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"Restricted"

"THE 1968 UNIDO INDUSTRIAL SURVEY MISSION TO KENYA"

Final Report, Part II

By P. Olof Grane, Industrial Engineer

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

"This Report has not been cleared with the Bureau of Technical Assistance Operations of the United Nations which does not therefore necessarily share the views expressed."

December, 1969

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Preliminary Outline of Sectoral Industrial Development in Kenya

INTRODUCTION

1. The author of this part of the Mission's Report has, after visiting approximately 100 Kenyan industries in various parts of the country, come to the conclusion, that there is scope for industrial development in two particular sectors, namely the chemical sector and the building materials and components sector. Natural resources and agro-industrial wastes is another sector of great importance, which, however, time has not permitted him to devote more than part interest to in connection with the two first mentioned sectors.

2. As the Kenya Government has expressed a desire that specific projects are identified, pre-feasbility studies have been made on certain projects, which seemed to be viable. They must later be completed with market studies and more exhaustive statistical information.

A. CHEMICAL INDUSTRY

3. The chemical industry is one of the most dynamic sectors in the industrial structure of both developing and developed countries, and investment in that industry is normally higher than in any other industrial sector. In many developing countries chemical industry sectors are in the early stage of development. In Kenya it is still in its infancy.

4. Chemical and allied products now being produced in Kenya include in addition to products from oil refining, the following:

Alcohol	Pyrethrum Extract
Caseine	Salt
Cement	Silicate of Soda
Charcoal	Soap
Essential Oils	Soda Ash
Industrial Gases	Sugar
Lime	Tanning Extract
Paints	Vegetable Oils
Paper	A.O.

5. The following chemical sectors are now being implemented in Kenya, namely:

polysynthetics, based on imported vinyl acetate

detergents, based on sulphonation of petroleum.

6. Under normal conditions of supply and demand in an expanding economy the availability of absic chemicals in Kenya could provide the basic for establishing further industries, such as pulp and paper, textile, plastics, fine chemicals, organic and inorganic chemicals, solvents, etc. Since such basic chemicals as caustic soda, chlorine, sulphuric acid, etc. are usually produced in developed countries on a large scale at low cost, the economies of scale of such production in Kenya must be carefully considered. In addition, because of the need to utilize a variety of products made, Kenya should consider the development of one or more basic chemical complexes in areas serviced by transportation and labour and close to markets and raw materials. Such complexes could take maximum advantage of backward and forward integration of products.

7. Ethanol

Ethyl alcohol is being produced in Kenya by fermentation of molasses. Approximately 100,000 tons of sugar is now being produced annually in Kenya from which 25,000 tons of molasses is obtained. When the present facilities have reached full production, 135,000 tons of sugar and 37,000 tons of molasses will be produced. One of the plants is producing alcohol at a rate of about 500 tons per year but its capacity is only utilized to about 25%. Surplus molasses is being used in cattle-feed or is exported, while some until recently has simply been dumped.

8. At present the alcohol is used in beverages or as methylated spirit and as a solvent. In addition, alcohol can be further concentrated and used as an additive with gasoline in quantities up to 25% of volume. If all gasoline presently used were to be mixed with 25% alcohol, Kenya could dispose of approximately 35,000 tons of alcohol yearly! The 37,000 tons of molasses produced, could theoretically be converted to about 8,000 tons of alcohol or 2.5 million gallons.

9. Alcohol - gasoline mix constitutes an excellent motor fuel with a suitable high octane value for road vehicles and its use would depend on the price at which the alcohol can be produced. If introduced in Kenya, it could be substituted for part of imported oil and a hitherto little-used waste product could be utilized. The alcohol-gasoline mix, in some countries called "bentyl", could be marketed besides the common gasoline.(1)

(1) As is done successfully in South Africa for example.

and the Government could influence its price by fixing the price for alcohol[(2)].

10. Besides molasses as raw material for alcohol production, other products, which are rich in starch, can be used, such as maize, cassava, potatoes, etc. It should also be mentioned that the alcohol fermentation gives valuable yeast as a by-product. The fermentation rates can be controlled so that the production of yeast is increased considerably and the alcohol production is reduced as may be needed to meet market requirements.

11. Kenya presently imports all bakery yeast (200 tons of a value of £50,000 in 1968[(3)]) and the consumption of bread has increased 500% during the last 5 years. Continued growth in bread consumption is expected. A study of the production of yeast should therefore be considered.

12. As mentioned above, yeast can be produced from such products as maize, cassava, etc., but also from such agricultural wastes as maize cobs, bagasse, and probably also from papyrus, whereby the hydrolysis is carried out in 2 stages, so as not to destroy the pentosans. Valuable torula yeast, which is receiving increased importance in animal feeds and also as a nutrition additive for humans, could be produced.[(4)]

13. An important use for alcohol, where petrochemical feed stocks are not available, is as a raw material for the production of acetaldehyde, acetic acid, ether, ethylene etc., and subsequent production of secondary compounds based on the primary chemicals.

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(2) If the agreement with the oil refinery prevents this use, agreements like laws, can be changed.

(3) East Africa: 600 tons at a value of £180,000.

(4) Edible yeast could easily be recovered by the breweries by installing a rotary vacuum filter, an autolyzer and a yeast drier plus a pasteurizer for the waste beer. Such an installation would cost about Shs.300,000 one brewery, which has a production of 7,500 barrels (@ 32 gallon) per week, could recover approximately 4,000 lbs. of 30% yeast during 14 hours, i.e. 8,400 kgs. of yeast with 90% dry matter per day, which is an appreciable and valuable quantity.

Example: One of the sugar mills can at full capacity produce about 14,000 tons of molasses. This quantity can be transformed into 3,000 tons of alcohol in a plant costing about £135,000. Cost of production will be:

Depreciation, 10% of £135,000	£13,500
Interest, 6% on £135,000	8,100
Maintenance, 2% on £135,000	2,700
Steam, 30,000 tons @ Shs.13.50 (5)	20,250
Other operating costs, incl.labour	6,750
	£51,300

This corresponds with a processing cost of Shs. 0.27 per litre.

14. Thus the importance of ethyl alcohol is clearly seen and the possibilities for establishing a chemical industry based on its conversion will be studied further in this report.

15. Acetic Acid

Acetic acid is a component received in the condensation products from destructive distillation of wood. It can also be produced by fermentation of ethyl alcohol but is presently generally produced (in countries not having access to petrochemical feed stocks) by the oxidation of acetaldehyde, which is produced from ethyl alcohol through a dehydrogenation process.

16. Acetic acid has a major industrial use in the food and pharmaceutical industry.

17. Acetic acid is also the raw material for the production of such chemicals as acetic acid anhydrid, which is used to introduce acetyl groups and in the production of acetyl cellulose, in the paint and plastics industries and in the production of vinyl acetate, a raw material for polyvinyl acetate (PVA).

18. Since acetic acid is a useful raw material in the chemical industry, Kenya should consider its use in the overall planning of establishing of an

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(5) Steam (being produced from bagasse) and other utilities are supposed to be produced in an already existing plant. No price has been put on molasses, as the calculation is for the processing cost only.

alcohol industry. While certain products mentioned, such as ethylene, and acetyl cellulose probably will not be viable to produce in a first stage of operation, many products can be made, that will make the proposition interesting. In the following therefore, a brief estimate of the capital involved in such an industry will be made and three different proposals for further processing of the alcohol will be made.

19. As all molasses in Kenya is being handled by one company[(6)] the total production of molasses will be used as basis for this calculation. In processing, which ought to be done in the Nyanza province, molasses from the coastal sugar mill cannot very well be included, but instead some additional molasses from Uganda, which is being handled by the same company, can be included, and therefore the total Kenyan figure will be used in this calculation. It should also be mentioned, that the above mentioned company, through a Geneva based subsidiary is dealing on a world wide basis in alcohol and will be approached by the Mission to consider the production of alcohol in Kenya for export and domestic use and possible further processing into various chemicals.

20. To ferment 37,000 tons of molasses, a total fermentation volume of 1,000 m^3 would be required, which could be done in 10 fermentation vats. These could be housed in a building covering about 1,000 m^2, being 10 meters high and having a second floor at the 5 meter level. Part of the building would go up to 25 meters in a tower for distillation columns. Estimating local deliveries for fermentation vats (in mild steel) piping, etc., at £50,000 and land and buildings at £35,000 plus cost for a total volume of 11,000 m^3 storage capacity (molasses in concrete bins) the total erected investment will be about £280,000.

21. The production cost for alcohol will depend on the price put on the molasses and the cost for steam, power, water, etc. The price for molasses must correspond with the export price. This price varies. It has been at a sugar mill in Nyanza as low as Shs. 22 and is now Shs. 38 per ton. An average of Shs. 30 will therefore be used. Steam can be produced from either furnace oil or wood. Price for furnace oil is Shs. 100/ton in Mombasa and freight to Nyanza is Shs. 105/ton, i.e. Shs. 205/ton delivered at the plant.

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(6) United Molasses of London

Fuel cost for steam, using about 100 kgs. of oil per ton steam, would be Shs. 20.50/ton and including other operating costs a price of Shs. 23/ton steam is likely. Fire wood is sold in Nairobi at a price of Shs. 40/ton and in Eldoret it can be had for Shs. 25/ton. This of course would give a very low price for the steam, and therefore the availability of sufficient wood-fuel in the area should be investigated. For this calculation however, the higher price will be used. Electricity is calculated at 12 cts. per kilowatthour. However, it must be mentioned, that by installing a back-pressure turbine, the steam needed in the process will be able to produce the necessary electricity, which then will cost less than the figure suggested.

22. An estimate for the yearly production cost of 8,000 tons of alcohol would then be as follows:

<u>Capital Cost</u> (depreciation, interest & Maintenance), 18% on investment	£50,000
<u>Raw Material and Utilities</u>	
Molasses, 37,000 tons @ Shs. 30	55,000
Steam, 40,000 tons @ Shs. 23	46,000
Electricity, 800,000 kwh. @ Shs. 0.12	4,800
Water, 240,000 m^3 @ Shs. 0.50/m^3	6,000 (7)
Process water, 100,000 m^3 @ Shs.1/m^3	5,000
<u>Labour</u>	
1 Supervisor, 1 assistant, 8 shift workers, 4,600 Shs./mo	2,750
<u>Administration and Overheads</u>	
Plus contingencies	6,450
	£176,000

This gives a total cost of £22 per ton 96% alcohol. The main factors influencing the cost are the prices for molasses and steam and those items must therefore be thoroughly investigated.

23. If dehydration of the alcohol is desired, (for use as motor fuel) this would necessitate a further investment of about £60,000 and the consumption

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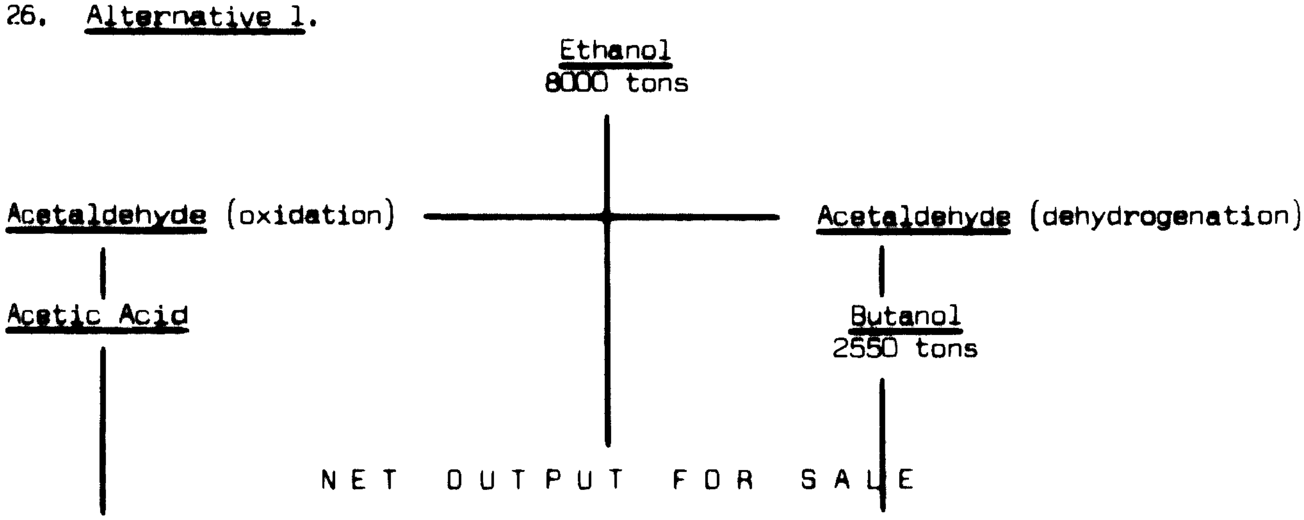
(7) The cooling water consumption depends on the water temperature and may have to be adjusted. On the other hand the quantity can be decreased by the installation of a cooling tower, whereby the net consumption will be only about 10% of the figure given.

of utilities per ton 99.6% alcohol would be 2,000 kgs. of steam, 65 m^3 of cooling water and 20 kwh. of electricity.

24. If the above mentioned quantity of 8,000 tons of alcohol were to be exported f.o.b. Mombasa at world market price, which is about £42 per ton, and freight from Nyanza to Mombasa is calculated at £5/ton, the gross profit would be about £120,000 per year.

25. As has been mentioned before, various chemicals could be produced, using the alcohol as a raw material and although export of the alcohol may be a first step in the processing of the molasses, at a later stage or immediately following the first stage, such further processing may prove desirable and viable. In the following, three alternatives are suggested.

26. Alternative 1.



	1. Acetic Acid 1350 tons	2. Ethyl Acetate 1000 tons	3. Butanol 1500 tons	4. Butyl Acetate 1500 tons
World market price, £/ton	63	91	84	120
Value, £	85,000	91,000	126,000	180,000

Total Value, alternative 1: £482,000

Alternative 2

Ethanol
8000 tons
|
Acetaldehyde
7100 tons
|
Acetic Acid
5050 tons
|
Acetic Anhydride
6900 tons
|

Net output for sale:	Vinyl Acetate 5500 tons
Work market price, £/ton	80

Total Value, alternative 2: £440,000

Alternative 3

Ethanol
8000 tons
|
Acetaldehyde
7100 tons
|
Acetic Acid 6400 tons —— Acetic Anhydride 4500 tons

Net output for sale:	Acetic Acid 3000 tons	Vinyl Acetate 3600 tons
World market price: £/ton	63	80
Value, £	189,000	288,000

Total Value, alternative 3: £477,000

27. It has unfortunately been impossible, in the short time at disposal, to calculate the production costs for the various alternatives and therefore only the values of the products have been indicated. Which of these alternatives or combination of them should be pursued cannot be decided until an investigation of the market, domestic as well as East African and world market, has been done. However, it might be mentioned, that the plant for the production of poly-synthetics, mentioned in paragraph 5, page 1, which is now being built in Nairobi, will have a capacity of 2,500 tons/year. The main raw material will be imported vinyl acetate and thus an important client for one of the products will be at hand. The other products are important solvents used in the paint industry etc.

28. It is obvious, that Kenya alone cannot take the total output of either the alcohol or its derivatives, but as it seems likely that the products can be produced and sold at world market prices and in some countries (like India for example) the prices are between two and three times the world market prices and in East Africa probably also higher prices can be obtained, it is <u>recommended</u> that a detailed study of the production of alcohol and its derivatives is considered.

29. <u>Caustic Soda and Chlorine</u>

Caustic soda is one of the most commonly used basic chemicals. In 1968 Kenya imported 2,300 tons and the whole of East Africa imported 9,600 tons. Consumption is increasing. No domestic production exists but raw materials for its manufacture are available, namely soda ash, gaylussite and/or salt. When the Broderick Falls pulp and paper project goes into production, their planned requirements of 4,700 tons of caustic soda will provide a ready market. Kenya's need at that time will be some 8,000 tons, which could support a caustic soda production.

30. It has been stated that Broderick Falls, if and when they go into production, will produce their own caustic soda in an electrolytic plant - using salt[8] - and obviously they could make this plant large enough to produce and fill the demand of the rest of Kenya (or East Africa), should the economics show that this is feasible. However, through electrolysis also chlorine is won and as the consumption in the pulp and paper mill is calculated to be 2,000 tons/year and an electrolytic unit produces 1 ton of chlorine and 1.13

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(8) Kenya now produces both crude and refined salt, but for electrolytic purposes the salt has first to be further refined.

tons of caustic soda, they will obviosuly first have to dispose of or find a use for 2,200 tons of chlorine[9] before they can think of expanding the caustic soda production. One possibility is that they produce the exact amount of chlorine needed and import the missing part of caustic soda. Should that be the case the necessary amount of caustic soda could be produced from gaylussite, should the East African Industrial Research Organization go ahead with their plans to erect a pilot plant for that purpose, and find that the process is economical[10].

31. One Kenyan company[11] has declared, that they might be interested in running the caustic soda - chlorine plant as a separate entity, in which case they probably would produce the total needs for East Africa of caustic soda and chlorine and use the surplus chlorine in the manufacture of chlorinated compounds. However, it is doubtful whether a plant situated in Broderick Falls could be competitive and the Mission believes that a plant there will only be able to produce for their own consumption.

32. Under such circumstances a more centrically located electrolytic plant, preferably as an integrated part in a chemical complex, should be investigated, and some suggestions to that end will be made at the end of this chapter.

33. <u>Charcoal and By-products</u>

A large number of small firms and farmers in Kenya produce charcoal from various types of trees and bushes, often combined with range clearing operations. Generally a simple pit is dug in the ground, 1 - 2 ft. deep and 6 - 8 ft. in diameter, the pre-cut wood is filled in with small kindling wood in the centre and a half-sphere is built up which is covered with refuse and mud. Openings are left at the base to regulate the air entrance. Charring takes about 5 days.

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(9) Present consumption in Kenya of chlorine for water treatment, bleaching powder, etc., is relatively insignificant, but could of course then be filled by the local production.

(10) Experience on gaylussite processing in Ethiopia might be consulted first.

(11) Twiga Chemical Industries Limited.

34. A somewhat more sophisticated kiln is the portable steel kiln with a diameter of 7.ft. 6.in. and a height of 8.ft. which has a capacity of 11 cu.yds. It produces 25 - 35 bags (@ 80 lbs.) of charcoal in 2 - 3 days, depending upon the type of wood used.

35. A stationary variant of the portable kiln is built of brick but has a steel lid. It is cheaper in construction, has less heat losses and gives a higher yield but needs longer cooling period. This kiln could be provided with an electric driven fan to speed up the charring period and also, if provided with a condensation unit, some by-products could be recovered, mainly tar.

36. Proper retorting kilns, using the produced permanent gas for the pryolysis and recovering the tar and pyrolignous acid are not in use in Kenya.

37. In order to study the possibilities for a more technical approach to charcoal production, the Mission has, together with the FAO Range Management Project, selected various trees and shrubs, which have been tested by the East African Industrial Research Organization[12], the results of which appear in the following table:

---

(12) At present time, E.A.I.R.O. have only tested 6 out of 17 species and on those tested, values for methanol and charcoal density are still missing.

38. TABLE I.

Destructive Distillation of some Kenyan Woods and Shrubs

	No.1. COMMIPHORA AFRICANA	No.2. BOSWELLIA HILDERBRANDTII	No.3. ACACIA DECURRENS	No.4. EUCALPTUS SOLIGNA	No.5. PINUS RADIATA	No.6. PODOCARPUS
Moisture content at distillation %	30.74	12.71	12.31	11.28	9.01	10.11
Yields ex 100 g. dry weight (g)						
Charcoal	37.62	34.37	32.82	35.95	27.92	30.59
Tar	8.18	8.14	7.97	10.72	13.50	10.60
Aqueous* Condensate	21.57	22.94	27.36	29.75	30.77	27.15
Gas	19.66	17.15	18.51	12.59	18.94	19.45
Total	87.03	82.60	86.66	89.01	91.13	87.79
Acetic Acid (%)	3.09	2.34	5.70	4.11	3.21	2.65
Gas Composition (Vol.% of sum of CO_2, CO, H_2, CH_4)						
CO_2	29.6	28.3	45.5	38.5	32.1	24.0
CO	22.0	20.2	25.6	33.8	33.4	32.3
H_2	20.7	22.7	20.2	5.2	7.9	18.1
CH_4	27.7	28.8	8.7	22.5	26.6	25.6
Charcoal Composition, Wt.%						
Moisture	2.67	2.69	3.44			
Ash	7.30	7.26	2.24			
Volatile Matter	12.57	14.34	17.37			

* Corrected for initial moisture content.

39. The two first species, Commiphora Africana and Boswellia Hildebrantii, can be regarded as a pest which covers thousands of square miles of land in Kenya and cause a problem for the ranges. They are considered as valueless and money is spent on their removal for clearing the range.

40. The tests, which have been carried out, show that charcoal can be produced from both species and while the ash content is higher than for the black wattle (No.3), this should not prevent its use for domestic purposes.

41. Two other shrubs, which also are a nuisance on the range, namely Tarconanthus Camphoratus (Leleshwa) and Lippia Javanica, were noticed to have a foilage with a highly aromatic odor. The Mission therefore submitted foilage of these two shrubs to steam distillation. The first mentioned showed a yield of between 0.11 and 0.23% of essential oil. The other shrub gave a yield of 0.37%. It now has to be investigated whether these oils can find any commercial use(13).

42. The black wattle (No.3) is used industrially for the production of charcoal. As this is done in a concentrated area in stationary kilns, the Mission believes it could be of interest to recover some by-products. As can be seen from Table 1, about 8% tar and 5.70% acetic acid are the theoretical yields. The aqeous condensate also contains methanol.

43. As the charcoal is produced from debarked wattle, and the bark is rich in organic substance, a renewed test has been requested on debarked wattle. The result is not yet available but industrial yield from 50,000 tons of debarked wattle can be presumed to be 15,000 tons of charcoal, 3,500 tons of tar, 2,000 to 2,500 tons of acetic acid and 1,300 tons of methanol.

44. The Eucalyptus Soligna, which has turned out to be less suitable for sawn wood, is now largely used as fuel-wood. The test shows, that it gives a high yield of both charcoal and tar as well as acetic acid, and is obviously an excellent raw material for a charcoal industry.

45. The pine (No.5) of which there are now large plantations in Kenya, and which will be used more and more for sawn wood and eventually for the manufacture of pulp and paper, and which will produce much thinnings and waste, shows a low yield of charcoal but a high yield of valuable pine tar products. The Podocarpus (No.6), which is used for the production of sawn wood and plywood, shows higher yield of charcoal than the pine, but low compared to the other species. Tar yield is high while the yield of acetic acid is very low.

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(13) Will be done by E.A.I.R.O.

46. In order to recover condensation by-products from the pyrolisis of wood, i.e. from the charcoal manufacture, the distillation process must be carried out in a closed retort or oven without admittance of air. The process can be divided into four different stages:

1. The evaporation stage. This process takes place at an average temperature of 340° F and external heat must be supplied to offset the requirements.
2. The pre-exothermic stage. Further heat must be applied to raise the temperature of the dry wood up to the point of the exothermic reaction, 540° F.
3. The exothermic stage. The reaction now proceeds with a liberation of heat and the temperature rises to between 700 and 750° F as the result of the heat evolved.
4. The cooling period, which usually takes place at atmospheric pressure in the presence of the hydrocarbon gases so that an absorbtion can take place to condition the charcoal and prevent its subsequent combustion. Heat is liberated during this conditioning period.

47. The simplest type of retort is a horizontal, cylindrical steel oven heated externally from a fire box. The volatile products are taken off and led to a scrubber and/or water cooled condensors, where tar and pyrolignous acid is recovered. The process is a batch process.

48. Wood carbonization, system Perstorp, takes place as a discontinuous process in vertical retorts and is effected by circulating gas at a temperature of about 900° F. The hot gas enters at the top of the retort and leaves at the bottom at a reduced temperature, the direction of the gas flow being the same as the gravitational flow of the tar. This method serves to prevent immoderate heating of the tar and thereby avoids cracking of its valuable components. The gases are led to the condensation unit and the non-condensable gas is used partly as circulating gas, partly to heat the circulating gas[14].

49. A continuous working retort is the Lambiotte retort with top and bottom sections with special valves permitting charging and discharging without air intake. This type of retort is cheaper in investment cost, saves labour and

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(14) A second hand retorting plant of this type, with a capacity of 13 tons of wood per day, and with a replacement value of $700,000, can be made available from Sweden at a cost of $135,000.

has lower operating cost but produces different coal and by-products. The temperature in the carbonizing zone is higher and the coal produced is extremely low in volatile components. Such coal is not suitable for use in blast furnaces. The tar obtained is not of the same good quality as that from a batch process.

50. To decide whether recovery of by-products from the charcoal manufacture in Kenya can be a viable proposition depends on the amount and composition of the pyrolignous acid in comparison to the local price of steam. In Eldoret, where charcoal is already produced industrially and where wood-fuel costs Shs. 25 at the boilers, it is probable that such recovery can be feasible, especially as it can be made as an integrated part of an existing industry. As another activity of the industry in question is the preservation of telephone, telegraph and fence poles with imported creosote and diesel oil, the tar and/or tar-oils, perhaps with the addition of pentachlorphenol, could probably be used instead. The Mission recommends that a study of the viability of recovery of by-products from charcoal manufacture in the Eldoret area is carried out.

51. As was explained in paragraph 33, much charcoal is produced in Kenya in earth pits or small portable kilns. The Mission recommends that further studies are carried out to determine the type of kiln or retort that can be used on a semi-industrial scale and which gives better coal and better yields and may make it possible to recover some by-products, at least tar, which can find use to water-proof houses, preserve fence poles, serve as a fuel, etc. It is suggested that this is done in close cooperation with the FAO/Range Management Project, who have recently acquired a portable kiln for use in charcoal production in connection with range clearing projects. Close cooperation should also be kept with the East African Industrial Research Organization, who are making further tests on other Kenyan trees and shrubs than the originally chosen by the Mission. Such other species are for example the coffee tree and mangrove.

52. In the coastal area mangrove, which produces an excellent, dense charcoal, apparently is cut and shipped to Somalia where it is carbonized and then exported to countries in the Indian Ocean area. It seems natural that the carbonizing also should be done in Kenya and as it appears that the overseas market for charcoal is quite substantive, it may be that industrial production of charcoal, with or without recovery of by-products, could be feasible at the

coast, and the Mission therefore recommends that such a project is included in the overall study of charcoal manufacture in Kenya.

53. When charcoal is produced in earth pits, the peasants do not make use of smaller branches and twigs, which are simply burnt to clear the place, because there is no market for such small coal that they would produce. However, such coal can be used as fuel in industry where it is finely ground and blowed into a kiln or furnace and used similarly as gas or fuel oil. It can also be briquetted and is then generally ground and mixed with some of the tar and then pressed to briquettes which are again heated when a hard, dense - and expensive - briquette is produced. A simpler way is to mix the charcoal powder with about 5% of a starch binder in a paddle mixer and then run it through a vertical fluxer and a press where the briquettes are formed. The green briquettes then are dried during 3 to 4 hours at a temperature of about 275^{0} F, (or simply in the sun, if that is possible).

54. Also wood waste can be made into briquettes and then charred. The self-bonding feature of wood waste is utilized in this process whereby saw-dust, shavings and other waste, ground to oatmeal size, is compressed under very hich pressure (25,000 psi) and the friction at this extreme pressure generates enough heat to produce the necessary plasticity for self-bonding. Other vegetable residues and wastes for example coffee husks, rice hulls, sisal waste, etc., can also be treated according to the same process but it is essential that they are dry, i.e that the moisture content is below 10%, preferably 6%.

55. Formaldehyde is one of the basic organic chemicals with a wide use in the manufacture of various resins. As a water solution it is used in the tanning and textile industries. The largest use is perhaps in the manufacture of urea - and phenol formaldehyde resins, which are used in the production of glues and moulding compounds. The plywood industry in Kenya are using appreciable quantities of such resin glues and the whole East African market with 6 factories, including the chipboard factories in Uganda and Tanzania, plus another plywood factory going up in Kenya and two more projected in Tanzania, will certainly be able to support a resin plant. Such resins (thermo-setting) are generally produced in batch processes and the units are fairly small.

56. If liquid resins were to be produced in say, Nairobi, the distance to consumers in Uganda and Tanzania is relatively large, so the resin, if shipped in liquid form, would at arrival have used up perhaps half of its shelf life[15], and therefore a resin in powder form, i.e. spray dried, would be preferable. In such a case the minimum economic unit would be 5,000 tons per year (because of the additional investment for a spray drying unit), which however would be too big for the East African market. This problem seems to be solved now by a new type of resin, which has a shelf life of 6 months, and therefore the Mission recommends that the production of urea - resorcine - and phenol-formaldehyde resins in Kenya is investigated. Production could be started using imported formaldehyde but at a later stage the formaldehyde could be produced from imported synthetic methanol or perhaps from methanol recovered from charcoal production.

57. Furfural

Plants and agricultural wastes such as bagasse, maize cobs, groundnut hulls, cotton-seed hull bran, pyrethrum marc, coconut shells, spent wattle bark, etc. containing pentosans, produce furfural when treated with diluted sulphuric acid. Yields from 5 to 22% of furfural can be obtained.

58. Furfural is a product which has a wide range of application in the chemical and mineral oil industry. Thus it is used as a selective solvent in the production of lubricating oils and the oil refinery in Mombasa will need 100 tons of furfural per year, when their new lubrication oil plant goes on stream. Furfural is also used in edible oil refining, and it can be used instead of formaldehyde as preservation and desinfection agent. The fungicide feature of furfural is used in the preservation of grain,wood, etc., and it has been used as a weed killer and a vermin killing agent.

59. Furfural has great importance as raw material for the production of adipin acid, an intermediate in the production of polyamids (nylon) but perhaps the most important field of use is the production of duroplastic synthetic resins, whose most characteristic property is that they can be cast. The derivatives of furfural are used as solvents and intermediary products.

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(15) Shelf life is the time a resin can be stored without polymerizing or have its quality affected.

60. Thus the wide use of furfural is clearly seen and next step is to establish the size of the present and future local market in Kenya as well as in the whole of East Africa. It is probably not possible to produce furfural in Kenya and, including transport cost to distant overseas consumers, be able to compete with world market prices. However, the market in East Africa and the Indian Ocean area may be accessible and sufficient for a Kenya producer. Such a market study can unfortunately not be carried out by this Mission. On the other hand, it must also be established whether furfural at all can be produced in Kenya at a reasonable price and be economically feasible and such a preliminary study is detailed below.

61. Raw materials which are available in Kenya for a possible production of furfural are listed in the following table.

TABLE 2

Some Agricultural Wastes and Residues produced in Kenya 1968 (16)

	Dry Weight Tons	Theoretical Yield of Furfural %
Bagasse	120,000	17
Maize Cobs	75,000	22
Maize Stalks	600,000	16
Coffee Parchment	8,000	13
Sisal Waste	140,000	4
Spent Wattle Bark	25,000	7
Pyrethrum Marc	8,000	15

62. As raw materials in large quantities near to a proposed plant must be available in order not to cause high collection and transportation cost, possible raw materials in Kenya are bagasse and maize cobs and/or maize stover. Spent wattle bark is another possible source, and so is papyrus. Papyrus is a nuisance in Lake Victoria, where it grows not only along the coast but also as floating islands (of which some 400 threatened Kisumu harbour in April this year, some of them containing several hundreds of tons of papyrus). At present money is paid for hauling these islands and dragging them ashore, cutting them up and letting them rot. If such an operation could be combined with furfural production, a problem might be solved and a new industry promoted. As the main cost item in furfural production is the raw material, the price at which the papyrus can be collected and delivered at a proposed plant site, is of prime importance.

(16) As calculated from the crop production.

63. Bagasse gives a higher yield of furfural than papyrus, but as it is now used as fuel in the sugar process, and would have to be replaced by fuel oil, which would be very expensive, and no surplus is or will be available, its use in furfural production in Kenya is not possible.

64. Maize cobs are the raw material which gives the highest yield of furfural. In Kenya now, the cobs are not collected but left in the fields. With a different harvesting system, this could of course be done but they could also be collected by hand if a reasonable price were offered. As maize is grown in certain areas and by large farms, such concentrated collection seems possible, and although it has to be further investigated, for the purpose of this study it will be assumed that maize cobs will be the raw material. It should be pointed out however, that different raw materials, for example maize cobs and spent wattle bark can be processed successively or at the same time.

65. The capacity of furfural plants in U.S.A. for example, are 10,000 to 15,000 tons per year, which makes production economically attractive. However, there are also smaller plants in the world, although they may have a protected market, but as that may be the case for Kenya, the economic viability of a plant with 2,000 tons output per year of furfural will be studied. The selling price will be assumed to be the world market price c.i.f. Mombasa plus 10%.

66. **FINANCIAL ESTIMATE**

For a Furfural Plant with dis-continously working reaction Plant and subsequent continuous furfural distillation.

Type	BMA 181169
Capacity	2,000 tons/year
Working Hours	24 hours/day
Working Days	300 days/year
Proposed Location	Eldoret

A. CAPITAL EMPLOYED		
1. Land, 1,500 m^2, incl. roads, railway siding and improvements		Shs. 50,000
2. Buildings, 4,000 m^3 @ Shs. 110/m^3		440,000
3. Machinery and equipment, supporting structure, tanks, compressor, insulation	3,300,000 340,000	
Steam generator, 7 ton/h	340,000	
Cooling tower	170,000	
	4,150,000	
Freight to Mombasa	204,000	
Est. forwarding charge	102,000	
Erection, 300 men/mo @ Shs.500	150,000	
Supervision, 10 men/mo @ 8,500	85,000	
Tools and tackles	104,000	4,795,000
Spare parts, 3% on machinery & Equipment	100,000	100,000
		5,385,000
4. Preliminary expenses and administration during building period, publicity		60,000
Total Investment Cost:		Shs. 5,445,000
5. Working capital, 3 mo production and sales costs, excl. depreciation and contingencies		709,000
Total Capital Employed:		Shs. 6,154,000
B. ANNUAL COST OF PRODUCTION AND SALES		
1. Raw Materials and Utilities:		
Maize cobs, 28,000 tons @ Shs.35/ton	980,000	
Sulphuric acid, 360 tons @ Shs.280/ton (17)	101,000	
Soda ash, 60 tons @ 300 Shs./ton	18,000	
Electricity, 230,000 kwh. @ Shs.0.12/kwh.	27,600	
Steam (12 atm), 47,400 tons @ Shs.10/ton	474,000	
Cooling water, 46,000 m^3 @ Shs. 0.15/m^3	6,900	
Boiler feed ", 38,000 m^3 @ Shs. 0.75/m^3	29,000	1,636,000
2. Labour:		
1 Foreman @ Shs. 800/mo	9,600	
24 Labour @ Shs. 350/mo	84,000	
2 Mechanics @ Shs. 500/mo	12,000	105,600

(17) The cost for sulphuric acid, calculated in paragraph 78 has been used plus freight cost to Eldoret from Thika.

3. Maintenance:			
Maintenance and repairs, 3% on machinery and equipment		Shs.	100,000
4. Overheads:			
General works overheads and insurance			86,000
5. Depreciation:			
Buildings, 5% on Shs. 440,000	Shs. 22,000		
Machinery, 10% on Shs. 4,795,000	479,500		501,500
6. Interest:			
8% on total investment, Shs. 5,445,000			435,600
7. Administration:			
1 Plant superintendent	36,000		
1 accountant	12,000		
1 secretary	6,000		
2 clerks	12,000		66,000
8. Selling Costs:			
Sales manager, advertising and publicity, discounts, telephone, mail, etc. 12% on sale			610,000
9. Contingencies:			20,300
Total Cost:		Shs.	3,560,000

C. PROFIT POTENTIAL

Sales: 2,000 tons furfural @ Shs. 2,550/ton		5,100,000
Excess steam, 10,000 tons @ Shs. 8		80,000
		5,180,000
Less: Cost of production		3,560,000
Gross Profit	Shs.	1,620,000

= 30% on total investment cost.

67. Sulphuric Acid

Sulphuric acid plays a key role in the chemical industry. As transportation cost is high in relation to its price, production on a relatively small scale can sometimes be justified in developing countries. Kenya is now paying from three to five times the world market price for the acid it imports. If there was a local production, not only would the users benefit from a lower price (as is shown in the following), but consumption would probably increase and new users would appear, eventually leading to still more economical production.

68. As raw material for sulphuric acid production in Kenya one would probably use imported elemental sulphur(18), the price for which has decreased drastically during the last year, depending on increased world production from refinery and sour gases occasioned in part by stricter anti air-pollution laws. Thus the present price for sulphur c.i.f. Mombasa is Shs. 350/ton compared with Shs. 800 one year ago.

69. For future use the pyrite deposits in Bukura constitute a possible local source (19), and it is important that they are further explored as soon as possible (not only for their sulphur content but also for possible non-ferrous metals).

70. Another possible source of sulphur in Kenya is the refinery gases. However, as crude oil low in sulphur is now being used and furthermore the gas-oil fraction is not de-sulphurized, there is under present circumstances little chance of obtaining sulphur from this source.

71. A third source of sulphur in Kenya is gypsum. Lately, what seems to be a large deposit has been discovered in the Kajiado area and gypsum is now being delivered from that deposit to both cement factories in Kenya and will probably also be delivered to the cement plant in Uganda. However no estimate of the size of the deposit has been made and although gypsum produces the cheapest sulphuric acid, the investment cost in such a plant is many times the one in a sulphur burning plant and the size of the plant would have to be so large that it would be unthinkable for Kenya circumstances. It has only been mentioned for the sake of completeness.

72. The size for a sulphuric acid plant to be proposed for Kenya does not so much depend on how much sulphuric acid is used or imported at present but on how much <u>can</u> be used. One important factor then is whether the production of sulphate of ammonia might be viable, as this would require a

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(18) Which for example is done by the sulphuric acid plant in Tororo, Uganda.

(19) The deposit is estimated at minimum 5 million tons. Analysis shows 42% sulphur.

sizeable amount of acid. Sulphate of ammonia is cheap and easy to handle, it is not hygroscopic and it is easy to manufacture and now that the big nitrogen fertilizer project in Mombasa has been abandoned, it seems opportune to start the manufacture of fertilizer in Kenya on a more modest scale (perhaps using cheap ammonia from Kuwait), which will benefit the country in many ways. The 1968 imports of nitrogenous fertilizers were 38,000 tons of which sulphate of ammonia was 6,300 tons. Not only is the use of fertilizers increasing, but if sulphate of ammonia was produced within the country its proportion might increase and to work with an estimated consumption of 10,000 tons[20] in 1971 seems to be safe. Consumption of 10,000 tons of sulphate of ammonia corresponds with 7,500 tons of sulphuric acid.

73. Sulphuric acid is also used in the production of super-phosphates of which Kenya imported close to 20,000 tons in 1968. In the Lake Victoria area carbonatites have been found, which contain apatite although the phosphorous content is low, but with a suitable concentration method they could be used. This needs more exploration, but must be kept in mind and be planned for. One must also remember, that with gas available from Lake Kivu and with sulphuric and phosphoric minerals available, the prerequisites for a regional, industrial complex are at hand, but admittedly this may be far off. If the production of super-phosphates is to take place in Kenya[21], it must be based on imported rock phosphates and the plant be situated at the coast, where production of sulphuric acid also would be cheapest.[22]

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(20) The program launched by the Ministry of Agriculture for increased production of maize, aiming at the export of 400,000 tons in 1974 produced on an acreage of 750,000 necessitates increased yields which only can be achieved with increased use of fertilizers and recommended quantities of 2 cwt. of super-phosphate and 3 cwt of nitrogenous fertilizer per acre will require 60,000 tons of super-phosphate and 90,000 tons of nitrogenous fertilizers. And this is for one crop only!

(21) There now exists a small plant in Uganda.

(22) The Mission has discussed a project for a combined super-phosphate sulphate of ammonia plant in Mombasa based on a 200 ton/day sulphuric acid plant. The plans however are still much too preliminary to be dealt with in this report.

74. Another consumer of sulphuric acid could be a rayon fibre plant. The consumption of rayon fibre in Kenya at present is about 3,600 tons which corresponds to a consumption of 4,000 tons of sulphuric acid, and when the 10,000 spindle rayon mill in Tanzania goes into production the consumption of rayon in East Africa will increase considerably.

75. Sulphuric acid is in Kenya used by the steel industry and can be used in the production of metallic sulphates, such as aluminium[(23)], iron, magnesium, copper, chromium[(24)], etc. Present consumption of aluminium sulphate in Kenya is 1,500 tons and in the whole of East Africa 3,000 tons/year. In addition to this, Broderick Falls will need 1,300 tons per year.

76. If, in order to make preliminary estimates of the size of a possible sulphuric acid plant in Kenya, one assumes that either the needs of sulphate of ammonia or rayon fibre shall be fulfilled by local production plus some 3,000 to 4,000 tons of metallic salts, one arrives at a sulphuric acid production capacity of 10,000 tons per year.

77. Before any decision to build a sulphuric acid plant in Kenya can be taken, a market survey and a complete feasibility study must of course be undertaken, which, again, unfortunately this Mission has not had the time to do. However, based on a proposed 10,000 tons per year capacity and in order to show at what approximate price sulphuric acid can be produced in Kenya, the investment and production cost for such a plant is made.

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(23) During the war, Kenya produced alumium sulphate using clay and locally produced sulphuric acid, according to a method developed by EAIRO.

(24) Chromium salts could be produced in Kenya using the chromite deposits in West Pokot, which are estimated at 60,000 tons and using sulphuric acid and local soda in the process. Chromium salts are used in the tanning industry in Kenya and chromic acid in the galvanizing industry.

.8. **FINANCIAL ESTIMATE**
For a Sulphuric Acid Plant

Type:	Sulphur burning plant, without heat recovery
Capacity:	30 tons/day
	10,000 tons/year
Working Hours:	3 shifts, 24 hours/day
Working Days:	350 days/year
Proposed Location:	Thika.

A. CAPITAL EMPLOYED

1. Building site, 5 acres @ Shs. 5,000 including utilities and improvements		Shs. 25,000
2. Factory builuings, including pumping station and water tower, transformer, and main el.equipment		200,000
3. Machinery and equipment, including spare parts and storage tanks	1,400,000	
trpt and insurance	80,000	
installation	120,000	1,600,000
4. Preliminary expenses		100,000
Total Investment Cost:		Shs. 1,925,000
5. Working capital, 3 months production and sales cost, excl. depreciation and contingencies		490,000
Total Capital Required:		Shs. 2,415,000

B. ANNUAL COST OF PRODUCTION AND SALES

Sulphur, 1/3 ton/ton acid, 3,333 tons @ Shs. 430		1,430,000
Water, 18 m^3/ton acid, 180,000 m^3 @ Shs. 0.50/m^3		90,000
Boiler feed chemicals		20,000
		1,540,000
2. Labour:		
Foreman, 1 @ Shs. 800/mo	9,600	
Labour, skilled, 1 x 3 shifts, @ Shs.500/mo	18,000	
Semi-skilled, 1 day shift @ Shs.350/mo	4,200	
Un-skilled, 1 x 5 day shift @ Shs.200/mo	12,000	43,800
3. Other Operating Costs:		
Steam (25)	-	
Electricity (26) 30 kwh/ton acid, @ 12 cts/kwh	36,000	
Maintenance & repair, 9 Shs/ton	90,000	126,000

(25) Plants producing more than 20 tons acid/day have surplus steam available.

(26) Waste heat recovery can render plant self-supporting.

4. Administration & Selling Costs:		
18% on cost		Shs. 450,000
5. Interest:		
8% on total investment cost		154,000
6. Depreciation:		
Building, 20 years	10,000	
Machinery 10 years	160,000	170,000
7. Contingencies:		36,200
	Total:	Shs.2,520,000

Cost price Shs. 252/ton Acid

C. PROFIT POTENTIAL

Price paid for sulphuric acid imported from Uganda, 1968, according to the import statistics (27), Shs. 700/ton (28)

Thus, 10,000 tons @ Shs. 700	Shs 7,000,000
Less costs	2,520,000
Gross profit	4,480,000

= 185% on total capital employed

79. As can be seen from this pre-investment study, sulphuric acid can be produced at a price much lower than what is now paid for imported acid. The Mission recommends that a complete feasibility study is carried out on the production of sulphuric acid and sulphates in conjunction with studies of the manufacture of other basic chemicals.

80. The Mission has discussed with interested parties various possibilities for establishing a chemical complex based on the production of sulphuric acid. As has been mentioned before, this could involve either the production of sulphate of ammonia or rayon. As interest for the latter has been forthcoming, a very preliminary lay-out of such a complex is made in the following.

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(27) Price paid in Nairobi for commercial acid, 98 - 100% H_2SO_4, density 1.84 in 250 kg. steel drums (deposit for drum Shs. 160) is Shs.298/drum, i.e. Shs. 1,200/ton!

(28) Sulphuric acid was imported from overseas in 1968 at a c.i.f. cost price of £69 per ton i.e. Shs. 1,380/ton. It is said that recently imports at dumping prices have been received, but no economic analysis can be based on such prices.

81. Present local consumption of rayon fibre is 3,600 tons per year. Taking into consideration an expanding market, a daily output fo 20 tons is taken as a basis plus production of 5 tons per day of cellophane, or a total production of 25 tons per day.

82. Raw material for the production of rayon is cellulose, which to begin with has to be imported but can later be produced by Broderick Falls. The chemicals needed for its production are 0.85 tons of sodium hydroxide(29) per ton of rayon for the production of alkali cellulose, 0.6 tons of carbon disulphide for dissolving the alkali cellulose and 1.10 tons of sulphuric acid for the precipitation of the rayon fibre.

83. The sodium hydroxide has to be produced in an electrolytic plant from salt. Production capacity should be 30 tons/day. By-products will be hydrogen and chlorine. Surplus chlorine can be converted into hydrochloric acid which again can be used in steel pickling and for the production of, for example, copper-oxy-chloride, a useful pesticide.

84. Carbon disulphide can be produced in an electric furnace from charcoal and sulphur. Capacity should be 15 tons/day.

85. The sulphuric acid should be produced in a plant like the one already described. However the capacity will have to be increased to 50 tons per day, which will further decrease the cost price. The surplus sulphuric acid can be used to produce metallic sulphates such as aluminium sulphate, etc.

86. A by-product from the rayon production will be sodium sulphate. It will be recovered in a quantity of 37 tons per day in the form of glaubersalt. Calcined, it will produce 12 tons of sodium sulphate. When Broderick Falls go into production they will need 5,800 tons of salt cake (glauber salt) per year and there will be no need to calcine that quantity.

87. A chemical complex as outlined, will need approximately 2.5 million gallons of process and cooling water per day, i.e. 400 m^3 per hour or 4 cu.ft. per second. For this reason the complex must be situated where there is an abundance of water and for that reason the town of Thika is proposed. There, two rivers

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(29) Must be iron free!

are found, the Chania river and the Thika river. The minimum flow in the Chania river is 51 cu.ft./second and in the Thika river 11 cu.ft./second. Both rivers join beyond Thika town. The water is of good quality and, as can be seen from the given figures, abundant.

88. Other reasons for situating the proposed complex in Thika are the existence of good road and railroad connections. Labour is also abundant and electric power is available.(30) Thus many facts speak for situating the complex in Thika.

89. The Mission has not had the time to work out even a preliminary cost estimate for the proposed complex, but recommends that this is done in cooperation with the interested investors.

90. Resume:

The Mission has discovered much interest in Kenya in the production of chemicals and believes that several of those dealt with in this chapter may eventually prove viable for domestic production. Obviously there must be other chemicals which also are of interest and can be produced, but it would go beyond the purpose of this exercise to go into more detail. Below, the various chemicals discussed are listed in their various complexes.

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(30) The complex will most probably install a steam turbine and produce a large part of its own electricity.

91. Proposed Chemical Complexes in Kenya

	Production	Raw Materials Local	Raw Materials Imported
A. Broderick Falls:			
1. Cellulose	45,000tons/year	Wood	
2. Sodium Hydroxide	4,700 tons/year(31)	Salt	
3. Chlorine	2,000 tons/year(31)	Salt	
B. Eldoret:			
4. Tanning extract	12,000 tons/year	Wattle Bark	
5. Fibreboard	6,000 tons/year	Wattle Bark	
6. Charcoal	15,000 tons/year	Wattle	
7. Tar	3,500 tons/year	Wattle	
8. Acetic Acid	2,500 tons/year	Wattle	
9. Methanol	1,300 tons/year	Wattle	
10. Furfural	2,000 tons/year	Maize cobs or Wattle Bark	
C. West Nyanza:			
11. Ethanol	8,000 tons/year	Molasses	
12. Acetic Acid	3,000 tons/year	Molasses	
13. Solvents	-	Molasses	
14. Vinyl Acetate	3,600 tons/year	Molasses	
D. Thika:			
15. Sulphuric Acid	15,000 tons/year		Sulphur
16. Sodium hydroxide	9,000 tons/year	Salt	
17. Carbon disulphide	4,500 tons/year	Charcoal	Sulphur
18. Rayon staple fibre	6,000 tons/year	Cellulose(32)	
19. Cellophane	1,500 tons/year	Cellulose	
20. Chlorine	8,000 tons/year	Salt	
21. Hydrochoric Acid		Salt	
22. Sodium Sulphate	11,000 tons/year	By-product	
23. Metallic sulphates	5,000 tons/year	Clay, etc.	
24. Copper-oxy-chloride	1,000 tons/year	Copper-scrap	

(31) Consumption.

(32) To be imported at the beginning, later from Broderick Falls.

E. Nairobi

25.	Polyvinyl Acetate	2,500 tons/year	Vinyl Acetate (33)	
26.	Thermo setting resins and glues	2,000 tons/year		Urea and phenol + Formaldehyde (34)

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(33) To begin with imported, then from complex in Nyanza.

(34) Can at a later stage be produced from either imported synthetic methanol or methanol recovered from charcoal production.

B. Building materials

92. The diversity and complexity of the building materials and components market and the absence of statistical data pertaining to production, import and consumption plus the present change in distribution channels for these products in Kenya, make it difficult to get a clear picture of this sector. However its importance is growing with the increasing building activity and the Mission is of the opinion that a full scale study of the building materials and components market ought to be done. Earlier studies of which the Mission is aware, namely the United Nations Mission to Kenya on Housing in 1964 (1) and the study made by the University College of Nairobi of the Kenyan building industry (2) have only lightly touched upon the building materials sector. The ECA/Bouwcentrum Mission to Kenya in 1967 recommends among other things that a study of the building materials industry should be undertaken.

93. This Mission has collected some information on the building materials sector and has tried to identify some products, which could be produced in Kenya. Pre-investment studies on a few of them has been made.

94. Sand and gravel.

The occurence of sand and gravel varies of course over the country and the Mission can naturally not have acquired any knowledge of the whereabouts or qualities of these products. However the Mission wishes to express the hope that the Materials Branch of the Ministry of Works, which during many years has been testing soils, sands and ballasts from all over the country, should publish a resume of its findings, which would be a valuable contribution to the knowledge of these products and would enable contractors and builders to look for the proper raw materials in the right places.

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(1) United Nations Mission to Kenya on Housing, prepared for the Government of Kenya by L.N. Bloomberg and Charles Abrams, United Nations, 1964.

(2) Constraints & Costs in the Kenya Building Industry, by E.J. Wells and E.R. Rado, Institute for Development Studies, University College, Nairobi, 1968.

95. Crushed stone.

Existing quarries seem to be undercapitalized and have low output but at least in Nairobi there now apparently are plans for the establishment of a large, well equipped aggregate producing plant. (3) On the slopes of Mt. Longonot there are large deposits of pumice, which at times are used in the manufacture of concrete or concrete blocks. As the pumice is easily excavated and a railway station is near by, the price for this aggregate in Nairobi is lower than for crushed stone. As it has good insulating properties, makes the concrete lighter and is cheaper, it ought to be used more frequently.

96. Cement

Production of cement in Kenya by the two cement companies was 544,000 tons in 1968, while consumption was 181,000 tons; the surplus was exported. With new cement plants going up in Africa and the Indian Ocean area, it may become harder to export and domestic consumption ought to be encouraged. This can be done in the form of production of more cement consuming products, such as cellular lightweight concrete, asbestos-cement products and cement stabilized earth blocks.

97. Raw materials for cement production are abundant, although for one of the plants they involve transportation from relatively distant quarries. The quality of the cement is up to and above standard.

98. Lime

Limestone deposits in the country are extensive. Lime-burning is being done in two places, one being at Koru, Homa Bay, near Lake Victoria, using Miocene lake limestones and another at Turoka near Kajiado, 16 miles from Nairobi, using marble stone. Earlier there was a third producer in Mombasa, using coral, but that enterprise closed operations one year ago. The Koru lime contains traces of manganese and is therefore not pure white, while the marble used at Turoka is somewhat dolomitic and consequently contains magnesia.

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(3) See ref. no. 2

99. Besides burnt lime, both manufactureres also produce ground limestone for agricultural purpose, and the Turoka firm also produces terrazo chips and marble sand. Only the Koru firm produces hydrated lime. Monthly production of all the lime products from the two firms is about 1,000 tons. Lime is imported from Tanzania and sells at considerably higher price than the locally produced lime.

100. It is the Missions opinion, that more lime could by used and would be used if it was more readily available, especially in hydrated form. At present contractors hesitate to use quick-lime, which must be slaked, and if the slaking is not done properly, bad results are achieved. It is suggested that a proposition which the mission has made to one mining company to set up lime-burning between Athi River and Nairobi from a pure limestone deposit which has been discovered, should be followed up, and that hydrated lime should be manufactured. It is important, that a well designed hydrator is used so that high quality lime can be produced. The Mission also hopes that negotiations which are going on to put the Mombasa lime-burner back into operation, shall succeed. Equipment for the production of hydrated lime does exist there.

101. Gypsum

Gypsum occurs at several localities in the North-Eastern province in the Coast province, and also in the Kajiado area in the Rift Valley. In this latter area there are two producers, one of whom is providing one of the cement plants in Kenya with its entire supply of gypsum and the other with part of its needs. The other producer calcines the gypsum and produces building plaster though on a relatively small scale. The first deposit is said to be 12 miles long and 1 mile wide but no real estimate of the tonnage has been made. However output has been steadily increasing and in July this year the production figure for 1968 had already been doubled. The second deposit, which is 10 miles apart from the first one, has been estimated to contain 8 million tons. Both enterprises are interested in finding new use for gypsum and the Mission has proposed the manufacture of gypsum slabs, fibrous plaster, plaster board, ceiling panels and/or acoustic tiles.

102. Plaster of Paris can be made either in a rotary kiln, on a travelling grate belt or in calcining kettles. Genuine hard plasters however must be produced in autoclaves.. For a relatively low production, the calcining kettle is ideal. The procedure consists of milling the rock in a hammer-mill and then passing it through a desintegrator to produce a fine powder. The powder is then calcined in the kettle, which is oil-heated and equipped with a stirring device. The operation is a batch process. The calcined powder is then put through an atomizer taking the powder down to about 300 mesh. By varying the grain size, the temperature and the time in the kettle, the setting time of the plaster can be varied according to what is requested and the use to which it will be put.

103. Gypsum slabs, for partition walls, poured from a plaster mix with or without aggregate can be made in a fairly simple, water-cooled machine, (4) which produces 12 to 24 slabs 50 x 66 cm, 6, 8 or 10 cm thick per working cycle of 10 minutes. The slabs can be made with tongue and groove. These slabs weigh 55, 75 and 95 kgs/m^2 respectively. Their cost depends of course mainly on the price the plaster, which is the main raw material, can be purchased or produced at. The machine produces about 250 m^2 per 8 hour shift operated by two men, it needs 20kw of electricity supply and also process and cooling water. The machine costs £11,000 plus freight cost to Mombasa estimated at £450. As partition walls are easily and quickly erected with these slabs and no water is introduced in the building, they may find a good market in Kenya, provided they can be produced at a competitive price.

104. Fibrous plaster is a thin sheet or slab of plaster, reinforced with a fibre, usually sisal fibre. This makes the slab so strong that it can be produced in large sheets, usually storey high and 4 to 6 ft wide but even larger sheets up to 24ft x 9ft are produced.

105. The production is usually carried out on a half industrial half artisan scale where the only machinery needed is a mixer and some transport facilities. The plaster mix is poured on large concrete tables, which may have a flat

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(4) For example the Exakta by Wehinger, Austria.

steel surface or the concrete itself may be trowelled to a high gloss. Plastic surfaces are also used. The table is greased before the mix is poured. Steel bars, 1/16 in. thinner than the sheet thickness required are laid at the edges of the table to retain the plaster while it is setting. Retarders are used to modify the setting time. When the plaster has been poured, cut and fluffed up teased sisal fibre is spread evenly over the surface - about 11 ounces per sq. yd. - and then forced into the plaster with a roller, whereafter the surface is smoothed. While the plaster is setting on one table the crew casts another sheet on a second table. When the sheets have set they are lifted into a vertical position and carried to the drying racks.

106. The fibrous plaster is used in countries as far apart as Spain and Australia. (5) The main use is as an internal lining for walls and as ceiling panels and as it is fire-proof, strong and easily fixed it could well find a market in Kenya where both raw materials exist. Its price will mainly depend upon the price of the plaster. Today building plaster costs £30/ton in Nairobi, which is very high but with larger or additional production it will probably decrease.

107. The investment for machinery and additional equipment for a small plant with 6 tables producing 2,000 sq. ft. fibrous plaster per shift with a crew of 6 men, will cost less than £5,000. Consumption of raw materials will be 500 tons of plaster and 20 tons of sisal (6) per year.

108. <u>Plaster board</u> refers to panels made of plaster, the surface and longitudinal edges being sheathed in a closely adhering special cardboard, which has the double function of exterior reinforcing and surface finishing. It has the same use as the fibrous plaster. It is produced in large, fully automatic industrial plants where the plaster mix is discharged continously between a lower and upper endless cardboard web, which passes at production speed over a forming table, through a combined convection-radiation drier followed by a cooler and cutting and trimming station.

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(5) In Australia further information may be had from:
The Associated Fibrous Manufacturers of Australia, 24, Bond Street, Sydney N.S.W.

(6) Kenyas production of sisal is 50.000 tons per year.

109. The capacities of plaster board plants are generally 1000 or 2000 m^2 per hour, the smallest having an output of 250 m^2 per hour producing 1.5 million m^2 or 15 mill. sq. ft. per year, working 3 shifts. Even this quantity is large for the Kenyan market where the output from one shift would suffice.

110. A market study must be made to determine whether the output from a 1-shift operation i.e. 500,000 m^2/yr can be sold in Kenya or East Africa. This Mission has not been able to make such a study but as it is necessary to know at what price plaster board can be manufactured a cost calculation has been carried out for a 3-shift operation and the break-even point has been decided to see if a 1-shift operation is possible.

111.

COST ESTIMATE

for a 250 m^2 per hour Plaster board plant

A. Plant cost

1.	Machinery and equipment, including silos, mixer, forming station, conveyors, drier, take-off unit, etc.	3,150,000 shs
2.	Transformer, 400 kw, cables etc.	290,000
3.	Erection and commissioning	740,000
4.	Freight to Mombasa	40,000
		4,220,000 shs
5.	Land, 15,000 m^2, and factory building, 100 x 24 x 5/12 m	1,600,000 shs
6.	Workshop, laboratory, admin. building, roads, forklift trucks a.o. equipment	850,000 shs
7.	Hot-oil unit w. pipes and compressor 5,000 l/min, 8 atm	330,000 shs
	Total investment cost	7,000,000 shs

B. Raw material cost and utilities.

		kg/m²	shs/m²
1.	Gypsum	6.3	0.63
2.	Wood pulp	0.1	0.19
3.	Foam		0.02
4	Adhesive	0.006	0.03
5.	Starch	0.05	0.10
6.	Accelerator	0.1	0.10
7.	Retarder	0.1	0.5
8.	Cardboard	0.7	1.20
9.	Glassfibre		0.20
10.	Water	6.0	0.05
11.	Heat transfer oil	9.0	0.25
12.	Electricity	0.30 kwh	0.04
		Total material cost:	2.86 shs/m²

C. Production cost (3 shifts operation)

		shs per sq.m. board
1.	Capital cost (7)	0.36
2.	Material cost	2.86
3.	Labour, 45 men, 3 shifts (8)	0.16
4.	Administration, 10 persons, 1 shift (9)	0.05
5.	General overheads and repairs	0.34
	Total production cost:	3.77 shs/m²

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(7) at 8% per annum and an amortization of 10 years average capital cost.

(8) with 9 operators and 1 foreman per shift; 4 mechanics, 2 electricians, 4 drivers and 5 packers per 2 shifts.

(9) with 1 technical and 1 commercial manager, 9 clerks.

D. Break-even point.

112. To decide the break-even point, a sales price corresponding to the sales price in Europe has been used, namely 42 cts/sq.ft. As is seen in diagram 1, page 40 the break-even point then is at 45% of capacity. This means that to run the factory in one shift only will result in loss. However if the sales price is increased 20% to 50 cts/sq.ft. the break-even point will move to 25% of capacity, which means that a one-shift operation in that case is possible although it is not very profitable.

113. A more detailed cost calculation and a market study will have to be made before a decision can be taken whether the manufacture of plaster board in Kenya is feasible, and the Mission recommends that such a feasibility study is considered.

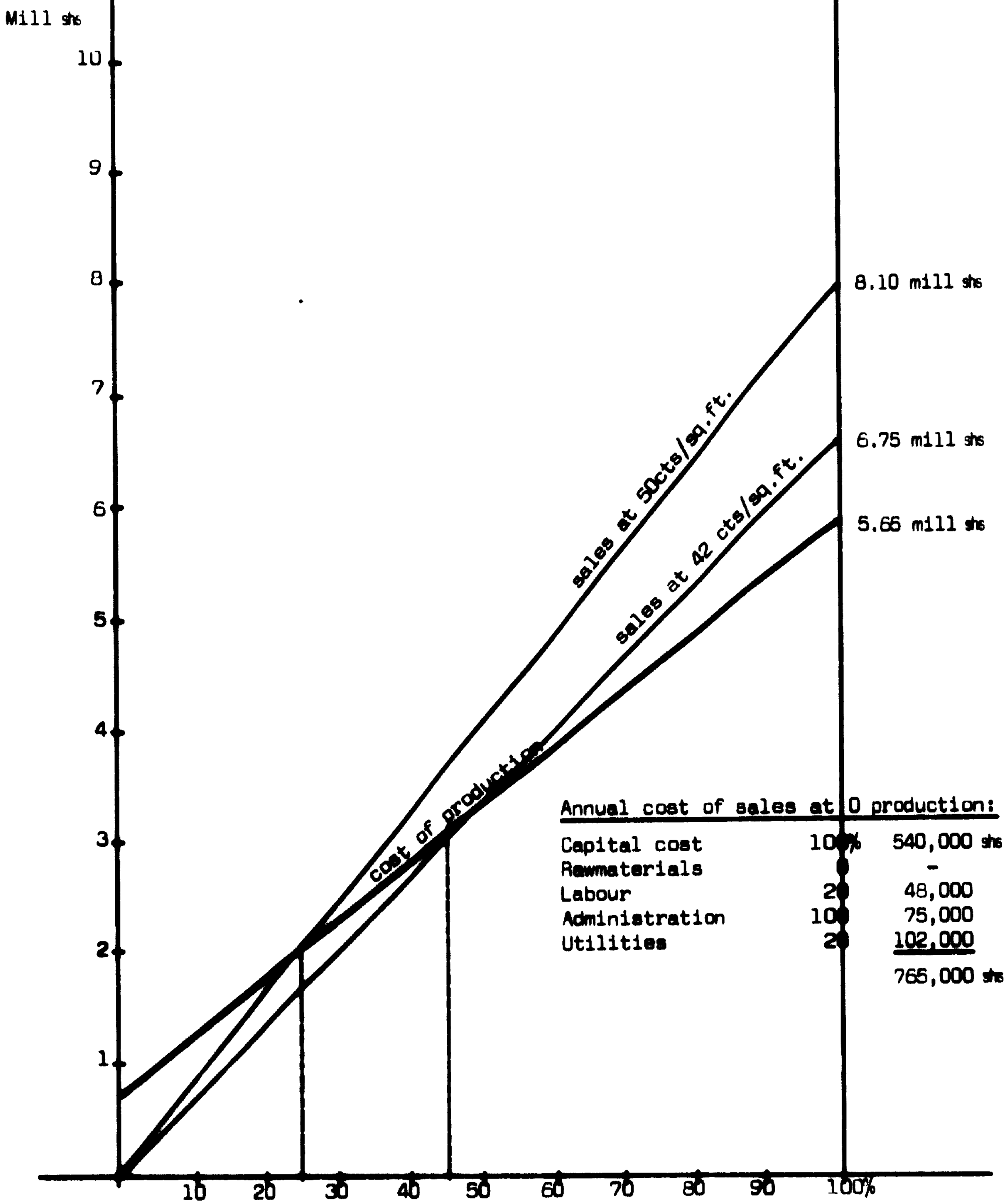
114. Acoustic tiles is a product which could easily be produced in Kenya and used instead of imported tiles. Various types can be manufactured, but if one wishes to find use for gypsum, they should be made from plaster of Paris and mixed for example with vermiculite, pumice or sawdust and/or shortfibre asbestos if that is available at a reasonable price. Overseas this type is made with mineral wool, but as that is not available in Kenya one could possibly use waste from textile mills.

115. The manufacture may be very simple, similar to that used for the production of fibrous plaster. A number of moulds or frames, the size of the tile to be produced, for example 12" x 12", are put on a table with a smooth surface, the mix is poured into the moulds (which have no bottom), and the upper surface is levelled with a wooden ruler. This should be done with a few quick strokes so that a relatively rough surface is obtained. The surface should not be smooth, because the rough surface gives the tile the sound absorbing quality. When the tile has set, it is taken out of the frame and stacked vertically and allowed to dry. The sound absorbing quality can be increased if the tile is provided with a series of small holes, i.e. it is perforated. This can be done with a die, full of spikes, but must be done at just the right moment of setting for the plaster.

Diagram 1.

1.5 million m²/year Plaster board plant

Break-even point



P.O. Grane

116. The Mission believes acoustic tiles can advantageously be produced in Kenya, and has recommended the gypsum producers to consider such manufacture.

117. Concrete products.

Concrete blocks are commonly used all over Kenya. Factory made blocks generally are of good quality, while blocks made on the building sites sometimes seem to be of low standard. This depends on the machine and on the raw materials and the mix used. While in some instances a good, clean, sharp sand is used in other instances the sand is too fine and the practice of using 3 parts of quarry dust to 2 parts of sand, 5 parts of ¼" aggregate and 1 part of cement, cannot but give a low quality concrete block. (10)

118. Concrete pipes and other concrete products are likewise produced by several firms in Kenya. Spun concrete pipes from 4 in. to 48 in. are produced. Other products are electric poles, fence poles, paving slabs, road curbs, floor tiles, etc. Concrete roof tiles of high quality are produced in Nairobi and another producer exists in Mombasa.

119. Readymixed concrete is not p duced in Kenya but the Mission recommends that such production is started in the largest consumption centres. Such concrete, made under controlled factory conditions is of high quality and can be depended upon; it saves cement, saves time for the contractor and speeds up building. In Nairobi such a plant might be combined with a modern, well-equipped quarry.

120. Cellular lightweight concrete is a modern, structural building material, with low weight and high compressive strength. It has good thermal insulating properties, it can be worked like wood (can easily be sawn, cut and nailed) and is fire resistant. It can be produced in blocks but also as reinforced, storey high slabs for partition walls and as load-carrying walls and roofing slabs.

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(10) Natural stone has and still is being used as a structural wall material, but may with increasing labour costs, at least in the urban areas, more be replaced by concrete blocks. The stone is being entirely produced, cut and dressed by hand, using hammer and chisel. The Mission has in one quarry introduced a handsaw with tungsten carbide teeth, which seems to be able to speed up the production.

121. The raw materials for cellular concrete are a siliceous and a calcareous material, which are ground finely together, mixed with water to form a slurry to which a porosing agent is added. The slurry is poured in a mould where it rises and after setting it is steam cured in autoclaves at 8 atmospheres steam pressure and 180°C. The siliceous and calcareous components then form stable calcium-hydro-silicates, which constitute the finished product.

122. The siliceous raw material generally used is silica sand, but pozzolanas can also be used. In Kenya there is good riversand and the rhyolitic lavas that occur in several places have pozzolanic properties, some of a high standard and may make a very good product. The calcareous raw materials used are cement and/or lime, which are both available in Kenya. The porousing agent however, a special aluminium powder, has to be imported, but as the amount needed is about 1 lb per cu.yd. this is insignificant.

123. The minimum economical size of a cellular lightweight concrete plant has an output of 250 cubic yards per 24 hours. Cost for machinery and equipment is about 2½ million dollars. To this must be added costs for land and buildings, quarry equipment and trucks, steam plant and water purification, etc. plus 6 months working capital, as it concerns a new product to be introduced.

124. It is very probable that a decent sized cellular lightweight plant is just what the Nairobi area needs to fill its requirements of structural building material, and the Mission recommends that a complete study is carried out to decide whether this is feasible or not.

125. Structural clay products

The pre-requisites for production of clay bricks and other clay products do not seem to be at hand in Kenya. The raw material the clay, which sofar has been used, is not of the proper quality for production of ceramic products, and that may be the reason why the brickworks in Kenya go bankrupt.

126. In Mombasa there are two brick works, one of which went bankrupt five yearsago and was then bought up by the creditors. They have a very difficult clay, which when drying gives a very high rate of breakage and on top of this it must be burnt at a very high temperature (1100°C) to reach the ir-reversible

point, and that for 24 hours. Under such circumstances it is not easy to run the works economically.

127. In the Nairobi area in the Gatharaini valley, there are two brick works, which during the last years have been closed off and on. The larger one, which has a capacity of 110 tons of bricks per day, seems now to have definitely ceased operation. Looking at the bricks, this is understandable, because they are full of fissures and micro-fissures, revealing that the clay, which is the black cotton soil, is unsuitable (it is Aloysite), and in spite of bringing in plastic clay 9 miles from Karura, a quality product could not be made. However there is the possibility, of treating the clay in a pre-preparation plant, which would cost approximately £45,000, which could remedy the faults, but the present owner does not think this is worth while trying, especially as the market is uncertain. The smaller brick work, which is situated next to the larger one, produces some brick from time to time, when there is demand for them.

128. In the Highlands in places like Eldoret and Kitale clay bricks are produced in a less sophisticated way. When someone intends to build a house or needs bricks, he sends his men in the bush where they dig the clay, hand-mould bricks, puts them in a clamp, cuts wood-fuel and fire the bricks. The bricks are not and cannot be of any outstanding quality, but they build houses with them and they stand up. As people seem to be more brick minded in this area it is possible that industrial brick manufacture there could be feasible.

129. In the Nairobi area, where the clay is unsuitable, it is doubtful whether a new brick works, which is being contemplated, can be successful. Although a clay has been discovered, which shows the right properties, the deposit is in Masai land, where it is difficult to get a lease, and the transport cost to Athi River, where the plant would be located, will probably be high. Even if a first class product is produced, which it supposedly would be, the market has, because of the earlier, limited and off-and-on production of low quality, probably built up a certain resistence to brick products. It is therefore of vital importance, that a proper market study is made before any step is taken.

130. The large brick works in the Gatharai[illegible] valley, wh[illegible] closed down, has been advised by the Mission that as they [illegible] concrete and concrete products, they should join them and [illegible] expanded clay aggregate, which, when used as ballast in concrete [illegible] a strong and light structure saving in weight, foundations and [illegible] steel.

131. The process, which is used in the production of expanded clay [illegible] is characterized by heating clay nodules to such a temperature that [illegible] bound water or gases are driven off at a stage when the clay is just soft and about to melt, whereby the interior pressure of the gases makes the clay nodule expand in volume. Immediately thereafter the nodules are [illegible] off and thus stay porous, with the interior similar to pumice [illegible] with an exterior hard skin around the nodule.

132. Some clays show this bloating effect, others not, and therefore the clay to be used must first be properly tested. If the Gatharai[illegible] clay should prove not usable, the other clay from Karura might prove suitable, and besides it is much more plastic. Another property of importance is the lime content, which should be low, as otherwise the melting point will [illegible] high. If an otherwise easily available and suitable clay shows a low bloating effect, this can be remedied by mixing in an organic substance, which gives off gases at the right temperature. Mostly used is spray dried [illegible] sulphite liquor, which would then have to be imported. There are however other substances, which can be used, one of them being dried sewage sludge (11).

133. There are, in principle, three different types of kilns which can be used in the production of expanded clay, namely the rotary kiln (LECA), the moving grate belt (LURGI) and the vertical kiln (DETOON). Only the rotary kiln and the vertical kiln give spherical nodules and of these the vertical kiln is cheaper and has lower fuel consumption. The Mission will provide the interested party with cost information, which it has not yet had time to do and recommends, that a feasibility study for the production of expanded clay aggregates is carried out.

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(11) The city of Nairobi, produces such sludge at a rate of 10 tons/day with a moisture content of 17%. They also have surplus gas of 50,000 [illegible] per day, containing 60% methan which could be used to dry the sludge.

Hardboard

134. Time and again, plans for a fibreboard mill have been discussed in Kenya, but so far no definite proposal has resulted from these discussions. The main reason for this has been that the East African market, and particularly the Kenya market, has been considered to be too small. The imports of fibreboard can be seen in the following table:

Table 3

Imports of Fibreboards and other building boards of woodpulp or of vegetable fibre, '000 sq.ft.

	Kenya			East Africa		
	1966	1967	1968	1966	1967	1968
Chipboard	155	180		529	589	
Hardboard	5,797	3,555	13,553	14,218	10,283	34,250
Softboard	2,762	1,787		5,951	5,040	
Other	807	1,484		929	1,841	
Total	9,521	7,006	13,553	21,627	17,753	34,250

In 1968 the various boards were taken together in the import statistics, but if the same distribution as previous years is assumed, i.e. about 60% being hard board, then the 1968 figures would be 8 million sq.ft. for Kenya and 20 million sq.ft. for the whole of East Africa, or in tons (assuming 5 mm board) 3,600 tons in Kenya and 9,000 tons for East Africa. This later figure is an economical unit.

135. The building activity in Kenya - and consequently the use of building materials - is illustrated in Table 2.

Table 4

Total planned and projected expenditure on housing public and private sector, in million £

1968	1969/70	1970/71	1971/72	1972/73	1974/75
6.7	7.15	4.46	10.63	12.25	13.68

Source: Development Plan

136. If the consumption of hardboard follows the projected expenditure on housing, Kenya will double its consumption during the Plan period and will have reached 6,000 tons, which is the smallest economical hardboard mill, in 1972. As planning and erection of a mill will take two years, it is time to start the planning now, and in the following a pre-feasibility study will be made.

137. Plans for an integrated fibreboard - sawmill - woodwool cement board mill have been proposed. It is the Missions opinion, that fibreboard should be manufactured where the rawmaterials are found and woodwool cement board should be manufactured where the consumption is. Thus a fibre board mill should be situated in the forest areas while a woodwool cement board plant should be located in or near Nairobi.

138. It is not the intention to make a study of a conventional fibreboard mill, but to try to exploit the unique circumstances which make a specially suitable rawmaterial available, which may decrease the processing cost and probably make a 6,000 ton integrated fibreboard plant feasible.

139. In the manufacture of wattle extract, the bark is chipped finely and then processed with steam in autoclaves at a temperature of 240^{O}F at a pressure of 30 psi for a duration of 5 hours. The diffusion liquor is drawn off and the spent, chipped and cooked fibrous mass is well suited for the manufacture of hardboard and tests, which have been carried out for the Mission (12) show that an excellent board can be manufactured from it, and as part of the processing has already been carried out, it must obviously be cheaper to use this rawmaterial than any other. It is true, that the spent bark must be replaced by other fuel, but its value as fuel is minor. The spent bark, when put into the furnace of the boiler, has a moisture content of 70%. Thus 700 kgs of water must be evaporated, which takes 100 kgs of dry bark, with the result that 1 ton of spent bark can be replaced by 200 kgs. of wood.

(12) By the Swedish Forest Products Laboratory.

140. Two types of bark are treated, namely green bark (fresh) and stick bark (stored and dried). The analysis show the following composition:

	Green bark	Stick bark
Extractable	28.3%	46.2%
of which is tannin	20.9	34.2
Water	47.4	12.9
Fibre	24.3	40.9

141. The amount of extracted, spent bark produced by the largest extracting company in Kenya is 160 tons per day with a moisture content of 70% i.e. 48 tons of dry fibre per day. This is done during the harvesting season for wattle, which lasts about 6 months per year. During the rest of the year either surplus of spent bark stacked for later use (13) or thinnings, which are mostly left in the woods, or wood wastes and sawdust from the sawmilling operation can be used. Thus industrial wastes of little value can be transformed into valuable fibreboard and the economy of the wattle extraction can be improved.

142. The question of water can constitute a basic problem when a fibreboard plant is being planned and closed-circuit or dry processing at times must be utilized. However in this particular case the wattle extract company is situated very close to the Sosiany river, which 1931 - 1963 had a mean flow of 73,356 acre ft., i.e. 101 c.ft./sec. The proposed plant will use approximately 0.3 cu.ft./sec of process water. However permission to use water from the river must first be applied for from the Water Appointment Board who also will stipulate the conditions under which the effluents may be discharged back into the river. The quality of the water may be judged from the fact that Eldoret town takes its entire water supply from the said river.

143. In the following a cost estimate for a fibreboard mill under the previous conditions will be made. The initial capacity will be laid out for

(13) It would be preferred if spent bark could be used the year round as there otherwise will be a slight difference in colour and quality. The bark is also cheaper than the wood. This is something that has to be studied.

a production of 20 tons per day, i.e. 6000 tons per year. It is cheaper to run a 6000 tons plant at full capacity than a 10,000 tons plant at 60% capacity. The investment cost for the larger plant, in machinery only, is 30% higher. However, the layout for the plant should of course be made for future expansion. A thorough market investigation of Kenya's future needs, of the Common Market's development and possible exports to other neighbouring countries, a study which this Mission has not had the time or opportunity to make, must ultimately decide the size of the plant.

144. The Cost Estimate will be based on the following:

(a) the mill will run 160 days on spent bark and 140 days on wood.

(b) the value of the spent bark is equivalent to its replacement by wood-fuel the cost of which, in this case, is Shs.25/ton at the boilers. Thus 1 ton of spent bark = 0.2 ton of dry wood or 0.3 ton wood @ Shs. 25 = Shs. 7.50/ton.

(c) no value has been stated for thinnings, wood waste or sawdust or what quantity might be available; therefore the price for wood-fuel will be used, although this obviously is too high, as waste at most mills is burnt or given away.

145.

COST ESTIMATE

For a 6,000 tons per year Fibreboard Mill

Plant Cost

(a) General costs for plant site, road works, wood yard, water and sewage, power connection, etc.	Shs.	200,000
(b) Building cost		1,300,000
(c) Production equipment, including log chipper, chip screen, defibrating machine capacity 25 tons/24 hrs., raffinating machine with decker of screw type, capacity 40 tons per 24 hrs., sizing department, 1 Fourdrinier machine for 25 tons/hour planned to be expanded to 50 tons/hour, 1 2000 tons press with 10 openings, heat treatment and conditioning equipment, steam plant, water pump station and water treatment plant, impregnating department, production control department, repair shop equipment, consulting cost and projecting fee including supervision of building work and erection.		5,600.000 (14)
(d) Freight and transport cost for 250 tons of machinery		90,000

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(14) If the mill should be designed for spent bark only, this price can be lowered as it includes log chipper and both defibrating and raffinating machines. However, it might be wise to have the possibility of using wood as well.

C. Interest on invested capital, 8% on 7.3 mill.Shs.	98
D. Depreciation of total plant cost over 10 years, 10% on 7.3 million shillings	122
Shs.	368

146. This cost price, although being indicative only, can be compared with the c.i.f. value for imported hardboard, which in 1967 (latest available figure) was Shs. 440 per ton. Present sales price in Nairobi is Shs. 48 minus 10% discount for large quantities for an 8' x 4' 6 mm hardboard, sheet, which equals Shs. 2,700/ton.

147. The Mission recommends that the suggestion to integrate a fibreboard mill with the present wattle extraction plant and sawmill is followed up and that more detailed studies are made. The Swedish Forest Products Laboratory has undertaken to carry out tests on the raw materials during a period of 2 months for a fee of Shs. 13,000 for which they need 500 kgs. of dry, spent wattle bark. The Mission has passed this information on to the company concerned, who have also received a sample of the hardboard produced from their spent wattle bark.

148. Asbestos Cement Products

Asbestos-Cement products are finding an increasing use in Kenya, especially in the form of A/C sheeting for industrial buildings and for roofing in low-cost housing. A/C products in the form of pipes are also imported and the quantities are seen in Table 5.

TABLE 5

Imports of Asbestos Cement Products, Tons

	1967	1968
Sheets and tiles	5,020	5,800
Pipes	1,515	2,250
	6,535	8,050

149. The total imports in 1968 were 8,050 tons, and if consumption increases with the projected building activity (See Table 4, page 45) Kenya will be using 10,000 tons by 1970. This is the output from a 1-cylinder plant working 3 shifts and in the following the economical feasbility for installing such

a plant in Kenya will be studied.

150. Raw Materials

(a) Cement. Cement is produced by two cement factories, one in Athi River, 16 miles south-east from Nairobi and the other just north of Mombasa. Both produce cement in surplus quantities. The price in Nairobi is Shs. 251/ton, in Athi River Shs. 244/ton and in Mombasa Shs. 187/ton. Bulk deliveries are Shs. 8/ton less.

(b) Asbestos. Anthophyllite is the only asbestos mineral occuring in any quantity in Kenya. Mining has been done for over 30 years but output has with few exceptions been only a couple of hundred tons per year. The deposits, so far as is known, with one exception, are small. In 1967 production was only 50 tons. However, there are indications that Kenya has more asbestos[17], but exploration must be done to find out the location and magnitude of the deposits. The U.N.Mineral Resources Survey in its last Report has recommended that exploration for asbestos be carried out.

151. A deposit of anthophyllite in Makimyambu, Taita Hills, Coast province, has recently been surveyed by the Mines & Geological Department and the ore reserves have been estimated at 1 million tons. Unfortunately the ore is heavily contaminated with carbonates and the tensile strength of the fibre is low. The Mission has had a sample of this and other ores tested[18] with a view of possibly mixing in a smaller amount with imported asbestos. The received statement says: "The asbestos ore from Makimyambu seems to be more suitable than the Sigor or Wewey samples. It contains plenty of sand, which can be taken off by milling and by carefully preparing the asbestos. There are some fibres, of sufficient strength so we believe at least a limited quantity of 10 to 15% of these fibres could be used, if they can be delivered in clean quantities."

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(17) Until recently a very good asbestos has been delivered from Kitale to a Nairobi firm, but production has ceased because of illness.

(18) Gebr.Wehrhahn, Delmenhorst, Germany.

152. Obviously, the quality of the only known, large deposit in Kenya is poor, and no production of A/C products can be based on that deposit. However, it is not necessary to base a local A/C production on local asbestos. Only very few countries can do that. The overwhelming majority import the asbestos and as Kenya can get a very good long-fibre asbestos from one of the neighbouring countries, namely Swaziland, the economical feasibility of production of A/C products will be made, based on such import.

153. The estimate will be based on the following prices per short ton f.o.b. Lourenco Marques:

Quality HVL 3:	R200.00
HVL 4:	R160.50
HVL 5:	R123.60

Both sheets and pressure pipe production will be foreseen. The following mixtures will be used:

<u>Sheets</u>:	15% HVL 3 @ Shs. 2,200	=	Shs. 330
	25% HVL 4 @ Shs. 1,760	=	Shs. 440
	60% HVL 5 @ Shs. 1,360	=	Shs. 816
			Shs.1,586
	Freight to Mombasa		50
	Rail to Athi River		100
			Shs.1,736/ton
<u>Pipes</u>:	25% HVL 3 @ Shs. 2,200	=	550
	35% HVL 4@ Shs. 1,760		616
	40% HVL 5 @ Shs. 1,360		544
			Shs.1,710
	Freight to Mombasa		50
	Rail to Athi River		100
			Shs.1,860/ton

154. Three possible sites for the plant can be chosen between namely Mombasa, Athi River and Nairobi. The lowest cost of production would be achieved in Mombasa and the highest cost in Nairobi. Transport cost to the largest consumption centre would be highest from Mombasa and likewise breakage. Therefore, for the purpose of this calculation, Athi River has been chosen as site for the plant. If the plant can be situated next to the existing

existing cement plant, cement can be transported pneumatically to the A/C plant and no large silo will be necessary for cement storage, resulting in corresponding savings.

155. When planning the part of the plant for the production of pipes one can chose between a proper pressure pipe machine or a Magnani pipe plant, which however can only manufacture low-pressure pipes. While the latter plant is considerably less expensive only the former can produce high-pressure quality pipes and therefore a fully automatic pressure pipe machine has been chosen.

156. As the consumption of A/C products in Kenya will not be so great as to allow both the pipe machine and the sheet machine to run 3 shifts the year round, it will be assumed that the sheet machine runs 200 days per year and the pipe machine 100 days per year with for example 2 weeks sheet production, 1 week pipe production, etc., while the same labour force is being used. As sheet plant and a pressure pipe plant work approximately according to the same system, the same preparation line consisting of desintegrator, balances, turbopulper and rabbling vat can be used as well as other additional equipment such as settling tanks, vacuum installation, spraywater pumps, backwater pumps, etc. In the following the investment cost and cost of production for such a plant are estimated.

157. FINANCIAL ESTIMATE

For a combined Plant for manufacturing Asbestos-cement pressure pipes and flat and corrugated sheets.

Type:	Wehrhahn 1-cylinder sheet machine + 1 fully automatic pressure pipe machine.
Capacity:	10,000 tons/year per machine
Working Hours:	24 hours/day
Working Days:	300 days/year
Proposed Location:	Athi River

A. CAPITAL EMPLOYED

1. Building site, 6 acres @ Shs. 5,000	Shs. 30,000
2. Factory buildings, 3,000 m^2	364,000
3. Roads, foundations, fencing, water tower, transformer, etc.	150,000

4. Machinery and equipment:

Material preparation	shs 280,000	
Pressure pipe production	1,170,000	
Pipe finishing	300,000	
Socket finishing	236,000	
Additional equipment	535,000	
Laboratory equipment	150,000	
Spare parts	155,000	
Mandrels, pipe production	185,000	
Mandrels, socket production	46,000	
Sheet production	360,000	
Templates + intermediate plates	125,000	
Additional equipment	15,000	
Working and spare parts	44,000	
	3,601.000	
Transport + insurance and transport to site	180,000	
Installation	225,000	4,006,000
5. Preliminary expenses and administration during building period, publicity		100,000
	Total investment cost	shs 4,650,000
6. Working capital,		
3 mo production and sales cost, excl. depreciation and contingencies		1,500,000
	Total capital requirement,	6,150,000 shs

B. ANNUAL COST OF PRODUCTION AND SALES

Raw materials:		
Sheet production, 200 days,		
Cement, 5,000 tons @ shs 220 (19)	shs 1,000,000	
Asbestos, 850 tons @ shs 1736	1,475,000	
Water, 3,000 m^3 @ shs 0.50	1,500	
Pipe production, 100 days,		
Cement, 2,500 tons @ shs 220 (19)	550,000	
Asbestos, 435 tons @ shs 1860	810,000	
Water, 1,500 m^3 @ shs 0.50	750	shs 3,937,250
Labour:		
1st shift, 1 engineer @ 2000 shs/mo	24,000/yr	
1 foreman @ 800 "	9,600	
3 mechanics @ 600 "	21,600	
22 labour @ 350 "	92,400	
2nd and		
3rd shift 2 x 1 foreman @ 800 shs/mo	19,200	
2 x 3 mechanics @ 600 shs/mo	43,200	
2 x 12 labour @ 350 "	100,800	310,800
Utilities		
Electricity, 200 days x 70 kw x 24 h		
@ 0.12 shs	40,300	
100 days x 300 kw x 24 h		
@ 0.12 shs	86,400	
Sieves,	36,000	
Felts, 25 pieces	150,000	
Lubricants,	20,000	332,700
Maintenance		40,000

(19) Present price is shs 244/ton. For delivery in bulk and to a large customer, 10% discount has been allowed.

Depreciation:		
Building, 20 yrs	25,500	
Machinery, 10 yrs	400,000	425,500
Interest:		
8% on total investment cost,		370,000
Administration:		
1 plant superintendent	36,000	
1 accountant	12,000	
1 secretary	6,000	
2 clerks	12,000	66,000
Selling costs:		
Sales manager, salesmen, commissions, advertising and publicity, service, telephone, mail, etc. 12% on sales.		925,000
Contingencies:		42,750
	Total costs shs	6,450,000

C. PROFIT POTENTIAL

Sales: 6,666 tons of sheets @ 770 shs/ton (20)	= 5,130,000	
Less 20% sales discount, breakage, etc.	1,026,000	4,104,000
3,334 tons of pipes @ 1,200 shs (21)	4,000,000	
Less 10% discount	400,000	3,600,000
		7,704,000
Less cost of production		6,450,000
Gross profit	shs	1,254,000

= 27% on total investment cost.

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(20) This corresponds with present selling price in Nairobi, including a recently introduced 15% discount.

(21) Present selling price in Nairobi for imported 8 in. pipe, class B is 1640 shs/ton and for the same pipe, class D, 2200 shs/ton. A 4 in. drain pipe costs 1035 shs/ton.

Other building materials, and components

158. Wood-wool cement board is another type of building board which could probably advantageously be produced in Kenya. It is now imported in significant quantities and is used as ceiling panels and for partition walls. Other uses are for roofing and also as fill-in material in wooden frame houses. In many countries it is used for low-cost housing projects. The large panels, which are strong and light, are quickly erected. The raw materials used are wood-wool mixed with cement, both of which are available in Kenya.

159. Machinery and equipment for a plant producing 1.7 million sq.ft. per year of 2 in. board, i.e. 10,000 cu. yard per year, will cost approximately £60,000 erected in Kenya. Cost of production would probably be under 1 shs per sq.ft.

160. As an alternative to cement as binder, also plaster of Paris can be used. Recently a different type of glue-like binder has come to use, which is said to produce a superior board, although it may be somewhat more expensive. The Mission believes that a type of bonded wood-wool board could find a market in Kenya and recommends that a study for such manufacture is carried out.

161. Straw board is made from wheat or rice straw which is pressed together under heat developing and utilising the self-bonding feature of the straw. The board is produced in panel form, similar to the wood-wool cement board, only it is clad with kraft paper. The raw material, the straw, exists in Kenya although it is at present not collected. When harvesting, the straw is cut high. However the Kenya Farmers Association have made it understood that straw for this purpose could be collected.

162. Machinery and equipment for a plant producing 3 million sq.ft. per year would cost about £45,000 installed in Kenya. Cost price would probably be approximately 1 shs per sq.ft. or similar to wood-wool cement board. The two types of board can in many instances be substitute for each other.

163. Before either type of board is considered for manufacture in Kenya, it is important to find out whether by-laws and regulations permit their use in the various forms contemplated and that the acceptance of governmental and local authorities is secured.

164. Chipboard is being produced in Uganda and another plant is under construction in Tanzania and both together will be able to more than cover the whole East African market. There is however one possibility that could make it feasible to also erect a plant in Kenya, namely if the extrusion process was employed which can use valueless sawdust and convert it into large sized panels of tubular board up to 5 in. thick which can be used directly as loadbearing exterior wall elements. If such a plant is directly combined with an assembly-line production of standardized prefabricated houses it may not only be feasible but also profitable and thereby contribute to solving the housing problem in Kenya. The Mission recommends that a complete cost estimate of the manufacture of extruded tubular board is made.

165. Laminated plastics is a modern sheet material which also in Kenya is being used in increasing quantities, and it is possible that a plant for such production could be viable to cover the East African market. A plant using ready-made resin films, with a capacity of 1.2 million sq.ft. per year with machinery mainly consisting of a 2400 ton hydraulic press with 4 openings and including a high pressure steam boiler would cost approximately £42,500 erected in Kenya. Sales volume could be expected to be about 1 million sq.ft. the first year and selling price can be assumed to be 1.70 shs per sq.ft. The cost of prodcution and the profitability remain to be studied. The Mission suggests that a further study of such a project is considered.

166. Sand lime brick is another type of building material which has been used for many years in other countries. It is produced by dry-pressing a mixture of graded silica sand with 5 - 10% of hydrated lime and then steam-curing the bricks in autoclaves at 8 atmospheres pressure, whereby a strong bond is obtained. As clay bricks have had no great success in Kenya, mainly depending on un-suitable raw materials, sand-lime brick may be the answer. The machinery is not very complicated, it consists of mainly a mixer, a press, a steam-plant and autoclaves. The bricks produced have exact dimensions and are strong. One draw-back might be that they are only produced in one standard size, 9" x 4½" x 3" and consequently it takes more bricks, more mortar and more time to build a wall with these bricks than with large sized concrete blocks for example, which are so common in Kenya. The cellular concrete, mentioned before, which is also a sand-lime product, may therefore be prefered, if it can be produced at a competitive price, and as it is produced in large sized blocks and panels.

167. Iron mongery, pipes, sanitary and electrical fittings are mostly imported but nails, screws and simpler hinges are produced in Kenya. It seems that this is a sector where more products could be manufactured in Kenya.

168. Pitch fibre pipes, which are being used as drain pipes are imported to Kenya, in an amount of close to 500 tons per year and East Africa takes over 1,000 tons per year. The raw materials are coal-tar pitch and waste paper with the addition of some asbestos. Lately work has been done in the U.K. on using oil residues which seems to have had success and in that case all the raw materials would be found in Kenya. However the size of a plant is large and a production capacity of 3,500,000 ft. calculated as 4 in. pipe is considered to be the minimum size to be run efficiently. The cost of such a plant would be in the region of £250,000. It is possible that the U.K. firm who now exports to East and West Africa as well as to the Middle East might be interested in setting up a joint venture in Kenya and do the export to other countries from here. The Mission suggests that this idea is followed up.

169. Wood might be the building material which should have been mentioned first, as it is one, if not the principal natural resource of Kenya. As however its creation, extraction and utilization falls under the aegis of FAO, as does housing, it will not be dealt with in this Report and it only may be mentioned that hardly any house can be built without using wood in one form or another.

170. Resume:

While it may be possible that each one of the different building materials, which the Mission has recommended for further study, by itself may be a viable proposition, it will certainly not be possible to produce all of them side by side in Kenya. This is why the earlier used ad hoc approach cannot any longer be allowed. The whole sector must be studied and the costs and advantages of the various types of building materials be compared and evaluated against each other. The main type of housing that is expected to be built during the foreseeable future must also be taken into consideration. If the majority of houses should for example by 2 - or 3 - bedroom houses of 400 to 500 sq.ft. and not costing more than a few hundred pounds, (22) then it

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(22) According to the Development plan 56% of the demand for housing can only afford to pay less than £450

seems that the way to build such houses may be the prefab concrete panel houses of the type that the City Council of Nairobi are building or the prefab wooden houses of the type the Forest Industries Training Centre in Nakuru are turning out.

171. For further expansion, an alternative to a large, modern, prefab house manufacturing plant with a high output could be a certain number of smaller, well-managed, centrally directed units, located in strategic places in the country, where locally acquired building material could be put together into a number of modular elements according to a common system and plan . Flexibility and alternative use of a number of building materials should be foreseen to avoid high transportation cost, but be limited and strictly standardized. If this were to be combined with a centrally produced "Wet Unit" comprising of the kitchen and sanitary equipment, which only has to be put in its place in the house and be connected to the mains, a considerable saving in cost, skilled labour and time of installation and erection could be achieved.

172. While large-scale housing schemes in developed countries are one of the answers to the housing problem, this may, for various reasons, not yet be feasible in Kenya. There however exists one system which the Mission believes could be used to advantage here; the shell of the house could be erected in 2 days and at a low cost. The construction is done in the following way. On a prepared concrete slab a hemi-spherical plastic-impregnated canvas balloon is inflated. It is covered with prewelded steel mesh whereafter concrete is sprayed on it to form the shell of the house. Openings for door and windows as well as for a chimney are left. The concrete surface is smoothed and after a day or two, when it has set sufficiently to carry its own weight, the balloon is de-flated and put up on another slab. The concrete can be made with mixed-in pumice aggregate or scoria to make it better heat insulating. Another possibility is to spray polyurethane foam on top of the concrete followed by a coat of a bituminous emulsion. Partition walls and sanitary equipment are then installed in the house.

173. This type of house, because of its hemi-spherical construction, needs very little steel and the shell can be thin and consequently little concrete will be needed. A house with a diameter of 23ft. for example will have a floor area of 400 sq.ft. and a wall-roof area of 830 sq.ft. (if it is a complete half-sphere). If the shell is made 3 in. thick it would use 207 cu.ft. of

concrete, which with the Nairobi price of 6 shs/cu.ft. then would cost £62. To this has to be added the cost of labour, the reinforcing, the partition walls and sanitary and electrical installation, etc. It does appear that the house could be built at a low price in Kenya and the Mission recommends that a complete cost estimate is made and that a pilot scheme is considered.

174. In some countries people might object to live in a round house, but in Kenya, where the large part of the population already live in round houses, this ought not cause any problem.

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ANNEX NO. 1.

1. The Mission has been asked by a Kenyan fir. to investigate the cost of production for the manufacture of ladies sanitary towels. The estimate has been based on the production of 500,000 packets @ 10 towels per year.

2. **Cost Estimate**

for the manufacture of ladies sanitary towels.

Machinery:	Risell, fully automatic.
Capacity:	60 towels per minute

A. Annual Sales:

500,000 packets @ shs 2,00		1,000,000 shs
Less 25% retailer discount	250,000	
Less 10% wholesaler "	75,000	325,000
		675,000 shs
less Cost of Production		508.225
Net profit before taxes		166,775 shs

Shewing 33% on cost.

B. Annual Cost of Production:

Rawmaterials	336,000 shs
Labour	28,800
Other operating costs	63,425
Administration	50,000
Depreciation, 10% on machinery	30,000
	508,225 shs
	i.e. 1.02 shs/packet

Rawmaterials:

Prices.

Wood pulp, cif Mombasa	1,680 shs/ton	
handling charges	20	
duty	-	
trpt to Nairobi	197	1,897 shs/ton
2-fold paper, cif Mombasa	3,150 shs/ton	
handling charges'	20	

duty	-	
trpt to Nairobi	140	3310 shs/ton
Non-woven mtrl.cif Mombasa	264 shs/1000 m^2	
Handling charges	2	
duty	-	
trpt to Nairobi	10	276 shs/1000 m^2
Plastic coated paper, cif M.	476 shs/1000 m^2	
handling charges	3	
duty	-	
trpt to Nairobi	14	493 shs/1000 m^2

__Cost,__ for 500,000 packages:

Wood pulp, 45 tons @ 1897 shs/ton	86.365 shs
2-fold paper, 7.5 tons @ 3310 shs/ton	24,825
Non-woven, 500,000 m^2 @ 276 shs/1000 m^2	138,000
Plastic paper, 50,000 m^2 @ 493 shs/1000 m^2	24,650
	272,840 shs
Less waste, 5%	13,160
	286,000 shs
Glue and packing mtrl, 500,000 @ 0.10 shs	50,000
	336,000 shs

__Labour:__

1 technician, 1000 shs/mo	12,000 shs
1 assistant, 400 "	4,800
5 packers, 200 "	12,000
	28,800 shs

__Other operating costs:__

Power and light, 90 kwh/day, 250 days: 22.500 kwh @ 20 cts	4,500 shs
Water	500
Maintenance	5,000
Rent, 500 shs/mo	6,000
Interest on loan, 8½% on 280,000	23,800
Royalties, 4% on 590,625	23,625
	63,425 shs

CAPITAL REQUIREMENTS

Machinery cif Mombasa	276,500 shs
handling charges	3,000
duty	-
trpt to Nairobi	1,500
	281,000 shs
Installation,	
1 engineer, 1 mo @ 150 sh/day subsistence	
175 " salary	9,750 shs
Labour	1,400
Start-up expenses	5,000
Contingencies	2,850
	300,000 shs
Working capital, 6 mo rawmaterials	170,000 shs
Total capital required	470,000 shs

A N N E X II

Solar Water Heaters.

1. Solar water heating has become accepted in many countries like Colombia, Spain, Israel, India and Australia to produce domestic hot-water supply. In countries like those mentioned, where there is plenty of sunshine simple equipment can utilize and convert the solar energy into useful heat to distill salt or brackish water, to produce hot-water or to heat furnaces. In Kenya with its warm climate and ample sunshine it could certainly be worth while installing solar heaters. A short description of such heaters will therefore be given.

2. A solar heater consists of 3 sections, the flat plate solar absorber, the circulation system and the storage tank.

3. The absorber plate consists of a copper-plate, for example 4 ft x 4 ft onto which a system of $\frac{1}{2}$" copper-tubes has been welded and through which the water to be heated is circulating. The copper-plate, which is painted black, to increase the absorbtion, acts as a heat exchanger, it absorbs the radiant energy from the sun and transfers it to the water. The temperature of the water may reach between 40^{0}C and 60^{0}C and can even, under certain circumstances, reach the boiling point. The absorber must be covered with glass to prevent heat loss by convection (acts very much like the glass in a green house).

4. When the water is heated its density decreases and it rises whereby thermo-siphon circulation occurs. The hot water enters the storage tank, with which it is connected and cold water flows downwards and enters the absorber. Thus the longer the absorber is subjected to the sun-rays the more is the water heated each time it circulates through the absorber.

5. The size of the storage tank will depend on the needs of the household but must be large because of the intermittent nature of the solar energy. It must also be well insulated as must the hot water pipes be.

6. The investment cost for a solar water heater is greater than for a gas or electric heater but once installed the sun does not send any bills for energy. Only maintenance costs must be taken care of. The Mission recommends that the production of solar water heaters is being considered.

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