	500
Complex 2 (Urea)	596	698	250	700
Complex 3 (TSP)	1,128	1,283	350	900
Total	3,330	4,036	830	2,200

Source: GFC and consultant estimates.

Although GFC (especially the Central Department) is heavily overstaffed, even compared to similar-size complexes in other developing countries, nevertheless at the time of the mission, management was planning to increase the staff further to about 4,030.

3.7 Training. No formal training is available. New employees have to learn by exposure. Refresher courses for older employees are not available. No cross-training is organized to allow personnel to be relocated in other areas without disruption.

Plant Technical Reliability and Efficiency

3.8 The main production problems GFC faces relate to urea and TSP, which have the lowest production rates compared to nameplate capacity of GFC's fertilizer products. Over the 1984-87 period, production of urea and TSP averaged 52% and 37% of nameplate capacity respectively. For the same period, production of CAN remained around 85%. 9/ The low production rates of urea and TSP are primarily due to bottlenecks in the production of intermediate products such as ammonia and carbon dioxide (used for the production of urea) or phosphoric acid (used for the production of TSP). These production bottlenecks have two main technical causes:

(a) Deficiencies in the steam systems, which lead to frequent shutdown of the ammonia plant of Complex No. 2 and consequently to losses of ammonia and carbon dioxide; 10/ and

(b) the poor quality of the phosphate rocks used as raw material for the phosphoric acid plant and the inadequate design of the plant.

Deficiencies in the steam systems are largely due to the poor quality of the boiler feed water and cooling water, a consequence of inadequate water treatment and of inadequate equipment maintenance. The following paragraphs describe in more detail the sources and causes of production inefficiencies and present technical recommendations for eliminating them.

Utilities and Offsites

3.9 Steam system deficiencies. One of the major technical problems of the GFC fertilizer factory is the poor quality of boiler feed water and cooling water. The water quality is below operational specifications for two reasons:

(a) inadequate water filtration and demineralization; and

9/ See Chapter II.

10/ A by-product of the ammonia production process.

(b) intake of water highly polluted by effluents from the TSP and phosphoric acid plants.

The inadequately treated water causes severe operating problems (corrosion) which have resulted in poor operation of boilers and cooling towers. This situation has been aggravated by maintenance problems with the oil-fired boilers caused by the use of high-sulfur oil. These boilers and the high pressure waste heat boiler in the ammonia plant (Complex No. 2) have frequently broken down. In the absence of an integrated steam system within GFC's installations, these breakdowns have led to shutdown of the ammonia plant and consequently to a reduced production of urea. According to the mission's estimates, if the quality of the boiler feed water and cooling water were adequately improved and carefully controlled, the ammonia/urea complex would need only a few modifications to run at 90% of its design capacity (instead of at 53%, the rate reached in 1986). Furthermore, if normal operations were achieved, the 6.4 MW electric power generator in the sulfuric acid plants could be operated and could provide 35% of GFC's total electric power requirements.

3.10 Recommendations for improving the steam systems. The reliable supply of boiler feed water and cooling water is vital for continuous high-capacity operation. To achieve this objective, the following urgent measures are recommended:

(a) modify the effluent disposal system of the TSP complex to avoid discharging corrosive effluents into GFC's water reservoir. Detailed studies will be necessary to design such modifications;

(b) add new water treatment facilities for filtration and mineralization;

(c) increase boiler capacity by 75 tph by adding a new boiler (40 bar steam);

(d) switch the boiler of Complex No. 3 from fuel oil to natural gas firing (to prevent further corrosion problems);

(e) interconnect, integrate and bring under a single management the (40 bar) steam systems of the three complexes (including the one recommended above). This measure would allow the whole steam system to operate with one boiler down and would ease regular preventive maintenance; and

(f) provide operations and maintenance staff with extra training and support frcm international water treatment experts.

The mission also recommends that the Homs complex be made practically independent of the main electrical grid, by adding to the new 75 tph boiler a 15 MW cogeneration system.

Spare Parts Storage and Management

3.11 A large warehouse built to consolidate the storage of all spare parts and consumables into one building cannot be used for this purpose. It is exposed to excessive dust and corrosive fumes from the nearby sulfuric acid, phosphoric acid and triple superphosphate plants. These fumes cause heavy corrosion of spare parts in this building.

3.12 At present in the absence of a general warehouse, stores are maintained in several buildings dispersed in various locations within the complex. This results in adverse effects on logistics, central record keeping and manpower. Centralization would improve this situation.

3.13 Warehouse Operation and Record Keeping. Inventory of spare parts is very high. Many spare parts have not shown movement since plant start-up. Some of the equipment has never been opened or uncrated and the internal condition of these parts is questionable. Because plants and equipment are from many origins, standardization has never been attempted and would be very difficult. Reordering scheduling has never been determined so that essential parts are often out of stock. However, from a general point of view, spare parts warehousing appears well identified, protected and accessible, and records are well-kept. GFC has plans to computerize record keeping.

3.14 Workshop Facilities. The general machine shop is equipped to handle just about any machining job on anything except oversized and extra heavy equipment. However, less than 25% of the shop equipment is used regularly. The balance of the equipment, representing over 90% of investment in shop equipment, is used rather sporadically. Until now, subcontracting has not been considered although Homs has an established infrastructure as does Damascus, only two hours away. Both have a variety of services to offer.

3.15 The Central Electricity workshop is overloaded with burned out electrical motors originating from Complex No. 3. Corrosive dust is pervasive and becomes trapped in newly rewound coils. Although the causes for frequent failure of electric motors has not yet been investigated it is highly probable that the dust problem is one of the main causes.

3.16 The instrument repair and calibration shops are adequate but should be airconditioned and could use additional equipment for electronic instrument control and calibration. To ensure adequate maintenance of instruments the shops should be centralized with additional needed equipment.

Complex No. 1 (ammonia, nitric acid and CAN)

3.17 As already mentioned, this complex as initially designed included three plants producing ammonia and nitric acid as intermediate products and CAN fertilizer. It started in 1972 and was the first GFC plant. It operated according to its original configuration until 1982. Operating rate for the years 1978 through 1981 was only:

- Ammonia, 53% of design capacity
- Nitric acid and CAN, 46.4% of design capacity

The major reason for the low operating rate was the poor design of both the secondary reformer and the waste heat boiler in ammonia plant No. 1.

3.18 Ammonia plant No. 1 11/ was shut down in 1982 with the start up of the 1,000 tpd Kellogg ammonia unit installed in Complex No. 2. Since that time, a reliable supply of ammonia to the nitric acid and CAN plant has been assured through use of intermediate storage, and these plants have operated at an average of 83.7% of design capacity.

3.19 Reliability problems in the nitric acid and CAN plants of Complex No. 1 are related to poor process control and poor plant design. The poor design also results in a poor quality of the final CAN product: the present product has a high moisture content, poor size distribution, and is difficult to store and handle.

3.20 Operational problems in the nitric acid and CAN plants have been aggravated by interruptions due to problems with the steam supply. These problems can be corrected if the recommended program to integrate the utility sections of the GFC complex is followed (para. 3.10).

3.21 From a safety point of view the foundations of both the nitric acid and the CAN plant should be tested and the integrity of the prilling tower of the granulation unit should also be inspected. This is required as the limestone subsoil may have deteriorated severely due to phosphoric and perhaps nitric acid leakage. The prilling tower itself should be checked for nitrate corrosion.

Improving the Reliability and Efficiency of Complex No. 1

3.22 Ammonia Plant. The future of ammonia plant No. 1 depends on (i) the technical and financial feasibility of restarting and operating this plant; and (ii) on the market strategy of GFC. Under the present circumstances there is no need to operate the 150 tpd ammonia plant. Full attention should be focused on running ammonia plant No. 2 (1000 tpd) at high capacities. (For measures recommended for ammonia plant No. 2, see annexes 1 and 2).

3.23 A future rehabilitation and restart of ammonia plant No. 1 could cover a forecasted ammonia deficit in Syria in the next decade for a few years only. Before considering such a step, it is worthwhile to

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11/ Daily capacity 150 t.

consider the alternative of a new ammonia plant of at least 1000 tpd or the possibility of importing ammonia on long-term contract.

3.24 Nitric Acid Plant. To improve the operability and efficiency of the nitric acid plant some changes are proposed designed to increase its reliability, to facilitate start-up, and to increase acid strength from a low 47-49% to 55%. These changes should lead to a significant reduction in NO_x emissions, which currently cause a serious air pollution problem.

3.25 CAN Plant. The CAN plant needs some changes in the evaporation, prilling and cooling section to improve the quality of the product. Several other minor improvements are also proposed.

3.26 Although the energy savings obtainable in the nitric acid and CAN plants are relatively small it is still economically feasible to reduce energy consumption and air pollution in these plants.

Complex No. 2 : Ammonia and Urea

3.27 As already mentioned, Complex No. 2 consists of a 1000 tpd Kellogg ammonia plant and a 1050 tpd Stamicarbon urea plant. The plants were first started up in 1981 and projected to provide some 311,850 tpy of urea and 116,000 tpy of ammonia. Actual operation from 1983 thru 1986 resulted in an average production capacity of only 45.6% for the ammonia plant and 51.3% for the urea plant. Both operations were severely hindered by lack of good utility supplies such as:

- Boiler feed water
- Cooling water
- Steam

3.28 Ammonia Plant. The ammonia plant has the additional constraint that the maximum average offtake of ammonia from the 1000 tpd plant is only 600 tpd for urea plus 140 tpd for CAN, for a total of 740 tpd of ammonia. The development of a market for the additional 260 tpd ammonia would reduce the production cost of ammonia considerably, to some extent because of improved efficiency at a 1000 tpd production rate and to a greater extent because average fixed costs would be directly reduced by a factor of one third.

3.29 For the CAN complex, a matter of great concern is the unreliable supply of utilities to the ammonia and urea plants. Proposed changes are largely those required to provide the needed utilities.

3.30 The main problem in the ammonia-urea plants is the substandard boiler feed water supply, which is disastrous for the 100 bar waste heat boiler in the ammonia plant. Over the past few years 75% of the down time of the ammonia plant was a result of the waste heat boiler failure. Any downtime of the ammonia plant results in shut down of the urea plant, which uses the carbon dioxide (CO_2) from the ammonia plant to synthesize urea from ammonia and carbon dioxide. In addition, the urea plant suffers from an unreliable supply of 40 bar steam. The two offsite boilers serving the urea plant (2x60 tph) do not have sufficient capacity to start and run the urea plant with one boiler if the other one is closed down. 12/ As already mentioned, a total redesign of the steam system and much improved preventive maintenance procedures are required together with a full integration of the 40 bar steam system and installation of a new 75 tph boiler to feed the system with 40 bar steam.

3.31 Safety. Both the ammonia and urea plant need a thorough safety audit including inspection of the status of the foundations and a mechanical and materials check on corrosion. The refrigerated ammonia storage has never been checked since start-up in 1981 and should also be audited.

3.32 Energy efficiency. The energy efficiency of the ammonia plant can be improved considerably: the present energy consumption per ton of ammonia is 17% above design. Because the ammonia plant feedstock will be converted shortly from naphtha to natural gas it is advisable to delay any indepth energy auditing of the plant until the plant has run continuously for some time after the conversion. Energy savings clearly have a lower priority than reliable operation. Several energy saving projects are proposed (Annex 1 and 2) but should be implemented only after the plants are operating more reliably.

3.33 Although the urea plant can save some steam a more important issue for the near future will be expansion of its capacity. As soon as the ammonia plant is operating satisfactorily there will be an overproduction of ammonia for which there is no on-site demand: expansion of the capacity of the urea plant will be one of the first steps required to bring the production capacities at the site into balance. The licensor of this urea process, Stamicarbon, has developed a special package for these cases. The licensor claims that a capacity increase of 35% is feasible. At an assumed expected annual capacity of 311,850 t urea a 35% increase will generate 109,000 t urea. About 76,700 t ammonia is required for this extra production, which is exactly the present unused capacity of the Kellogg ammonia plant. The ammonia production on site from this plant alone (ignoring the small outdated ammonia plant) is therefore sufficient to allow full CAN and urea production.

3.34 There are several options for using the capacity of ammonia plant No. 2 fully (Annex 5); however, each option must be analyzed in more detail for reasons described below:

12/ To remedy this, GFC has already installed a steamline from the 40 bar boiler in the TSP plant, but this boiler can provide only 15 tph steam, which is not sufficient.

(a) use of anhydrous ammonia for direct application as a fertilizer: Syrian agriculture may not have the right structure to develop this option. A special distribution system is required, farm size may not be sufficient to apply ammonia economically, and crops might not be suited to fertilization with anhydrous ammonia;

(b) production of ammonium phosphate made from ammonia and phosphoric acid: this could be an attractive option but requires a phosphoric acid plant capable of operating at least at 80% of design capacity. As long as this level of operation is not achieved, the production of ammonium phosphate should not be considered;

(c) production of additional urea in a new plant: this option should only be studied if it is proved that the operation of the ammonia plant No. 1 is economically feasible; indeed, if a new urea plant were to be supplied only with the incremental production of the ammonia plant No. 2, this plant would not be efficient because its capacity would be too small.

(d) production of additional ammonium nitrate if more ammonium nitrate in Syria is a desirable option: this would require a new nitric acid and CAN plant. If this option is chosen it is perhaps worthwhile to replace the old CAN plant with one large plant served by both the old nitric acid plant and a new one.

(e) production of ammonium sulfate: this option is less attractive and only feasible if it is decided not to produce single superphosphate (see section on TSP complex). This product is not very economically attractive because ammonium sulfate is a by-product of several chemical processes in the iron and steel industry (in general, when sulfur prices are high, prices of by-product ammonium sulfate are lower than those for directly produced ammonium sulfate).

These options would be the subject of a separate feasibility study if expansion of the urea plant is not feasible.

3.35 A feasibility study is required to assess the merits of each option. It is recommended that such a study be started immediately because the implementation of any option would take 3-5 years while an over-production of ammonia from plant No. 2 can be expected within 1-2 years following rehabilitation.

Complex No. 3: Sulfuric Acid, Phosphoric Acid, and Triple Super Phosphate (TSP)

3.36 General. The TSP plant, designed and built by Industrial Export of Roumania, was commissioned in 1981. Table 3.2 shows the design capacities of the three major sections of the plant and actual 1986 production.

Table 3.2. TSP PLANT - DESIGN CAPACITY AND 1986 ACTUAL PRODUCTION

	Design Capacity (tpd)	Actual Operation 1986	Rate (%)
Sulfuric acid	1700 a/	810 tpd	48
Phosphoric acid	533 a/	268 tpd	50
Triple superphosphate	1500	583 tpd	39

Source: GFC and the mission.

a/ Two trains.

3.37 Phosphoric Acid Plant. The heart of the TSP complex is the phosphoric acid plant. This plant is in poor condition and major efforts will be needed to improve it. The problems can be traced to three main causes:

(a) a very poor phosphate rock quality high in chloride causing severe corrosion problems, high in magnesium causing low filtration rates and difficult operation, and with a high moisture content (10%);

(b) inadequate design of the plant, resulting in incorrect design of the rock attack section and mixing sections;

(c) poor maintenance, compounding the problems mentioned in (a) and (b).

There are also serious environmental problems related to the disposal of gypsum (a by-product from the reaction between phosphate rock and sulfuric acid) and effluent (para. 3.41-3.44).

3.38 Sulfuric Acid Plants. The sulfuric acid plants are of Lurgi design and are capable of a long stable operation. However, the plants cannot be operated continuously at full capacity due to the very low onstream time of the phosphoric acid plant. The frequent start-ups and shutdowns are causing premature equipment failure and will shorten the useful life of the plants. Considerable maintenance is required before these plants will be able to operate satisfactorily. As soon as these plants can be operated continuously the existing 6.4 MW generator can also be started up. This would save GFC $1.5 million annually on its electricity bill at present tariffs.

3.39 Triple Superphosphate Plant. This plant is of inadequate design and is badly maintained. The design of the phosphoric acid/phosphate rock mixer is not adequate. All belt conveyors will have to be replaced and the granulation system consisting of an unusually large number of pan granulators (12) should be scrapped and replaced by one drum granulator. 13/ To renovate this plant to an acceptable operating condition, the granulation section, all the belt conveyors, the mixing system, the electrical system and parts of the instrumentation/-control system must be redesigned.

Improving the Reliability and Efficiency of Complex No. 3

3.40 The most important plant in this complex is the phosphoric acid plant. Before any steps are taken to rehabilitate this plant, all steps must be coordinated with the phosphate mining company. Any improvement in reliability will be nullified if the quality of the phosphate rock is not well defined and stable. A considerable effort must be made to improve the quality of the rock by lowering the chlorine content (and the magnesium content also, if possible) and to improve the filterability in the phosphoric acid plant by maintaining a low clay content in the rock. The feasibility of using wet rock should also be studied. This would eliminate the need to dry the phosphate rock at the mine. To avoid a serious delay in the rehabilitation of the phosphoric acid plant, GFC should consider importing good quality phosphate rock on a temporary basis.

Environment and Safety

Environmental Problems

3.41 Complex No. 3 (TSP, sulfuric acid, phosphoric acid) has severe environmental problems related to disposal of gypsum and disposal of effluent containing fluorine.

3.42 Gypsum disposal from the phosacid plant is a major problem because it is highly contaminated with phosphoric acid and fluorine compounds. At the moment gypsum from the filters is conveyed to trucks for disposal a few miles outside Homs. If the phosacid plant were run at design capacity (533 tpd P_2O_5), disposal using this method would probably become unmanageable. Because storage of gypsum at or near the site is impossible from an environmental point of view, the only alternative methods for gypsum disposal are:

13/ Pan granulators are not suitable for TSP granulation and 12 pan granulators in parallel are extremely difficult to operate.

(a) removal by slurry pipeline to a site in the desert where no subsoil and groundwater contamination can take place (the disposal site would have to be selected with great care because of the potential ecological impact);

(b) removal to the phosphate mine, which could possibly reuse the water from the slurry;

(c) use of the gypsum as a soil conditioner in agriculture. This would require building a conditioning plant to prepare the gypsum in a form the farmer could use. It is doubtful whether all the gypsum generated could be disposed of using this method. Also, GFC would need to provide a subsidy as costs of preparing the gypsum would be higher than possible revenues.

To resolve the gypsum problem, GFC should undertake a separate study, partly in coordination with the phosphate mining company (GCPM), partly with the Ministry of Agriculture. 14/

3.43 Another environmental issue is the disposal of effluents containing toxic compounds. One of the main effluents in a phosphoric acid complex is waste water containing fluorine. Such fluorine solutions are highly corrosive if not neutralized and fluorine compounds in higher concentration are poisonous to humans, animals and plants. At the moment these effluents are disposed into a lake that serves the city of Homs for drinking water. The lake flows over into the Orontes River, which discharges into the Mediterranean Sea.

3.44 Besides being a danger to human health, the runoff of effluents into the lake creates problems for the plant. As already mentioned, use of cooling water and of the boiler feed treatment water from this same lake recirculates the diluted effluent through all the cooling systems of the plants and partly through the boilers, leading to severe corrosion problems. A solution to the effluent problem (i.e., treatment of effluent) has to be found quickly to keep the Homs fertilizer complex operable.

Environmental Audit

3.45 Fertilizer factories like the one at Homs normally have several emissions and waste products which could pollute the environment. Table 3.3 lists the emissions and liquid/solid effluents per plant:

14/ At the time of the ESMAP mission these problems were partially under study by GFC and GCPM.

Table 3.3. TOXIC CHEMICAL EMISSIONS AND EFFLUENT DISCHARGES OBSERVED AT THE GFC FERTILIZER PLANT, 1988

	Emissions	Discharges Liquid	Discharges Solid
Complex 1			
Ammonia plant	NO_x (furnace) NH_3 (purge gas)	NH_3 (scrubber)	Catalysts
Nitric acid plant	NO_x (plant stack)		
Calcium ammonium nitrate plant	NH_3 (dryer) dust	NH_3+NH_4NO_3, dust	Dust
Complex 2			
Ammonia plant	As for the ammonia plant of Complex 1		
Urea plant	NH_3	NH_3 + urea	-
Complex 3			
Sulfuric acid plants	SO_2 + SO_3	H_2SO_4(diluted)	Dust (sulfur) Catalyst
Phosphoric acid plants	HF, SiF_4 dust (phosphate)	H_3PO_4. HF, H_2SiF_6	Dust (phosphate)
Triple superphosphate plant	HF, SiF_4 Dust (phosphate, Triple)	H_3PO_4, Triple H_2SiF_6	Dust (phosphate, Triple).

Source: GFC and mission.

In such a fertilizer complex, effluents and emissions must be strictly controlled to: (a) keep the plants in operable condition; (b) make working conditions medically acceptable; (c) prevent deterioration of the direct environment; and (d) keep air and water pollution outside the complex within medically and socially acceptable limits. In the follow-up to the consultants' study, an environmental audit should be made to quantify the environmental problems.

Safety

3.46 The following specific, very serious safety problems need priority attention:

(a) the contractor and the plant designer for ammonia plant No. 2 have both advised GFC that the header condition in the gas reformer furnace is such that contractor's personnel will not go near the reformer during operation (gases in the header are at 30 bar and 800 C). This problem has to be addressed immediately because of the explosion and fire hazard;

(b) a dangerous situation has probably developed in connection with the foundations of several plants and buildings because of spillage of acids on site (nitric, sulfuric, phosphoric and hydro fluosilicic acids) which react with the limestone subsoil and can cause cave-ins; and

(c) hazardous conditions may exist in ammonia plant number 1. This plant has been closed down since 1982. Before restarting this plant the equipment and instrumentation system have to be tested thoroughly.

A comprehensive safety audit of the ammonia, urea, sulfuric acid and nitric acid plants, including all foundations and underground piping, ammonia pressure storage and atmospheric storage should be made as soon as possible.

There are also many so-called housekeeping safety problems which can be solved by increasing awareness, improving discipline and training, and ultimately by enforcement. Some examples are:

- No smoking signs are generally disregarded.
- Smoking areas are not clearly defined.
- Safety helmets and safety glasses are worn only by some foreign subcontracted personnel.
- Roads and other access ways are not maintained.
- Tripping hazards are ever present.
- Material is obstructing access to equipment (particularly in shops).
- Loose objects are left unattended on elevated areas.
- Manholes are left open.
- Housekeeping ranges from poor in general to very bad in Plant No. 3 (TSP).
- Scrapped material is piled all over the complex.

IV. REHABILITATION PROGRAM: PROPOSED MANAGERIAL AND TECHNICAL ASSISTANCE

4.1 The general conclusion of the consultants' and of the mission's study is that the present operation of GFC should and could be drastically improved. If necessary steps are not taken on short notice, the situation will become highly critical and probably unmanageable. Major efforts are required in order for GFC to operate at acceptable levels of reliability, efficiency, and safety and to minimize pollution of the environment.

4.2 These efforts fall into two separate categories. Each requires implementation of a specific action program as part of an overall long-range rehabilitation plan:

(a) institutional rehabilitation, including improvement of GFC's organization, personnel management, technical skills, and preparation of an investment program. This institutional rehabilitation calls for the development of a managerial and technical assistance program; and

(b) physical rehabilitation and improvement of existing production lines and utilities. This technical rehabilitation calls for the development of an investment program and for technical assistance.

Organization

4.3 Due to over-centralization of top-level management and insufficient coordination and integration of production and maintenance operations, the present GFC organization is not effective. The mission recommends that GFC's organization be reviewed so that:

- Most technical and operational decisions can be made at lower levels, leaving the General Management free to deal with overall policy and coordination.

- Coordination of production and maintenance operations can be improved.

- Lines of responsibility can be clearly defined for production processes, maintenance and utilities.

More specifically, the mission recommends that:

(a) the company be restructured into separate Production, Maintenance, Administration, and Technical and Engineering Departments;

(b) the new Production Department have two production divisions; one for nitrogen fertilizer production (ammonia, urea, nitric acid and calcium ammonium nitrate) and one for phosphate fertilizers comprising the present complex no. 3;

(c) utilities be organized in a separate division under the Production Manager and all steam systems not directly related to a process plant (like the waste heat boilers in the ammonia and sulfuric acid plants) be integrated under one manager. This would also include the water treatment demineralization plant;

(d) maintenance be thoroughly reorganized within the new Maintenance Department and a system of preventive, predictive maintenance be introduced as soon as possible. The introduction of preventive, predictive maintenance procedures must be accompanied by adequate training which would be repeated in subsequent years; and

(e) safety be supervised by a special manager reporting to the Production Manager;

<u>Personnel</u>

4.4 As discussed in Chapter III, the personnel situation at GFC is rather serious, involving lack of control by GFC of human resources management, overstaffing, and insufficient skills. The mission makes the following recommendations:

(a) management should be allowed to administer its own personnel policy within guidelines. This step, which would have to be discussed with the Government, should include: responsibility for selection of personnel; authority to promote, demote, reward or discipline as an indispensable managerial tool; and authority to determine, within national guidelines, wages, salaries, and other benefits or incentives to encourage personnel to join and stay with the company;

(b) staffing should be reduced (probably by attrition), not increased; and

(c) training programs should be developed and implemented without delay to address the following needs:

- training of new personnel (turnover of personnel is high and new employees have to learn by exposure);

- refresher courses;

- cross training, allowing personnel to be relocated in other areas without disruption;

- maintenance training to solve maintenance problems caused by faulty operation; and

- safety training to solve the problem of tampering with protective devices by teaching the safety aspects of protective devices and the dangers of tampering with them.

4.5 The training program should include basic chemical plant orientation and training for new personnel and continuing training and refresher courses for more experienced personnel. The training course for new personnel would consist of 10 to 12 weeks of lectures and workshop reviews of plant equipment and construction. The importance of using proper operations and maintenance techniques in order to achieve high onstream time will be emphasized.

Maintenance Training

4.6 Although integration of the maintenance services in the new Maintenance department and the introduction of preventive maintenance procedures would be part of the task of the management consultant, the technical consultants would be responsible for training in practical maintenance operations.

4.7 It is particularly important to provide maintenance training for certain complex items of equipment to avoid down time or keep it as short as possible. This maintenance training would be coordinated by the training coordinator, assisted by the maintenance adviser and the equipment expert, who would be members of the technical consultant's team.

Operations

4.8 To return the GFC plants to normal production with adequate safety and environmental protection, GFC needs to:

(a) undertake the following audits and detailed engineering studies:

- safety and environmental protection audits.

- engineering and feasibility studies for adding a new steam boiler, integrating steam systems and installing electricity cogeneration systems.

- pre-feasibility and feasibility studies for optimizing ammonia consumption (onsite or offsite, in Syria or abroad), expanding the existing urea capacity, and maximizing the use of sulfuric acid if the quality of the phosphate rock does not permit full use of the capacity of the phosphoric acid plants; 15/

(b) carefully design its investment program for physically rehabilitating the existing facilities; 16/ and

(c) improve operational and maintenance procedures.

Managerial and Technical Assistance Program

4.9 Given the size and complexity of the recommended institutional rehabilitation program, GFC does not have the capability to carry out the program with its own technical resources. The mission recommends that GFC obtain consulting services. The services of both a management consultant and a technical consultant group are needed. The management consultants would deal with the purely administrative and personnel aspects of the restructuring while the technical consultants would be responsible for preventive maintenance and quality control. The two tasks are so widely different that probably no consultant firm could implement the whole program on the basis of its own expertise. 17/ The following actions are recommended:

(a) Hire a management consultant to (i) study a reorganization of GFC; (ii) propose a minimum three year action program to achieve the reorganization; (iii) assist top management of GFC in creating a social plan for redundant personnel (reduction of staffing by attrition, promotion of creation of small enterprises to provide services for GFC, especially relevant in

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15/ See Annex 5.

16/ See Chapter V.

17/ It may be possible to have one management consultant firm that would subcontract the technical consultancy to a technical consultant firm.

the maintenance sector, and other innovative steps); (iv) assist GFC for two or three years in carrying out the reorganization. 18/

(b) Hire a technical consultant at the same time to:

(i) organize technical training courses for personnel who would be relocated; and

(ii) introduce preventive maintenance and maintenance quality control procedures for general management, production management, maintenance management and all maintenance employees.

4.10 It would be helpful for GFC if the management consultant could also advise top management and the relevant Government authorities on the best ways and means to get GFC finances in good order. Financial rehabilitation is necessary to successful management reorganization and implementation of projects and for the operation of the company in subsequent years.

Operations Technical Assistance Program

4.11 Because improvement of the operation at Homs and transfer of needed technology to the plant and staff is urgently needed, a technical assistance consultant team should join GFC as soon as possible. Personnel in the team will fit into place corresponding with particular needs at Homs. The suggested team includes:

1 Senior Adviser and Manager for both technical services and assistance in training and maintenance;
1 Engineering Adviser and Assistant Manager;
4 Phosphate Operation Advisers;
2 Steam and water treatment experts;
2 Lab Technicians to introduce proper analysis methods for production and product quality control.

18/ The management consultant must not only have experience in reorganizing companies in general. More specific organization knowledge is required to restructure the whole maintenance service, a crucial function in any chemical company, including detailed preventive and predictive maintenance procedures and introduction of data bases for existing equipment.

The mission also recommends adding an ammonia expert to the team to assist with ammonia and urea production for, say, two years.

4.12 Because from a production and financial point of view Complex No. 2 (the ammonia/urea plant) is by far the most important complex, priority should be given to a quick rehabilitation of these two plants, as well as their steam and cooling water systems and maintenance facilities. The mission recommends that the process licensors of these plants be asked to carry out studies for plant improvements: Kellogg for ammonia and Stamicarbon for urea. These two studies should have high priority. The study of the urea plant should include (as a separate item) a production increase of 35% to balance the ammonia production on site.

Operations Training and Coordination

4.13 The training of operating personnel could be combined with the maintenance training mentioned in para. 4.6.

Summary of Proposals to be Included in a Managerial and Technical Assistance Program

4.14 The managerial and technical assistance program would include the following proposals for improvements in GFC:

(a) Organization and management

- Review of the structure of top management and recommendations for change.
- Review of the company organization, administration, financial situation and salary structure and recommendations for improvements.
- Reorganization of existing departments into Production, Maintenance, Administration, Technical and Engineering Departments.
- Reorganization of existing operational departments into one Production Department under a Technical Director, with three Production divisions (for the production of nitrogen, and phosphate fertilizers and for operation of the utilities). The Production Department would also include small units for laboratories, environmental monitoring, safety and energy efficiency monitoring.

- Reorganization of existing maintenance services into one Maintenance Department with subdivisions for planning, data bank, operational maintenance and instrument maintenance.

(b) Safety

- Organization of safety audits and recommendations for their implementation.

(c) Specification of the rehabilitation program

- Review of operational/technical status of utilities and of the three complexes (with priority on complex 2).

- Recommendations for direct improvement in the reliability of plant and utility operations.

- Assignment of priorities to all identified projects.

- Proposals for, agreement on, and organization of implementation of reliability and efficiency improvements 19/ for GFC's facilities.

(d) Performance of detailed feasibility studies

- Feasibility studies for existing boilers, integration of steam systems, and for a 75 t/40 bar new steam boiler with cogeneration of electricity by adding a 15 MW cogeneration system and cogeneration of electricity in both sulfuric acid plants.

- Feasibility study for expanding the existing urea capacity by 30-35%.

- Feasibility study for optimization of ammonia consumption on site or for export from the site either within Syria or abroad.

- Feasibility study for the maximum use of sulfuric acid if rock quality does not permit full use of the capacity of the phosphoric acid plants (Annex 5).

- Recommendations for improvements in the efficient use of raw materials.

19/ The implementation time schedules for the complexes may be greatly different. In particular, the work needed for Complex 3 may take three years or more.

- Recommendations for process improvements to increase reliability and efficiency of the originally designed processes.

- Introduction of quality control for processes and products.

V. REHABILITATION PROGRAM: PROPOSED INVESTMENT PROJECTS

Objectives and Scope

5.1 Objectives. To improve its fertilizer industry sufficiently to meet increasing local demand for fertilizers, and to achieve desired energy efficiency improvements, Syria will need to carry out a substantial investment program. For analytical purposes as well as to facilitate implementation, this program can be broken down into three components:

(a) A reliability improvement program. Actions to be undertaken under this program will aim at restoring conditions in GFC's plants to prevent further deterioration of the facilities and at removing key technical bottlenecks in order to increase production rates to around 80% of nameplate capacities. These actions should be given the highest priority.

(b) An efficiency improvement program. This program encompasses actions aimed at improving GFC's situation by further reducing operation costs. This program has a high priority but should be implemented only as a companion to the first one.

(c) A capacity expansion program. As already stated in Chapter III, existing production facilities present some capacity imbalances (for example, the ammonia plant located in the urea complex 20/); furthermore, existing production capacities, even if they were fully utilized, would not be sufficient to meet the rapidly increasing demand for fertilizer in Syria, particularly for urea. The consultant and the mission have identified several projects aimed at expanding production capacities at Homs. Some of these projects (like installing a new cogeneration unit or revamping the ammonia plant) may be postponed until after existing capacities are more fully utilized. However, the rationale for implementing other expansion projects early (for example, revamping the urea plant for additional capacity), is strong, and Syrian authorities have to make a strategy decision either to postpone them (which would reduce total capital requirements) or to implement them

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20/ The ammonia plant's capacity is higher than is required to meet demand for ammonia for producing CAN and urea. If operability and reliability conditions in GFC's complexes are improved, as recommended in this report, there will be an unused ammonia production capacity of about 80,000 MTY.

as part of the reliability improvement program (grouping into one project several actions relating to the same unit in order to minimize global costs and reduce perturbations to plant operation 21/ and to benefit at an earlier stage from increased capacity).

5.2 Scope of the investment program

(a) Restoring maintenance facilities and procuring critically needed spare parts and instruments.

(b) Securing reliability of steam supply by revamping water treatment facilities, adding a new boiler and rehabilitating and integrating the steam production and distribution system.

(c) Developing an electricity cogeneration unit.

(d) Rehabilitating utilities and production facilities in the three complexes, particularly in the ammonia-urea complex (utilities and the urea plant) and in the TSP complex (phosacid and TSP plants).

(e) Increasing production capacities for ammonia and urea.

(f) Reducing environmental pollution; and

(g) Ensuring a reasonable level of safety.

Table 5.1 summarizes the investment projects. A detailed list is provided in Annex 1.

21/ For example, by reducing process interruptions or frequent shutdowns of the unit to be revamped, by using only one contractor or by installing equipment of a size appropriate to the intended final capacity of the plant.

Table 5.1: INVESTMENT PROJECTS: COST AND PRIORITIES

	Cost US$ '000)	Priority
Reliability improvement program		
• Restoring general maintenance capabilities	7,212	1
• Improving steam supply	7,783	1
• CAN complex	1,513	1 a/
• Urea complex	363	1
• TSP complex	7,504	
Subtotal	24,375	
Efficiency improvement program		
• Utilities and off-sites	275	1/2
• CAN complex	2,998	2/3
• Urea complex	9,025	1/2
• TSP complex	725	2
Subtotal	13,023	
Rehabilitation/Production expansion program		
• New cogeneration unit	5,250	2
• CAN plant	1,975	3 b/
• Expansion of the ammonia plant	7,375 c/	3
• Expansion of the urea plant	6,750 c	1/2
• TSP complex	6,675 c	2/3
Subtotal	28,025	
Total	65,423	

a/ Except for a few operations which could be implemented at a later stage.

b/ Except for the repair of underground damage (US$ 150,000 to be undertaken urgently), equivalent to US$ 58 million at the official exchange rate of US$ 1.00 = 11.25 LS, to which physical (15%) and price (10%) contingencies have been added to compensate for the preliminary character of the estimates.

c/ The distinction between the three categories of investments (technical, reliability, efficiency improvement and rehabilitation/production expansion) is somewhat arbitrary and is used mainly for convenience. Some projects under "Rehabilitation/Production expansion program" may also be implemented to improve the reliability of the complexes. Their costs have been incorporated in the program costs for the financial and economic analyses of the rehabilitation program (see Annex 1).

Costs and Structure of the Investment Program

5.3 Investment costs. A preliminary evaluation of project costs is based on the mission's findings and ESMAP estimates. More precise estimates would require detailed engineering studies, a precise specification of the investment program and collection of price quotations. Excluding technical assistance costs for implementing the investment program (accounted for in the cost of the managerial and technical assistance program 22/), the total investment costs would amount to about US$ 56 million (foreign component) and LS 97 million (local component).

5.4 The structure of the investment program. The largest share (41%) of the investment costs is for the ammonia/urea complex where the main actions would consist of revamping the utilities, modifying the urea plant process (by using the latest Stamicarbon technology) to improve energy efficiency, and extending ammonia and urea production capacities. Rehabilitation of the TSP complex would represent a significant share (27%) of the investment, due largely to the rehabilitation of the phosacid and TSP plants. Improving general utilities and offsite facilities would represent 18% of the global budget, of which 11% would be allocated for securing steam supply and 7% for installing a new 15 MW cogeneration unit. Restoring general maintenance capabilities would require some 10% of the budget, mainly for procuring critical equipment and instruments. The CAN complex would require the smallest share (9%) of the investment program.

5.5 If rehabilitation of the phosacid plant should prove not feasible, and if it is possible to keep the sulfuric plants of the TSP complex running, GFC could consider developing a single superphosphate facility contingent on the availability of sulfuric acid. This could prove to be a good solution for providing the Syrian market with phosphate fertilizers. According to preliminary estimates, a single superphosphate plant would cost about US$ 20 million for a capacity of about 4,600 mtd. The investment costs could be reduced by using some equipment from the existing plant and from the then defunct phosacid plant.

Priorities

5.6 To realize the substantial reliability and efficiency improvements identified in the Homs complexes, GFC needs to carry out a comprehensive technical investment program. However, it would be

22/ See Chapter IV.

unrealistic to undertake any significant investment projects without first improving the institutional framework and beginning implementation of the managerial and technical assistance program described in Chapter IV. The technical investment program and the managerial technical assistance program are to be fully integrated and coordinated.

5.7 The highest priority should be given to improving the operability and reliability of the Homs complexes to avoid any further deterioration of existing facilities and to raise production rates up to some 80% of nameplate capacities. If this objective is achieved, substantial energy efficiency improvements and direct cost reduction can be achieved also The managerial and technical assistance program would be instrumental in improving the operability and reliability of the Homs complexes and should be considered as a key component of the related program of actions ("reliability improvement program").

5.8 Further efficiency improvements can be achieved with additional investments. While some specific actions 23/ may be highly desirable, the efficiency improvement program should be given a lower priority and be implemented as auxiliary to the reliability improvement program.

5.9 Generally speaking, expansion of capacity should be given the lowest priority (even though expansion of production capacity, particularly for urea, seems highly profitable), to the extent that:

(a) improving utilization of existing capacities would prove much more profitable;

(b) capacity expansion would be feasible only if the reliability of the utilities systems (particularly the steam production and distribution system) is adequate; and

(c) further detailed engineering and market studies are necessary. GFC should undertake certain of these studies now, giving particular consideration to proposals for revamping the urea plant for additional capacity and for installing a new 15 MW cogeneration unit.

5.10 In the detailed list of investment projects presented in Annex 1, each specific project is weighted according to priority.

23/ See Annexes 1, 3 and 4.

VI. EXPECTED RESULTS: PRELIMINARY FINANCIAL AND ECONOMIC ANALYSIS

6.1 Scope of the analysis. Based on consultant and mission findings, a preliminary financial and economic analysis has been carried out on two of the three components of the proposed GFC rehabilitation program, the reliability improvement program and the efficiency improvement program. The third component (capacity expansion) has been excluded because (a) it has a much lower priority, and (b) to determine its feasibility, further detailed engineering studies beyond the scope of the ESMAP activity would be needed.

Base Objectives and General Assumptions

6.2 The expected targets. The main objectives of the reliability and efficiency programs are to:

(a) increase the rate of utilization of existing production capacities; and

(b) reduce the variable unit cost of production.

These objectives are presented in Table 6.1.

Table 6.1: PRODUCTION AND COST TARGETS

	Production (mty '000)			Variable Unit Cost b/ (LS/mt)		
	Initial a/	Target	% Increase	Initial	Target	% Decrease
			Reliability Improvement Program			
Ammonia	c/	c/		961	654	32
CAN	109,919	111,600	2	583	374	36
Urea	171,109	311,850	82	870	481	45
TSP	192,720	445,500	131	1,243	1,013	18
			Efficiency Improvement Program			
Ammonia				654	610	7
CAN	No impact on the production levels			374	336	10
Urea		- do -		481	425	12
TSP		- do -		1,013	1,008	< 1

a/ Based on 1986 data.
b/ Financial cost.
c/ Ammonia is an intermediate product whose production level is determined by demand from the CAN and urea complexes. One objective of the rehabilitation program is to remove bottlenecks in ammonia production to meet the internal needs of GFC. It is assumed, through the financial and economic analysis, that the supply of ammonia will match the demand emanating from other CAN and urea production lines.

It is expected that, mainly as a result of institutional and technical improvements achieved through the managerial and technical assistance programs, production increases will not require additional staff and could in fact be accompanied by a reduction in personnel. For the sake of the financial and economic analysis, it is assumed that personnel levels will remain stable.

6.3 Assumptions. Based on experience gained with other projects of similar size, assumptions have been made on the amount of time needed to achieve program objectives, and on what would be a realistic schedule for investment. These assumptions are summarized in Table 6.2 and detailed in Annex 2.

Table 6.2: ASSUMPTIONS ON INVESTMENT OUTLAYS AND PROGRESS FOR REACHING THE TARGETS

Reliability Improvement Program	
Production targets achieved in	5 years
Cost targets achieved in	5 years
Investment implemented in	5 years
Efficiency Improvement Program	
(Start 1 year after the reliability improvement program)	
Cost targets achieved in	4 years
Investment implemented in	4 years

Source: Mission estimates.

Preliminary Financial Analysis

6.4 Global results. The rehabilitation program, if successfully implemented, would lead to a substantial increase in GFC's cash flow and would be highly profitable. After achieving production and cost targets, annual cash flow would be increased by around LS 525 million (equivalent to US$ 46.7 million at the official exchange rate), the net present value of the rehabilitation program 24/ would be around LS 1.8 billion (equivalent to US$ 160 million), and the internal rate of return would be about 69%. The high profitability of the rehabilitation would essentially stem from the reliability improvement program; at a 12% annual discount rate, the efficiency program would lead to a slightly negative NPV. Table 6.3 summarizes the preliminary financial results, which are detailed in Annex 3.

24/ Over a 15-year period with a discount rate of 12%.

Table 6.3: GLOBAL FINANCIAL RESULTS (US$ '000) a/

	Annual cash flow increase	NPV	IRR (%)
Reliability improvement program	44,611	160,646	77
(Production increase)	(22,646)	-	-
(Cost reduction)	(21,965)	-	-
Efficiency improvement program	2,121	374	11
Rehabilitation program	46,732	160,271	69

Source: Mission estimates.

a/ Based on the official exchange rate of US$ 1.00 = LS 11.25.

6.5 Results by production lines. A large share of the costs of the rehabilitation program is for actions which do not relate directly to specific production lines, i.e., the managerial and technical assistance program (including maintenance improvements), and improvements to the general utilities and offsites. To provide some indicative results by production lines, these costs have been apportioned to the CAN, urea and TSP production lines, based on consultant and mission estimates. 25/ A breakdown of the results indicates that, should the rehabilitation projects prove to be technically possible in the TSP complex, the most impressive results can be obtained in this complex (53% of the total NPV of the rehabilitation program) and in the ammonia/urea complex (42%). The results are summarized in Table 6.4. Annex 3 gives additional details.

25/ Respectively, 5, 80 and 15% for the CAN, urea and TSP production lines.

Table 6.4: FINANCIAL RESULTS BY PRODUCTION LINES a/

	Investment Costs	Annual Cash Flow Increase: Production Increase US$ '000	%	Cost Reduction US$ '000	%	Total US$ '000	%	NPV Total US$ '000	%	IRR
CAN										
Reliability improvement	3,366	126	...	2,073	4	2,199	5	7,200	4	54
Efficiency improvement	2,988	-	-	376	1	376	...	-477	...	6
Subtotal	6,354	126	...	2,449	5	2,575	5	6,723	4	39
Ammonia/urea										
Reliability improvement	23,412	9,440	20	10,801	23	20,241	43	69,560	43	64
Efficiency improvement	9,245	-	-	1,547	3	1,547	3	-1,705	-1	11
Subtotal	32,657	9,440	20	12,348	26	21,788	46	67,855	42	56
TSP										
Reliability improvement	15,626	13,080	28	9,091	20	22,171	48	83,884	52	101
Efficiency improvement	766	-	-	198	...	198	...	255	...	22
Subtotal	13,392	13,080	28	9,289	20	22,369	48	84,139	52	99
Total GFC										
Reliability improvement	42,404	22,646	48	21,965	47	44,611	96	160,646	100	77
Efficiency improvement	13,000	-	-	2,121	5	2,121	4	-375	...	11
Total	55,404	22,646	48	24,086	52	46,736	100	160,271	100	69

Source: Mission estimates.

a/ At the official exchange rate of US$1.00 = LS 11.25.

Preliminary Economic Analysis

Price Distortions.

6.6 Fuel oil. The Government-set price for fuel oil paid by GFC is LS 786/t. This is a high sulfur oil (3.5% S) for which the FOB Mediterranean price at the date of comparison was $64/t. At the official exchange rate of LS 11.25/US$ the local price is nearly equivalent (US$ 70) to the border price, while at the shadow exchange rate (LS 27/US$) the price is US$ 29, 55% below the commercial price.

6.7 Natural gas. In 1988 the price for natural gas was quoted as LS 520/1000 m^3 or US$ 0.53 per GJ (US$ 0.56/MBtu) at the shadow exchange rate of LS 27/US$ (or $1.28 at the official exchange rate). While this price (US$ 0.53 GJ) is comparable to that in other Middle-Eastern countries it does not take into account its current substitution value for naphtha and fuel oil. Using the economic value of these products the price used in the evaluation of the project is estimated at 80% of its fuel substitute value: LS 1840/1000 m^3 or US$ 1.38/GJ. (US$ 1.92/MBtu).

6.8 Electricity. Electricity, a minor cost element in fertilizer production, is subsidized. However, the sizeable electricity subsidies for industrial users have been reduced through two tariff increases, resulting in an average tariff for industrial users of LS 0.36/kWh by the end of 1987, in effect tripling GFC's electric bill in six months. The Public Establishment of Electricity (PEE), the national electric utility, estimates that even this increase will not be sufficient to cover the economic cost of electricity supply for this class of consumers. PEE has calculated the marginal cost of electricity supply to industry at LS 0.51/kWh at the official exchange rate. The marginal cost as calculated by the Power Efficiency mission of the Bank is about US$ 0.08/kWh. 26/

6.9 Converted at the shadow cost of foreign exchange (LS 27/US$), the economic cost of electricity supplied to GFC would be LS 1.92/kWh. At this cost, the inherent economic subsidy in the present electricity price is about LS 1.56/kWh or a total subsidy per year of more than LS 1 billion for the fertilizer industry.

6.10 Phosphate rock. GFC pays LS 100/ton for phosphate rock (quality 61% BPL). The price leader for phosphate rocks in this area is Jordan with a quality of 70/72% BPL. The current price FOB Akaba for rock of this quality is US$ 27/ton. For 61% BPL the price would be US$

26/ The marginal cost is based on an energy cost of US$ 0.055/kWh and a capacity cost of US$ 0.023/kWh for an average plant demand of 40% of maximum demand. See "Syria: Electric Power System Efficiency Study," Annex 7. UNDP/ESMAP 089/88.

23.50 or LS 634/ton, using the same LS 27/US$ conversion rate. However, price comparisons are difficult to make because of the unreliable quality of the phosphate rock GFC is receiving from the mine.

6.11 Sulfur. The price of 1920 LS/ton that GFC pays for imported sulfur is well above the FOB Middle East price of US$ 100/ton at the official exchange rate of LS 11.25/US$. Adjusting for transport costs, an estimated delivered Homs price is US$ 120/ton. Converted at the marginal GFC cost of foreign exchange the economic cost of sulfur would be LS 3240/ton.

6.12 Urea. In March 1988, the Middle East bulk FOB price for urea was US$ 107/ton. Adjusting for transport and bagging, the local price would be around US$ 140/ton, equivalent to LS 3780/ton at the shadow cost of foreign exchange (LS 27/US$).

6.13 Triple super phosphate. In March 1988, the Moroccan bulk FOB price of TSP was about US$ 161/ton. Adjusting for transportation and bagging, the local price would be about US$ 190/ton (equivalent to LS 5130/ton when converted at the shadow cost of foreign exchange).

6.14 Calcium ammonium nitrate. There is no international market for CAN where prices could be observed. For the purpose of a preliminary economic analysis, a reference price for CAN has been determined based on the price of ammonium nitrate with the same nitrogen content as the CAN produced by GFC. Following this method, a reference price of US$ 140/ton has been retained for CAN (including transport and bagging).

Shadow cost of foreign exchange

6.15 Over the official exchange rates, there is an unrestricted promotion rate which is set by the Government, based on conditions in the unofficial exchange rate market. This rate was set at LS 27/US$ in March 1988, and has been used in this report as a proxy to the shadow rate of exchange. 27/

27/ See "Syria: Energy Efficiency Improvement in the Cement Sector," ESMAP No. 099/89, July 1989.

Table 6.5 summarizes the prices used for the financial and economic analysis.

Table 6.5: PRICES USED FOR THE FINANCIAL AND ECONOMIC ANALYSIS

		Economic prices (LS)	Financial prices (LS)
1. Outputs	Unit		
• CAN	t	3780	1425
• Urea	t	3780	1625
• TSP	t	5130	1825
2. Inputs			
• Natural gas	M_3	1.84	0.52
• Fuel oil	t	2160	786
• Electricity	kWh	1.92	0.36
• Phosphate rock	t	635	100
• Sulfur	t	3240	1920
3. Exchange rate			
• LS/US$		27	11.25

Source: Mission estimates.

Economic Results

6.16 Global results. The rehabilitation program would lead to substantial economic results. Based on economic or reference prices as indicated above, the program, if all its targets were achieved, would increase GFC's annual cash flow by LS 1.6 billion (equivalent to US$ 115 million at the shadow exchange rate). The discounted economic cash flow would be around LS 5.8 billion (US$ 214 million) and the economic internal rate of return about 100%. Table 6.6 summarizes the preliminary economic results, which are detailed in Annex 4.

Table 6.6: GLOBAL ECONOMIC RESULTS (US '000) a/

	Annual cash flow increase	NPV	IRR (%)
Reliability improvement program	55,357	211,297	111
(Production increase)	(19,766)	-	-
(Cost reduction)	(35,591)	-	-
Efficiency improvement program	3,220	4,891	24
Rehabilitation program	58,577	216,188	100

Source: Mission estimates.

a/ Based on the shadow exchange rate.

It should be noted that, based on economic prices, the efficiency improvement program would prove to be profitable whereas, with financial prices, it would lead to slightly negative results.

6.17 Results by production line. Based on the rules for apportioning overhead costs of the rehabilitation program presented in para. 6.5, economic results have been determined by production lines. These are summarized in Table 6.7 and detailed in Annex 4. As for the financial results, a breakdown of the global results indicates that the most substantial improvements can be obtained in the TSP complex 28/ (61% of the total economic NPV of the rehabilitation program) and in the ammonia/urea complex (33%).

28/ If rehabilitation projects in this complex prove to be technically feasible.

Table 6.7: ECONOMIC RESULTS BY PRODUCTION LINES a/

	Investment Costs (US$ '000)	Annual Cash Flow Increase: Production Increase (US$ '000)	%	Cost Reduction (US$ '000)	%	Total (US$ '000)	%	NPV Total (US$ '000)	%	IRR
CAN										
Reliability improvement	2,807	120	...	3,251	6	3,371	6	12,853	6	96
Efficiency improvement	2,632	-	-	417	...	417	...	-65	...	11
Subtotal	5,439	120	...	3,668	6	3,788	6	12,788	6	70
Ammonia/urea										
Reliability improvement	22,376	4,998	9	14,684	25	19,682	34	67,065	31	64
Efficiency improvement	8,249	-	-	2,280	4	2,280	4	3,409	2	24
Subtotal	30,575	4,998	9	16,964	29	21,962	38	70,474	33	57
TSP										
Reliability improvement	14,013	14,648	25	17,656	30	32,304	55	131,379	61	254
Efficiency improvement	731	-	-	523	1	523	1	1,546	...	64
Subtotal	14,744	14,688	25	18,179	31	32,827	56	132,925	61	250
Total GFC										
Reliability improvement	39,146	19,766	34	35,591	61	55,357	95	211,297	98	111
Efficiency improvement	11,612	-	-	3,220	5	3,220	5	4,891	2	24
Total	50,758	19,766	34	38,811	66	58,577	100	216,188	100	-

Source: Mission estimates.

a/ At the shadow exchange rate of US$1.00 = LS 27.00.

Sensitivity Analysis

Results

6.18 Discount rate and investment. Neither the financial nor the economic results will be substantially modified by changes in either the discount rate or the investment level, within reasonable limits; and in neither case would the profitability of the rehabilitation program be jeopardized.

Table 6.8: SENSITIVITY OF THE ECONOMIC AND FINANCIAL RESULTS OF THE REHABILITATION PROGRAMS TO THE DISCOUNT RATE AND INVESTMENT LEVEL

	Economic results			Financial results		
	NPV (10^6\$US) a/	(%)	IRR (%)	NPV (10^6\$US) b/	(%)	IRR
Discount rate						
10%	255	(+18)	100	191	(+20)	69
12% (base case)	216	(0)	100	160	(0)	69
14%	184	(-15)	100	135	(-16)	69
Investment level						
Base case	217	(0)	100	160	(0)	69
+ 10%	212	(-2)	90	156	(-3)	63
+ 20%	209	(-4)	83	152	(-5)	58

Source: Mission estimates.

a/ Converted at the shadow exchange rate (US\$1.00 = LS 27.00).
b/ Converted at the official exchange rate (US\$1.00 = LS 11.25).

6.19 Rhythm of achievement of targeted improvements. The results of the rehabilitation program appear to be quite sensitive to the rhythm at which targeted improvements can be achieved. In the base case, it has been assumed that the results will be fully achieved 29/ after 5/6 years

29/ See para. 6.20 for sensitivity of the results to the level of achievement of the targeted improvements.

following an average progress path. 30/ Both the financial and the economic results would be noticeably improved (reduced) if progress was faster (slower) as indicated in Table 6.9, where the results of several scenarios are presented.

Table 6.9: SENSITIVITY OF THE ECONOMIC AND FINANCIAL RESULTS OF THE REHABILITATION PROGRAMS TO THE RHYTHM OF ACHIEVEMENT OF THE TARGETED RELIABILITY IMPROVEMENTS

	Economic results			Financial results		
	NPV (10^6\$US) a/	(%)	IRR (%)	NPV (10^6\$US) a/	(%)	IRR
Base case	216	(..0)	100	160	(0)	69
Scenario 1 b/	204	(-6)	81	150	(-6)	58
Scenario 2 b/	197	(-9)	73	144	(-10)	54
Scenario 3 b/	229	(+6)	122	171	(+7)	81

Source: Mission estimates.

a/ See notes a and b, Table 6.8.

b/ Rate of achieving targeted reliability improvements

	Years 1	2	3	4	5	6
Base scenario	0	15	40	60	80	100
Scenario 1	0	10	20	50	80	100
Scenario 2	0	5	15	40	80	100
Scenario 3	0	20	50	70	90	100

6.20 Rate of achievement of targeted improvements. The final targeted improvements may not be achieved. However, as indicated in Table 6.10, the improvement potential is so impressive that even a partial success would bring GFC some substantial economic and financial results. Even if targeted improvements were realized at only 20% of what is expected, the rehabilitation program would prove economically profitable and financially neutral.

30/ See Annex 2.

Table 6.10: SENSITIVITY OF THE ECONOMIC AND FINANCIAL RESULTS OF THE REHABILITATION PROGRAMS TO THE RATE OF ACHIEVEMENT OF THE TARGETED RELIABILITY IMPROVEMENTS

	Economic results			Financial results		
	NPV (10^6US$) a/	IRR (%)	NPV (%)	(10^6US$) a/	(%)	IRR
Rate of achievement b/						
100% (base case)	216	(0)	100	160	(0)	69
80%	177	(-19)	86	127	(-21)	58)
60%	130	(-40)	68	88	(-45)	46
40%	78	(-64)	48	46	(-71)	31
20%	24	(-89)	24	2	(-98)	13

Source: Mission estimates.

a/ See notes a and b, Table 6.8.
b/ The rate of achievement is defined as the percentage of the improvement potential which is actually realized when the rehabilitation program is fully implemented. In this case, it is assumed that the rates are the same for production and cost improvements.

6.21 Price sensitivity. As one would expect, the results of the rehabilitation program are quite sensitive to the prices of fertilizer (shadow price for the economic analysis and GFC's selling price for the financial analysis). However, this sensitivity is moderated by the fact that improvements include cost reductions representing a large share (around 64%) of the improvement potential.

Table 6.11: SENSITIVITY OF THE ECONOMIC AND FINANCIAL RESULTS OF THE REHABILITATION PRC 'RAMS TO FERTILIZER PRICES

	Economic results			Financial results		
	NPV (10^6US$) a/	IRR (%)	(%)	NPV (10^6US$) a/	(%)	IRR
Base case	216	(0)	100	160	(0)	69
Price decrease: 10%	186	(-14)	87	133	(-17)	60)
: 20%	156	(-27)	75	106	(-34)	50
Price increase: 10%	246	(+14)	114	188	(+17)	79
: 20%	277	(+28)	128	215	(+34)	89

Source: Mission estimates.

a/ See notes a and b, Table 6.8.

The sensitivity of the economic results to the shadow exchange rate is extremely low: a decrease of 50% of the shadow exchange rate would reduce the IRR from 100% to 98% and an increase of 50% would increase it from 100% to 101%.

FINANCIAL COSTS OF THE REHABILITATION PROGRAM

1. Tables included in this annex indicate the costs of the rehabilitation program as follows:

Table 1: Summary of investment and technical assistance program costs.

Table 2: Distribution of investment and technical assistance program costs over the three complexes

Table 3: Investment and technical assistance program: projects, priorities and costs

Table 4: Estimated costs for management consultants

Table 5: Estimated costs for safety audit

2. Costs have been estimated in 1988 US dollars and Syrian pounds, using the official exchange rate of US$1 = LS 11.25 when necessary. A 25% provision for contingency has been added to base estimates. The overhead costs (relating to investments for the institutional programs, safety and maintenance, utilities and offsites) have been distributed over the three production complexes based on the judgment of the consultants and ESMAP as follows:

CAN complex	5%
Urea complex	80%
TSP complex	15%

3. The distinction between "technical reliability improvement," "efficiency improvement" and "production expansion" is somewhat arbitrary, and is used mainly for convenience.

Table 1: Summary of investment and technical assistance program costs

	Total cost (000 US$)	Total cost (000 LS)
Institutional program	13818	155447
Safety and maintenance	7212	81131
Utilities and offsites		
Technical reliability	7783	87561
Efficiency improvement	275	3094
Rehabilitation/production expansion	5250	59063
Sub-total	13308	149717
CAN Complex		
Technical reliability	1513	17016
Efficiency improvement	2988	33609
Rehabilitation/production expansion	1975	22219
Sub-total	6475	72844
Urea Complex		
Technical reliability	363	4078
Efficiency improvement	9025	101531
Rehabilitation/production expansion	14125	158906
Sub-total	23513	264516
TSP Complex		
Technical reliability	7504	84425
Efficiency improvement	725	8156
Rehabilitation/production expansion	6675	75094
Sub-total	14904	167675
Total	79229	891329

Sources: Consultant and mission estimates

Notes: (a) These cost estimates include a 25% provision for contingencies.

(b) The exchange rate used is the 1987 official exchange rate (US$ 1 = LS 11.25).

(c) The distinction between the three categories of investments (technical reliability, efficiency improvement and rehabilitation/production expansion) is somewhat arbitrary and is used mainly for convenience.

Table 2: Distribution of investment and technical assistance costs over the three complexes (US$ 000)

	CAN	Urea	TSP	Total
Technical reliability	2953	23412	11826	38192
Efficiency improvement	3001	9245	766	13013
Rehabilitation/production expansion	2238	18325	7463	28025
Total	8192	50982	20055	79229

Sources: Consultant and mission estimates

Notes: (a) The overall rehabilitation program includes three components that do not specifically concern any one of the complexes: the institutional program, safety and maintenance measures and utilities and offsites improvements/rehabilitation. The costs of these components have been spread over the production complexes for indicative purposes based on the judgment of the consultant and the mission as follows:

- CAN Complex: 5 %
- Urea Complex: 85 %
- TSP Complex: 15 %

The institutional program and the safety and maintenance measures have been considered as technical reliability improvement measures.

(b) See Table 1, Note (c).

Table 3: Investment and technical assistance program: projects, priorities and costs

	Content	Priority	Costs Foreign (000 US$)	Local (000 LS)	Total costs (000 US$)	(000 LS)
1.	Institutional programs					
1.1.	Managerial assistance program	1A	1880	2970	2680	30150
1.2.	Potential Personnel reduction	2A				
1.3.	Motivation training	1B	600	600	817	9188
1.4.	Technical assistance program	1A	6240	6000	8467	95250
1.5.	Costs associated with the above programs	1A	1350	1500	1854	20859
	Sub-total 1.		10070	11070	13818	155447
2.	Safety and Maintenance					
2.1	Safety audit	1A	62	45	83	928
2.2	Central warehouse:filter air	1B	250	250	340	3828
2.3	Central warehouse:pressurize	1B	35	300	77	867
2.4	Central warehouse:seal building	1B	25	200	53	602
2.5	Shop facilities	1B	300	300	408	4594
2.6	Spare parts:critical equipment	1A	4000		5000	56250
2.7	Spare parts:instruments	1A	1000		1250	14063
	Sub-total 2.		5672	1095	7212	81131
3.	Utilities and offsites					
3.1.	Technical reliability improvement					
3.1.1	Pressure sand filter in complex #2	1A	150	338	225	2531
3.1.2	Sludge treatment system in complex #2	1A	50	563	125	1406
3.1.3	Auto backwash system in complex #2	1A	150	225	213	2391
3.1.4	Third demineralization unit in complex #2	1A	200	225	275	3094
3.1.5	Alternate raw water supply system	1A	150	337	225	2531
3.1.6	Switch all TSP boilers to natural gas	1B	500	1125	750	8437
3.1.7	Integrate all 40 bar steam systems	1B	250	675	388	4359
3.1.8	Make study of condensate return system in complex #3	1C	20	112	37	421
3.1.9	New 40 bar 75tph boiler in complex #2	1A	3500	3375	4750	53438
3.1.10	Integrate GFC utilities	1B	300	413	421	4734
3.1.11	Repair the 40 bar boiler in complex #3	1A	250	563	375	4219
	Sub-total 3.1.		5520	7949	7783	87561
3.2.	Efficiency improvement					
3.2.1	Eliminate steam losses	1B	100	900	225	2531
3.2.2	Eliminate water losses	1B		450	50	563
3.2.3	Reduce unnecessary power consumption	1C				
3.2.4	Improve preventive maintenance	1B				
3.2.5	Improve housekeeping management	2A				
	Sub-total 3.2.		100	1350	275	3094
3.3.	Rehabilitation/production expansion					
3.3.1	New 15 MW cogeneration unit *	2B	4000	2250	5250	59063
	Sub-total 3.3.		4000	2250	5250	59063
	Sub-total 3.		9620	11549	13308	149717

4.	CAN Complex					
4.1.	Technical reliability improvement					
4.1.1	Alleviate clogging secondary WHB:	3				
	- Replace secondary refractory liner	3	100	338	163	1828
	- Replace secondary reformer burner	3	20	56	31	352
	- Install quench.	3	75	338	131	1477
4.1.2	Inspect ammonia plant for:	3	50	56	69	773
	-Crystallization check (piping and vessels)	3				
	- Ferrite in tubes	3				
4.1.3	New blower system in ammonia plant	1C	100	450	175	1969
4.1.4	New shutdown system for ammmonia plant	1B	75	338	131	1477
4.1.5	Improve process control in the CAN plant	1C	150	563	250	2813
4.1.6	Replace evaporation system in the CAN plant	1C	125	450	206	2320
4.1.7	Replace the neutralizer sparger in the CAN plant	1C	20	56	31	352
4.1.8	Modify the cooler and dryer in the CAN plant	1C	50	338	100	1125
4.1.9	Modify the prilling system	1C	50	225	88	984
4.1.10	Repair the bucket elevators in the CAN plant	1B	20	450	75	844
4.1.11	Revamp the product storage	1B		563	63	703
	Sub-total 4.1.		835	4219	1513	17016
4.2.	Efficiency improvement					
4.2.1	Switch ammonia plant to natural gas (feedstock and fuel)	3	1000	1688	1438	16172
4.2.2	Increase acid strength	2A	700	3375	1250	14063
4.2.3	Use better quality gauze in ammonia plant	2A				
4.2.4	Make optimization study	3	50	113	75	844
4.2.5	Revamp process condensate recovery system	3	100	338	163	1828
4.2.6	Perform technical audit of nitric acid/CAN plants	2A	40	113	63	703
	Sub-total 4.2.		1890	5625	2988	33609
4.3.	Rehabilitation/production expansion					
4.3.1	Modernize of ammonia plant's instrumentation	3	200	563	313	3516
4.3.2	Repair underground damage *	1B	20	1125	150	1688
4.3.3	Repair building in CAN plant *	3	10	2250	263	2953
4.3.4	Use ammonia plant # 2's purge gas in ammonia plant # 1	3	800	2250	1250	14063
	Sub-total 4.3.		1030	6188	1975	22219
	Sub-total 4.		3755	16031	6475	72844
5.	Ammonia and Urea Complex					
5.1.	Technical reliability improvement					
5.1.1	Replace manifolds/headers in reformer	1A	150	338	225	2531
5.1.2	Reduce start-up time of the ammonia plant	1B	30	113	50	563
5.1.3	Improve ammonia flow control in urea plant	1A	25	113	44	492
5.1.4	Improve CO2 flow control in urea plant	1A	25	113	44	492
	Sub-total 5.1.		230	675	363	4078
5.2.	Efficiency improvement					
5.2.1	Saturate ammonia plant feedgas	2B	450	563	625	7031
5.2.2	Saturate ammonia plant process air	2B	450	563	625	7031
5.2.3	Provide steam reheating for power and reformer in ammonia plant	2B	1500	2250	2125	23906
5.2.4	Install a suction chiller in ammonia plant	2B	400	1125	625	7031
5.2.5	Revamp urea plant (Stamicarbon technology)	1B	3000	9000	4750	53438
5.2.6	Reduce urea carry over from evaporators	1B		113	13	141
5.2.7	Eliminate steam losses/steamleaks	1C		338	38	422
5.2.8	Improve insulation	1C		225	25	281
5.2.9	Make other studies	1C	150	113	200	2250
	Sub-total 5.2.		5950	14288	9025	101531
5.3.	Rehabilitation/production expansion					
5.3.1	Revamp ammonia plant for additional capacity	3	5500	4500	7375	82969
5.3.2	Revamp urea plant for additional capacity	1C	5000	4500	6750	75938
	Sub-total 5.3.		10500	9000	14125	158906
	Sub-total 5.		16680	23963	23513	264516

6.	TSP Complex					
6.1.	Technical reliability improvement					
6.1.1	Improve rock grinding	1C	200	225	275	3094
6.1.2	Rehabilitate phosacid plant:	1C				
	- Replace agitators	1C	400	440	549	6175
	- Replace piping	1C	2000	3375	2875	32344
	- Improve process control	1C	100	1013	238	2672
6.1.3	Replace belt conveyors in TSP plant	1C	1000	1575	1425	16031
6.1.4	Replace electrical system in TSP plant	1C	200	338	288	3234
6.1.5	Make minor modifications to TSP processes	1C	200	338	288	3234
6.1.6	Phase out pangranulation	1B	200	5000	806	9063
6.1.7	Make some process/equipment studies	1B	50	113	75	844
6.1.8	Revamp the effluent treatment system	1B	250	3375	688	7734
	Sub-total 6.1.		4600	15790	7504	84425
6.2.	Efficiency improvement					
6.2.1	Replace sulfuric acid catalyst with LP catalyst	2B	550	338	725	8156
	Sub-total 6.2.		550	338	725	8156
6.3.	Rehabilitation/production expansion					
6.3.1	Install rock grinding facilities (if feasible)	2B	2000	3375	2875	32344
6.3.2	Modify filtration system *	2A	1500	2250	2125	23906
6.3.3	Modify fluorine recovery system in phosacid plant *	2A	200	2250	500	5625
6.3.4	Upgrade instrumentation in phosacid plant *	2A	250	338	350	3938
6.3.5	Replace vertical hot gas filters in sulfuric acid plant *	3	500	1125	750	8438
6.3.6	Make engineering studies *	1B	50	113	75	844
	Sub-total 6.3.		4500	9450	6675	75094
	Sub-total 6.		9650	25578	14904	167675
	Total		55447	89285	79229	391329

Sources: Consultant and mission estimates

Notes: (a) Items marked with an asterisk could also be considered as projects aimed at improving technical reliability/efficiency even if they have a lower priority rating. For preliminary financial and economic analysis, their costs have been included into the program costs.

(b) Among each goup of priorities, some sub-groups ("A", "B", "C") have been introduced to show, within each group, relative degrees of urgency. The letter "A" indicates the highest degree of urgency. This ranking is based on the judgment of the consultants and of the mission.

(c) The exchange rate used is the 1987 official rate (US$ 1 = LS 11.25). For the economic analysis, a shadow exchange rate has been used (see annex 4).

(d) The second and third columns of the table are base cost estimates with no contingency provision. A 25% provision for contingency has been included in the total costs (expressed in US$ in the fourth column and in LS in the fifth).

Table 4. ESTIMATED COSTS FOR MANAGEMENT CONSULTANTS

Base rate $15,000/man month

Foreign cost Consultant fee:

Year 1 5 man = 60 mm	US$900,000
Year 2 3 man = 36 mm	540,000
Year 3 2 man = 24 mm	360,000
Total	US$1,800,000

Local cost subsistence. Base $80/diem

Year 1 5 man 80x330x5	$132,000
Year 2 3 man 80x330x3	79,200
Year 3 2 man 80x330x2	52,800
Total	US$264,000

Travel cost (air travel) as foreign cost)

Base 1 month leave, 4 trips/year.

Year 1 5 man 5x4x2000	US$40,000
Year 2 3 man 3x4x2000	24,000
Year 3 2 man 2x4x2000	16,000
Total	US$80,000

Local costs are converted according to the official rate of LS 11.25 = US$1

US$264.000 = LS 2,970,000

Total cost including subsistence and travel: US$2,144,000

Source: Consultant and mission estimates.

Table 5. ESTIMATED COSTS FOR SAFETY AUDIT
(including foundation and structures)

Foreign cost

Audit	2 Ammonia plants	2 man 2x5 days	10 man day
	1 Urea plant	1 man 1x3 "	3 man day
	1 Nitric acid plant	1 man 1x2 "	2 man day
	1 CAN plant	1 man 1x2 "	2 man day
	2 Sulfuric acid plant	2 man 2x3 "	6 man day
	2 Phosacid plant	1 man 1x3 "	3 man day
	1 TSP plant	1 man 1x2 "	2 man day
	Boilers & steam system	3 man 3x4 "	12 man day
	Electrical systems	1 man 1x4 "	4 man day
	Water systems	1 man 1x3 "	3 man day
			47 man days
	Report writing		30 man days
	Total		77 man days

77 man day = 4 months

At $13,000/month: 13,000 x 4 = US$52,000

Local cost - subsistence: 47 days at $80 = $4,000 = LS 45,000

Travel costs for, say, 5 men are required
(1 team leader, 1 civil engineer,
1 electrical engineer, 1 steam engineer
and 1 mechanical engineer)

5 return trips 5 x 2000 = US$10,000

Total cost including subsistence and travel US$66,000

Source: Consultant and mission estimates.

Table 1: Expected annual rate of implementation of the rehabilitation program
Reliability and efficiency improvements and investment schedule

	Years					
	1	2	3	4	5	6
Reliability improvement program						
(a) Production increases over time		15	40	60	80	100
(b) Variable cost reduction		15	40	60	80	100
Efficiency improvement program						
(a) Variable cost reduction			20	40	80	100
Schedule for investments						
(a) Reliability improvement program	15	40	40	5		
(b) Efficiency improvement program		10	35	50	5	

Sources: Mission estimates

Notes: *(a) The rates of improvement (production increases and cost reductions)* are defined as percentages of the total improvements expected from the rehabilitation program: for example, if the reliability improvement program is to increase the production of urea by 140 740 tpy over the current level, it is assumed that the increase in urea production will be 15% of 140,740 t after the second year, 40% after the third year and so on.

(b) It has been assumed that the rhythms of production and cost improvement are the same for the three complexes; a more detailed and realistic set of assumptions would need detailed studies beyond the scope of this activity.

(c) For the schedule of investment, the rates indicated in the table reflect assumptions on the percentage of the total investment outlays to be realized each year.

Table 2: Expected influence of the reliability improvement program on unit consumptions

			Initial situation (1986 data)	Evolution of technical coefficients						Final targets
Product line	Input	Unit	Unit cons	year 1	year 2	year3	year 4	year 5	year 6	Unit cons
Ammonia	Natural gas	m3	1536.83	1536.83	1469.06	1356.10	1265.73	1175.37	1085.00	1085.00
	Fuel oil	t								
	Electric power	kWh	191.40	191.40	166.44	124.84	91.56	58.28	25.00	25.00
	Cooling water	m3	495.00	495.00	458.25	397.00	348.00	299.00	250.00	250.00
	Boiler feed water	m3	2.66	2.66	2.66	2.66	2.66	2.66	2.66	2.66
	Other									
Urea	Ammonia	t	0.61	0.61	0.61	0.60	0.59	0.59	0.58	0.58
	Natural gas	m3			18.45	49.20	73.80	98.40	123.00	123.00
	Fuel oil	t	0.28	0.28	0.24	0.17	0.11	0.06		
	Electric power	kWh	93.90	93.90	84.95	70.04	58.11	46.18	34.25	34.25
	Cooling water	m3	205.00	205.00	189.70	164.20	143.80	123.40	103.00	103.00
	Boiler feed water	m3								
	Other									
CAN	Ammonia	t	0.41	0.41	0.40	0.40	0.40	0.39	0.39	0.39
	Steam	t	0.60	0.60	0.56	0.50	0.46	0.41	0.36	0.36
	Electric power	kWh	171.60	171.60	152.61	120.96	95.64	70.32	45.00	45.00
	Cooling water	m3	65.00	65.00	64.03	62.40	61.10	59.80	58.50	58.50
	Boiler feed water	m3	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
	Catalyst (Pt)	Gram	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	Other									
TSP	Fuel oil	t	0.17	0.17	0.15	0.11	0.09	0.06	0.03	0.03
	Electric power	kWh	292.80	292.80	252.70	185.86	132.39	78.92	25.45	25.45
	Sulfur	t	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
	Phosphate rock	t	1.81	1.81	1.79	1.77	1.74	1.72	1.70	1.70
	Cooling water	m3	265.00	265.00	240.70	200.20	167.80	135.40	103.00	103.00
	Boiler feed water	m3	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30
	Other									

Sources: Consultant and mission estimates

Notes: (a) Unit consumption is given per metric ton of output.

(b) The evolution of the technical coefficients (unit consumption) is derived from the assumptions presented in Table 1 of this annex.

Table 1: Expected influence of the rehabilitation program on variable production costs (LS) (financial results)

Product line	Input	Unit	Unit cost	Initial situation (1986 data) Unit cons	Cost	With technical reliability improvement program Unit cons	Cost	With further efficiency improvement progam Unit cons	Cost
Ammonia	Natural gas	m3	0.52	1536.83	799.15	1085.00	564.20	1000.00	520.00
	Fuel oil	t	786.00						
	Electric power	kWh	0.36	191.40	68.90	25.00	9.00	25.00	9.00
	Cooling water	m3	0.05	495.00	24.75	250.00	12.50	250.00	12.50
	Boiler feed water	m3	5.00	2.66	13.30	2.66	13.30	2.66	13.30
	Other				55.00		55.00		55.00
	Variable cost	LS			961.11		654.00		609.80
Urea	Ammonia	t	see above	0.61	586.27	0.58	379.32	0.58	353.68
	Natural gas	m3	0.52			123.00	63.96	65.00	33.80
	Fuel oil	t	786.00	0.28	220.08				
	Electric power	kWh	0.36	93.90	33.80	34.25	12.33	34.25	12.33
	Cooling water	m3	0.05	205.00	10.25	103.00	5.15	103.00	5.15
	Boiler feed water	m3	5.00						
	Other				20.00		20.00		20.00
	Variable cost	LS			870.41		480.76		424.96
CAN	Ammonia	t	see above	0.41	392.13	u.39	253.10	0.38	228.68
	Steam	t	100.00	0.60	60.00	0.36	36.00	0.25	25.00
	Electric power	kWh	0.36	171.60	61.78	45.00	16.20	45.00	16.20
	Cooling water	m3	0.05	65.00	3.25	58.50	2.93	58.50	2.93
	Boiler feed water	m3	5.00	0.30	1.50	0.30	1.50	0.25	1.25
	Catalyst (Pt)	Gram	225.00	0.05	11.25	0.05	11.25	0.04	9.00
	Dolomite	t	200.00	0.14	28.00	0.14	28.00	0.14	28.00
	Other				25.00		25.00		25.00
	Variable cost	LS			582.91		373.97		336.05
TSP	Fuel oil	t	786.00	0.17	133.62	0.03	25.15	0.03	25.15
	Electric power	kWh	0.36	292.80	105.41	25.45	9.16	25.45	9.16
	Sulfur	t	1920.00	0.37	718.08	0.37	712.32	0.37	712.32
	Phosphate rock	t	100.00	1.81	181.00	1.70	170.00	1.65	165.00
	Cooling water	m3	0.05	265.00	13.25	103.00	5.15	103.00	5.15
	Boiler feed water	m3	5.00	1.30	6.50	1.30	6.50	1.30	6.50
	Other				85.00		85.00		85.00
	Variable cost	LS			1242.86		1013.28		1008.28

Sources: Consultant and mission estimates

Notes:

(a) All costs are expressed in Syrian Pounds (LS). Where conversions have been made, the official exchange rate (US$ 1 = LS 11.25) has been used.

(b) Unit consumption ("Unit cons") is expressed per metric ton of outpout

(c) The variable cost is expressed per metric ton of output.

(d) GFC used naphtha for ammonia production in 1986 but began to convert to natural gas in 1987. For the sake of the comparative analysis, the reference situation has been determined as if GFC had been using natural gas as feedstock for the ammonia plant.

Table 2: Financial results of the rehabilitation program: CAN Complex

	Unit	Years 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Initial production	t	109919	109919	109919	109919	109919	109919	109919	109919	109919	109919	109919	109919	109919	109919	109919
Reliability improvement																
(a) Expected total production	t	109919	110171	110591	110928	111264	111600	111600	111600	111600	111600	111600	111600	111600	111600	111600
(b) Expected increase in production	t		252	672	1009	1345	1681	1681	1681	1681	1681	1681	1681	1681	1681	1681
(c) Initial variable cost	LS	583	583	583	583	583	583	583	583	583	583	583	583	583	583	583
(d) Expected variable cost	LS	583	551	498	456	415	374	374	374	374	374	374	374	374	374	374
(e) Expected decrease in variable cost	LS	0	32	85	127	168	209	209	209	209	209	209	209	209	209	209
(f) Selling price	LS	1425	1425	1425	1425	1425	1425	1425	1425	1425	1425	1425	1425	1425	1425	1425
(g) Investment outlays	000 LS	5680	15147	15147	1893											
(h) Cash flow increases	000 LS	0	3756	9980	14927	19845	24733	24733	24733	24733	24733	24733	24733	24733	24733	24733
. due to prod. increase	000 LS		212	566	849	1132	1416	1416	1416	1416	1416	1416	1416	1416	1416	1416
. due to cost reduction	000 LS	0	3543	9414	14078	18712	23317	23317	23317	23317	23317	23317	23317	23317	23317	23317
(i) Net cash flow series	000 LS	-5680	-11391	-5167	13034	19845	24733	24733	24733	24733	24733	24733	24733	24733	24733	24733
Results																
- Discounted cash flow	000 LS	81008														
- IRR	%	54														
Efficiency improvement																
(a) Variable cost decrease	LS			8	16	31	38	38	38	38	38	38	38	38	38	38
(b) Expected variable cost	LS	583	551	490	440	384	336	336	336	336	336	336	336	336	336	336
(c) Investment outlays	000 LS		3362	11765	16808	1681										
(d) Cash flow increases	000 LS			909	1779	3467	4232	4232	4232	4232	4232	4232	4232	4232	4232	4232
(e) Net coh flow series	000 LS		-3362	-10856	-15029	1786	4232	4232	4232	4232	4232	4232	4232	4232	4232	4232
Results																
- Discounted cash flow	000 LS	-5375														
- IRR	%	6														

Sources: Consultant and mission

Notes:
(a) Discounting rate: 12 % .
(b) Targets for production increases and cost reduction are indicated in annex 2.
(c) Production, cost and investment figures for the years 1 to 6 are derived from the assumptions in annex 2.

Table 3: Financial results of the rehabilitation program: the Ammonia/Urea Complex

	Unit	Years 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Initial production	t	171109	171109	171109	171109	171109	171109	171109	171109	171109	171109	171109	171109	171109	171109	171109
Reliability improvement																
(a) Expected total production	t	171109	192220	227405	255554	283702	311850	311850	311850	311850	311850	311850	311850	311850	311850	311850
(b) Expected increase in producti	t	0	21111	56296	84445	112593	140741	140741	140741	140741	140741	140741	140741	140741	140741	140741
(c) Initial variable cost	LS	870	870	870	870	870	870	870	870	870	870	870	870	870	870	870
(d) Expected variable cost	LS	870	811	712	634	557	481	481	481	481	481	481	481	481	481	481
(e) Expected decrease in variabl	LS	0	60	158	236	313	390	390	390	390	390	390	390	390	390	390
(f) Selling price	LS	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
(g) Investment outlays	000 LS	39508	105354	105354	13169	0	0	0	0	0	0	0	0	0	0	0
(h) Cash flow increases	000 LS															
. due to prod. increase	000 LS	0	15930	42481	63721	84962	106202	106202	106202	106202	106202	106202	106202	106202	106202	106202
. due to cost reduction	000 LS	0	11461	35946	60311	88853	121512	121512	121512	121512	121512	121512	121512	121512	121512	121512
(i) Net cash flow series	000 LS	-39508	-77963	-26927	110863	173815	227714	227714	227714	227714	227714	227714	227714	227714	227714	227714
Results																
- Discounted cash flow	000 LS	782560														
- IRR	%	64														
Efficiency improvement																
(a) Variable cost decrease	LS	0	0	11	23	45	56	56	56	56	56	56	56	56	56	56
(b) Expected variable cost	LS	870	811	701	612	512	425	425	425	425	425	425	425	425	425	425
(c) Investment outlays	000 LS	0	10401	36402	52003	5200	0	0	0	0	0	0	0	0	0	0
(d) Cash flow increases	000 LS	0	0	2574	5758	12724	17400	17400	17400	17400	17400	17400	17400	17400	17400	17400
(e) Net cah flow series	000 LS	0	-10401	-33828	-46245	7523	17400	17400	17400	17400	17400	17400	17400	17400	17400	17400
Results																
- Discounted cash flow	000 LS	-1705														
- IRR	%	11														

Sources: Consultant and mission

Notes: See notes for Table 2.

Table 6: Financial results of the rehabilitation program: the TSP Complex

		Years														
	Unit	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Initial production	t	192720	192720	192720	192720	192720	192720	192720	192720	192720	192720	192720	192720	192720	192720	192720
Reliability improvement																
(a) Expected total production	t	192720	230637	293832	344388	394944	445500	445500	445500	445500	445500	445500	445500	445500	445500	445500
(b) Expected increase in production	t	0	37917	101112	151668	202224	252780	252780	252780	252780	252780	252780	252780	252780	252780	252780
(c) Initial variable cost	LS	1243	1243	1243	1243	1243	1243	1243	1243	1243	1243	1243	1243	1243	1243	1243
(d) Expected variable cost	LS	1243	1208	1151	1105	1059	1013	1013	1013	1013	1013	1013	1013	1013	1013	1013
(e) Expected decrease in variable cost	LS	0	34	92	138	184	230	230	230	230	230	230	230	230	230	230
(f) Selling price	LS	1825	1825	1825	1825	1825	1825	1825	1825	1825	1825	1825	1825	1825	1825	1825
(g) Investment outlays	000 LS	26369	70317	70317	8790	0	0	0	0	0	0	0	0	0	0	0
(h) Cash flow increases	000 LS															
. due to prod. increase	000 LS	0	22073	58862	88292	117723	147154	147154	147154	147154	147154	147154	147154	147154	147154	147154
. due to cost reduction	000 LS	0	7942	26982	47438	72535	102275	102275	102275	102275	102275	102275	102275	102275	102275	102275
(i) Net cash flow series	000 LS	-26369	-40302	15527	126940	190258	249429	249429	249429	249429	249429	249429	249429	249429	249429	249429
Results																
- Discounted cash flow	000 LS	943702														
- IRR	%	101														
Efficiency improvement																
(a) Variable cost decrease	LS	0	0	1	2	4	5	5	5	5	5	5	5	5	5	5
(b) Expected variable cost	LS	1243	1208	1150	1103	1055	1008	1008	1008	1008	1008	1008	1008	1008	1008	1008
(c) Investment outlays	000 LS	0	862	3017	4310	431	0	0	0	0	0	0	0	0	0	0
		8620														
(d) Cash flow increases	000 LS	0	0	294	689	1580	2228	2228	2228	2228	2228	2228	2228	2228	2228	2228
(e) Net cah flow series	000 LS	0	-862	-2723	-3621	1149	2228	2228	2228	2228	2228	2228	2228	2228	2228	2228
Results																
- Discounted cash flow	000 LS	2866														
- IRR	%	22														

Sources: Consultant and mission

Notes: See notes for Table 2.

Table 5: Financial results of the rehabilitation program on GFC (consolidated results)

	Unit	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Years														
Initial production	000 LS	786401	786401	786401	786401	786401	786401	786401	786401	786401	786401	786401	786401	786401	786401	786401
Reliability improvement																
(a) Expected total production	000 LS	786401	890264	1063370	1201855	1340339	1478824	1478824	1478824	1478824	1478824	1478824	1478824	1478824	1478824	1478824
(b) Expected increase in production	000 LS	0	103863	276969	415454	553938	692423	692423	692423	692423	692423	692423	692423	692423	692423	692423
(c) Initial variable cost	000 LS	452531	4[illegible]531	452531	452531	452531	452531	452531	452531	452531	452531	452531	452531	452531	452531	452531
(d) Expected variable cost	000 LS	452531	495232	555249	593296	622551	643078	643078	643078	643078	643078	643078	643078	643078	643078	643078
(e) Investment outlays	000 LS	71557	190818	190818	23852	0	0	0	0	0	0	0	0	0	0	0
(f) Cash flow increases	000 LS	0	61162	174251	274689	383918	501876	501876	501876	501876	501876	501876	501876	501876	501876	501876
. due to prod. increase	000 LS	0	38216	101909	152863	203817	254771	254771	254771	254771	254771	254771	254771	254771	254771	254771
. due to cost reduction	000 LS	0	22946	72342	121826	180101	247104	247104	247104	247104	247104	247104	247104	247104	247104	247104
(g) Net cash flow series	000 LS	-71557	-129656	-16567	250836	383918	501876	501876	501876	501876	501876	501876	501876	501876	501876	501876
Results																
- Discounted cash flow	000 LS	1807270														
- IRR	%	77														
Efficiency improvement																
(a) Variable cost decrease	000 LS	0	0	3777	8225	17771	23860	23860	23860	23860	23860	23860	23860	23860	23860	23860
(b) Expected variable cost	000 LS	452531	495232	551472	585071	604781	619219	619219	619219	619219	619219	619219	619219	619219	619219	619219
(c) Investment outlays	000 LS	0	14624	51185	73121	7312	0	0	0	0	0	0	0	0	0	0
(d) Cash flow increases	000 LS	0	0	3777	8225	17771	23860	23860	23860	23860	23860	23860	23860	23860	23860	23860
(e) Net cah flow series	000 LS	0	-14624	-47407	-64896	10459	23860	23860	23860	23860	23860	23860	23860	23860	23860	23860
Results																
- Discounted cash flow	000 LS	-4214														
- IRR	%	11														
Global rehabilitation program																
(a) Cash flow increases	000 LS	0	61162	178028	282914	401688	525735	525735	525735	525735	525735	525735	525735	525735	525735	525735
(b) Investment outlays	000 LS	71557 623287	205442	242003	96973	7312	0	0	0	0	0	0	0	0	0	0
(c) Net cash flow series	000 LS	-71557	-144280	-63975	185941	394376	525735	525735	525735	525735	525735	525735	525735	525735	525735	525735
Results																
- Discounted cash flow	000 LS	1803057														
- IRR	%	69														

Sources: Consultant and mission

Notes: See notes for Table 2.

Table 1: Expected influence of the rehabilitation program on variable production costs (LS) (economic results)

Product line	Input	Unit	Unit cost	Initial situation (1986 data) Unit cons	Cost	With technical reliability improvement program Unit cons	Cost	With further efficiency improvement progam Unit cons	Cost
Ammonia	Natural gas	m3	1.84	1536.83	2827.77	1085.00	1996.40	1000.00	1840.00
	Fuel oil	t	2160.00						
	Electric power	kWh	1.92	191.40	367.49	25.00	48.00	25.00	48.00
	Cooling water	m3	0.05	495.00	24.75	250.00	12.50	250.00	12.50
	Boiler feed water	m3	5.00	2.66	13.30	2.66	13.30	2.66	13.30
	Other				55.00		55.00		55.00
	Variable cost	LS			3288.31		2125.20		1968.80
Urea	Ammonia	t	see above	0.61	2005.87	0.58	1232.62	0.58	1141.90
	Natural gas	m3	1.84			123.00	226.32	65.00	119.60
	Fuel oil	t	2160.00	0.28	604.80				
	Electric power	kWh	1.92	93.90	180.29	34.25	65.76	34.25	65.76
	Cooling water	m3	0.05	205.00	10.25	103.00	5.15	103.00	5.15
	Boiler feed water	m3	5.00						
	Other				20.00		20.00		20.00
	Variable cost	LS			2821.20		1549.85		1352.41
CAN	Ammonia	t	see above	0.41	1341.63	0.39	822.45	0.38	738.30
	Steam	t	100.00	0.60	60.00	0.36	36.00	0.25	25.00
	Electric power	kWh	1.92	171.60	329.47	45.00	86.40	45.00	86.40
	Cooling water	m3	0.05	65.00	3.25	58.50	2.93	58.50	2.93
	Boiler feed water	m3	5.00	0.30	1.50	0.30	1.50	0.25	1.25
	Catalyst (Pt)	Gram	540.00	0.05	27.00	0.05	27.00	0.04	21.60
	Dolomite	t	480.00	0.14	67.20	0.14	67.20	0.14	67.20
	Other				25.00		25.00		25.00
	Variable cost	LS			1855.05		1068.48		967.68
TSP	Fuel oil	t	2160.00	0.17	367.20	0.03	69.12	0.03	69.12
	Electric power	kWh	1.92	292.80	562.18	25.45	48.86	25.45	48.86
	Sulfur	t	3240.00	0.37	1211.76	0.37	1202.04	0.37	1202.04
	Phosphate rock	t	729.00	1.81	1319.49	1.70	1239.30	1.65	1202.85
	Cooling water	m3	0.05	265.00	13.25	103.00	5.15	103.00	5.15
	Boiler feed water	m3	5.00	1.30	6.50	1.30	6.50	1.30	6.50
	Other				85.00		85.00		85.00
	Variable cost	LS			3565.38		2655.97		2619.52

Sources: Consultant and mission estimates

Notes: (a) All costs are expressed in Syrian Pounds (LS). Where conversions have been made, the shadow exchange rate (US$ 1 = LS 27) has been used.

(b) Unit consumption ("Unit cons") is expressed per metric ton of output.

(c) The variable cost is expressed per metric ton of output.

(d) See note (d) for Table 1 of annex 3.

Table 2: Economic results of the rehabilitation program: the CAN Complex

	Unit	Years 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Initial production	t	109919	109919	109919	109919	109919	109919	109919	109919	109919	109919	109919	109919	109919	109919	109919
Reliability improvement																
(a) Expected total production	t	109919	110171	110591	110928	111264	111600	111600	111600	111600	111600	111600	111600	111600	111600	111600
(b) Expected increase in production	t		252	672	1009	1345	1681	1681	1681	1681	1681	1681	1681	1681	1681	1681
(c) Initial variable cost	LS	1855	1855	1855	1855	1855	1855	1855	1855	1855	1855	1855	1855	1855	1855	1855
(d) Expected variable cost	LS	1855	1734	1535	1377	1222	1068	1068	1068	1068	1068	1068	1068	1068	1068	1068
(e) Expected decrease in variable cost	LS		121	320	478	633	787	787	787	787	787	787	787	787	787	787
(f) Selling price	LS	3780	3780	3780	3780	3780	3780	3780	3780	3780	3780	3780	3780	3780	3780	3780
(g) Investment outlays	000 LS	11368	30316	30316	3789											
(h) Cash flow increases	000 LS		13827	36738	54943	73037	91017	91017	91017	91017	91017	91017	91017	91017	91017	91017
. due to prod. increase	000 LS		485	1294	1942	2589	3236	3236	3236	3236	3236	3236	3236	3236	3236	3236
. due to cost reduction	000 LS		13342	35444	53002	70449	87782	87782	87782	87782	87782	87782	87782	87782	87782	87782
(i) Net cash flow series	000 LS	-11368	-16488	6422	51154	73037	91017	91017	91017	91017	91017	91017	91017	91017	91017	91017
Results																
- Discounted cash flow	000 LS	347039														
- IRR	%	96														
Efficiency improvement																
(a) Variable cost decrease	LS			23	44	84	101	101	101	101	101	101	101	101	101	101
(b) Expected variable cost	LS	1855	1734	1512	1334	1138	968	968	968	968	968	968	968	968	968	968
(c) Investment outlays	000 LS		7106	24072	35532	3553										
(d) Cash flow increases	000 LS			2492	4829	9313	11250	11250	11250	11250	11250	11250	11250	11250	11250	11250
(e) Net cash flow series	000 LS		-7106	-22381	-30703	5760	11250	11250	11250	11250	11250	11250	11250	11250	11250	11250
Results																
- Discounted cash flow	000 LS	-1773														
- IRR	%	11														

Sources: Consultants and mission

Notes: (a) Discounting rate: 12 %. Shadow exchange rate US$ 1 = LS 27
(b) Targets for production increases and cost reduction are indicated in annex 2.
(c) Production, cost and investment figures for the years 1 to 6 are derived from the assumptions in annex 2.

Table 3: Economic results of the rehabilitation program: Ammonia/ Urea Complex

	Unit	Years 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Initial production	t	171109	171109	171109	171109	171109	171109	171109	171109	171109	171109	171109	171109	171109	171109	171109
Reliability improvement																
(a) Expected total production	t	171109	192220	227405	255554	283702	311850	311850	311850	311850	311850	311850	311850	311850	311850	311850
(b) Expected increase in production	t		21111	56296	84445	112593	140741	140741	140741	140741	140741	140741	140741	140741	140741	140741
(c) Initial variable cost	LS	2821	2821	2821	2821	2821	2821	2821	2821	2821	2821	2821	2821	2821	2821	2821
(d) Expected variable cost	LS	2821	2626	2304	2050	1799	1550	1550	1550	1550	1550	1550	1550	1550	1550	1550
(e) Expected decrease in variable cost	LS		195	517	771	1023	1271	1271	1271	1271	1271	1271	1271	1271	1271	1271
(f) Selling price	LS	3780	3780	3780	3780	3780	3780	3780	3780	3780	3780	3780	3780	3780	3780	3780
(g) Investment outlays	000 LS	90420	241121	241121	30140											
(h) Cash flow increases	000 LS															
. due to prod. increase	000 LS		20241	53977	80965	107954	134942	134942	134942	134942	134942	134942	134942	134942	134942	134942
. due to cost reduction	000 LS		37512	117550	197080	290133	396473	396473	396473	396473	396473	396473	396473	396473	396473	396473
(i) Net cash flow series	000 LS	-90420	-183367	-69594	247905	398087	531415	531415	531415	531415	531415	531415	531415	531415	531415	531415
Results																
- Discounted cash flow	000 LS	1810749														
- IRR	%	64														
Efficiency improvement																
(a) Variable cost decrease	LS			40	80	159	197	197	197	197	197	197	197	197	197	197
(b) Expected variable cost	LS	2821	2626	2264	1970	1640	1352	1352	1352	1352	1352	1352	1352	1352	1352	1352
(c) Investment outlays	000 LS		22272	77953	111362	11136										
(d) Cash flow increases	000 LS			9107	20374	45022	61569	61569	61569	61569	61569	61569	61569	61569	61569	61569
(e) Net coh flow series	000 LS		-22272	-68846	-90988	33886	61569	61569	61569	61569	61569	61569	61569	61569	61569	61569
Results																
- Discounted cash flow	000 LS	92041														
- IRR	%	24														

Sources: Consultant and mission

Notes: See notes for Table 2.

Table 4: Economic results of the rehabilitation program: the TSP Complex

	Unit	Years 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Initial production	t	192720	192720	192720	192720	192720	192720	192720	192720	192720	192720	192720	192720	192720	192720	192720
Reliability improvement																
(a) Expected total production	t	192720	230637	293832	344388	394944	445500	445500	445500	445500	445500	445500	445500	445500	445500	445500
(b) Expected increase in production	t		37917	101112	151668	202224	252780	252780	252780	252780	252780	252780	252780	252780	252780	252780
(c) Initial variable cost	LS	3565	3565	3565	3565	3565	3565	3565	3565	3565	3565	3565	3565	3565	3565	3565
(d) Expected variable cost	LS	3394	3259	3035	2855	2675	2495	2495	2495	2495	2495	2495	2495	2495	2495	2495
(e) Expected decrease in variable cost	LS	171	306	531	710	890	1070	1070	1070	1070	1070	1070	1070	1070	1070	1070
(f) Selling price	LS	5130	5130	5130	5130	5130	5130	5130	5130	5130	5130	5130	5130	5130	5130	5130
(g) Investment outlays	000 LS	56753	151340	151340	18918											
(h) Cash flow increases	000 LS															
. due to prod. increase	000 LS		59326	158202	237303	316405	395506	395506	395506	395506	395506	395506	395506	395506	395506	395506
. due to cost reduction	000 LS	32964	70551	155921	244670	351599	476708	476708	476708	476708	476708	476708	476708	476708	476708	476708
(i) Net cash flow series	000 LS	-23789	-21464	162783	463056	668004	872214	872214	872214	872214	872214	872214	872214	872214	872216	872214
Results																
- Discounted cash flow	000 LS	3547233														
- IRR	%	254														
Efficiency improvement																
(a) Variable cost decrease	LS			6	13	25	32	32	32	32	32	32	32	32	32	32
(b) Expected variable cost	LS	3394	3259	3028	2842	2650	2464	2464	2464	2464	2464	2464	2464	2464	2464	2464
(c) Investment outlays	000 LS		1974	6908	9869	987										
(d) Cash flow increases	000 LS			1864	4370	10024	14133	14133	14133	14133	14133	14133	14133	14133	14133	14133
(e) Net cah flow series	000 LS		-1974	-5044	-5498	9037	14133	14133	14133	14133	14133	14133	14133	14133	14133	14133
Results																
- Discounted cash flow	000 LS	41783														
- IRR	%	64														

Sources: Consultant and mission

Notes: See notes for Table 2.

Table 5: Economic results of the rehabilitation program on GFC (consolidated results)

	Unit	Years 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Initial production	000 LS	2050939	2050939	2050939	2050939	2050[illegible]	2050939	2050939	2050939	2050939	2050939	2050939	2050939	2050939	2050939	2050939
Reliability improvement																
(a) Expected total production	000 LS	2050939	2326207	2784986	3152009	3519033	3886056	3886056	3886056	3886056	3886056	3886056	3886056	3886056	3886056	3886056
(b) Expected increase in production	000 LS		275267	734047	1101070	1468093	1835117	1835117	1835117	1835117	1835117	1835117	1835117	1835117	1835117	1835117
(c) Initial variable cost	000 LS	1373758	1373758	1373758	1373758	1373758	1373758	1373758	1373758	1373758	1373758	1373758	1373758	1373758	1373758	1373758
(d) Expected variable cost	000 LS	1340794	1447568	1585417	1659866	1702724	1714228	1714228	1714228	1714228	1714228	1714228	1714228	1714228	1714228	1714228
(e) Investment outlays	000 LS	158541	422777	422777	52847											
(f) Cash flow increases	000 LS	32964	201457	522388	814962	1139128	1494646	1494646	1494646	1494646	1494646	1494646	1494646	1494646	1494646	1494646
. due to prod. increase	000 LS		80053	213473	320210	426947	533683	533683	533683	533683	533683	533683	533683	533683	533683	533683
. due to cost reduction	000 LS	32964	121405	308915	494752	712181	960963	960963	960963	960963	960963	960963	960963	960963	960963	960963
(g) Net cash flow series	000 LS	-125578	-221319	99611	762115	1139128	1494646	1494646	1494646	1494646	1494646	1494646	1494646	1494646	1494646	1494646
Results																
- Discounted cash flow	000 LS	5705021														
- IRR	%	111														
Efficiency improvement																
(a) Variable cost decrease	000 LS			13463	29573	64359	86952	86952	86952	86952	86952	86952	86952	86952	86952	86952
(b) Expected variable cost	000 LS	1340794	1447568	1571953	1630293	1638365	1627276	1627276	1627276	1627276	1627276	1627276	1627276	1627276	1627276	1627276
(c) Investment outlays	000 LS		31352	109733	156762	15676										
(d) Cash flow increases	000 LS			13463	29573	64359	86952	86952	86952	86952	86952	86952	86952	86952	86952	86952
(e) Net coh flow series	000 LS		-31352	-96270	-127189	48683	86952	86952	86952	86952	86952	86952	86952	86952	86952	86952
Results																
- Discounted cash flow	000 LS	132052														
- IRR	%	24														
Global rehabilitation program																
(a) Cash flow increases	000 LS	32964	201457	535852	844535	1203486	1581598	1581598	1581598	1581598	1581598	1581598	1581598	1581598	1581598	1581598
(b) Investment outlays	000 LS	158541	454129	532510	209609	15676										
(c) Net cash flow series	000 LS	-125578	-252672	3341	634926	1187810	1581598	1581598	1581598	1581598	1581598	1581598	1581598	1581598	1581598	1581598
Results																
- Discounted cash flow	000 LS	5837073														
- IRR	%	100														

Sources: Consultant and mission

Notes: See notes for Table 2.

SUGGESTED ALTERNATIVES FOR THE PRODUCTION OF NITROGEN AND PHOSPHATE FERTILIZERS

Table 1 identifies the practical alternatives GFC might want to consider for the production of nitrogen and phosphate fertilizers. In the choice of alternatives the following criteria were used:

(a) ammonia production and consumption on site to be in balance;

(b) ammonia plant No. 2 to be fully utilized before ammonia plant No. 1 is considered for operation;

(c) the capacity of the two sulfuric acid plants to be utilized fully and their steam production used for generating electricity;

Table 1: PRODUCTION OPTIONS FOR GFC

Legend:

AI	=	Ammonia plant No.1
AII	=	Ammonia plant No. 2. AII* = with 25% prod. expansion
U	=	Urea plant. U* = with 31% production expansion.
NA	=	Nitric acid plant
CAN	=	Calcium ammonium nitrate plant
SA	=	Sulfuric acid plants
PA	=	Phosphoric acid plant
TSP	=	Triple superphosphate plant
SSP	=	Single superphosphate plant (possible future project)
DAP	=	Diammonium phosphate plant (possible future project)

	Complex No.	Plants	Annual Capacities ('000 ton)	
Base Case 1	1	NA + CAN	CAN	= 124
	2	AII+U	U	= 312
			Surplus NH_3	= 75
	3	SA+PA+TSP	TSP	= 445
Case 2	1	NA + CAN	CAN	= 124
	2	AII + U*	U	= 420
	3	SA + PA + TSP	TSP	= 445
Case 3	1	NA + CAN	CAN	= 124
	2	AII + U*	U	= 420
	3	SA + PA + TSP + SSP	TSP	= 445
			or SSP	= 1,180 a/
Case 4	1	NA + CAN	CAN	= 124
	2	AII + U*	U	= 421

	3	SA + SSP	SSP	= 1,366
Case 6	1	AI + NA + CAN	CAN	= 124
	2	AII + U*	U	= 421
	3		Surplus NH_3	=
	4	SA + PA + TSP	TSP	= 445
		or	or	
		SA + PA + TSP + SSP	SSP	= 1,188
		or	or	
		SA + SSP	SSP	= 1,366
Case 7 b/	1	NA + CAN	CAN	= 124
	2	AII* + U*	U	= 421
	3	SA + PA + DAP c/	DAP	= 340

a/ Proposed is an one-line SSP of 2300 tpd + changes in TSP plant to produce SSP (1700 tpd) - total 4,000 tpd SSP

b/ The production of ammonium sulfate on site to run the sulfuric acid plants at maximum capacity is not considered because ammonium sulfate is a cheap by-product on world markets from other chemical processes and steel production. The preferred alternative if the phosphoric acid plant has to be bypassed, is the production of single superphosphate for the home market.

c/ DAP 18-48 requires approx. 80,000 t ammonia.

Basic capacities used annually for production alternatives:

	Daily Capacity		Annual Production
AI	150 t	150 x 330 x 0.9 =	44,550 t NH_3
AII	1000 t	1000 x 330 x 0.9 =	297,000 t NH_3
AII	1,200 t (20% cap. increase)	1,200 x 330 x 0.9 =	356,400 t NH_3
U	1,050 t	1,050 x 330 x 0.9 =	311,850 tpy
		requires 0.57 x 311,850 =	177,755 tpy NH_3
U*	1,400 t (35% cap. increase)	1,400 x 330 x 0.9 =	420,000 t U
		requires 0.57 x 420,000 =	240,000 tpy NH_3
CAN	390 t	390 x 330 =	124,000 t CAN
SA	1,700 t	1,700 x 330 x 0.9 =	504,900 t H_2SO_4
PA	537 t as P_2O_5	537 x 330 x 09 =	160,000 t P_2O_5
		requires 2.9 x 160,000 =	± 464,500 t H_2SO_4
TSP	1,500 t	1,500 x 330 x 0.9 =	445,500 t TSP
		requires 0.34 x 445,500 =	151,470 t P_2O_5 ex phosacid

Capacities per year for proposed additional plants:

SSP: 504,900/0.37 H_2SO_4 = 1,365,000t SSP per year or $\frac{1,365,000}{330 \times 0.9}$ = 4,600 tpd in 2 lines of 2,300 tpd).

DAP: 160,000/0.47 = 340,400 t DAP per year or $\frac{340,00}{330 \times 0.9}$ = 1,150 tpd to take all phosacid production and this requires 61,300 t NH_3 per annum.

TRAINING

Operations Training

The task of the training team for operations is interalia the preparation of manuals, selecting instructors, organizing class room and field training sessions. The services of competent, experienced personnel are available from fertilizer plant consultants or operating firms who have the advantage of experience as well as access to documentation to assist the company through the development and implementation of the detailed program.

A preliminary program for suggested services to accomplish the recommended training steps includes an overall training coordinator who will plan and administer the operation and maintenance training at site and elsewhere.

The program will include:

- preparing needed documentation
- importing instructors as necessary
- sending personnel from Homs to other locations for courses or training at other plants
- collecting and maintaining needed reference materials.

Maintenance Training

The responsibilities for the maintenance training include:

- coordinating with the management consultants to reorganize maintenance and implement the preventive maintenance procedures, programs and schedules
- record keeping on maintenance for all important equipment
- providing lubrication schedules
- regularly inspecting the maintenance status of the steam systems (such as steam traps, steam pipe leaks and steam valves)
- reviewing spare parts to reduce the excess now present in some areas while assuring that needed parts are available.

ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAM

Activities Completed

Country	Project	Date	Number
ENERGY EFFICIENCY AND STRATEGY			
Africa Regional	The Interafrican Electrical Engineering College: Proposals for Short- and Long-Term Development	3/90	112/90
	Participants' Reports - Regional Power Seminar on Reducing Electric System Losses in Africa	8/88	087/88
Bangladesh	Power System Efficiency Study	2/85	031/85
Bolivia	La Paz Private Power Technical Assistance	2/90	111/90
Botswana	Pump Electrification Prefeasibility Study	1/86	047/86
	Review of Electricity Service Connection Policy	7/87	071/87
	Tuli Block Farms Electrification Prefeasibility Study	7/87	072/87
Burkina	Technical Assistance Program	3/86	052/86
Burundi	Presentation of Energy Projects for the Fourth Five-Year Plan (1983-1987)	5/85	036/85
	Review of Petroleum Import and Distribution Arrangements	1/84	012/84
Burundi/Rwanda/Zaire (EGL Report)	Evaluation de l'Energie des Pays des Grands Lacs	2/89	098/89
Congo	Power Development Study	5/90	106/90
Costa Rica	Recommended Technical Assistance Projects	11/84	027/84
Ethiopia	Power System Efficiency Study	10/85	045/85
The Gambia	Petroleum Supply Management Assistance	4/85	035/85
Ghana	Energy Rationalization in the Industrial Sector of Ghana	6/88	084/88
Guinea-Bissau	Recommended Technical Assistance Projects in the Electric Power Sector	4/85	033/85
	Management Options for the Electric Power and Water Supply Subsectors	2/90	100/90
Indonesia	Energy Efficiency Improvement in the Brick, Tile and Lime Industries on Java	4/87	067/87
	Power Generation Efficiency Study	2/86	050/86
	Diesel Generation Efficiency Improvement Study	12/88	095/88
Jamaica	Petroleum Procurement, Refining, and Distribution	11/86	061/86
Kenya	Power System Efficiency Report	3/84	014/84
Liberia	Power System Efficiency Study	12/87	081/87
	Recommended Technical Assistance Projects	6/85	038/85
Madagascar	Power System Efficiency Study	12/87	075/87
Malaysia	Sabah Power System Efficiency Study	3/87	068/87
Mauritius	Power System Efficiency Study	5/87	070/87
Mozambique	Household Electricity Utilization Study	5/90	113/90
Panama	Power System Loss Reduction Study	6/83	004/83
Papua New Guinea	Energy Sector Institutional Review: Proposals for Strengthening the Department of Minerals and Energy	10/84	023/84
	Power Tariff Study	10/84	024/84

ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAM

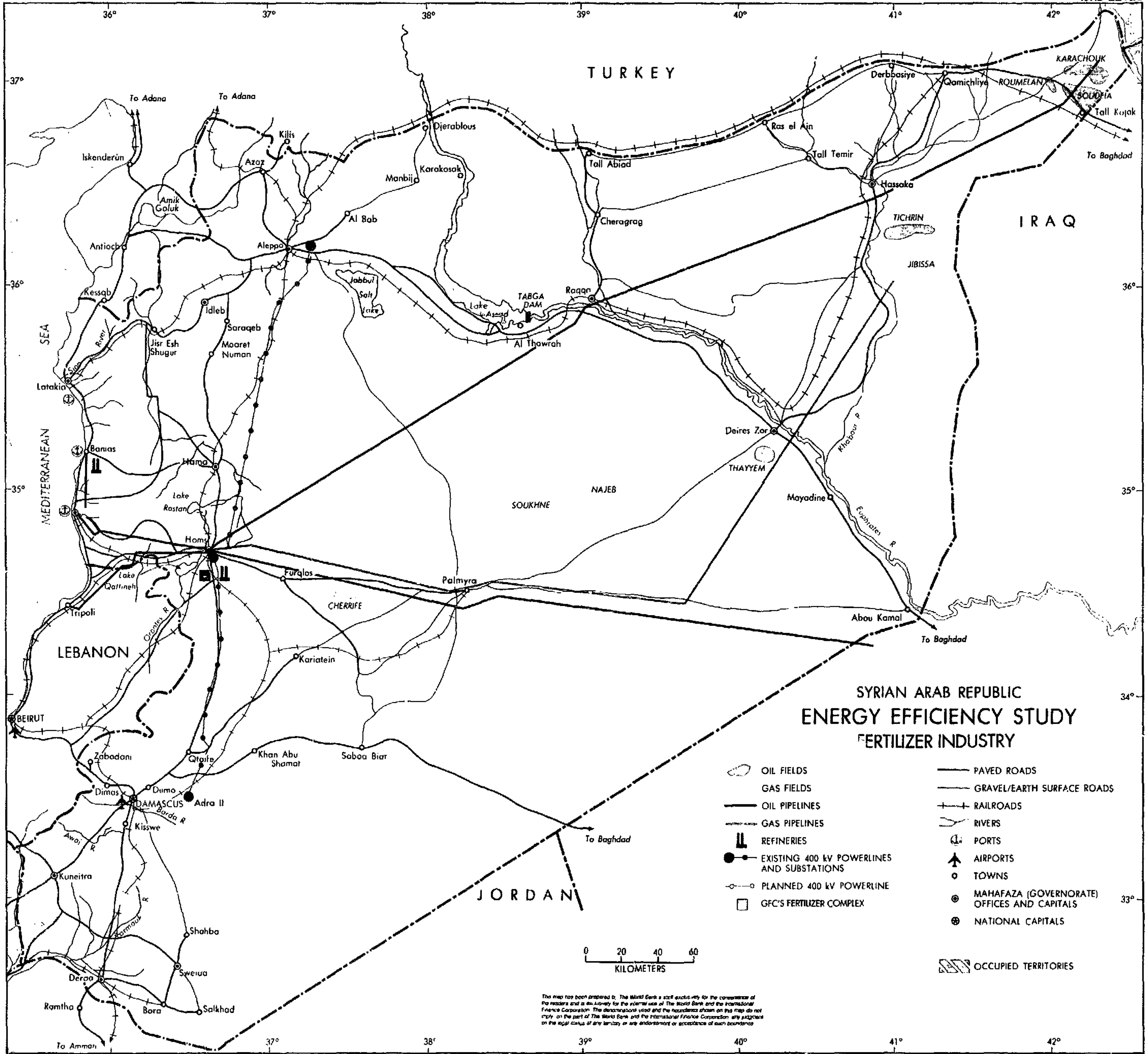
Activities Completed

Country	Project	Date	Number
ENERGY EFFICIENCY AND STRATEGY (Continued)			
Senegal	Assistance Given for Preparation of Documents for Energy Sector Donors' Meeting	4/86	056/86
Seychelles	Electric Power System Efficiency Study	8/84	021/84
Sri Lanka	Power System Loss Reduction Study	7/83	007/83
Syria	Electric Power Efficiency Study	9/88	089/88
	Energy Efficiency in the Cement Industry	7/89	099/89
Sudan	Power System Efficiency Study	6/84	018/84
	Management Assistance to the Ministry of Energy and Mining	5/83	003/83
Togo	Power System Efficiency Study	12/87	078/87
Tunisia	Interfuel Substitution Study	5/90	114/90
Uganda	Energy Efficiency in Tobacco Curing Industry	2/86	049/86
	Institutional Strengthening in the Energy Sector	1/85	029/85
	Power System Efficiency Study	12/88	092/88
Zambia	Energy Sector Institutional Review	11/86	060/86
	Energy Sector Strategy	12/88	094/88
	Power System Efficiency Study	12/88	093/88
Zimbabwe	Petroleum Supply Management	2/90	109/90
	Power Sector Management Assistance Project: Background, Objectives, and Work Plan	4/85	034/85
	Power System Loss Reduction Study	6/83	005/83
HOUSEHOLD, RURAL, AND RENEWABLE ENERGY			
Burundi	Peat Utilization Project	11/85	046/85
	Improved Charcoal Cookstove Strategy	9/85	042/85
Cape Verde	Household Energy Strategy Study	2/90	110/90
China	Country-Level Rural Energy Assessments: A Joint Study of ESMAP and Chinese Experts	5/89	101/89
	Fuelwood Development Conservation Project	12/89	105/89
Costa Rica	Forest Residues Utilization Study, Volumes I & II	2/90	108/90
Côte d'Ivoire	Improved Biomass Utilization--Pilot Projects Using Agro-Industrial Residues	4/87	069/87
Ethiopia	Agricultural Residue Briquetting: Pilot Project	12/86	062/86
	Bagasse Study	12/86	063/86
The Gambia	Solar Water Heating Retrofit Project	2/85	030/85
	Solar Photovoltaic Applications	3/85	032/85
Ghana	Sawmill Residues Utilization Study, Vol. I & II	10/88	074/87
Global	Proceedings of the ESMAP Eastern and Southern Africa Household Energy Planning Seminar	6/88	085/88
India	Opportunities for Commercialization of Non-Conventional Energy Systems	11/88	091/88
Indonesia	Urban Household Energy Strategy Study	2/90	107/90
Jamaica	FIDCO Sawmill Residues Utilization Study	9/88	088/88
	Charcoal Production Project	9/88	090/88
Kenya	Solar Water Heating Study	2/87	066/87
	Urban Woodfuel Development	10/87	076/87

Activities Completed

Country	Project	Date	Number
HOUSEHOLD, RURAL, AND RENEWABLE ENERGY (Continued)			
Malawi	Technical Assistance to Improve the Efficiency of Fuelwood Use in the Tobacco Industry	11/83	009/83
Mauritius	Bagasse Power Potential	10/87	077/87
Niger	Household Energy Conservation and Substitution	12/87	082/87
	Improved Stoves Project	12/87	080/87
Pakistan	Assessment of Photovoltaic Programs, Applications and Markets	10/89	103/89
Peru	Proposal for a Stove Dissemination Program in the Sierra	2/87	064/87
Rwanda	Improved Charcoal Cookstove Strategy	8/86	059/86
	Improved Charcoal Production Techniques	2/87	065/87
Senegal	Industrial Energy Conservation Project	6/85	037/85
	Urban Household Energy Strategy	2/89	096/89
Sri Lanka	Industrial Energy Conservation: Feasibility Studies for Selected Industries	3/86	054/86
Sudan	Wood Energy/Forestry Project	4/88	073/88
Tanzania	Woodfuel/Forestry Project	8/88	086/88
	Small-Holder Tobacco Curing Efficiency Project	5/89	102/89
Thailand	Accelerated Dissemination of Improved Stoves and Charcoal Kilns	9/87	079/87
	Rural Energy Issues and Options	9/85	044/85
	Northeast Region Village Forestry and Woodfuel Pre-Investment Study	2/88	083/88
Togo	Wood Recovery in the Nangbeto Lake	4/86	055/86
Uganda	Fuelwood/Forestry Feasibility Study	3/86	053/86
	Energy Efficiency Improvement in the Brick and Tile Industry	2/89	097/89

IBRD 22128



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