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Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
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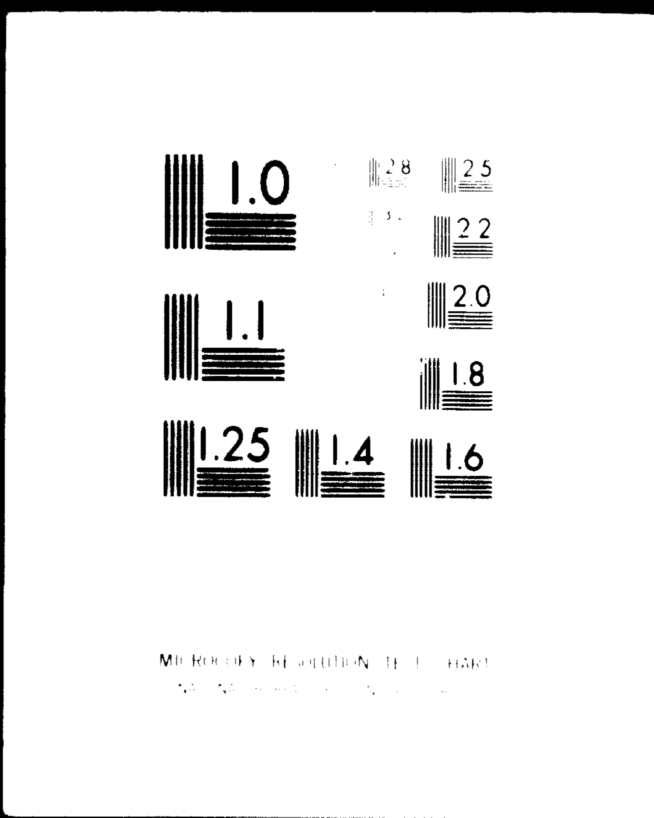

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U N I D O

BACKGROUND AND OUTLINE

FOR UNIDO ASSISTANCE

for

RWANDA.

THE DEVELOPMENT OF A FERTILIZER INDUSTRY

BASED ON LAKE KIVU NATURAL GAS

Fredrik Sager
Interregional Adviser
Industrial Technology Division
UNIDO

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SYNOPSIS

The present state of knowledge on the various aspects of the subject is reviewed, starting with the studies on the gas dissolved in the lower layers of the Lake, the bathymetric information and the estimation of the total gas reserves.

Following this, the Cape Rubona pilot plant for the extraction and washing of Lake Kivu gas is described. Operating data are given and reference is made to the lessons which have so far been learnt from six years of operation. The possibility of increased utilisation is reviewed with particular emphasis on the use of Lake Kivu gas for the production of Nitrogenous Fertilizers which is considered a sine qua non requirement for Rwanda's economic "take-off". In conclusion a plan is drawn up for the steps leading towards the implementation of such a programme.

TABLE OF CONTENTS

I. INTRODUCTION

Facts and statements reported elsewhere will not be repeated here unless they are found to be absolutely necessary for following the case developed hereafter.

The pertinent literature in the form of reports or publications is listed in chapter VII.

A selected number of sources believed to be useful for immediate reference and/or not generally available have been reproduced in full and are presented under chapter VIII.

First hand information was obtained in the course of the writer's recent visit to Rwanda (13 through 17 July) which he undertook at the request of the Executive Director as a member of the mission headed by Mr. A. Sylla (memo Mr. A. Sylla to Mr. E. Ward, dated 14 June). This visit also fell within the specification for the SIS Mission 68/323 (RWA-13), copy of which is to be found under chapter VIII - attachments. Cape Rubona pilot plant was visited on this occasion. The findings of the inspection are reported in chapter III.

On 2 August the writer met in Brussels with MM. van Vlaenderen and Fredrick, both of OCD (Organisme de Coopération au Développement) and M. Froment of Union Chimique Belge, all having been connected with the Lake Kivu project from the very beginning.

In the course of the conversation the technological and hydrological aspects of the Lake Kivu project were discussed. Interesting contributions were made by the Belgian experts in particular concerning the bathymetric exploration of the lake dealt with in chapter II.

In connection with the subject of gas utilization the writer received from M. Froment copy of a study just published by the Université libre de Bruxelles, dealing with "The establishment of a fertilizer plant in Rwanda, based on Lake Kivu gas". The author, M. J.-F. Wouters was guided in his work by M. J. Bosquet, professor of the Université libre de Bruxelles and director of the engineering division of Union Chimique Belge, and assisted throughout by M. Froment.

The full reproduction of this report can be found under chapter VIII - attachments.

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II. GAS COMPOSITION, BATHYMETRIC DATA, ESTIMATED GAS RESERVES

The average gas composition in the layer 275 to 425 metres below lake surface level is reported as follows:[1,7,8)]

CH_4	24,9 %
CO_2	73,5 %
H_2S	0,05 %
Inertes	1,55 %

Nineteen spot samples taken at a depth of 300 m gave the same result and so did six further spot samples taken at depths varying from 275 to 445 m below the level of the lake surface. The measurements included the determination of the volume ratio gas/water and methane/water which varied with the depth from 1,203 to 2,400 and 0,3158 to 0,499 respectively. It was concluded that gas composition and solubility of gas is homogenous at constant level[7,8)].

The first bathymetric map was produced by Damas in 1937[7)]. On behalf of the "Institut Royale des Science Naturelles", Brussels, a revision of this map was undertaken by Capart[1)].

Calculations effected by extrapolation indicate 50.10^9 Nm^3 as an approximate estimation of the total methane reserves in the lake.

The gas reserves are of a dynamic nature as fresh gas is continuously being formed by plankton decomposition. So far no data are available to calculate the exact yearly increment of the gas reserves[1,8)].

The importance of complete bathymetric data, in particular for the shore-type of recovery plant is obvious.

The closer the collecting pipe can be placed to the vertical position, the smaller will be the risk of loss of suction which will occur when the force of the gaslift becomes equal to the friction loss of the rising gas and water stream.

The criteria for the choice of the site for the next gas recovery plant will obviously be the vicinity to the point of gas utilization and the under-water profile of the lake shore.

It is, therefore, recommended that a complementary bathymetric survey be undertaken soonest, particularly in the region of Kibuye. According to MM. Froment and van Vlaenderen, referred to in the introduction, such a study could be executed within three to four weeks. An appropriate vessel appears to be still in the region and the echo sounding equipment could easily be obtained on loan from a specialized firm.

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III. THE CAPE RUBONA PILOT PLANT FOR THE RECOVERY AND WASHING OF LAKE KIVU NATURAL GAS

The flow chart and equipment list, drg. no. 67359 by Union Chimique Belge (attachment 3) gives a detailed description of the pilot plant installed by Union Chimique Belge in 1962.

The process includes two con-current washing stages. The washing medium is water from the lake with a p_H of 9,3. At the time of inspection gas was recovered from the lake at the rate of 270 m^3/h. Of this approx. 30 m^3/h were used for energy requirements for washing and compressing the gas to 2,5 to 4,0 at, giving a net production of 240 m^3/h, equivalent to 2.10^6 m^3/year at 95 % operating efficiency. Further 6 l/h of fuel oil were used which, according to the respective calorific values, correspond to about 12 m^3/h of gas, giving an equivalent total gas consumption of 15.5 % for process requirements.

The lower calorific value of the gas produced was 4.500 Kcal/m^3 corresponding to 6.000 Kcal/Nm^3. (The lower calorific value for methane is 9.313 Kcal/Nm^3.)

Union Chimique Belge have patented some of the features of this unique plant. Patent rights and the plant have subsequently been transferred to the Rwandese Republic under a special convention. The plant is presently operated by REGIDESO, the Rwandese successor of the "Régie des Eaux". The gas is sold to the Bralirwa Brewery at 4.5 UScts/m^3.

Three sorts of problems are requiring attention:

(a) materials of construction
(b) the disengagement of the gas from the water
(c) the washing process

For the present plant the problems under(a) are of an urgent nature. Corrosion of the metallic parts by H_2S is causing serious trouble and some of the main valves cannot be operated any longer. Unless appropriate measures are taken the plant will probably be unfit for further operation in about 3 to 4 years.

The six years of operation have provided valuable experience concerning material as well as process engineering problems and have led to a number of studies dealing with possible improvements[2,4,6].

The FED (Fonds Européen de Développement) is presently considering a short term project with the aim of improving the Cape Rubona plant. The amount of US$ 280.000 has been earmarked for this purpose.

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IV. THE UTILIZATION OF LAKE KIVU NATURAL GAS, A REQUIREMENT FOR RWANDA'S ECONOMIC "TAKE-OFF"

The methane dissolved in the deep waters of Lake Kivu represent for the time being the only known hydrocarbon reserve of the region.

As for its utilization as fuel the methane finds a competitor in the important peat deposits, particularly these at Ruhengeri and Rugezi. Hydroelectric power projects have also to be considered under this angle.

Although methane has a clear advantage over peat both, as far as handling and combustion are concerned, the labour intensive aspect of the peat industry on one hand and the uniqueness of the methane as chemical raw material on the other, point towards a "nobler" utilization of the gas.

With the population growing faster than the production and the availability of food per inhabitant decreasing while the soil is being rapidly exhausted a state of affairs is developing in Rwanda for which the creation of a local fertilizer industry represents the most direct approach towards breaking the vicious circle of underdevelopment and creating conditions necessary for the conomic "take-off"[3,8].

The figures for the foreign trade deficit in the years 1964,65, and 66 expressed in US$ were 460,000, 7,000.000 and 14,000.000 respectively and provide further evidence for the situation[5].

Calculations have shown that nitrogenous fertilizers can be produced economically from Lake Kivu gas[8].

The production cost of 1 ton of Urea at a rate of 300 t/d was estimated to be US$ 57.5/t. Approximately 60.10^6 Nm^3/year methane would be required to produce 300 t/d of Urea.

The transport only of one ton of Urea from a port in Western Europe to Kigali would amount to approx. US$ 93, the connection being assured by rail from Mombassa to Kampala (1210 km) and from there by road to Kigali (556 km).

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V. THE STRATEGY FOR INCREASING THE PRODUCTION AND UTILIZATION OF LAKE KIVU NATURAL GAS

As indicated in chapter III, the total of the gas produced is at present sold to the nearby brewery where it is used as boiler fuel. According to information collected locally this covers only two thirds of the requirements.

The following further gas consumptions have recently been listed as probable[6]:

Funda, tea factory	420.000 m^3/y	at	4.500	Kcal
Gisenyi, domestic use and various	145.000 "	" "	4.500	"
Pyrethrum, drying of flowers	3,600.000 "	" "	4.500	"
extraction plant	900.000 "	" "	4.500	"
Ruhengeri, domestic use	70.000 "	" "	4.500	"
Glass factory, lime kiln and Iron foundry	3,490.000 "	" "	4.500	"

When considering increased production, the first point to be clarified is the advisability of reshaping the Cape Rubona pilot plant into a prototype which could be used as a pattern for standard sized units.

An analysis of the situation shows that in order to reach this goal many pieces of the present equipment would have to be scrapped, while for others, like the compressor for example, a multiple would have to be provided. In conclusion, the idea of revamping the pilot plant to a commercial prototype can be dismissed.

The logical way to proceed appears to be a two-phase approach based on a short- and a long-term programme. The short-term action would concern the most urgently needed repairs and improvements of the Capo Rubona pilot plant to secure its continued operation and to increase its output in order to satisfy at least the total requirements of the brewery.

The implementation of this phase is under consideration by the FED, as indicated earlier in chapter III.

The long-term programme should include all the necessary steps for the creation of a suitable commercial prototype of which as many units as required could be built in order to make up the total demand. Experience obtained in the six years of operation of the Cape Rubona plant and in its forthcoming revamping should be reflected in the design of the prototype.

The specifications for synthesis raw material being considerably more stringent than for fuel, the problems associated with the design and location of the gas washing plant (or plants) will have to be thoroughly investigated at an early stage.

As for the quantity of gas to be recovered per unit it will be advisable not to exaggerate the up-scaling from the pilot plant. The first reason for this comes from technological consideration, while the second one is given by the necessity to know more about the effect of continued increased exploitation on the stratification of the deep waters, or euphemistically speaking about the "caviation" of the gas holding layers.

Considering on one hand these limitations and on the other the necessity to develop the latent fertilizer market, the first logical step after the creation of the prototype appears to be the installation of an Ammonia-Urea unit of the skid mounted, shop fabricated type with the modest production capacity of say 100 t/d of Urea, requiring about 20.10^6 Nm^3 of methane per year. It can be anticipated that two or at the most three prototype units should be sufficient for producing this quantity.

In programming the operations the first or better the first two prototype units should be tested for some time with the gas output being used as fuel.

Upon successful termination of the tests the balance of the required number of prototype units and the Ammonia-Urea plant can be ordered. The main advantage of the proposed type of plant for its use in a development project like the one under consideration here is its mobility and last but not least the relatively short time required to get into production. Thirteen months is a good average for the time elapsed between the signing of the contract and full operation. Preliminary calculations for this set-up indicate the production cost of Urea to be practically the same as the one quoted in chapter IV.

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VI. THE PROPOSED UNIDO ASSISTANCE FOR THE IMPLEMENTATION OF THE PROGRAMME

In accordance with the ideas developed in the foregoing chapter, it is proposed to provide UNIDO assistance for the long-term programme which could conveniently be split into two phases:

(a) a preparatory phase concerned with the elaboration of technical and economic data necessary for proceeding with the construction of the prototype unit for gas recovery and washing

and

(b) the productive phase entailing the creation of a prototype unit, based on the information obtained under (a). This phase would logically include a pre-investment study for a fertilizer plant, assistance for developing the potential fertilizer market and the elaboration of a schedule for the implementation of the programme. It will be advisable to wait with the drawing up of the details of this phase until the preparatory phase is more advanced.

The preparatory phase should include the following:

review all available bathymetric information and carry out further exploration with the aim of completing the bathymetric map, particularly in such zones which appear most appropriate for the location of a fertilizer plant

inspect the Cape Rubona pilot plant and review all pertinent reports and any data and result which may be available on the FED short-term Revamping Programme

pin-point the unsolved technical problems relating to process and materials of construction which may require further experimental work prior to proceeding with the design of a commercial prototype unit

draw up a plan for any experimental work that may be needed and provide a comprehensive cost estimate for same, covering material, labour and supervision, indicating foreign and local currency disbursements separately

make recommendations for the most appropriate gas recovery and gas washing process to be used with full consideration of the gas specifications for synthesis feed stock

make recommendations concerning the choice between on- and off-shore installations

indicate the most appropriate locations for the gas recovery and washing plant as related on one hand to the bathymetric information and on the other to the utilisation of the gas

make recommendations concerning the suitable size of a commercial prototype unit

provide a cost estimate for this prototype unit with a break-down into a foreign currency component and another one for local labour, services and auxiliary material which can be purchased locally estimate the gas production cost per thermal unit on the basis of the recommended prototype plant

prepare tender specifications for the prototype plant

prepare a tentative schedule for the implementation of the project

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VII. LITERATURE

1. NOTE PRELIMINAIRE SUR LES GAZ DECOUVERTS DANS LES EAUX PROFONDES DU LAC KIVU, J. Kufferath and D.M. Schmitz, 1954

* 2. DONNEES POUR LA MISE EN VALEUR DU GISEMENT DE METHANE DU LAC KIVU, G. Bergniez, Académie Royale des Sciences d'Outremer, 1960

3. ETUDES PREALABLES A LA CREATION D'UNE USINE D'ENGRAIS AU RWANDA, J. de Lavallée, poste RWA-11-C, rapport no. 17, annex 2, 1966

4. ETUDE PRELIMINAIRE SUR LA MISE EN VALEUR DU GISEMENT DE GAZ METHANE DU LAC KIVU, E. Maurel, Sofregaz, 1966

5. WORLD BANK and IDA: Annual Report 1966 - 1967

* 6. ETUDE SUR L'USINE D'EXTRACTION DE GAZ METHANE A GISENYI, V. Berenfeld, Regideso, 1967

* 7. LE GAZ METHANE DU LAC KIVU, MINISTERE DU COMMERCE, DES MINES ET DE L'INDUSTRIE, Republique Rwandaise, 1968

* 8. ETABLISSEMENT D'UNE USINE D'ENGRAIS AU RWANDA, A PARTIR DU GAZ DU LAC KIVU, J.-F. Wouters, Université libre de Bruxelles, 1968

* The full reproductions of the references marked with asterisks are to be found under chapter VIII - attachments.

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VIII. ATTACHMENTS

1. MAP OF RWANDA AND BURUNDI

2. MAP OF LAKE KIVU

3. CAPE RUBONA PILOT PLANT - FLOW CHART AND EQUIPMENT LIST UCB, 1963

4. SPECIAL INDUSTRIAL SERVICES PROJECT DATA SHEET re: 68/323 (RWA-13)

5. EXTRAIT DE L'ETUDE PRELIMINAIRE SUR LA MISE EN VALEUR DU GISEMENT DE GAZ METHANE DU LAC KIVU, E. Maurel Sofregas, 1966

6. NOTE PRELIMINAIRE SUR LES GAZ DECOUVERTS DANS LES EAUX PROFONDES DU LAC KIVU, J. Kufferath and D.M. Schmitz, 1954

7. ETUDE SUR L'USINE D'EXTRACTION DE GAZ METHANE A GISENYI, V. Berenfeld, Regideso, 1967

8. LE GAZ METHANE DU LAC KIVU, MINISTERE DU COMMERCE, DES MINES ET DE L'INDUSTRIE, Republique Rwandaise, 1968

9. ETABLISSEMENT D'UNE USINE D'ENGRAIS AU RWANDA, A PARTIR DU GAZ DU LAC KIVU, J.-F. Wouters, Université libre de Bruxelles, 1968

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