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PRE INVESTMENT STUDY FOR THE MANUFACTURE OF BIOMASSES (AGRICULTURAL WASTE) GASIFICATION SYSTEMS IN ZIMBABWE

Final Report

Project n. US/GLO/81/109
Contract 89/191

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baldo & c. srl
CONSULTING ENGINEERS

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1. PROJECT BACKGROUND AND HISTORY

The project concerning the biomass gasification systems production was born as part of a more ample program finalized to the promotion of industrial investments for the production, in developing countries, of machinery and equipment for the utilization of renewable energy (solar, wind, biomass and other).

It has been conducted by UNIDO with the financement of the Italian Government and with cooperation of ENEA, the Italian national agency for nuclear and alternative energy.

Various Italian industries and local sponsors were interested, what resulted in meetings and subsequently in cooperation agreements. In this context, a letter of intent for the establishment of a joint venture was made between Cochrane Engineering of Zimbabwe and SES, an Italian company owning the know-how for manufacturing biomass gasification systems.

Subsequently, as part of the UNIDO project XA/RAF/90/602 two experimental biomass gasification systems, supplied from India and the same SES were supplied to Cochrane to carry out a number of experimental tests on the actual use of such energy generation systems in Zimbabwe.

The tests shown that SES system, slightly modified by Cochrane Engineering can perfectly meet with local requirements and could completely be produced in Zimbabwe.

In the meantime the Italian Company SES has been dissolved and therefore the various patents and technology in biomass gasification belongs to her parent Company, the ENI Group.
Contacts should be initiated through IPO office in Milan in order to continue the transfer of technology.

2. MARKET AND PLANT CAPACITY

2.1 THE PRODUCT: THE BIOMASS GASIFIER PLANT

2.1.1 GENERAL INFORMATION

Wood and biomasses are perfectly renewable energy, available in large amounts (tropical forests are reported to cover an area equal to 15% of the total world surface); wood is largely used as firewood especially for domestic cooking and heating; but the quantity used in any country appears to vary significantly over a period as a function of government directives, want of preserving forestry, environmental considerations and the cost and ease of handling of conventional fuels in rural areas; even if reliable statistics are not available, there is no doubt about its usefulness as an energy source; "social forestry" programs are known to be investigated. There are doubts about the efficiency of its exploitation: on this point there is ample space for action.

In addition to wood, there are large amounts of wastes or by-products (originating from wood working, agricultural and, sometimes, domestic garbage) which are an important reserve of energy and whose utilization as fuel is a "whole profit", being something of no other value and often a source of possible pollution.

Typical examples of such by-products are listed below:

- rice husk, coffee shell, grass cutting, saw dust, bagasse, cotton waste;
- peanut shell, walnut shell, cabbage-palm shell, babassu shell, fruit pits; exhausted barks from tanning extraction;
- chipped wood, shell and floss coconut, trimmings, peat.

Wood and such wastes can be efficiently utilized in three main ways depending on the specific requirement of energy users, that is:

- direct combustion
- gasification
- carbonization

2.1.2 PERFORMANCE AND APPLICATIONS

The average value of the heat output (LHV) from the direct combustion of 1 Kg. of such fuels, with 10% moisture and 5% ash, can be estimated at about 3900 kcal. This calorific value is largely dependent on moisture content which can reach 60%; so, whenever possible, it is convenient to dry the waste before incineration.
Direct combustion is mainly suitable for materials of very small sizes such as those listed above in the first group. Hot products of combustion can be used as a drying means or for production of hot water or steam, for technological use as well as for power production.
If electricity is the only required production, gasification is probably th most suitable method, especially for small or middle power demands: the produced gas, after washing, is fed directly to a diesel generator; the wood consumption can be estimated in the range of 1.2 to 1.3 kwh/kg.
With the carbonization process, in a vertical retort, from 1 Kg of fuel the following products can be obtained (using an external source of heat for the process):

- charcoal (LHV = 7300 kcal/kg) 0.150 to 0.400 Kg/kg
- tar 0.050 to 0.150 Kg/kg
- pyroligneous acid 0.200 to 0.400 Kg/kg
- fuel gas (LHV = 2500 kcal/kg) 0.140 to 0.350 Kg/kg

The carbonization system can be a solution for producing, at the same time, charcoal, gas, pyroligneous acid and tar.
Charcoal has applications in the metallurgical process or as an easily handled fuel for many domestic uses; gas can be burnt and pyroligneous acid and tar treated for separating very useful chemicals: solvents, acetic acid, turpentine, creosote and lube oils.
Charcoal itself can be further treated to obtain activated carbon, a well known auxiliary for the food or chemical industries.

2.1.3 THE SES GASIFIER PLANT

The SES model GE 40 gasification unit as supplied from the manufacturer is illustrated in Figures 2.1.1.a. The unit consisted of the following components:

a) The gas generator

This is a down-draught type gas reactor, with a fixed fuel bed. The fuel was fed manually in batches at the top of the generator, and the ash is removed manually from the base of the unit. Air for partial combustion during normal operation by natural means enters just above the ignition zone, and thus the unit operates at near atmospheric pressure. The hot gas leaves the unit via two rectangular ports 180° apart. There is a dial thermometer (0-400° C) on each outlet port.

b) The forced draught fan

A small centrifugal type fan provided combustion air for starting the process, and could be of a 12 V supply.

c) Bed type filter

The hot gas from the generator passes through a filter bed that consists of metal swarf. This removes the large dust and soot particles from the gas. There are two identical units in the system and the gas is passed through them in parallel.

d) The (scrubber) cooler

The gas from the two filters passes through a concurrent water scrubber. Hot gas and water pass in parallel inside a set of finned tubes. There is a wire gauze at the bottom of each of the cooling pipes. Ambient air in cross flow is passed over the tube bank using a 0,37 kW, 380V axial fan. The cooling water is recirculated from a sump at the bottom of the cooler using a 1,5 kW 380V centrifugal pump. The water level is made up manually and can be checked by opening a gate valve. There is a dial thermometer in the water basin, and two mercury in gas thermometers in the gas stream on this unit. This unit removes small and medium sized dust particles in the gas stream, and the gas leaving it is saturated.

e) Disk type filter

The moist gas from the scrubber is passed in parallel through two sets of three disk filters in series.

These are cooled by a 0,37 kW, 380V axial type fan blowing over the six cylinders.

By changing the gas flow, excess water and fine dust particles are removed by this unit.

f) Bed type final filter

This is a large cylinder into which the gas passes into the bottom. Wood wool filter medium is placed on a grill support above the gas inlet and finally out of the filter. There is a drain to remove any condensate from the filter. Its large size reduces the gas velocity significantly and removes the majority of any remaining water and dust before the gas is passed to the generating set.

g) Gas ducting

The ducting between the gas generator and the mechanical bed type filter is in mild steel piping. All ducting between the other units described above is flexible and made of plastic over a spiral wound wire.

h) Flares

There is a flare on the gas generator off one of the rectangular ports and one just prior to the electrical generating set. These are used during start up and shutting down the plant.

i) Gas mixing valve

Gas and air are mixed by two valves that are linked by a turnbuckle for adjusting to set the appropriate air fuel ratio. This arrangement reeds the air and fuel to a carburettor specifically suited to producer gas.

j) Generating set

An internal combustion engine drives a brushless AC generator. Speed is controlled by a mechanical governor that is connected to the mixing valve linkage system.

k) The condensor moisture tank

On the gas reactor above the hot gas outlets there is a tank which allows vapour to condense. This unit collects tars that must be regularly removed from the system.

l) Control panel

In the panel there is a key switch to stop/start the engine. There is a stop buttom. The following instruments are used:

1 Oil pressure indicator 0-10 bar
2 Water temperature indicator 40-120°C
3 An ammeter for each phase 0-150 amp
4 Voltmeter

5 Kilowatt meter
6 Frequency meter 45-65 Hz
7 Hour meter

m) The batteries
On the engine/generator mounting frame there are located two 12V batteries. There is a battery charger included to charge the batteries during normal operation. During start up the batteries provide essential power for the forced draught fan.

2.1.4 AGRICULTURAL WASTES TO BE USED IN CONJUNCTION WITH GASIFIERS

The materials to be used should be chopped in pieces with size of approx. 50 mm.
Corn cobs could be an ideal "fuel" for pre gasification system, taking also into consideration the fact that corn is one of the major crops in Zimbabwe.
Cotton stalks could also be a source of material to be gasified. The cotton stalks must be burned within 30-40 days from cotton picking to avoid spread of plant disease.
It is worth remembering that at the renewable energy center of Khartum (Sudan), a gasification station seccessfully operated with cotton stalks.
Coffee husks could also be used, perhaps in conjunction with other residues and with corn cobs or wood pieces.
The tests carried out in Zimbabwe under projct XA/RAF/90/602 have anyway shown that both the SES gasifier and an other one imported from India are not suitable for operation with residues but corn cobs. Design changer should be made in order to allow the gasifier to operate with other "fuels".
On the other hand the corn cob is available in large quantities in the whole country. The importance of cotton growing suggests, anyway, the opportunity to carry out extensive tests in order to make the gasifier also suitable for operation with cotton stalks.

2.1.5 SES GASIFIER: PLANT SPECIFICATIONS

a) Fuel to be used
Fuel size: 50x50x50 mm
Fuel types: wood (recommended)
corn cobs
mixture of other agricultural residues with the above
Moisture content: 15-25%

b) The power capacity

Maximum capacity	40 kW
Rated capacity	35 kW

Note: these capacities are with dry wood

c) The generator

Rated fuel input	1,3 kg/kWh
Rated gas output	120 Nm^3/hr
Rated gas cv	not stated
Thermal efficiency	75-80%
Energy	0,410 GJ/hr
Turn down ratio	1:3
Hopper capacity	not stated

d) Pressure drops

Rated pressure drop	600 mm water gauge
Maximum allowed	1000 mm water gauge

2.1.6 PLANT OPERATION

Corn cobs have the following typical characteristics:

Diameter	30 mm
Length (cut into 3 pieces)	40-60 mm
Volatiles	80,2% m/m
Fixed carbon	16,2% m/m
Ash	3,6% m/m
Carbon	45,31% m/m
Hydrogen	7,16% m/m
Gross calorific value	15,58 MJ/kg
Bulk density	130 kg/m^3

A sun-dried sample usually contains about 6% moisture.
Samples tested varied from 10-15% moisture.
Specific useage of the fuel varied from 1,4 kg/kWh at high loads, to 4,1 kg/kWh at low loads (about 25 to 30 kg/hr of corn cobs).

The typical gas composition is:

Carbon monoxide	18,0% v/v
Oxygen	1,5% v/v
Carbon dioxide	10,5% v/v
Hydrogen	not measured
Volatiles	not measured

The gross calorific value of this gas would be 2,2 MJ/m³ at STP (neglecting the hydrogen).

Dust in the gas was less than 7 mg/Nm³ and there is no tars present after the gas is filtered.

It is worth noting that the experience gained during the tests carried out as part of the project XA/RAF/90/602 suggested a number of modifications to the SES gasification plant.

2.1.7 PLANT COMPONENT AND THEIR AVAILABILITY IN ZIMBABWE

As already described the system to produce electrical energy from agricultural wastes includes the following main components:

- producer gas system (gasifier)
- diesel engine (modified)
- electric generator

The producer gas system (gasifier) can be produced by Cochrane Engineering in Zimbabwe under licence.

The diesel engines are imported in Zimbabwe by various companies.

It has to be modified in order to be suitable for operation with produced gas. Several companies in Zimbabwe have the necessary expertise to undertake the modification work including:

Incare Zimbabwe, Harare
Leyland Zimbabwe, Harare
Cummins Zimbabwe, Workington
Mike Appel Harare, Harare
Geoff's Motor (PVT) Ltd, Harare

A suitable type of electric generator is already produced in Zimbabwe.

In fact Messrs. South Wales Electric (PVT) Ltd. in Harare, who are part of the Hawker Siddeley Group in the United Kingdom, are already manufacturing a range of AC generators in the range 28-44 Kw.
Out of the three major components of the system, therefore, only the gas producer plant technology should be introduced in Zimbabwe.

2.1.8 SYSTEM APPLICATION

The gasification systems basically produces energy that is therefore used for a variety of applications.
Main applications are the same for which diesel generators are currenty employed, i.e.:

- Rural electrification: remote village and houses, holiday resorts
- Village power: remote villages, islands, social centres, schools
- Telecommunications: radio and TV repeaters, radio telephones, satellite receivers, radar stations, etc.
- Water pumping: drinkable water for villages, irrigation systems, etc.
- Medical: hospitals, medical equipments, health care centres and mobile medical units
- Lighting: houses, street lights, rural villages, town districts

2.2 THE MARKET OF GASIFICATION SYSTEMS IN ZIMBABWE

2.2.1 ENERGY IN ZIMBABWE

The total quantity of energy consumed in Zimbabwe in 1982 amounted to 244 Peta Joules (PJ or 1015 Joules) or 40 million barrels of oil equivalent. [1]
Wood accounted for over 50% of the total energy consumption, the other fuel supplies were coal and coal products (20%), liquid fuel (11.3%) and electricity (11.1%).

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[1] Source: Policy options for energy and development in Zimbabwe. The Beijer Institute, Royal Swedish Academy of Sciences, 1985.

Rural energy consumption accounted for over 60%. The majority of this was used by rural household for cooking (133 PJ). Fuelwood and construction wood accounted for nearly 99% of the energy used by rural households.

Agricultural energy consumed 20.8 PJ or 8.5% of natural end use demand. The large scale commercial farming sector used over 90% of all energy used in agriculture.

Mining and manufacturing establishment consumed nearly 50 PJ. Coal and coke are the most important industrial energy fuels followed by electricity.

The transportation sector 28.2%, diesel fuel the most important followed by coal and petrol.

In 1982 these end-use energy demand were met through the consumption of 8.96 million tonnes of wood, the extraction of 2.8 million ton coal, the generation of 7.8 thousand GWH and the consumption of 630,000 ton of liquid fuel.

ENERGY CONSUMPTION IN 1982 AND (2002). ALL DATA IN PETA JOULES

	PARAFFIN	DIESEL	LPG	COAL/COKE	ELECTRICITY	FUEL WOOD
Rural household	0.74(1.2)			2.7(1.84)	0.13(0.2)	102.2(167.82)
Urban household	0.25(0.68)		0.02(0.04)	0.7(2.23)	3.45(8.02)	3.19(9.18)
Agriculture		2.78(2.82)		8.79(8.79)	1.94(2.05)	7.32(7.32)
Industry		0.91(1.75)		14.14+13.45	17.35(33.61) (28.27+23.26)	
Municipality					1.34(3.88)	
Informal ind.		---			0.02(0.04)	0.24(063)
Commercial		0.37(0.72)			2.04(3.96)	

According to demographic projection in 2002 the population should be 14.4 mil and 60% of population will live in the rural areas.
Total energy forecast is in 2002 399.5 PJ or 65.3 million barrels oil equivalent.
The demand for wood will grow to nearly 13.7 million tons by 2002.
This will result in serious wood shortage where neither yields nor stocks will be sufficient to meet demand in the majority of the country.

Mashonaland East will begin to experience absolute shortage of accessible wood resources in 1992.
Manicaland and Masvingo will face the same problems in 1997.

Critical shortage of fuelwood will occur in the next decade forcing rural households to revert to other more expensive commercial fuels, thus placing a heavy burden on them.

Rural areas currently face shortage of development energy particularly for draught power and water pumping.

Electricity generation will increase to 15.4 thousand GWh by 2002.

Farm forestry has the advantage they do not take land out of agricultural production. Small, unused parcels of hard can be devoted to tree-crop production and if species are carefully selected, trees can be interplanted with agricultural crops with no appreciable decrease in yelds.

Urban electrification could result in a saving of about 563,000 tons of wood and 20 mil litres paraffin.

In 1985 only 200,000 households were electrified, mainly urban areas while the bulk of the rural households that are over 1,150,000 in number rely on fuelwood for cookies, heating and lighting.
Paraffin is used largely for lighting in rural households.

In 1982 rural households are divided as follows:

	POPULATION ('000)	AVERAGE HOUSEHOLD SIZE	NUMBER OF HOUSEHOLDS (1000)
Communal areas	4,331.5	5	866.3
Resettled areas	128.7	4.7	25.8
Small scale commercial farms (SSCFA)	182.1	7	26
Large scale commercial farms (LSCFD)	1,068.4	4.5	237.4
TOTAL	5,710.6	4.9	1,155.5

RURAL HOUSEHOLD END USE ENERGY CONSUMPTION (PETA JOULES OR MILLION GIGA JOULES)

	FUELWOOD	PETROLEUM	PARAFFIN	COAL	ELECTRICITY	TOTAL
Communal areas	79.56	22.44	0.60	---	0.11	102.71
Resettled areas	2.46	0.90	0.01	---	---	3.37
SSCFA	2.57	0.18	---	---	---	2.76
LSCFD	17.67	3.93	0.12	2.7	0.02	24.43
	102.26	27.45	0.73	2.7	0.13	133.27

In communal areas 0.1% of the households have electricity and 0.6 uses paraffin. In large-scale farms 0.1% have electricity and 0.4 uses paraffin.

ENERGY FOR AGRICULTURE (PETA JOULES) BY SOURCE

	DIESEL	COAL	ELECTRICITY	WOOD	TOTAL
Commercial	0.02	---	---	---	0.02
Large-scale farms	2.65	8.75	1.81	7.27	20.49
Resettlement	0.01	---	---	---	0.01
State farms	0.07	0.02	0.10	---	0.19
Small scale farms	0.02	---	---	---	0.01
Small scale irrigated farms	---	---	0.01	---	0.01
Cooperative farms	0.02	0.02	0.02	0.04	0.1
	2.79	8.79	1.94	7.31	20.83

Large scale farm uses 95.3% of all diesel coresponding to 45.5 GJ/ha 93.3% of electricity is also used by large-scale farms corresponding to 3.1 GJ/ha while the state farms use 6.2 GJ/ha.

URBAN HOUSEHOLD END USE ENERGY CONSUMPTION IN 1982 (PETA JOULES)

	PARAFFIN	LPG	ELECTRICITY	COAL	FUEL WOOD	TOTAL
High density areas	0.15	0.01	0.88	0.7	2.35	4.09
Low density areas	0.1	0.01	2.57	---	0.84	3.51
	0.25	0.02	3.45	0.7	3.19	7.6

Total of 344,000 urban household (299,000 in high density areas).

A high density household will use an average of 17.9 MJof energy per annum. A low density 30.5 MJ Electricity average consumption is 22.3 GJ/household in low density and 3.8 in high density.

As far as the electric energy is concerned Zimbabwe is a net importer. The electrical energy distributed is shown in the following table:

(VALUES IN MILLION KWh)

YEAR		OF WHICH IMPORTS
1980	7,272	---
1981	7,254	11.2
1982	7,742	15.3
1983	7,466	18.4
1984	7,455	13.1
1985	8,093	13.5
1986	8,498	21.7
1987	8,713	16.8
1988	9,037	17

A shown in the enclosed map the grid is quite extended but only geographically and not as far as the number of households connected.

In fact the construction of the grid has been carried out, in the past, in order to privilege the mining and the large farms activities. If comparing the distribution of the grid with the map of the population in the country a large portion of population has no access to electrical energy from the grid.

The programmes of rural electrification and extension of the grid stated in 1974-1985 have slowed down or even halted in 1986 due to the lack of foreign exchange needed to import equipment and items needed (transformers, insulators, meters, etc.).

The lack of distribution equipment and their high cost make the connection very expansive for households not only in the rural areas but also in the urban areas (the connection fee is 2500 $ in urban areas).

The number of households connected is now estimated in 300,000 over a total of 1,700,000. The consumption of electric energy by the households is therefore low as shown by the following table.[2]

YEAR	ELECTRIC ENERGY USED BY DOMESTIC CONSUMERS (millions of kWh)
1980	928
1981	990
1982	988
1983	926
1984	926
1985	1,221
1986	1,278
1987	1,298
1988	1,363
1989 (estimates)	1,445

The situation is also bad from the reliability of energy supply and since 1989 the number and length of black-outs have been increasing.

Summarizing the energy supply/use data it can be pointed out that:

[2] Quarterly Digest of Statistics, Central Statistical Office, Harare, June 1989

- Conventional energy supply is in shortage.
- Only a limited number of households (approximately 20%) are supplied with energy. In rural areas electrification is insignificant.
- Only large commercial farms are supplied with energy and this is generally only used to power irrigation schemes and few other points within the farms.
  Small scale farms, commercial land, resettled lands have very little access to power, therefore to irrigation. Jeopardizing, in many cases the efforts to increase yield.

2.2.2 TRADITIONAL ENERGY SAVING

It is worthy of mention the fact that for each MWatt (i.e. 1,000 kW) of alternate energy production systems installed the amount of traditional fuel oil saved may be evaluated in the range of more than 800 tons per year, saving about 450,000 US Dollars at the current price of diesel oil.
It has been seen that the major application of gasification systems will be to operate modified diesel engines.
Considering that Zimbabwe is not producing oil and this kind of energy is all imported the installation of agricultural wastes gasification systems will turn into a net import substitution.

2.2.3 POTENTIAL MARKET IN ZIMBABWE

<u>Pumps</u>
The BEIJER Institute[3] study indicates that "one solution to the problems of low productivity in communal agriculture is the expansion of irrigation into communal areas". However, if this option is to be seriously pursued, careful through must be given to the energy source being used to pump the irrigation water. Diesel pumps would required increased imports of fuels, and electric pumps would require expensive extension of the electricity grid.
If the policy is to be pursued, an evaluation of alternative pumping technologies should provide an integral part of the analysis.
As a matter of fact, several studies and symposis have discussed the water pumping and compared various energy sources:

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[3] See previous note

- wind mill
- ox pump
- hand pump
- electric pump
- solar pump
- diesel pump

The results of these studies are variable and depend on the site and hypothesis taken for the main variables which are:

- availability of money
- availability of foreign currency
- fuel escalation probability
- availability of wind
- actualization factor etc.

Market could be taken by diesel engines operating with gas generated by agricultural wastes gasification systems.

Household applications

It has been seen that 70 to 80% of all households are in lack of electric energy. The gasification systems in conjunction with diesel engines district/village application, providing energy for household applications and street lighting + light + refrigeration + radio/TV/communication to local social services.

Beside the social aspect of the availability of electric energy there is also the import substitution one that should be taken into consideration. A large amount of paraffin (over 70,000 tons/year) is imported and its use is mainly for lighting purposes plus the large amount of diesel oil that would be served (also imported).

Water pumping

Only large commercial farms are supplied with energy. Small scale farms, communal land, resettled lands have very little access to power, therefore to irrigation, jeopardizing, in many cases, the efforts to increase yield.

Diesel engines are used in several cases but there are enormous problems due to the imported fuel cost and to the spare parts availability.

The typical irrigation schema in the communal lands would require a power ranging between 15 to 45 HP (but for maize growers also 7-15 HP would be sufficient) and

therefore well within the possibilities of gasifiers coupled with modified diesel engine.
Various agencies (including AGRITEX) has tried to form users groups for the irrigation scheme and to shore the fixed cost investment, but the programme was not very successful due to the high cost of fuel. Surface irrigation requires an average of 2 kW/ha while sprincker irrigation requires 0.9-1 kW/ha.

Milling

The milling is usually carried out in Service Centers with an installed power of approximately 30-40 HP.
Only few service centers are connected to the grid.
The majority is using diesel engines.
The service centers could really become the focal points: the farmer could bring to the center the maize for milling as well as the cobs. The cobs will be purchased by the mill owner under the form of a discount on the cost of milling.

Rural electrification: the growth points and the cooperatives

The availability of cheap electrical energy at the service center would not be limited to milling operation. The mill is usually integrated in the "growth point" and therefore the availability of energy could turn into various activities (refrigeration for food and drugs storing, shops, cottage industries, etc.).
In addition the social activities of the growth point would be enhanced (school, dispensary, etc.).
Cooperatives could also be interested in improving their supply of energy decreasing the dependence upon imported diesel oil.
In Zimbabwe the cooperative mouvements is quite important and presently includes the following organization:

SECTOR	COOPERATIVES	
	REGISTERED	ALREADY IN OPERATION
Agriculture	386	195
Mining quarrying	52	38
Manufacturing	308	171
Transport storage	50	14
TOTAL	796	418

Conclusions

We believe that a large potential market exist for agricultural wastes gasification systems in Zimbabwe. The market penetration will depend on:

- availability of foreign currency (this drawback could be overcome by partial local production of equipment);
- future price trends of diesel fuel (we believe it will increase under the pressure of the World Bank recommendations).

Main markets will be:

- farmers (mainly for water pumping);
- commercial enterprises in growth points and rural areas (refrigeration, lighting, cottage type industrial operations);
- municipalities (district lighting, supply of energy to households, etc.)
- governmental agencies (schools, railways, communication, army);
- Town Councils and Rural District Councils (schools, staff housing, etc.)

2.2.4 POTENTIAL EXPORT MARKET

Most of the countries of the Austral Apice Region lack oil therefore diesel oil. On the other hand agricultural wastes are abondant and could be used to fuel modified diesel engines.

The possibility of export of gasifiers is therefore real in the whole sub-region and in other PTA countries.

2.2.5 BENEFITS ARISING FROM THE LOCAL PRODUCTION OF AGRICULTURAL WASTES GASIFIERS

Benefits arising from the production of gasifiers in Zimbabwe will be the following:

- decrease of import of electric energy;
- saving of electric components and electric lines (grid system) for distribution to final users;
- decrease of foreign exchange for diesel fuel, paraffin and other materials presently used for lighting purposes;
- increase of agriculture output due to increased irrigation;
- decrease of food losses due to increased refrigerators availability;

- additional job opportunities for additional crops processing (increasing yeld of agriculture due to irrigation);
- better living conditions (lighting, food refrigeration, radio and TV sets fed by available electric energy, etc.);
- educational benefits from use of audio-visual aids in schools;
- better conditions for growth points developments;
- decrease of deforestation (saving of fuelwood);
- clean and renewable energy.

2.2.6 CONCLUSIONS

On the basis of the market survey and of the tests carried out in Zimbabwe on two types of producer gas systems it is recommended that Zimbabwe starts the production of producer gas generators. The typical size will be the 44 Kw system because this is the average power required for small to medium size irrigation schemes and service centers with milling facilities.

3. MATERIALS AND INPUTS

3.1 COMPONENTS

The major components materials of the system are (see attached dwg 2.1.1.A):

- reactor
- mechanical filtering unit
- cooling unit
- final filter
- safety filter
- diesel engine (modified)
- control panel
- disk type filters
- condensers
- air blast fan
- cooling unit fan
- disk type filter fan
- cooling unit pump
- exhaust
- air filter
- mixing valve
- battery cells - 2X12V
- pressure gauge
- air inlet valve
- condensate drain valve
- pressure drain valve
- filter drain valves - 6 off
- thermometer
- pressure gauge
- temperature gauge
- condensate drain valve
- control valve

3.2 EVALUATION OF COSTS

The following estimate has been prepared by the Zimbabween partner, the Cochrane Engineering on the basis of the 44 Kw SES generator already incorporating the proposed modifications including the new gas cleaning equipment designed by Cochrane Engineering itself.
The evaluation has been based on the drawings that have been supplied by SES.
The prices quoted are all ex-works and include for 10% sales tax for Zimbabwe gasifiers.
Units manufactured in Zimbabwe for export are not subject to sales tax.

ITEM	PRICE Z$	FOREIGN CURRENCY REQUIRED
Generator unit complete	180,500	18,000
Gas cleaning equipment	69,500	1,500
Diesel engine (conversion estimated)	125,000	70,000
Generator 44 KW complete with control panel	45,000	6,000
Fees, royalty agreement for the generator -5%	9,025	9,025
TOTALS	429,025	104,525

The system would be provided by Cochrane Engineering on turn-key basis.
The generator would be purchased in Zimbabwe and would be of local manufacturer.
The engine would be purchased locally (but imported) and locally modified.
The gas cleaning equipment has been engineered and is produced by Cochrane Engineering.
The generator would be produced by Cochrane Engineering under licence.

4. LOCATION AND SITE

The production of the generators will take place in the existing workshop of Cochrane Engineering.
No additional fixed capital investments are needed.
Transfer of know-how would take place by delivery of appropriate drawings and full specifications of material and components.
Cochrane skilled personnel is perfectly equipped to carry out all engineering activities needed to "indigenise" the construction of the gas generator.

5. PROJECT ENGINEERING

The modified gasification equipment proposed can be manufactured by any medium size engineering company with metal cutting, rolling, welding and machine shop facilities.

The Cochrane Engineering workshop meets with the required specifications both from the point of view of availability of all equipment and machine tools needed as well as the skill of the engineers and workers.

As suggested by Cochrane Engineering further field testing of the modified plant incorporating any modifications found necessary, batch production runs could commence.

6. IMPLEMENTATION SCHEDULE

• Signature of licence agreement	x
• Additional field testing on modified plant	x + 2 months
• Transfer of drawings and specifications	x 2 months
• Engineering of the modified plant and preparation of shop drawings based on indigenous raw materials	x + 6 months
• Production of first batch of 5 plants	x + 10 months

7. FINANCIAL AND ECONOMIC EVALUATION

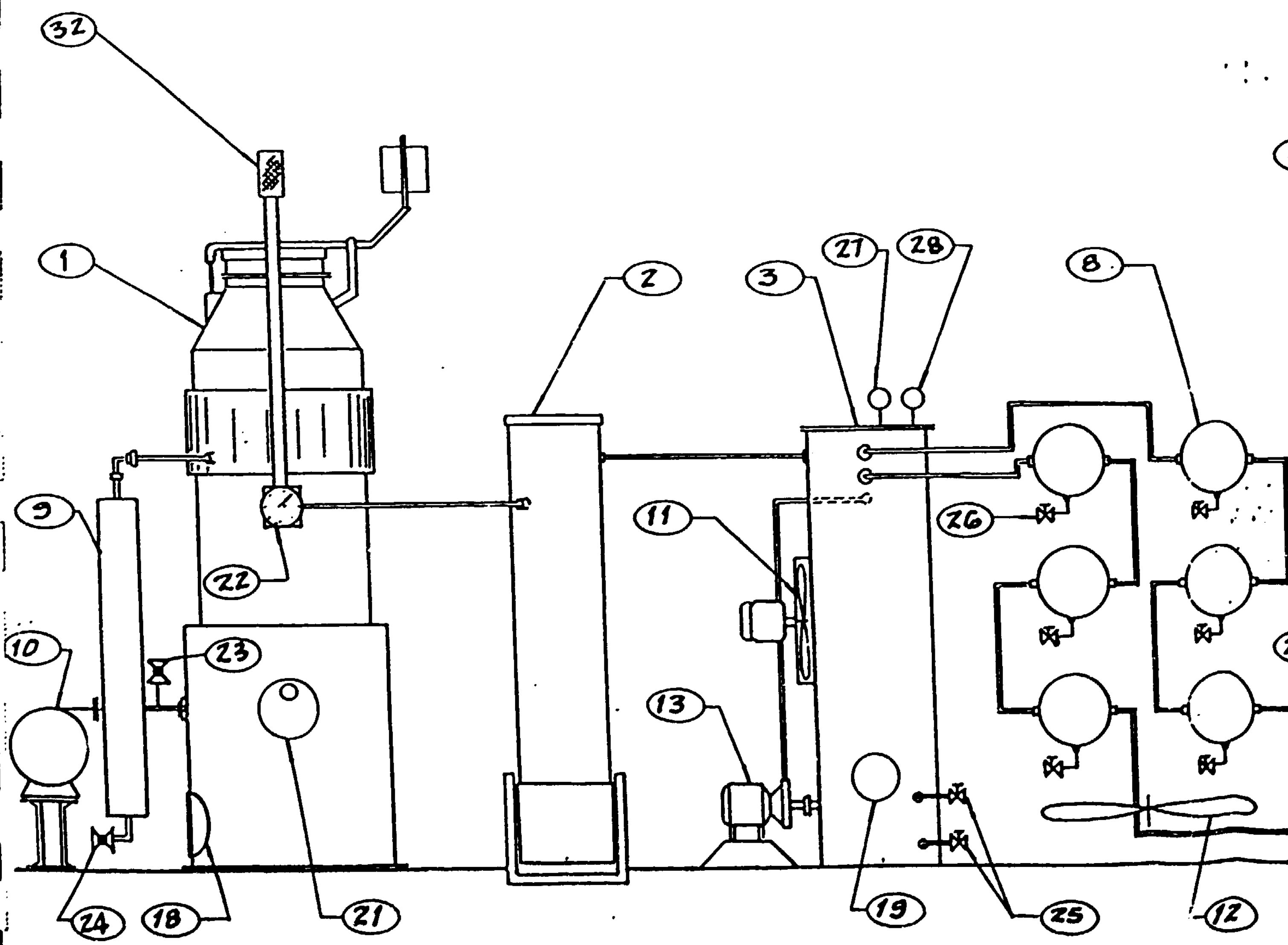
No fixed capital investment is needed, no additional personnel required.
It is anticipated that, under these circumstance, the COMFAR would be of little significate.
The existing workshop of the Cochrane Engineering Co. can manufacture the gas generators on the base of the market requirements.
The saving in foreign currency for the installation (and retrofitting of existing diesel generators too) of agricultural wastes based gas generators can be estimated as follow.
The installation of 22 generators, 44 KW each would save 450,000 US$ per year of input of diesel oil.
Taking into consideration that the foreign currency component in the construction of 22 plants is approximately 440,000 US$ the result is that the foreign portion cost can be depreciated in the first year of operation and than the savings can be cumulated.
Considering 10 years of operating life the 22 plants will generate cumulate savings in foreign currency of approx. 4 Million US Dollars.

33	
32	CONTROL VALVE
31	CONDENSATE DRAIN VALVE
30	PRESSURE GAUGE
29	TEMPERATURE GAUGE
28	PRESSURE GAUGE
27	THERMOMETER
26	FILTER DRAIN VALVES – 6 OFF
25	PRESSURE DRAIN VALVES
24	CONDENSATE DRAIN VALVE
23	AIR INLET VALVE
22	PRESSURE GAUGE
21	INSPECTION DOOR AND GLASS
20	SAWDUST REMOVAL DOORS
19	INSPECTION DOOR
18	ASH REMOVAL DOOR
17	BATTERY CELLS – 2 OFF x 12V Ea.
16	MIXING VALVE
15	AIR FILTER
14	EXHAUST
13	COOLING UNIT PUMP
12	DISK-TYPE FILTER FAN
11	COOLING UNIT FAN
10	AIR BLAST FAN
9	CONDENSER
8	DISK-TYPE FILTERS – 6-OFF MOUNTED 3 ROWS, 2 COLUMNS
7	CONTROL PANEL
6	ENGINE (TESSARI)
5	SAFETY FILTER
4	FINAL FILTER
3	COOLING UNIT
2	MECHANICAL FILTERING UNIT – 2-OFF
1	REACTOR
PRT NO	DESCRIPTION

FIG 2.1.1.a.

SES MODEL GE 40 GA

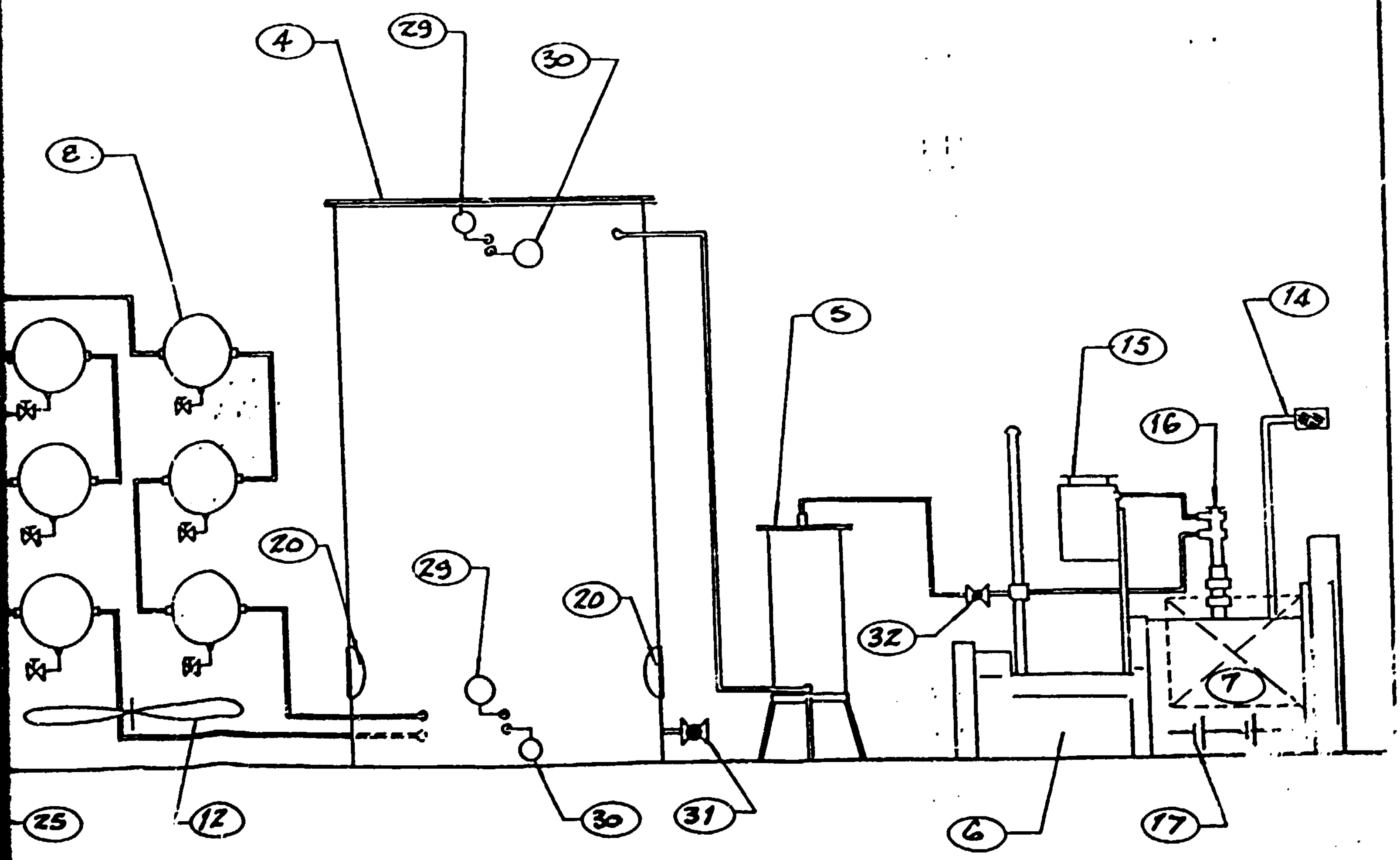
FIG 2.1.1.a.



SECTION 1

...SL GE 40 GASIFIER

...1.1.a.



SECTION 2