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

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DRAFT cleared by Mr. Volodin

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DECEMBER, 1989

Consultant: Doo Nam OH
backst. Off: M. Nikolaeva/Mr. Volodin

TECHNICAL REPORT

ON

SUDAN - REN CHEMICALS AND FERTILIZER LTD.

PREPARED FOR THE REPUBLIC OF SUDAN BY THE UNIDO

BASED ON THE WORK OF DOO-NAM OH. EXPERT
IN PROJECT IMPLEMENTATION AND
OPERATION OF FERTILIZER PLANTS

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THE VIEW PRESENTED.

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1. ABSTRACT.

As part of the United Nations Development Programme project, a consultant was sent to the Republic of Sudan by the United Nations Industrial Development Organization (UNIDO) to evaluate present status of machineries, staff and infrastructure at Sudan-Ren Chemicals and Fertilizer and to find any possible way of revitalizing the plant or to provide some recommendation beneficial to the country.

In the course of his one month mission (Nov. 13 to Dec. 12, 1989), the consultant have evaluated the machineries and equipments in the plant and reviewed the technical and economic documents.

In his proposal, he recommended;

1. The electric power plants consisting of two steam boilers supplied by BORSIG G.M.b.H. and two turbines/generators supplied by SIEMENS could be operated to supply electricity to the town network (6.5MW x 2 = 13MW).

2. Ammonia and Urea plants could be put into operation when Sudan-Ren could obtain raw materials such as naphtha and fuel oil or its alternative natural gas at the reasonably low prices so that production cost excluding debt service charges and profit become less than selling price of imported urea in the Khartoum area.

3. In case the plants as erected be going to be not operated for longtime as several years, the special preservation procedures from machinery and equipment etc. suppliers are to be strictly followed.

2. PRESENT STATUS

2.1 Staff;

Sudan-Ren Co., has discharged most of its experienced employee except the following

AT OFFICE

One Director
One Accountant
One Secretary

AT PLANT

One Technician (Mechanic)
Four Security Guards.

The Director joined the company about two years ago and he is not engineer.
The Technician joined the company at the end of 1981 when plant was almost mechanically completed.
Therefore there are no body in the company who knows on the technical matters.

I was introduced to former Managing Director for just few minutes.

2.2 Factory;

The plants were almost mechanically completed.
The machineries and equipments are in general not in a bad condition.
The corrosion on the machineries, equipment and piping etc. is not so severe.
This is believed mainly due to the low humidity conditions in this country.
The relative humidity at rainy season (July 12, 1975) was only 31 present.

The most important two big machineries are Co_2 compressors in urea plant and multiservice compressors in Ammonia plant which was designed to handle synthesis gas, recycle gas and Ammonia gas for refrigeration.
The pistons and valves of above machines were not installed in consideration of long non-operation.

The pumps were able to rotate by turning the coupling by hand.
The valves on the piping were hardly to open and close, since it was not greesed on the spindle.
Pipe inside condition of cooling water main line was a little corroded state.
Various kind of catalyst and resins were believed not charged in the vessels or reactors.

During my visit to plant on November 21, and 23, 1989 I was not able to find out the following materials which the plant should have prepared for the operation.

a) Spare parts of Machineries and Equipments.

b) Tools and Equipment for the maintenance during operation.

c) Catalyst and its spare

d) Chemicals, resins and its spare

e) Communication system.

f) Workshop equipments and machineries. Only one lathe, one drilling machine and one boring machine were installed in the workshop.

I was later verbally advised that some of above materials are separately stored in the several containers.

did not see

3. BRIEF TECHNO-ECONOMIC REVIEW

3.1 Ammonia Process Plant;

Ammonia is to be manufactured by twin plants having a combined designed production capacity of 172 metric tons per day and a common waste heat facility.

The process used is well tried steam reforming of naphtha and the primary reformer has been supplied by Selas.

Basic design is from N-Ren corporation and detailed engineering is from Voest-Alpine A.G in Austria.

Eventhough N-Ren bid document shows that N-Ren designed P.D.Q plants built and in operation at the moment of April, 1975 were 9 places including 4 plants in U.S.A., N-Ren designed P.D.Q plant is not so well known as Kellogg or Uhde designed plants.

Therefore it is the consultants opinion that Sudan-Ren, send its able engineers to the places where P.D.Q plants are in operation and collect every technical information experienced for the future commissioning and commercial operation.

The consultant note that this process plant have been constructed in the form of engineering modules and in the concept of skid mounted equipment, enabling the transportation to the plant site easier and site construction simplified, compared with the usual assembly at site of large numbers of piece-small items, as in customary.

Therefore, in case the plant is dismantled and moved to the place where cheap natural gas is available, it would be easier, compared with usual assembly, and would expected less cost.

3.2 Urea Process Plant;

The urea plant is a single stream unit with a designed production capacity of 272 MTD of granulated urea fertilizer and includes a twin bagging plant for the product.
The IVO MAVROVIC process is used to synthesis urea melt and a NORSK HYDRO pan granulation process supplies the finished product, which is then bagged.

Scientific Design (S.D) plants Inc. is the basic designer and Dominion Bridge Co., Ltd. in Canada is the supplier.

Apart from such famous urea process as Stamicarbon, Mitsuitoatsu, Snam Progeti, Montedison, Chemico, CPI-allied, Inventa, Lonza-lummus, Pechney Grace, Weatherly, and C&I/Girdler, this IVO MAVROVIC process is believed not so well known, it is the consultant's opinion that Sudan-Ren send its able engineers to the places where IVO MAVROVIC process plants are in operation and collect every technical information for the future operation.

3.3 Utility Plants;

The unreliability of the public electricity supply has necessiated Sudan-Ren incorporating a complete oil fired power plant of 2x6.5MW into the fertilizer complex, to ensure long term continuous production of Urea fertilizer. To improve the overall economics, process steam is supplied from the power plant boilers, after partial expansion in the steam turbines.

Raw water for the processes, power plant and cooling system make-up come from 6-deep wells adjacent to the site.

3.4 Staff for Operating and Maintaining The Complex;

As it was noted before, there are only 8 persons at the moment working for the company, including four security guards.

It is the consultants' opinion that Sudan-Ren should have some kind of Management Agreement with experienced foreign company in this field, to provide management expertise and guidance to Sudan-Ren throughout commissioning of the plant and operation phase. Such arrangement would be beneficial, where a country is planning to develop a new industry using capital intensive processes and currently processes no indigenous expertise in such matters.

Such management contractor should train all local personnel necessary to operate and maintain the fertilizer complex.

Together with local trained staff, a substantial team of expatriate specialist personnel have to be employed during the early years of production.

3.5 Supply of Feedstock and Fuel to the Plant Site;

The initial concept for this plant was to deliver naphtha feedstock by pipeline from Port Sudan to the Khartoum Site. Fuel oil would be delivered by railway tankcars. Pipeline delivery of Naphtha subsequently proved to be impossible and the present position would appear to be, both Naphtha and Fuel oil delivery by road tankcars.

a) Pipeline delivery of Naphtha :

The oil products pipline between Port Sudan and Khartoum opened in late 1977 and is currently operating at approximately 85% of its designed capacity.

It was originally considered as the means of delivery of Naphtha for the project. It is physically impossible to transport fuel oil through this pipeline.

The unforeseen increase in demand for petroleum products has further compounded this problem.

The design capacity of the pipeline is 100m^3 per hour, and currently transmitting 85m^3per hour. The capacity can be increased upto 140m3 per hour by the installation of new boaster stations i.e. 860,000 tons per year.

1981, the quantity of hydrocarbons transported from Port Sudan to Khartoum is approaching 1 million tons per annum and demand is growing at over 10% p.a.

Therefore even if pipeline capacity increase is achieved, no guarantee can be given that Naphtha can be delivered to Khartoum using this pipeline.

Currently the pipeline transmit diesel oil, gasoline, domestic kerosine and aviation kersoine..

Notwithstanding these capacity limitation, there is an overriding problem which mitigates against the pipeline being used for delivery of Naphtha. All premium gasoline is "Leaded" - that is; small quantities of organic lead products are added to it in order to improve its octane rating.

Unfortunately, an ammonia plant cannot tolerate the presence of lead even in minute quantities as this will damage the catalyst used for the reforming process which forms the first stage of ammonia production from Naphtha.

b) Railway Tankcar Delivery :

The Sudan railway is equiped with narrow guage and single track, and the level of maintenance of the lines is low; namely, since balast is not used, the roadbed is very soft and weak, so that there are many troubles such as the washing away of the roadbed during rainy season, derailment of wagons caused by breakage of rails, accidents etc.

There are also problems of unstable operation caused by overheating of metal box, accidents of the rolling stock and trouble of locomatives.

Besides, during the cotton shipping season, which last from January to July, about 800,000 tons of cotton are sent from the producing area around Khartoum to Port Sudan. The railway is fully occupied, transmitting cotton during this period.

It is therefore unfortunate but to some extent understandable why Sudan Railway officials made clear that it is almost impossible to depend on it.

c) Trucking Operation (Road Tankcar Delivery) :

It is understood that new Khartoum-Port Sudan highway was completed in 1978, and this is a single carriageway, 8 meterwide for two way traffic (1250 KM Length).

The following is abstract from the report prepared by the experts from East-West Group. U.S.A. in July, 1981.

Annually, the Sudan-Ren facility will require 50,000 tons of Naphtha and 52,000 tons of fuel oil. These requirement can be met by the purchase of sixteen 30 tons Naphtha tankers, thirteen 40 tons fuel oil tankers and twenty seven tractors.

TANKER REQUIREMENT

	Naphtha	Fuel Oil
Annual plant requirement (tons)	50,000	52,000
Tanker capacity (tons)	30	40
Work weeks per year	50	50
Number of loads annually	1,667	1,300
Avg. No. trips per week per tanker	2.5	2.5
Number of loads per week	33	33
Tankers required	13	10
Shunting tankers	1	1
Spare tankers	2	2
Total tankers requirement	16	13

The General Petroleum Corporation is believed to purchase Naphtha on behalf of Sudan-Ren. Because such purchases can only be made in bulk quantities by shiploads, two 15,000 tons storage tanks must be constructed at Port Sudan to hold about 220 days Naphtha requirement.
Since fuel oil could be purchased directly from the Port Sudan refinery, no similar storage will be required.

The total estimated capital cost of the project as defined above is U.S.D. 5,850,000 which may be broken down as follows:

Item	No.	Cost/Item	Total cost(USD)
Naphtha Tankers	16	20,000	320,000
Fuel Oil Tankers	13	20,000	260,000
Tractors	27	70,000	1,890,000
15000 Tons Storage Tanks	2		2,500,000
Spare Parts	1	247,000	247,000
Repaire Equip.	1	430,000	430,000
Contingency			203,000
Total			5,850,000

COST OF TRUCKING (U.S.D. PER TON)

	Naphtha	Fuel Oil
Fuel	13.80	10.76
Lube/Grease	0.61	0.64
Tolls	0.42	0.33
Tires	3.45	3.45
Labor	5.93	5.93
Insurance	3.22	3.22
Maintenance	1.00	1.00
Debt Service	9.00	9.00
Total :	37.45	34.33

All above are estimate in 1981.

3.6 Brief Economic Review

a) MANUFACTURING UREA

GENERAL

The two main factors determining fertilizer costs, the cost of raw materials and investment, can vary significantly for diferent site location and it is important to take this into account when projecting fertilizer costs and prices.

Upto about 1979,more than 70% of the world's ammonia capacity was based on natural gas, with about 15% based on Naphtha and the remainder from oil and several other sources. The energy crisis of 1979 which resulted in disproportionate increase in Naphtha prices meant that many plants based on Naphtha, particularly in Europe and Japan, were no longer competitive and had to close down or change to natural gas.

It seems almost certain, and particularly for nitrogen fertilizer, for the export market, that natural gas will remain the main feed stock during the next decade and beyond.

Another important factor influencing the investment and production costs of urea is the size of the operation.
Although urea plant upto 2000 t.p.d. have been built, as have 1500 t.p.d. ammonia plants,the complex comprising plants to produce about 1000 t.p.d. ammonia and 1700 t.p.d. urea is probably still the most popular combination.

Another factor influencing investment cost is the site location.
Investment for a site with available supporting infrastructure (mostly in developed country) is less than that for a site where supporting infrastructure is not available (mostly in developing country).

DISCUSSION

As it is shown in above, the factors influencing urea fertilizer costs are ;

Raw materials
Investment
Site Location
Plant size etc.

Taking above factors into account for Sudan-Ren chemicals and fertilizer Co., it is clear that none of above factors stand favourably to the company.

b) Urea Price Change

Urea price during the period from 1975 to 1984 was fairly good for the supplier, ranging 250 - 300 USD. per ton.

From end of 1984, the price started to decline mainly due to the export from East Europe and Middle East where ammonia production is based on natural gas which would otherwise be flared.

Early 1985, the urea price had fallen down below 200 USD. per ton and end of 1985 the price had fallen down further to below 100 USD. per ton.By this time, many plants based on imported naphtha, particularly in Europe and Japan, were no longer competitive and had to close down.

It is unfortunate to the Sudan-Ren that urea price had dramatically fallen down at the moment the plant had been mechanically almost completed.

c) Urea Production Cost;

The mission period at site for 3 weeks were not enough for the consultant to find out all the facts took place in the past 10 years in Sudan-Ren and thereafter to provide production cost of urea during operation, it would be preferable just to refer the production cost provided by CREMER & WARNER LTD. in 1982.

Consultant's intention of providing this section is not to show exact figures, but to give some idea on the role of raw material to the production cost.

PRODUCTION COST ESTIMATE

February 1982 by C & W.

Variable Cost

	Rate per MT.		Cost per Unit	Cost per MT. Urea ($) at 70% Oper.	at 100% Oper.
	70%	100%			
1. Naphtha	583KG	516KG	U$333	194.3	172
2. Fuel Oil	595KG	526KG	U$201	119.6	106
3. Raw Water	20.51M³	20.51M³	NIL	-	-
4. Electric power	1101KW	975KW	INCLUDE in 2.	-	-
5. Catalysts				1.3	1
6. Chemicals & Oil				9.6	8.5
7. Bags for Urea				20	20
8. Maintenance Materials				16.7	16.7
				361	324

Fixed Cost

	Rate per MT. 70%	Rate per MT. 100%	Cost per Unit	Cost per MT. Urea ($) at 70% Oper.	Cost per MT. Urea ($) at 100% Oper.
1. Labour and overhead				33.4	23.4
2. Administrative & Sales.				8	5.6
3. Insurance				4	2.8
4. Management Fee				2.3	1.6
5. MGT Incentive Bonus				-	2.8
6. Fuel oil for turn-around and start up.				1	0.7
				48.7	37.0
Sub-total fixed plus variable cost				410	361
Debt service charges				272	190
Profit of 5% of total cost				34	17.5
Urea selling price at factory gate				716	578.5
(1 USD. = 0.9 £)					

d) Breaking Point of Plant Operation

As the magnitude of cost for the various cost items are shown in the Figure, it is very easy to see that raw material such as Naphtha and fuel oil (172 + 106 = 278 USD. per MT. of Urea) and debt service charges due to the financing for the investment are the two main factors mostly influencing the production cost.

If we scrutinize the debt service charges, it would be recognized that this cost accrue regardless of the operation :-
That means Sudan-Ren have to pay back to the banks the loan interest and principal due, whether the plants are in operation or not.
Therefore, for the determination whether the plant shall be operated or close down, the debt service charges and profit are the items which should not be in consideration.

Then it will be recognized that the only big items influencing the cost is the raw material, namely Naphtha and fuel oil.

Therefore, my recommendation to Sudan-Ren is that the plant should be put into operation, when Sudan-Ren could obtain raw materials at the reasonably low price so that SUBTOTAL FIXED plus VARIABLE COST become less than selling price of imported urea in the Khartoum area.

3.7 Alternatives;

Since the production cost by using imported Naphtha and fuel oil would be too high compared with the imported urea price, it would be worthwhile once to consider whether there would be any alternative way economically achieved.

Methanol Production

It was known that ammonia plant could be converted to methanol production with some modification by experienced engineering firm and by the cnage of synthesis catalyst. However, this alternative seems to be not recommendable, since it would be not economically feasible.

For the production of methanol, same kind of raw materials, such as Naphtha and fuel oil is to be used, production cost of methanol by using imported Naphtha and fuel oil would be much higher than that it is produced in the plant where cheap natural gas is available in the adjacent site.

And further to this, there are not so much consumption of methanol in the Sudan, and also additional investment is required for the modification.

Oil Gasification

Since fuel oil price (Bunker-C) is generally cheaper than Naphtha in the international market and there are processes, such as SHELL or TEXACO OIL GASIFICATION, to produce ammonia using fuel oil, it may look like urea so produced would be cheaper.

However, the operability of these processes are known as not so good as plants using Naphtha as raw material, and in the case of Sudan-Ren, additional big investment is required for achieving this.
Therefore this alternative is also not recommendable.

4. RECOMMENDATION;

1. The electric power plants consisting of two steam boilers supplied by BORSIG G.M.B.H., Berlin, and two turbines/generators supplied by SIEMENS could be operated to supply electricity to the town network (2x6.5MW).

2. Ammonia and urea plants could be put into operation when Sudan-Ren could obtain raw materials such as Naphtha and fuel oil or its alternative natural gas at the reasonably low price so that production cost excluding debt service charges and profit become less than selling price of imported urea in the Khartoum area.

3. If plants as erected be going to be not operated for long time as several years, the special preservation procedures from machineries and equipment etc. suppliers are to be strictly followed.

ANNEX-1, ACTIVITIES REQUIRING BEFORE PLANT OPERATION.

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The following are considered to be the necessary activities which Sudan-Ren should persue before plant to operate.

1. Scout several engineers who have enough experience of ammonia-urea plant operation and are reliable, and send to the plants in operation using same technology; namely ammonia plants designed by N-Ren and urea plants using IVO MAVROVIC process, and collect technical information or difficulties experienced by them for the preparation of future operation.

2. Complete any pending construction works.

3. Hire experienced commissioning manager in the level of plant manager to have his general master plan of future operation.

4. Under the advice of commissioning manager, hire additional chemical, mechanical and electrical engineers for the preparation of future operation and maintenance.

5. Irvestigate whether the following items were adquately secured in number and quality.

   a) Spare parts of machinery. equipment electrical and instruments etc.

   b) Catalyst and its spare.

   c) Resins, chemicals and its spare.

   d) Tools, and equipment required for maintenance during operation.

   e) Workshop equipments for mechanical, electrical and instrument.

6. Scout or hire local operators, mechanics, and electrician etc., and have them train for the future operation.
   May be special training programme require.

7. Establish transportation plan for raw materials such as Naphtha and fuel oil.

8. May be, additional financing is required for the transportation of raw materials, for the procurement of spare parts etc., and for hiring experienced expartriates.

9. Establish precommissioning and refurbishing plan for Ammonia, Urea and utility plants.

10. Establish MAN-MONTH requirement for the engineers of important machineries and equipment suppliers and MAN-MONTH requirement for the process licensers respresentatives.

11. Proceed based on above plan. The schedules and plans should be revised whenever revision is necessary.

ANNEX-2, GENERAL PROCEDURES FOR LONG PRESERVATION OF PLANTS.

If plants as erected be going to be not operated for long-time as several years, the special preservation procedures from machinery and equipment etc., suppliers are to be strictly followed.

In case such special procedures are not available, the following general procedures could be applied for the time being.

Once whole system is fully inspected and rusts are all removed, following periodical checks are recommended to be conducted.

a) For Machinery; Fill governor oil,

   1) Shaft turning once a day for small unit.
      Once a week for large unit.

   2) Lube oil circulation 3 times a day.

b) For Equipment;

   1) Catalyst vessel to be sealed with nitrogen.

   2) Vessel, pipe and heat exchanges are also to be sealed with Nitrogen.

c) For Electricals;

   1) Motors : Overhaul and cut breaker.

   2) UPS : Check once a season.

   3) MCC : Cleaning and check.

   4) Conduit : Replace corroded parts.

d) For Instrument;

   1) Transmitter : Maintenance and calibration

   2) Control and safety valves : Overhaul

   3) Board Instruments : Calibration

   4) Orifice and thermowell :replace gaskets..

ANNEX-3, BRIEF HISTORY OF SUDAN-REN.

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In early 1970's the Government of the Sudan undertook number of large agricultural projects to realize some of country's enormous agricultural potential.

In line with this development, the Government decided to produce fertilizer in the country to meet its own demand.

Therefore, the Government comissioned several foreign organization, such as Japan consulting Institute (J.C.I) and Cremer and Warner consulting Engineers of London (C.W), to make feasibility study of manufacturing fertilizer in the Sudan.

J.C.I. reported in February, 1972, that such a project was feasible and a factory with a production capacity of 200,000 tons per year of urea could be justified in the light of the potential demands of agriculture, having regard to the future developments then projected. This report was in favour of Port Sudan location.

An economic review was made by C&W in 1974, in view of dramatic changes in world urea prices and cost escalations affecting current projects.
This review showed that, on the basis of 200,000 tons per year urea capacity, the financing arrangements previously envisaged would result in unacceptably high prices for the urea.

C&W recommanded a urea production capacity of 400,000 tons per year which would need to be linked with an ammonia plant of 800 tons per day capacity.

In a plant of this capacity it would be economically justified to incorporate cetrifugal compression.
This would allow processes using modern technology, backed up with much proven experience, to be installed.

Following the issue of the "Invitation to Bid" for a 400,000 tons per year fertilizer plant for Port Sudan in December, 1974 to SNAM POGETTI, TECHNIMONT, TOYO ENG, CHEMICO, KLOCKNER, KELLOGG AND N-REN, only technimont and N-Ren submitted the bids.

In addition to the bid for the large plant, N-Ren put forward alternative proposals for two small plants to be built at Khartoum, at the terminal of the pipeline from Port Sudan.

N-Ren corporation, an american company suggested the Sudan Government to enter into a joined venture to erect P.D.Q. (Package, Delivered, Quickly) units and will seek the finance for the plants.

Sudan-Ren chemicals and fertilizer Ltd., was created as a joined venture between the Sudanese Government owing 65% of the shares and N-Ren corporation owing 35%.
A Founders Agreement between the two parties was signed, including undertakings by N-Ren to supply and construct the project plant and to seek financing and to provide management and training for the project.

The Government had undertaken to ensure an adequate supply of Naphtha and fuel oil to the project and to purchase the entire output of urea at a price sufficient to enable Sudan-Ren to meet all its obligation.

The first phase, which is already constructed, is 90,000 tons urea per year capacity.
The original contract price set in 1975 was financed by export credits (from Austria, Germany and Canada), by shareholder contribution and by commercial bank loan to cover the foreign exchange share of the Sudanese Government equity.

In 1978 it was made clear to Sudan-Ren by General Petroleum Corp that due to the increase consumption of petroleum products, especially gasoline, all Naphtha produced by the refinery is consumed and no surplus to be supplied to the company for fertilizer production.

In late 1979 a letter from G.P.C. was sent to Sudan-Ren confirming the impossibility of supplying Naphtha. So Naphtha has to be imported.

It was intended that the Naphtha have to be transported to site by the pipeline, but due to certain difficulties this becomes impossible so the raw materials (Naphtha and fuel oil) have to be transported by road or rail.

Regarding the rail road transportation of Naphtha, it was also made clear by railway officials that with the prevailing conditions of the railway, it is almost impossible to depend on it.
So the only alternative is to use road transport.

The construction is 99% completed and most parts of the plant were mechanically accept.
The plant is not yet commissioned.