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MANUFACTURE OF FERTILIZERS USING COKE OVEN GAS IN THE BORIS KIDRIC PLANT, LUKAVIC, YUGOSLAVIA 1/

(Up-dated study of 26 June 1973)

(TS/YUG/74/002/11-01/05)

Report prepared for the Government of Yugoslavia

by

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for the United Nations Industrial Development Organization (UNIDO) as Executing Agency for the United Nations Development Programme

1/ The views and opinions expressed in this report are those of the author and do not necessarily reflect the views of the Secretariat of UNIDO. This document has been produced without formal editing.

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1.00 INTRODUCTION

1.01

In June 1973 a study was carried out on the extension of the existing small ammonia plant for the use of coke oven gas which will be produced in new coke oven batteries, now under construction. If considering the progress realized, it is safe to assume that the coke oven gas for the ammonia production will be available as follows:

1976	:	250	million	Nm^3	p.a.
1978	:	300	"	"	"
1980	:	350	"	"	"

As the construction of the new coke ovens continues progressing according to schedule, nothing needs to be changed regarding the timing of the project.

1.02

Since last year, three facts are to be made responsible for the interest in making the project advance rapidly:

(1) the progress realized in the construction of the new coke ovens which can hardly be started, before having an economical use for the gas; this obliges the Management to proceed with a maximum of dynamism;

(2) the new situation which arose last year on the energy sector has caused an uncertain situation on the fertilizer market with a very substantial increase of prices; this is a unique opportunity for introducing a new production on the world market;

(3) an improvement on the credit market, as far as loans for the industrial development in Yugoslavia is concerned which makes the plant Management optimistic as to the possibility of financing the new ammonia project.

1.03

The Management is confident that the time has come to put the project into practice, and more specifically

- to examine its feasibility,
- to investigate the possible uses for the ammonia produced in a new plant.

The Management has reached the conclusion that an ammonia plant in the order of 550 tonnes per day using coke gas as raw material should be constructed. Some time later, a similar plant, but working with natural gas, should be planned. The use of the ammonia should also be investigated; the Management is quite sure that 200 tonnes ammonia per day can be sold in Yugoslavia without transformation into other nitrogen products.

It seems quite sure that in 1978 enough coke oven gas will be available for the production of 550 tonnes ammonia per day, which confirms the statement already mentioned in our previous report. As far as a possible use of natural gas is concerned, which is not available in the Republic of Bosnia and Herzegovina, it will depend on negotiations still pending between that republic and another Yugoslav republic.

As far as an exportation of nitrogen products is concerned, the Management is by no means opposed to taking it into consideration, since there exists a railway communication between the Boris Kidric concern at Lukavac and the Adriatic harbour of Ploce at a distance of about 300 kms. After the re-opening of the Suez Canal, this will have a particular importance.

The Management expects the mission to determine

(a) the best technologies to be used,
(b) to help in establishing contacts with the most reliable constructing firms, and finally,
(c) to advise on construction and financing.

1.04

The terms of reference of the present mission were:

1. up-date the feasibility study completed in May 1973 by UNIDO on the cost of raw materials for the production of fertilisers and overhead as well as capital investment costs;

2. advise on the choice of technology to be used for the production of ammonia as well as for urea using coke oven gas feedstock for the ammonia plant;

3. extend the feasibility study completed and evaluate the capital investment costs required for the production of urea using CO_2 available from the ammonia plant. Determine the capacity for the urea production facilities;

4. estimate the investment and manufacturing cost as well as saleability of the products including urea;

5. advise on engineering contractors possessing the know-how and experience to implement this project.

1.05

It will be understood that, due to the very fluctuating situation on the specific markets, an evaluation of different elements will not be as accurate as is generally expected, but we hope that it will give sufficient indications for an evaluation of the project's profitability.

1.06

The expert wishes to express his gratefull acknowledgment to Mr.A.Baco, General Manager, of the Boris Kidrič Concern, Mr. S. Kapetanović, Technical Director of the Fertiliser Plant, Mr. S. Nurbegović, Mr.R. Arnaut and all their staff for their comprehensive cooperation in carring out his mission and elaborating this report.

1.07

Last but not least, we wish to thank the UNDP Resident Representative, Mr.A.S.Dam, and his staff for their kind assistance in facilitating in every respect the expert's stay in Yugoslavia.

2.00 CONCLUSIONS AND RECOMMENDATIONS

2.01

Since the completion of our previous study, entiteled "Manufacture of Fertilizers using Coke Oven Gas in the "Boris Kidrič" Plant, Lukavac, Yugoslavia" the situation on the raw materials and on the fertilizers market has fundamentally changed. The study had therefore to be up-dated and adapted to the new sitation.

Due to the present world-wide tight supply of nitrogen fertilizers, exportation of urea had to be taken into consideration, Lukavac being in the position to use for this purpose the Adriatic port of Ploče. Moreover, the "Boris Kidrič" concern is entirely autonomous as far as raw materials are concerned and consequently in a favourable position to compete on the international markets. It is therefore recommended to orientate the planning of the plant towards producing more urea than proposed before, i.e. 168.000 t. instead of 144.000, which is about the maximum obtainable with the gas available.

2.02

On the other hand, there is a possibility to sell about 200 tpd ammonia to a neighbouring soda ash factory. This cannot be declined in consideration of the fact that the other Yugoslave nitrogen plants are much too far away. This is, of course, an unavoidable limitation to CAN and urea.

2.03

Like everywhere else, during the last year raw materials and labour have become more expensive in Yugoslavia. The "Boris Kidrič" management consequently had also to increase the price of the gas and of the utilities and to raise the salaries and wages considerably Consequently, the government also increased the authorised prices for fertilizers, so that the new selling price for CAN is now D 1645 instead of D 896.56 as before, and that of urea D 2002, instead of the former price of D 1.531. Both prices apply for the product bagged and sold at works. The fertilizers are subsidised by the government as they always were.

In order to keep the manufacturing costs as reasonable as possible, it is therefore recommended to avoid over-staffing of the new production units.

2.04

Due to the new orientation towards producing more urea, the CAN production is now kept at 400 t.p.d. which requires only a small change in the CAN plant, but needs an extension of the nitric acid plant which already at the present output of 300 t CAN per day works at full capacity.

2.05

Regarding the ammonia plant, it is now recommended to continue using the Linde plant and to feed the tail gas together with the remaining fresh coke oven gas into the steam reformer of a single train unit. Should the technical management reject that idea, then a BASF partial oxidation system with reciprocating compressors will have to be installed, although it will be more expensive in investment and manufacturing costs. A decision in this respect has not yet been reached, and the choice will depend on the assurances and guaranties to be given by the constructors, who will immedictly be contacted.

2.06

For the manufacture of urea, one of the processes with recirculation of the unconverted reactants is recommended.

2.07

The amount of gas for heating the reformer has been recalculated, especially in consideration of the fact that coke oven gas instead of natural gas will be used. As a result, less gas will be necessary for heating, and more left for the process Consequently more ammonia will be produced.

2.08

Due to the low hydrocarbon contents in the coke oven gas, the CO_2 yielded will not be sufficient for the manufacture of any substantive quantity of urea. It is therefore recommended to install a lime stone kiln which is self-suporting by the sale of quicklime or slaked lime without giving any value to the developing CO_2. This not being mentioned in the terms of reference of the mission, a special feasibility study on this subject will have to be carried out.

2.09

The investment costs and the manufacturing costs have been recalculated on the basis of the new production program. The total of the investment is evaluated at D 630 million (at the present rate: 42 million dollars). The production costs of ammonia will be about D 1200, that of urea D 1277 and of CAN D 837.

2.10

Regarding the saleability of the products Agrohemija and a prominent nitrogen broker company were consulted. At present, any quantity of CAN and urea can be placed, and as to the future, Agrohemija is positive as far as domestic sales are concerned, the broker company however is only reasonably optimistic, since nobody can forsee what can happen in the cours of the three or four years until a new plant is on stream. But the prospects regarding increase of demand are generally considered as good, especially for urea.

2.II

A list of constructors of ammonia and urea plants can be found in the Annex.

2.12

Finally, we recommend to take into consideration that it is possible to carry out the project, as exposed in the present report, in two or three steps: first constructing a plant to manufacture ammonia for sale, and later on enlarging the CAN factory and installing the urea plant.

3.00 THE MARKET SITUATION

3.01

In spite of the fact that during 1973 the forecasted consumptions of 420.000 t nitrogen have not been attained, the Authorities show much optimism as to the outlook for the future, attributing the failure rather to a limited production, than to anything else.

The official consumption figures for 1973 are as follows:

Production	374.400 t N	=	455.000 t NH_3
Import	74.700 " "	=	91.000 " "
Export as NPK	60.000 " "	=	73.000 " "
Stock	5.800 " "	=	7.000 " "

Hence, the local consumption, (production + import) - (export + stocks), was of 345.000 t N against 420.000 t as forecast.

3.02

Nevertheless, Dr. Babović, the Agronomist of Agrohemija responsible for the preparation of the new domestic consumption forecast, asserted in an interview with the expert, although his new figures were not yet official, that the nitrogen consumption might in 1985 be well over 800.000 t, instead of the 710.000 t forecast last year (see our report part 3.05).

The Government's "Green Plan" predicts for 1985 the following domestic consumptions

Slovenia	65.000 t N	=	79.000 t NH_3
Croatia	260.000 " "	=	316.000 " "
Bosnia and Herzegovina	95.000 " "	=	115.000 " "
Serbia	400.000 " "	=	486.000 " "
Macedonia	60.000 " "	=	73.000 " "
Montenegro	6.000 " "	=	7.000 " "
Total of Yugoslavia	886.000 t N	=	1076000 t NH_3

This figure is of the same order than that quoted by Dr. Babović, but we were not able to ascerain, if the two figures are the result of independent investigations or if they are coming from the same source. In any case, we believe that the risk of constructihg of new capacities in the order of 1000 t NH_3 p.day is at present quite justified, especially in consideration of what is exposed in the following paragraphs.

3.03

In addition to the domestic sonsuption, the petroleum crisis, the expected reopening of the Suez Canal and the increasing demand all over the world are opening unforseen possibilities of fertilizer exportation at very favourable conditions. In fact, urea which two years ago quoted about $ 60 p.t fob European harbour, is quoting today $ 300 p.t. Manufacturers of fertilizers buy actually ammonia at $ 160 p.t.

3.04

On the other hand, the installed capacities of production in Yugoslavia are still the same as last year, i.e. about 560.000 t N or 680.000 t NH_3 p.a. out of which the plant in Priština with a capacity of 110.000 t N p.a. is still not in operation. In Pančevo, troubles are experienced with a single stream 1000 t NH_3 per day plant using natural gas. This shows the fragility of the supply, and our belief, supported by the executives of Agrohemija, is that there exists a real need for new ammonia production capacities. The Managemnt of the "Boris Kidrič" concern also shares these views and is decided, to use all possible means in order to carry out the present project and to start, immediately after, a study on a 1000 t.p.d. ammonia plant to be constructed in a few years from now and using Yugoslavia natural gas.

3.05

In this connection, we still maintain that an overcapacity of 1o-2o% is economically sound, especially in a country where an increase of only 5-1o% p.a is anticipated, but which nevertheless has good agricultural possibilities. Even if there were no chances of fertilisers exports (which in fact exist), this will always be a good chance to export cereals obtained by the use of more fertilisers. Presently, Yugoslavia starts already succesfully to export corn. Regarding the export of fertilizers, the geographical situation of Lukavac is very favourable, since the plant is connected by a direct railway with the Adriatic port of Ploče at a distance of about 3oo kms.

3.06

Regarding the choice of fertilizers to be produced in Lukavac, the management still intends not to use imported raw materials. This is particularly right today, because of the independence from foreign sources and their prices policies. The plan of the Lukavac concern is therefore to continue manufacturing CAN for domestic use and to start a production of urea.

In one previous report, we suggested a relation between CAN and urea of about 1:0.9, but now the chances of exportation having considerably improved, we suggest a CAN to urea ratio of 1:1.3, i.e. 4oo t CAN and 525 t urea per day. In fact, urea is the richest nitrogen carrier and more suitable for transport than any other solid nitrogen fertiliser and, on the other hand, Lukavac is, as already mentioned, in a geographically favourable position for oversea export.

4.000 THE NEW PLANS FOR PRODUCTION OF NITROGEN IN THE BORIS KIDRIČ PLANT AND THE TECHNOLOGY RECOMMENDED

4.001

Since the last year, when the previous report was made, the planning of the future fertilizers production has developed considerably. On the international market, the situation has become hectic, due to the rise in prices of the raw materials. The Boris Kidrič Concern working with indigeneous raw materials and being therefore independent from imported natural gas, is now in a favourable position to compete on the international market. On the other hand, the Management decided to raise the wages and salaries as well as prices of the coke oven gas and the utilities. Internationally, the investment costs have also undergone a rise. All these reasons call for a reconsideration and an updating of the feasibility study, particularly with a view to exportable products.

4.002

On the contrary, no change was experienced as to coke oven gas supply which will be available at the time scheduled last year. Hence, the quantities of the natural gas available will be

250 million Nm^3 p.a. from 1976,
300 " " " " 1978,
350 " " " " 1980.

If the overhaul of the existing coke ovens is postponed, the situation from 1978 on may be even more favourable than foreseen. This however will be of little importance for the future nitrogen plant, since the factory can anyhow hardly be expected to be working before three years from now.

4.100 AMMONIA

4.101

As to manufacturing process for ammonia, the last year's recommendation to use the hydrocarbon reforming with steam is maintained, in spite of the fact that, to our knowledge, until now no steam reforming plant for coke oven gas has been constructed. However, constructors interviewed during the last

ACHEMA exibition in Frankfurt maintain that the high hydrogen and the low methane concentrations in the gas have no major influence on the issue, provided special calculations of the reformer itself are undertaken. The old Bartholomé-Sachsse process is much too expensive, and cannot compete with the modern methods. The BASF low pressure and high pressure partial oxidation have been, to our knowledge, applied only for small plants up to approximatively 300 tonnes ammonia per day.

And finally, a combination of a gas separation of the coke oven gas with partial oxidation of the residual tail gas (the quantity would not be large enough for steam reforming) would yield roughly 300 to ammonia per day from the gas separation (Linde) and 360 to p. day from the tail gases at a price much too high if compared with other processes. In fact, according to records of the present production, the cost of ammonia produced in a Linde plant would, in a new plant, be much over D 2000 p.to. (see p. 14)

For a plant of the envisaged size and based on coke oven gas it appears safe enough to entrust with its construction one of the renown firms having great experience in the building of steam reformers.

4.102

Actually, the Boris Kidrič Concern produces 100 t p. day ammonia in a 12 years old LINDE plant which works satisfactorily. The records show that the maintenance costs of the plant are 5% of the plant's value, but expressed in new Dinars, without taking into consideration of the depreciation of the currency during the last 12 years. It is assumed that the plant which is already paid off can still remain in operation for a number of years, without showing serious troubles, and it is therefore recommended to continue keeping it in operation.

4.103

The 46 million Nm^3 tail gas from the Linde plant should no longer be used for heating purposes, but fed, together with 230×10^6 Nm^3 fresh gas, into a steam reforming unit and credited to the Linde plant at a value of D 0.35 per Nm^3, which corresponds to the value of the tail gas, when used for the manufacture of ammonia. The amount of the fresh gas fed into the Linde plant being 120 million Nm^3 per year, the amount of the total gas used for ammonia production will then be 350 million Nm^3 and correspond to the total gas available. The flow sheet of the process can be seen on the next page.

4.104

The ammonia produced will be of 210.000 to p. year or 650 to p. day. Out of this total quantity 32,000 to per year or 100 to per day will be yielded by the Linde plant, and the remaining 175 to 180.000 to p. year or 540 to 560 to p. day by the steam reforming unit.

4.105

This arrangement has two advantages, i.e. it helps reducing the investment costs and it is flexible enough to allow, if necessary, to work below capacity, without increasing the costs per ton of product. For instance, during the initial period, when only 250 million Nm^3 gas will be available, it will be possible to work with the reforming plant alone at its full capacity, thus absorbing the whole gas amount available.

4.106

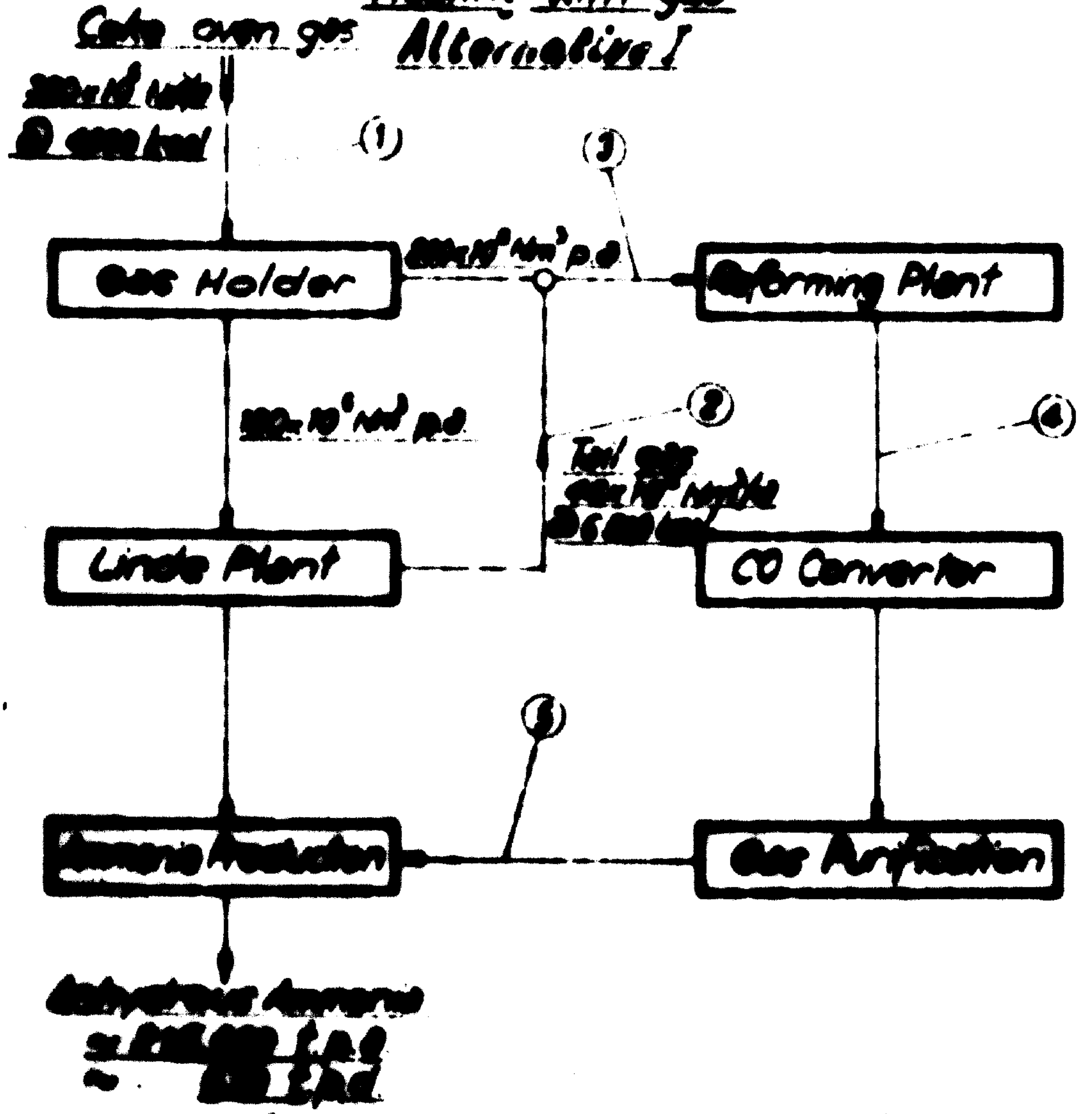
The tables "AMMONIA (1)" and "AMMONIA (2)" on pp 14 and 15 show a tentative calculation of the production costs of ammonia, when manufactured according to the recommended arrangement. As a result, are produced in one year:

32.000 t ammonia from the Linde plant at D 1676 p.t.	D 53.636.000
175.000 t ammonia from the reformer at D 1114 p.t.	D 194.921.000
207.000 to ammonia at an average of D 1200 p.to	D [illegible]

with an estimated investment of about D [illegible] million.

PROPOSED FUTURE FLOW SHEET

Heating with gas



Approx. gas composition vol. %

	1	2	3	4	5
H_2	[illegible]	4.0?	[illegible]	[illegible]	[illegible]
CH_4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CO	[illegible]	[illegible]	[illegible]	[illegible]	-
C_nH_m	[illegible]	[illegible]	1.0?	-	-
N_2	[illegible]	[illegible]	[illegible]	3.0?	[illegible]
[illegible]	[illegible]	-	1.3?	[illegible]	–
[illegible]	[illegible]	[illegible]	[illegible]	~30?	-

TENTATIVE CALCULATION OF PRODUCTION COSTS

(Alternative I)

AMMONIA (1)

(LINDE Plant)

Production: 100 t/d or 32.000 t/320 d

(No investment)

	Quantity p.a.	Price D	Costs D p.a.	Costs D/t	%
1) Raw materials:					
Gas (4200 kcal/Nm³) Nm³	120×10^6	0.22	26.400.000	825	38.6
Catalyst			225.000	7	0.3
2) Labour	66		3.032.000	95	4.5
	32		3.089.000	97	4.6
	16		1.617.000	50	2.3
3) Utilities:					
Power kWh	56×10^6	0.32	17.920.000	560	26.2
Cooling water m³	4×10^6	0.35	1.400.000	44	2.1
Desalted water m³	26.000	5.50	143.000	4	0.2
4) Maintenance					
5% of 145×10^6			7.250.000	227	10.6
5) Auxiliary products			2.330.000	73	3.4
6) Laboratory			750.000	23	1.1
7) Overhead			3.370.000	105	4.9
8) Depreciation			-	-	-
9) Insurance 0.6%			840.000	26	1.2
Subtotal			68.396.000	2.136	100
10) Credit for tail gas Nm³ (6200 kcal/Nm³)	46×10^6	0.35	14.780.000	462	
Total			53.616.000	1.676	

TENTATIVE CALCULATION OF PRODUCTION COSTS

(Alternative I)

AMMONIA (2)
(heating with coke oven gas)

Production 570 t p.d. or 18[illegible],000 t per 330 d.

x) Investment D 410 MM

	Quantity p.a.	Price D	Costs D.a.	Costs D.t.	%
1) Raw materials:					
Coke gas Nm^3	160×10^6	-.22	35,200,000	192	17
Tail gas Nm^3	46×10^6	-.35	16,100,000	88	8
Catalyst etc.		30	5,490,000	30	3
2) Labour	51	63,326	3,230,000	18	2
Foremen and mechanics	42	77,736	3,265,000	18	2
Supervision and management	16		1,617,000	9	1
3) Utilities					
xx) Power kWh	70×10^6	-.32	22,400,000	122	11
Cooling water m^3	40×10^6	-.35	14,000,000	77	7
Desalted water	370,000	550	2,035,000	11	1
xxx) Gaseous fuel	70×10^6	-.22	15,400,000	84	8
4) Maintenance 5%			20,000,000	109	10
5) Auxiliary products		20	3,660,000	20	2
6) Laboratory		850	498,000	3	-
7) Overhead ([illegible] of labour and supervision)			4,096,000	22	2
8) Amortisation					
of cash payment (D 123 MM)			12,300,000	67	6
of credited sum (D 287 MM)			37,170,000	203	19
9) Insurance [illegible]			2,460,000	13	1
Totals			198,841,000	1,086	100

x) [illegible] paid in cash, and 70% in [illegible] instalments at a compound interest of [illegible] p.a.

xx) [illegible] kWh p.t NH_3 incl. initial compression to 40 Atm (287 kWh/t)

xxx) 1.6×10^6 [illegible] p.t NH_3

4.107

In addition to the process described above, which in the following is called "Alternative I" the costs of ammonia produced according to two other alternatives, both based upon steam reforming alone, were calculated of which in the one coke oven gas is used for the heating of the reformer (Alternative II), while in the other (Alternative III) the reformer is heated with fuel oil, so as to have more gas available for ammonia production. The investments for the alternatives II and III are estimated respectively at D 450 million and 570 million. The cost of ammonia will be D 1,060 p.t for the Alternative II and D 1,250 for the Alternative III which is due to the much higher cost of fuel oil which per kcal is about three times as expensive as coke oven gas.

4.108

Resuming, the three above alternatives can be presented as follows:

<u>Alternative I</u> (using the existing Linde plant combined with steam reforming and using coke oven gas as fuel)

Production: 670 t p. day
Investment: D 410 million
Ammonia cost: D 1,200 p. tonne

<u>Alternative II</u> (steam reforming alone using coke oven gas as fuel, no Linde Plant)

Production: 670 t p. day
Investment: D 450 million
Ammonia cost: D 1,060 p. tonne

<u>Alternative III</u> (steam reforming using fuel oil)

Production: 840 t p. day
Investment: D 570 million
Ammonia cost: D 1,250 p. tonne.

For the calculation of the production cost of urea and CAN, the most likely, although not the lowest cost of D 1,200 per tonne ammonia will be used (Alternative I).

TENTATIVE CALCULATION OF PRODUCTION COSTS

(Alternative II)

AMMONIA (3)

(Heating with gas)

Production: 67o t p.d. or 215.000 t p.a. (320 days)

x) Investment: D 45o MM

	Quantity p.a.	Price D	Costs p.a.	Costs p.t.	%
1) Raw materials:					
Process gas ([illegible] kcal/[illegible]) m^3	27o x $1o^6$	o.22	59.4oo.ooo	276	26
Catalyst, say		3o.oo	6.45o.ooo	3o	3
2) Labour	51	63.326.oo	3.23o.ooo	15	1
Foremen and mechanics	42	77.736.oo	3.265.ooo	15	1
Supervision and management	16		1.617.ooo	8	1
3) Utilities:					
xx) Power kWh	86 x $1o^6$	o.32	27.52o.ooo	128	12
Cooling water m^3	5o x $1o^6$	o.35	17.5oo.ooo	8o	8
Desalted water m^3	45o.ooo	5.5o	2.475.ooo	12	1
xxx) [illegible] fuel ([illegible] kcal/[illegible]) m^3	8o x $1o^6$	o.22	17.6oo.ooo	82	8
4) Maintenance 5%			22.5oo.ooo	1o5	1o
5) Auxiliary products		2o.oo	4.3oo.ooo	2o	2
6) Laboratory		2.5o	538.ooo	3	
7) Overhead ([illegible] of labour + supervision)			4.o56.ooo	19	2
8) [illegible] [illegible] p.a.					
of cash payment (D 135 MM)			13.5oo.ooo	63	6
of credited sum (D 315 MM)			4o.758.ooo	19o	18
9) [illegible]			3.ooo.ooo	14	1
Total			227.744.ooo	1.o6o	1oo

x) [illegible] in cash, and [illegible] in annual instalments at a compound [illegible] [illegible] p.a.

[illegible] [illegible], including compression to [illegible] Atm (227 kWh/t) [illegible]

TENTATIVE CALCULATION OF PRODUCTION COSTS

(Alternative III)

AMMONIA (4)

(Heating with oil)

Production: 840 t p.d. or 270.000 t in 320 days

x) Investment: D 570 MM

	Quantity p.a.	Price D	Costs D p.a.	Costs D/t	%
1) Raw materials:					
Gas (4.200 kcal/Nm^3) Nm^3	350 x 10^6	0.22	77.000.000	285	23
Catalyst, say		30.00	8.100.000	30	2
2) Labour:	51	63.326.00	3.230.000	12	1
Foremen and mechanics	42	77.736.00	3.265.000	12	1
Supervision and management	16		1.617.000	6	
3) Utilities:					
xx) Power kWh	110 x 10^6	0.32	35.200.000	130	10
Cooling water m^3	60 x 10^6	0.35	21.000.000	78	6
Desalted water m^3	550.000	5.50	3.025.000	11	1
xxx) Fuel, t	46.000	1.530.00	70.380.000	261	21
4) Maintenance 5%			28.500.000	106	8
5) Auxiliary products		20.00	5.400.000	20	2
6) Laboratory		2.50	6.750.000	25	2
7) Overhead (50% of labour + supervision)			4.056.000	15	1
8) Depreciation: 10% p.a.					
of cash payment (D 171 MM)			17.100.000	63	5
of credited sum (D 399 MM)			51.670.000	191	15
9) Insurance 0.6%			3.420.000	13	1
Total			339.713.000	1.258	100

x) 30% of which in cash, and 70% in annual instalments at a compound interest of 5% p.a.

xx) 400 kWh p.t NH_3 incl. initial compression to 40 Atm ([illegible] kWh/t

xxx) 1.6 x 10^6 kcal p.t NH_3

4.109

As to the manufacture of urea from ammonia, it is general practice to use for that purpose the CO_2 resulting from the reforming of the hydrocarbons during the manufacture of ammonia. Although in our case the by-product CO_2 would theoretically be more than sufficient for a daily production of 525 tonnes of urea, the losses during the scrubbing of the gas are high enough to make it questionable. The problem will therefore have to be discussed with the constructor of the ammonia plant or a separate study about a self-sufficient production of CO_2 from limestone will hav to be envisaged. In both cases, the value of the CO_2 which otherwise would be vented can be considered zero for the evaluation of the manufacturing costs of urea.

4.110

On the other hand, there is a possibility mentioned by the Management of selling 200 to ammonia per day to a neighbouring soda ash factory and an already existing need of 100 t ammonia p. day for the manufacture of 300 t CAN. With a minor change in the installation of the factory, this production can be increased to yield 400 t per day, so that the consumption of ammonia will be of about 135 t per day, leaving a balance of about 305 t ammonia per day for other purposes, in this case for the manufacture of 585 t urea per day. To put it briefly:

200 t ammonia per day for sale
135 t ammonia per day for the production of 400 t CAN
305 t ammonia per day for the production of 585 t urea

Total: 640 t ammonia per day.

4.111

This solution seems to be very favourable under the present circumstances, because it necessitates the lowest investment. In fact, there would be necessary to invest:

for the ammonia factory (640 t/d)	D 410 million
for the urea plant (585 t/d)	D 100 "
for the extension of the nitric acid plant	D 25 "
for the adaptation of the CAN plant to produce 400 t CAN p.day	D [illegible] "
Total:	D [illegible] million

4.112

The sales per year can be imagined as follows:

64.000 t ammonia	at the local price of	D 3200 :	D 205 million
128.000 t CAN	" " " "	" 1649 :	" 211 "
28.000 t urea	" " " "	" 2802 :	" 78 "
140.000 t urea for export FOB European harbour		" 4500 :	" 630 "
		Total	D 1.124 million

The comparison with the production costs shows that the investment could practically be paid off after one year of operation.

4.113

Another attractive possibility if using 640 t p.d. ammonia (Alternative I) could consist in not changing at all the output of the CAN factory. The production programme could then be the following:

200 to ammonia per day:	200 t NH_3
300 t CAN per day:	100 " "
600 t urea per day:	340 " "
	640 t NH_3

There are still other, more or less attractive possibilities of using the ammonia produced according to either one of the three alternatives proposed in para 4.108. They will only depend on the policy of the Boris Kidrič Management with regard to the marketing of its production.

4.200 UREA

4.201

There exist several processes to manufacture urea from ammonia and carbon dioxide, out of which the BASF, the CHEM, the Montecatini or the STAMICARBON process can be mentioned as, to our knowledge, the most used. All of them have their advantages and, may be, also their disadvantages. The present study is based on the STAMICARBON process. The reaction takes place in two steps. In the first step ammonium carbamate is formed which in the second step decomposes into urea and water. Since the equilibrium is at about 50%, the difficulty consists in using the unreacted components. In factories in which great quantities of ammonium salts are produced, the unreacted components can easily be used for this purpose. Where it is not case, the urea is separated and the rest is recycled into the reactor by a somehow complicated procedure. Great constructors use processes developed by Montecatini or STAMICARBON; the cost of the plant as well as the other conditions will have to be examined, before taking a final decision.

The chemistry of the urea process is presumed to be known. It can be found in the specialised literature, books and periodicals. A tentative calculation of the production costs can be consulted on page 22.

4.300 CALCIUM AMMONIUM NITRATE (CAN)

4.301

The Management and the technical staff of the Boris Kidrič Concern are most familiar with the production of CAN, and there is at present no necessity to go into details, when dealing with this product. However, it seems worth while reminding that it may not be difficult to extend to 400 t p.d. the present production rate of 300 t p.d., if the nitric acid plant, which at present is at the peak of its capacity, is expanded by 30%. The costs of the amendments necessary, are estimated at D 30 million, and the calculation of the production costs for nitric acid and for CAN can be found on pp 23 and 24.

TENTATIVE CALCULATION OF PRODUCTION COSTS

UREA 46%

Production: 525 t p.d. or 168.ooo t in 32o days

x) Investment: D 2oo MM

	Quantity p.a.	Price D	Costs p.a.	Costs p.t.	%
1) Raw materials:					
Ammonia t	95.76o	1.2oo	114.912.ooo	684	61
CO_2 t	127.ooo				
2) Labour:	8	63.236	5o6.ooo	3	
Foremen and mechanics	2o	77.736	1.555.ooo	9	1
Supervision and management	8		8o8.ooo	5	
3) Utilities:					
Power 13o kWh/t = kWh	21×10^6	o.32	6.72o.ooo	4o	4
Water, cooling	12×10^6	o.35	4.2oo.ooo	25	2
Steam 26 at, 23o°	18o.ooo	12o.oo	21.6oo.ooo	129	12
4) Maintenance 5%			1o.ooo.ooo	59	5
5) Auxiliary products:			3oo.ooo	2	
6) Laboratory:			13o.ooo	1	
7) Overheads (50% of labour + supervision)			1.435.ooo	9	1
8) Depreciation: 10% p.a.					
of cash payment (D 60 MM)			6.ooo.ooo	35	3
of credited sum (D 140 MM)			18.13o.ooo	1o8	1o
9) Insurance o.6%			1.2oo.ooo	7	1
Subtotal for unpacked product			187.496.ooo	1116	1oo
xx) Bagging etc.			27.o48.ooo	161	
Total of product p.t. in bags			214.544.ooo	1277	

x) 30% of which in cash, and 70% in annual instalments at a compound interest of 5% p.a.

xx) According to the plant's records.

TENTATIVE CALCULATION OF PRODUCTION COSTS

NITRIC ACID (24% N)

Production: 27o t p.d. or 86.ooo t p. 32o days

Additional investment: D 25 MM in cash

	Quantity p.a.	Price D	Costs p.a.	Costs p.t.	%
1) **Raw materials:**					
Ammonia	25.3oo	1.2oo	3o.36o.ooo	353	68
Catalyst (loss o.12 g/t)		15o	1.548.ooo	18	3
2) **Labour:**	4	63.236	253.ooo	3	1
Foremen and mechanics	11	77.736	855.ooo	1o	2
Supervision and management	1		1oo.ooo	1	
3) **Utilities:**					
Power kWh	o.77 x 1o⁶	o.32	246.ooo	3	1
Cooling water m³	12 x 1o⁶	o.35	4.2oo.ooo	49	9
Desalted water m³ (boiler feed + process)	65.ooo	5.5o	358.ooo	4	1
4) **Maintenance**, say			3.ooo.ooo	35	7
5) **Auxiliary products**			225.ooo	3	1
6) **Laboratory**			1oo.ooo	1	
7) **Overheads** (5o% of labour + supervision)			6o4.ooo	7	1
8) x) **Depreciation:** (1o% of D 25 MM)			2.5oo.ooo	29	5
9) **Insurance** o.6%			3oo.ooo	3	1
Total			44.649.ooo	519	1oo

x) The 12 years old plant itself is already written off.

TENTATIVE CALCULATION OF PRODUCTION COSTS

CAN, 27% N

Production: 400 t p.d. or 128.000 t p. 32o days

Additional investment: D 5 MM in cash

	Quantity p.a.	Price D	Costs p.a.	Costs p.t.	%
1) Raw materials:					
Ammonia	22.000	1.200	26.400.000	206	30
Nitric acid 24% N	81.500	519	42.299.000	330	49
Limestone	28.200	75	2.115.000	17	3
2) Labour:	30	63.326	1.900.000	15	2
Foremen and mechanics	45	77.736	3.498.000	27	4
Supervision and management	2		200.000	2	
3) Utilities:					
Power 4o kWh/t = kWh 5	5.1×10^6	0.32	1.632.000	13	2
Water m^3	3.8×10^6	0.35	1.330.000	10	2
Steam t 16 at	28.800	90	2.592.000	20	3
Gas Nm^3	1.400.000	0.22	308.000	2	
4) Maintenance 5%					
5) Auxiliary products:			500.000	4	1
6) Laboratory			100.000	1	
7) Overheads (50% of labour + supervision)			2.799.000	22	3
8) x) Depreciation: 10%			500.000	4	1
9) Insurance 0.6%			384.000	3	
Sub-total for unpacked product			86.977.000	676	100
xx) Bagging etc.			20.608.000	161	
Total p. t in bags			107.185.000	837	

x) The 12 years old plant itself is already written off.

xx) According to the plant's records.

ANNEX

LIST OF SOME CONSTRUCTORS OF FERTILIZER PLANTS

1. L'AIR LIQUIDE S.A., 75 Quai d'Orsay, PARIS
2. CHEMICO/CHEMICAL CONSTRUCTION CORPORATION, NEW YORK
3. DAVY-POWERGAS, 5 KÖLN, Aachenerstrasse 953
4. FOSTER WHEELER CORPORATION, 666 Fifth Avenue, NEW YORK, USA
5. FRIED-KRUPP, MASCHINEN- und STAHLBAU, D-414 Rheinhausen, POSTFACH
6. HEINRICH KOPPERS GMBH, Moltkestr. 29, ESSEN, DEUTSCHLAND
7. HOECHST-UHDE INTERNATIONAL GMBH, D-46 DORTMUND, Deggingstrasse 10-12
8. HUMPHREYS AND GLASGOW LTD., 22 Carlisle Place, LONDON SW1
9. KELLOGG CONTINENTAL B.V. de Boelelaan 589, P.O. Box 5295, AMSTERDAM, NEDERLAND
10. ETS. KUHLMANN, 25, BD. de L'Amiral Bruix, PARIS 16e
11. LURGI GESELLSCHAFT FÜR CHEMIE UND HUTTENWESEN M.B.H., D-6 FRANKFURT/M, Gervinusstrasse 17 - 19
12. ORONZIO DE NORA, Via Bistolfi 35, MILANO
13. PETROGAS-INGENIEURSBUREAU N.V., Bodesand 34, ROTTERDAM, NEDERLAND
14. J.F. PRITCHARD AND COMPANY, KANSAS CITY
15. SOCIETE CHIMIQUE DE LA GRANDE PAROISSE, 9 Avenue Schuman, 75007, PARIS
16. SNAM PROGETTI, SAN DONATO MILANESE, ITALIA

[redacted]

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