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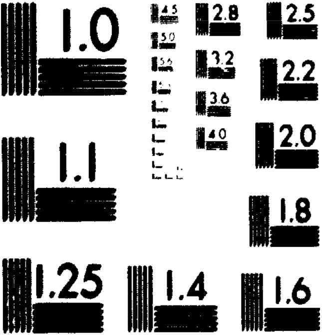

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UNIDO

SI/ETH/79/803

FEASIBILITY STUDY ON THE PRODUCTION OF ETHANOL FROM MOLASSES IN ETHIOPIA

000076

OY ALKO AB

1980

SI/ETH/79/803

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FEASIBILITY STUDY ON THE PRODUCTION OF ETHANOL FROM MOLASSES IN ETHIOPIA

UNIDO Contract No. 80/33
Project No. SI/ETH/79/803
Activity Code 11 20 32. 1. C

Contractor: Oy Alko Ab
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INDEX

ANNEXES

FOREWORD

The objective of this work was to carry out a detailed technico-economic feasibility study on the production of ethanol from molasses for use mainly as a gasoline additive.

Responsibilities of the contractor

A project group of three persons was assigned by the contractor, Oy Alko Ab, Finland, to implement the feasibility study and other responsibilities of the contractor.

In addition to the project group several of Alko's technical and financial experts have been assisting in the work.

The project group started its work in Ethiopia 28th February 1980 and returned 2nd April.

Briefing at UNIDO, Vienna of the team leader was February 26 - 27 and debriefing April 15 - 16. 1980.

- The techno-economic feasibility study

  The study gives the outlines of the technical solutions and the total investments including rentability calculations.

  The report is compiled mainly by the project group. Financial and economic calculations and evaluation are made by one of Alko's experts of economics.

- International tender specifications

  A request for quotation has been made separately and accompanies this report.

- Advise on project financing and Government participation

  The project group discussed several times on financing of the project with representatives of possible financers in Ethiopia, Vienna and in Finland. Discussions with representatives of the Ethiopian Government have also been conducted.

- Recommendations for monitoring project implementation

  The Ethiopian government might need technical assistance from an impartial specialist for comparison of tenders and choosing the machinery and equipment contractor.

  Supervision of the erection and installation work as well as assistance during test run period and start-up shall be included in the responsibilities of the plant supplier. Further recommendations and advising is included in the report.

Calendar difference

In Ethiopia the Gregorian calendar is in use. The year starts September 11 in the Julian calendar year. The Ethiopian and the European years are thus overlapping.

Ethiopian statistics are made in accordance with the Gregorian calendar, but in this report all figures are handled in accordance with the Julian year. Therefore, there might be some inaccuracy in the figures presented. 1st January 1980 in the Julian calendar falls in year 1972 in the Gregorian calendar.

Rajamäki, Finland 22nd May 1980

Olli Kauppila

I SUMMARY

Project background and history

The Ethiopian Sugar Corporation (ESC) desires to embark upon a programme of alcohol production from molasses for use as additive to gasoline. Ethanol can be used as an adjunct in gasoline resulting in considerable savings in crude oil.

The promoters of the project are the Provisional Military Government of Socialist Ethiopia/Ministry of Industry, and the United Nations Industrial Development Organisation (UNIDO), which has paid for the feasibility study made by the State Alcohol Monopoly of Finland, Ltd (Oy Alko Ab).

Market and plant capacity

The use of ethanol in Ethiopia depends on the consumption of gasoline, which in turn depends on the number of cars and on government regulations.

The total number of cars is approximately 46 000.

Total sales of gasoline this year will be c. 120 000 ton and the demand is growing. Because of the ever increasing price of petroleum, which takes more and more foreign currency, the Ethiopian Government regulates gasoline sales.

The refining capacity of the Asab Oil Refinery, governed by the Ethiopian Petroleum Corporation, is currently 650 000 ton crude oil per year.

Gasoline as well as other oil products are distributed via private oil distribution companies.

Ethanol will be utilized as a blend with gasoline (10 - 20 %). Since 70 - 75 % of the total gasoline consumption is in the

Central Region of the country blending of ethanol and gasoline can occur either at the distributors stores in Addis Ababa or at a blending station in Nazareth.

The production of ethanol could start 1983 - 1984. The gasoline consumption in the Central Region will then be c. 125 000 ton. The maximum amount of ethanol in the blend (20 %) would in this case be 27 000 ton. The plant capacity will be 20 000 ton/a.

The production of ethanol from the molasses available is as follows

1984	15 000 ton
1985	15 500 "
1986	17 500 "
1987	20 000 "
1990	20 000 "

No marketing problems are anticipated and it will be possible to double the use of ethanol in the blend. Because of lack of raw material it is not possible to increase the production of ethanol in the first years.

Materials and inputs

The production of molasses, which will be the raw-material for the alcohol production, is at present 53 000 ton/year. It increases with the sugar production and will be 90 000 ton in 1985 and 110 000 ton in 1990.

For full capacity production of power alcohol the annual need for molasses is 86 000 ton.

Other users of molasses are the potable spirit industry, 12 - 20 000 ton per year and baker's yeast industry (possible), 4 000 ton per year. Export of molasses, 10 -30 000 ton/a, is forecasted.

Auxiliary materials for the process are the chemicals listed below.

Chemical	Amount needed annually, ton
Sulphuric acid	70
Formalin	100
Caustic soda	75
Sodium hypochlorite	10
Diammonium phosphate	25
Magnesium sulphate	5
Defoaming agent	12
Benzene	60

Utilities needed for the process are:

Steam c. 10 ton/h, 3-4 bar
Electricity maximum 580 kW, 380 V, 3-phase, 50 Hz.
Process and cooling water c. 10 000 m^3/d, 22^oC.

Location and site

Suggested is the Wonji Sugar Estate in Shewa Kefle Hager in the county of Yerer & Kereyu c. 120 km south from Addis Ababa.

A suitable site for the power alcohol factory is an open field in Wonji headquarters area (site 1, Map 3, ANNEX 19). The distance to the water canal is 50 m, to the boiler house 300 m and to the molasses dam 200 m.

Project engineering

The planned full production capacity is 60 ton ethanol per day. The production is based on fermentation of sugars in molasses and on distillation and dehydration of ethanol.

International tenders will be requested and companies offering equipment are asked to use their own technologies. The best solution will optimize energy consumption and investment costs

The intention is to use domestic energy as far as possible. The distillation remnant vinasse is either concentrated by evaporation and then burnt in a special boiler or digested anaerobically to methane which is burnt. In the first case 85 % of the steam needed is generated with vinasse and in the second case 90 %.

Plant organization and manpower

The power alcohol plant will be a part of the existing sugar factory.

The manpower required to operate the power alcohol plant is
2 engineers or chemists
12 foremen or other staff members
22 skilled workers
34 semiskilled workers
11 other workers

Total manpower will be 81.

For special services staff and labour is available from the sugar factory.

The training of engineers has to start at least 9 months before the start up of the factory and of the others 1 - 6 months before start.

Implementation schedule

The general implementation schedule is presented in ANNEX 27. The main timing in the schedule is:

i 8 months for proposals and choosing the machinery contractor ii 15 months for delivery of main equipment

iii 5 months for assembly

Financial and economic evaluation

Total investment costs in M Birr:

	Without vinasse treatment	Vinasse evaporation and burning	Vinasse digestion and methane burning
Machinery	20.1	26.9	31.0
Buildings	4.6	4.75	5.0
Other	1.0	1.05	1.05
Total	25.7	32.7	37.05

The following list of possible financiers has been compiled:

1) European Investment Bank
2) UNIDO
3) Ethiopian Government

Capital costs are calculated with a rate of intrest of 8 % and with depreciation rates used by ESC.

Total production costs with full capacity are:

M Birr	Without vinasse treatment	Vinasse evaporation and burning	Vinasse digestion and methane burning
Capital costs	4.022	5.191	5.909
Fixed costs	1.270	1.550	1.720
Operation costs	5.174	3.191	3.075
Total	10.466	9.932	10.704

The lowest total production costs are reached with vinasse evaporating and burning.

Rentability and return on investment for full capacity are as follows:

Million Birr	No vinasse treatment	Vinasse burning	Methane burning
Price of Ethanol	17.950	17.950	17.950
Total costs	10.466	9.932	10.704
Economical gain	7.484	8.018	7.246
Return on investment	46 %	40 %	36 %

Vinasse burning gives the highest economical gain, but the best return on investment is in the case of no vinasse treatment (= burning oil).

The pay back period is 5.2 years with no vinasse treatment or with vinasse burning, but 5.8 years in the methane burning alternative.

Cash flow analyses are presented in ANNEX 28 - 30.

Break-even analysis of base alternative (no vinasse treatment) gives that the break-even point is at 41 % production rate, 8 284 ton/a.

Sensitivity analysis is made for the no vinasse treatment alternative with full capacity:

i If the price of oil increases by 10 % in real terms yearly rentability improves 119 % and break-even point improves from 41 % to 24 %.

ii If the price of machinery increases by 50 % from the estimated the rentability declines 28 %. The break-even point declines to 58 %.

iii If 30 000 ton of molasses is exported with a net income of 140 Birr/ton and the power alcohol plant produces only 13 000 ton/a ethanol the rentability declines 3.6 %.

National economic evaluation

Net savings in foreign currency:

Million Birr	No vinasse treatment	Vinasse burning	Methane burning
Full production, no export of molasses	5.14	5.47	4.85
Reduced production + molasses export	12.79	12.60	11.96

From the currency balance point of view it is most profitable to continue the export of molasses. Molasses export alone is no solution. Because it is possible that molasses export sometimes ceases it is wise to plan the capacity of the alcohol factory for total molasses amount available exluding potable spirit and baker's yeast.

Future perspectives

The demand for gasoline in 1990 will be 226 000 ton. If 25 % of the cars in Ethiopia in 1990 are ethanol cars and the rest use blended gasoline (20 % ethanol), the demand for ethanol will grow so that a 100 000 ton/a ethanol plant seems viable.

Sugar cane is the prime raw material in the future. There are also vaste, potential areas in Ethiopia for starch crop cultivation, but according to present knowledge starch as a raw material does not compete with sugar cane.

II PROJECT BACKGROUND AND HISTORY

Project background

The Ethiopian Sugar Corporation (ESC) desires to embark upon a programme of alcohol production from molasses for use as an additive to gasoline and also as a raw material for chemical production if appropriate. Ethanol (fermentation anhydrous alcohol) can be used as an adjunct (10 - 20 %) in motor car fuel (gasoline) resulting in considerable savings in crude oil. Crude oil prices are continually rising and increasing demand needs ever increasing amounts of foreign currency. In recent years there has also been a considerable import of refined gasoline (1980: 32 000 m^3).

ESC has three sugarmills: one in Metehara, one in Wonji and one in Shoa, ANNEX 1. Metehara is about 200 km from Addis Ababa, Wonji and Shoa about 120 km southeast of Addis Ababa.

ESC also plans to build a new sugarmill in Fincha-a about 300 km northwest of Addis Ababa. The Fincha-a mill will start production about 1985.

The Metehara, Wonji and Shoa mills currently produce 156 000 ton sugar per year. The production is growing and in 1985 it will be about 240 000 ton and in 1990 about 260 000 ton. The production of the Fincha-a mill will be about 75 000 ton per year. Production figures per mill are presented in ANNEX 2.

The production of molasses, which will be the raw-material for the ethyl alcohol production, is at present 53 000 ton/year. It increases with the sugar production and will be 90 000 ton in 1985 and 110 000 ton in 1990 in Metehara, Wonji, Shoa and Fincha-a together. The production of molasses in Fincha-a alone will be about 30 000 ton/year. Production figures per mill are in ANNEX 3.

Most of the molasses is now exported (25 000 ton 1980, 30 - 40 000 ton 1981) or used in the beverage industry (12 000 ton 1980, 17 000 ton 1985). Local use as cattle-feed is very small (less than 5 %). The rest of molasses is spread on roads or dumped.

The distance between Metehara and Wonji is 120 km, Metehara and Shoa 126 km, Wonji and Shoa 6 km. It is most economical to build a distillery at one of these mills. Any of the three sugarmills is suitable for this purpose, but the high temperature of cooling water in Metehara means additional cooling costs and therefore Wonji and Shoa would be prefered. The three locations are compared in Chapter V and in ANNEX 15.

The anhydrous alcohol produced in the distillery will be denatured with gasoline (1- 3 %) to prevent misuse. It will then be transported either to a Nazareth terminal, where road tankers coming from Asab Refinery can take about 10 % of ethanol into their gasoline load, or it will be sent to Addis Ababa and mixed (10 - 20 %) with gasoline by the distributors (Shell, Agip, Mobil, and Total). By using alcohol in gasoline it is possible to reduce or eliminate tetraethyl-lead.

Project promotor and initiator

The initiator of the project is the Ethiopian Sugar Corporation (ESC), address: P.O. Box 133 Addis Ababa, Ethiopia

The promoters are the Provisional Military Government of Socialist Ethiopia/Ministry of Industry, Addis Ababa and the United Nations Industrial Development Organisation (UNIDO), Vienna, which has paid for the feasibility study made by the State Alcohol Monopoly of Finland, Ltd (Oy Alko Ab).

Possible financers will be the European Investment Bank, UNIDO, Ethiopian Government etc. (See Chapter IX).

Project history

ESC has made a desk study on the extraction of ethanol from molasses for use as an admixture to petrol (Addis Ababa, 29th, July, 1978).

The results of the study were promising and on July 10th, 1979 the Government's Projects, Policy and Planning Department asked UNIDO for assistance in the project study.

UNIDO sent out a Request for Proposal 15th November 1979 (N:o P. 79/38). SI/ETH/79/803):

- i to prepare a techno-economic feasibility study on power alcohol production from molasses
- ii prepare international tender specifications for the recommended type and size of power alcohol plant
- iii advice on project financing and Government participation
- iv recommend arrangements to be made by Government for monitoring project implementation
- v submit a report on the above items.

Alko was chosen as contractor and a contract was signed 15th February 1980 by UNIDO and 26th February by Alko. The project group from Alko (Olli A.P. Kauppila/Team Leader, Chem.Eng., Patrick D. Stelwagen, Chemist and Anders E. Aejmelaeus, Chem.Eng.) started work 28th February in Addis Ababa.

III MARKET AND PLANT CAPACITY

The use of power alcohol

Power alcohol when used in concentrations under 25 % in gasoline is a very useful additive. Usually the alcohol concentrations in the blend vary from 10 % to 20 %. At these concentrations car engines do not need any modification and the "strength" (kilometers/liter) of the mixture is about the same as the "strength" of plain gasoline, because ethanol has certain advantageous properties when used in mixtures.

The ethanol used in mixtures must be dehydrated to 99.5 %, because when mixed with gasoline any water can separate and stop the carburettor.

It is also possible to use neat ethanol as a car engine fuel, but in this case existing engines must be modified. Modification costs are not high, but the engine requires about 30 - 40 % more ethanol than gasoline for the same number of kilometres.

For new types of special alcohol engines ethanol is an economic fuel. Ethanol is used as 93 - 94 % by weight, which saves dehydrating costs in production. The octane rate number of such a fuel is high and makes it possible to increase the compression ratio to 1:15. Then ethanol can compete with gasoline even in consumption per kilometre.

Alcohol cars have already been built in Brazil by many vehicle manufacturers.

A more detailed report on the use of ethanol as fuel is presented in ANNEX 4.

Consumption of gasoline and other oil products

The use of ethanol in Ethiopia depends on the consumption of gasoline, which in turn depends on the number of cars and on government regulations.

The total number of cars is approximately 46 000. The amount of gasoline cars is 38 000 - 40 000, the rest have diesel engines (ANNEX 5).

Two grades of gasoline are available:

	Octane number	Ex-refinery price	Market price (Addis Ababa)
Mo Gas Regular	79 - 83	0.45 Birr/l	0.755 Birr/l
Mo Gas Premium	90 - 93	0.532 "	0.90 "

Total sales this year will be c. 120 000 ton, and the demand is growing. Because of the ever increasing price of petroleum, which takes more and more foreign currency, the Ethiopian government regulates gasoline sales. (At the moment 7 liters per day with governement card and 15 liters per week for private cars).

Despite rationing, the consumption of gasoline grows because improving and increasing economy needs more and more transport.

Forecasts for the growth of gasoline consumption are 10 % per year, but rationing tries to keep it lower.

The refining capacity of the Asab Oil Refinery, governed by the Ethiopian Petroleum Corporation, is currently 650 000 ton crude oil per year. All capacity is used and in addition c. 32 000 m^3 of regular gasoline at a price of 544 - 724 Birr/m^3 are imported this year. The capacity of the Asab Oil Refinery will be increased to 1 Mton/ year in the near future. At the time of this study the price of imported crude oil was 36 US Dollar/barrel. Crude oil is imported from several countries.

The consumption figures of different oil products 1978 - 1979 and forecast demand figures for 1980, 1985 and 1990 are in ANNEX 6, and gasoline consumption in the whole country and in the central region are in ANNEX 7.

Gasoline distribution

Gasoline as well as other oil products are distributed via four oil distribution companies, which in order of sales are:

Shell Oil Company
Agip Oil Company
Mobil Oil Company
Total Mer Rouge Company

Sales figures for 1979 for the different companies are in ANNEX 6.

The distribution companies buy the oil products from the Asab Oil Refinery. The companies have storage tanks in Asab (Shell and Mobil), Massawa, Dire Dawa and Addis Ababa (ANNEX 8).

Oil products for the Central Region (Addis Ababa) are transported by tankers to Djibouti and then by tank trucks or train to Addis Ababa. The consumption in the Central Region is c. 70 % of the total.

The Nothern Region gets its oil products via Massawa by tankers and tank trucks and the environs of Asab by tank trucks.

The amount of ethanol available in the period before 1990 is sufficient for the Central Region. Therefore there is no need to transport the ethanol farther than to Addis Ababa.

Blending of ethanol with gasoline

In the near future there are no possibilities to use neat alcohol as fuel for cars because the quantity of ethanol available will be relatively small and because there are no suitable cars for this purpose.

Ethanol will therefore be utilized as a blend with gasoline (10 -20 %). The blending of ethanol and gasoline is a fairly simple operation. It needs a pump, a flow meter and a blending tank.

In principal it is possible to perform the blending operation at distributors' stores in Addis Ababa. Some investment for equipment is needed, but not very big because part of the equipment is already available.

To prevent misuse of alcohol it is necessary to denature it with gasoline (1 - 3 %) in the distillery store before transport.

There are other alternatives for the blending. If the Ethiopian authorities wish to centralize the control of the blending it is possible to perform the blending operation in the distillery store or at a Nazareth blending station.

This is suitable because the tanks of the trucks or trains are loaded only to 80 % in the very hot Asab area to avoid expansion losses and for safety sake. In the cooler Shewa (Shoa) Region it is possible to add an additional 10 % load.

To avoid heavy traffic on the vulnerable Nazareth - Wonji (or Shoa) road it is a good solution to build a blending station with pumps, flowmeters and storage tanks in Nazareth, beside the railway, so that blends in railway tanks can also be made.

With this alternative it will be convenient to denature the alcohol already in the distillery.

<u>Supply of ethanol</u>

The production of ethanol could start 1983 - 1984. The gasoline consumption then in the Central Region will be c. 125 000 ton = 170 000 m^3. The maximum amount of

ethanol in the blend (20 %) would in this case be 27 000 t = 34 000 m^3.
The production of ethanol from the molasses available (ANNEX 3) is as follows

TABLE 1

1983 (3 months)	3 750 ton =	4 700 m^3
1984	15 000 "	18 700 "
1985	15 500 "	19 400 "
1986	17 500 "	21 900 "
1987	20 000 "	25 000 "
1990	20 000 "	25 000 "

The amount of ethanol available is about 11 % of the forecasted total gasoline consumption in the Central Region. No marketing problems are anticipated and it will be possible to double the use of ethanol in the blend. Because of the lack of raw material there are not many possibilities of increasing the production of ethanol in the first years.

The capacity of the power alcohol plant corresponds to the molasses available from year 1985 in Wonji, Shoa and Metehara plus a 10 - 20 % overcapacity. To utilise this overcapacity some additional molasses from Fincha-a (300 km north west from Addis Ababa) has to be transported. Another possibility is to cultivate some additional cane to produce cane juice and use this for alcohol production.

Other uses of molasses and ethanol

- Potable spirits

The largest domestic use for molasses until now has been the production of potable spirits. There are four distilleries working in Ethiopia. The biggest is the Makanissa distillery with a production of 2 700 l ethanol per day. In a near future the capacity will increase to 7 200 l/d. The three other distilleries are the Agaki, Sebata and Asmara distilleries together producing 5 400 l/d. The Agaki distillery will be shut down after Makanissa's expansion and the total production capacity without

Agaki will be c. 11 000 l/d. Molasses consumption in modern distilleries is about 4.5 kg molasses per 1 kg of rectified spirit. The molasses amount needed for 11 000 l/d is c. 40 000 kg/d.

If the annual production period is 10 months the amount of molasses needed will be 12 000 ton/a. At present the distilleries are using 9 - 15 kg of molasses per kg of alcohol which means that the demand of molasses for full capacity will be at least 24 000 ton/year, which is too much. Approximate consumption figures of molasses for potable alcohol are presented in ANNEX 3.

A modernization of the potable spirit distilleries is necessary to lower their molasses consumption.

Molasses for potable spirit is currently transported from Wonji by tank trucks. After the Fincha-a sugarmill has started, the molasses for potable alcohol will come from Fincha-a and the Wonji molasses will be used exclusively for power alcohol.

Instead of a modernization of the distillery equipment in old distilleries it seems possile to build a central distillery for raw potable spirit in Fincha-a. The alcohol will then be transported to the old distilleries for rectification and for beverage production.

There are only theoretical possibilities to use raw-materials other than molasses for potable spirits. The equipment in the distilleries is not suitable for starchy material and, besides, starchy materials are expensive and needed more for food.

- Baker's yeast

There is no baker's yeast production in Ethiopia.

Dried baker's yeast is imported from different producers. The consumption today is c. 200 ton/year, but could be higher if the price were lower. The import of dried baker's yeast 1973 - 1978 has varied from 143 ton to 427 ton with import values up to 1.4 M Birr/year. The production of 1000 ton dried yeast/year seems to be quite feasible because there are possibilities for export in addition to the domestic demand.

Approximately 4 000 ton of molasses/a is needed for the yeast production. (It can be obtained from Fincha-a after 1986). Matters in connection with import, use and production of baker's yeast were discussed with representatives of the Ethiopian Food Corporation.

The investment for a yeast factory is c. 20 M Birr.

- Chemicals from molasses or from ethanol

Some import figures of molasses- or ethanol-based chemicals are presented in ANNEX 9. According to the figures there is no economic advantage in starting to produce these chemicals.

- Molasses as cattle feed

Investigations on the use of molasses as a cattle feed in Ethiopia have been made 1975 - 1976. The use of molasses as cattle feed is still very low: less than 5 %.

- Power alcohol as a household-fuel

Alcohol is a handy househould-fuel but the amount available for this purpose is too small. 25 000 m^3 ethanol/year would satisfy the demand of c. 0.5 Million people.

-Export of molasses

Export of molasses has varied from year to year. From 1975 to 1979 there was no export. The prices are improving and today the export price of molasses is 107 US Dollar/ton. The export forecast for the next years is 10 - 30 000 ton/a.

Molasses export alone is no solution to the problem of saving foreign currency, because amounts and prices are variable and never cover all the molasses available. When export prices are very high it might be sensible to export limited amounts of of molasses as well as produce power alcohol. This would diminish the alcohol production and very careful total optimization would be necessary.

By-products

By-products of alcohol production are carbon dioxide (CO_2) and vinasse.

- CO_2

The amount of CO_2 from fermentation is almost as great as the production of alcohol. Collection and purification costs are not high (c. 10 cents/kg) but at the moment the demand for CO_2 is not very extensive and besides, breweries are starting to collect CO_2 for their own use from beer fermentation.

There is no reason to invest in CO_2-collecting equipment now, but it is quite possible to do it later on if the market for CO_2 increases.

- Vinasse

There are three alternatives for using vinasse, the distillation residue containing c. 10 % dry matter:

Alternative 1.

Use of vinasse as fertilizer in the sugar cane fields.

Alternative 2.

Evaporation of vinasse and burning the concentrate to obtain energy.

Alternative 3.

Digesting vinasse anaerobically and using the generated methane as fuel in boilers and the effluent as fertilizer.

Each alternative will be discussed in following chapters.

IV MATERIALS AND INPUTS

The materials and inputs required for the production of power alcohol are classified in three groups: raw materials, auxiliary materials and utilities.

Raw material

The raw material for the process is cane molasses.

- Availability of molasses

The yearly availability of molasses in Ethiopia 1980 - 1990 and its estimated use for different purposes is presented in ANNEX 3. In the first years 1984 - 1986 there will not be enough molasses for full capacity of power alcohol production, but from 1986 full capacity production is possible.

- Price of molasses

The price of molasses can be calculated as zero. Taking into account handling and storage including pumping costs but excluding transportation a price of 10 Birr/ton has been estimated.

- Quality of molasses

Determinations of the quality of molasses from Metehara, Wonji and Shoa have been performed by the contractor. The results are presented in ANNEX 10. In the calculations 50 % fermentable sugars in molasses has been assumed.

- Need for molasses

The molasses needed for the planned production of power alcohol is presented in ANNEX 3. For full capacity (20 000 ton power alcohol/a) the annual need is 86 000 ton.

- Storage of molasses

In both the possible locations for a power alcohol plant combined with a sugar factory (see Chapter V.) there already exist storage capabilities for the molasses:

2600 ton molasses at Wonji and 4000 ton at Shoa. In addition, there is 8500 ton storage capacity at Metehara.

Auxiliary materials

Auxiliary materials for the process are the chemicals listed below. Also listed are the annual chemical requirements for full capacity of the plant (20 000 t power alcohol/a), their price per ton (1.5 x present world market price) and the price per produced ton of power alcohol.

TABLE 2

Chemical	Amount needed annually, ton	Price Birr/ton	Birr/ton power alcohol
Sulphuric acid	70	160	0,6
Formalin	100	810	4,0
Caustic soda	75	970	3,6
Sodium hypochlorite	10	650	0,3
Diammonium phosphate	25	2 030	2,5
Magnesium sulphate	5	570	0,1
Defoaming agent	12	5 700	3,4
Benzene	60	1 900	5,7
Total			20,7

- Specifications and quality of the chemicals

Sulphuric acid, H_2SO_4, 60^0 Be, technical grade (Standard: DIN 19618)

Formalin, 35 % formaldehyde in water, technical grade

Caustic soda, (Sodium hydroxide, Sodium hydrate, lye), NaOH, 47 %, technical grade (Standards: DIN 19615: AWWA B 501)

Sodium hypochlorite, (jawelle water, bleaching liquor, chlorine bleach), NaClO, 10 %, technical grade (Standards DIN 19608: AWWA B 300)

Diammonium phosphate, 20 % nitrogen, technical grade

Magnesium sulphate, technical grade

Defoaming agent, e.g. Struktol J650
Benzene, technical grade

- Alternative chemicals

In place of formalin pentachlorophenol is widely used in alcohol plants in Brazil. The annual need of pentachlorophenol for the power alcohol plant is 1 ton.

Urea can be used in place of diammoniumphosphate. Cyclohexane can be used in place of benzene.

- Auxiliary materials also include factory supplies,

i.e: maintenance materials
spare parts
tools, wear and tear material
oils, grease
cleaning material

The cost for such factory supplies are included in the overhead costs.

Storage capacity of chemicals and other auxiliary material for 0.5 years supply is needed.

Utilities

The utilities needed for the plant and the power alcohol process are: Steam, electricity and water.

Steam

- Need of steam

Specification of the steam: 3 - 4 bar

Amount:	For distillation	7.6 t/h
	For molasses sterilization and other requirements	1.5 t/h
	Total amount needed:	9.1 t/h

To be conservative a demand of 10 t steam/h has been used in the financial calculations.

- Supply of steam

The supply of steam for the production of power-alcohol is often satisfied by burning bagasse. Since practically no surplus bagasse is available, alternative supplies of energy for steam must be considered.

Alternative sources for energy for steam

i Fuel oil

The amount of fuel oil needed to satisfy the energy demand is 6150 t/a. When the price of fuel oil at the sugar estate is calculated as 284 Birr/t, the cost of oil for the development of steam is 1.75 Million Birr/a with present fuel oil prices.

Since fuel oil is an imported product it should be avoided as a possibility.

ii Wood

Since the net amount of forest in Ethiopia is already declining, the use of wood for the production of energy for the power alcohol plant must be rejected.

iii Geothermal energy

Ethiopia has a big potential for geothermal energy, although information about time, amount and price is not available.

iv Electricity

The electrical power needed to produce the steam for the process is 5.6 MW. With a price of 80 Birr/MWh, the annual cost for electricity to develop the steam is 3.6 Million Birr.

v Energy saving

The best way to produce energy is to save it elsewhere. It is possible to obtain a surplus of bagasse ranging from 6.6 % up to 36 % from a sugar factory. (2) pp. 93 and 99. The heat value of bagasse samples from Wonji and Shoa have been determined by the State Technical Research Centre in Finland (ANNEX 11).

vi Concentration and burning of vinasse

A waste product of the distillery process is vinasse. Energy can be recovered from the vinasse by concentration and burning. A calculation in ANNEX 24 shows that 85 % of the steam needed can be obtained from vinasse. Extra investment costs for the vinasse concentration and burning installation is 7 Million Birr.

vii Methane gas from vinasse

Methane gas can be produced from the vinasse by anaerobic digestion. The gas can in turn be used for the production of steam. A calculation in ANNEX 25 shows that 30 % of the total steam needed can be obtained from methane. The investment cost for a methane plant is c. 11 Million Birr.

- Combinations of the above

From an energy-viewpoint the methane-alternative seems most attractive, especially since the methane output is conservatively estimated. A part of the energy needed for steam must in any case be developed by an alternative method. The amount of make-up steam needed is approx. 1 t/h. The only realistic possibilities are to produce the make-up steam with bagasse, electricity or fuel oil.

The best alternative is to save energy in the sugar factory to obtain a bagasse surplus. The cost of electric energy for the make up steam is c. 400 000 Birr/a. The power needed is c. 620 kW. The cost of fuel oil is correspondingly 194 000 Birr/a.

Electricity

- Need of electricity: Min about 300 kW, max 580 kW

- Price of electricity

The price of electricity used in this study is 0.07 Birr/kWh. (The price of electricity per produced ton of power alcohol is 16.3 Birr).

The production and price of electricity in Ethiopia is presented in ANNEX 12.

Water

For the production of ethanol both process water and cooling water are needed.

- Process water

Need for process water

The need for process water without circulation is 700 m^3/d, and with circulation 300 m^3/d.

Availability of process water

The amount of condensate water from the sugar factory is of the magnitude of 100 m^3/h.
Process water is also available if the above mentioned evaporation of vinasse is implemented.

Quality of the condensate water

The quality of Wonjis condensate water has been determined by the contractor. Analytical results are presented in ANNEX 13.

Price of process water

The price of process water has been calculated as 0.64 Birr/m^3, mainly pumping costs. The price of process water per produced ton of power alcohol is 7.4 Birr.

- Cooling water

Need for cooling water
The need for cooling water for the process depends on the temperature of the water. The approximate amount for full capacity without circulation of cooling water is 9 000 m^3/d.

Availability of cooling water
An unlimited amount of cooling water is available from the Awash river.

Quality of cooling water
The temperature of the Awash-water is 20 - 23^o C: a mean temperature of 22^{o}C has been assumed. Analysis of the Awash river water is presented in ANNEX 14.

Price of cooling water
The price of cooling water is mainly pumping costs, and has been estimated at 0.1 Birr/m^3. The price of cooling water per produced ton of power alcohol is 14.8 Birr.

The needs and costs of all utilities have been calculated for full capacity of the power alcohol plant, 20 000 t alcohol/a.

Transportation

Transportation facilities are discussed in Chapter V. Transportation costs for molasses, alcohol and fuel oil are presented in ANNEX 26.

The transportation costs are calculated for full capacity of the power alcohol plant.

V LOCATION AND SITE

A technically and economically feasible location for a power alcohol plant is in combination with an existing sugar factory. The main reasons are:

- The availability of molasses
- The availability of factory services including electricity, water, maintenance etc.
- The availability of functioning infrastructure: roads, accesses, water, etc.
- The availability of social services for the manpower including housing, medical services, recreation, schools, etc.

Location alternatives

The existing alterratives are the sugar factories in a) Wonji, b) Shoa and c) Metehara, Map 1 (ANNEX 1)

Comparison of the alternatives

A comparison with reference to 21 variables is presented in ANNEX 15).

Elimination of the Metehara location.

Metehara sugar factory is eliminated mainly for the following reasons:

- The cooling water temperature is higher causing extra investment and operation costs for water cooling
- The availability of engineers and skilled staff is unsatisfactory compared with Wonji/Shoa.
- The climate is hotter than in Wonji/Shoa

Description of the locations in Wonji and Shoa Map 2 (ANNEX 16).

The sugar estates are only 6 km apart having a common cane sugar plantation of 5 900 ha.

Climate

Information on the climate in Wonji is presented in ANNEX 17.

Temperature

The minimum and maximum temperatures 1976 were 10.4 and 29.8°C respectively. The annual average minimum and maximum are 13.3 and 28.4°C (3).

Rainfall

The average rainfall over 26 years is 811.8 mm/a (3).

Winds

The prevailing winds are from the east. The areas immediately to the northwest west and southwest of the sugar factory boiler houses are dusty and sooty and not suitable as factory-sites.

Earthquakes

The East-African Rift Valley, where the locations are, is an earthquake area, but the risk for earthquakes is not considered to be a problem.

Location

The Wonji/Shoa sugar estates are located in Shewa Kefle Hager (Shoa Administrative Division), in the awaraja (county) of Yerer & Kereyu.

Site and terrain

The population in the Yerer & Kereyu awraja was 354 600 in 1977. In the small towns in the neigborhood of the sugar factories the population in 1977 was: Wonji Gefersa 4 750 and Wonji Alemtena 4 000 (3). In connection with the Wonji factory there is a confectionery factory.

Neighbours

About 7 km from Wonji sugar factory is a power station at Koka Dam. The town of Nazareth (population 69 500 in 1977) is at a distance of c.14 km. The distance from Nazareth to Addis Ababa is 110 km.

Height

The sugar plantation and the sugar factories are at a height of 1500 m above sea level. A few km away is Lake Koka. The Awash river flows by the plantation. To the west and northeast of the plantation there are ridges rising to a height of 1700 and 1950 m above sea level. To the south and south-west the land is flatter.

Transport facilities

Roads

The road from the sugar estate to Nazareth is an all-weather macadam road with a bridge over the Awash river. The Nazareth - Addis Ababa road is a good all-weather asphalt road. The road-net in and between the sugar factory areas consist of macadam roads.

Railway

The nearest railway station is in the town of Nazareth, 14 km away with connections to Addis Ababa and Djibouti (Distances: Addis Ababa c. 110 km, Djibouti c. 675 km.).

Water supply

Characteristics

Analyses of the Awash river water, condensate water from Wonji sugar factory and drinking water from Wonji and Nazareth are presented in ANNEXES 13 and 14. The temperature of the Awash river water is 22°C (20 - 23°C).

The drinking water in the sugar factory areas is defluorinated ground water.

Power supply

Electricity

Electricity is available from the interconnected system, Koka Dam, and internally generated in the sugar factories (1.24 MW Wonji, 1.9 MW Shoa). The electric power (ac) is 380 V, 3-phase, 50 Hz. The electricity tariff is presented in ANNEX 12.

Steam

The production of steam in the sugar factories is:
Wonji: 32 t/h, 15 kg/cm^2, 310°C.
Shoa: 35 t/h, 21 kg/cm^2, 350°C.

Communications

Automatic telephone

The Ethiopian Sugar Corporation main office in Addis Ababa has telex-communications.

Waste disposal

Waste water from both sugar factories is pumped to a lagoon, 400 l/s from each, 800 l/s together and further pumped to be spread on the cane fields.

Manpower

Total manpower in both sugar factories including the plantation is 6 500. The staff is 117 persons. The salaries for different manpower groups is presented in ANNEX 18.

Construction, erection and maintenance facilities

Both sugar factories have developed maintenance, erection and construction facilities, including workshops and carpenter shops. Building materials; iron, cement and planks are available in Addis Ababa.

Living conditions

Housing

All permanently employed manpower has free housing, free medical services, free water, and electricity at a reduced rate.

Recreation etc.

In the Wonji headquarters there are bathhouses, a club, cinema, guest house, tennis court, swimming pool, a school, slaughter house, police, a public bus station, a big modern hospital with outpatients department, a football field and a recreation field. In Shoa there are 2 football fields, schools (including a vocational training centre), a tennis court, swimming pool and a tea house.

Site alternatives

There are 4 alternative sites for a power alcohol plant. 2 sites are in the Wonji headquarters area (LOCATION A, Map 2, ANNEX 16) and 2 sites are in the Shoa sugar estate headquarters area (LOCATION B, Map 2, ANNEX 16).

The sites in Wonji headquarters Area (Location A) Map 3 ANNEX 19.

- Location A, site 1

An open field, 160 x 60 m, c. 1 ha, where a shop is now situated. A flat, plane area with a beautiful big tree.
Distances:
to the water canal: 50 m
to the boiler house: 300 m
to the molasses dam: 200 m
A road runs along the east side of the site.

- Location A, site 2

A uncleared space between a water canal and the Awash river.
A plane area with sparse vegetation c. 1.5 ha.
Distances:
to the water canal: 70 m
to the Awash river: 50 m
to the boiler house: 400 m
to the molasses dam: 200 m
The nearest road is c. 20 m distant on the cther side of the canal.

The 2 sites in Shoa headquarters area (Location B) Map 4. ANNEX 20.

- Location B, site 1

A flat, plane area (190 x 150 m, c. 2.8 ha) south of the sugar factory building.
Distances:
to the water canal: 140 m
to the boiler house: 140
to the molasses dam: 250 m
to the waste water canal: 170 m

The site is surrounded on 3 sides by roads.

- Location B, site 2

A flat, plane beautiful park area with trees, 100 x 150 m, c. 1.5 ha.

- Location A, site 1

An open field, 160 x 60 m, c. 1 ha, where a shop is now situated. A flat, plane area with a beautiful big tree.
Distances:
to the water canal: 50 m
to the boiler house: 300 m
to the molasses dam: 200 m
A [illegible] runs along the east side of the site.

- Location A, site 2

A uncleared space between a water canal and the Awash river.
A plane area with sparse vegetation c. [illegible].5 ha.
Distances:
to the water canal: 70 m
to the Awash river: [illegible]0 m
to the boiler house: [illegible]0 m
to the molasses dam: 2[illegible] m
The nearest road is c. [illegible] distant on the other side of the canal.

The 2 sites in Shoa Headquarters area (Location B) Map 4.
ANNEX 20.

- Location B, site 1

A flat, plane area (190 x 150 m, c. 2.[illegible]) south of the sugar factory building.
Distances:
to the water canal: 140 m
to the boiler house: 140
to the molasses dam: 250 m
to the waste water canal: 170 m

The site is surrounded on 3 sides by roads.

- Location B, site 2

A flat, plane beautiful park area with trees, 100 x 150 m, c. 1.5 ha.

Distances:
to the water canal: 90 m
to the boiler house: 280 m
to the molasses dam: 160 m

Roads run along 2 sides of the site.

All four sites are sheltered from the soot and dust of the boiler houses and situated near the factory buildings of the sugar estates.

In the contractors opinion Location A, site 1 seems to be the best site for the power alcohol plant. A thorough study of the ground has anyhow to be made before final decision.

VI PROJECT ENGINEERING

Production programme

The planned full production capacity is 75 m^3=60 t ethanol per day (24 hours), which gives 25 000 m^3 = 20 000 t 100 % ethanol per year (=333 working days). The sugar factories operate 245 - 250 days/a. Since the alcoholplant will not be dependent on energy for its process from the sugar factory this comparatively long yearly production period is possible.

The amount of molasses available restricts the annual production of ethanol. The production from the first full years are as follows:

1st year 15 000 t alcohol
2nd year 15 500 t alcohol
3rd year 17 500 t alcohol
4th year 20 000 t alcohol (full capacity)

Supply programme

Power alcohol consumption should be fairly steady. For small variations in comsumption and for factory shut-down (1-2 months) some 5 000 m^3 storing capacity would be sufficient.

Technology

The production of ethanol from molasses is based on the fermentation of fermentable sugars in molasses by yeast (Saccharomyces) into ethanol and on the concentration of the ethanol by distillation.

The theoretical reaction is:

$$C_6H_{12}O_6 \xrightarrow[\text{nutrients}]{\text{yeast}} 2C_2H_5OH + 2CO_2$$

monosaccharide ethanol carbon dioxide

The reaction liberates 92 100 J (22 000 cal) of heat per 1 mole (180 g) glucose.

The production occurs as follows:

1. Pumping and measuring of molasses and water
2. Adjusting pH with sulphuric acid
3. Sterilisation and clarification of molasses wort
4. Pumping molasses wort for fermentation and adding water
5. Adding recovered and regenerated yeast and adding nutrients
6. Fermentation
7. Recovering the yeast
8. Distillation of fermented wort
9. Dehydration of ethanol
10. Storage and delivery

An example of a production flow sheet is in ANNEX 21.

There are traditional technology and more advanced technologies for the production of power alcohol. In traditional technology the pretreatment of the molasses is simply blending with water, acidifying with sulphuric acid and possibly decanting. Fermentation occurs batchwise in open vessels, yeast is made separately for every batch, the fermentation time is 24 - 48 hours and the end concentration of ethanol in the wort varies from batch to batch. Distillation of wort and dehydrating the ethanol are separate processes. The demand for energy in the process is high (11 MJ/kg EtOH), but investment for equipment for a capacity of 75 m^3/d is low (c. 7 M Birr FOB, waste treatment exluded).

In more advanced processes molasses is sterilised and clarified continuously. Fermentation is continuous or semicontinuous. Yeast circulates, the amount of yeast being fairly high, and the fermentation time is less than 12 hours. The fermentors are closed. Distillation and dehydrating columns are connected in series to minimize the energy demand. The level of energy consumption in the process is c. 7.5 MJ/kg EtOH out of which about 80 % can be produced from vinasse. Investment in equipment is higher than in the traditional process (c. 15 M Birr/75 m^3/d, FOB).

There are also even more advanced methods under development using tower fermentors and immobilized yeast.

Because international tenders will be requested there is no reason to describe the process equipment in more detail. Companies offering equipment will use their own several technologies.

The inclination should be towards foreign currency saving, the best solution will optimize energy consumption and investment costs.

The following items must be considered when planning the process and equipment:

An analysis of the molasses is in ANNEX 10. Mean fermentable sugar content of molasses is 50 %. Theoretically 1 kg of sugar gives 0.511 kg of ethanol but in reality there are some side reactions and losses and 90 % yield is common. Therefore 1 kg of 50 % molasses gives 0.230 kg of ethanol: i.e. 4.35 kg molasses is needed for 1 kg of ethanol.

The names and amounts of nutrients and chemicals needed for the process are in TABLE 2 p. 23.

The fermentation process can be continous, semicontinous or batchwise. In each case the circulation of yeast is recommended. This makes it possible to keep the amount of yeast high enough to shorten the fermentation time, to guarantee a good yield in fermentation, and to minimize the size of the fermentors.

For process water there is condensate water from the cane sugar process. An analysis of the condensate is in ANNEX 13.

For cooling purposes there is water from Awash river. The temperature of the water in Wonji and Shoa is

20^o - 23^oC (Mean 22^oC) and in Metehara 27^o - 30^oC. Analyses of the river water are in ANNEX 14.

The sugar content of the wort for fermentation is usually 12 -16 % and pH 4.5 - 5.5.

Proper clarification of the wort is necessary because of the circulation of yeast. Yeast has to be separated with a suitable centrifuge, washed and acidified to pH 2 - 3 to prevent bacterial growth.

The fermentation temperature is usually 28 - 32^oC. Water from the Awash river is suitable for cooling purposes in Wonji and Shoa, but in Metehara it will be necessary to cool the water before using it.

Distillation and dehydration take the greatest part of the energy needed in the process. It is therefore wise to connect the columns in series.

Production equipment

The capacity of pumping and measuring equipment must at least equal the continuous fermentation capacity, which is 11 ton/h molasses and 20 - 40 m^3 H_2O/h, depending on the concentration of wort. Capacities three times higher would be better for batch fermentation.

A small pump (capacity 0 - 200 l/h) is necessary for pH adjustment. All material in contact with H_2SO_4 must be of acid-resistant quality.

Direct or indirect heating equipment is needed for sterilisation of the wort. Sterilisation time and temperature are interdependent.

For clarification of the wort it is possible to use decanting vessels, but centrifuges will give better results. When working continuously the capacity of the clarification apparatus has to be at least the same as the capacity of fermentation (30 - 50 m^3/h) and in batch fermentation three times higher.

If the concentration of wort after clarification is unsuitably high for fermentation, some water (or vinasse) has to be pumped and measured into the wort. In continuous or semicontinuous fermentation the amount of wort pumped to the fermentors also has to be regulated.

In addition, chemicals, nutrients and yeast in solution or as slurries must be measured and pumped to the wort before fermentation.

Fermentation vessels will be closed and ethanol has to be scrubbed from the carbon dioxide before venting CO_2 to the athmosphere. CO_2 has no commercial value at the moment. The fermentation reaction liberates 1.41 MJ/Kg EtOH. The cooling surfaces have to be large enough to keep the temperature below 32°C (cooling water temperature 22°C).

The number of fermentation vessels and total fermentation volume depends on the fermentation method, concentration of wort and fermentation time. Mean volume is about 600 m^3 for a fermentation time of 12 hours and final ethanol concentration of 9 vol-%.

Energy saving in the distillation of fermented wort and dehydration of ethanol is the aim, but investment in distillation equipment must still be kept reasonable. The final goal is to minimise the use of foreign currency.

A typical energy consumption value is 8.5 MJ/kg EtOH. A suitable final concentration of ethanol is 99.5 % by weight. Analytical standards for power alcohol are in ANNEX 22.

Two alternatives are available for storage and delivery.

Alternative 1
Storage mainly at the factory. Power alcohol is transported to gasoline distributors in Addis Ababa and mixed with gasoline by the distributors.

Alternative 2
Part is stored in the factory and part in Nazareth. Total storage capacity c. 5 000 ton. Tank trucks coming from Asab can stop in the Nazareth depot and take c. 10 % power alcohol into the gasoline they are carrying. This is possible because when starting from the hot Asab-area (50°C) they can fill only 80 % of the container, and in Nazareth, where it is cooler, it is possible to take on 10 % more liquid.

In both cases it is recommended that the power alcohol is denatured with gasoline before storing (1 - 3 %).

There are not yet national safety regulations or standards in Ethiopia, but it is recommended to follow good, reasonable regulations and standards, e.g. ISO, DIN etc.

First of all it is important to remember that ethanol is an inflammable liquid in the 1st class, and secondly that there are those who want to steal it for drinking or sale.

Auxiliary equipment

Transport
Tank trucks are needed to transport molasses from the other sugar factories. Yearly transport of molasses is 6.6 Million ton-km.

Tank trucks are also needed to transport finished power alcohol from the factory to Nazareth or to Addis Ababa. The transport capacity needed is in the first case 0.3 Million ton-km/year and in the second case 2.4 Million ton-km/year.

There is a railway from Metehara to Djibouti, Nazareth and Addis Ababa.

Steam

Energy demand in a distillery producing 75 m^3/d power-alcohol is c. 10 ton/h steam (Chapter IV) and 500 kW electric power. There is some surplus boiler capacity in certain sugar factories. Boilers use bagasse as fuel and only in Metehara is there a possibility of using oil instead of bagasse.

There is some surplus bagasse during the campaign, but this will be used during the off-season and for starting-up the factories after the annual break.

The intention is to use domestic energy as far as possible for power alcohol production. There are two alternatives for this:

Alternative 1. Vinasse is concentrated to c. 60 - 70 % dm by evaporation and then burnt in a special boiler to obtain process steam. Net steam production in a 75 m^3 alcohol/d distillery is c. 7.7 ton/h. Investment including evaporator and boiler is c. 7 M Birr.

Alternative 2. Vinasse is fermented anaerobically to methane, which is collected and burned in a boiler. Net steam production will be 8.2 ton/h and investment costs including fermentor and boiler are 11 M Birr.

If heavy furnace oil is burnt the only investment is for the boiler, c. 3 M Birr. In this case a continuous flow of foreign currency of c. 1.75 M Birr/a at full capacity is needed to to pay for the energy.

On the other hand, foreign currency is also needed in alternatives 1 and 2 to buy the equipment, but the pay-back in these cases will occur within a limited time.

Buying a boiler that is suitable for both heavy furnace oil and methane gives the possibility of starting with oil and building methane fermentors later on.

Electricity

There is some surplus turbine capacity in the different sugar factories. If this can be utilised without extra costs it is wise to use it as much as possible. On the other hand, commercial electricity is available (Chapter IV) at a reasonable price, and therefore extra turbines for the power alcohol plant are unnecessary.

The need for high pressure boilers must be investigated. For an alcohol plant a pressure of 4 bar is sufficient, but integration with the sugar factory might make a high pressure boiler more advantageous because it is possible to connect it to existing turbines.

Electric standards are 380 V, 3-phase, 50 cycles.

Emergency power is not needed.

Water

Condensate water from the sugar process is available in a reservoir. Consumption of water in the process is 30 - 50 m^3/h. Pipelines from reservoir to plant (distance 200 m) and a pump are needed.

River water from the Awash river is available for cooling purposes. Mean consumption of water is 375 m^3/h. Pipelines from the river (distance 400 m) and a pumping station are needed. It might be possible to use the existing pipeline for the sugarmill.

Sewage disposal

There are no government rules for sewage disposal. The only restriction is that the fish in the Awash river shall stay alive. It is, however, as well to remember that river water serves as process water in each sugarmill, and without treatment. Therefore it is most important to keep the river water clean.

Sewage water from the sugarmills are usually dumped on to the cane fields. There seems to be no reason why not this should continue in the future, but it is recommendable to analyse the soil before choosing the place for dumping. Random analysis of the soil in a Wonji - Shoa cane field gave fairly high Na and Ca contents (ANNEX 23).

The different vinasse handling processes give more or less effluent. Evaporation and burning leaves only ash and condensate water, and is therefore preferred from the point of sewage treatment. Ash is valuable as a fertilizer.

Anaerobic fermentation of vinasse removes organic material and leaves semicleaned effluent (water and sludge, both of which are quite harmless when dumped on to the cane field.) Vinasse itself when spread on the cane field can be useful as a fertilizer, but in certain cases it could make the salt content of the soil too high and it is therefore necessary to be careful when using it on the fields.

Workshop equipment

There are fairly large workshops at each sugarmill, and the demand for additional mechanical, electrical or other equipment should be very small.

Laboratory

There are big laboratories in each sugarmill where the necessary analyses could be done, but a small laboratory for simple analyses in the distillery itself is recommended.

Storage and warehouse equipment

A fork lift truck for transfer of chemicals, nutrients and other materials in the warehouse is recommended.

In the molasses and power alcohol stores only pumps and measuring equipment for the denaturation of gasoline are needed. Gasoline for denaturing purposes also needs a storage tank about 100 m^3.

Communications

Only telephone is needed in the distillery. Other services are via the sugarmill office.

Heating, ventilation, air conditioning

Heating is not needed. Effective ventilation is necessary in the fermentation department (CO_2) and power alcohol storage (inflammable liquid) if they are indoors. Outdoor assembling gives natural ventilation.

There is no primary need for air conditioning.

Spare parts

A limited amount of spare parts for production equipment is needed. Recommendations and offers are requested from suppliers in the tender.

<u>Service equipment</u>

Office equipment

A limited amount of office equipment is needed. Typewriters, furniture for three offices, etc.

Canteen

No separate canteen is necessary.

Medical service

Medical service is organized by the sugarmill.

Plant security

Supervision is organized by the sugarmill. Fire protection equipment for distillation and dehydration department and for power alcohol storage are important. Recommendations and prices are requested from suppliers in tender.

Plant yard cleaning and service

Cleaning and service are organized by the sugarmill.

Staff welfare and residential buildings

Staff welfare is organized by the sugarmills. Residential buildings are needed for staff and permanent labour. Buildings will be built by local constructors.

The residential needs are as follows

Category A	2
Category B	12
Category C	22
Category D	45

Site preparation and development

Even, dry ground and firm soil are found for building. Soil is easy to excavate. Existing pipes, cables, powerlines and roads are not far away from the factory site (100 - 300 m), and utility connections for construction and assembly are available via the sugarmill.

Main roads are good, side roads poor but rather short (10 - 16 km). Road connections reach the site.

There are railway sidings only at Metehara. For Wonji and Shoa the nearest railway is in Nazareth.

It is possible to use domestic constructors for site preparation works.

Buildings and civil work

Because there are no cold periods in Ethiopia most of the buildings can be constructed lightly. The rainy period from july to september imposes however a need for roofs to protect the equipment.

Storing tanks, fermentors, centrifuges and distillation columns need rather heavy foundations.

VII PLANT ORGANIZATION AND MANPOWER

The power alcohol plant will be a part of the existing sugar factory. It can benefit from many of the services available in the factory.

Manpower requirement

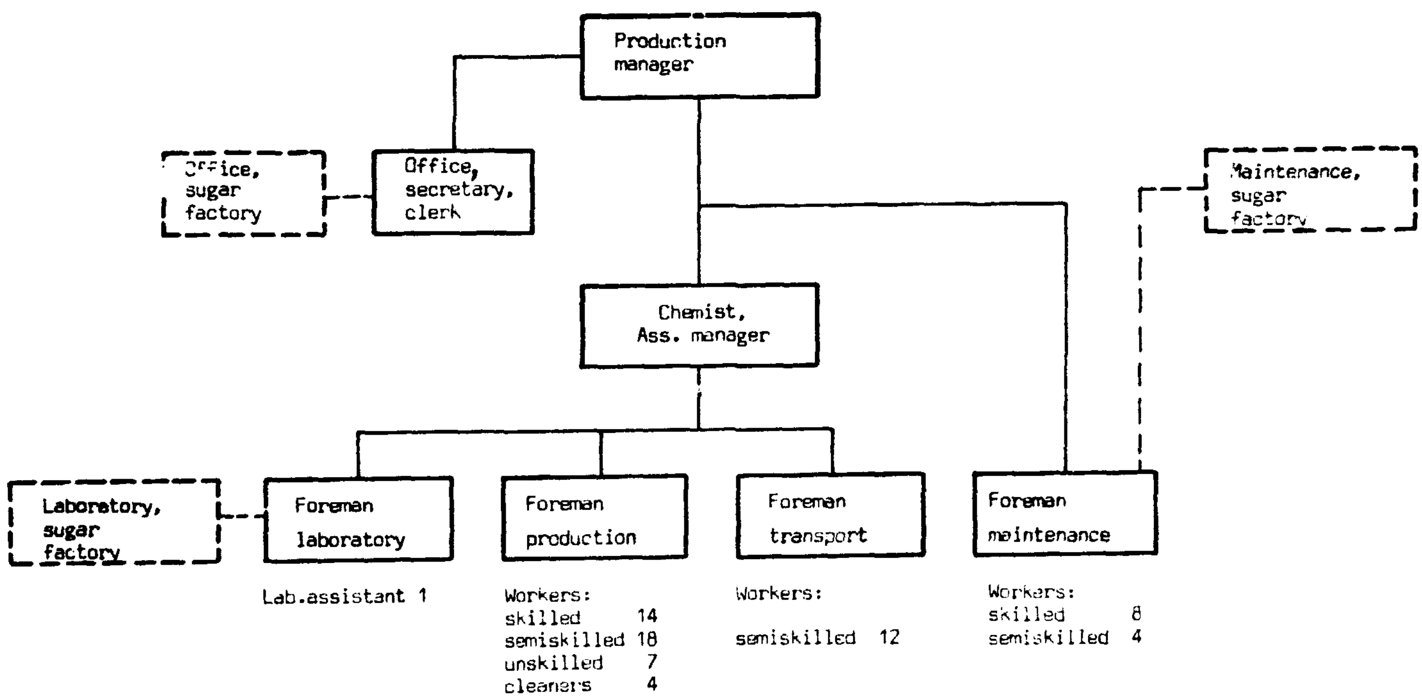
The manpower required specifically for operating the power alcohol plant:

	Number of persons		
STAFF	Day-work	3-shiftwork	
Production manager	1		
Chemist, assist.manager	1		
Foreman, laboratory	1		
Foremen, factory		5	
Foreman, transport	1		
Foremen, maintenance	2		
Secretary	1		
Clerk	1		
Laboratory assistant	1		
Subtotal	9	5	= 14
LABOUR			
Workers, skilled		14	
Workers, skilled, service	8		
Workers, semiskilled		22	
Workers, semiskilled, transport	12		
Workers, unskilled	7		
Cleaners	4		
Subtotal	31	36	= 67
Total manpower	40	41	= 81

Staff and labour is available for special services from the sugar factory.

Plant organization

A power alcohol plant organization is presented below.



Training requirements

- The production manager and the chemist/assistant manager shall have university-level education.

- Preproduction training
  The production manager, the chemist and 2 - 3 of the production foremen shall be trained by the plant supplier. The training shall be started well in advance and be continued during the machinery installation and test-run periods.
  For skilled and semiskilled workers Makanissa Distillery in Addis Ababa is a suitable training object. Further special training during the machinery installation and test-run periods shall be provided by the plant supplier.

Additional training is possible during the production start-up and production.

Employment schedule

Production manager and chemist,	9	months	before	start-up.
3 production and maintenance foremen	6	"	"	"
The rest of the foremen	4	"	"	"
Skilled workers,	3	"	"	"
Semiskilled workers,	1	"	"	"

Overhead costs

The overhead costs comprise the following cost centres.

- Service cost centres
  - Social service
  - Plant management
  - Transport
  - Purchasing
  - Stores
  - Repair and maintenance
  - Power, heat, light
  - Steam
  - Water supply
  - Laboratories
  - Effluent disposal
- Administration and finance cost centres
  - General administration
  - Personnel
  - Training
  - Accounting and bookkeeping

The salaries of staff and labor are presented in ANNEX 18.

VIII IMPLEMENTATION SCHEDULE

The general implementation schedule of the power alcohol project is presented in ANNEX 27.

Tender specification is made in order to give bidders the possibility to suggest their own technology within certain limits. This type of tender specification gives the possibility to choose the most optimal and compact design as to energy consumption and saving foreign currency but it also means that much effort has to be put in the evaluation of the proposals and choice of the contractor.

The main timing in the schedule is:

i 8 months for proposals and choosing the machinery contractor

ii 15 months for the delivery of main equipments

iii 5 months for assembly

iv 4 months for testing the equipment

IX FINANCIAL AND ECONOMIC EVALUATION

The main aim of the project is to minimize the foreign currency demand. In the process itself the purpose is to obtain as good an energy relation (output energy/input energy) as possible. The use of the distilling residue, vinasse, for energy production gives a good chance for this aim to be realised in the long run. In the short term it means foreign currency investment in equipment.

As a base for the calculations heavy furnace oil has been used as primary input energy source, and the use of vinasse as energy source has then been compared with furnace oil.

Total investment costs

Base. Furnace oil as energy source, comprising: machinery, molasses treatment equipment, fermentation equipment, distillation and dehydrating equipment, storage tanks, blending equipment and boiler for furnace oil.

Buildings include the different distillery constructions, office and laboratory, storage constructions, boiler house and blending station.

Furniture is for the office, laboratory, control room and wash room.

Tank trucks are needed for transporting molasses, fuel, power alcohol and chemicals.

Housing, of different categories, are needed for staff and workers employed permanently in the power alcohol plant.

TABLE 3

INVESTMENT COSTS, FOREIGN AND DOMESTIC

- Base

	Foreign currency Million Birr	Domestic currency Million Birr
Machinery	20.1	
Buildings	-	4.6
Furniture	-	0.05
Trucks	0.35	
Houses	-	0.6
	20.45	5.25
Total investment	25.70 Million Birr	

A more detailed breakdown of the investment costs is presented in ANNEX 27 A.

- Advanced alternative 1

Vinasse is concentrated by evaporation and burnt to obtain steam. A description of the process is in ANNEX 24.

Machinery in addition to the base comparises an evaporator and a boiler suitable for vinasse burning.

Constructions for the evaporator are needed in addition to the base alternative.

Some extra housing is necessary for workers operating the evaporator (4 persons).

TABLE (4)

INVESTMENT COSTS

Advanced alternative 1

	Foreign currency Million Birr	Domestic currency Million Birr
Machinery	26.9	
Buildings		4.75
Furniture		0.05
Trucks	0.35	
Houses		0.65
	27.5	5.45
Total investment	32.7 Million Birr	

- Advanced alternative 2

Vinasse is digested anaerobically and the methane produced burnt in a boiler. A description of the process is in ANNEX 25.

Machinery in addition to the base alternative comprises a methane digester and equipment for using methane in a boiler.

Some extra housing is necessary for workers operating the fermentation (4 persons).

TABLE (5)

INVESTMENT COSTS

Advanced alternative 2

	Foreign currency Million Birr	Domestic currency Million Birr
Machinery	31.0	
Buildings		5.0
Furniture		0.05
Trucks	0.35	
Houses		0.65
	31.35	5.7
Total investment	37.05 Million Birr	

Project financing

As a result of discussions with representatives of the Ethiopian Governement, UNIDO officials, representative of the Delegation of the Comission of the European Communities to Socialist Ethiopia, and other authorities, the following list of financiers has been arrived to:

1) European Investment Bank (EIB) in the limits of the Lomé II-Convention (5)

2) UNIDO

3) The Provisional Military Government of Socialist Ethiopia

The African Development Bank, the Arab Bank for Economic Development in Africa, and The World Bank have also been mentioned in discussions (Interviews in the Reference list).

Total production costs

Total production costs, capital costs, fixed production costs and operating costs have been calculated.

The use of heavy furnace oil for steam production has been used as a base for the calculations and comparisons.

Capital costs

TABLE 6
DEPRECIATION RATES

	1st year	Subsequent years
Machinery	16 %	12 %
Buildings	5 %	5 %
Furniture	10 %	10 %
Trucks	20 %	20 %
Houses	5 %	5 %

Capital costs are calculated with a rate of interest of 8 %. The formula of the periodic payment is:

$$PMT = PV \left(\frac{i}{1 \quad (1 + i)^{-n}} \right)$$

n = number of time periods
i = periodic interest rate, expressed as a decimal value
PMT= periodic payment
PV = present value or principal

TABLE 7

DEPRECIATION AND TOTAL CAPITAL COST

	1st year		Subsequent years	
	Depreciation M Birr	Capital cost M Birr	Depreciation M Birr	Capital Cost M Birr
Machinery	3.216	4.211	2.412	3.397
Buildings	0.230	0.469	0.230	0.469
Furniture	0.005	0.078	0.005	0.007
Trucks	0.070	0.088	0.070	0.088
Houses	0.030	0.061	0.030	0.061
Total	3.551	4.907	2.747	4.022

In energy alternatives 1 and 2 (burning of vinasse or methane gas) there are additional depreciations and total capital costs as follows.

Alt. 1	+ 1.099	+ 1.445	+ 0.827	+ 1.169
Alt. 2	+ 1.767	+ 2.329	+ 1.331	+ 1.887

Fixed costs

In a process like the alcohol production, labor costs are not dependent on production rate. Therefore they are calculated as fixed costs including overhead, maintenance and insurance costs.

TABLE 8

FIXED COSTS

	% of total investment	Costs, M Birr
Maintenance	3	0.77
Insurance	1	0.26
Staff and overhead	-	0.10
Labour cost	-	0.14
Total		1.27
Alt. 1		+ 0.28
Alt. 2		+ 0.45

Operating costs

Operating costs depend on the production rate. The following operation costs have been calculated:

Raw material (Chapter IV, p. 22)	43 Birr/t EtOH
Chemicals (Table 2 p. 23)	20,2 Birr/t EtOH
Steam (Chapter IV, p. 25)	87,5 Birr/t EtOH
Electricity (Chapter IV, p.27)	16,3 Birr/t EtOH

Water (process + cooling) (Chapter IV, pp. 27, 28)	22,2 Birr/t EtOH
Transportation	69,5 Birr/t EtOH

Transportation costs are calculated as a mean value of road transports for Wonji and Shoa (ANNEX 26).

TABLE 9

OPERATING COSTS for different years of production (from 1st full year to full capacity)

	1st year M Birr	2nd year M Birr	3rd year M Birr	Full capacity (4th year) M Birr
Production of ethanol ton	15 000	15 500	17 500	20 000
Materials and Inputs	2.838	2.933	3.311	3.784
Transportation	1.043	1.077	1.216	1.390
Total	3.881	4.010	4.527	5.174

In energy alternatives 1 and 2 (burning of vinasse or methane, ANNEXES 24 and 25) the following deductions are gained:

Alt. 1	./. 1.488	./. 1.537	./. 1.734	./.1.983
Alt. 2	./. 1.574	./. 1.627	./. 1.837	./.2.099

TABLE 10

TOTAL PRODUCTION COSTS

	1st year M Birr	2nd year M Birr	3rd year M Birr	Full capacity M Birr
Capital costs	4.836	4.022	4.022	4.022
Fixed costs	1.270	1.270	1.270	1.270
Operation costs	3.881	4.010	4.527	5.174
Total	9.987	9.302	9.819	10.466

In energy alternatives 1 and 2 the total costs are changing as follows:

Alt. 1	+ 0.237	- 0.088	-0.285	- 0.534
Alt. 2	+ 1.205	+ 0.710	+0.500	+ 0.238

Rentability calculations

The price of ethanol has been calculated as the same as the world market gasoline price spring 1980, 600 Birr/m^3. The gasoline price is predicted to rise by 3 % in real terms annually (Interview 18). As the price of fuel oil also is rising the price of ethanol is predicted to rise by 2.6 % in real terms annually.

Ex distillery price of ethanol and ex refinery price of gasoline

The total production costs per liter of 100 % ethanol will with the base alternative be:

1st year	0.533 Birr/l
2nd year	0.479 "
3rd year	0.448 "
full capacity	0.419 "

The present ex refinery prices for regular and premium gasoline are 0.45 and 0.532 Birr/l respectively.
Compared with each other the ex distillery ethanol price will in the future grow along with the inflation when at the same time the price of gasoline will increase 3 % yearly in real terms.

TABLE 11

RENTABILITY

The plant is supposed to have its first full year in 1984.

M Birr	1984 1st year	1985 2nd year	1986 3rd year	1987 Full capacity
Price of Ethanol	12.469	13.214	15.313	17.950
Total costs	9.987	9.302	9.819	10.466
Economical gain	2.482	3.912	5.494	7.484

In energy alternatives 1 and 2 the rentability changes as follows

M Birr

Alt. 1	- 0.237	+ 0.088	+ 0.285	+ 0.534
Alt. 2	- 1.205	- 0.710	- 0.500	- 0.238

Financial evaluation

TABLE 12

RETURN ON INVESTMENT

The calculations are according to the formula:

$$100 \times \frac{\text{Economical gain + capital costs}}{\text{Total investment}}$$

Year	Base (oil)	Alt. 1 (vinasse)	Alt. 2 (methane)
1984	28 %	26 %	23 %
1985	31 %	28 %	25 %
1986	37 %	34 %	29 %
1987	45 %	40 %	36 %

TABLE 13

PAY BACK PERIOD (1) p. 179

	3rd year M Birr	4th year M Birr	5th year M Birr	6th year M Birr
Economical gain	2.482	3.912	5.494	7.484
Interest	1.285	1.275	1.275	1.275
Depreciation	3.551	2.747	2.747	2.747
Profit	7.318	7.934	9.516	11.506

	Amount M Birr	Balance M Birr
Year 1	-	7.710
2	-	25.984
3	7.318	18.666
4	7.934	10.732
5	9.516	1.216
6	11.506	-

Pay back time is approx. 5.2 years.

Energy alternative 1 gives the same pay back period as the base alternative. Alternative 2 lengthens it to 5.6 years.

Simple rate of return (1) p. 180

First full capacity year.

$$\frac{\text{Net profit + Interest}}{\text{Total investment}} \times 100 = \text{Simple rate of return} =$$

34.1 % for base (oil)
29.5 % for Alt. 1
24.5 % for Alt. 2

<u>Cash flow analysis</u>
(1), p. 206

A cash flow analysis is made for the base (oil) energy-alternative and for both the other alternatives (vinasse burning and methane). (ANNEXES 28 - 30).

<u>Break-even analysis</u>
(1), p. 184

The break even analyses is performed according to the following formula:

$$\frac{\text{Fixed cost}}{\text{Sales-Oper.costs}} \times 100 = \frac{5292}{17950-5174} = 41\ \% = 8284\ \text{t}\ 100\ \%\ \text{ethanol}$$

A graphical determination is presented in ANNEX 31.

<u>Sensitivity analysis</u>

Sensitivity analysis is made for the base (oil burning) alternative with full capacity as follows:

i The real term price of oil increases by 10 % yearly
ii The price of machinery increases 50 % from the estimated
iii 30 000 t of molasses is exported at a price of 107 US Dollar/ton = 230 Birr/t. Net income when transportation and other costs have been deducted is 140 Birr/ton.
The power alcohol plant produces only 13 000 ton ethanol.

Break-even point = BEP

i (Price of oil + 10 % = 8.67 (excl. heavy oil)

$$BEP = \frac{5292}{26845 - 5174} = 24\ \%$$

ii Price of machinery + 50 %

$$BEP = \frac{7392}{17950-5194} = 58\ \%$$

In case of a 10 % increase in oil price the original break-even point (41 %) improves to 24 % and in case of a 50 % machinery price increase the break-even point declines to 58 %.

Rentability

i Price of oil + 10 % = 8.67 (exl. heavy oil)

Sales income in first full year	26.845 M Birr
Costs	10.466 "
Economical gain	16.379 M Birr
Original economical gain	7.484 "
Improvment	8.895 M Birr
	= 119 %

ii Price of machinery + 50 %

Sales income in first full year	17.950 M Birr
Costs	12.586 "
Economical gain	5.364 M Birr
Original economical gain	7.484 "
Decrease	./. 2.120 M Birr
	= ./. 28 %

iii Molasses export 30 000 t

Sales income from alcohol	11.668 M Birr
Sales income from molasses	4.200 "
Income total	15.468 M Birr
Costs	8.255 "
Economical gain	7.213 M Birr
Original economical gain	7.484 "
Decrease	./. 0.271 M Birr
	= ./. 3.6 %

In case of a 10 % increase in real term oil price the economical gain more than doubles (+ 119 %). In case of a 50 % increase in machinery price the economical gain declines 28 %, but is still acceptable. Molasses export has not much influence on the economical gain (- 3.6 %).

National economic evaluation

Currency balance

i Base (oil burning), full capacity. No molasses export.

1. Currency outflow now

Import of 25 000 m^3 gasoline/a	17.95 M Birr/a
Molasses export 30 000 t/a	6.0 "
Net outflow	11.05 M Birr/a

2. Currency outflow with power alcohol production

Chemicals	0.4 M Birr/a
Furnace oil	1.75 "
Foreign capital costs	3.76 "
	5.91 M Birr/a
Net savings in foreign currency	5.14 M Birr/a

ii Alternative 1 (vinasse burning)

1.	Currency outflow as above	11.05 M Birr/a
2.	Currency outflow with ethanol production	
	Chemicals	0.40 "
	Furnace oil	0.26 "
	Foreign capital costs	4.92 "
		5.58 M Birr/a
	Net savings in foreign currency	5.47 M Birr/a

iii Alternative 2 (methane)

1.	Currency outflow as above	11.05 M Birr
2.	Currency outflow with ethanol production	
	Chemicals	0.40 M Birr/a
	Furnace oil 10 %	0.18 "
	Foreign capital costs	5.62 "
		6.20 M Birr/a

Net savings in foreign currency 4.85 M Birr/a

iv Molasses (30 000 t/a) is exported and power alcohol is produced at reduced capacity (Base alternative)

1.	Currency outflow now	
	Import of 25 000 m^3 gasoline	17.95 M Birr/a
	Molasses export 30 000 t/a	6.9 "
	Net outflow	11.05 M Birr/a 2.

Currency outflow with reduced ethanol production (to 65 %)

	Base	Alt. 1	Alt. 2
Chemicals	0.26	0.26	0.26
Furnace oil	1.14	0.17	0.11
Foreign capital costs	3.79	4.92	5.62
./. molasses export 30000 t	6.9	6.9	6.9
Net outflow	- 1.74	- 1.55	- 0.91
Net savings in foreign currency	12.79	12.60	11.96 M Birr/a

From a currency balance point of view it seems most profitable to continue the export of molasses when the price is high enough.

The pay back period for the plant is quite short and the rate of return high. This is due to the facts that on the other hand the price of raw material, molasses, is set low and on the other hand the price of the product is compared with the price of imported gasoline.

The price of gasoline used, 600 Birr/m^3, is an approximate and conservative mean of the lowest and highest import prices in Ethiopia in the spring 1980, 540 and 720 Birr/m^3. The price of gasoline is expected to increase, especially in the long run.

The export price of molasses is much higher than the low local price used. Due to lack of transportation equipment and because the quality of the molasses has not always corresponded to export quality criteria and demands, only part of the molasses in Ethiopia can potentially be exported.

An estimation of the future development of molasses prices is difficult. On the other hand the increasing demand of molasses tend to increase the prices, on the other hand the implementation of new sugar factories is keeping the prices in balance.

It seems safe to say that the molasses world market prices will not decrease. Molasses export alone is no solution, but a certain molasses export in addition to ethanol production might give the best result.

Shadow prices

The shadow price in Ethiopia for foreign currency is high, 3 - 4 Birr per US Dollar the official exhange rate being 2.07 Birr/US Dollar. On the other hand the shadow price for labour costs are very low.

X FUTURE PERSPECTIVES

In a developing and economically growing country like Ethiopia the need for car engine fuel is continually increasing. According to ANNEX 6 the demand for gasoline in 1990 will be 226 000 t = 308 000 m^3. If 25 % of the cars in Ethiopia in 1990 were ethanol cars and the rest of the cars are using 20 % ethanol-gasoline mixture, it would mean a demand for ethanol of approximately 98 000 ton/a.

This is possible because in the near future special cars using neat ethanol will become available.

Because there are other uses for ethanol too, a 100 000 t/a ethanol plant seems viable.

The question then is how to obtain raw material for the plant. In ANNEX 32 some properties of potential raw materials are given. Because starchy raw materials are more expensive to produce and process, sugar cane must be considered the first candidate in the future.

Sugar cane

The potential areans for sugar cane cultivation in Ethiopia are enormous (Intervieuws 7,8). (6). Merely in different river valleys 50 projects have been identified. On 4 of these, full feasibility studies have been completed, on 35 preliminary studies and 11 projects are only "identified".

The areas are:

	Gross Irrigable Area
For the 50 identified projects	704 000 ha
For the 20 highest ranking projects	337 000 ha

For the top ten projects	167 000 ha
For the 4 feasibility-studied projects	100 000 ha

In the Gambella area in Illubabor there is a potentially irrigable area of approx. 1 Million ha.

The indicative costs/ha (1978 prices) for preparing these irrigated areas are 5 800 - 11 600 Birr/ha.

Starchy materials

Alcohol can also be produced from other crops containing carbohydrates (starch and/or sugar). The starch must first be converted to sugar, and then the sugar can be fermented to alcohol.

The disadvantages of starchy materials compared with sugar are:

1) higher operation costs
2) higher investment costs
3) more delicate and sensitive process
4) higher energy-input/t alcohol
5) not always an available energy source (as bagasse is for sugar-cane)
6) larger cultivation area requirements per ton alcohol ANNEX 32)

There are vast potential areas in Ethiopia for starch-crop cultivation.

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INTERVIEWS

In meeting and discussions with the following persons representing government corporations, authorities and institutions as well as private companies and foreign institutions we have obtained valuable information and data.

1
Ethiopian Sugar Corporation

1.1
Head Office, Addis Ababa
28.2. - 31.3.1980

Ambaye Petros, Manager/Research and Planning Division
Meressa Teklemariam, Head/Project and Planning Dept.
Negussie Abboye, Manager/Materials Services Dept.
Colonel Tefheme, General Manager

All matters in connection with the study. The team's HQ. Telex, telephone, secretary.

1.2
Metehara Sugar Factory and Plantation, Metehara
5.3.1980

Kassahun Ayele, Chief Engineer
Ghebreyohannes Berhe, Chief Chemist
Lhelseged Mitiku

The production of sugar, molasses and bagasse. Energy-services, maintenance, personnel-administration, staff, water services and-quality, manpower, salaries, manpower-costs, housing, social circumstances, standards, legal demands, safety regulations, etc. Environments, wast water treatment, climatic conditions. Possible sites for an alcohol-plant. Transportation possibilities and other infrastructure. Factory, stores.

1.3
Wonji Sugar Factory and Wonji/Shoa Plantation, Wonji
6.3. - 24.3.1980.

Abboy Haile, Operations Manager
Legese Gulty, Factory Manager
Asrat Sileshi, Technical Manager
Salomon Barahi, Chief Chemist
Melessa Mergia, Acting Senior Chemist

The production of sugar, molasses and bagasse. Energy services, maintenance. Water services and -quality. Personnel administration, staff, manpower, housing, social circumstances. Environments, waste-water treatment, climatic conditions. Possible sites for an alcohol-plant. Transportation possibilities and other infrastructure. Plantation. Plan of the factory area.

1.4
Shoa Sugar Factory and Wonji/Shoa Plantation, Wonji
6.3., 24.3.1980

Debrai Alem, Technical Manager
Atnafu Mebrate, Processing Manager

The production of sugar, molasses and bagasse. Energy services, maintenance. Water services and -quality. Environments, wast-water treatment. Possible sites for an alcohol plant. Transportation possibilities and other infrastructure. Plan of the factory area.

1.5
The Provisional Military Government of Socialist Ethiopia/
Ministry of Industry
28.2., 8.3., 28.3.1980

Woldu G. Michael, Head/Planning Dept.
Teserra Kifeten, Coordinator

28.2.1980 Introduction, The Ministry's and the Contractor's views and expectations,

8.3.1980 Preliminary information on the basis of the first week's contacts. Represented at the meeting were:
Ministry of Industry
UNIDO, UNDP
Project Study Agency
Ethiopian Sugar Corporation
Ethiopian National Energy Comission
(Ministry of Mines, Energy and Water Resources)
National Revolutionary Development Campaign and Central Planning Supreme Council (NRDC/CPSC)
Ethiopian Science and Technology Commission
Oy Alko Ab
14 persons

28.3.1980 Preliminary summary of the results of the feasibility study (inofficial, written report, 15 pages + 7 Annexes). Extensive discussion. Represented at the meeting were:
Ministry of Industry
UNIDO, UNDP
Project Study Agency
Ethiopian Sugar Corporation
Ethiopian National Energy Commission
(Ministry of Mines, Energy and Water Resources)
CPSC
Ministry of Mines, Energy and Water Resources
Ethiopian Science and Technology Commission
Addis Ababa University
Oy Alko Ab
16 persons

Standards, legal demands, safety regulations, financing, other uses for molasses.

3
UNIDO, Africa Hall, Addis Ababa
28.2 - 31.3.1980

Bernt Bernander, Resident Representative
Dieter Martz, Junior Programme Officer

Practical matters almost every day.

4
UNDP, Africa Hall, Addis Ababa
28.2 - 31.3.1980

Marshad Raval, Administrative Offices
Makonnen, Deputy Administrative Officer
N.N. Accountant Officer

Practical and administrative matter almost every day.

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FAO, Africa Hall, Addis Ababa
28.2.1980

Mr. Goudie, Senior Agricultural Adviser and FAO
Country Representative

Possible cultivation areas for sugar cane and starch-rich crops in Ethiopia. Starch-rich crops for ethanol production.

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Ministry of State Farms, Addis Ababa
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Tegenu Yifru, Head/Planning Dept.

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Taye Worku, General Manager
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Melesse Endelaman, Head/Planning dept.

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Ghebru Woldegiorghis, Executive Secretary,/Head of Ethiopian National Energy Commission

Omar Mohamed Gella

The availability of energy, use of energy for transport, industry, household. Energy sources, the price of energy, trends, imported an domestic energy. Expectations on the study. Financing.

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Ethiopian Petroleum Corporation, Addis Ababa
3.3., 7.3., 10.3.1980

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3.3.1980

Yoannis Gebre-Mikael, Manager

Oil products, product prices, trends. Consumption regional distribution, trends. Distribution system, distribution regions. Transport, transports costs. Storage, regional storage capacities. Blending possibilities.

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Mobil Oil East Africa Ltd. (Oil product distribution company),
Addis Ababa
3.3.1980

Bemnet Tesfa-Egzi, Operations Manager
Tsegay Mehtsun, Projects Manager

Oil products, product prices, trends. Consumption, regional distribution, trends. Distribution system, distribution regions. Transport system, costs. Storage, regional storage capacities. Blending possibilities.

14
Total Mer Rouge S.A (Oil product distribution company),
Addis Ababa
3.3.1980

Demissie Shibeshi, Manager

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Shell Ethiopia Ltd (Oil product distribution company),
Addis Ababa
4.3.1980

Nahu-Senaye Araya, Sales Manager

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N.N. Head of a Dept.

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4.3.1980

Haile Lul Tebicke,Commissioner
Shiferan Jammo, Head/Development Projects Agency
Izaddin Ali, Chairman/Natural Resources Council

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Dr Becker

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Risto Lokka, Attache

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Kassa Kuryie, Chemist/Distillery
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Tesfu Zewdu, Manager

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Gaim H Ghiorghis, Manager/Foreign Trade Division
Megersa Wakjira, Head/Planning and Research Dept.

Consumption, import of dried bakers´s yeast. Import prices, trends. Bread consumption, trends. Bakeries. Export possibilities for dried yeast. Dry yeast technology.

26
Central Statistical Office, Addis Ababa
14.3.1980

Ethiopia Statistical Abstracts

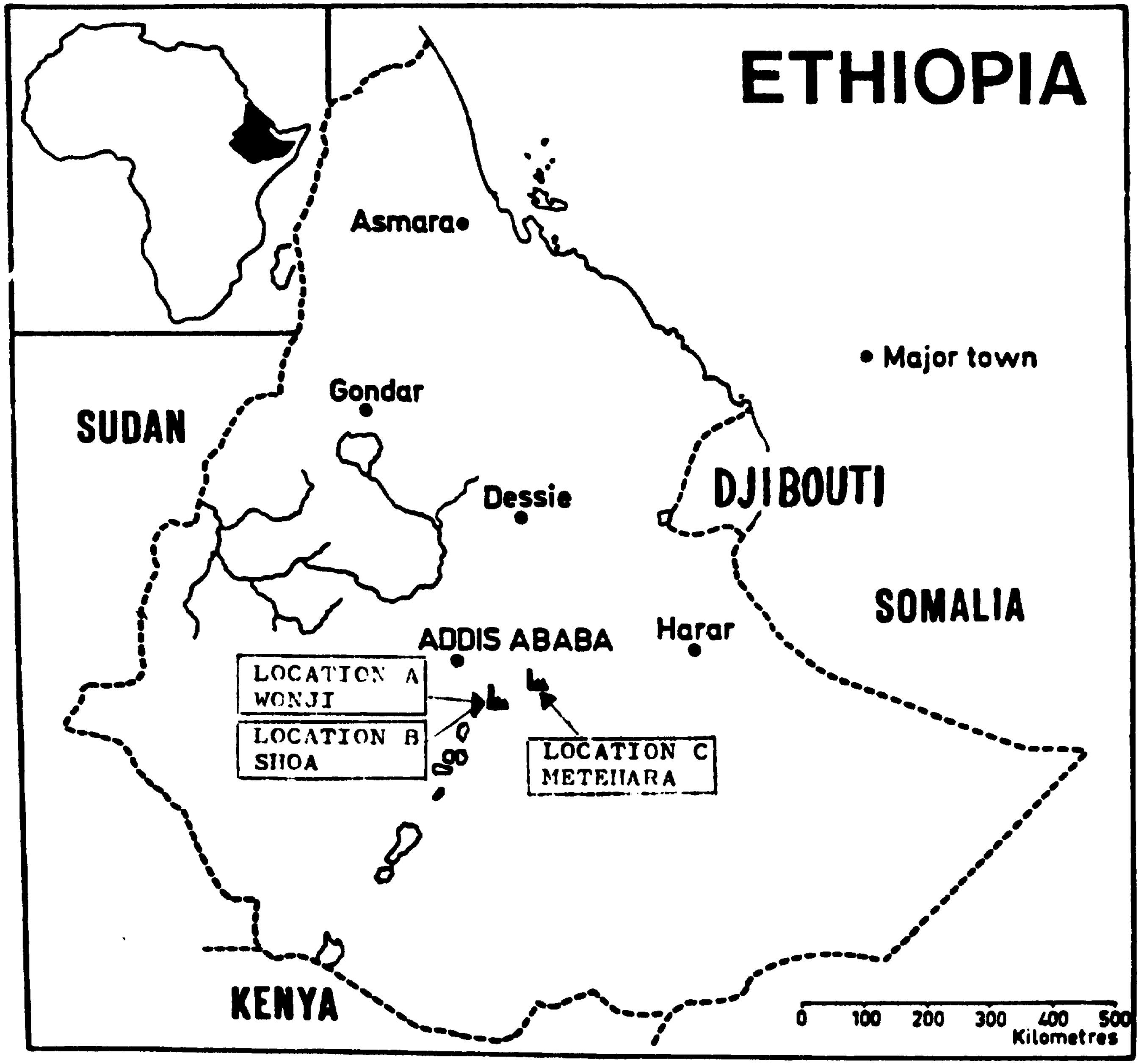
27
National Chemicals Corporation, Addis Ababa
17.3., 18.3.1980

Hailu Regassa, Head/Planning Dept.
N.N. , Administrative Manager

Import, consumption and import prices for chemicals, which could be produces from molasses or ethanol.

28
Ethiopian Mapping Agency, Addis Ababa
14.3., 17.3.1980

Maps of the sugar factory areas.


ETHIOPIA
Asmara
• Major town
Gondar
SUDAN
Dessie
DJIBOUTI
SOMALIA
ADDIS ABABA
Harar
LOCATION A WONJI
LOCATION B SHOA
LOCATION C METEHARA
KENYA
0 100 200 300 400 500
Kilometres

MAP 1

ANNEX 2

PRODUCTION FIGURES OF THE SUGAR FACTORIES IN ETHIOPIA 1954 - 1990

Campaign/ sugar mill	1954-1955	1962-1963	1969-1970	1971-1972	1972-1973	1975-1976	1978-1979	1979-1980	1985	1990
Metehara			15 672		57 172		75 000	75 000	120 000	120 000
Wonji	28 000			28 409		31 470		36 650	42 000	42 000
Shoa		24 000		39 600		41 500		44 300	50 000	50 000

The output of molasses is approx. 40 % of the amount of sugar.

The output of bagasse is approx. 270 % of the amount of sugar.

SI/ETH/79/803

ANNEX 3

MOLASSES AVAILABILITY AND USE IN ETHIOPIA 1980 - 1990

Year	Amount available, t					Use, t				Export, t	Balance, +/-
	Metahara	Wonji	Shoa	Fincha-a	Total	Power alcohol	Liquors[x]	Bakers yeast[x]	Total use		
[illegible]	25 000	12 000	13 000	-	53 000	-	12 000	-	12 000	25 000	+ 16 000
[illegible]	25 000	14 000	18 000	-	60 000	-	12 000	-	12 000	40 000	+ 8 000
[illegible]	36 000	14 000	18 000	-	68 000	-	12 000	-	12 000	30 000	+ 26 000
[illegible]	43 000	14 000	18 000	-	30 000	18 000	15 000	-	33 000	30 000	+ 17 000
[illegible]	48 000	14 000	18 000	-	80 000	65 000	15 000	-	80 000		0
[illegible]	48 000	14 000	18 000	10 000	30 000	68 000	17 000	3 000	88 000		+ 2 000
[illegible]	48 000	14 000	18 000	20 000	100 000	76 000	20 000	4 000	100 000		0
[illegible]	48 000	14 000	18 000	30 000	110 000	86 000	20 000	4 000	110 000		0
[illegible]	48 000	14 000	18 000	30 000	110 000	86 000	20 000	4 000	110 000		0
[illegible]	48 000	14 000	18 000	30 000	110 000	86 000	20 000	4 000	110 000		0
[illegible]	48 000	14 000	18 000	30 000	110 000	86 000	20 000	4 000	110 000		0

x Estimate

THE USE OF ALCOHOL-GASOLINE BLENDS AND OF PURE ALCOHOL IN INTERNAL COMBUSTION ENGINES

1 INTRODUCTION

Ethyl alcohol has been used as a fuel for internal combustion engines already in the end of the last century. Because of the low gasoline prices of the past, alcohol and alcohol blends have not been widely used, exept during wartimes when gasoline has not been available. As gasoline prices have steeply rised during the last years, many countries have been studying the possibility of producing ethanol to be used as motor fuel and some countries have already started a big scale ethanol production for this purpose.

2 USE OF ALCOHOL IN SPARK-IGNITION AND DIESEL ENGINES

The octane number of pure ethanol is 110.9 (1). In blends ethanol increases the octane rate of the blend. The higher the octane number of the fuel is, the more will it tolerate compression whithout self-ignition. This is an advantage in spark-ignition engines as their efficiency is higher the higher the compression ratio is, but a disadvantage in diesel engines as ethanol decreases the cetane rate of the fuel. At the time being a lot of investigation is done around the world to develop diesel engines which could be fuelled with pure alcohol or alcohol blends.

2.1 Use in spark ignition engines

2.1.1 The use of alcohol-gasoline blends

Ethanol and gasoline mix readily in all proportions in temperatures higher than -30^{o}C (1). When some amounts of water is added to the blend it will separate in two layers: an alcohol-water layer and a gasoline layer. The water tolerance of the blend increases with the temperature and the amount of alcohol used. When anhydrous alcohol (water content less than 0.5 %) is used no separation will occur in temperatures occurring in Ethiopia. The water tolerance also depends on the chemical nature of the gasoline. Gasoline which contains high amounts of straight-chain hydrocarbons have a lower water tolerance than gasoline, which contains high amounts of aromatic compounds. The water tolerance decreases as the molecular weight increases (1). An example of a water tolerance diagramme is presented in Appendix 1. (2).

Alcohol increases the octane number of the blend. It also depends on the chemical nature of the gasoline used. When the gasoline contains high amounts of parafinic, saturated hydrocarbons, blending with ethanol will increase the octane rate number more, than if the gasoline contains high amounts of olefinic hydrocarbons (1). In blends of 10 - 20 % ethanol, depending on the gasoline, some or all of the tetraethyl lead used to rise the octane rate number of the pure gasoline, can be omitted.

In Appendix 2 (2) a blending chart is presented. It gives the Blending Octane Value (BOV) of ethanol in the blend versus the octane rate number of a base gasoline used, measured by the research method, which is the more common one, and the motor method. The octane rate number of the blend can be obtained from the following equation:

$$\text{O.N. (Blend)} = \text{O.N. (Base)}\,(1 - x) + \text{BOV}\,(x\ \text{Alcohol})$$

where:

O.N. (Blend) = the octane rate number of the blend
O.N. (Base) = the octane rate number of the base gasoline
(1 - x) = volume fraction of base gasoline in blend
x Alcohol = volume fraction of Alcohol in blend

It is noticeable that higher amounts of tetraethyl lead than 0.2 % will not increase the octane rate number anymore, but alcohol increases the octane rate number continuously until the octane rate number of pure alcohol is reached (1).

The calorific value of alcohol is about 70 % of that of gasoline. In blends up to 20 % this is compensated by the higher thermal efficiency of the engine caused by the alcohol. The main reason for this is the higher latent heat of alcohol which cools the cylinder and results in more efficient working temperatures. Road tests made by the Finnish State Technical Research Institute show no increase of fuel consumption with a 15 % alcohol-gasoline blend. Similar results have also been reported in litterature (3), (5). The stoichiometric air/fuel ratio for alcohol fuel is smaller than that of pure gasoline. In other words, the air-fuel mixture should be richer when using alcohol. Most of the cars are already set to run slightly rich and will thus not present any problem when up to 20 % alcohol is used. If the engine is designed to run exactly on stoichiometric air-fuel ratio, some loss of driveability can be noticed. This can be wery easily avoided by using a slightly bigger nozzle in the carburator. This will result in very small increase in both fuel consumption and power output.

No other modifications are necessary when blends with up to 20 % alcohol are used. Special care has to be taken that the engines and fuel delivery systems do not have any parts that are soluble in or reactive with alcohol. This is very easily done. Before storage of an alcohol-gasoline blend for the first time, storage tanks should be very carefully cleaned as they very often contain some water and rust on the bottom, which will be picked up by the alcohol and may clog the carburator.

High altitudes will effect the driveability quite similarily as it does when pure gasoline is used. The thin air will result in a slight loss of power output but will not present any bigger problems for alcohol-gasoline blends than for pure gasoline.

The alcohol-gasoline blend combusts more completely than pure gasoline which results in cleaner effluent gases. As tetraethyl lead is not needed the emissions will be completely lead-free. The carbon monoxide and hydrocarbon emissions will also be substantially lower.

2.1.1 The use of neat alcohol

Alcohol can also be used neat, that is without blending with gasoline, in engines specially adapted for it. In this case, as no separation problems will occur, there is no need for the alcohol to be anhydrous (6), (7).

Pure alcohol can be used in existing engines after some modification has been done. The fuel consumption will however be greater than with gasoline. The higher thermal efficiency does not anymore compensate the lower calorific value of alcohol in high alcohol concentrations or when used as pure. When used in specially designed engines alcohol is a competitive fuel to gasoline. The high octane rate number enables the use of higher compression ratios which result in higher efficiency (6). A gasoline fuelled car with a low fuel consumption has an overall efficiency of about 27 %. A hydrated alcohol adapted engine has an efficiency of 39 %. This compensates quite well the lower calorific value of ethanol. In actual car use the volumetric fuel consumption is 10 - 15 % higher for hydrated alcohol (strength about 95 %) than for gasoline (3).

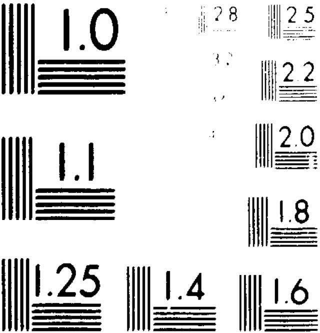
Several countries are already producing cars which are equipped with neat alcohol engines.

2.2 Use in diesel engines

Alcohol can be blended with diesel oil when blend stabilizing additives are used. (3). Blends which contain small amounts of alcohol can be used in diesel engines with high compressions ratios, as the small amount of alcohol still permits ignition. The cetane rating can be increased by additives which usually are nitrogenated organic compounds (3), (4). Another possibility would be to use simultaneously but separately both alcohol and diesel fuel so that the diesel fuel ignites normally and acts like a spark for the alcohol ignition. This can be accomplished either with a carburator for the alcohol and the normal diesel injection system for the diesel fuel, or with an alcohol injection immediately after the diesel injections. In the former system generally 40 % of the total fuel consumption can be covered with alcohol and in the latter even better results can be obtained. (3). Existing diesel engines need however modifications before they can be runned with alcohol containing fuels. Fuel consumption figures will be a lot more favourable for diesel fuel than for alcohol since the diesel engines already benefit from the high efficiency provided by the high compression ratios. The calorific value of diesel fuel is a lot higher than that of alcohol.

3 ENGINE WEAR

The life expectancy for an alcohol fuelled engine is about the same as for a petrol fuelled one. In some cases even lower engine wear has been reported from Brazil where large tests have been runned (3). The oil film in the cylinder maintains well when hydrated alcohol is used. Less dilution of the lubricating oil has been found than with gasoline. Water in the cylinder is always in the vapour state and does not effect the cylinder walls. This is not surprising if compared with the fact that steam engines are very longlifed. The higher compression ratios do not mean very much higher compression pressures in the cylinder because of the cooling effect of vaporizing alcohol due to the high latent heat. Because of this the mechanical loads will not be bigger in alcohol fuelled engines. Because of the lower air to fuel ratio needed for alcohol, more fuel can be combusted in the cylinder than if gasoline was used. Because of this, more power can be obtained by using alcohol, at the expence of


1.0
2.8
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

a higher fuel consumption. This fact has been used in racing cars since the beginning of the century. In this case the engine wear will of course be greater. If the engine is adjusted for minimum fuel consumption, the only slightly higher torque and power will not have much influence on wear (3).

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VTT Tiedotus, Sarja IV, Kemia 25. 1980. Communications of the Finnish State Technical Research Centre, Serie IV, Chemistry)

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6. W Bernhardt, H Menrad: Äthanol aus Biomasse als Kraftstoff für Automobile, Branntweinwirtschaft 2.3.1980. pp. [illegible]-91.

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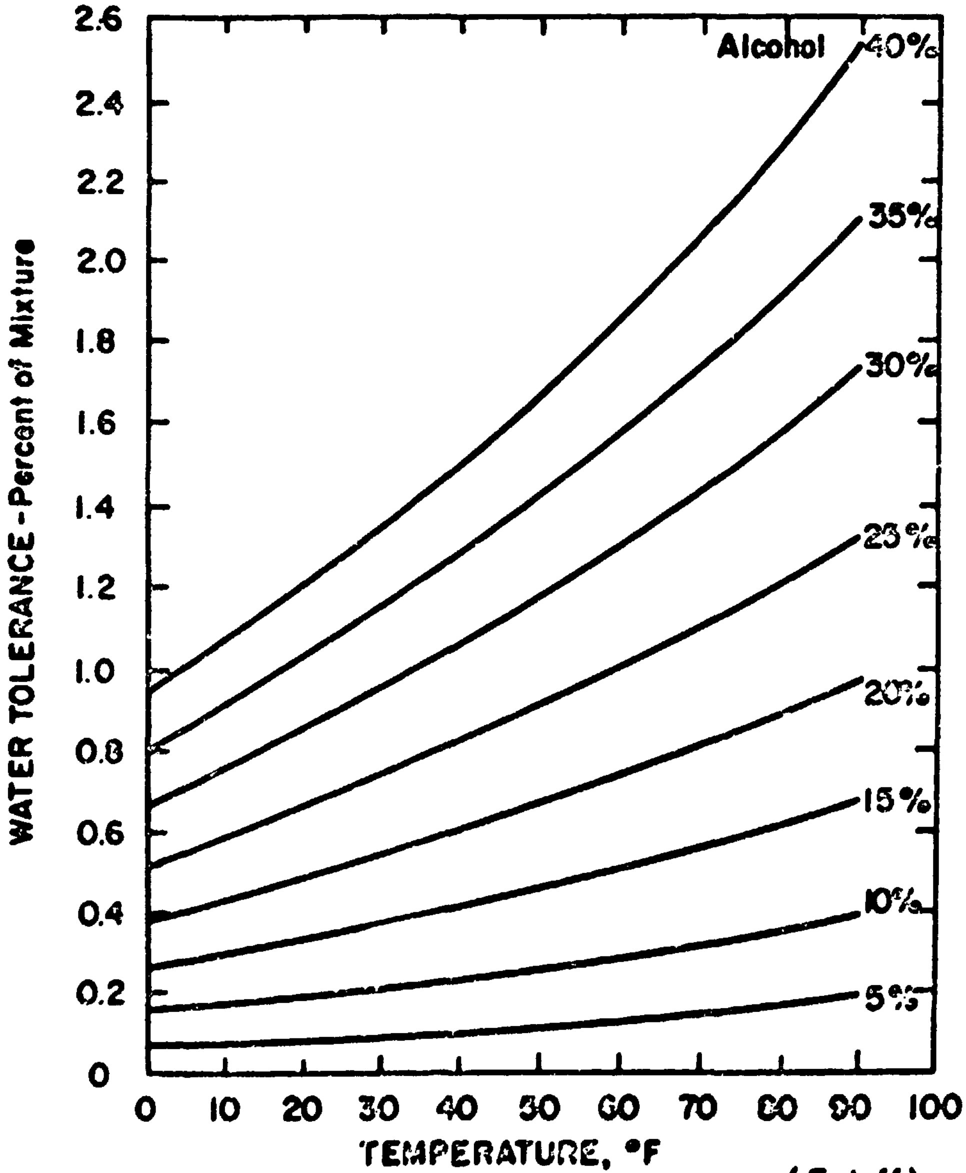
FIGURE 3—WATER TOLERANCE OF ETHYL ALCOHOL GASOLINE BLENDS



(Egloff)

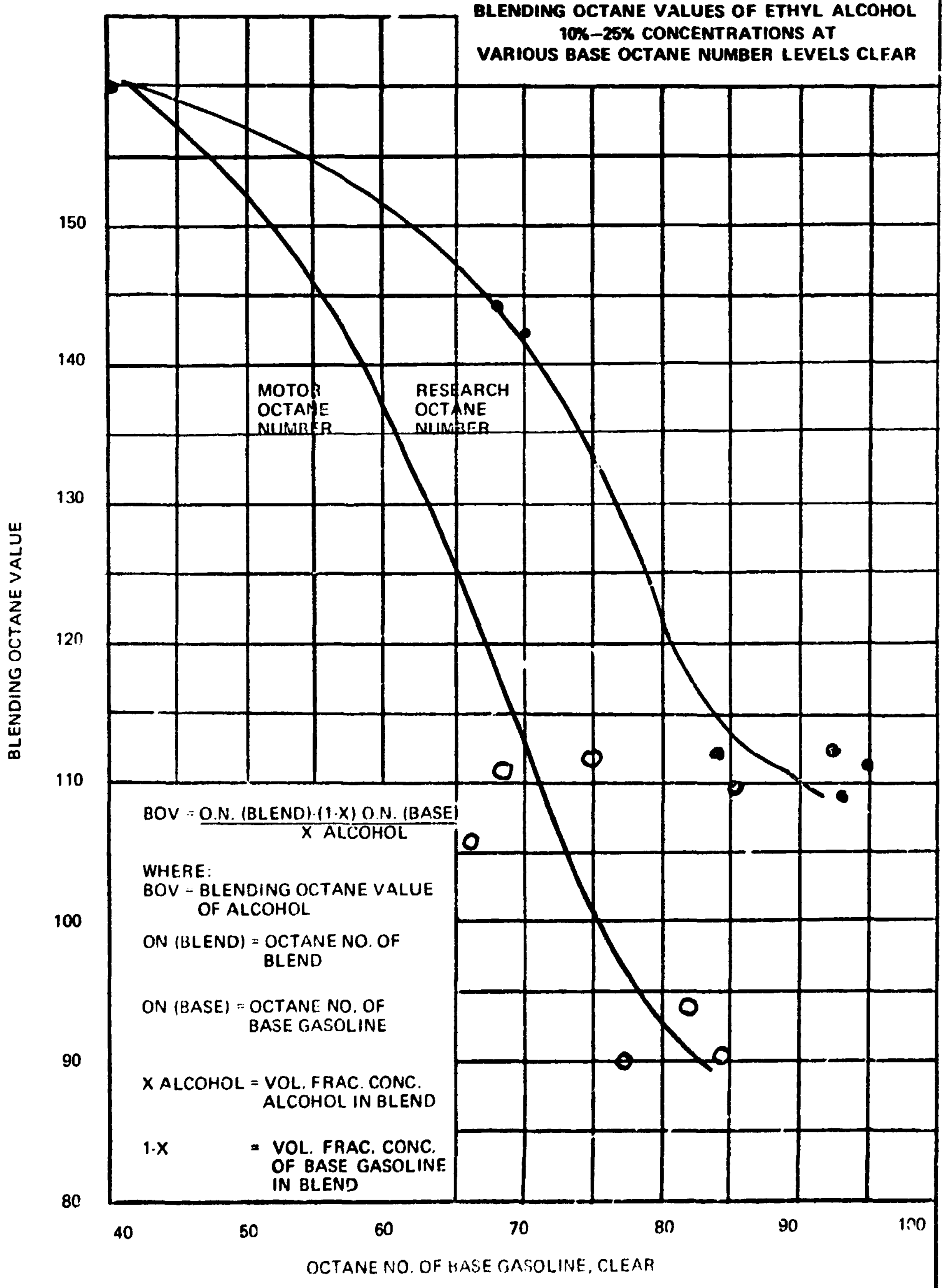


FIGURE 1
BLENDING OCTANE VALUES OF ETHYL ALCOHOL 10%–25% CONCENTRATIONS AT VARIOUS BASE OCTANE NUMBER LEVELS CLEAR

NUMBER OF CARS IN SERVICE IN ETHIOPIA 1979 - 1981

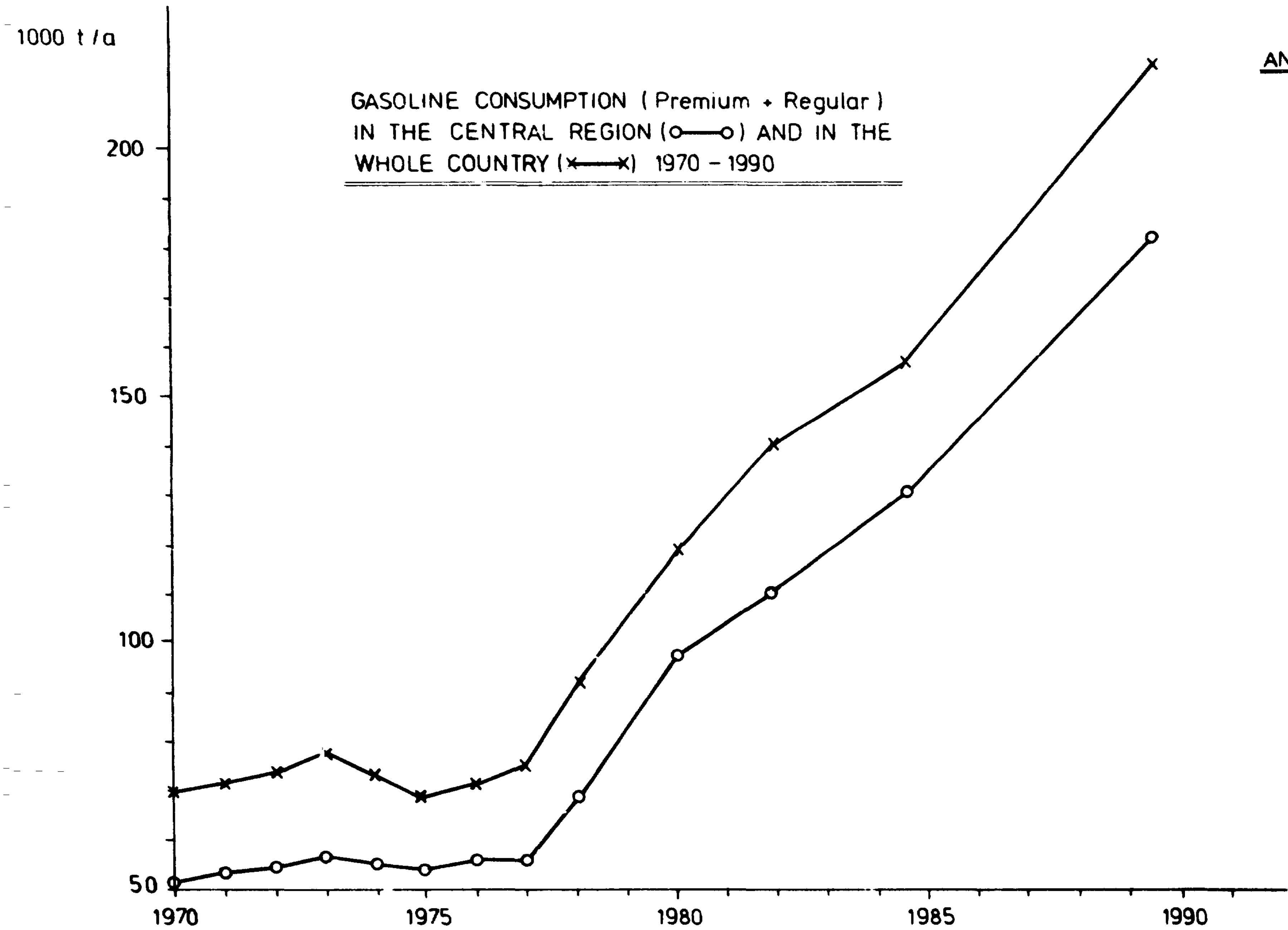
CAR - TYPE	NUMBER OF CARS 1979	1980	1981 x)	Remarks
Gasoline - cars	38 352	no estimates	available	Confirmed by Road Transport Authority
Diesel - cars				
Small buses	2 001	2 171	2 376	Confirmed by Public and National Transport Corporation
Town - buses	124	124	144	1979 figures as confirmed by Public Transport Company 1980, 1981 figures by Public Transport Corporation
Big freight lorries	3 546	4 484	4 925	Confirmed by Freight Transport Company and Transport Corporation
Big tank lorries	582	570	570	"
Subtotal diesel cars	6 253	7 349	8 015	
Grand total all cars	46 635	4[illegible] 731	46 397	

x) estimate

CONSUMPTION, SALES AND FUTURE DEMAND OF PETROLEUM PRODUCTS IN ETHIOPIA

Product	Density	Consumption 1978	Sales 1979 Distribution Companies				Total sales 1979	Demand, Forecast		
			Agip	Mobil	Total M.R.	Shell		1980	1985	1990
MoGas Regular	0,730	93 500 t	30 000 t	17 000 t	18 000 t	34 500 t	100 000 t	120 000 t	168 000 t	226 000 t
Premium	0,739			100 t		400 t				
Diesel Oils	0,832	213 000 t	70 000 t	46 500 t	54 500 t	79 000 t	250 000 t	316 000 t	465 000 t	673 000 t
Fuel Oils	0,926	57 000 t	17 500 t	11 000 t	12 500 t	30 000 t	71 000 t	210 000 t	311 000 t	449 000 t
Aviation fuels	0,770	77 500 t		38 000 t				81 500 t	113 000 t	147 000 t

ANNEX 7


1000 t /a
GASOLINE CONSUMPTION (Premium + Regular)
IN THE CENTRAL REGION (o—o) AND IN THE
WHOLE COUNTRY (x—x) 1970 - 1990
200
150
100
50
1970
1975
1980
1985
1990

STORAGE CAPACITIES OF THE FUEL DISTRIBUTION COMPANIES IN ETHIOPIA

Distribution company	Agip		Mobil			Total Mer Rouge			Shell			Total storage capacity				
Location	Addis Ababa	Massawa	Addis Ababa	Massawa	Asab	Addis Ababa	Massawa	Dire Dawa	Addis Ababa	Asab	Dire Dawa	Addis Ababa	Massawa	Asab	Dire Dawa	Whole country
Type of fuel (density)																
MoGas Regular (0,730) " Premium (0,739)	440 m^3	3 330 m^3	410 m^3	1 300 m^3	-	480 m^3 100 m^3	1 300 m^3 1 300 m^3	100 m^3 -	1 860 m^3 60 m^3	3 100 m^3 -	265 m^3 50 m^3	3 290 m^3	7 250 m^3	3 100 m^3	415 m^3	14 055 m^3
Diesel Oils (0,832)	1 170 m^3	9 000 m^3	410 m^3	-	1 800 m^3	1 600 m^3	10 100 m^3	300 m^3	1 800 m^3	8 900 m^3	265 m^3	4 990 m^3	19 100 m^3	10 700 m^3	565 m^3	35 355 m^3
Fuel Oils (0,926)	120 m^3	7 000 m^3	-	-	8 000 m^3	300 m^3	5 500 m^3	-	-	1 100 m^3	-	420 m^3	12 500 m^3	9 100 m^3	-	22 020 m^3
Avation Fuels (0,770)	-	6 840 m^3	1 886 m^3	4 650 m^3	-	-	600 m^3	-	310 m^3	2 600 m^3	171 m^3	2 196 m^3	12 090 m^3	2 600 m^3	171 m^3	17 057 m^3

CONSUMPTION QUANTITY AND IMPORT VALUE OF MOLASSES - BASED CHEMICAL PRODUCTS IN PLANTS UNDER THE MINISTRY OF INDUSTRY

Product	Quantity kg	Import value Birr
Citric acid	4 276	32 565
Monosidum glutamate	-	-
Acetone	3 255	15 346

Source: Citric acid, acetone: 1979 Budget
monosidium glutamate: no information available

IMPORT QUANTITY AND VALUE FOR ACETIC ACID

Year	Quantity, kg	Value, Birr
1973	16 050	9 621
1974	10 000	17 020
1975	5 000	8 495
1976	13 000	20 303
1977	26 333	33 021
1978	536 404	874 611?

Source: Annual External Trade Statistics

ANALYSES OF MOLASSES FROM METEHARA, WONJI AND SHOA SUGAR FACTORIES

The cane molasses samples were obtained from the sugar factories trough Ethiopian Sugar Corporation's main office in Addis Ababa, Ethiopia.

The analyses were performed by Oy Alko Ab:s Central Laboratory, Fermentation Dept. in Helsinki, Finland.

RESULTS

	Molasses from		
	Metehara (5.3.1980)	Wonji (March 1980)	Shoa ([illegible])
Brix, °	90	90	[illegible]
pH	5,5	5,8	[illegible]
Invert sugar (Bertrand), %	16,3	14,2	[illegible]
Total sugar as sucrose (Clerget + Bertrand), %	55,6	51,2	[illegible]
of which sucrose, %	35,2	37,7	[illegible]
Invert sugar (as sucrose), %	17,4	13,5	[illegible]
Nonfermentable sugars, %	5,1	2,9	[illegible]
Volatile acids as acetic acid, %	0,33	0,36	[illegible]
Nitrogen, N, %	0,47	0,35	[illegible]
Phosphorus, P, %	0,02	0,03	[illegible]
Sodium, Na, mg/kg	226	2 000	870
Potassium, K, mg/kg	44 600	58 800	[illegible]
Calcium, Ca, mg/kg	9 725	8 575	[illegible]
Magnesium, Mg, mg/kg	1 210	1 920	[illegible]
Nitrite, NO_2^-, mg/kg	less than 3	less than 3	less than [illegible]
Ash (sulphated), %	14,0	17,7	[illegible]
Water (Fischer), %	20,9	[illegible]	[illegible]

SI/ETH/79/803 ANNEX 11

TECHNICAL RESEARCH CENTRE OF FINLAND

INVESTIGATION REPORT
(Translation from Finnish) [illegible]

Fuel- and lubricants laboratory

Ordered by	Oy Alko Ab, Rajamäen tehtaat Väkiviinalaboratorio, 05200 Rajamäki
Order	17.4.1980/Patrick Stelwagen
Samples	Two approx. 0.5 kg bagasse samples Sample 1 Shoa (Ethiopia) Sample 2 Wonji "

Results

		Sample 1 Bagasse Shoa	Sample 2 Bagasse Wonji
Humidity at arrival	DIN 51718 % by weight	53.5	45.[illegible]
Volatile material in dry matter	DIN 51720	80.9	80.4
Calorimetric heat value in dry matter	DIN 51900 MJ/kg	18.86	18.71
Effective heat value in dry matter	DIN 51900 MJ/kg	17.61	17.48
Effective heat value in arrival state	DIN 51900 MJ/kg	6.87	8.91

The methods used can be obtained from the Technical Research Centre of Finland.

Espoo 2.5.1980

TECHNICAL RESEARCH CENTRE OF FINLAND
Fuel- and lubricants laboratory

Laboratory chief	Erkki Ekman
Assistant	Raili Silvasti

THE PRODUCTION AND PRICE OF ELECTRICITY IN ETHIOPIA

1. PRODUCTION, WHOLE COUNTRY 1976

Generating capacity	[illegible]73 MW
Production	433 000 KWh Total
	[illegible] 000 " hydro-
	137 000 " thermal

2. PRODUCTION, WONJI/SHOA-REGION

Station	Awash I (Koka)	Awash II (Nazareth)
Capacity	43 000 kW	[illegible] kW
Production	93 000 KWh	42 [illegible] " [illegible]

3. BIG INDUSTRY COMMERCIAL TARIFF

Maximum demand charge (per month)

First 50 kW	12 Birr/kW
Next 200 kW	10 "
For balance of kW	6 "

KWh-charge (per month)

First [illegible] KWh, per kW max. demand				7 cents/kWh
Next 200 KWh	"	"	"	[illegible] "
For balance of KWh				[illegible] "

References: Statistical Abstract 1977 [illegible]
Personal communications

WATER ANALYSES, DRINKING WATER AND CONDENSATE, ETHIOPIA

Sample from	Wonji sugar factory	Wonji, Well 2	Wonji		Nazareth
Date	17.3.1980				
Type of water	Condensate	Drinking water	Drinking water		
Analyzed by	ALKO	ETHIOPIA	ETHIOPIA		ETHIOPIA
Analysis			Sweet factory	Hospital	
Temperature, °C					38
pH	(3,4)	7,2	7,6	7,6	7,6
Hardness, °dH	0,1		4,7	5,0	5,1
" as $CaCO_3$, mg/l		172			
Conductivity, mS/m	27,3		119,3	112	
$KMnO_4$-cons., mg/l	90		0,95	0,95	8,5
Alkalinity, mg/l $CaCO_3$		441			
CO_3^{--}, mg/l		0	10	9	
HCO_3^-, mg/l		538	719	750	445
Total residue, mg/l	144	692	818	970	623
Suspended solids, mg/l	35				
Fixed residue (loss of weight on ignition, 550°C), mg/l	12				
Total N, mg/l	10,1				
P_2O_5, mg/l			n.d.	n.d	
PO_4^{3-}, mg/l					0,0[illegible]
Cl^-, mg/l	76	33	61	39	40
NO_2^-, mg/l			n.d.	n.d.	n.d.
NO_3^-, mg/l			4,0	0,1	0,02
Fe, mg/l	0,76	0,5	< 0,05	0,25	0,05
Mn, mg/l			< 0,05	< 0,05	n.d.
NH_4^+, mg/l		n.d.	0,8	0,5	0,35
Ca^{++}, mg/l		55			29
Mg^{++}, mg/l		9			6,5
F^-, mg/l		11,[illegible]			0,8
SO_4^{--}, mg/l		255	7,0	9,5	n.d.
SiO_2, mg/l	0,84		90	108	

( ) : uncertain figure

n.d. : not detectable

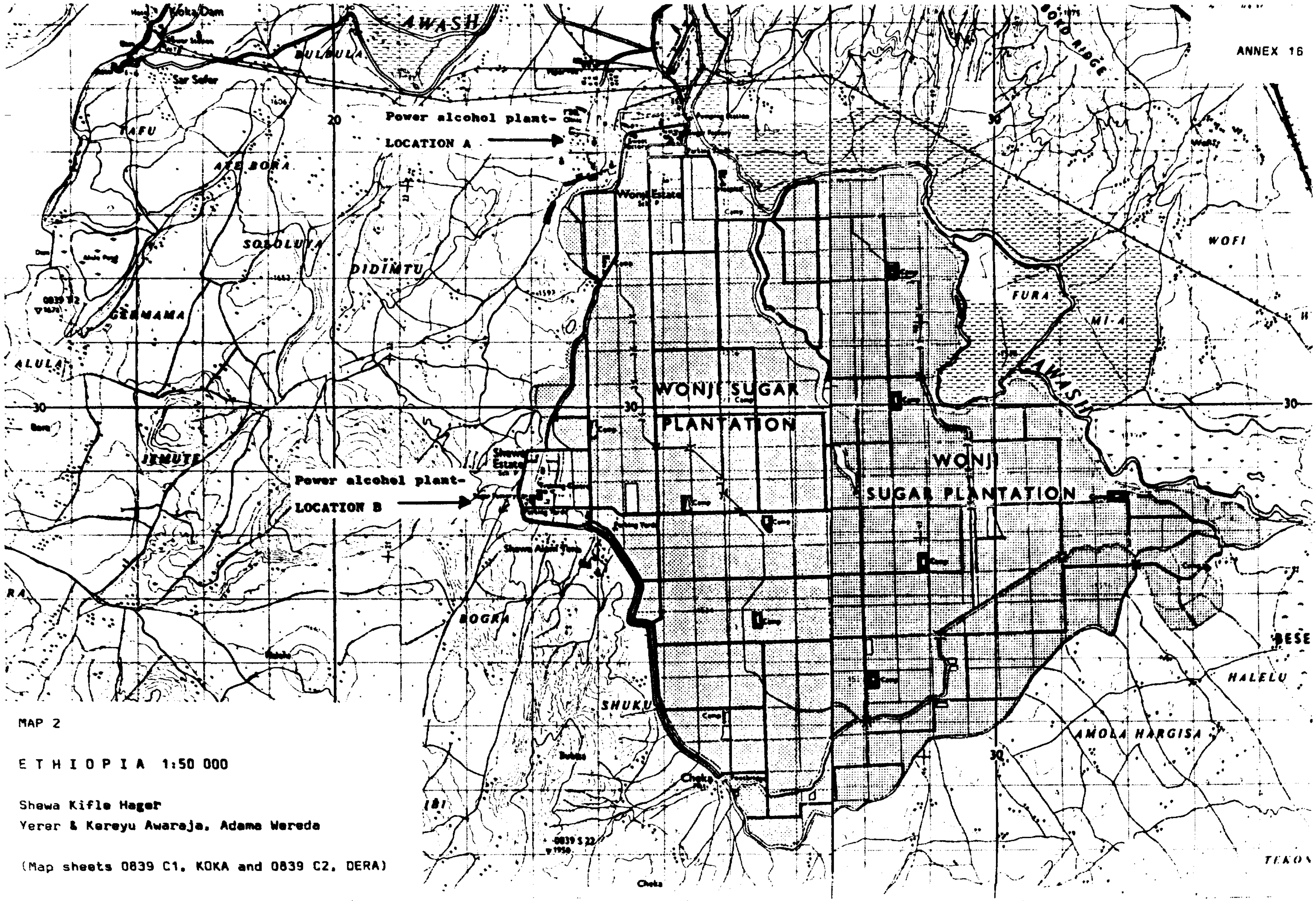
WATER ANALYSES, AWASH RIVER, ETHIOPIA

Sample from	M'nara	Shoa, canal	Wonji		Metehara	
Date	5.3.1980	24.3.1980	Aug. 1977	7.11.	14.11.	27.11.[illegible]
Analyzed by	ALKO	ALKO	ETHIOPIA		ETHIOPIA	
Analyses		Note: Extremely warm period			Note: heavy rains	Note: occasional rains
pH	(7,8)	(7,9)	8,2	7,8	7,9	7,8
Hardness, °dH	4,5	5,0				
Conductivity, mS/m	34	32,6				
$KMnO_4$ consumption, mg/l	21	30		15,5	[illegible],8	10,[illegible]
BOD_5, mg/l				2,3	2,8	2,8
Dissolved oxygen, mg/l				7,3	7,4	[illegible]
Total residue, mg/l	344	384	160	338	448	42[illegible]
Suspended solids, mg/l	84	127	27,5-[illegible]*	184	240	155
Fixed residue (loss of weight on ignition), mg/l	235	240		32[illegible]	44[illegible]	424
Total N, mg/l	3,0	6,6				
Total P, mg/l	< 0,1					
Cl^-, mg/l	12,4	1[illegible]		13,0	8,0	[illegible]
NO_2^-, mg/l				n.d.	n.d.	n.d.
NO_3^-, mg/l	(< [illegible])			2,4	1,0	1,[illegible]
Fe, mg/l	3,9	6,[illegible]				
Mg, mg/l	< 0,05					
Na^+, mg/l			16			
K^+, mg/l			10			
NH_4^+, mg/l	(0,13)			0,25	[illegible]	[illegible]
Ca^{++}, mg/l			23			
SiO_2, mg/l	22,5	21,[illegible]	50			
Bacteria, [illegible]			4 [illegible]	12 000		87[illegible]
Coliforms/[illegible] ml				1 700		1[illegible]

( ) : uncertain figure
n.d. : not detectable
* depending on rain conditions

COMPARISON OF THE ALTERNATIVE LOCATIONS FOR A POWER ALCOHOL PLANT IN ETHIOPIA

Variable	Metehara	Wonji	Shoa
Condens water - availability	surplus	surplus	surplus
Cooling water - availability	unlimited	unlimited	unlimited
(Awash river) - temperature	29-30°C	20-22°C	20-23°C
- cooling costs	c. 1,4 M Birr/a	-	-
Ground water temperature	32°C	20-25°C	20-35°C
Waste disposal	dumping in fields	dumping in fields	dumping in fields
Molasses production			
storage capacity	8 500 t	2 600 t	4 000 t
Steam production	35 t/h	32-35 t/h	35 t/h
- charact.	25 kg/cm², 360°C	15 kg/cm², 310°C	21 kg/cm², 350°C
Electricity production	3,1 MW	1,24 MW	1,9 MW
Surplus bagasse	-	+ [illegible]	-
Total transport costs			
Transp. possibilities	+	+	+
Engineers and skilled labour-availability	-	+	+
Climate	-	+	+
Sites for a power alcohol plant availability	+	+	+
Social services for manpower	+	+	+
Infrastructure, roads etc.	+	+	+
Maintenance facilities	+	++	++
Construction and erection facilities	+	++	++



MAP 2

E T H I O P I A 1:50 000

Shewa Kifle Hager
Yerer & Kereyu Awaraja, Adama Wereda

(Map sheets 0839 C1, KOKA and 0839 C2, DERA)

MAXIMUM AND MINIMUM TEMPERATURES AND TOTAL RAINFALL
IN WONJI METEOROLOGICAL STATION

1

Location — 08° 31′ North of Equator
39° 15′ East of Greenwich
at a height of 1 500 m ower sea-lewel

2

Average rainfall — 811,8 mm (max. 1 176,0 mm 1958
min. 479,0 mm 1974 ower 26 years)

3

Monthly maximum and minimum temperatures and total rainfall 1976. Relative humidity and evaporation measured in Wonji/Shoa sugar plantation 1973.

Month	Max. temp. °C	Min. temp. °C	Rain, mm	Relative humidity, %	Evaporation (class A pan) mm/d max.-min.
January	28,2	13,6	0		
February	29,1	12,7	0	30	12,0 - 2,0
March	29,1	12,7	0		
April	29,5	13,7	72,4		
May	29,3	14,0	93,3		
June	29,8	15,2	66,2		
July	27,3	15,7	114,1		
August	27,0	14,9	203,7	72	10,0 - 1,8
September	28,1	13,9	90,2	70	10,0 - 1,0
October	29,1	10,8	0	40	10,2 - 0,45
November	27,2	10,4	11,9	20	10,0 - 4,0
December	27,2	11,4	20,2	37	10,0 - 2,0
Annual	28,4	13,3	672,0		

References: (3), (4), Personal communications

SALARIES OF DIFFERENT MANPOWER GROUPS
IN THE SUGAR FACTORIES IN ETHIOPIA

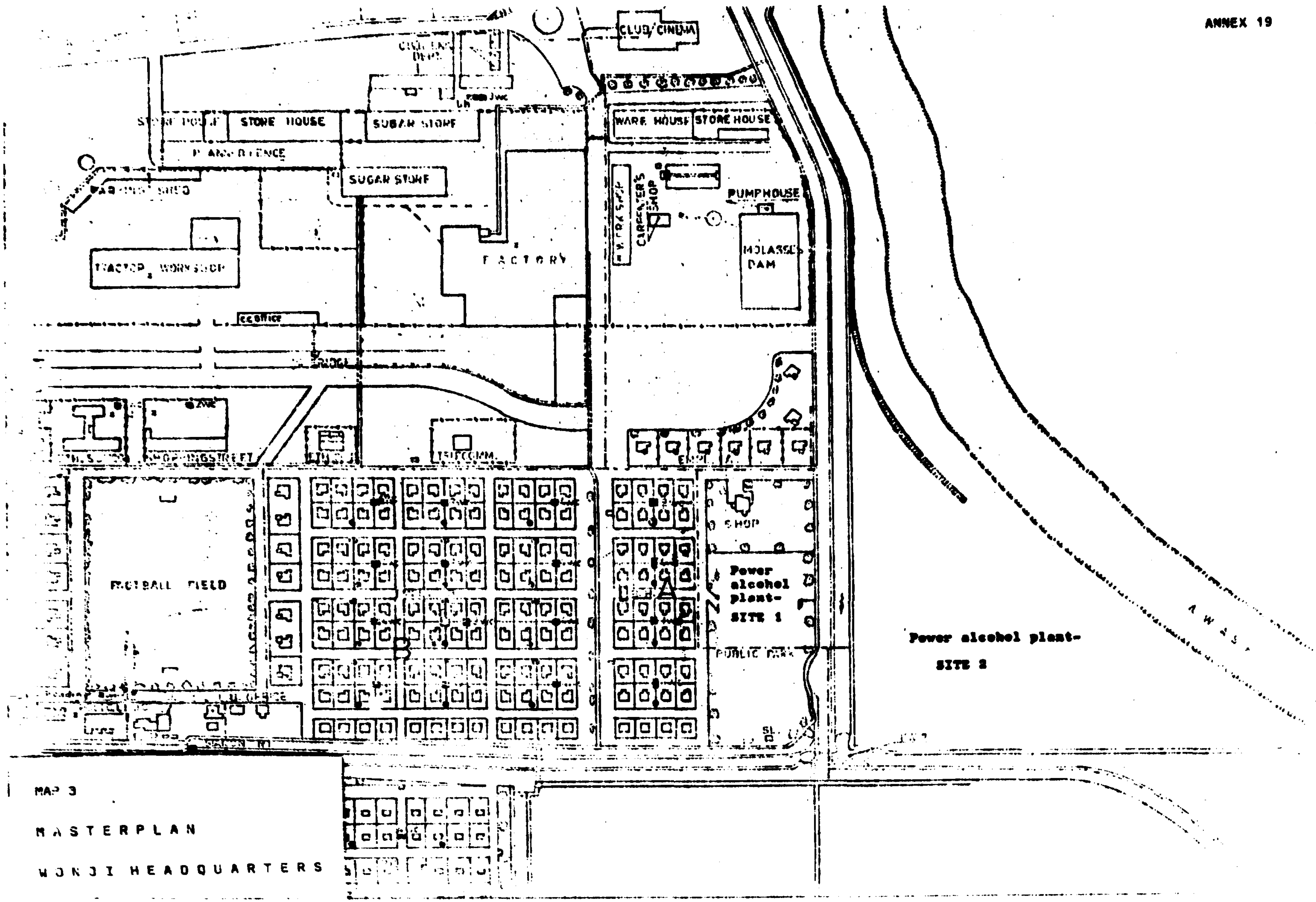
Occupation	Salary, Birr/month
Senior Engineer	over 1500
Freshly Examined Engineer	720
Foreman	467 - 769
Highly skilled, qualified technician	280 - 420
Skilled, qualified technician	230 - 370
Highly skilled worker	155 - 300
Semiskilled worker	81 - 240
Unskilled worker	49 - 178

All permanently employed manpower has in addition free housing, free medical services, free water and electricity at a reduced rate.

From a salary of less than 60 Birr/month no tax is deduced. From salaries from 60 - 1500 Birr per month the taxes rise from 1 to 12 %. The tax on salaries exceeding 1500 Birr/ month is up to 75 % on the exceeding amount.

The vacation allowed after 1 year of employment is 14 d and for additional years 1 d/year up to a maximum of 35 d.

ANNEX 19

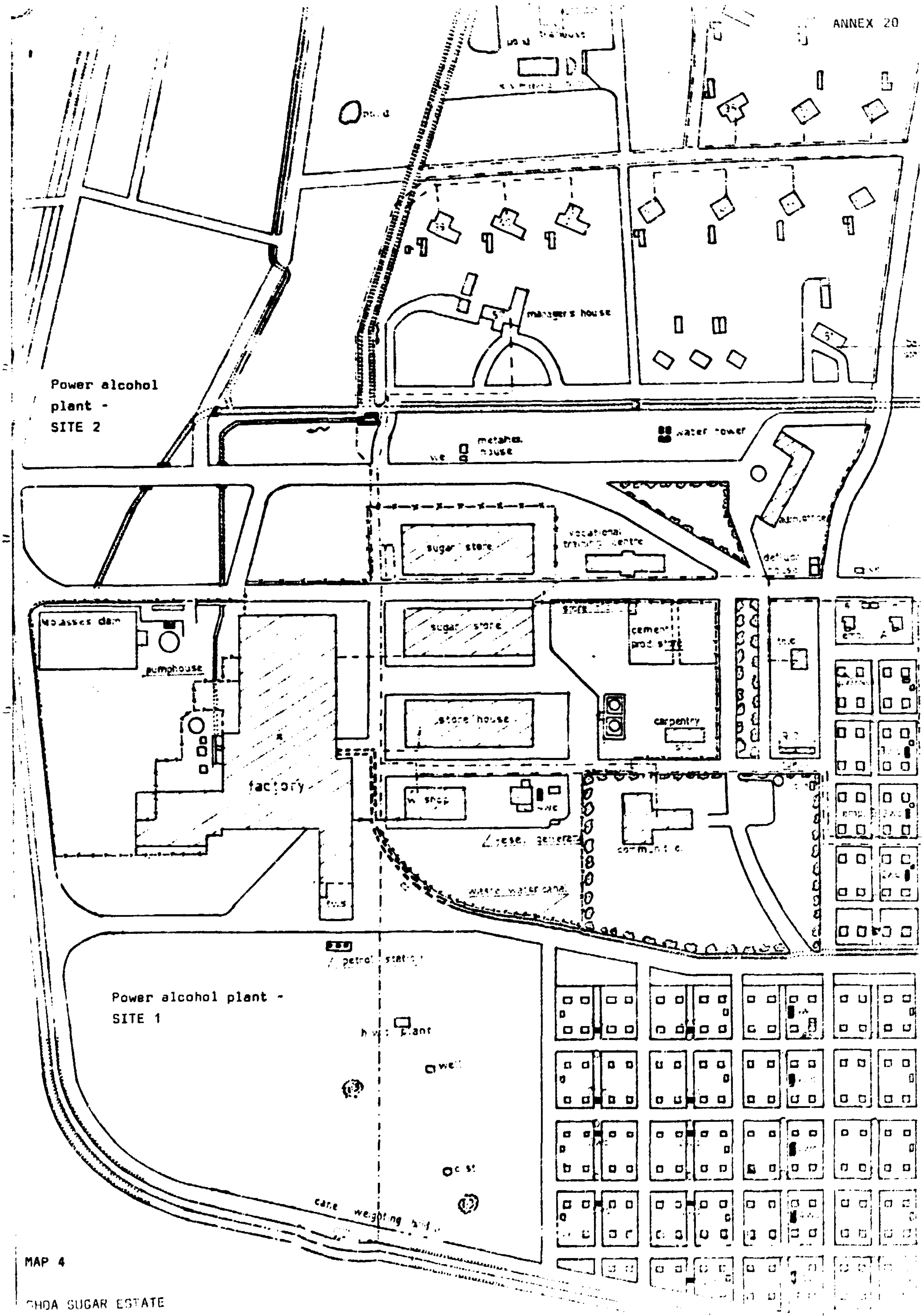


MAP 3

M A S T E R P L A N

W O N J I H E A D Q U A R T E R S

ANNEX 20

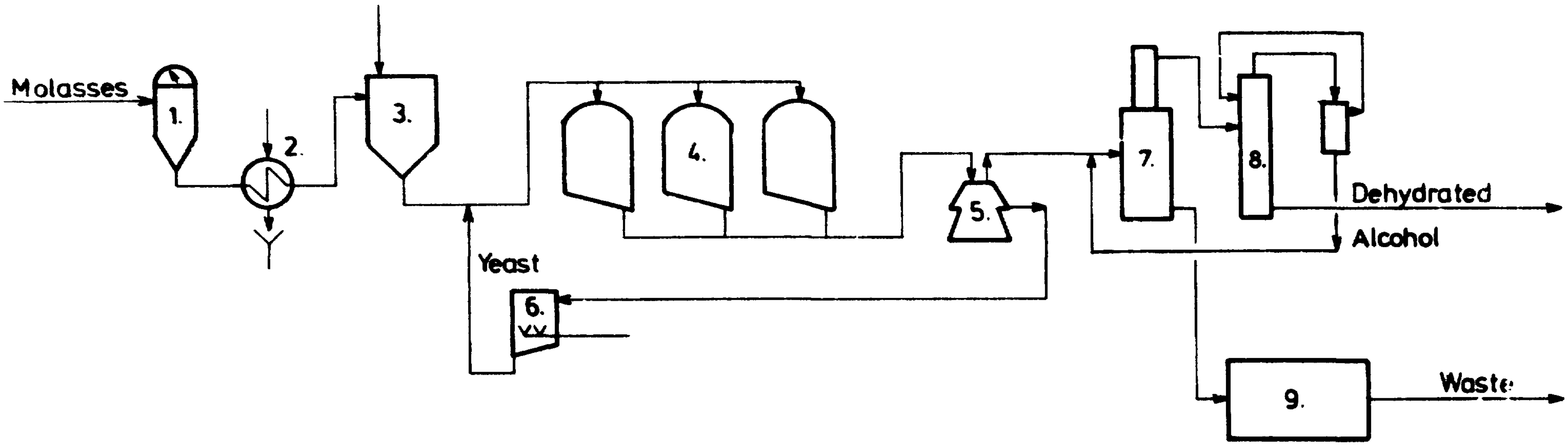


MAP 4

SHOA SUGAR ESTATE
HEAD QUARTERS

SI/ETH/79/803

GENERAL FLOW SHEET OF THE POWER ALCOHOL PROCESS



1. Measuring and acidifying
2. Sterilization
3. Dilution
4. Fermentation
5. Yeast separation
6. Yeast propagation / preparation
7. Distillation
8. Dehydration
9. Valorization / handling of vinasse

16.5.1980 TH / IS

ANALYTICAL STANDARDS FOR POWER ALCOHOL

	Absolute alcohol	Technical alcohol
Real force min. (^{o}GL)	99.3	91.1
Density max ($20^{o}/4^{o}$C)	0.7915	0.8150
Dried substance max (mg/l)	50	50
Suspended solids	no	no
Acid max (mg/l) (as acetic acid)	30	30
Aldehydes max (mg/l) (as acetaldehyde)	not specified	60
Esters max (mg/l) (as aethylacetate)	" "	80
Fusel oils max (mg/l) (as isoamyl alcohol)	" "	60
Copper max (ppm)	0.7	Not specified
Alcalinity	neg.	neg.

ANALYSIS OF A SOIL SAMPLE FROM WONJI/SHOA SUGAR PLANTATION

Soil type: Clay soil with poor mould

Results		Short comments
Humus, %	2.7	
Acidity, pH	7.6	High
Exhangeable calcium, Ca, mg/l	7 500	High
Exhangeable potassium, K mg/l	1 050	High
Readily soluble phosphorus, P, mg/l	18	Quite low
Exhangeable magnesium, Mg, mg/l	910	High
Nitrate-nitrogen, N, mg/l, less than	10	Very low
Soluble boron, B, mg/l	0.7	Low
Acid soluble copper, Cu, mg/l	8.0	Low
Exhangeable manganese, Mn, mg/l	1.3	Very low
Readity soluble sodium, Na, mg/l	425	Very high
Soluble chloride, Cl^-, mg/l	53	Normal

The sample was taken 6.3.1980
The analysis was performed by Soil Testing Company
(Hämeentie 155 A, 00560 Helsinki, Finland) 18 - 31.3.1980

EVAPORATION AND BURNING OF VINASSE

The vinasse from the distillery contains combustible substances generally about 60 % of its dry matter and therefore energy can be produced by evaporation and burning the vinasse.

The amount of vinasse formed with full capacity of the power alcohol distillery is 38 t/h, which contains approximately 10 % dry substances.

The economy of evaporation and burning is greatly dependent on the concentration degree at evaporation. Most calculations are made according to 60 % dry substance in the vinasse syrup and so the gross amount of energy in this case is around 14 t steam/h. Since the evaporation takes 6.3 t steam/h, the net energy from burning vinasse is 7.7 t steam/h which comprises about 85 % of the total steam demand in the distillery.

The investment cost for a vinasse evaporation and burning installation is about 7 Million Birr.

In general the advantages and disadvantages of the process are the following:

Advantages

- relatively small investment cost
- actually no wastes (ashes can be used as fertilizer and condensate can be used as process water)
- small retention time (vinasse syrup can be stored)

Disadvantages

- demands careful operation
- demands much cleaning
- demands special boiler

In this case the most important factors are:

1. Investment cost
2. Difficulties in good and economic operation to have maximum concentration in vinasse syrup

Both factors are dependent on equipment design, which has to be carefully studied. Moreover good training of process personnel is necessary.

METHANE GAS FROM VINASSE

One of the most studied and interesting methods to valorize and treat wastes is the anaerobic production of methane gas to be used as a fuel substitute.

Also in the case of treating vinasse at a molasses distillery it has to be considered.

The amount of methane in this particular case is approximately 1000 Nm^3/h. The heat value is 5500 $Kcal/m^3$ and the effiency of the plant is 90 %.

The net amount of energy gained via anaerobic degradation of vinasse and burning in a steam boiler will be approximately 8.2 t steam/h which covers about 90 % of the total steam demand in the distillery.

The investment cost for a methane plant is approximately 11 Million Birr.

In general the methane plant shows the following advantages and disadvantages:

Advantages:

- the process is reliable
- equipment is not very complicated
- the use of methane in steam boiler is easy
- it demands practically no break downs

Disadvantages

- investment cost is quite high
- the process is not easy to regulate to produce its maximum

- the start up takes a relatively long time
- storing the methane gas is quite expensive
- the effluent from the methane plant may need further purification
- it smells

In this particular case the most important factors are:

1. The reliability, both process and equipment
2. The maximum methane production

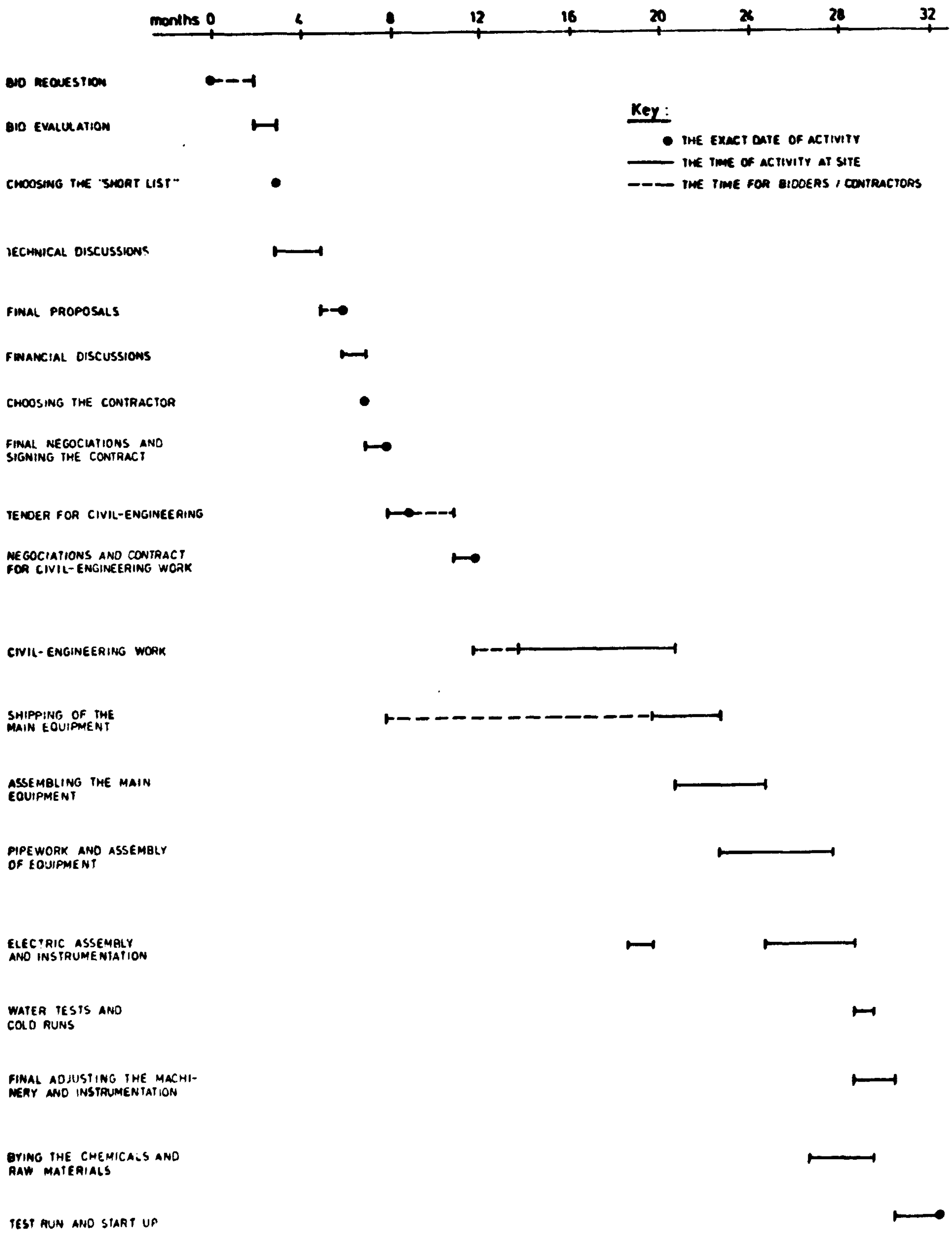
The first point is fulfilled and the second can be achieved, because the feed into the plant is quite steady as to its amount and composition. However, a great attention has to be paid on training of the process workers.

TRANSPORTATION COSTS

Matter transported \ Factory site	Metehara	Wonji	Shoa
Molasses	0,493 M Birr/a	0,735 M Birr/a	0,757 M Birr/a
Alcohol:			
I to Addis Ababa	0,624 "	0,312 "	0,328 "
II to Nazareth	0,026 "	0,026 "	0,041 "
Fuel oil (Base Alternative)	0,508 "	0,604 "	0,608 "
Total			
I Blending in Addis Ababa	1,625 M Birr/a	1,651 M Birr/a	1,693 M Birr/a
II Blending in Nazareth	1,027 "	1,365 "	1,406 "

Cost of molasses	Metehara	0,186 M Birr
transports by train	Wonji	0,362 "
and truck	Shoa	0,398 "

IMPLEMENTATION SCHEDULE FOR POWER ALCOHOL PROJECT



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INVESTMENT COSTS BREAKDOWN
- Base alternative

	Foreign currency Million Birr	Domestic currency Million Birr
Engineering	1.0	
Process equipment including pipes (FOB)	13.0	
Erection, insulation, instrumentation and electrical assembly	4.5	
Freight and insurance	1.0	
Contingency	0.6	
Land, site development and production buildings incl. furniture		4.65
Trucks	0.35	
Houses (staff and labour)		0.6
	20.45	5.25
Total investment	25.7 Million Birr	

C A S H - F L O W — M Birr

(base / oil heating)

YEAR	Construction 1	2	Start Up 3	4	5	Full Capacity 6	7	8	9	10	11
Production, t 100 %	0	3 750	15 000	15 500	17 500	20 000	20 000	20 000	20 000	20 000	20 000
A. Cash inflow	7.710	21.312	12.469	13.214	15.313	17.950	18.416	18.895	19.386	19.890	20.408
1 Financial Resources	7.710	18.274									
2 Sales Revenue		3.038	12.469	13.214	15.313	17.950	18.416	18.895	19.386	19.890	20.408
B. Cash outflow	-7.710	-20.812	-11.324	-10.891	-11.151	-11.541	-11.284	-11.027	-10.770	-10.513	-7.044
1 Total assets	-7.710	-17.990									
2 Operating costs		-1.605	-5.151	-5.280	-5.797	-6.444	-6.444	-6.444	-6.444	-6.444	-6.444
3 Working capital		-0.600	-0.600	-0.600	-0.600	-0.600	-0.600	-0.600	-0.600	-0.600	-0.600
4 Debt service											
a) Interests		-0.617	-2.079	-1.799	-1.542	-1.285	-1.028	-0.771	-0.514	-0.257	
b) Bank Loan repayments			-3.212	-3.212	-3.212	-3.212	-3.212	-3.212	-3.212	-3.216	
- short term			- 284								
C. Surplus/Deficit	0	0.500	1.145	2.323	4.162	6.409	7.168	7.868	8.616	9.377	13.364
D. Cumulative Cash Balance	0	.500	1.645	3.968	8.130	14.539	21.707	29.575	38.191	47.568	60.932

16.5.1980 ST

CASH-FLOW (Alt 1 / vinasse) M Birr

YEAR	Construction 1	Construction 2	Start Up 3	Start Up 4	Start Up 5	Full Capacity 6	Full Capacity 7	Full Capacity 8	Full Capacity 9	Full Capacity 10	Full Capacity 11
Production, t 100 %	0	3 750	15 000	15 500	17 500	20 000	20 000	20 000	20 000	20 000	20 000
A. Cash inflow		25.928	12.469	13.214	15.313	17.950	18.416	18.895	19.386	19.890	20.408
1 Financial Resources	9.810	22.890									
2 Sales Revenue		3.038	12.469	13.214	15.313	17.950	18.416	18.895	19.386	19.890	20.408
B. Cash outflow	-9.810	-25.348	-10.946	-10.700	-10.692	-10.764	-10.436	-10.110	-9.782	-9.456	-5.041
1 Total assets	-9.810	-22.890									
2 Operating costs		-1.373	-3.943	-4.023	-4.343	-4.741	-4.741	-4.741	-4.741	-4.741	-4.741
3 Working capital		-0.300	-0.300	-0.300	-0.300	-0.300	-0.300	-0.300	-0.300	-0.300	-0.300
4 Debt service											
a) Interests		-0.785	-2.616	-2.289	-1.962	-1.635	-1.308	-0.981	-0.654	-0.327	
b) Bank Loan repayments			-4.087	-4.088	-4.087	-4.088	-4.087	-4.088	-4.087	-4.088	
C. Surplus/Deficit	0	.580	1.523	2.514	4.621	7.186	7.980	8.785	9.604	10.434	15.367
D. Cumulative Cash Balance	0	.580	2.103	4.617	9.238	16.424	24.404	33.189	42.793	53.227	68.594

ANNEX 29

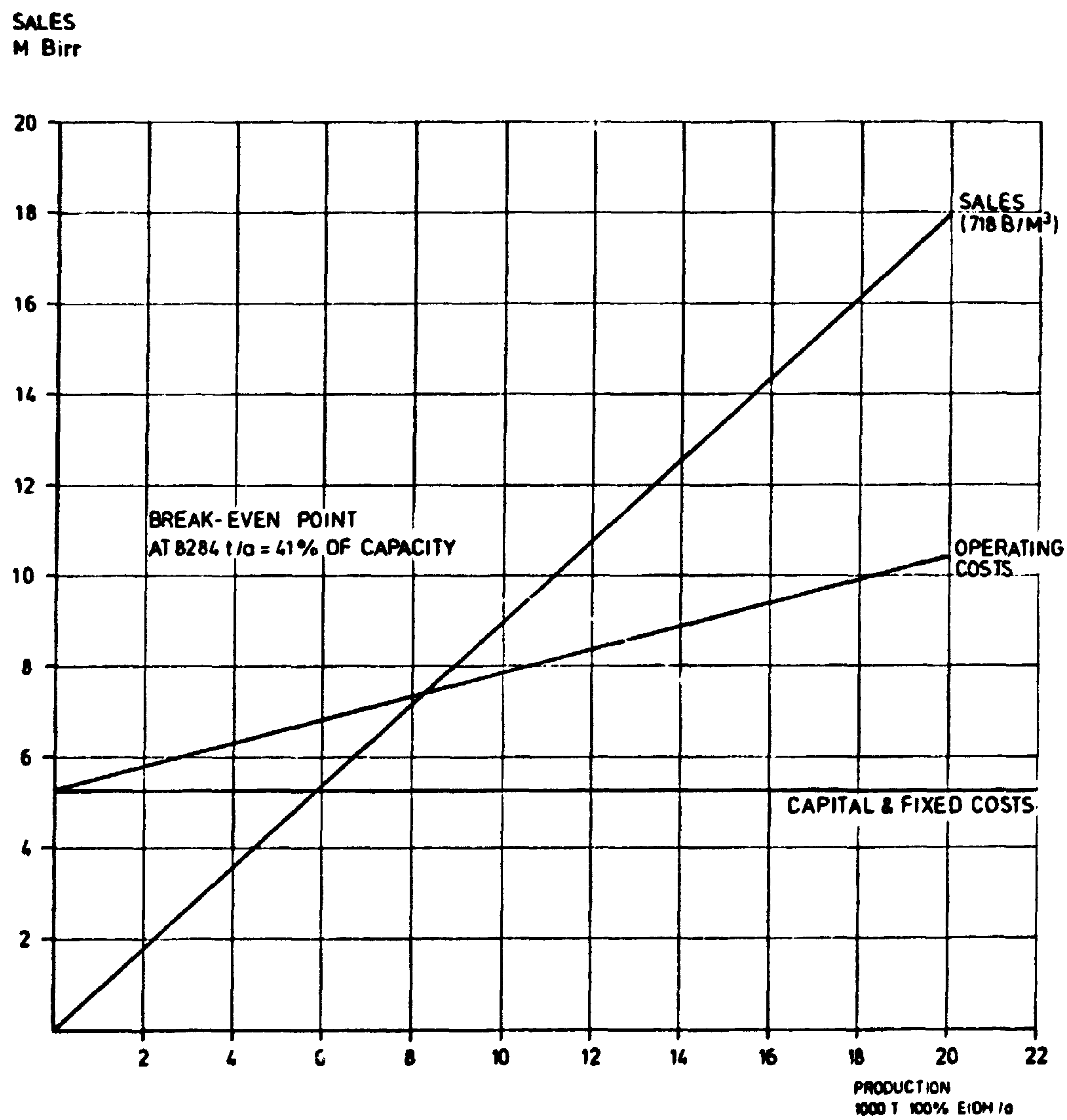
16.5.1980 ST

CASH-FLOW (Alt 2 / methane) M Birr

YEAR	Construction		Start Up			Full Capacity					
	1	2	3	4	5	6	7	8	9	10	11
Production, t 100 %	0	3 750	15 000	15 500	17 500	20 000	20 000	20 000	20 000	20 000	20 000
A. Cash inflow	11.100	29.005	12.469	13.214	15.313	17.950	18.416	18.895	19.386	19.890	20.408
1 Financial Resources	11.100	25.967									
2 Sales Revenue		3.038	12.469	13.214	15.313	17.950	18.416	18.895	19.386	19.890	20.408
B. Cash outflow	-11.100	-28.505	-11.964	-11.598	-11.535	-11.550	-11.180	-10.810	-10.440	-10.070	-5.075
1 Total assets	-11.100	-25.900									
2 Operating costs		-1.437	-4.027	-4.103	-4.410	-4.795	-4.795	-4.795	-4.795	-4.795	-4.795
3 Working capital		-0.280	-0.280	-0.280	-0.280	-0.280	-0.280	-0.280	-0.280	-0.280	-0.280
4 Debt service											
a) Interests		-0.888	-2.965	-2.590	-2.220	-1.850	-1.480	-1.110	-0.740	-0.370	
b) Bank Loan repayments			-4.625	-4.625	-4.625	-4.625	-4.625	-4.625	-4.625	-4.625	
- short term			-0.067								
C. Surplus/Deficit	0	.500	.505	1.616	3.778	6.400	7.236	8.085	8.946	9.820	15.333
D. Cumulative Cash Balance	0	.500	1.005	2.621	6.399	12.799	20.035	28.120	37.066	46.886	62.219

16.5.1980 ST

BREAK-EVEN ANALYSIS
BASE ALTERNATIVE (OIL)



CULTIVATION AREA DEMAND FOR DIFFERENT SUGAR- AND STARCH-RICH CROPS FOR THE PRODUCTION OF 100 000 TON OF ETHANOL/YEAR

CROP	Carbohydrate content, %	YIELD/a t/ha	YIELD/a t sugar/ha	YIELD/a t EtOH/ha	Area required for 100 t EtOH, ha
Sugar cane	12	120	14,4	7,2	14 000
Corn (Maize)	71	3	2,1	1,1	91 000
Wheat	67	1,1	0,74	0,37	270 000
Barley	72	2	1,4	0,70	143 000
Millet	71	1,5	1,1	0,60	170 000
Sorghum	73	2	1,5	0,80	125 000
Teff	70	1,0	0,70	0,40	250 000
Cassava	28	15	4,2	2,1	48 000
Potato	19	40	7,6	3,8	26 000
Sweet potato	29	30	8,7	4,4	23 000
Yam	20	12	2,4	1,2	83 000
Banana	20	12	2,4	1,2	83 000
Beans, Peas	59	1	0,60	0,30	333 000

References: (3), (7), (8), (9), (10)

with
09913

OY ALKO AB

P.O. Box 350
SF - 00101 HELSINKI, FINLAND

REQUEST FOR QUOTATION

75 000 liter/24hours distillery,
Adama district, Shoa (Shewa) region, Ethiopia

1. GENERAL

1.1 Purpose of the bid requisition

This call for bids has for its purpose the supply of materials and services for a distillery, partly integrated with a sugar factory, with an average daily capacity of seventy five thousand (75 000) liters of absolute alcohol from cane molasses.

1.2 General feature of the distillery

The absolute alcohol will be produced starting from cane molasses both of local production and transported from other Ethiopian sugar factories. The alcohol produced must conform to the rules and norms in Ethiopia and to the specification in paragraph 10.2.

1.3 Production and equipment of the distillery

1.3.1 Capacity and process units

The distillery will be constructed to produce absolute alcohol according to the recipe conditions.

By-products of the distillation will, as above, be according to the recipe conditions, and not higher than a percentage to be established and guaranteed relative to the absolute alcohol produced. The plant will be of proportions to produce 25 million liters absolute alcohol calculated as $100^{\circ}GL/15^{\circ}C$ during eleven (11) months of a year. The operation of the plant will be assured for 24 hours with three shifts of 8 hours. The proportions of the factory will therefore be made for a daily capacity of 75 000 litres.

This distillery will be designed with reasonable automation and great importance is paid to protection against contamination and ease of operation and control.

The distillery shall include:

- receiving station and storage for molasses
- a department for preparing the wort
- a fermentation department
- a distillation and dehydrating department
- steam generation station
- a storage and forwarding station
- a department for handling and exploiting vinasse
- auxiliary equipment, if any, for cooling and process water

1.3.2 Recieving station and storage of molasses

Molasses will be transported to the distillery by trucks and from the local sugar factory by pipeline. In order to assure the continuity of the alcohol process molasses will be metered, checked and stored before use.

It will therefore be necessary to provide:
a) installation for metering the amount of molasses
b) installation for sampling (bulk sample)
c) installation for storing molasses with total capacity of 1 000 m^3

1.3.3 Preparation of the wort

During the running of the distillery the molasses is pumped from the storage tanks to the preparation department where the molasses is heated, weighed, diluted, clarified and sterilized.

This department will be designed to achieve:

- a reduction in amount of calcium
- a reduction in amount of colloids
- a steady and regulated percentage of sugars and nutrient salts
- an adequate asepsis of the wort

This section shall therefore include:

a) a metering installation for the molasses entering into the process
b) a dilution plant for the molasses
c) a clarification plant for the molasses, where the solids will be washed in order to reduce losses of fermentable sugars
d) a sterilization plant for the molasses in the primary dilution step
e) an installation for adjusting the pH of the wort and its different component parts: the percentage of sugars and nutrient salts

1.3.4 Fermentation

The wort prepared in the preparation department shall be conveyed into the fermentation department.

This department will be designed to obtain as good a yield as possible and the sterilization system in particular will be studied.

This department shall include the following installations:

a) an installation for preparing the pure yeast culture
b) an installation for anaerobic fermentation. This installation may be continous or batch. Bidder has to indicate and guarantee the performance of the fermentation process.
c) installation for recovering or recycling the yeast
d) installation for scrubbing the carbon dioxide.

1.3.5 Distillation, rectification and dehydration

To save energy, the bidder shall strive to reduce the energy consumption and the risk of blocking the distillation column.

The operating conditions of this department will be designed to be as easy as possible with reference to the following:

- to allow a great flexibility in the process in order to achieve a stable running between 50 - 110 % of the nominal capacity
- to design an automatic control of the main parameters
- to assure, in case of an unplanned shut-down, that the department can be made safe.

The following features are to be provided:

- the capability of completely inspecting the plates of the distillation column without disassembly
- ease of cleaning and/or replacement of plate and/or scrubber organs
- a material designed to resist corrosion.

1.3.6 Storage and transport of alcohol

The alcohol will be stored in a set of containers with necessary control apparatus.

The capacity of the containers will be such as to permit the storage of 20 % (twenty per cent) of the annual production.

The transport will be by truck. It will therefore be necessary to provide:

a) an installation for storing 5 000 m^3 total capacity
b) an installation for metering and transporting in bulk
c) an installation for denaturing the alcohol with gasoline

1.3.7 Handling and exploiting the vinasse

The bidder shall propose a method for treating and exploiting the vinasse in order to economize the whole distillery.

1.3.8 Steam generation station

The bidder shall offer a steam generation station in accordance to the steam consumption guaranteed.

1.3.9 Control system

The grouping of the most important control instruments on a central panel is desired.

The control loops and the following indication means will be provided.

- Metering station and storage of molasses
  Concentration of molasses (Brix)
  Total accounting of molasses

- Preparation
  pH control
  final density control
  accounting of the molasses

- Fermentation
  temperature control and recording

- Distillation
  Alcohol percentage control
  Control of heating the columns
  Recording of important temperatures
  Pressure controls
  Accounting and totalization of the absolute alcohol

- Alcohol storage
  Level indications
  Accounting of alcohol transportation

1.3.10 Buildings

The distillery as a whole may be installed in a single building where the sections of fire risk are separated and/or isolated.

2 LIMITS OF THE SUPPLY

The equipment according to paragraph 1, being part of the installation, will be part of supply as well as following:

- electric motors
- operating and control panels
- piping
- gate valves and fittings
- metallic support frames
- metallic building frames
- metal stairs gangways
- covering of the buildings roofs
- all electrical materials required for the plant
- fire extinguishing network
- thermal insulation
- painting, at work of the devices and equipments
- lining the metalframe buildings (prepainted shuts double face)

- sound insulating devices
  (not above 80 dB at 1 meter from installation which produces noise)
- auxiliary materials for electric assemblies
- freezing units
- fermentation air compressors
- spare parts for two on-stream years

The following will be at supplier´s expense up to the final acceptance:

- nutrient salts
- ion exchange resins, if needed
- pure cultures of yeast

Training the personnel will be at the supplier´s expense as above

The supplier shall indicate in his offer:

- number and classes of the Master of the Works he shall train or technically assist

- as a function of the personnel classes, the detailed programs he is going to establish by indicating duration and geographic places where they shall take place

- number, quality and duration for the intervention of the suppliers personnel to be charged with these services.

- list of documents, means etc. to be utilized or established by the supplier.

Finally, the assistance to the assembly work, with the personnel to be indicated as to the classes and number of persons and the assistance to the performance tests and to start up the factory will be for account and expences of the supplier.

3 EXCLUSIONS

The following items are excluded from the supply

- the following consumption raw materials required for operation of the factory: Oil and grease, chemical products for the process, excepting nutrient salts and ion exhange resins until final acceptance.

- the erection of the factory (the assistance to the assembly work by personnel and time indicated by the supplier will be excepted as well as assembly of the special machines and instruments.)

- the civil engineering work.

4 DOCUMENTS AND INFORMATION TO BE INCLUDED IN THE BID

The supplier has to include in the bid the following documents:

- process diagrams and material balance
- flow diagrams and utilities balance
- piping and instrument diagrams
- installation plans
- suggested lay-out
- suggestion for civil-engineering work (foundations, buildings except steel structure, shelters etc.) which are closely connected with the process and/or demanded by the installation

as well as the following information:

- characteristics of the waste waters coming from the factory

- static and dynamic forces on the foundations

- weight and dimensions of the machines and equipment
- packing list
- maximum dimensions and weight of the single packages.

5 UTILITIES AVAILABLE

Waters

- river water	amount unlimited temperature 20 - 23°C (see Appendix 1.)
- condensed water	amount 100 m^3/h (see Appendix 2.)
Electric power	380 V 3-phase 50 Hz

6 GEOGRAPHICAL AND METEOROLOGIC CONDITIONS

Location	08°31' North of Equator 39°15' East of Greenwich 1 500 m above sea Level
Rainfall	average 811.8 mm/a
Temperature	max 30°C min 10°C
Relative humidity	max 72 %, August

7 ACCEPTANCE OF THE FACTORY

After the mechanical inspection and preliminary acceptance the start-up shall begin. Production will start within 20 days from the starting day.

The performance test will take place at the latest on the 21st day after the starting day.

The final acceptance shall take place one year after the date of the provisional inspection.

8 PRICE SPLITTING

The subdivision of the prices will be made according to the following list of subassemblies:

	Equipment weight	FOB-price
Metering station		
Molasses storage		
Preparation of the wort		
Fermentation		
Preparation of yeast culture		
Distillation, rectification and dehydrating		
Storage and transport of alcohol		
Steam boiler		
Vinasse handling		
Recovery of yeast		
Piping, valves		
Thermal insulation		
Electric material		
Control equipment		
Frames		
Spare parts		
Training		

9 CODES AND NORMS

Equipment, installations and buildings for the factory will be made according to the codes, norms and standards approved by the Ethiopian authorities or, if these are lacking, according to the generally accepted European codes, norms and standards.

10 GUARANTEES

For the different periods considered as indicated in the paragraph 7 the hereunder guaranteed performances shall be verified simultaneously.

10.1 Production rise to the standard level

During this period, the supplier shall guarantee that the plant shall process at least.... metric tons of molasses and that the production of pure alcohol shall not be lower than the theoretical production capacity in the period considered.

10.2 Performance test

a) Quality
From the general point of view, the quality of the alcohol shall be according to the standards and decrees in force in Ethiopia.

The product shall satisfy the following demands:

- real force: minimum 99,5 GL
  at the temperature of 15°C
- dry extract: les than 50 mg/l
- appearance: clear without colour before and
  after dilution with distilled water
- percentage of non-alcohol material: maximum 200 mg/l
  with the following maxima: acid (as acetic acid 30 mg/l
  esters (as ethyl acetate) 100 mg/l
  aldehydes (as acetalaldehyde) 70 mg/l
- copper: less than 0,7 mg/l

b) Production capacity

The distillery shall produce daily 75 000 (seventyfive-thousand) liters per 24 hours. All of the guarantees will be verified during the performance tests to be carried out during four (4) consecutive weeks of seven (7) days each.

The daily production capacity of the distillery shall be verified by averaging the production made in these twenty eight (28) days. Moreover, every day, based upon an average sample taken once every eight hours, a Barbet test and strength by areometer shall be made.

c) Yield

- The yield shall not be lower than 29 liters of total alcohol at 100°GL at 15°C per 100 kg molasses containing 50 % of fermentable sugar.
- At the output from the distillation, rectification and dehydration department, the loss of alcohol shall not be higher than:
  0.4 % of the total alcohol entering the department for the liquid effluents
  0.2 % of the total alcohol entering into the department for the gaseous effluents

d) Consumptions

For the daily production as guaranteed hereabove the supplier shall indicate and guarantee the following consumptions referred to one hectolitre of pure alcohol at 15°C.

- Steam
  The quantity of saturated steam at 4 effective bars consumed by the distillery shall be lower than .... kg/per hectolitre of alcohol 100°GL/15°C.

- Electric energy
  The electric energy consumption by the distillery shall be lower than ... kW per hectolitre of alcohol 100°GL/15°C.

- Process water
  The quantity of process water used by the distillery shall be lower than .... cu.m. per hectolitre of alcohol 100°GL/15°C.

- Chemical products
  Products and quantities are to be specified by the supplier.

- Nutrients
  Products and quantities are to be specified by the supplier.

e) Analysis methods

The analysis methods will be according to the legal and professional standards in force in Ethiopia.

The determination of the quality of the alcohol shall be to the laboratory agreed to by the Ethiopian authorities.

The fermentable sugars of the molasses used will be determined starting from an average sample of molasses, using a biological assay and following the standard fermentations carried out by a qualified laboratory.

The dry materials and ashes shall be determined by means of passage in a furnace.

11 PENALTIES

A penalty for not meeting the guaranteed values will be applied.

The exact definiton of these penalties and the corresponding amounts will be defined and established in the contract.

APPENDIX I.

WATER ANALYSES, AWASH RIVER, ETHIOPIA

Sample from	M'hara	Shoa, canal	Wonji	Metehara		
Date	5.3.1980	24.3.1980	Aug. 1977	7.11.	14.11.	27.11.1967
Analyzed by	ALKO	ALKO	ETHIOPIA	ETHIOPIA		
Analysis		Note: Extremely warm period			Note: Heavy rains	Note: occasional rains
pH	(7,6)	(7,0)	8,2	7,8	7,9	7,9
Hardness, °dH	4,5	5,0				
Conductivity, mS/m	34	32,6				
$KMnO_4$-consumption, mg/l	21	30		15,5	26,9	10,5
BOD_5, mg/l				2,3	2,8	2,8
Dissolved oxygen, mg/l				7,3	7,4	7,6
Total residue, mg/l	344	384	180	336	448	420
Suspended solids, mg/l	84	127	27,5-5500^x	164	242	158
Fixed residue (loss of weight on ignition), mg/l	236	240		320	446	404
Total N, mg/l	3,0	6,6				
Total P, mg/l	< 0,1					
Cl^-, mg/l	12,4	12		13,0	8,0	10,0
NO_2^-, mg/l				n.d.	n.d.	n.d.
NO_3^-, mg/l	(< 0,5)			2,4	1,2	1,5
Fe, mg/l	3,9	6,8				
Mn, mg/l	< 0,05					
Na^+, mg/l			16			
K^+, mg/l			20			
NH_4^+, mg/l	(0,13)			0,06	0,07	0,06
Ca^{++}, mg/l			23			
SiO_2, mg/l	22,5	21,5	50			
Bacteria/ml (37°C, 24 h)			4 400	17 000		670 000
Coliforms/100 ml				1 700		1 600

(   ) : uncertain figure

n.d. : not detectable

^{x}depending on rain conditions

APPENDIX 2.

WATER ANALYSES, DRINKING WATER AND CONDENSATE, ETHIOPIA

Sample from	Wonji sugar factory	Wonji, Well 2	Wonji		Nazreth
Date	17.3.1980				
Type of water	Condensate	Drinking water	Drinking water		
Analyzed by	ALKO	ETHIOPIA	ETHIOPIA		ETHIOPIA
Analysis			Sweet factory	Hospital	
Temperature, °C					38
pH	(3,4)	7,2	7,6	7,6	7,6
Hardness, °dH	0,1		4,7	5,0	5,1
" as $CaCO_3$, mg/l		172			
Conductivity, mS/m	27,3		119,3	112	
$KMnO_4$-cons., mg/l	90		0,95	0,95	8,5
Alkalinity, mg/l $CaCO_3$		441			
CO_3^{--}, mg/l		0	10	9	
HCO_3^-, mg/l		538	719	750	445
Total residue, mg/l	144	692	818	970	623
Suspended solids, mg/l	35				
Fixed residue (loss of weight on ignition, 550°C), mg/l	12				
Total N, mg/l	10,1				
$P_2O_{5\,3-}$, mg/l			n.d.	n.d.	
PO_4, mg/l					0,05
Cl^-, mg/l	76	33	61	39	40
NO_2^-, mg/l			n.d.	n.d.	n.d.
NO_3^-, mg/l			4,0	0,1	0,02
Fe, mg/l	0,76	0,5	<0,05	0,25	0,05
Mn, mg/l			<0,05	<0,05	n.d.
NH_4^+, mg/l		n.d.	0,8	0,5	0,35
Ca^{++}, mg/l		55			29
Mg^{++}, mg/l		9			6,5
F^-, mg/l		11,0			0,8
SO_4^{--}, mg/l		255	7,0	9,5	n.d.
SiO_2, mg/l	0,84		90	108	

( ) : uncertain figure
n.d. : not detectable