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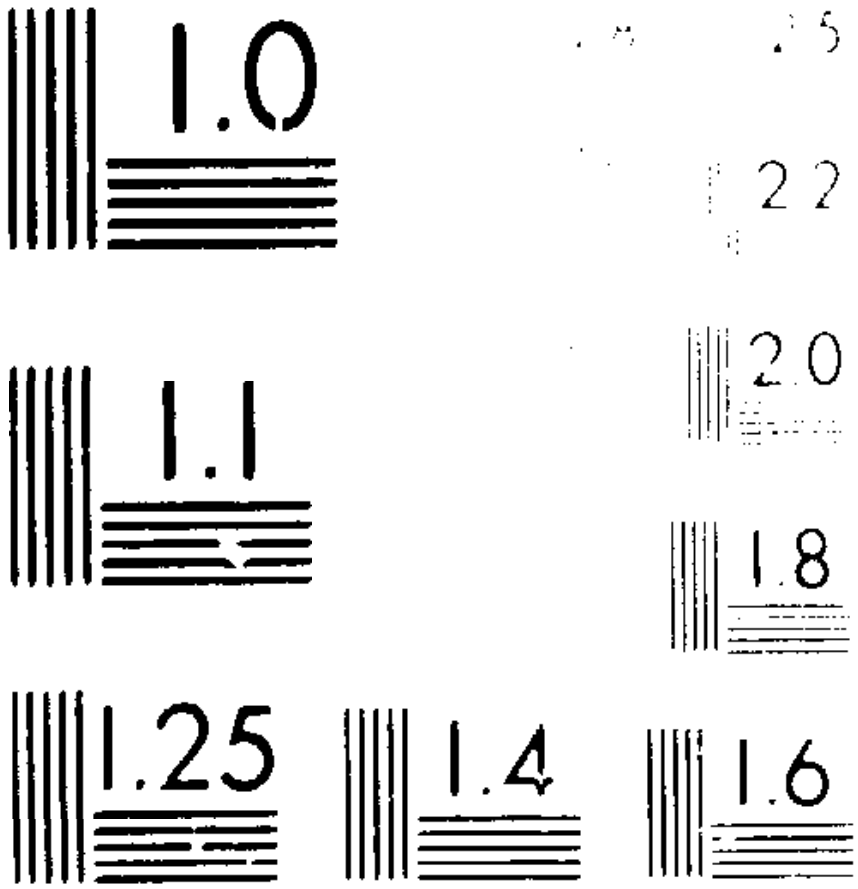
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Sierra Leone, June 1981.

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Sierra Leone. P R O D U C T I O N

OF

CHARCOAL BRIQUETS AND PYROLYSIS OIL

FROM FORESTAL AND AGRICULTURAL WASTE

Asseesment of the possibilities of a small scale
Charcoal Industry .

UNDP Project: DP/SIL/78/002/11 - 55/31.2.C.

INDUSTRIAL PROGRAMMING AND PROJECT ELABORATION

Freetown, June 1981.

R) Sierra Leone

TECHNICAL REPORT: Production of Charcoal Briquets and Pyrolysis Oil from Forestal and Agricultural Waste in Sierra Leone

A Pre-feasibility Study of a small scale Charcoal Industry

Prepared for the Government of Sierra Leone

by

Dr. Walter Emrich
Expert in Charcoal Production

Under: Project DP/SIL/78/002/11 - 55/31.2.C.:
Industrial Programming and Project Elaboration

A Project of the United Nations Development Programme, executed by the United Nations Industrial Development Organisation (UNIDO).

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The information on which the results and conclusions of this study are based was contributed by numerous contacts of governmental agencies, public institutions and private industries of Sierra Leone.

Particular consideration to the work was given by UNDP, the Ministry of Industry and Commerce, the Ministry of Agriculture, the National Development Bank, the Forest Industry Product Corporation, the Sierra Leone Produce Marketing Board, the Sierra Leone Oil Refinery, the National Workshop, which helped greatly facilitate the mission of the Expert.

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- All figures of prices, costs in Leone, if not otherwise stated --

Chapter 1 Summary

1. Objective of the study

This study investigates the preliminary feasibility of industrial charcoal making from forestal and agricultural waste on a small scale basis in Sierra Leone.

The products are charcoal briquets produced according to the standards of the European markets and pyrolysis oil made as a substitute for fuel oil consumers in the country.

2. Market

Annual shipments of 2,300ts of charcoal briquets (proposed plant capacity) represent under 1% of the demand in Europe and will be absorbed easily (sales contracts for a three year sales term are obtainable).

The present fuel oil consumption in the Freetown area is estimated to be 70,000ts/y. The expected output of 2,500ts pyrolysis oil can therefore be utilised as such or blended with the fuel oil of the local refinery.

3. Raw Material

In order of availability the following types of raw material can be utilised: Forest residues from tree felling, saw mill waste (saw dust, off-cuts, slabs), waste of furniture production, rice hulls, coffee huller waste, cocoa pods and palm oil shells.

It is estimated that four plants of the envisaged capacity could be supplied permanently.

4. Technology

Bio-Carbon, G.M.B.H.(FRG) have developed together with a major U.S. Company a continuous vertical-flow retort for energy recovery from biomass. The commercial feasibility of these plants have been proved since more than ten years.

5. Sales Revenue

1. Production year (50% capacity) : Le 362,250 (in foreign currency)

Le 316,500 (in local currency)

Total Le 678,750

2. Production year (100% capacity) : Le 724,500 (in foreign currency)

Le 633,000 (in local currency)

Total Le1,357,500

6. Investment Costs

Total Le684,300 of which are in foreign currency Le370,000.

Investment in fixed assets : Le628,000.

Investment in working capital : Le56,300.

Investment cost do not include cost of land.

By selecting the smallest feasible plant size the investment cost can be reduced to an estimated Le550,000.

7. Location

Location of the first plant preferably in the area of Kenema. Site to be selected yet.

8. Manpower Requirements

These are for three shift operation at full capacity (2 year):-

a) Staff 13 salaries Le 40,080/y

b) Labour 42 wages : Le 61,400/y

Total 55 : Le 101,480/y

9. Project Financing

It is proposed that the total investment will be financed as follows:-

50% or Le342,150 by equity participation

50% or Le342,150 by a long term loan from the National Development Bank.

10. Profitability

a) Simple rate of return

- first year of production (50% capacity)

Gross profit/net profit		Le 257,750
		38% on sales
		75% on equity

- following years of production (100% capacity)

Sales revenue		Le1,357,000
Operating costs	Le 375,200	
Depreciation	53,600	
Average Int. Cost	31,360	Le 460,160
Average gross profit p. annum		Le 896,840
		66 % on sales
		262 % on equity
Average net profit after taxes (55 %)		Le 415,000
		31 % on sales
		121 % on equity

b) Pay Back period of investment 18 months after start-up

c) Dividents from 4th year of operation 15%: Le 203,550/y

d) Investment incentives

The above profitability is based on following investm. incentives provided by the government:

- duty free import of machinery, equipment and spares
- duty free import of packaging material
- duty free export of charcoal briquets to Europ. markets
- income tax holiday for three years

11. National Economic Value

a) Gross value added of the project at full capacity:

	Le	1,083,300
	or	80 % on sales revenue
Net value added:	Le	1,029,700
	or	76 % on sales revenue

b) Foreign exchange effects

This is only negative in the year of investment (-Le370,000). This will be offset within the first year of production by foreign exchange saving for imports of the fuel oil supply and by the sales revenue for the charcoal briquets exports.

c) Capital requirements per job created: Le 12,450

of which in foreign exchange Le 6,750

This suggests that the project is rather capital intensive but ranges in the average group of modern industrial production in Sierra Leone.

12. Feasibility Study

Although there is no doubt that the project will be viable and highly profitable it is fundamental to obtain additional results by a feasibility study before implementation.

These will include:

- plant site selection
- complete plant layout
- composition of raw material mixes
- composition and quality test of the charcoal briquets
- composition and calorific data for the pyrolysis oil
- financial evaluation in cooperation with the National Development Bank.

The estimated costs for the feasibility study are:

1.5 mammonths in Sierra Leone X)	USD	8,000
airtickets	USD	3,000
rental car, three weeks	USD	2,100
Laboratory tests in USA	USD	8,500
travel expenses	USD	3,000
airfreight for raw material samples	USD	1,500
Engineering work, evaluation of results writing of report	USD	12,000
Total	USD	38,100

X) it is assumed that lodging and food will be provided locally

Chapter 2 General Description

2.1 The Products

The carbonisation process yields three different products:-

- Char/charcoal (solid fuel).
- Pyrolysis oil (liquid fuel).
- Heating gas (gaseous fuel).

The produced char/charcoal is usually agglomerated into briquets or pellets.

The usual form of a charcoal briquet is the pillow shape. They are composed of a binder (starch and molassis), an energy extender (incombustibles) and contain ignition enhancing agents also.

Pyrolysis oil is a dark brown liquid with calorific properties similar to fuel oil. It can be pumped and is transportable in barrels as well as in tank cars.

The heating gas contains CO and hydrogen and is therefore a good fuel normally utilised in burners of steam boiler systems, brick factories, etc.

2.2 Process description

A diagram of the carbonisation process has been attached in the appendix.

The raw material is reduced in size (hogging, shredding and crashing) if necessary and stored in the open air.

From the storage the feed is received and conveyed into a dryer (if moisture content of raw feed exceeds 30%). The dried feed then is carried over to the carboniser.

Here thermally decomposition to char, oil and heating gas takes place. The char is continuously removed from the bottom of the carboniser and after cooling with a waterspray taken to the char storage bin.

The oil and gas vapours are drawn through a port in the top of the carboniser into the off-gas system.

At first they flow through a scrubber-chiller and all oil vapours are condensed. The pyrolysis oil is taken to a storage tank.

The remaining heating gas is further drawn into the burning chamber, which supplies the hot gas for the raw material dryer and the briquet dryer.

For the briquetting of the charcoal (not shown in the diagram) the dissolved binder, the energy extender and the ignition enhancer are mixed together.

The briquetting is usually done with a roller press.

The 'green' (wet) briquets are dried and cured.

After bagging the charcoal briquets are ready for warehousing or immediate shipment.

2.3 The raw materials

Literally hundreds of different feedstocks have been tried successfully by the carbonisation industry during the last decade. The most commonly used are:-

- wood: Leftovers from clear cuttings, brushes, branches, bark, leaves and roots.
- wood wastes of saw mills, lumber mills, and furniture industry: Slabs, sawdust, shavings and chips.
- nut shells: Peanut, coconut, cocoa and husks.
- agricultural industry: Rice hulls, sugar cane bagasse, cotton stocks, residues of coffee plantations, etc.
- municipal waste.

Also strange stuff like slaughter house waste and chicken droppings underwent carbonisation.

2.4 Plant location

At this stage of the study is no need to engage in detailed considerations concerning the site of the project.

However, the plant should be located near the raw material sources, which are naturally in rural areas.

Carbonisation reduces the bulk of the raw material considerably. On the other side the gained products are transportable by road and rail. Therefore also shipments for export markets can be made from remote areas successfully.

The costs for land vary considerably in Sierra Leone. They have therefore not been included in this study.

Although the envisaged carbonisation plant will not require more than 500m2 of space, the investment cost (or operational cost factor if the land is leased) should not be overlooked when the investment decision is taken.

3.1 Demand

A market research to determine the present demand and future projections of the domestic market has not been done, due to the lack of time and statistics.

However, the results of such a search are not of imminent relevance to this study.

3.1.1 Domestic demand for charcoal briquets

The charcoal market in Sierra Leone is characterised by four factors:-

- Lump charcoal is the only commodity.
- The charcoal is sold by volume rather than weight in jute bags and also loose.
- Charcoal is sold as household fuel and for ironing and blacksmithing only.
- There are no charcoal imports.

The supply of charcoal is steady throughout the year and prices are high if compared with those in the U.S.A. and European countries.

Spotchecks made in Freetown and other parts of the country show, that they vary between Le .45 and Le .55 (Freetown) per Kg.

Due to the high charcoal prices firewood dominates the market for household fuels, and often it is readily available for self-cutting.

Since charcoal briquets are not known it cannot be expected that the consumer will adopt them easily, also at a competitive price.

It also will take some time to make the consumer aware of the advantages of charcoal briquets, especially the considerable longer cooking times they do provide.

3.1.2 Export markets for charcoal briquets

It is quite clear that the total of the charcoal briquet production has to be released to export markets within the initial period of the new venture.

Therefore the opinion of a charcoal import company (Carbon International,Ltd., FRG) has been obtained.

The closest markets are the European countries which also pay higher prices for standard quality charcoal briquets than the U.S.A. (for specifications see appendix).

More than eight Non-European countries are servicing these markets presently. Imports have doubled since the early seventies and the briquet market is expected to progress on a rate of 7 to 8% in the foreseeable future.

Last year imports of charcoal were exceeding 150,000ts, including a charcoal briquet share of 40%.

Since the energy crunch became visible the European consumer are more and more becoming aware of the energy saving advantages of charcoal briquets.

Therefore it can be safely assumed that the market share for the briquets will improve further.

The present cif-price, Northern European ports will raise from Le435 to Le475 per metr.t, delivered in 3Kg bags and shipped dead stacked in 40' container, after September 1.

3.1.3 Domestic demand for pyrolysis oil

The oil is an excellent substitute for fuel oil and its calorific value is about 60% of that.

It can be utilised as such or blended with fuel oil.

The annual fuel oil production of the Sierra Leone Refinery is 70,000ts at present.

The estimated 2,500ts pyrolysis oil of the envisaged plant represent therefore only 3.5% of the domestic market.

The refinery price of the fuel oil is Le1.48c per gallon, including the excise tax and the mark-up of the distributor the purchase price for the local industrial consumer is Le2.30c per gallon.

The calculation of the sales revenues has been based on a market price of Le1.90c per gallon taking into account that the purchaser of large oil quantities enjoys a discount price.

Applying 60% of the above adjusted market price i.e. Le1.14c per gallon the sales of 551,600 gallons (= 2,500ts) will revenue at full capacity Le633,400 annually.

3.2 The proposed capacity of the plant, given by the investment costs not exceeding Le650,000, is based on specifications obtained from the manufacturer of the equipment (see Chapter 5).

The nominal (technical feasible) capacity of the plant which can be build under the above ceiling figure is 2,300ts of charcoal briquets and 2,500ts of pyrolysis oil as the main by-product annually.

To meet this production the carbonising plant will have to be run 280 days on three consecutive shifts.

The briquetting plant will have to be operated 280 days per year on two consecutive shifts (appr. 5t/h).

For the nominal capacity breakdowns, extra maintenance, cleaning shut-offs have been taken into account.

Therefore after the usual start-up time of six months the full capacity of 100% will be achieved.

3.3 Production programme and sales forecast

The sales potential of the products will not be critical for the viability of the project.

Export markets will easily absorb the comparative small amount of charcoal briquets and it will in no way affect price levels.

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In fact so far the charcoal briquets are concerned it is very likely that large scale customers will not engage in long-term contracts with the new venture until higher capacity figures can be suggested.

Table 3.1 Estimate of Production and Sales Revenue

Year	1	2	3
Envisaged Production	50%	100%	100%
Quantity of charcoal briquets produced	1,150ts	2,300ts	2,300ts
Cif-price N.Europ. ports	Le470-/t	Le470-/t	Le470-/t
Ocean + Inland freight	Le130-/t	Le130-/t	Le130-/t
Ex-factory price/t	Le340	Le340	Le340
Sales commission/t	Le 25	Le 25	Le 25
Net sales price/t	Le315	Le315	Le315
Sales Revenue for Charcoal briquets *	Le362,250	Le724,500	Le724,500
Sales Revenue for Pyrolysis oil	Le316,500	Le633,000	Le633,000
Total sales revenue	Le678,750	Le1,357,500	Le1,357,500

* Foreign currency

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Chapter 4 Material Inputs

4.1 Raw Materials

All essential raw materials are available in Sierra Leone. They can be either found accumulated - saw mill wastes, rice hulls, palmoil kernel shells and peanut shells - in confined areas or are scattered around like coffee plantation wastes, coconut shells, which have to be collected and carried to the plant.

It was not possible to asses the total quantity of the waste materials, which would also include the forestal residues from the tree felling and clear cuttings. However, it can be safely assumed that the raw material basis in Sierra Leone would support several plants of the envisaged capacity permanently.

The yield of 100Kg raw feed is estimated to be 30Kg char, 28Kg pyrolysis oil and 27Kg of heating gas. The balance constitutes the process losses.

By experience these figures are being considered as conservative, but they have to be established by a pilot plant test, if the project should become reality.

Since the first plant will be erected on the spot of accumulated raw materials only retrieval costs for the feed have to be applied as raw material cost.

In the maximum range they are estimated to be Le5 per meter t. of raw feed (air dry).

Therefore Le30,000 have to be allocated for an annual input of 60,000ts of raw material.

4.2 Auxiliary Materials

4.2.1 Binder

Starch or molassis guarantee a realiable quality for export briquets.

Although the country grows casava in abundance there is no starch production at the present.

However, molassis is readily available from the new established sugar factory in

Based on the world market price for molassis the cost of the annual demand for 200 meter ts. can be estimated to be Le8,000 (incl. freight).

4.2.2 Energy extender

The addition of fire brick dust or grinded oyster shells will make a good long burning charcoal briquet.

The cost for the annual demand of 150ts is estimated to be Le15,000 (incl. freight).

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4.2.3 Ignition enhancer, fermentation preventer

Both chemical agents have to be imported. They are applied in therapeutical dosis.

An annual allocation of Le3,000 will be sufficient.

4.3 Packaging Material

The normal export bag for charcoal briquets is the three-layer 3Kg - paper bag, three colour printed and five 3Kg bags are packed in one baler bag consisting of brown craft paper with one colour printing.

All bags have to be imported. The number and cost can be accurately estimated.

Based on todays prices in the U.S.A. the annual cost for 770,000 3Kg bags and 154,000 baler bags are Le129,400 (freight included).

4.4 Factory Supplies

These include, maintenance materials such as oils, grease and cleaning materials as well as consumption of wear and tear parts and tools.

The costs of these are estimated to be about 2% of the cost of plant and equipment or Le9,000 per year of which are Le7,000 in foreign currency.

Chapter 4.

4.5 Utilities Page - 11 -

4.5.1 Electricity

Electricity consumption of the plant is 80 Kw/h or 537,600 per year.At a rate of Le .12 p. Kw the total consumption will be Le 64,512 at full capacity p. year.

It is assumed that the plant will be erected at a site where electricity is sufficiently supplied from a public net.

In the case power provisions can not be made by the Sierra Leone Power Supply Comp. a generator has to be installed.

Therefore Fritz Werner Industrie - Ausstatungen,G.m.b.H. (FRG) has been contacted to obtain detailed technical and price information.

It is suggested to establish a producer gas operated unit,which are commercially proved and readily available for installation.

The common fuel in use are wood waste or charcoal.Therefore independance from surging oil prices can be definitely achieved.

The generator unit consists of a gasifier and the attached power generator.These units may be run continuously around the clock.Refueling per day and occasional filter cleanings are the only necessary operations.

The unit prices depend on the power output.The envisaged generator will cost Le 90,000.- plus freight costs.

The costs per Kw are mainly composed by the depreciation of the investment and will not exceed the above stated rate for the electricity from a public net.

The investment of the generator installation has not been taken into account,but must be considered after the plant site selection has been made eventually.

4.5.2 Fuel

Since plant provides its own heating gas there is no fuel to be purchased.

4.5.3 Water

The plant requires cooling and process water. The estimated demand is 900 litre/h, i.e. 200 gallons/h.

Annual demand will be .,344,000 gallons.

The cost of water in Sierra Leone consist of a flat rate which is included in the overhead costs, and a rate of Le1.20c per 1,000 gallons.

The variable costs of water are therefore Le1,600 per year. (Cost of water for sanitary purposes is in included in overhead costs).

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Table 41. Estimate of Production cost: Material Inputs

Item	Cost Foreign	Local	Total
1. Raw material	-	30,000	30,000
2. Auxiliary materials	-		
Binder	-	8,000	8,000
Energy extender	-	15,000	15,000
Chemicals	3,000	-	3,000
3. Packaging materials	129,400	-	129,400
4. Factory supplies	7,000	2,000	9,000
5. Utilities			
Electricity	-	64,512	64,512
Fuel	-	-	-
Water	-	1,600	1,600
	139,400	121,112	260,512

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Chapter 5 Project Engineering

5.1 Technology

Bio-Carbon, G.M.B.H. (FRG) has been approached for information on the most appropriate technology for producing charcoal and pyrolysis oil from various forestal and agricultural wastes.

This company is specialising in traditional and industrial charcoal techniques, and they have developed together with a U.S. company a multi-purpose converter with a complete oil recovery system.

For the selection of the technology several points had to be taken under serious consideration.

The investment capital for the plant is limited by the government of Sierra Leone to a total of Le450,000 to 500,000 and the supply of foreign currency is short.

While labour is abundant the plant should employ as many workers as possible and finally the project will be located in a rural area.

These facts cut out a fully mechanised operation. However, to achieve an adequate plant capacity and a certain standard of quality the totally manually operation is also not feasible.

Therefore the semi-mechanised plant would be the workable middle course.

5.2 Production Process

An abridged description has been given in chapter 2 already and a flowsheet diagram is attached in the appendix.

Raw material preparation: All raw material particles larger than 40mm in length and bigger than 30mm in diameter will be shredded or hogged before processing.

Carbonising and oil recovery: After drying the reduced raw feed is conveyed into the carboniser, which consists of a vertical shell with refractory lining and automatically operated in - and outlet ports.

The thermal decomposition of the feed takes place under a controlled temperature range of 450 to 500C.

The temperature is maintained partly by the process itself (dry distillation = exothermic reaction) and by controlled air injection.

The formed oil vapours leave the top of the carboniser through a porthole and are consequently scrubbed with water cooled oil.

Preparing the char for briquetting: The char is mixed with the water-dissolved binder, energy extender, ignition agents and if necessary with a fermentation preventer in a paddle mixer.

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Briquetting: To achieve uniform briquets a roller press with exchangeable moulds will be employed.

Bagging unit: Consists of an adjustable balance with hopper bin. Provisions are made, that 3 - 5 - 10 and 20Kg bags can be filled. The bags will be closed with two electric hand-sewing machines.

5.3 Equipment

5.3.1 Production Equipment

The supplier offers all parts, which cannot be locally made. The package will include the following items:-

- one shredder
- one moveable conveyor belt for the raw feed
- one dryer for the raw feed
- one upper section of the converter and one lower section, including raw feed screw and char locks, air injection pump and two sets of the refractory lining
- one scrubber chiller with oil pump
- one char elevator
- one paddle mixer
- one high speed stirrer
- one roller press
- one briquet dryer
- one balance
- two electric sewing machines
- one burner chamber for the flare-up stack of the off-gases
- one control panel
- all electric motors.

The cost of the package quoted by the supplier amount to

Fob	USD280,000
Estimated C & F charges	USD 42,000
Cif Freetown	USD322,000
Le1.01c per USD	Le325,000
Local charges for clearing and transport to be 7%	Le 23,000
Total cost (import duty excl.)	Le348,000

5.3.2 Transport - Office and Laboratory equipment

As transport one car may be sufficient for personal transport. It is estimated to cost Le8,000.

For office equipment and furniture an allocation of Le7,000 may be sufficient.

For the laboratory equipment an allocation of Le6,000 is being considered as sufficient.

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Table 5.2 Estimate of Investment Cost: Equipment

Item	Cost Foreign	Local	Total
1. Production Equipment			
a) Imported	325,000	23,000	348,000
b) Local supply	-	90,000	90,000
2. Transport	-	8,000	8,000
3. Office equipment	-	7,000	7,000
4. Laboratory equipment	6,000	-	6,000
5. Primary stock of spare parts incl. in 1.	-	-	-
Sub-Total	331,000	128,000	459,000
Contingency 10%	33,000	13,000	46,000
Total	364,000	141,000	505,000

5.4 Civil Engineering Works

5.4.1 Based on the space requirements for office and laboratory space, it is estimated that a building with 100m2 floor space will be sufficient.

At an estimated cost of construction of Le400 per square meter, the building willcost Le40,000.

Only the briquetting plant, the finished briquets, the packaging material and the spare parts for the plant have to be sheltered.

It is normal practice to cover them under one roof with three separate enclosures. A covered area of 220m2 can be considered as sufficient.

The cost for this roof with three partitions are estimated at Le15,000.

If the plant will be established partly in an existing or rented building, these two amounts can be deducted from the investment cost. In that case the rent should be included in the operating cost.

5.4.2 Site preparational development cost

These have not been taken into account in this study since it will depend very much where the plant will be erected. If this was done on an existing factory site the cost will be low.

This issue will have to be taken under consideration when an investment decision is taken.

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5.4.3 Outdoor Works

These include amongst others investment cost in supply of utilities, communications, sewage system, waste treatment facilities, roads, parking lot, outdoor lighting and fencing.

As these cost are not easy to project, an amount of Le6,000 i.e. about 10% of the building cost, is estimated to be sufficient.

Table 5.3 Estimate of Investment Cost: Civil Engineering Works

Item	Cost Foreign	Local	Total
1. Site Preparation and Development	-	-	n.n
2. Buildings	-	55,000	55,000
3. Outdoor Works	-	6,000	6,000
Sub-Total	-	61,000	61,000
Contingency 10%	-	6,100	6,100
Total	-	67,100	67,100

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Chapter 6 Manpower Requirements

6.1 Organisational Structure

The proposed plant, as when established will be headed by a General Manager who will run the venture through the Administrative, Department and the Production Department.

6.1.1 Administrative Department

This will be run by the Assistant Manager for Administration, who will be responsible financial management, accounting, budget control, personnel management, procurement of materials and supplies, store keeping and marketing.

6.1.2 Production Department

This will be headed by a Technical Manager, and will be composed by the following sections:

a) Raw material preparation.
b) Charcoal and Pyrolysis oil station.
c) Briquet preparation.
d) Briquetting station.
e) Bagging station.
f) Warehousing.
g) Laboratory/Quality control.
h) Maintenance shop.

It is visualised that labour is interchangeable if required according to the production programme.

During the start-up period of six months less labour is required within the section group c) - e).

Whereas section groups a) - b) and c) - e) are supervised by one foreman for each group the laboratory and maintenance shop are reporting directly to the production manager.

6.2 Personnel Costs

Table 6.1 Estimate of Production cost: Wages

No.	Section group Function	Category	No.	Salary/Wages Monthly	Salary/Wages Annual	Number of Shifts
1.	Prod. Manager	Managerial	1	500	6,000	-
2.	a) - b)					
	Foreman	Supervisory	1	200	2,400	-
	Operator	Skilled	3	450	5,400	three
	Labour	Unskilled	6	480	5,760	three
3.	c) - e)					
	Foreman	Supervisory	1	200	2,400	-
	Operator	Skilled	3	450	5,400	three
	Forklift driver	Semi-skilled	1	100	1,200	-
	Labour	Unskilled	21	1,680	20,160	three
4.	f)Lab/Quality control					
	Technician	Supervisory	1	200	2,400	-
	Helper	Unskilled	2	160	1,920	-
5.	g)Maintenance					
	Welder	Skilled	1	150	1,800	-
	Helper	Unskilled	1	80	960	-
	Sub - Total		42	4,650	55,800	
	Surcharge	10%		470	5,600	
	Total		42	5,120	61,400	

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Table 6.2 Estimate of Production cost: Salaries

	Function	No.	Salary Monthly	Annual
1.	General Manager	1	1,000	12,000
2.	Ass. General Manager	1	500	6,000
	Administration			
3.	Secretary(senior)	1	250	3,000
4.	Secretary(junior)	1	100	1,200
5.	Accountant	1	300	3,600
6.	Clerk	2	200 x 2	4,800
7.	Store Keeper	2	100 x 2	2,400
8.	Messerger	1	70	840
9.	Driver	1	80	960
10.	Security	2	70 x 2	1,680
	Sub - Total	13	3,040	36,480
	Surcharge 10%		300	3,600
	Total	13	3,340	40,080

During the start-up period (6 months) when production is below full capacity labour requirements are less and can be estimated as follows:

Table 6.3 Estimate of Production cost: Start-up Period

	Category Function	No.	Salary/Wages Monthly	Six Months
1.	Administration	13	3,040	18,240
2.	Production			
	Managerial	1	500	3,000
	Supervisory	3	600	3,600
	Skilled	7	1,050	6,300
	Semiskilled	1	100	600
	Unskilled	18	1,440	8,640
	TOTAL	43	6,730	40,380

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Chapter 7 Overhead Costs and Depreciation

7.1 Factory Overheads

a) Maintenance of civil engineering works
5% of construction cost = Le 3,500.-/y

b) Maintenance of plant and equipment

3% of plant and equipment value (spare parts are included in factory supplies) = Le15,000.-y
(Le7,000 in foreign exchange)

c) Water

2% of the market value of the buildings
(sanitary water included) = Le 500.-y

d) Electricity

4Kw/h for lighting i.e. 16,000Kw/y = Le 2,000.-y

Total Le21,000.-/y

7.2 Administrative Overheads

a) Staff cost (table 6.2) = Le40,080.-/y
b) Office supplies, communication and travel = Le 7,000.-/y
c) Insurance, 1% of value of fixed assets = Le 5,500.-/y
d) City rates = Le nn

Total = Le52,580.-/y

7.3 Depreciation

They have been calculated on the basis of the percentages displayed in the following Table.

Table 7.1

Item of investment	%	Investment cost in fixed assets	Depreciation
1. Buildings and and civil works	5	67,100	3,300
2. Plant machinery and equipment	10	438,000	43,500
3. Transport, laboratory office equipment	20	21,000	4,000
4. Pre-Investment cost	5	56,452	2,800
Total		582,552	53,600

Note: Financial Overhead costs (interest) will be discussed in Chapter 9.

...../22.....

Table 7.2 Estimate of Production Cost: Overheads

Item	Cost		
	Foreign	Local	Total
1. Factory Overheads	7,000	14,000	21,000
2. Administrative Overheads	-	52,580	52,580
3. Depreciation	-	53,600	53,600
Total	7,000	120,180	127,180

...../23.....

7.1 Factory Overheads

a) Maintenance of civil engineering works

5% of construction cost = Le 3,500.-/y

b) Maintenance of plant and equipment

3% of plant and equipment value (spare parts are included in factory supplies) (Le7,000 in foreign exchange) = Le15,000.-/y

c) Water

2% of the market value of the buildings (sanitary water included) = Le 500.-/y

d) Electricity

4Kw/h for lighting i.e. 16,00Kw/y = Le 2,000.-/y

Total = Le21,000.-/y

7.2 Administrative Overheads

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b) Office supplies, communication and travel = Le 7,000.-/y

c) Insurance, 1% of value of fixed assets = Le 5,500.-/y

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Chapter 8 Project Implementation

8.1 Project Implementation Management

As soon as the decision to go ahead with the project is taken it is advisable to appoint a person who will be in charge of the implementation of the project. In addition to the project manager a secretary to assist in administrative matters may be required. The project manager will take care of the following activities:-

- selection of the site and purchase or lease of the land.
- planning and supervision of construction work.
- selection, purchase and installation of equipment.
- ensure availability of sufficient raw materials.
- undertake pre-production marketing activities to ensure that the product meets adequate demand when production starts.
- obtain government approval for establishing the plant, for importing the equipment and (if required) for obtaining a development certificate with the necessary investment incentives.

It is envisaged that these activities will take about one year. A more detailed implementation schedule will have to be prepared as and when an investment decision is taken.

8.2 Cost estimates for Project Implementation.

8.2.1 Project Implementation Management

The cost of one manager and a secretary for the duration of one year are Le15,000 (table 6.7).

8.2.2 Administrative Expenses

These cover the cost of travel, transportation, communications, office supplies, rent, etc. and may amount to Le6,000 which includes a visit to the manufacturer of the equipment abroad to inspect the equipment and negotiate the contract.

8.2.3 Cost of factory design

These are included in the construction cost.

8.2.4 Cost of start-up Engineer

The cost of installation and commissioning of the plant are included in the cost of equipment, except the local subsistence allowances for two engineers for three weeks at a rate of Le106 per day i.e. Le4,452 in total.

8.2.5 Cost of Preproduction Labour

One month wages may be necessary. This will amount to Le2,500 (est.).

8.2.6 Interest during construction

It is assumed that 50% of the investment in Fixed Assets made by borrowed funds i.e. Le225,000, will remain deployed during the construction stage of the project. At an interest rate of 15%, interest cost to be capitalized will amount to Le22,500 (8 months).

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8.2.7 Consultancy and Personnel Training Programme Cost

It is necessary to employ consultant during the period of the implementation as advicer to the project manager. Also the technical plant manager and two foremen have to be trained outside of the country.

These costs have not been taken into account because it is normal that the assistance of an consultant and the training programme are being sponsored by bi-lateral or multi-lateral development organisations.

8.2.8 Laboratory Tests

It is necessary within the earliest stages of the implementation period to perform with the raw materials some pilot plant tests. By those tests the eventual recipe and composition of the briquets and the calorific data of the pyrolysis oil have to be determined.

Another purpose is to obtain samples of the future products for the pre-production market approach.

The costs are difficult to estimate. However, an allocation of Le6,000 is sufficient.

Table 8.1 Estimate of Investment Cost: Project Implementation

Item	Cost Foreign	Local	Total
1. Management of Project Implementation	-	15,000	15,000
2. Administration cost	-	6,000	6,000
3. Commissioning of Plant Start-up Engineer	-	4,452	4,452
4. Pre-production Labour	-	2,500	2,500
5. Pre-operational Interest	-	22,500	22,500
6. Consultancy/Personnel Training programme	-	-	-
7. Pilot plant test	6,000	-	6,000
Total	6,000	50,452	56,452

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Chapter 9 Financial Evaluation

9.1 Total Investment Costs

Sum of fixed investments (incl. production capital cost and investments in fixed assets) and net working capital.

9.1.1 Fixed Investment Costs

Table 9.1 Fixed Investment Costs

Category	From Table	F.C.	L.C.	Total
1. Land & Land Development	-	-	-	n.n.
2. Buildings & Civil Works	5.3	-	67,100	67,100
3. Plant Machinery & Equipment	5.2	364,000	141,000	505,000
4. Pre-Production Capital Costs	8.1	6,000	50,400	56,400
Total initial fixed investment costs		370,000	258,000	628,000

F.C. = Foreign currency
L.C. = Local currency

9.1.2 Net Working Capital

a) First minimum requirements of current assets and liabilities have been calculated as follows:-

- Accounts receivable: 30 days at production costs minus depreciation and interest (= operating costs).

- inventory: local raw materials30 days, imported raw materials 100 days.

  Spare parts 180 days, finished products 15 days at factory costs + administrative overheads (operating costs).

- cash in hand: 15 days of total production costs, less raw materials utilities and depreciation.

- accounts payable: 30 days for raw materials and utilities.

b) The co-efficients of turnover have been calculated for the components of current assets and liabilities by dividing 360 days by the number of days of minimum coverage.

c) Current liabilities are deducted from the sum of current assets to obtain net working capital.

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Table 9.2 Working Capital Requirements

Item	X	Y	Requirements Start-up 2 Year 50%	Requirements Full Capacity 3 Year 100%
1. Current Assets				
A) Accounts receivable	30	12	12,000	16,750
B) Inventory				
a) Raw materials				
- local	30	12	2,200	4,400
- imported (packaging mat.)	100	3.6	17,950	35,900
b) Spareparts	180	2	4,500	4,500
c) Finished products	15	24	6,000	8,375
C) Cash in hand	15	24	10,090	7,300
D) Total Current Assets			52,740	77,225
2. Current Liabilities				
A) Accounts payable	30	12	10,500	20,900
3. Working Capital				
A) Net working capital			42,240	56,325
B) Increase in working capital			-	14,085
4. Cash Balance				
Total production costs			421,000	480,100
less: Raw materials			92,700	185,400
Utilities			33,050	66,100
Depreciation			53,600	53,600
Total Balance			241,650	175,000
5. Required Cash Balance	15	24	10,090	7,300

X = minimum days of coverage
Y = co-efficient of turnover = 360 days/X

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9.1.3 Sum of Total Investment Costs

Table 9.3

Item	Construction 1 Year F.C.	L.C.	Total	Start-up 2 Year	Full 3 Year	Total F.C.		Total
1. Fixed Investment	370,000	258,000				370,000	258,000	628,000
2. Working Capital (increase)	-	-	628,000	42,200	14,100	-	56,300	56,300
Total Investment Costs	370,000	258,000	628,000	42,200	14,100	370,000	314,300	684,300

F.C. = Foreign currency
L.C. = Local currency

Figures are rounded

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9.2 Project Financing

Two alternative ways of financing are possible:-

1. With outside financing e.g. 50% by equity capital and 50% by a long-term loan from the National Development Bank.

2. Without outside financing i.e. 100% by equity.

In general alternative 1. is more profitable for the investor and therefore only this way will be discussed below.

9.2.1 Outside Financing

The total investment costs amount to Le684,300 of which at least 50% has to be financed by equity capital contributed by the investors from their own funds (NDB - requirement).

The remaining 50% can be granted by a long-term loan mat 15% interest a grace period of two years and an amortisation period of 8 years (working capital requirements are included in this loan, which is normal practice of NDB).

Financing proposal:	Le342,150	Equity 50%
	Le342,150	NDB - Loan 50%
	Le684,300	Total

Table 9.4 Interest and Amortisation Schedule

Year	Outstanding	Amortisation	Interest
1	-	-	-
2	342,150	-	51,322
3	342,150	42,770	51,322
4	299,380	42,770	44,907
5	256,610	42,770	38,492
6	213,840	42,770	32,076
7	171,070	42,770	25,660
8	128,300	42,770	19,245
9	85,530	42,770	12,830
10	42,760	42,760	6,414
Total	342,150	342,150	282,268

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Table 9.5 Net Income Statement

Period	Constr.	Start-up	Full Capacity			
Year	1	2	3	4	5	10
Production Programme	0	50%	100%		.....	100%
1. Sales Revenue	-	678,750	1,357,000	1,357,000	1,357,000	1,357,000
2. Production Cost	-	421,000	480,100	473,685	467,270	435,192
3. Gross Profit	-	257,750	876,900	901,315	907,730	939,808
4. Tax (55%)	-	-	-	-	499,250	516,890
5. Net Profit	-	257,750	876,900	901,313	[illegible]	[illegible]
6. Dividends (15%)	-	-	-	-	203,550	203,550
7. Undistributed Profits	-	257,750	876,900	901,313	204,930	219,368
8. Accumulated Undistr. Profits	-	257,750	1,134,650	2,035,963	2,240,893	3,308,848
Ratios						
Gross Profit on Sales (%)		38	65	66	67	68
Net " " "		38	65	66	30	31
Net Profit on Equity (%)		75	256	263	119	124

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Appendix

Export Specification for Charcoal Briquets

Carbon content	60% minimum
Moisture	4% maximum
Binder	ca. 9%
Incombustibles (ashes + energy extender)	ca. 22%
Shape	pillow
Size	40 x 35 x 30mm

Burning characteristics:-

- must be overashed to 75% 15' after ignition.
- reaches cooking temperature 20' after ignition.
- cooking time prolonged to 2 hours and 30'.

Packaging:- 3Kg paper bag, three layer, customer label
10Kg bag kraftpaper
5 three Kg. bags in one bale, kraftpaper

Safety regulations:- Can be shipped by truck, rail and ocean going vessels, except by airplanes.
After drying and curing immediate shipment permitted.
Must not be loaded together with saw dust, wood chips.

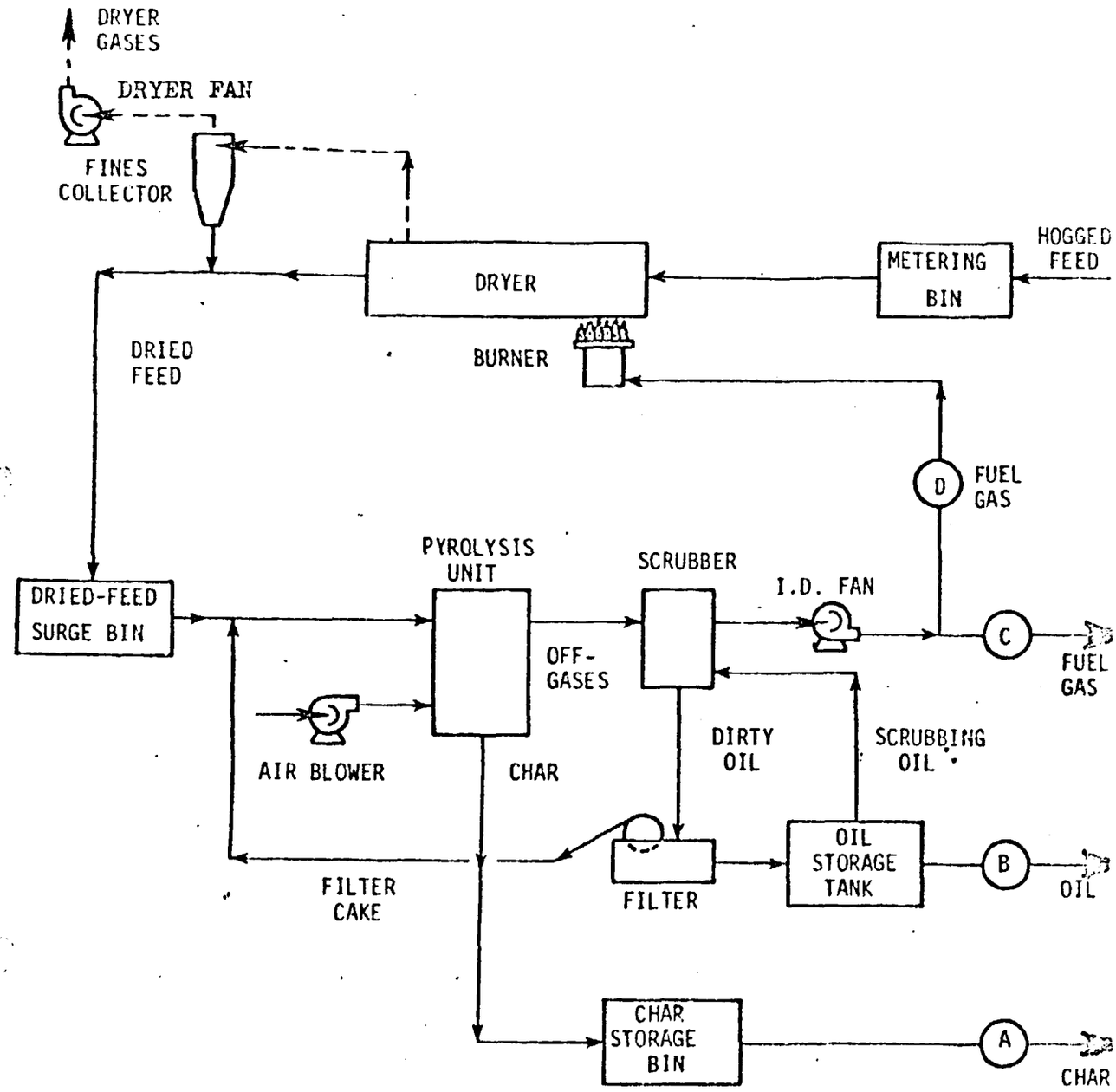

FIGURE 1. Generalized Flow Diagramm for the Integrated Pyrolysis Process (IPP).
Char Briquetting Plant not included.

P R O D U C T I O N
OF

Charcoal Briquets and Pyrolysis Oil from Forestal and Agricultural Waste in Sierra Leone

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Ref: Feasibility Study

An assessment of the possibilities of a small scale charcoal industry made by UNDP (UNDP Project: DP/SIL/78/002/11-55/31.2.F.) has proved the viability of this project and shows its significant economic value.

For the project implementation it is necessary to obtain additional results by a feasibility study and laboratory tests.

The study should include the following items:

- Plant site
  Selection of the plant site in the Kenema area, establishing of the plant layout

- Electricity Supply

  Selection and evaluation of a producer gas operated generator

- Raw Material

  Laboratory tests with various raw material compositions to determine the optimal capacities of the converter and off-gas system, size reducing equipment and raw feed dryer

- Products

  Composition of raw char (incombustibles, fixed carbon, volatiles, bulk density)
  Composition of charcoal briquets, selection of binder composition, energy extender, fermentation preventer and ignition enhancer. Commercial data of the charcoal briquets (burning characteristics, strength, bulk density)
  Pyrolysis oil
  Composition, viscosity, flow properties, burning test

  Calorific values of charcoal briquets and pyrolysis oil

- Pre-production marketing

  Supply of charcoal briquet samples to selected customers in Europe to obtain sales contract

- Project Engineering

  Specification on equipment and machinery and pro-forma costs.

  Evaluation of local equipment supply in cooperation with the National Workshop

- Project Financing

  Evaluation of financing in cooperation with the National Development Bank.

- Final report

The estimated costs of the study are:

1.	1.5 man/months Charcoal Production Eng. (Team Leader)	US$11,250
2.	1.5 man/month Industrial Economist (marketing expert)	11,250
3.	Travel expenses*	8,000
4.	Laboratory tests and Technical advisory	12,500
	Freight for test material	1,500
5.	Report editing and other non considered cost(contingencies)	500
	TOTAL	$45,000

*This does not include local (Sierra Leone) transport, secretariat and other related facilities.

It is estimated that the feasibility study can be completed within four months.

Sierra Leone 3 July 1981

[redacted]