Centre for
Industrial Development
(ACP-EEC Lomé Convention)

CID CDI

Centre pour le
Développement Industriel
(Convention ACP-CEE de Lomé)

INVENTORY OF ADAPTED TECHNOLOGIES FOR ACP COUNTRIES

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P R E F A C E

During the last four years, the Centre for Industrial Development (CID) in Brussels has undertaken the task of searching for, identifying and drawing up of profiles of industrial technologies which have been proven to be successfully adapted to the socio-economic conditions of African, Caribbean and Pacific (ACP) countries. The compilation of these profiles into an inventory for publication and dissemination is thus a logical step towards effectively responding to one of the mandates established under the Industrial Cooperation of the ACP/EEC Convention of Lome. The CID has been specifically charged with the responsibility to have

> *"studies carried out on the possibilities and potential for industrial development of the ACP States, bearing in mind the necessity for adaptation of technology to their needs and requirements, and to ensure their follow up."*

Although much has been published and publicised in the realm of appropriate and intermediate technologies, the technical and economic data necessary to establish their commercial viabilities are often scanty and inadequate for an investment assessment and for technology transfer. With a view to bridging this gap, a study group was set up with membership drawn from ACP and EEC experts, institutions and industrialists to elaborate the important criteria to be used in evaluating the cost benefit of selected technologies to hosting ACP States. Given the heterogeneity of the economic resource potential that can be found among ACP States, a wide range of investment capital and plant capacities have had to be accommodated in this inventory.

The reaction to the preliminary issues of this inventory has been quite tremendous and has excited considerable demand for the information contained therein. Perhaps what it has done more than anything else is to offer the opportunity to users of this inventory of Adapted Technologies (IAT) to become identifiers and evaluators of industrial project ideas relevant to their economic setting. The Centre's objective goes much further, as it is our wish to assist ACP potential investors planning to exploit any of these published technologies with the identification of knowledgeable and reliable joint venture partners, negotiation of licensing arrangements and the search for concessionary sources of implementation financing.

Finally, I should like to thank all the individuals and organisations who have given permission for the materials used as well as those who have contributed to make this publication possible.

Dr. I. A. AKINRELE
Deputy Director

24 November 1982.

NOTICE

This Inventory has been prepared for the use of ACP promoters, entrepreneurs, as well as for ACP organisations dealing with industrial development.

The information contained in it is supplied free of charge and should not be re-used for sale or commercial benefit.

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INTRODUCTION

Out of the 63 ACP countries, 44 have less than 5 million inhabitants, and 21 have less than 500,000 inhabitants. One is immediately confronted by the problem created by limited markets for industrial products, which determine the planned capacity of production units.

The small size of these markets, coupled with transport and distribution problems in countries with large land areas (which is the case of most African countries) leads ACP promoters to opt for small and medium-sized industrial projects. This in turn contributes to the decentralization of industrial activities matching the financial and technical capacity of ACP promoters.

The search for small and medium scale technologies and their transfer to ACP countries is not always easy. They are often based on processes and equipment which, in Europe, are now seldom used, having been replaced by more sophisticated technologies with higher production capacities. Thus, a large number of small and medium sized industrial projects are blocked and many interesting possibilities remain unexploited.

In order to solve these problems the CID has undertaken over the last few years a work programme on adapted technologies to stimulate small and medium sized industrial projects in ACP countries. The objectives of the programme are to identify the technologies, to proceed with their technical and economic evaluation, to diffuse them as widely as possible to ACP countries, and finally to assist with the promotion and implementation of projects based on the technologies presented.

In the search for and the selection of the technologies, the following criteria have been applied :

- technologies which have proved commercially viable in either developing or industrialized countries;

- low investment costs, placing the projects in the small and medium sized industry range at the ACP countries' level;

- technologies oriented to industrial production or services, meeting the basic needs of the population : food, housing, clothing, health...;

- adding value to local raw materials and resources;

- relative simplicity of the technologies used;

- supply of import substitution products (foreign currency savings).

Obviously a given technology will not be able to satisfy all these criteria, the relative importance of which has to be determined by ACP promoters, taking into account the needs and priorities related to their projects.

The technologies, identified with the cooperation of experts, industrialists and specialized organisations from ACP and EEC countries, are presented as industrial profiles including the basic technical and economic data necessary for assessing the economic viability of the projects.

Such an evaluation is made on an illustrative basis using the Net Present Value method, taking a standard range of costs for the various production factors for the sake of simplicity. The aim of the method is to give a quick answer to the following question :

" for a given discount rate (10, 20 and 30%), what is the minimum revenue required (i.e. the selling price of the product or services) to make the project viable ?".

This economic evaluation should be considered as a rough approximation intended to give an idea of the viability of the projects in determined conditions. It should be carried out in a complete way on the basis of actual costs and specific local conditions, when a promoter has decided to go ahead with the implementation of a project based on one of the technologies presented.

To date 58 profiles have been published in threee successive volumes of the "Inventory of Adapted Technologies for ACP Countries", which have been widely diffused. Increasing interest has been aroused both from ACP promoters and organisations dealing with industrial development.

The three previous volumes have now been edited into one volume for convenience and ease of reference. The profiles are classified by industrial sectors according to the International Standard Industrial Classification (ISIC) system, with a special sector for the applications of alternative energy.

A few profiles already published have been withdrawn for a number of reasons. Some for example require complete revision, with up-dated information. Investment and production costs in this revised volume still refer to figures contained in the original profiles and are related to the year in which they were produced, assuming that in any case an actual up-dating of all figures will be needed for each concrete project.

It is obvious that, in the field of adapted technologies, many possibilities remain to be exploited. The CID is therefore continuing its programme, and in this respect, any contributions and suggestions from ACP and EEC experts, industrialists and specialized institutions for further profiles will be appreciated. These can cover :

- technologies similar to the ones already published, but with alternative production processes, different outputs or fresh sources of technologies,....

- new technologies which have not yet been published, meeting the criteria given above.

It is important to note that the final objective of the work programme is the effective implementation of small and medium size industrial projects based on adapted technologies. In this respect the CID can assist ACP promoters along the different stages of promotion and implementation of their projects including :

- pre-feasibility and feasibility studies;
- negotiations with technology suppliers;
- joint-venture liaison;
- search for project finance;
- implementation and start-up of production;
- training of personnel.

The promoters are invited to contact the CID which will supply further information and the required assistance.

1. RECONSTITUTED MILK PLANT

(ISIC Code 3112 - produced 1981)

This profile deals with a plant producing UHT milk from milk powder, milk fat, and water. The capacity of the plant is 4,500,000 litres per annum. The fixed investment amounts to $1,278,200 and 27 people are employed.

1. PRODUCT DESCRIPTION

This profile considers a plant producing reconstituted pasteurized then sterilized and packaged milk. The method of packaging the milk will affect the costs, and in this case the cheapest method, packaging in compound plastic film bags, is assumed to be used. The output is UHT milk, that is, it has received ultra high temperature treatment.

2. DESCRIPTION OF TECHNOLOGY

The equipment needed is as follows:

a) module for the recombination and pasteurization of milk, with cleaning system;
b) a module for ultra high temperature treatment;
c) heating plant module;
d) refrigeration module;
e) compressed air module;
f) standard module for the regeneration of drinking water;
g) auxiliary fluids and water saving systems;
h) electrical equipment and connection to transformer; and
i) packaging equipment.

The milk is reconstituted from milk powder, anhydrous milk fat, and regenerated drinking water. It is then pasteurized to destroy micro-organisms and improve the keeping quality. Sterilization of the milk is done by the UHT method, using steam to heat the milk. The procedure increases the rate of heating and cooling so as to give the minimum of chemical change consistent with the required bacteriological kill. After heating, the milk must immediately be cooled in order to retard the growth of surviving bacteria. As many instruments are pneumatically operated, the plant has its own air compressor. Equipment for making the plastic bags used for packing is also necessary.

3. LEVEL OF OUTPUT

The daily output considered in this profile is 15,000 litres of milk. For a single shift, 8 hour day, and 300 days per year, this gives an annual output of 4,500,000 litres.

4. EMPLOYMENT AND EMPLOYMENT COSTS

			$
1	Manager	at $4,000 per annum	4,000
4	Supervisors	at $2,400 " "	9,600
7	Skilled Workers	at $1,920 " "	13,440
15	Semi-skilled Workers	at $1,200 " "	18,000
27			45,040
		Other Annual Labour Costs:	4,504
		Total Annual Labour Costs:	49,544

5. DATA FOR ECONOMIC ANALYSIS

A. INVESTMENT COST

		$
i)	Fixed Investment :	
	Machinery and Equipment	1,098,200
	Land and Building (1500m² x $20; 1000m² x $120)	150,000
	Erection Cost	30,000
		1,278,200
ii)	Working Capital :	
	Stock of materials(3 months)	222,750
	Wages and Salaries(2 months)	8,257
		231,007
iii)	Residual Value :	$
	10% of Equipment Costs	109,820
	50% of Land and Building Cost	75,000
		184,820

B. ANNUAL OPERATING COSTS

		$	$
i)	Materials :		
	Milk powder(413t)	405,000	
	Milk fat	270,000	
	Special Compound for Plastic Bags	198,000	
	Water and Detergent	18,000	
			891,000
ii)	Wages and Salaries :		49,544
iii)	Electricity :		18,000
iv)	Fuel :		48,000
v)	Repairs and Maintenance :		10,000
vi)	Overheads		10,000
			1,026,544

C. EVALUATION (Values in US $)

This is based on a 10 year operating life, a 3 year build-up to full capacity production, and a residual value for buildings and equipment. Fixed investment is $1,278,200. Working capital is taken in 3 instalments over the first three years of operation and the residual value ($184,820) and working capital ($231,007) are returned in the 10th year of operation.

The production costs build up as follows:

	Year 1 (65%)	Year 2 (75%)	Year 3 (100%)
Materials	579,150	668,250	891,000
Wages and Salaries	32,204	37,158	49,544
Electricity	11,700	13,500	18,000
Fuel	31,200	36,000	48,000
Repairs and Maintenance	6,500	7,500	10,000
Overheads	6,500	7,500	10,000
	$667,254	$769,908	$1,026,544

The following are the results of NPV analysis:

Discount Rate	Present Value of Total Costs	Annual Revenue Required for Given Discount Rate	Revenue Required per litre
10%	7,078,319	1,259,539	0.28
20%	5,199,375	1,394,985	0.31
30%	4,132,504	1,545,526	0.34

2. GARI PRODUCTION

(ISIC code 3113 - produced 1979)

Gari, a dried cassava product, is an important carbohydrate food consumed in particular in West and Central Africa. The production process described in this profile involves washing and peeling the tubers, which are then grated and subjected to fermentation, before being dewatered, cooked and dried. The plant uses about 18 tonnes of tubers per day, producing 800 tonnes of gari per year of 250 working days. It provides employment for 54 persons in single shift working. The initial investment is almost $2.5 million.

1. PRODUCT DESCRIPTION

Gari is the name given to a dried cassava product. Grating and fermenting the washed and peeled tubers are essential stages in the process before drying.

It is a very important carbohydrate food consumed in most West African and Central African countries and is a main article in the diet of about 100 million people.

As normally prepared it is a straw-coloured, coarse-textured meal. It has usually a characteristic acid odour. At normal moisture levels (8 to 10%) it keeps well at ambient temperature for several months. When kept at higher moisture levels mould growth and unacceptable off-flavours develop.

Gari is usually cooked with boiling water into a thick paste or dough and used as a side dish with a meat, fish or chicken stew. It is also made up into a thick suspension in cold water with added sugar and supped with a spoon or drunk as a beverage.

The preparation of gari has been traditionally done in most African societies by women and girls but in the last few decades it has become a much disliked household task, especially by the younger. Attempts to mechanize the process have been attempted at different times but it was only in the early 1960's that serious sustained research was done on it by the Federal Institute of Industrial Research, Oshodi, Nigeria. With this work as a basis later collaboration between the FIIR and a British firm of engineers resulted in the development of an industrial process with suitable machinery for gari manufacture.

Gari produced by this method on the plant designed for it is indistinguishable from gari produced by the traditional method. Patents are held by the engineering company in respect of different parts of the plant.

2. LOCATION

Gari processing plants could be established at suitable sites throughout the West African countries from Gambia to Cameroun and even to Zaire.

Commercial plants, including two very large ones, are already operating successfully in several of these countries, especially in Nigeria and Guinea.

3. DESCRIPTION OF TECHNOLOGY

The main stages in the process can be briefly described as follows:

a. Washing and peeling the tubers

After harvesting washing the tubers is normally done in cold water in galvanised iron tanks made for the job or in large plastic baths. Adhering soil and other dirt can be readily removed by brushing the tubers with a stiff brush.

Peeling can be done manually with sharp steel knives and, in a labour-intensive plant, this would be the preferred method. Surface blemishes, protuberances, or small holes can be dealt with at the same time.

A method of mechanical removal of the skin (strictly speaking, the cortex) by abrasion on a carborundum plate rotating at the bottom of a special vessel has been developed. But to obtain complete removal of the cortex and to deal with surface blemishes it may be necessary to remove up to one-third of the substance of the tuber - an economically unsatisfactory position.

b. Grating the peeled tubers

This is done mechanically on rotary graters and presents no significant problems. The degree of fineness of the grated particles can be varied within limits by adjustments to the grater. This is important since the degree of fineness of the finished gari can be an important factor in consumer acceptance.

c. Fermentation

This process is of fundamental importance for the development of the highly-valued sharp flavour of the finished gari. Much research on the microbiology of the process has been done and different micro-organisms have been isolated from the fermenting material and are believed to have some part in the final flavour. Both lactic acid and acetic acid producing organisms appear to be involved in the process.

In the process now being described the fermentation takes place in a stainless steel fermentation vessel. As in the traditional process this takes place at ambient temperature (28 to 30°C) for a period of 48 to 72 hours.

d. Pressing (or dewatering)

This process involves the removal of the liquid material which has been produced from the grated cassava particles during the fermentation process. In the traditional process the object was achieved by putting the fermented mass into cotton bags and setting heavy stones on the bags for up to one day. In this process dewatering is done by putting the fermented mass into terylene bags and allowing them to stand inside special cylindrical vessels until all free moisture drains out.

e. Cooking and drying

It is now recognised that one of the critical factors in the production of gari of the desired consistency and swelling properties is the degree of gelatinisation of the starch granules. Virtually all the granules have to be gelatinised and this stage is carried on in the cooking operation.

The gelatinised gari is then transferred to the separate drying vessel for drying at a slow rate. Both the cooking and drying vessels are fitted with screw stirrers to maintain the material in constant movement during these stages of the process.

f. Packaging

Normally large cotton bags are used for packing the dry gari for transportation to wholesalers. In turn they transfer it in weighed quantities into flexible heat-sealed plastic containers for retail sale.

4. LEVEL OF OUTPUT

In the notes which are developed for investment and other costs in the next section one of the plants available commercially is used as a basis of calculation. This plant utilizes 2240 kg. of raw cassava tubers per hour and produces 400 kg. of finished cassava (at 8 to 10% moisture) per hour. It is assumed that the plant would work 250 days per year with an 8-hour working day.

5. EMPLOYMENT

Manager 1, Administrative and office staff 5, Shift Supervisors 2, Process operators 8, Quality Control staff 4, Labour (mainly for tuber cleaning and peeling) 24, Engineering staff 6, Drivers 4, making a total of 54 persons.

It should be noted that this total does not take into account staff who would be involved in the actual agricultural operations. It further assumes that the total of about 18 tonnes of cassava tubers due to be processed each day are within easy reach of the factory and are loaded on to the lorries by the agricultural labour force.

No provision is made for labour used in the operation of any sewage disposal plant in use.

The following rates of pay have been used in the economic evaluation (mid 1978 prices):

(i) annual rates : Manager $7000, executive office $4500, clerk (2) $2500, supervisor (2) $4500, senior quality control staff $4500, junior quality control staff (3) $3500.

(ii) daily rates: typist (2) $7, process operators (8) $7, craftsmen (6) $10, driver $6, unskilled labour (24) $3.

6. ECONOMIC ANALYSIS

A. INVESTMENT COST

Fixed investment.

Item	Local cost $	Imported cost $	Total $
Land, incl.agricultural land	20,000	-	20,000
All civil work incl. site preparation	550,000	120,000	670,000
Plant and equipment	150,000	780,000	930,000
Freight and insurance	15,000	310,000	325,000
Installation costs	35,000	130,000	165,000
Transport	40,000	100,000	140,000*
Contingencies at 10%			225,000
Total			2,475,000

* This item is assumed to be repeated at end year 5 and end year 10.

B. ANNUAL OPERATING COSTS

	$	Total $
i) Materials:		
Cassava tuber	89,600	
Detergents	4,000	
Packaging	13,000	
Boiler water treatment	10,000	
		116,600
ii) Wages and Salaries:		92,500
iii) Water and Fuel:		
Electricity	60,000	
Process water	15,000	
Fuel for steam	12,500	
		87,500

		$	Total $
iv)	Motor transport:		
	Fuel and oil	40,000	
	Insurance	15,000	
	Servicing	5,000	
	Spares	20,000	
			80,000
v)	Repairs and maintenance: (5% installed plant and equipment)		71,000
vi)	Overheads:		
	1% fixed capital	24,730	
	5% working capital	2,885	
			27,615
			475,215

C. Working Capital

12% annual operating costs 57,026

D. Residual Value after 15 years

10% of the equipment value and on transport of material	153,500
50% of land and civil works	375,000
	528,500

E. EVALUATION (values in US $)

This is based on 15 year operating life, a 3 year build up to full capacity production, and a residual value for land, building and equipment. Fixed investment is 2,475,000 including for the pre-investment expenses. Working capital, 57,026, is taken in 3 instalments. On year 1 : 19,010; on year 2 : 19,008; on year 3 : 19,008. The residual value, 528,500, and working capital 57,026, are returned in the 15th year of operation.

Thus, production costs build up as follows :

	Year 1 (1/3)	Year 2 (2/3)	Year 3 (full)
Materials	38,866	77,734	116,600
Wages and salaries	92,500	92,500	92,500
Fuel and water	29,167	58,333	87,500
Motor transport	48,000	64,000	80,000
Repairs and maintenance	23,667	47,333	71,000
Overheads	27,615	27,615	27,615
	259,815	307,515	475,215

The following are the results of NPV analysis :

Discount Rate	Present value of total costs	Annual revenue required	Revenue required per kilo
10%	5,783,027	860,101	1.07
20%	4,482,229	1,153,038	1.44
30%	3,833,970	1,498,815	1.70

3. SMALL-SCALE FRUIT CANNING

(ISIC Code 3113 - produced 1981)

This profile describes a technology available in India for the production of canned mango slices and mango pulp. Process modifications can be made to utilize other types of fruit. The fixed investment amounts to about $22,000 and 15 people would be employed.

1. PRODUCT DESCRIPTION

The technology of the plant is based on machinery and equipment made in India. It is capable of processing different fruits for the manufacture of fruit slices in cans, concentrates, jams, etc. This technology profile considers only one fruit, mango, as the basic raw material for the production of mango slices and mango pulp. If an investor decides to use other fruits as well it is possible to adjust the production process.

2. DESCRIPTION OF TECHNOLOGY

The manufacturing process consists of peeling the ripe mangoes and cutting these into slices of almost equal size after which they are put in brine (2%) or a solution containing 0.95% to 1% citric acid to prevent browning. The next stage is to put the slices into cans containing sugar syrup with 0.3% to 0.5% citric acid. The cans are further processed in boiled water for about 30 minutes.

The residue from the mangoes after slicing is used to get the pulp by squeezing out the juice. The pulp is further processed and put into cans, as with mango slices.

The following are the main operations:

a) Sorting and Grading. The ripe mangoes are first sorted on the basis of size, colour and maturity of the fruit. Fruits with blemishes are also sorted out. The quality of the final product largely depends on careful sorting and grading of ripe mangoes. Before putting the prepared fruit slices into cans a final sorting is also carried out.

b) Washing. Fruits are thoroughly washed to remove impurities. This may be done by soaking, agitation or spraying.

c) Peeling and Cutting. The fruits are carefully peeled and cut into slices. Special knives are used for this operation.

d) Washing and Sterilizing. The cans are cleaned and washed with a steam jet. The normal practice in small-scale production is to wash the cans in hot water, but the present trend is to sterilize the cans before use.

e) Can Filling. At this stage, the prepared fruits are put into cans. Automatic operation is usually carried out, although choice grades of fruits are canned by hand to prevent bruising.

f) Syrup Making. Sugar is used to make syrup. A steam jacketed kettle is used for preparing syrups. A smaller quantity of water is used to yield heavy syrups. The proportion of sugar in the syrup is accurately tested by hydrometer before use.

g) Exhausting. For this purpose the cans are passed through a tank of hot water at about 82°C to 88°C. The purpose of exhausting is to prevent overfilling and create a vacuum after sealing. The vacuum depends on the temperature of the can at the time of sealing after exhausting. The time of exhaust varies from 5 to 20 minutes so as to allow the temperature in the middle of the can to reach 79°C.

h) Sealing. The cans are sealed immediately after the process of exhausting.

i) Sterilizing. The canned fruits are made safe against attacks by micro organisms through heat treatment. During this, heat is transferred to the canned fruit by conduction and convection.

j) Cooling. The heat-treatment is followed by a period of cooling in cold water.

k) Labelling. The next stage is to put labels on the outer surface of the can. It can be done manually or by machines.

l) Storing. The cans are stored in a cool place as high temperatures can shorten the life of the product.

Machinery and equipment of the plant include:

- Steam generator, complete with all accessories, blower and motorized water feed pumps;
- Flattened can reforming unit consisting of can reformer with rubber roller and hand flanger;
- Heavy duty can sealer;
- Can washer and sterilizer;
- Pulper (capacity 0.5 to 1 tonne per day);
- Hydraulic juice press;
- Stainless steel storage container;
- Filter press (capacity 90-150 litres per hour);
- Preparation and filling tables;
- Steam jacketed pressure vessels;
- Exhaust box, and
- Cooling tanks.

3. LEVEL OF OUTPUT

Because of the seasonal nature of operation, the plant is assumed to operate 180 days a year. One tonne of mangoes are processed daily. One shift operation of 8 hours is considered. The level of annual output is 180 tonnes per year. The final product contains sugar, water and a small amount of citric acid, besides the main input, mangoes.

4. EMPLOYMENT AND EMPLOYMENT COSTS

			$
1	Manager	at $4,000 per annum	4,000
1	Chemist	at $3,000 " "	3,000
1	Supervisor	at $2,400 " "	2,400
1	Accountant/clerk	at $2,400 " "	2,400
2	Skilled Workers	at $1,920 " "	3,840
5	Semi-skilled Workers	at $1,200 " "	6,000
4	Unskilled workers	at $ 720 " "	2,880
15			$24,520
	Other Annual Labour Costs:		2,452
	Total Annual Labour Costs:		$26,972

5. DATA FOR ECONOMIC ANALYSIS

A. INVESTMENT COST

		$
i)	Fixed investment :	
	Machinery and Equipment	8,810
	Land and Buildings	12,500
	Transport and installation	1,000
		$22,310
ii)	Working Capital :	
	Stock of materials(3 months)	7,167
	Wages and Salaries(2 months)	4,495
		$11,662
iii)	Residual Value:	
	10% of Equipment Costs	981
	50% Building cost	6,250
		$ 7,231

B. ANNUAL OPERATING COSTS

			$
i)	Materials :		
	Mangoes	25,000	
	Flattened cans	2,667	
	Chemical/preservative	333	
	Labels and packing	333	
	Miscellaneous	333	28,666
ii)	Wages and Salaries		26,972
iii)	Water and Electricity		167
iv)	Repairs and Maintenance		500
vi)	Overheads		600
			$56,905

C. EVALUATION (Values in US $)

This is based on a 10-year operating life, a 3 year build up to full capacity production and a residual value for buildings and equipment. The fixed investment amounts to $22,310. The working capital ($11,662) is taken in three instalments over the first three years. Working capital and residual value ($7,231) are returned in the tenth year of operation.

Production costs build up as follows over the first three years:

	Year 1 (65%)	Year 2 (75%)	Year 3 (100%)
Materials	18,633	21,500	28,666
Wages and Salaries	17,532	20,229	26,972
Power, Water & Fuel	109	125	167
Maintenance	325	375	500
Overhead	390	450	600
	$36,989	$42,679	$56,905

The following are the results of NPV analysis:

Discount Rate	Present Value of Total Costs	Annual Revenue Required for Given Discount Rate	Revenue Required per kilogram
10%	344,170	61,243	0.34
20%	239,283	64,199	0.35
30%	179,936	67,295	0.37

4. DRY MILLING OF MAIZE

(ISIC code 3116 - produced 1979)

Wet milling of maize is a highly sophisticated and capital-intensive process. Pounding, the traditional small-scale method for the production of meal, on the other hand is very wasteful. This profile describes an alternative small-scale method, dry milling by machine, which greatly reduces waste. The milling capacity is 250 kg. maize per hour (500 tonnes per year); employment is 2 people; and total investment is approximately $8,100.

1. INTRODUCTION

Africa produces about 17 million tonnes of maize annually out of a world total of over 300 million tonnes. Egypt and South Africa together account for about 11 million tonnes of the African total and South Africa exports more than 3 million tonnes of its 8 million tonnes a year.

Maize is the dominant cereal crop in East Central and Southern Africa and it is also grown in West Africa. Some form of pounding or dry milling is used to prepare the grains for cooking. Little is fed to animals. Wet milling on the other hand is a highly sophisticated and capital-intensive process which separates out the starch which is sold as corn flour; the yield is 70 per cent of the maize. The remaining 30 per cent is the raw material for cooking oil, adhesives, edible colouring, corn syrup, animal feedstuffs, etc. which are by-products of the wet mill.

2. LOCATION

Since maize has been pounded in large mortars to meal for some centuries in Africa, the farmer has to see positive advantages to himself before he carries his maize to a mill. Maize is stored at the farm on the cob and with the sheath still in place. Small silos of timber, mud and thatch are used, proof against rain, minor flooding, rodents and birds.

When required for food, the cobs are stripped and the grains, cleaned of rubbish, are ready for processing. Pounding is not only hard work but wasteful of food. It is usual to pound and then winnow the broken grains to separate out the "peels" (the coating on each grain) and the embryos. The operations are required until the maize left is reduced to a suitable mealiness for cooking. Losses are high and can be as much as 40 per cent if all traces of peel and embryos, as well as some starch, are removed, leaving almost pure white starch.

The alternative, to carry the maize grains to the nearest mill which may be a two hour walk, 8-10km there and back, is generally acceptable. The mill should be located so that more than enough maize is grown within a radius of 4-5km to provide the mill with 2,000 hours work per year. A circle of 5 km encloses nearly 2,000 ha and the yield per ha is likely to be 2 tonnes. Generally, maize fields are small and scattered and the area may in practice only contain 250 ha of maize, yielding 500 tonnes.

Farmers usually live in small villages, surrounded by their fields and grazing areas. The mill should be located in the main village of the area likely to supply maize for milling. This village probably has the best access to the nearest main road for the supply of diesel oil and for transport of surplus meal for sale elsewhere.

3. TECHNOLOGY OF MACHINE MILLING

A great advantage of machine milling over pounding is that the relatively hard and tough peels and embryos are thoroughly broken up and incorporated in the meal, together with the starch. The starch provides calories for energy but the peels and embryos supply oil and protein, giving an almost balanced human food, after cooking. This whole meal does not keep well due to the oil in the embryos going rancid, so a farmer has to go fairly frequently to the mill with his maize.

Machine mills can separate out the peels and embryos which are valuable concentrates for stock-feeding; the fairly pure starch then keeps for longer periods but it has little nutritional value. In view of the deteriorating relation of food production to population in Africa it is desirable that maize mills should produce whole meal. Milled maize is becoming popular and is being produced in increasing quantities. It can replace the white maize meal preferred by the higher income groups.

The commonest forms of power mills are hammer mills and plate mills. They are single-stage; a stator with an internal power-driven rotor which pulverizes the grains of maize, the meal escaping through a fine steel or brass screen. The loss, as flour dust, is low, under 1 per cent, a notable improvement on hand pounding.

Mills are on the market for rural use, with hourly capacities ranging from 100 to 1,000 kg of meal. Their power requirement is about 25 HP/hour per tonne of meal. Much bigger capacity mills are built for areas with large quantities of maize surplus to the needs of the growers. Roller mills are manufactured mainly for the production of fine corn-flour. The peels and embryos are discarded and used for stock-feed. Hand-powered maize mills are available, based on a small coffee mill design and therefore requiring much effort.

In view of the cost of fuel there is now a case for making more use of oxen. A pair of small animals can supply about 0.2 HP or more for some hours a day. If they produce 1 HP/hour in a day, this is power enough to mill 40 kg of maize, which will feed twenty people for five days, on a basis of 150 kg a head annually. This is a typical average consumption for a predominantely maize eating people.

4. INVESTMENT COST

A typical hammer or plate mill with a capacity of 250 kg of maize an hour needs about 6 HP to drive it. Operating in daylight hours only, for 2,000 hours annually, it will mill 500 tonnes of maize, the production of about 250 ha.

The cost of such a mill, including its engine, is $4,400 f.o.b. A small platform scale costs $600 f.o.b. The building and other auxiliary equipment are of local manufacture costing $2,000; giving a total investment in local terms of about $8,000 including freight and insurance on the mill and platform scale.

5. EMPLOYMENT

With a supply of about 2 tonnes of maize a day to be weighed before and after milling and also fed to the hopper of the mill, not more than two full-time jobs are created.

6. MAINTENANCE

Day to day maintenance of the machinery is of a very minor nature, well within the capacity of the mill staff. A visit from a qualified mechanic with access to spare parts, is desirable once every few months. These mills and engines are designed for minimum attention in rural areas.

7. ANNUAL REVENUE AND OPERATING COSTS

In the rural areas for which these small mills were designed, it is probable that the mill income is in the form of maize or meal at a rate of 10 to 15 per cent of the maize brought to the mill. A 15 per cent milling charge is now more likely on 500 tonnes a year, at $110 per tonne worth about $8,250.

8. ECONOMIC ANALYSIS

The profitability of a 250 kg/hour maize mill is analysed, using the preceding data.

A. INVESTMENT COST	$
Fixed investment	
Machinery price f.o.b.	5,000
Freight and insurance	1,000
Building and auxiliary equipment	2,000
	8,000
Working capital	
1 month's wages and salaries	117
Total investment	8,117

B. ANNUAL OPERATING COSTS	$
Wages and salaries	1,400
Fuel	900
Lubricants	90
Repairs and maintenance	300
Miscellaneous	210
	2,900

C. ANNUAL REVENUE 8,250

D. EVALUATION (values in US $)

This is based on 10 year operating life and a 3 year build up to full capacity production. Fixed investment is 8,000 including for the pre-investment expenses. Working capital, 117, is taken on year 1. The residual value, 800, and working capital 117, are returned in the 10th year of operation.

Thus, production costs build up as follows :

	Year 1 (1/3)	Year 2 (2/3)	Year 3 (full)
Wages and salaries	1,400	1,400	1,400
Fuel	300	600	900
Lubricants	30	60	90
Repairs and maintenance	100	200	300
Miscellaneous	70	140	210
	1,900	2,400	2,900

The following are the results of NPV analysis :

Discount Rate	Present value of total costs	Annual revenue required	Revenue required per tonne of milling
10%	24,250	4,608	9.21
20%	18,926	5,559	11.11
30%	15,922	6,684	13.36

5. RICE - MILLING

(ISIC Code 3116 - produced 1979)

The aim in rice milling is to remove the husks from paddy. In this profile, followinga brief description of the alternative technologies available, a 1 ton per hour rubber roll rice mill is evaluated. This mill produces 1,340 tons of rice (from 2.000 tons ofpaddy) per year and employs 7 people. The total investment is about $43.750.

1. INTRODUCTION

Rice mills are used for removing the hard inedible husks from threshed and dried paddy. Paddy is the only cereal which cannot be used as food, or as animal feed, until its husk has been removed. The removal of the husk exposes the brownish bran which coats the white grain of edible rice. The dry husks weigh about 20 percent of the paddy grain and have a fuel value about one-third that of coal. The bran weighs nominally 10 percent of the paddy but commercial bran includes some powdered rice. Pure bran contains 30 or more percent of proteins and oils. It has a high feed value, if stabilized by heating within 24 hours; otherwise, it goes rancid and unpalatable to livestock. Removal of the bran from the brown rice produces the main product, white rice.

2. LOCATION

The ideal location for a rice mill is a site surrounded by paddy fields, which means generally at a village inhabited by the paddy farmers. Most of a country's paddy farmers only cultivate very small fields adding up on occasion to one hectare of paddy per farmer. The farmer who has harvested, threshed and dried his grain paddy then has the option of having it pounded and sieved to rice at home or carrying it to a mill. If the nearest mill is inconveniently far away, he will put his paddy into home-made storage and his family will pound paddy to rice as it is needed. A mill should therefore generally be of small capacity and sited within easy walking distance, say 2 km of the most distant fields likely to supply it. In a wholly paddy growing area, this means that over 1,000 ha of paddy fields are within a half hour walk. If the village is on a power-grid, the mill could be electrically driven.

3. TECHNOLOGY

a/ Pounding

Traditionally, for milleniums grain paddy has been pounded in large wooden mortars using heavy wooden pestles. Sieving follows pounding to separate the loosened husks and the process is repeated until most of the husks have been removed. Pounding to produce a ton of edible rice from paddy takes about 1,000 hours. The yield of rice, more than half of it broken grains, is normally under 50 percent on paddy.

The discards are a mixture of crushed husks, powdered rice and bran. The high silica content of the husks renders the discards totally unsuitable for stock-feed.

b/ Single-stage power milling

By far the commonest form of mechanical mill for paddy is a copy of a late 19th century coffee-grinder, widely used in Asia where over 90 percent of the world's paddy is grown. It is sometimes known as an Engelberg or kiskesan, and probably about a quarter million of them are in regular use.

It can, and normally does, produce white rice from paddy in one pass. The usual half tonne of paddy an hour size yields a quarter ton of rice an hour, over half of it in the form of broken grains. The discards, separated out by a fan, are as useless as the discards from pounding.
The power needed by this type of mill is about 20 HP/hour per ton of paddy processed. The power is mostly converted into heat absorbed by the products and later dissipated.

c/ Multi-stage mills

All multi-stage mills first remove the husks and later the bran from the brown rice. A simple two-stage process produces white rice still containing the undersized unripe grains of paddy. The purchaser picks them out by hand before cooking. A lightly milled rice is of good nutritional value because traces of bran and germ remain on the grains. When rice is a minor item of a mixed diet, the demand is usually for a highly polished rice, which means that it is almost pure starch, its outer layers having been milled off along with the bran. This white rice passes through second, even third stages of milling which call for a much more expensive milling unit, plus sorting and sifting stages. Breakage of rice grains is heavy in two-and multi-stage mills, about 40-45 percent of the grains being broken. If the broken grains are separated out, a simple matter, they sell for anything between 70 to 30 percent of the price of the whole grain (head) rice.

With two exceptions, the huskers and polishers in multi-stage mills are modifications of stone flour-mills that have been in use for at least two thousand years. They operate on the grain by a combination of pressure and abrasion. It is only by careful adjustments that these machines do not grind all the rice to flour. One of the exceptions is the rubber roll mill - two heavy iron or steel rolls of about 10 cm diameter, covered with about 2 cm of hard rubber compound, the milling surface. The rolls only break 2-3 percent of the rice grains when they crack off the husks. However, the roll surfaces themselves wear out rapidly, the life of a pair being between 10 and 70 tons of Indica variety paddy. The other exception is the modified coffee grinder, already mentioned, which forces the grain through a hard steel screen. It is used for hulling only, or bran removal only, in the multi-stage mills. Yields of rice from multi-stage mills are almost always in the 65-70 percent range on the input of paddy. This is a third more edible rice than pounding or single-stage milling can achieve. A typical one ton of paddy an hour rice mill, using only two-stages and one cleaning operation for the paddy, needs about 20 HP. More power is required when some grain is recycled for re-milling and when sorting out of the broken grains is carried out by machinery. These mills use bucket elevators to feed the various stages, and these elevators absorb appreciable power and need careful maintenance.

d) Decorticating to replace milling

The grain of paddy is similar to the groundnut in that each has a strong outer husk and a thin coating on the edible content. Each needs two stages of decorticating.

Machinery has been built which removes the husks of paddy and then the bran, using little power in doing so, because few grains are broken. The grains are decorticated, not milled. These machines are in an advanced stage of development and have already given excellent performances in temperate climates on grains of about 12 percent moisture content. Yields of head rice in these conditions is about 68 to 72 percent, about the yields obtainable on parboiled rice.

4. LEVEL OF OUTPUT

In areas where the rural population is 70 percent and upwards of the total, and paddy is by far the most extensive food crop, a major problem of the farmers is transporting their paddy to the mill. Their only alternative is the time-consuming and highly destructive home-pounding. A national policy could then be to build numerous small two-stage mills, initially a 1/2 ton of paddy an hour capacity, to be doubled if crops increase. In the tropics, yields of paddy range from 1.5 to 2.5 tons per ha per crop. A 1/2 ton mill, operating only in day-light hours, can work for 2,000 hours a year and needs 1,000 tonnes of paddy. The crop area ranges from 670 to 400 ha. This would be suitable if the paddy fields were scattered, occupying half or less of the area within 2 km of the mill, which is 1,256 ha. If paddy already dominates the area within 2 km of the mill, than a 1 tonne an hour mill will be needed, but it may be economic to start with a 1/2 ton mill and install another one if and when the farmers seem likely to bring more of their paddy for milling, rather than to continue with hand-pounding. The 1 tonne mill annually processing 2,000 tonnes of paddy grown 2 km or less away is a typical case for economic analysis.

5. EMPLOYMENT

A 1 tonne rural mill will probably run as a family business, with neighbours employed casually to move paddy from store to mill and rice to store, and to load rice surpluses on to trucks for sale in town. Neighbours are likely to be paid in rice rather than in cash.

Total employment is likely to be equivalent to seven persons fully employed at $700 a year each.

6. ECONOMIC ANALYSIS

A. INVESTMENT COST

Fixed investment	$
Equipment F.O.B.	25,000
Freight & installation (15%)	3,750
Land, building and handling equipment	10,000
	38,750
Working capital	5,000

B. ANNUAL OPERATING COSTS

	$
Wages and Salaries	4,900
Replacement of rubber rolls (40 pairs at $125)	5,000
Repairs and maintenance (10% of equipment)	2,500
Energy	500
	12,900

C. EVALUATION (values in US $)

This is based on 15 year operating life, a 3 year build up to full capacity production. Fixed investment is 38,750. Working capital, 5,000, is taken in one instalment on year 1. The working capital 5,000, is returned in the 15th year of operation.

Thus, production costs build up as follows :

	Year 1 (1/3)	Year 2 (2/3)	Year 3 (full)
Wages and salaries	4,900	4,900	4,900
Other inputs	2,667	5,333	8,000
	7,567	10,233	12,900

The following are the results of NPV analysis :

Discount Rate	Present value of total costs	Annual revenue required	Revenue required per 100 kilo of rice*
10%	124,382	18,499	1.36
20%	88,978	23,147	1.70
30%	79,741	31,162	2.35

* This is the processing cost for 100 kg of rice if the mill gets 68 kg of rice from 100 kg of paddy.

6. SMALL - SCALE RICE MILL

(ISIC Code 3116 - produced 1980)

This profile describes a custom rice mill processing paddy for customers. The maximum throughput of the mill is 0.5 tonne of paddy per hour; the initial investment $7,314; and the level of employment 4 people.

1. PRODUCT DESCRIPTION

The project described in this profile is designed to produce milled rice from threshed and dried paddy. It is designed as a custom milling operation where the clients bring in their own supply of raw paddy to be milled for a fee. While the economic evaluation is based on a custom milling operation, it is technically feasible for the operation to be conducted on a commercial basis with the owner buying and stocking raw paddy and selling milled rice; the basic evaluation can be modified for a commercial operation.

2. DESCRIPTION OF TECHNOLOGY

Each rice grain is encased in a protective husk (hull); within the husk is a kernel of brown rice. The husk should be removed from the grain with as little damage as possible to the bran layer and without breaking the brown rice grain. Following de-husking the bran layer on the brown rice is removed by a polishing operation, leaving white rice which is starch rich endosperm. The whiteness of the rice (related to the removal of the bran layer) depends largely upon technology and consumer preference.

In this profile an integrated machine consisting of a rubber roller sheller (for husk removal), a husk aspirator and an Engelberg huller (for polishing and de-husking any unhulled paddy) is evaluated.

The rubber roller sheller consists of two closely spaced rubber rollers rotating in opposite directions, and at different speeds. As the paddy is fed into the sheller, the grains are caught under pressure by the rubber and, because of the difference in speed, the husk is stripped off. The rate of recovery of rice from paddy is about 68-72 per cent, and a greater proportion of unbroken rice is obtained than with older rice milling technologies. However, wear on the rubber rollers is considerable particularly with the longer grain paddy varieties and the storage life of spare rubber rollers is short (say, six months) due to the perishability of the manufactured rubber. This means that a guaranteed supply of spares is necessary to ensure continued operation of the mill.

The Engelberg huller (which was developed for de-husking but is used for polishing in this unit) consists of a cast iron cylindrical fluted roller revolving on a horizontal axis inside a sheath casing. The lower half of the casting is of slotted sheet metal. Polishing is achieved by the shearing action on the grain produced by the movement of the roller flutes past a stationary blade. Some control over the degree of polish is possible by adjusting the distance between the blade and the roller.

3. LEVEL OF OUTPUT

The mill is capable of processing a maximum paddy throughput of 0.5 tonne per hour. Since the evaluation is for a custom milling operation which is subject to fluctuating demand, we assume an average throughput of 2.5 tonnes per day for 300 working days each year. This gives an annual throughput of 750 tonnes of paddy.

4. EMPLOYMENT

The mill employs a miller (considered as a skilled operative), 1 semi-skilled assistant and 2 unskilled workers.

5. DATA FOR ECONOMIC ANALYSIS

A. INVESTMENT COST

i) Fixed Investment:

	$
Equipment f.o.b.	2,100
Freight at 20%	420
Installation and commissioning at 10%	210
Total	2,730
Building $48m^2$ at $50	2,400
Land 176 m^2 at $5	880
Total	3,280
Total Fixed Investment	$6,010

ii) Working Capital:

	$
Spares	925
1 month's Wages	380
	$ 1,305

iii) Residual Value:

	$
10% on Equipment	273
50% on Building and Land	1,640
	$ 1,913

B. ANNUAL OPERATING COSTS

		$
i)	Wages and Salaries	
	1 Miller at $1,920	1,920
	1 Assistant at $1,200	1,200
	2 Unskilled at $720	1,440
		4,560
ii)	Power	873
iii)	Repairs and maintenance	1,850
		7,283

C. EVALUATION (Values in US $)

This is based on a 10 year operating life, and a residual value for buildings and equipment. Fixed investment is $6,010. Working capital is taken in one instalment of $1,305 on the first year. The residual value of $1,913 and working capital of $1,305 are returned on the 10th year of operation.

The yearly production costs amount as follows:

Wages and Salaries	4,560
Energy	873
Repairs and Maintenance	1,850
	$ 7,283

The following are the results of NPV analysis :

Discount Rate	Present Value of Total Costs	Annual Revenue Required	Revenue Required to process 100 Kgs
10%	51,434	8,371	1.11
20%	37,114	8,853	1.18
30%	29,292	9,475	1.26

7. PARBOILED RICE PLANT

(ISIC Code 3116 - produced 1981)

> This technology profile considers the processing of raw paddy in a boilerless parboiling system which is particularly suitable for small-scale operation. The installed capacity of the unit is 150 kg. per batch of 4 hours. Total daily output assumed is 600 kg of parboiled paddy. Total fixed investment is $ 4,400. Two unskilled workers are employed.

1. PRODUCT DESCRIPTION

A parboiling process is considered in which raw paddy is given a treatment before the milling. The process of parboiling is a hydrothermal method which helps in the gelatinization of starch within the rice grain. During the hydrothermal process, the starch granules undergo an irreversible swelling and fusion, thus changing the starch from a crystalline form to an amorphous one. This transformation brings a change of the orderly polyhedral structure of the compound starch granules into a coherent mass.

The main advantages of parboiling are:

a) easier shelling of parboiled paddy because of the splitting of the compact husk during parboiling;

b) rice grains acquire strength during parboiling, thus reducing the percentage of brokens;

c) because of the steaming of paddy, the cooked parboiled rice retains more food values of the grain such as proteins, vitamins and minerals than cooked milled rice of the same variety;

d) as parboiled rice is harder it is more resistant to insect infestation compared to raw milled rice;
and

e) high recovery of rice; 10% higher rice yield can be obtained by ordinary milling from parboiled paddy than from raw paddy.

2. DESCRIPTION OF TECHNOLOGY

There are three stages in the parboiling process, as shown below :

RAW PADDY

1. SOAKING

2. STEAMING

3. DRYING

PARBOILED PADDY

Soaking. During this process the void areas between rice grain and hull are filled with water and as the starch granules absorb water, there is an increase in the volume of paddy.

Steaming. In the steaming process, the soaked paddy is given a steam treatment for a given period, as a result of which the starch present in the rice grain is gelatinized.

Drying. During this process the moisture content of the paddy (which is as high as 45-50% after steaming) is reduced to about 14% for milling.

The boilerless system, as the name implies, does not use a boiler. Instead, a round pot, specially designed for this purpose, is used. It has one inside and one outside layer and the gap between the two is well insulated to save heat. The bottom of the pot is made in such a way that under the inside bottom there is a sliding bottom and the space between the two is wide enough to contain the amount of water required for the steaming process. There is a water inlet, with a gauge attached, to pour water to the required level. There is also an outlet pipe to drain the water. Paddy is put into a round perforated steel basket to allow steam to penetrate. This steel-basket is put into the steaming chamber of the pot. In order to ensure even distribution of steam to every layer of the grains, there are two perforated vertical pipes arising from the sliding bottom of the pot and there are also inter-connecting pipes.

The paddy is given a hot soaking for a period of 3 hours followed by steaming at 80°C for ten minutes. After steaming, the paddy is taken out for drying. Sun or mechanical drying not exceeding 60°C and in passes, will give the highest recovery of rice from paddy.

Firewood is used as fuel, although in India husk is reported to be used. If husk is used with firewood, it will save a part of the cost of firing.

3. LEVEL OF OUTPUT

The scale of production considered is specially suited for small-scale commercial rice milling. The pots can be designed to take 50 to 200 kg. of paddy per batch of 4 hours, although in the first batch one should allow an extra hour or so for the initial firing and heating. For lifting the paddy basket, a manually operated overhead crane may be installed. Such a system will be needed particularly in bigger capacity pots and when the scale of production is such that several pots are installed side by side.

For this technology profile, a small-scale operation of 600 kg. per day for 200 days a year is considered. Such a scale is particularly convenient for operating a small rice mill at capacity level, based on one-shift per day. Sun-drying is assumed and this is the reason for considering 200 days of production per year.

4. EMPLOYMENT AND EMPLOYMENT COSTS

The whole process is operated by two unskilled workers. Any supervision needed is provided by the rice milling management as the parboiling unit is an extension (or a part) of the rice milling operation. No training is necessary.

2 Unskilled workers at $720 per annum	$1,440
Other annual labour costs:	144
	$1,584

5. DATA FOR ECONOMIC ANALYSIS

A. INVESTMENT COST

		$
i)	Fixed Investment:	
	Land and buildings	3,000
	Fabrication, and installation of the pot, paddy-basket, etc.	800
	Manually operated crane	400
	Miscellaneous equipment	200
		$4,400
ii)	Working Capital:	$
	Stock of firewood	120
	(Paddy will be supplied by the rice mill. No stock of paddy is, therefore considered).	
	Wages (one month)	132
		$252
iii)	Residual Value:	$
	10% of Equipment Costs	140
	50% of Land and Building costs	1,500
		$1,640

B. ANNUAL OPERATING COSTS

		$
i)	Firewood (0.1/t of firewood per day at $40/T)	800
ii)	Wages	1,584
iii)	Repairs and Maintenance	100
iv)	Overheads	100
	Total	$2,584

C. EVALUATION (Values in US $)

Project life considered is 10 years. Because of the simple nature of the equipment and its installation, full production is assumed from year 1. Working capital ($252) and residual value ($1,640) are returned in the 10th year of operation.

The results of NPV analysis are as follows:

Discount Rate	Present Value of Total Costs	Annual Revenue Required for Given Discount Rate	Revenue Required per 100 kg of rice
10%	19,777	3,218	2,68
20%	15,106	3,604	3,00
30%	12,444	4,026	3,35

8. DECORTICATION OF GROUNDNUTS AND MILLET/SORGHUM

(ISIC code 3116 - produced 1979)

Decortication of both groundnuts and millet/sorghum is considered in one decorticating machine. A scale of 1 tonne/hr of paddy or 2 tonnes/hr of groundnuts is viewed. Total employment is seven people; the total investment required is US $40,000.

1. TECHNOLOGY

A machine is used for decorticating both groundnuts and millet/sorghum. The machine was designed, and has been built and field tested specifically for husking paddy, as a decorticator. Breakage of rice and groundnuts during decortication has been very low indeed; the husks and shells come off cleanly and are separated by a flow of air and are blown aside. Breakage is low, power consumption is also low and little heating of the grains or nuts occurs. Tests have not been made on millet or sorghum on the full-scale machine because they have not yet been available in sufficient quantity at the machine. Laboratory-scale tests indicated that millet could be decorticated with the same material.

Primary decorticating (shelling) of groundnut pods has traditionally been done by hand, one by one; a tedious process and a bottle-neck in the farmer getting the shelled crop fresh to the market. Hand-operated machines have been in use for years in some countries, a swinging bar and screen mechanism. The fact that they are by no means universal indicates that they have their limitations and hand decortication remains common. Power-operated decorticators have also been built in the past, and appear to have died out.

Groundnuts normally have high oil content, one reason for growing them. The oil extracted is edible, and the residual cake is a stock-feed concentrate.

To offset the very high cost of almonds, pistachios and hazelnuts, all extremely labour-intensive crops, a low-oil content groundnut has been bred for use in the confectionary trades to replace nuts traditionally used. For confectionary purposes, these nuts must be shelled without being broken in the process. Having a low oil content, they can be cooked in oil, at a controlled temperature and evenly browned. They have then the suitable quality to replace the traditional confectionary nuts.

Secondary decorticating removes the brown skin of the nut. Nuts are usually marketed raw, with this skin intact. The skin falls off when the nut is grilled or roasted and it can be removed by aspiration.

No machines appear to be on the market which have a large hourly capacity, say half a tonne of white nuts an hour, and able to carry out the two decorticating operations in succession, and without breaking the nuts. Machinery now in an advanced stage of development for primary and secondary decortication of paddy and rice has been laboratory tested with groundnuts in the shell. The machine settings had to be considerably altered to cope with the nuts but white nuts did emerge unbroken and free of shells and brown skins.

2. LOCATION

Groundnuts are mainly a cash crop with a large proportion being exported after shelling, that is, after the first of two decorticating processes. Unlike paddy, groundnuts grow on dry soil dependent on rainfall but better yields may be obtained with supplementary irrigation in the drier areas. It is important to dig up the pods and sun-dry them as soon as they are ripe. Shelling should follow soon, but a farm family with a tonne or more of harvested pods has a long task on their hands. Delay in harvesting can lead to development of a fungus on the nuts which is dangerous to livestock and ultimately to men.

A groundnut farmer usually grows his own basic food, maize, as well; the two harvests coincide. The result is that harvesting and shelling the groundnut pods is put off until the maize cobs are harvested and safely stored. Marketing centres and co-operatives, to which the farmers can bring their pods for shelling and sale, are the obvious locations for shelling machinery. The time for shelling is the early dry season so the machines are liable to be idle for most months in a year. Ideally, the marketing centres will also purchase paddy which, properly dried and stored, will keep well for a year or more. If there is no paddy grown in the immediate area, it can be brought in sacks by road for decorticating when the machinery is not needed for groundnuts.

For the groundnuts, the paddy husking machinery is adjusted to deal with the much larger groundnut pods. If the market wants white nuts, the second decorticating process used to whiten brown rice from the husker, can also be adjusted to remove the brown skin, or bran, from the shelled nuts.

3. LEVEL OF OUTPUT

The two-stage decorticators developed for extracting white rice from paddy are designed for a feed of 500 kg of paddy per hour. Two, three or four units can be sited side by side and driven by the same motor or diesel engine.

(a) <u>Groundnuts</u>

The diameter of the small types of groundnuts is about 8 mm, against 2.5 mm for long grain rice. The capacity of the decorticator husker is proportional to the gap between the rollers, so the 1/2 tonne an hour paddy decorticator should have at least double that capacity for small groundnuts and more for the larger variety. There are about 2,200 small variety nuts per kg. The yield of nuts from pods is about 70 percent by weight and a nimble-fingered child might shell 1,000 pods an hour and produce 1 kg of nuts from 1.40 kg of pods. If the family group of pods is 1,000 kg, hand shelling may take about 700 hours. The farmer's options are to use his children's free labour for some months, or to carry say 50 loads of pods, each of 20 kg. to the nearest shelling machine for sale, in the shell, at a slightly lower price per tonne based on the nuts.

But he is able to sell his crop as soon as it is harvested and dried, instead of in odd loads of nuts shelled by his children over a period of months. From the national viewpoint, the fresh machine-shelled nuts are of better quality and can be sold some months earlier to earn foreign exchange.

(b) Millet/Sorghum

Crushed, i.e. milled or pounded grain millet, is used for bread-making. Each grain is encased in a very thin brittle shell which is crushed with the starchy contents. The flour is, therefore, gritty and the bread likewise. If the shells could be removed and separated, the contents could be readily milled to flour for bread of better eating quality. Crushed millet is already used to "stretch" imported wheat for bread-making, in millet growing countries.

Attempts have been made to decorticate millet grains, using machinery in rice mills, but apparently without success. The only rice milling machine that might have been successful is the high speed rubber roll sheller, but the impact of the grain between the pair of hard rubber rollers is likely to smash both shell and contents, making separation impossible.

4. EMPLOYMENT

If some paddy decorticators are to be used after the groundnut harvest to shell the nuts, then more decorticators will be needed to cope with the paddy crop throughout the year. Only two men are needed to run a 1/2 tonne an hour paddy decorticator. With the same machine dealing with groundnuts at 1 tonne an hour, another two men will be required full-time for handling the pods, filling sacks of nuts, 700 kg an hour, and disposing of 300 kg of shell an hour, with casual labour for loading nuts, 7 to 10 tonnes a day, onto trucks for export.

The equivalent labour is seven men fully employed at $700 a year each.

5. ECONOMIC ANALYSIS

Input : 1 tonne/hour of paddy or 2 tonnes/hour of groundnuts

A. FIXED INVESTMENT

Fixed investment	$
Equipment	25,000
Land, building and handling equipment	10,000
	35,000
Working capital	5,000

B. ANNUAL OPERATING COSTS

	$
Salaries & wages	4,900
Repairs & maintenance	2,500
Energy	1,000
	8,400

6. EVALUATION (values in US $)

This is based on 10 year operating life, a 3 year build up to full capacity production, and a residual value for land, building and equipment. Fixed investment is 35,000. Working capital, 5,000, is taken in one instalment on year 1. The residual value, 5,000, and working capital 5,000, are returned in the 10th year of operation.

Thus, production costs build up as follows :

	Year 1 capacity (1/3)	Year 2 capacity (2/3)	Year 3 capacity (full)
Wages and salaries	4,900	4,900	4,900
Energy	400	700	1,000
Repairs and maintenance	900	1,700	2,500
	6,200	7,300	8,400

The following are the results of NPV analysis :

Discount Rate	Present value of total costs	Annual revenue required	Revenue required per hour of production
10%	84,395	16,037	7.12
20%	70,171	20,612	9.16
30%	61,242	25,710	11.42

9. PASTA PRODUCTION

(ISIC Code 3117 - produced 1981)

This profile deals with the production of pasta in a small factory capable of producing about 150 tonnes per year. The investment cost for this project is about $85,000 and 10 people would be employed.

1. PRODUCT DESCRIPTION

Pasta is commonly made by kneading semolina or wheat flour and water. Other substances can be added to modify the pasta. Eggs, gluten and casein are often used to modify the composition of the pasta; spinach, tomatoes and carrots are used to alter the taste. It is possible to use raw materials other than semolina or wheat flour. Using locally available raw materials - such as cassava or maize - would make the importation of semolina or wheat flour unnecessary, and would produce a pasta more adapted to the taste of the local people. This profile concentrates on a long pasta obtained from a laminated pasta cut lengthwise.

2. DESCRIPTION OF TECHNOLOGY

The manufacturing of pasta is basically quite simple, but requires a high degree of cleanliness and perfectly adjusted machines.

The stages involved are:

a) Raw materials purification;
b) Kneading and homogenization which takes place in a mechanical kneader;
c) Pressing and drawing, which gives the pasta the desired shape by pushing it through the dies of a mould. Pressing can be done by a screw press, a hydraulic press, or a three-phase continuous press, which carries out all three operations of kneading, homogenization and drawing.
d) On leaving the machines the pasta is cooled by ventilation. For long pasta, the pasta is delivered onto rods called "canes", and then taken to the driers.

The equipment needed is as follows:

1 mechanical kneader (trough capacity 25 kg)
1 calendering machine
1 longitudinal cutter
1 cane-loading gear
2 cane-driers (electric)

e) Drying evaporates the excess water from the pasta, and must follow immediately after the drawing and pressing phase. There are three phases:
   i) pre-drying - surface evaporation removing 30-35% of water.
   ii) softening - pasta is left to re-establish a moisture balance.
   iii) final drying - reduces the moisture content to a normal 12-13%.
   Long pasta is dried in "cane" driers; and

f) Packaging takes place after the pasta leaves the driers. Carton boxes of about 250 grammes are commonly used.

3. LEVEL OF OUTPUT

The output planned for in this profile is 75kg/hour, or about 150 tonnes per year.

4. EMPLOYMENT AND EMPLOYMENT COSTS

			$
1	Manager	at $4,000 per annum	4,000
1	Office clerk	at $1,200 " "	1,200
1	Keeper	at $ 720 " "	720
1	Plant Supervisor (foreman)	at $2,400 " "	2,400
2	Skilled workers	at $1,920 " "	3,840
4	Unskilled workers	at $ 720 " "	2,880
10			15,040
	Other Annual Labour Costs:		1,504
	Total Annual Labour Costs:		16,544

5. DATA FOR ECONOMIC ANALYSIS

A. INVESTMENT COST

i) Fixed Investment :

	$
Machinery and Equipment	40,000
Land and Building (500m^2 x $20; 175m^2 x $120)	31,000
Freight and Insurance	6,000
Erection and Start-up Costs	8,000
	85,000

ii) Working Capital :

	$
Stock of material(3 months)	6,435
Wages and Salaries(2 months)	2,757
	9,192

iii) Residual Value :

10% of Equipment cost (cif)	4,600
50% of Building cost	15,500
	20,100

B. ANNUAL OPERATING COSTS

		$
i)	Materials:	
	Semolina or flour(130t)	23,400
	Other Ingredients	2,340
ii)	Wages and Salaries	16,544
iii)	Water and Fuel:	
	Energy (12,000 kw)	480
	Filtered Water	132
iv)	Maintenance	2,550
v)	Overheads	1,000
	Total Annual Operating Costs:	46,446

C. EVALUATION (Values in US $)

This is based on a 10 year project life, a 2 year build up to full capacity, and a residual value for buildings and equipment. Fixed investment amounts to $85,000. Working capital ($9,192) taken in two installments over the first two years, and residual value ($20,100) are returned in the tenth year of operation.

Costs build up over the first two years as follows:

	Year 1 (65%)	Year 2 (100%)
Semolina	15,210	23,400
Other Ingredients	1,521	2,340
Wages and Salaries	10,754	16,544
Water and Electricity	398	612
Maintenance	1,658	2,550
Overheads	650	1,000
	$30,191	$46,446

The following are the results of NPV analysis:

Discount Rate	Present Value of Total Costs	Annual Revenue Required for Given Discount Rate	Revenue Required per kilogram
10%	352,673	60,530	0.40
20%	269,113	68,984	0.46
30%	220,995	78,316	0.52

10. BAKERS' YEAST PRODUCTION

(ISIC code 3121 - produced 1979)

Bakers' yeast is obtained by fermenting a sugar solution with certain strains of yeast. The commonest type of sugar solution is based on diluted molasses. In the production process described in this profile the diluted molasses solution is clarified, acidified and fortified with special nutrients, before being sterilized and cooled. The seed yeast is then added and the resultant mash fermented. Afterwards the yeast cells are separated from the spent mash by a centrifuging process. The yeast cells are compressed into solid blocks prior to packaging and distribution. The required plant produces 500 kg. of compressed yeast per 24 hour working day. A working year of 250 days will require an input of 650 tonnes of molasses. The plant costs $3.5 million and provides employment for 34 persons.

1. PRODUCT DESCRIPTION

Bakers' yeast is the product obtained by fermenting under suitable conditions sugar solutions with certain strains of yeasts. Diluted molasses to which small quantities of nutrient salts and other minerals have been added is the commonest type of sugar solution used.

The product is available commercially as compressed blocks of fresh yeast (with about 30% of dry matter) or as granules of dried yeast (with over 90% of dry matter) packed in sealed tins usually under an inert gas. Both types are used by the baking industry in the ACP countries as the supply situation requires but there is a strong preference for fresh yeast.

Fresh yeast has the advantage of cheapness but it requires to be kept in cool storage (around 4°C). Granulated dry yeast is much more expensive but it can be stored at ambient temperatures without serious loss of fermentative ability.

2. LOCATION

The method of manufacture described in this profile is suitable for general application in those ACP countries where there is a large bread making industry. Fortunately almost all the ACP countries have some sugar production factories where molasses is an unwanted by-product and which can be used as the main raw material. In its absence, however, solutions of granulated sugar can be used instead. Naturally, however, it is also more expensive.

In Nigeria, for example, where no wheat is grown commercially, the total imports for the first half of 1976 were just over 268,000 tonnes. At a 75% extraction rate this is equivalent to 201,000 tonnes of flour. If 80% of this is used in the bread-making industry, and that is the accepted figure, then 168,000 tonnes of flour goes into bread-making requiring about 1% of this weight as yeast. That gives for the six months period a total of 1,680 tonnes or just over 61 tonnes of yeast per week.

It is significant that in November 1976 the Federal Government of Nigeria commissioned a study of the bread industry which had as one of its main objectives the investigation of the local production of the main ingredients used in bread.

3. DESCRIPTION OF THE TECHNOLOGY

The process is well documented in various textbooks on the subject and need not be described in detail here. The outline of the process given here is adequate for an understanding of its nature.

The main stages are as follows :

(a) Dilution of molasses and its subsequent preparation

Molasses often contains up to 50% fermentable sugars and must therefore be diluted considerably with water till it reaches a figure of 14 to 15% sugars. It is then clarified to remove suspended solids, usually by filtration. It is next acidified with mineral acid and fortified with special nutrients such as ammonium salts, phosphates, and magnesium sulphate. This is followed by either high temperature pasteurization or full sterilization and, after cooling, it is ready for the addition of the seed yeast (or inoculum).

(b) Preparation of the inoculum and its addition to the substrate

The inoculum is a batch of seed yeast of the same type as that which it is planned to produce. It can be either a suspension of a batch of seed yeast kept for that purpose or a small quantity of a batch which has just been produced on the plant.

In either case it must be introduced into the diluted molasses under sterile conditions at the temperature at which the fermentation will proceed, usually 27 to 28°C.

(c) Fermentation of the mash

To obtain maximum yield of yeast from the fermentation there must be close control of temperature, acidity, and nutrient levels. In addition there must be constant and vigorous agitation of the mash. This is normally done by blowing through the mash a large volume of compressed air. The period during which the fermentation is allowed to proceed depends on various factors and is usually between 10 and 15 hours.

(d) Separation of the yeast cells

This is done by passing the whole substrate through centrifuges which separate the mash into a cream of yeast cells and spent mash. The latter is normally discarded and the former passes to the next stage.

(e) Washing and final centrifuging of the yeast cells

The yeast cells after removal from the centrifuge are suspended in water and any deposit of solid material arising from the fermentation is allowed to settle in the tank and is discarded. The suspension of yeast cells is then again centrifuged and a cream of pure yeast obtained.

(f) Compression and packing of the yeast

In this stage the yeast cream can be passed into a series of filter presses on the pads of which the yeast cells are deposited or it can be fed into a rotary filter (vacuum) press fitted with a scraper blade which removes the cells as they are deposited on the filter material.

In turn the yeast cells are compressed into solid blocks in special presses and are then suitably wrapped for packing and distribution.

4. LEVEL OF OUTPUT

It is suggested that a plant capable of producing 500 kg. of compressed yeast per 24 hour working day would be desirable in the larger ACP countries currently importing yeast. This would later be a module size for development of the industry.

It is worth noting that normal energy requirements for such a plant are limited and no high temperature treatments are required. All plant sanitation can be done by in-place cleaning at a temperature below 100°C.

Simple stainless steel vessels - as well as the more sophisticated vessels required - can also be cleaned at temperatures just under 100°C. using the normal sterilants.

It is worth noting that specialized skills and training are needed for this process. Such skills are similar to those needed in the brewing industry. No difficulty is anticipated in having operators able to do this type of work after suitable training.

5. LEVEL OF MANNING

Since the plant will be in operation on a 24 hour basis for a seven day week manning requirements are fairly heavy: Manager 1, Production Head 1, Typist 1, Shift Supervisors 4, Process Operators 16, Quality control staff 4, Mechanics 4, Cleaners 2, Driver 1.

If two plants of the same capacity were set up to produce yeast side by side in the same building, the level of manning would not be doubled but would rise by only about 50%.

The following rates of pay have been used in the economic evaluation:

(i) annual rates: Manager $7000, production head $6000, supervisors $4500, senior quality control staff $4500, junior quality control staff (3) $3500.

(ii) daily rates: process operators $7, mechanics $10, cleaners $3, driver $6.

6. ECONOMIC ANALYSIS

In this section the module described earlier in the profile and capable of producing 500 kg. of moist yeast per day is used as a basis for calculation.

Although the plant producing granulated sugar from cane is not likely to be in production throughout the year it is assumed that supplies of molasses (from cold store if necessary) will be available to the yeast plant as required, and that it will run for 250 days in each year.

As a basis for calculation of molasses to yeast the figure used is that supplied by one large manufacturer who states that, under good conditions, 1000 kg. of molasses (with 200 g. of yeast cells in suspension) can produce 190 kg. of moist yeast in 24 hours.

To produce 500 kg. per day (the figure suggested earlier) will require 2,600 kg. of molasses. The amount needed for the full year will therefore be 650 tonnes. The molasses is costed at the national figure of $50 per tonne.

A. INVESTMENT COST

Item	Local cost $	Imported cost $	Total $
Land, incl.agricultural land	10,000	-	10,000
All civil work incl. site preparation	600,000	250,000	850,000
Plant and equipment	150,000	1,700,000	1,850,000
Freight and insurance	15,000	340,000	355,000
Installation costs	50,000	20,000	70,000
Motor transport - lorry, van	30,000	15,000	45,000*
Contingencies at 10%			318,000
Total			3,498,000

* This item is repeated at the end of years 5, 10 and 15.

B. ANNUAL OPERATING COSTS

	$	Total $
i) Materials:		
Molasses	32,500	
Acid and nutrients	4,500	
Filter pads	500	
Packaging	10,000	
Detergents and sterilisers	9,000	
Boiler water treatment	8,000	
		64,500

			Total $
ii)	Wages and Salaries:		88,750
iii)	Water and Fuel:		
	Electricity	14,000	
	Process water	12,000	
	Boiler fuel	15,000	
			41,000
iv)	Motor transport:		
	Fuel and oil	3,500	
	Insurance	900	
	Servicing	700	
	Spares	1,500	
			6,600
v)	Repairs and maintenance: (5% installed plant and equipment)		113,750
vi)	Overheads:		
	1% fixed capital	34,970	
	5% working capital	2,500	
			37,470
			$352,070

C. WORKING CAPITAL

24% materials (2 months)	15,480	
12% other expenses (1 month)	34,510	
		$49,990

D. EVALUATION (values in US $)

This is based on 20 year operating life, a 3 year build up to full capacity production, and a residual value for land, building and equipment. Fixed investment is 3,498,000. Working capital, 49,990, is taken in 3 instalments. On year 1 : 16,663; on year 2 : 16,664; on year 3 : 16,663. The residual value, 10,000, and working capital 49,990, are returned in the 20th year of operation.

Thus, production costs build up as follows :

	Year 1 capacity (1/3)	Year 2 capacity (2/3)	Year 3 capacity (3/3)
Materials	21,500	43,000	64,500
Wages and salaries	88,750	88,750	88,750
Fuel and water	13,667	27,333	41,000
Motor transport	6,600	6,600	6,600
Repairs and maintenance	37,917	75,833	113,750
Overheads	37,470	37,470	37,470
	205,904	278,986	352,070

The following are the results of NPV analysis :

Discount Rate	Present value of total costs	Annual revenue required	Revenue required per kilo
10%	6,390,670	837,396	6.7
20%	5,101,685	1,249,739	10.0
30%	4,556,046	1,748,291	14.0

11. EDIBLE FISH MEAL PLANT

(ISIC Code 3122 - produced 1979)

> The fish meal described in this profile is made from cleaned, gutted fish together with the off-cuts obtained in the manufacture of fish fillets of high grade fish. The production process consists of the following stages : cooking the fish; production of fish cake by means of pressing; drying and grinding of the cake; and packaging for sale. The plant has a raw material intake of 2 tonnes per day, producing 72 tonnes of meal per year of 300 working days. It provides employment for 7 persons in single shift working, and has an initial investment cost of almost $0,5 million.

1. PRODUCT DESCRIPTION

Two distinct types of product are covered by the term fish meal in Western Europe. The older type of product - and the one with the much larger tonnage - refers to the product obtained from fish offals and non-commercial fish by a cooking and drying process. It is essentially a by-product of some of the modern large scale trawling industry. It is not considered suitable for human consumption and it is used almost entirely as an ingredient in the formulation of animal feedingstuffs. It is a good source of protein and minerals and is readily accepted in the diet by cattle, swine, sheep, goats and poultry.

The other - and newer - product is made from cleaned, gutted fish together with the off-cuts obtained in the manufacture of fish fillets of high grade fish for the fresh fish market. It is made by a similar process to that briefly mentioned above. It is this product which is dealt with in this document.

Some fish meal products of this kind have been available in recent years in some of the African countries, usually packed in heat-sealed plastic bags. One very popular brand was called "Joyfish". This was made in one of the Scandinavian countries. It is added to a vegetable stew as a savoury and the whole dish is eaten with a carbohydrate staple food such as rice, yams, maize, or a cassava product.

What is important is that a high standard of plant sanitation is maintained throughout the whole operation both in handling the fish prior to the processing and in ensuring good environmental hygiene in and around the processing plant. A thorough cleaning is essential after each production run of 8 to 9 hours.

2. LOCATION

Fish meal is already made in different ways in many of the ACP countries. Unfortunately, however, this is often done under poor hygienic and mechanical conditions and a poor and variable quality product is obtained.

The plant and equipment described in this document are already in use in Sri Lanka.

3. DESCRIPTION OF TECHNOLOGY

(a) This first stage consists in cooking the fish in cylindrical steam-jacketed ovens.

(b) This stage is the pressing out of aqueous material and any fish oil present in a screw-press (extruder) and so producing press fish cake of high protein value.

(c) Drying the pressed fish cake.

(d) Grinding the cake in a hammer mill.

(e) Packing the product in suitable containers for sale.

The cooker is fabricated of mild steel and is provided with a steam-jacket which completely encloses the cooker. It is fitted with a conveyor screw which continuously moves the fish material from the feeding end of the cooker to the discharge end.

On discharge from the cooker the wet material drops into the twin-screw press along which it passes and in which it is progressively pressed into a hard moist cake. During this process the aqueous material (and oil) is squeezed out and allowed to run to waste while the hard cake is discharged at the end of the screw press.

Ancillary equipment for the recovery of fish oil is also available if it is present in sufficient quantity. But this is unlikely to be the case in fish from tropical seas.

At this stage it is usual to add a small quantity of permitted antioxidant to the material to avoid the off-flavours which accompany oxidation of any traces of fat left in the meal.

The third stage - drying of the pressed fish cake - is carried out in a vessel similar to the cooker and also steam heated. It has in addition a steam-heated mainshaft. The mainshaft is driven by a 15 H.P. motor. Steam is supplied at a pressure of 85 p.s.i. and the process is so adjusted that the end-product, that is the pressed fish cake has a moisture of about 8%.

Grinding the cake to a powder is done in a hammer mill fitted with suitable screens to obtain the desired degree of fineness. The mill is driven by a 20 H.P. motor.

In the fifth and final stage the ground meal is passed to a bagging-weighing unit. Normally 5-ply paper bags with one or more of the plys coated with a moisture-proof plastic coating are used. They are usually of 25 kg. capacity.

The plant described above has a raw material intake of 250 kg. per hour and produces about 30 kg. of fish meal per hour depending on the nature of the raw material.

The plant also requires a boiler capable of producing about 165 kg. steam per hour at 85 p.s.i. Chemical treatment for the water supplied to the boiler is necessary. Some provision for disposing of waste materials is also required and needs to be provided for even if it is only a discharge pipe to a settling tank and an overflow pipe to the sea or river.

4. LEVEL OF PRODUCTION

It is suggested that a plant of the size already described should be used in the ACP countries. Where facilities exist for greater output then this size of plant can be used as a module.

Because of the highly perishable nature of the raw material in hot climates it is assumed that the plant will be in operation every day of the week for a period of 300 days (roughly 10 calendar months). It would not normally work more than one shift of 8 hours per day. The expected intake of raw materials during that period will be 600 tonnes and the normal output would be 72 tonnes.

5. MANNING LEVEL

The expected staffing for one such unit would be as follows : Manager and administration 1, Process operators 2, Cleaners 2, Mechanic/boiler-attendant 1, driver 1. This makes a total of 7 persons.

6. ECONOMIC ANALYSIS

A. INVESTMENT COST

All costs are shown in mid 1978 prices.

Fixed investment

	Local cost $	Imported cost $	Total $
Land, incl.agricultural land	10,000	-	10,000
All civil work incl. site preparation	60,000	40,000	100,000
Plant and equipment	30,000	150,000	180,000
Freight and insurance	10,000	60,000	70,000
Installation costs	35,000	5,000	40,000
Motor transport - lorry, van	40,000		40,000*
Contingencies at 10%			44,000
Total			484,000

* This item is assumed to be repeated at end year 5 and end year 10.

B. ANNUAL OPERATING COSTS

	$	Total $
i) Materials:		
Fish	30,000	
Packaging	5,000	
Detergents and cleaning	7,000	
Boiler water treatment	1,000	
		43,000
ii) Wages and Salaries:		17,800
iii) Water and Fuel:		
Electricity	3,000	
Process water	2,500	
Boiler fuel	3,500	
		9,000
iv) Motor transport:		
Fuel and oil	6,000	
Insurance	600	
Servicing	600	
Spares	1,000	
		8,200
v) Repairs and maintenance:		
(5% installed plant and equipment)		14,500
vi) Overheads:		
1% fixed capital	4,830	
5% working capital	490	
		5,320
		$97,820

C. WORKING CAPITAL
10% annual operating costs (1 month's expenses) $9,780

D. RESIDUAL VALUE $10,000

E. DATA

A number of assumptions have been made in order to simplify the calculations reported below. As mentioned earlier normal annual output is taken to be 72 tonnes: in year 1 and 2 this figure has been reduced to 24 tonnes and 48 tonnes respectively.

The following rates of pay were used in the evaluation :

(i) annual rate : manager $7,000

(ii) daily rates : process operators $7, cleaners $3, mechanic $10, driver $6.

F. EVALUATION (values in US $)

This is based on 15 year operating life, a 3 year build up to full capacity production, and a residual value for land, building and equipment. Fixed investment is 484,000. Working capital, 9,780, is taken in 3 instalments. On year 1 : 3,260; on year 2 : 3,260; on year 3 : 3,260. The residual value, 10,000, and working capital 9,780, are returned in the 15th year of operation.

Thus, production costs build up as follows :

	Year 1 capacity (1/3)	Year 2 capacity (2/3)	Year 3 capacity (full)
Materials	14,333	28,667	43,000
Wages and salaries	17,800	17,800	17,800
Water and energy	3,000	6,000	9,000
Motor transport	8,200	8,200	8,200
Repairs and maintenance	4,830	9,670	14,500
Overheads	5,320	5,320	5,320
	53,483	75,657	97,820

The following are the results of NPV analysis :

Discount Rate	Present value of total costs	Annual revenue required	Revenue required per bag of 25 kgs.
10%	1,172,772	174,426	60.56
20%	892,714	229,651	79.74
30%	761,984	297,883	103.43

12. SYNTHETIC SOFT DRINKS PLANT

(ISIC code 3134 - produced 1981)

This profile describes a scheme for manufacturing aerated synthetic soft drinks. An An initial investment of $25,008 is required for an annual output of 10,350 crates each of 25 bottles. The project would employ 13 people.

1. PRODUCT DESCRIPTION

Aerated soft drinks always are in demand. In these carbonated drinks, the oxygen which is normally present in the water solution, and which is sufficient to bring about fermentation, is displaced by carbon dioxide. The keeping quality of carbonated beverages is enhanced by adding 0.05 per cent sodium benzoate.

2. DESCRIPTION OF TECHNOLOGY

A typical formula for aerated synthetic soft drinks is given below:

Sugar	12.00 per cent
Citric Acid	0.20 per cent
Colour and Essence	0.5 per cent
Sodium Benzoate	0.05 per cent
Water	87.25 per cent

The following plant, machinery and equipment are required for the project described in this profile:

	$
Baby Boiler, 50 kg/hour evaporation capacity	1,250
Steam Jacketed Kettle - 200 litre capacity	875
Aerated Water Machine with cap sealing device	875
Printed Bottles of 200 ml. capacity : 25,000 at $0.20 per bottle	5,000
Wooden Crates : 1,000 at $1.25 per crate	1,250
Demineralization Plant	875
Office furniture and equipment	1,250
CO_2 Gas Cylinder Security	75
Laboratory Equipment	375
	11,825
Transport, Erection and Installation, etc.	1,183
	13,008

3. LEVEL OF OUTPUT

The projected level of output is at the rate of 1,000 bottles (40 crates) of soft drinks per day. At the rate of 5 1/2 days per week for 48 weeks of the year, with a 2% allowance for processing loss, this gives an annual net production rate of 258,750 bottles of aerated soft drinks (10,350 crates).

4. EMPLOYMENT

			$
1	Manager	at $4,000 per annum	4,000
1	Technologist	at $4,000 " "	4,000
2	Supervisors	at $2,400 " "	4,800
2	Skilled Workers	at $1,920 " "	3,840
3	Unskilled Workers	at $ 720 " "	2,160
1	Clerk/Accounts Clerk	at $1,920 " "	1,920
1	Storekeeper	at $1,200 " "	1,200
1	Salesman	at $1,920 " "	1,920
1	Watchman	at $1,200 " "	1,200
13			25,040
		Other Annual Labour Costs:	2,504
		Total Annual Labour Costs:	27,544

5. DATA FOR ECONOMIC ANALYSIS

A. INVESTMENT COST

i) Fixed Investment:

		$
Machinery and Equipment		13,008
Building Costs:		
Processing Hall	$100m^2$	
Stores and Godown	$70m^2$	
Office	$20m^2$	
Boiler Room	$10m^2$	
	$200m^2$	12,000
		25,008
Residual Value		2,500

ii) Working Capital:

	$
(Equivalent of 3 months' materials)	1,750

B. ANNUAL OPERATING COSTS

		$
i)	Materials:	
	7.15 tonnes Sugar at $300	2,145
	285,000 Crown Corks at $8.75 per 1,000	2,500
	11 CO_2 cylinders at $62.50	688
	Colour, Flavour, Chemicals, etc.	1,100
ii)	Wages and Salaries:	27,544
iii)	Water and Fuel:	1,500
v)	Repairs and Maintenance	3,675
v)	Overheads	1,450
	Total Annual Operating Costs:	40,602

C. EVALUATION (Values in US $)

This is based on a 10 year operating life, a 3 year build-up to full capacity production, and a residual value for buildings and equipment. Fixed investment is $25,008. Working capital is taken in 3 instalments : on year 1 : $584; on year 2 : $583; on year 3 : $583. The residual value of $2,500 and working capital of $1,750 are returned on the 10th year of operation.

The production costs build up as follows:

	Year 1 (1/3)	Year 2 (2/3)	Year 3 (3/3)
Materials	2,144	4,289	6,433
Wages and Salaries	27,544	27,544	27,544
Water and energy	500	1,000	1,500
Repairs and Maintenance	1,225	2,450	3,675
Overheads	1,450	1,450	1,450
	$ 32,863	$ 36,733	$ 40,602

The following are the results of NPV analysis :

Discount Rate	Present Value of Total Costs	Annual Revenue Required for Given Discount Rate	Revenue Required per crate
10%	264,069	50,174	4.85
20%	186,637	54,806	5.30
30%	143,328	60,171	5.81

13. MANUFACTURE OF OVERALS

(ISIC Code 3220 - produced 1981)

This profile describes a workshop for the production of overalls made out of double warp twill, commonly known as Denim cloth. Fixed investment amount to $182,400 and 29 people are employed.

1. PRODUCT DESCRIPTION

The overalls are one-piece garments made of double warp twill, commonly called Denim cloth.

2. DESCRIPTION OF TECHNOLOGY

There are five basic stages in the manufacture of overalls:

(a) the material is checked for proper width, colour, texture, and for possible faults;

(b) the fabric is marked with the trace for the cutter to follow and then lapped or folded into several layers depending on the number of pieces needed. The lapping can be done by hand or by using a lapping trolley;

(c) the material is cut out, using various types of tools such as the sword (a long rectangular blade), the belt saw, or electric knives fitted with disc or vertical blades;

(d) the pieces of material are arranged and then stitched together. Various types of sewing machines are used; and

(e) the last stage is finishing, which includes inspection, ironing, folding and packing.

Raw materials used include denim cloth, thread, buttons, and zip fasteners.

3. LEVEL OF OUTPUT

The workshop considered in this profile has a capacity of 300 pieces per 8 hour day. For a 300 day work year the production capacity is therefore 90,000 overalls per annum.

4. EMPLOYMENT AND EMPLOYMENT COSTS

			$
1	Manager	at $4,200 per annum	4,200
2	Clerks	at $1,200 " "	2,400
1	Caretaker	at $ 720 " "	720
3	Foremen	at $2,400 " "	7,200
14	Skilled Workers	at $1,920 " "	26,880
8	Unskilled workers	at $ 720 " "	5,760
29			$47,160
		Other Annual Labour Costs:	4,716
		Total Annual Labour Costs:	$51,876

5. DATA FOR ECONOMIC ANALYSIS

A. INVESTMENT COST

i) Fixed Investment :

	$
Machinery and Equipment	80,000
Land and Building ($1200m^2$, $420m^2$)	74,400
Freight and insurance (15% Equipment)	12,000
Installation (20% Equipment)	16,000
	$182,400

ii) Working Capital :

	$
Stock of materials(3 months)	241,284
Wages and Salaries(2 months)	8,646
	$249,930

iii) Residual Value :

	$
10% of Equipment Costs(cif)	9,200
50% of Building Costs	37,200
	$ 46,400

B. ANNUAL OPERATING COSTS

i)	Materials :		965,136
	Fabric (185,000m)	925,000	
	Thread	12,650	
	Buttons	10,800	
	Zip fasteners (90,000)	16,200	
	Trademark + size labels (90,000)	486	
ii)	Wages and Salaries :		51,876
iii)	Water and fuel		2,364
	Energy 58,000 kWh	2,320	
	Water $10m^3$	44	
vi)	Overheads :		2,000
	Total		1,021,376

C. EVALUATION (Values in US $)

This is based on a 10 year operating life, a 3 year build-up to full capacity production, and a residual value for buildings and equipment. The fixed investment amounts to $182,400. Working capital amounts to $249,930 taken in three instalments over the first three years of operation and the residual value ($46,400) and the working capital are returned in the 10th year of operation.

Production costs build up as follows over 3 years:

	Year 1 (65%)	Year 2 (75%)	Year 3 (100%)
Materials	627,338	723,852	965,136
Wages and Salaries	33,719	38,907	51,876
Water and Fuel	1,537	1,773	2,364
Overheads	1,300	1,500	2,000
	$663,894	$766,032	$1,021,376

The following are the results of NPV analysis:

Discount Rate	Present Value of Total Costs	Annual Revenue Required for Given Discount Rate	Revenue Required per item
10%	6,014,511	1,070,321	11.89
20%	4,117,414	1,105,064	12.28
30%	3,043,064	1,137,594	12.64

14. PLASTIC SHOE MANUFACTURING

(ISIC code 3560 - produced 1980)

This profile describes a system of shoe manufacturing using synthetic materials, with two alternative sole attaching methods. The level of output is 450 pairs of gents' shoes per day; the initial investment $ 225,000/345,000; and the level of employment 36 people.

1. PRODUCT DESCRIPTION

The proposals in this profile are based on a system of shoe manufacture embodying the latest technology in :

(a) Upper materials

(b) Upper assembly

(c) Simplified lasting

(d) Moulded sole attaching

The process involves the making of men's footwear having shoe upper material which may be welded and embossed by high frequency techniques. All the elements of the process have been proven in bulk manufacture.

In an overall comparison the advantages of this system over conventional methods are as follows :

(a) Lower material costs

(b) Reduction in number of operators

(c) Shorter operator training times to achieve the skill levels required

(d) Lower investment in machinery

(e) Reduced floor space

(f) Reduced indirect labour costs

These proposals are based on the manufacture of a man's Gibson town shoe (Derby) using synthetic upper material and replacing all conventional closing operations by high frequency welding. All shoe costings assume materials and components being supplied from the United Kingdom, the upper and lining materials being delivered in rolls.

The proposals cover the use of a single last shape with a size range of six sizes only, British 6, 7, 8, 9, 10 and 11. Alternatively European sizes 39-46 could be used giving eight sizes, if preferred.

The manufacturing unit is based on the output of one high frequency cutting and welding machine, and on this basis production of 450 pairs of shoes per day should be achieved when using reasonably trained and experienced operatives.

Two alternative methods of sole attaching are covered. The first uses pre-made PVC sole and heel units cemented on to the upper and the second uses the direct injection of PVC soles on to the upper, offering a substantially lower cost per pair.

2. DESCRIPTION OF TECHNOLOGY

(a) Cutting, upper assembly and lasting

The following operations will be necessary whichever method of sole attaching is adopted :

A. Cut all upper components from roll materials, i.e.

Vamps (1.7 mm material)
Quarter casters (1.7mm)
Quarter lining casters (0.8 mm lining material)
Vamp linings (adhesive coated fabric)

B. Size and reference mark quarter linings

C. Attach toe puff (box toe) to vamp

D. Attach lining to vamp

E. Weld top line of quarter to lining, embossing edge and punching and welding eyelet holes, (vamp may also be embossed)

F. Weld side seams of quarter to vamp

G. Attach shank unit to insole

H. Insert heel stiffener into back of upper.
Stitch lasting string around upper margin

I. Place upper in conditioning cabinet for required time, back form and string last on combined back forming and string lasting machine

J. Hook string over shank unit in waist to complete lasting operation

K. Place lasted uppers in heat setter

L. Secure lasted margin with hot melt cement

M. Scour and rough lasted margin.

(b) First sole attaching alternative

The following operation will be necessary to complete the shoes using pre-fabricated PVC sole/heel units :

N. Solvent wipe and apply adhesive to sole unit, apply adhesive to shoe bottom. Allow to dry

O. Re-activate adhesive, assembly sole unit to upper and bond in sole attaching press

P. Slip finished shoe from last

Q. Clean and inspect, paste and insert seat sock, insert laces

(c) Second sole attaching alternative

The following operations will be necessary to complete the shoes using PVC soles injected direct to the shoe bottoms :

R. Apply adhesive to shoe bottom

S. Slip lasted upper from making last

T. Relast upper on metal foot form of injection moulding machine, mould sole to upper, remove finished shoe from machine

U. Clean and inspect, paste and insert seat socks, insert laces

(d) Machinery Schedule

	Estimated output per 8-hour shift	Nb. required	Estimated F.O.B. Cost Values U.S $
i) Upper Preparation		(pairs	per machine)
Travelling Head Press	1,000	1	16,060
Material Gantry/Feed	-	1	2,365
Clicking Table (a)	-		100
Knife Storage Rack (a)	-		100
Lining Stamping Machine	800	1	1,978
Toe puff + lining attaching press	500	1	3,943
2 Station HF cutting and welding machine	-	1	46,552
HF Compression Welding Machine with Rotary Table	500	1	17,333
Work Racks (a)			430
Cutting Knives - for range of 6 sizes in 1 style			
HF Welding Tools for 6 sizes plain, vamp, Derby		12	538
Overlocking Machine	300	2	3.225
ii) Lasting/making Operations			$92,624
Upper Conditioning Unit		2	1,733
Combined String Lasting and Back Moulding Machine	250	2	13,115
Heat Setting Machine	600	1	4,945
Hot Melt Dispenser	900	1	2,021
Roughing and Scouring Machine with Dust Collection Unit	900	1	7,708
Work Racks (a)			430
Making Lasts - 6 sizes	150 pairs		3,763
			$33, 715

iii) Sole Attaching - Option I

Cement Activator		1	1,058
Single Station Sole Press	300	2	7,482
Work Benches (a)			430
Last Slipping Machine	1,500		3,064
			12,034

iv) Sole Attaching Option II

Lasting slipping Machine	1,500		3,064
Single station Injection Moulding Machine	150		74,132
Sole Moulds		6 pairs	27,139
			104,335

v) Finishing

Bench for Socking (a)	150
Bench for Cleaning (a)	150
	300

vi) Miscellaneous

Air Compressor	2,688
Air Pipes, Traps, Filters, etc...	1,021
Maintenance Equipment	2,365
Fume Extraction Bench for Cementing	1,122
	7,196

Note : (a) = Items locally produced with estimated cost added.

vii) Total Equipment Cost

Sole Attaching Option I (inclusive of transportation and installation costs)	188,931
Sole Attaching Option II (inclusive of transportation and installation costs)	309,214

3. LEVEL OF OUTPUT

The equipment specified is designed to manufacture approximately 400-500 pairs per day of gent's shoes. Any deviation from this specification may necessitate a review of the component costs, machinery requirements and production rates stated in this proposal. On this basis the annual output would be 118,800 pairs of shoes for a 5 1/2 day week (with an 8-hour daily shift) over 48 weeks of the year.

For this level operation some machines and operators will not be fully employed and some operators will be expected to perform more than one job.

4. EMPLOYMENT

Based on estimates from a "turnkey" proposal, and data independently gathered in a David Livingstone Institute study, the following staffing is required :

a. Staff and non-production employees

1	General manager	at $ 6,000 p. a.	6,000
1	Sales Manager	at $ 4,000 p. a.	4,000
1	Production Manager	at $ 4,000 p.a.	4,000
2	Sales Staffs	at $ 1,920 p.a.	3,840
4	Clerks	at $ 1,200 p.a.	4,800
2	Supervisors	at $ 2,400 p.a.	4,800
2	Storemen	at $ 1,200 p.a.	2,400
4	Maintenance Staff :		
	2 Skilled	at $ 1,920 p.a.	3,840
	2 Semi-skilled	at $ 1,200 p.a.	2,400
5	General labourers	at $ 720 p.a.	3,600
22			39,780

b. Direct production employees

6	Skilled	at $ 1.920 p.a.	11,520
6	Semi-skilled	at $ 1.200 p.a.	7,200
2	Unskilled	at $ 720 p.a.	1,440
14			20,160

c. Total Employment Costs

i) Staff and Non-production employees	39,780
ii) Direct production Employees	20,160
iii) Indirect labour costs (P.F. etc.)	5,884
	65,824

d. Basis for Production Labour
(8-hour shift)

	Approximate output per operator	Number of Operators	
		Theorical	Practical
<u>Upper Preparation Operations</u>			
- Cut upper and linings	1,000	.45)	
- Size and reference mark quarter linings	800	.56)	1
- Attach toe puffs and vamp linings	450	1	
- Weld and cut top lines	900		
	(plain vamp)	1	1
- Emboss, weld and cut vamps (optional)	or 450 (embossed vamp)		
- Weld side seams	500	0.9	1
- Insert stiffener and overlock stitch	300	1.5	2
			6
<u>Lasting/Making Operations</u>			
- Condition uppers and string last, load heat setter	225	2	2
- Take work from heat setter, secure margin with hot melt	900	0.5)	1
- Rough and scour margin	900	0.5)	
			3

Sole Attaching option I

- Cement shoe bottom, solvent wipe and cement sole heel unit	300	1.5	2
- Sole attach (1 operator 2 machines)	600	0.75	1
			3

Sole Attaching Option II

- Last slip	1,600	0,28)	
- Cement shoe bottom	800	0,56)	1
- Injection mould sole/heel (2 operators, 4 machines)	300	1,5	2
			3

Finishing

- Paste and insert socks	450	1	1
- General cleaning and inspection, box finished shoes	450	1	1
			2
Total direct labour, production operatives, using either Soling Option I or II)			14

5. ECONOMIC ANALYSIS

A. INVESTMENT COST

i) Fixed Investment

Equipment (installed)	$
Option I	188,931
Option II	309,214
Buildings - (say 250 m^2)	36,250

Total initial Investment		Residual value
Option I	$ 225,181	22,518
Option II	$ 345,464	34,546

ii) Working Capital

Stocks of spare parts	10,750
Stocks of materials (1 month's supply) (average options I and II)	47,614
Stocks of finished products (say 1 month's output valued in materials, etc...)	47,614
	105,978

B. ANNUAL OPERATING COSTS $

i) Materials

Option I	: Average material cost	=	5.31
	Cost for 118,800 pairs of shoes	=	630,828
Option II	: Average material cost	=	4.31
	Cost for 118,800 pairs of shoes	=	512,373

ii) Wages and salaries
Annual Employment Costs 65,824

iii) Water and Fuel
Electricity costs estimated at 4,500/year

iv) Motor transport
Estimated at 5,000/year

v) Repairs and Maintenance
Estimated for buildings and equipment at :
- Option I : $ 8,300
- Option II : $ 14,500

vi) Overheads
Including insurance, office expenses, sales expenses, etc.. 20.000

C. EVALUATION (values en U.S. $)

This is based on a 10-year operating life, 3-year build-up to full capacity production and a 10 per cent residual value for the fixed investment cost. Initial investment costs are $ 225,181 for Option I and $ 345,464 for Option II. Working Capital $ 105,978 in 3 instalments in the 1st, 2nd and 3rd years of operation, all returned at the end of the 10th year of operation; and the Residual Value at the end of the 10th year of operation; and the Residual Value at the end of the 10th year $22,518 for Option I and $34,546 for Option II.

Three year production build-up (Option I) :

	1/3rd Capacity	2/3rds Capacity	Full Capacity
Materials	210,276	420,552	630,828
Wages and Salaries	65,824	65,824	65,824
Water and Fuel	1,500	3,000	4,500
Motor Transport	5,000	5,000	5,000
Repairs and Maintenance	2,767	5,533	8,300
Overhead	20,000	20,000	20,000
	305,367	519,909	734,452

Three year production build up (Options III)

	1/3rd Capacity	2/3rd Capacity	Full Capacity
Materials	170,791	341,582	512,373
Wages and Salaries	65,824	65,824	65,824
Water and Fuel	1,500	3,000	4,500
Motor Transport	5,000	5,000	5,000
Repairs and Maintenance	4,833	9,667	14,500
Overhead	20,000	20,000	20,000
	267,948	445,073	622,197

The following two tables show :

i) The Present Value of Total Costs at the indicated discount rates;

ii) The Annual Revenue required to generate an Internal Rate of Return equivalent to the indicated discount rate;

iii) The selling price required per pair of shoes at the respective interest/discount rates.

Option I

Discount Rate	Present value of Total Costs	Annual Revenue required for given discount rate	Revenue required per pair
10%	4,208,351	799,662	6.73
20%	2.851,747	837,685	7.05
30%	2,093,903	879,052	7,39

Option II

Discount Rate	Present value of Total Costs	Annual Revenue required for given discount rate	Revenue required per pair
10%	3,733,503	709,433	5.97
20%	2,587,952	760,196	6.39
30%	1,945,292	816,663	6.87

15. SMALL-SCALE LEATHER MANUFACTURING

(ISIC code 3231 - produced 1979)

Manufacturing of finished upper leather from raw cattle hides is considered in two scales of production: 200-hides (scale A) and 400-hides (scale B) per day. Total fixed investment in scale A is US $579,000 and B, $959,000. The respective figures for employment are 78 and 129, of which 58 and 97 are production workers, respectively. Given that the scales considered are small for chrome-tanned upper leather, one needs to be very careful in the selection of machinery and equipment for the plants to be commercially viable. In scale 2, low-cost local machinery is used; while in B, wooden drums are locally made and the rest of the machinery, most of which are of simple mechanical type, are imported from Europe.

1. INTRODUCTION

A. GROWTH OF THE INDUSTRY

Rapid growth has been witnessed in the leather industry in many developing countries in recent years. For example, India, Pakistan, South Korea, Argentina and Brazil are exporting increasing volumes of finished leather to the developed world. A number of reasons can be advanced for such growth of leather manufacturing in developing countries.

First, the developing countries produce the main raw material for this industry, i.e. hides and skins. In 1975, the share of the developing countries of the total world cattle hides production was 41.3 per cent, as against 38.1 per cent in developed countries and 20.6 per cent in centrally planned economies.(1) The share of the developing countries in the production of sheep and goat skins is about 50 per cent of the world total.(2)

Second, the ready availability of cheap labour favours the growth of leather manufacturing in the developing world. This situation may be compared with the difficulty faced by the leather manufacturers in the developed countries where the wage cost is not only high but also it is difficult to attract labour to work in the wet and unpleasant environment of leather manufacturing.

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(1) UNIDO, **Draft World-Wide Study of the Leather and Leather Products Industry 1975-2000.** Prepared by the International Centre for Industrial Studies. Vienna, September 1977, p.22.

(2) **Ibid,** p.25, computed from the total production of skins shown as 1,428 million sq.m. in developed countries and 1,416 million sq.m. in developing countries.

Third, the growth of leather manufacturing in developing countries is helped by the simple nature of the technology involved, as against the "complex technology" of industries such as electronics, machine tools, etc. Moreover, the technology for leather manufacturing is easily available. Indeed, as will be found later on, many developing countries also manufacture tanning machinery and equipment.

Fourth, the investment cost is not very high in leather manufacturing. Investment cost for a plant having an annual capacity of 120,000 cattle hides and employing about 130 people will be less than US $1 million.

Fixed investment cost per employee thus turns out less than US $8,000. It is therefore not difficult to understand why leather manufacturing is considered as a labour-intensive investment.

Fifth, effluent treatment regulations are still not very strict in most developing countries. This is an important consideration, because if the manufacturers are required to treat their effluent strictly it will significantly increase their cost of production. This is probably one of the main reasons why the industry is dying in the developed countries where the governments are very cautious on environment protection.

B. THE PRODUCTS

The main products from the leather manufacturing industry are shoe uppers, sole leather, leather for travel goods, upholstery leather, etc. Of these, shoe upper leather is the most important item. In most developing countries, as much as 80 per cent of the total leather production is used by the domestic footwear industry and as sole leather is being increasingly replaced by synthetic materials, the chief use for leather is in the manufacture of shoe uppers.(3) That the demand for shoes is expected to increase with real income is substantiated by the available estimates of income elasticity of demand for leather footwear in developing countries.(4) Given the importance of shoe uppers this is selected as the chosen product for analysis. This technology profile will focus mainly on shoe upper leather with cattles liodes as the raw material.

Of the total hides and skins available in the world for leather manufacturing, about 90 per cent is obtained from cattle, sheep and goats, amounting to over 6 million tonnes a year of which cattle hides alone account for over 5 million tonnes.(5)

C. VALUE ADDED

It is estimated that the value added in finished leather is one-and-a-half to two-and-a-half times the prices of raw hides and skins.(6) The value added in leather goods is significantly higher at about ten times the price of raw hides and skins.(7) The development of leather

(3) United Nations, **Leather and Leather Products,** New York, 1971, p.85.
(4) Food and Agricultural Organization, Chapter 10: "Hides and Skins and Leather" in **Research Needs and Priorities in Relation to Certain Agricultural Commodities** Rome 1975, p.10.
(5) **Ibid,** p.1.
(6) United Nations, **Leather and Leather Goods, op. cit.** p.34.
(7) D. Winters, "The Leather Trade in Developing Countries: Prospects and Problems", **Leather: International Journal of the Industry,** November 1972, p.67.

manufacturing and leather goods industries, particurlarly for report, is therefore very attractive.

2. PRODUCT PROCESS

In leather manufacturing, the factory is commonly known as the tannery.(8)

A. TECHNICAL DESCRIPTION (9)

Different sub-processes involved in the processing of raw hides into finished upper leather include complicated and, at times, repeated operations. Any attempt to provide a generalized view of these operations can invite serious criticisms.(10) However, at the risk of simplifying the method of operations, a "normal" practice technology for the manufacture of leather is set out schematically in Chart 1.

1. **Soaking** is to restore wet-salted (or sun dried or dry-salted) hides to the original state i.e. the stage before flaying and also to remove dung, blood and soil from the hide.
2. **Cutting into sides,** as the term implies, is to cut the big hides into two parts.
3. **Liming** is a hair-removing operation.
4. **Fleshing** is the process of removing the connective tissues which usually adhere to the flesh part of the hide.
5. **Deliming, bating, pickling and tanning** are conceived as a combined operation. Deliming is the process of reducing the lime content in the hide; this will be followed by bating the hide with pancreatic or bacterial bates; pickling is the process of treating the hide with acids and common salt so as to make it ready for the tanning operation by using chromium salt powder.
6. **Sammying** is to reduce the moisture content of the wet hide.
7. **Sorting** is the process of sorting or grading the hides according to the grain quantity.
8. **Trimming** is to remove uneven rugged edges.
9. **Splitting** is to split the relatively thick hide into grain and flesh parts.
10. **Shaving** is the process of reducing the substance of the hide to the desired thickness by shaving the bottom part.
11. **Re-tanning, neutralization, fat-liquoring and dyeing** is another combined operation where the hide (or semi-finished leather as it is at this stage) is given a final tanning with vegetable or synthetic tanning materials; as chrome-tanned leathers are acidic they are neutralized before dyeing with the desired colours; fats are also used for softening the leather.
12. **Setting-out,** like sammying, is a process of reducing the moisture content.
13. **Drying** is to dry the damp leather.
14. **Conditioning** is to moisten the stiff-dried leather to 28 to 30 per cent moisture content.
15. **Staking** is to soften the leather.
16. **Buffing** is to sand-paper the defective surface of the leather.
17. **Re-dusting** is to clean the dust from the surface.
18. **Seasoning** is to treat the surface of the leather with a pigment solution, called "binders".

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(8) As will be apparent soon, "tanning", though an important operation, is only one of the sub-processes in the manufacture of leather.

(9) This section draws heavily from the study by M.M.Huq and h.Aragaw, **Leather Manufacturing in Developing Countries : A Study in Technical Choice.** (mimeo). David Livingstone Institute, University of Strathclyde, July 1977. See also J.H.Sharphouse, **Leather Technicians' Handbook,** Leather Producers' Association, London 1971.

(10) The leather manufacturers often find it useful to alter and even to omit some operations depending on the conditions and quality of raw materials available, the tanning process used and the type of product desired.

19. **Plating/embossing** is to give a smooth appearance or to put an artificial grain pattern on the surface of the leather.
20. **Spraying** is the process of putting the final colour on the surface of the leather.
21. **Glazing** is the process of adding a shiny look on the leather.
22. **Measuring** is to measure the area of the leather by sq.ft. which is a standard measure in the trade.

The conventional practice is to use wooden drums or paddles for sub-processes 1 and 3; wooden drums for 5 and 11; 2, 7 and 14 are done manually; in other sub-processes machines are used, although in some of these, e.g. 13 (drying), 17 (de-dusting), 18 (seasoning) and 20 (spraying) one also finds hand operation with the aid of simple tools.

B. EFFLUENT TREATMENT

In leather manufacturing, substantial effluent is generated which, if not fully treated, can cause air and water pollution. As mentioned in the beginning, strict effluent treatment regulations is one of the reasons for the decline of leather manufacturing in developed countries like West Germany, France and the United Kingdom.

Of the different methods of effluent treatment, the following two are commonly found in the leather industry: (a) Rotation system and (b) Lagoon system. The rotation system needs heavy construction and in terms of costs, a minimum size plant can be too costly for the factories considered in the present technology profile. Moreover the minimum capacity of the rotation treatment plant is significantly higher than the capacity considered for our selected tanneries. The alternative lagoon system is not only cheaper but also amenable to small-scale; for this system one will, however, need large space. The level of treatment in the lagoon system is not as good as that in the rotation system, but is usually accepted in most developing countries.

C. MAINTENANCE SHOP

The leather plant should be equipped with a maintenance shop capable of looking after the day-to-day machinery problems. The need for a well-equipped workshop is particularly great if there is no nearby facility. A well-equipped maintenance shop should have a centre lathe, a milling machine, a drill and other equipment. It will be manned by skilled workers headed by an experienced mechanical person.

D. BOILER ROOM

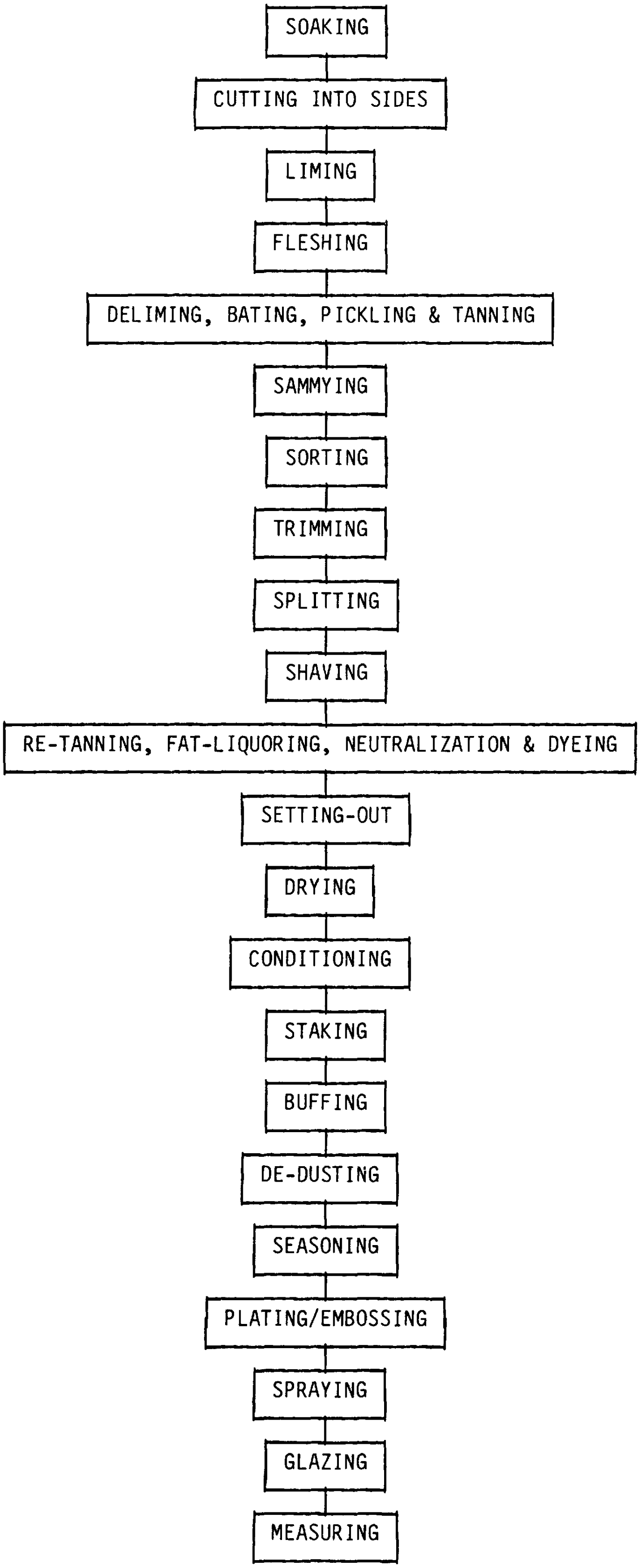
The plant should have an efficient boiler unit. Constant supplies of hot water are essential for the processing of raw hides into finished leather. In wet stages, hot water will be constantly needed.

E. CHEMICAL LABORATORY

The plant should also have a chemical laboratory to test the different chemicals used and also the products. A trained chemist should be in charge of the laboratory.

CHART 1

NORMAL PRACTICE TECHNOLOGY FOR PROCESSING CATTLE HIDES TO FINISHED UPPER LEATHER



3. ALTERNATIVE TECHNOLOGIES

A. SOURCES OF MACHINERY AND EQUIPMENT

Britain, West Germany and France are the three important tanning machinery manufacturers in Western Europe. Italy which has emerged as a leading tanning machinery manufacturer, along with Spain are the two main producers from Southern Europe. Czechoslovakia is a famous producer of tanning machinery in Eastern Europe, while Yugoslavia, Bulgaria and Romania are considered as new comers from the area in this field.

The growth of the tanning machinery industry has followed the growth of the leather industry in a number of developing countries, particularly in Asia and Latin America. Some of these countries even export tanning machinery and equipment, although at a limited scale, to the neighbouring countries. For example, one finds Chinese machinery in Nepal; Indian machinery in Sri Lanka and Bangladesh, and Taiwanese and South Korean machinery in Thailand. Pakistan also exports machinery to the neighbouring Afghanistan. In South America, Mexico is reported to have done well in exporting one particular machine (for the wet process), while a number of machines are now being produced in Argentina and Brazil under licence from some reputed foreign manufacturers. The business of the developing country tanning machinery manufacturers is, however, mainly confined to the domestic market.

B. SELECTED TECHNOLOGIES

For analytical purposes we have selected two operational plants, as shown below, from two South East Asian countries:

(i) Plant A, processing 200-hides per day, i.e. 1.2 million sq.ft. of finished leather per year.
(ii) Plant B, processing 400-hides per day, i.e. 2.4 million sq.ft. of finished leather per year.

C. TECHNICAL SPECIFICATION

The technology used is of the "modern" conventional type. Wooden drums are used for the wet stages, i.e. soaking, liming, and tanning, and also for re-tanning, fat-liquoring and dyeing. Both A and B use simple machinery and with the exception of the hydraulic press, the equipment in such sub-processes as fleshing, shaving, etc. has mechanical operation.

Technical specification of each plant is shown in detail in the following tables and, as may be seen, the source of equipment in A is domestic, while in B it is both domestic and foreign, wooden drums being obtained from the local source.

Table 1

Technical Specification of Plant A (Processing 200-hides per day)

	Sub-process	Type of Equipment	Source of equipment
1.	Soaking, liming and tanning	8 wooden drums (each 8' x 6') and 1 experimental drum	local
2.	Fleshing	1 mechanical fleshing machine	local
3.	Shaving	2 mechanical shaving machines	local
4.	Re-tanning, dyeing and fat-liquoring	5 wooden drums (each 8' and 6')	local
5.	Setting-out	1 mechanical setting-out machine	local
6.	Drying	1 toggle drying unit	local
7.	Staking	2 jaw-type staking machines	local
8.	Buffing	2 mechanical buffing machines	local
9.	Seasoning	Hand padding	local
10.	Spraying	1 hand spray booth and gun	local
11.	Ironing/pressing	1 hydraulic press	local
12.	Glazing	2 jaw-type glazing machines	local
13.	Measuring	1 pin-wheel measuring machine	local

Table 2

Technical specifications of Plant B (processing 400-hides per day)

	Sub-process	Type of equipment	Source of equipment
1.	Soaking, liming and tanning	8 wooden drums (each 8' x 6') and 1 experimental drum	local
2.	Fleshing	1 mechanical fleshing machine	imported from Europe
3.	Sammying and setting-out	1 sammying and setting-out machine	imported from Europe
4.	Shaving	2 mechanical shaving machines	imported from Europe
5.	Re-tanning, dyeing and fat-liquoring	5 wooden drums (each 8' and 8')	local
6.	Drying	1 paste-drying unit	imported from Europe
7.	Staking	2 jaw-type staking machines	imported from Europe
8.	Buffing	3 mechanical buffing machines	imported from Europe
9.	Seasoning	Hand padding and auto-drying unit	imported from Europe
10.	Spraying	2 spray booths and guns	imported from Europe
11.	Ironing/pressing	1 hydraulic press	imported from Europe
12.	Measuring	1 pin-wheel measuring machine	imported from Europe

D. INVESTMENT COST

	Plant A (200-hides/day) US $,000	Plant B (400-hides/day) US $,000
Land and buildings	180	309
Machinery and equipment*	251	563
Spares (15% of basic machinery cost)	29	55
Pre-operative expenses	19	32

* Includes duty on imported equipment, transport and installation costs.

E. PROJECT LIFE

The project life is 25 years, given proper maintenance and occasional replacement of small items. Initial investment is undertaken in year 0 and production starts from year 1 when only one-third of capacity is produced. Year 2 will have two-thirds of capacity production. Capacity operation is from year 3 onwards. The project is scrapped in year 25; the scrap value is put at 10 per cent of land and buildings cost.

Total number of days worked per year is 300.

F. TRAINING REQUIREMENTS

"On-the-job" training for most of the skilled operations.

4. OPERATING CHARACTERISTICS

A. MATERIAL INPUTS

The main raw material for the manufacture of finished upper leather is, of course, raw hides, As high as 50 to 60% of the total operating cost is for raw hides. For quality and capacity production, it is essential that the manufacturer gets good quality raw hides in adequate quantity. Every leather manufacturer knows that one can make bad leather from good hides, but one cannot make good leather from bad hides. Many developing countries are showing concern to improve the quality of raw hides. For example, in Kenya premium price is being paid for the quality raw hides and skins. Simple curing defects can seriously damage the raw material, thus affecting the quality of output, while flaying defects can reduce the yield quite significantly.

Next to raw hides, chemicals form a very important material input. About one-fifth to one-quarter of the operating cost can be in chemicals. Unlike raw hides, chemicals cover many products for tanning and finishing operations. There can be as many as 60 chemicals. Of these, only lime, salt and some types of vegetable tanning agents are found in some developing countries; other chemicals are, in most cases, imported.(11)

(11) The established chemical firms have subsidiaries in only a few developing countries such as India, Korea, Pakistan, etc.

Water is required in large quantities in pre-tanning stages; the exact quantity depends on the techniques used. For example, for soaking in paddles 9 parts of water may be needed for 1 part of weight of hide, while in wooden drums only 5 parts of water are needed. In any case, the leather manufacturing plant should be assured of regular supply of water either from wells, a nearby lake or the municipal source.

B. EMPLOYMENT

The employment figures are based on single-shift operation with the exception of extra work in certain sub-processes such as wet stages and drying.

Total costs/year in thousands of US$

		200-hides/day		400-hides/day	
		No.	cost/year	No.	cost/year
Skilled	at 1,000/year	31	31.00	54	54.00
Semi-skilled	at 850/year	17	14.45	31	26.35
Unskilled	at 700/year	10	7.00	12	8.4
Supervisory	at 1,200/year	6	7.2	9	10.8
Office	at 1,000/year	11	11.0	15	15.00
Management	at 3,000/year	3	9.0	5	15.00
	Total	78	79.65	126	129.55

C. OPERATING COSTS

At full capacity, in thousands of US $

	A	B
Raw hides (at 0,50 per sq.ft)	600	1,200
Chemicals (at 0,18 per sq.ft)	216	432
Electricity (at 0,035 per kwh)	19.17	39.96
Water (at 0,05 per 1,000 gal.)	8.58	16.00
Wages and salaries	79.65	129.55
Maintenance	59.2	71.75
Overheads	21.55	43.6
Effluent treatment	4.32	8.64
Packaging, sales and commission (4% of sales)	48.0	96.0
Total	1,056.47	2,037.50

D. SALES REVENUE

Finished leather is sold by sq.ft., a standard measure in the leather trade. The price of finished leather is closely linked with the price of raw hide, the main raw material. For purposes of calculation, we assume a conservative figure of $1.00 per sq.ft. Viewed against the price prevailing in European markets where finished leather is sold at $1.50 to $1.80 per sq.ft. our figure of $1.00 is understandably on the low side. Such a low figure is taken as a realistic price because the small-scale producer might sell part of his output locally at low prices. A small increase in the price of finished leather (say by 5 per cent from $1.00 to $1.05), other things remaining constant, will obviously improve the profitability substantially.

5. EVALUATION (values in US $) - Plant A

This is based on 25 year operating life, a 3 year build up to full capacity production, and a residual value for land, building and equipment. Fixed investment is 479,000. Working capital, 224,000, is taken in 3 instalments. On year 1 : 80,000; on year 2 : 72,000; on year 3 : 72,000. The residual value, 18,000, and working capital 224,000, are returned in the 25th year of operation.

Thus, production costs build up as follows :

	Year 1 capacity (1/3)	Year 2 capacity (2/3)	Year 3 capacity (full)
Materials	272,000	544,000	816,000
Wages and salaries	79,650	79,650	79,650
Water and electricity	9,250	18,500	27,750
Waste treatment	4,320	4,320	4,320
Packaging, sales and commissions	16,000	32,000	48,000
Repairs and maintenance	19,733	39,467	59,200
Overheads	21,550	21,550	21,550
	422,503	739,487	1,056,470

The following are the results of NPV analysis :

Discount Rate	Present value of total costs	Annual revenue required	Revenue required per hide
10%	9,394,473	1,146,274	19.10
20%	5,114,209	1,229,283	20.48
30%	3,456,390	1,319,736	21.99

6. EVALUATION (values in US $) - Plant B

This is based on 25 year operating life, a 3 year build up to full capacity production, and a residual value for land and building. Fixed investment is 959,000, including 32,000 for the pre-investment expenses. Working capital, 441,000, is taken in 3 instalments. On year 1 : 156,000; on year 2 : 142,000; on year 3 : 143,000. The residual value, 30,900, and working capital 441,000, are returned in the 25th year of operation.

Thus, production costs build up as follows :

	Year 1 capacity (1/3)	Year 2 capacity (2/3)	Year 3 capacity (full)
Materials	544,000	1,088,000	1,632,000
Wages and salaries	129,550	129,550	129,550
Water and electricity	18,653	37,307	55,960
Waste treatment	8,640	8,640	8,640
Packaging, sales and commissions	32,000	64,000	96,000
Repairs and maintenance	23,917	47,833	71,750
Overheads	43,600	43,600	43,600
	800,360	1,418,930	2,037,500

The following are the results of NPV analysis :

Discount Rate	Present value of total costs	Annual revenue required	Revenue required per hide
10%	18,140,962	2,213,484	18,45
20%	9,887,298	2,376,571	19,80
30%	6,690,867	2,554,741	21,29

7. SUMMARY AND CONCLUSIONS

This technology profile has been prepared to provide technical and investment guidelines for the processing of cattle hides for the manufacture of chrome-upper leather (i.e., shoe upper leather) at small-scales of production.

Leather manufacturing has shown good prospects of development in many develping countries and the industry is developing rapidly in, e.g. India, Pakistan, Argentina and Brazil. The main raw materials for this industry, i.e. raw hides and skins, are locally available, the technology is not very complex, and the industry is of the labour-intensive type offering food prospects of employment creation.

Information collected from two leather manufacturing plants are used here: one processing 200-hides per day and the other 400-hides per day. Technological differences between the plants are mainly because of differences in the source of machinery and equipment, developing country-made machinery being available at significantly lower prices than that from European sources.

For the manufacture of chrome-upper leather, both A and B (the selected tanneries) are normally considered as very small-scale by the European tanning machinery suppliers. The use of low-cost developing country-made machinery, particularly in the smallest scale (A) is, therefore, understandable. In the other scale considered, i.e. (B), developing country-made wooden drums have been used.

16. FIBREBOARD PLANT

(ISIC Code 3311 - produced 1979)

> Fibreboard is an inexpensive panel which can be produced using local resources in most ACP countries. This profile is based on a plant with a capacity of 24 tonnes per day, with an investment cost of $3,550,000 and employment of 172 people. It can produce hardboard, medium density board, and insulation board.

1. INTRODUCTION

Fibreboard is the least expensive panel to use in terms of cost per given surface area, and this is an important consideration for example in the internal surfaces of low cost housing. This type of industry is based on forestry raw materials which represent large local resources for most ACP countries.

2. TECHNOLOGY

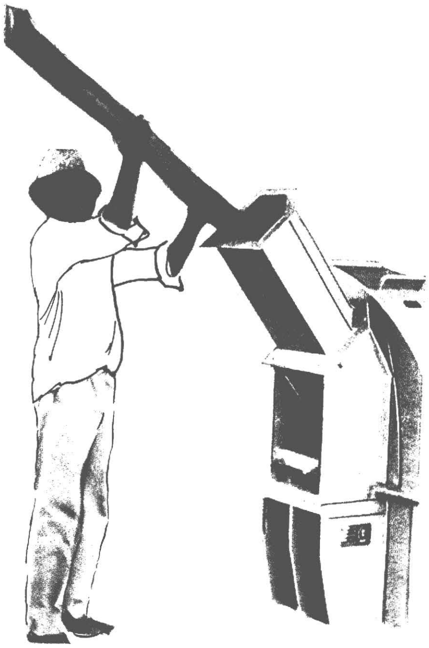
A. INPUT MATERIALS

Eucalyptus logs and pine and cypress sawmill residues can be used, with various proportions according to final product to be obtained:

- for hardboard : 75% eucalyptus
25% coniferous
- for medium density fibreboard : 50% eucalyptus
50% coniferous
- for insulation board : 25% eucalyptus
75% coniferous

In addition forest thinnings and tree tops can also be used. Debarking may not be necessary where bark is not too thick.

No chemical binding agents (synthetic resins) are required as for other types of board (particle board). Paraffin emulsion may be added for medium density fibreboard and insulation board to improve the wet strength.



Loading of logs

Boards getting out of the press

B. PROCESS DESCRIPTION

Basic process for hardboard :
- reducing logs into chips;
- digestion of chips by steam treatment under 9 atmosphere pressure in a stainless digester (batch system) : the chips are defibred and reduced into pulp;
- forming sheets of dewatered pulp;
- pressing sheets to obtain panels;
- heat treatment, finishing and trimming of panels.

For the other types of board the process is basically the same :

- insulation board (softboard): care has to be exercised to produce a fibre that is relatively coarse as to give a great volume with light weight, and at the same time enough fine fibre to provide the necessary binding. The best conditions must be determined by practical tests.
- medium density board : reduced pressure is required while pressing panels.

C. OUTPUT PRODUCTS

Types of products : hardboard, medium density board, insulation board.
Board size : 1,220 mm x 2,440 mm.
Thickness range : - hardboard 2.0 to 10.0 mm.
- medium density board 6.3 to 12.7 mm.
- insulation board 12.7 mm.

Board density : - hardboard : over 800 kg/m^3
- medium density board : 400 to 650 kg/m^3
- insulation board : 350 to 450 kg/m^3

Quality : Hardboard will meet the following British standard : B.S. 1142: Part 2: 1971. The properties of lighter boards depends on their density and the additives used.

D. REFERENCES

Industrial fibreboard production started fifty years ago and, since that time, has enjoyed a steady though unspectacular growth. Small-scale plants are operating in ACP countries.

3. PLANT CAPACITY

In industrialized countries, it is generally accepted that a fibreboard plant with an output capacity below 100 t/day is not viable. For developing countries, a capacity of 50 t/day has been considered feasible by scaling down the equipment, but without a change in technology. Practical reference has shown, however, that by adapting existing technology to a labour intensive system, fibreboard plants with a capacity of 24 t/day or even 12 t/day may become profitable in a developing country with low labour costs.

A. OUTPUT CAPACITY

The present profile is based on a 24 t/day fibreboard mill in an African country which started production in May 1975. The plant can produce hardboard, medium density board and insulation board.

A plant with a capacity of 12 t/day, which should be considered the absolute minimum, has been operating satisfactorily since 1971 in another African country, but the plant can produce only hardboard.

B. WASTE MATERIALS

If pulp washing is not required the white water circuit can be closed almost entirely. A sedimentation tank must be installed so that the fines suspended in the white water are deposited before it is recirculated. The disposal of waste for such small quantities of non-toxic water, is either by seepage or by sewage into a river.

If the pulp is washed because one wants to produce boards of a very light colour or because the raw material contains substances that must be eliminated, waste water disposal of about 30 m^3/hour must be assumed, and it may be necessary to build an oxidation pond for the waste water if there is no large river in the vicinity.

4. RAW MATERIALS AND UTILITIES

Working basis : 24t/day, 3 shifts operation, 270 days/year, i.e. = 6,480 t/year.

Item	Consumption per tonne board	Annual Consumption	Annual Cost $
Wood (oven dry)	1,100 kg	7,128 t	74,819
Electricity	600 kWh	3,888,000 kWh	124,416
Fuelwood	0.833 kg	5,398 t	48,582
Water	5 m^3	32,400 m^3	6,480
Maintenance	-	-	52,000
		Total	$306,297

5. WORKFORCE REQUIREMENT

Item	Number	Annual cost $
Managing Director	1	24,000
Deputy Manager	1	12,000
Chief engineer	1	3,000
Quality controller	1	2,000
Shift foremen	4	6,000
Storekeeper	1	1,500
Mechanics and electricians	6	9,000
Semi-skilled workers	16	18,000
Unskilled workers	130	65,000
Chief salesman	1	4,000
Salesman	1	2,000
Senior clerk	1	2,000
Assistant clerk	1	1,500
Typist/telephonists	3	3,000
Drivers	3	2,000
Watchmen	2	1,000
	172	$156,000

6. INVESTMENT COSTS

A. FIXED INVESTMENT	$
Land and site preparation	60,000
Buildings and foundations	400,000
Construction overheads	70,000
Plant contingencies	170,000
Production equipment (FOB Europe)	2,500,000
Freight and insurance	110,000
Clearing and transport to site	70,000
Local equipment, on site	80,000
Office equipment and vehicles	90,000
Total	3,550,000

B. PRE-INVESTMENT COSTS	$
Engineering costs	130,000
Erection costs	80,000
Interest during construction	190,000
Pre-operational costs	80,000
	480,000

C. WORKING CAPITAL

Estimated at 140,000

D. TOTAL CAPITAL REQUIREMENTS	
Investment	3,550,000
Pre-investment costs	480,000
Working capital	140,000
	4,170,000

Land : an area of about 2 ha should be available, so as to have sufficient space for a fresh water pool, a sedimentation tank, log storage, etc...

Basic data for the buildings:

total floor area covered	2,700 m^2
with a basement	280 m^2
with a second floor	50 m^2

The buildings can be kept very simple. In Africa, the supporting structure of the hangers consists of eucalyptus poles and the roof construction is made of wood trusses.

7. PRODUCTION COSTS

	$
Raw materials and utilities	306,297
Wages and salaries	156,000
General administration	50,000
Total	$522,297

8. TECHNOLOGY TRANSFER CONDITIONS

The technology offered is not subject to a patent registration, thus there are neither any royalties nor licensing agreement for the exploitation, and the know-how is supplied as a part of the whole offer.

9. TIME SCHEDULE FOR ERECTION OF THE PLANT

The equipment is delivered within 12 months after the date of order, and the plant installation takes a further 6 months.

10. SPECIFIC ASPECTS

A fibreboard plant may be economical in a developing country if some favourable conditions are satisfied :

- cheap raw material and fuel (waste wood from other wood industries, under-utilized plantations, excess sugar cane bagasse, etc....)
- cheap electric energy
- low general expenses (fibreboard plant attached to a parent industry such as saw mill or a sugar factory).

The value of the production can be increased by coating and laminating the boards. A laminating plant capable of laminating about half the output of the plant will require an additional overall investment of about $300,000.

The production of flush doors in the fibreboard plant itself may also be considered, provided an additional investment of about $100,000.

In some cases, the raw material supply may be a limiting factor, but with an appropriate treatment to be determined by laboratory or semi-industrial tests, most wood species can give good fibreboards.

Agricultural products may also serve as raw materials especially sugar cane bagasse.

If only bagasse is employed, the cost of the plant is slightly higher than with wood. Basically, instead of the wood chipper there would be a bagasse depithing machine, and the bagasse would be compacted before being fed into the digester.

If bagasse is employed to supplement a deficient wood supply, the dry preparation department will have to be equipped for the handling of both bagasse and wood. With 24 t/day capacity, the additional investment required for this can be estimated at $100,000-$150,000.

11. EVALUATION (values in US $)

This is based on 10 year operating life, a 3 year build-up to full capacity production, and a residual value for land, building and equipment. Fixed investment is 4,030,000, including for the pre-investment expenses. Working capital, 140,000, is taken in 3 instalments. On year 1 : 48,000; on year 2 : 45,000; on year 3 : 47,000. The residual value, 403,000, and working capital 140,000, are returned in the 10th year of operation.

Productions costs are as follows:

	1/3 capacity	2/3 capacity	full capacity
Raw materials (wood and fuelwood)	41,134	82,267	123,401
Electricity	41,472	82,940	124,416
Water	2,160	4,320	6,480
Wages and salaries (for 172)	124,800*	156,000	156,000
Maintenance**	17,330	35,000	52,000
General administration	60,000	60,000	60,000
Packaging and despatching (1% of sales)	6,500	13,000	19,500
Sales and commissions (3% of sales)	19,500	39,000	58,500
	312,896	472,527	600,297

* 80% of full capacity.

** Maintenance costs are shown as $52,000 at full capacity; as % of total machinery costs it turns out at 2% which should be considered as a low figure.

The following are the results of NPV analysis :

Discount Rate	Present value of total costs	Annual revenue required	Revenue required per metric tonne
10%	7,257,940	1,379,139	212.83
20%	6,229,429	1,829,855	282.38
30%	5,634,765	2,365,560	365.06

17. PAPER AND PAPERBOARD MANUFACTURE

(ISIC Code 3411 - produced 1979)

> This profile describes a plant which manufactures a range of good quality paper paper from raw materials which include waste paper and agricultural waste. Output from two-shift working is 210 tonnes of paper per annum. Initial investment is $186,422, and the plant employs 45 people.

1. PRODUCT DESCRIPTION

This technology was developed in India to produce up to one tonne of paper or paperboard per day from waste paper or agricultural wastes such as bagasse (sugar cane), sisal, cotton, jute, banana leaves or bamboo.

Depending on the raw material chosen, paper or paperboard can be made in weights from 65 grammes per m^2 (gsm) up to 300 gsm. Sheets can be produced in single or double thickness. Among the range of products are :

Art and engineering drawing paper, permanent document paper, blotting paper, filter paper, electrical insulation paper and board, coloured papers, boxboard, fileboards and card.

2. DESCRIPTION OF TECHNOLOGY

Most of the machinery in the plant is of a type used for many years in the Indian hand papermaking industry. The main improvement is the development of a cylinder mould machine to increase productivity in the actual forming of the paper.

(a) The raw material is sorted by hand and is then reduced to small pieces in the chopper.

(b) Atmospheric cooking then takes place with caustic soda or lime (1-3 per cent on the dry weight of raw material) in a digester.

(c) The material is pulped in a beater for 1-8 hours depending on the material, producing a slurry of 3 per cent fibre to 97 per cent water.

> (Note: if waste paper is the raw material, the chopper and digester are not needed, and only about one hour of beating is necessary).

(d) Washing, bleaching and dyeing, if required, are carried out in the beater after pulping.

(e) Pulp flows to the vat of the cylinder mould machine. The cylinder has a covering of wire mesh. It revolves in the vat which has a drain in the bottom. The water in the pulp flows through the mesh towards the drain leaving a deposit of the pulp on the face of the revolving cylinder.

(f) Endless felt passing on top of the cylinder picks up the pulp while the cylinder continues revolving in the vat to pick up more pulp. The pulp at this stage has lost some water but is still wet.

(g) As the felt carries the pulp away from the cylinder mould a little more water is lost through absorption and some more is squeezed out as the felt passes it between the squeeze roll and the cutting roll. Here the pulp is cut into sheets (size 110 x 66 cm = 0.726 m^2). These sheets are taken off the machine and built up into a stack with interleaved felts.

(h) The stack of pulp sheets passes through a hydraulic press.

(i) The sheets are separated and either air dried or passed through a drying tunnel.

(j) Finally the dry sheets of paper are put through a calendering machine to make them smooth and then guillotined to size.

In most cases almost 100 per cent of the input raw material ends up in the finished product, though there will be a loss of up to 50 per cent of the dry weight when the non-cellulose element in some agricultural wastes is extracted in the cooking and washing stages.

Some water will go to waste : how much depends on the amount of washing and bleaching to be carried out. To produce 1 tonne of paper will result in waste of between 1,000 and 45,000 litres. This waste water contains only very small traces of chemicals and would be safe to use for irrigation. If the cost of water justifies it, the waste water can be purified and used again.

In addition to the basic raw materials small quantities of the following may be needed:

> bleaching powder, titanium dioxide, diacol, rosin, alum, caustic soda and dyes.

If firewood is used for the digester up to 1 tonne per day will be needed for jute which requires a long cook. Other materials will need much less. The maximum amount of electricity required is 80 kW per operating hour or 1,280 kWh per day for two shifts.

Equipment costs (inclusive of motors):		$
Chopper		1,777
Vomitting digester		1,110
Beaters - 2		11,581
Agitators with pumps - 2		3,501
Cylinder mould machine		7,785
Couching trolleys and tables - 2		193
Press		4,322
Drier		4,111
Calendering machine		4,818
Guillotine and knife grinder		3,479
Test equipment (2 autovats, baby beater)		1,820
Starters and switches		4,337
Accessories and spares		5,996
		54,830
Freight and insurance		5,483
	Total	60,313

Cost of materials and other inputs:

For output of 0.8 tonnes of paper per day, 0.8 tonnes of high grade waste is required at $90 per tonne. Annual cost :	19,000

The following chemicals are required - the data refers to the maximum required of each chemical, no paper would have all these ingredients at full strength:

Caustic soda	3% per tonne paper	227
Rosin	2%	250
Alum	2.5%	32
Starch	6%	202
Titanium dioxide (whitener)	1%	71
Diacol	0.25%	3
Dyes	0.5%	116
		901

Electricity is required at the rate of 1280 kWh per day or 307,440 kWh per annum. The estimated cost is $12,300. The average water loss per day is 32,000 litres for two-shift operation at an estimated annual cost of $1,320.

Overhead costs are estimated at $10,000 for insurance, bank charges, post and telephone, local taxes and stationery and other office costs (including selling expenses).

3. LEVEL OF OUTPUT

Depending on the raw materials used from 0.6 to 1.2 tonnes of paper can be made in a three-shift day. For the purposes of this evaluation we assume that the basic raw material is waste paper, and we also assume two-shift working, giving an output of 0.8 tonnes of paper per day. On the basis of a 5.5 day week and 48 working weeks in the year the annual output would be about 210 tonnes of paper.

This level of output would be equivalent to approximately 11,000 sheets (22 reams) of 110 x 66 cm paper of weight 100 grammes per m^2 per day.

4. EMPLOYMENT

In India, with very low wage rates, it is the practice to have up to 25 workers per shift. In countries where labour rates are higher a total of 13 workers plus one supervisor per shift will suffice. For the purposes of the evaluation in this profile a total of 20 workers per shift is considered appropriate.

			$
1	Manager	at $4,000 per annum	4,000
2	Shift supervisors	at $2,400 " "	4,800
2	Office workers	at $1,000 " "	2,000
10	Skilled Workers	at $1,920 " "	19,200
16	Semi-skilled Workers	at $1,200 " "	19,200
14	Unskilled workers	at $ 720 " "	10,080
45			59,280
		Additional labour costs at 10%:	5,928
			65,208

5. DATA FOR ECONOMIC ANALYSIS

A. INVESTMENT COST

i) Fixed investment:

	$
Equipment	60,313
Buildings: Main building 360m² Secondary building 280m² (Structures at $56-45/m² and Foundations at $84-87/m²)	90,000
Civil Works - construction of digester cladding, beater troughs, base for cylinder mould machine, agitator tanks, drier tunnel 130 m³ at $80 per m³	10,400
Other fixed assets(furniture etc)	8,000
Erection and commissioning	17,709
	186,422

ii) Working Capital:

	$
Stocks of materials	3,500
Stocks of finished products	1,750
Stocks of spares	2,500
	$ 7,750

iii) Residual Value:

	$
10% of Equipment Cost and 50% of Building Cost	51,000

B. ANNUAL OPERATING COSTS

		$
i)	Materials:	19,901
ii)	Wages and Salaries:	65,208
iii)	Water and Fuel:	13,620
iv)	Repairs and Maintenance	4,500
v)	Overheads	10,000
		113,229

C. EVALUATION

A 20 year operating life has been assumed, with replacement of equipment between the 10th and 11th year of operation. A three year build-up to full capacity operation has been used, with working capital being added equally over these three years. The working capital and residual value are returned in the final year of operation.

The production costs build up as follows:

	Year 1 (1/3)	Year 2 (2/3)	Year 3 (3/3)
Materials	6,634	13,267	19,901
Wages and Salaries	65,208	65,208	65,208
Water and Fuel	4,540	9,080	13,620
Repairs and Maintenance	1,500	3,000	4,500
Overheads	10,000	10,000	10,000
	$ 87,882	$100,555	$113,229

The following are the results of NPV analysis:

Discount Rate	Present Value of Total Costs	Annual Revenue Required for Given Discount Rate	Revenue required per tonne of paper	Revenue required per ream of 110 x 66 cm paper(100g/m^2)
10%	1,094,189	143,376	682.74	24.78
20%	703,278	172,279	820.37	29.78
30%	542,670	208,239	991.61	36.06

These "factory gate" costs are based on the production of a good quality paper from high grade waste. A comparable import price for grey wrapping paper is $750 per tonne.

18. SMALL-SCALE PAPERBOARD PLANT

(ISIC Code 3411 - produced 1980)

The profile evaluates a small-scale paper plant which uses waste paper as a raw material, and which produces about 400 sheets of paper (each 0.55 m^2) per 8-hour shift. (Approximately 100,000 sheets per annum). The paper produced can be used for the production of egg or fruit packing trays. The initial investment is $5,000 and the plant employs 4 people directly.

1. PRODUCT DESCRIPTION

This simple plant for paper making was developed at a scale of 60 kilos per 8-hour shift. This is the output for one unit but several units can be operated together to give increased output.

The product is in the form of sheets of paper or board 85 cm x 65 cm. Using sets of special dies these sheets can be formed, while still wet, into three dimensional packaging such as egg trays, egg cartons, and fruit, meat and vegetable trays. In general the product is more suitable for packaging than for printing and writing.

2. DESCRIPTION OF TECHNOLOGY

Waste paper is the normal raw material, but with additional preparation equipment waste agricultural materials such as bagasse (sugar cane), sisal and banana leaves can be used.

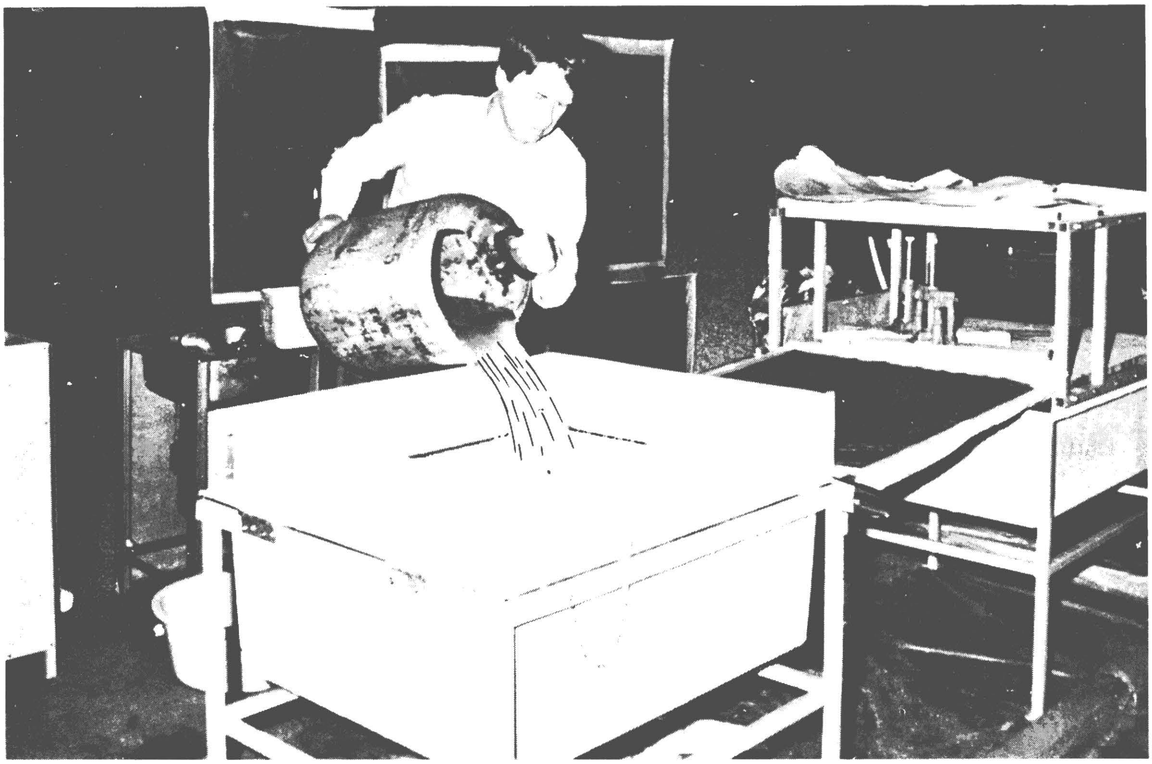
The waste paper is first soaked, then pulped in a machine derived from a domestic washing machine. Then the pulp is passed through a refiner which completes the job of breaking it down into basic fibres. The slurry from the refiner is poured onto a sheet of mesh stretched over the forming tank of the equipment and enclosed by a deckle. When a valve in the tank is opened moisture is sucked from the layer of pulp which is then pulled from the tank ready for pressing. The sheets of pulp formed on the machine are pressed in batches and hung up to dry.

The weight of the finished product is equal to that of the input: 60 kg of waste paper will yield 60 kg of fresh paper. About 60 litres of water will be lost through evaporation during the drying process for every 60 kg of paper.

Apart from waste paper, starch may be needed to improve the stiffness and strength of the paper. Dyes may be used to colour the paper. Electricity is needed to power the pulper and refiner at the rate of about 2.4 kWh per 8-hour shift.

A total of 7 m^2 of space is needed, with a supply of running water nearby. Electricity points for two machines per unit are required. To allow for storage of materials and finished products, as well as access to equipment, an additional 50 m^2 of building space has been added.

It is assumed that this small-scale paper plant will be run as an ancilliary to a larger operation, so that costs of management and of office services etc. have been aggregated into a "contribution to overheads".



The production unit with the main equipment

3. LEVEL OF OUTPUT

In one 8-hour shift the output will be between 40-60 kg, equal to about 480 sheets of paper, 240 sheets of 2-ply paperboard or 480 egg trays. These figures are for one unit. With a batch of three units the output may be a little over three times as much but there will be a considerable saving on labour.

At 50 kg per day, 5.5 days per week for 48 weeks of the year the total output will be 13,200kg of paper or 105,600 sheets of paper. Alternatively this would give approximately 52,800 sheets of 2-ply paperboard or 105,600 egg trays.

4. EMPLOYMENT

If sheet material is being made, the labour requirements would be one supervisor and 3 semi-skilled workers. For the manufacture of egg cartons, fruit trays etc. one additional worker would be required per unit, as well as the special forming dies as additional equipment.

	$
1 Supervisor at $ 2,400 per annum	2,400
3 Semi-skilled workers at $1,200 per annum	3,600
	6,000
Additional labour costs at 10 per cent	600
	6,600

5. DATA FOR ECONOMIC ANALYSIS

A. INVESTMENT COST

i) Fixed Investment:	$
Equipment	1,000
Buildings (57 m^2)	4,000
	5,000

ii) Working Capital:	$
Equivalent of 3 months' materials	300
iii) Residual Value:	2,500

B. ANNUAL OPERATING COSTS

	$
i) Materials:	1,320
ii) Wages and Salaries:	6,600
iii) Water and Fuel:	200
iv) Repairs and Maintenance:	120
v) Overheads:	1,200
	$9,440

C. EVALUATION

The evaluation is based on the calculation of the cost per 100 sheets of paper with a 10-year operating life of equipment, and a 2-year build up to full capacity production. Working capital expenditure is incurred in two equal parts in the first two years of operation, and is returned with the residual value in the final year.

Thus, production costs build up as follows:

	1/2 Capacity	Full Capacity
Materials	660	1,320
Wages and Salaries	6,600	6,600
Water and fuel	150	200
Repairs and Maintenance	60	120
Overheads	1,200	1,200
	$ 8,670	$ 9,440

The following are the results of NPV analysis:

Discount Rate	Present Value of Total Costs	Annual Revenue Required	Cost per 100 Sheets
10%	61,493	10,806	10.23
20%	43,725	11,581	10.97
30%	33,604	12,414	11.76

In some countries egg cartons, egg trays or fruit trays are imported at a cost of $20 or more per 100, compared with a factory gate production cost which would be about $10 per 100 in the case of this unit on the assumptions stated.

19. PAPERBOARD BOX PLANT

(ISIC Code 3412 - produced 1980)

This profile describes a technology for the manufacture of paperboard boxes on a small-scale. The initial investment is $4,945 for an annual output of 660,000 boxes of various sizes (a throughput of 22 tonnes of board per annum). The project employs 10 people.

1. PRODUCT DESCRIPTION

Finished products are generally marketed in suitable containers in order to ensure safe carriage, prevention of possible deterioration due to atmospheric conditions, and to achieve a better presentation of the product. Most pharmaceuticals are packed in tubes and/or cardboard containers, and liquids in glass bottles are often packed in cardboard boxes.

2. DESCRIPTION OF TECHNOLOGY

This project takes as its main raw material craft paperboard which has already been printed to the customers' specifications by an outside contractor. When the board has been cut into blanks of the appropriate size, they are fed into the rotary slotting and creasing machine where the necessary slots and folding lines are made. The prepared blank then goes to the corner cutting machine, and is then fed into the box stitching machine, after going through the bending machine.

Machinery and Equipment		$
Board cutter (hand operated)	107 cm	320
Standard rotary slotting and creasing machine (hand operated)	79 cm	320
Corner cutting machine (foot operated)	183 cm^2	320
Standard bending machine with four adjustable gauges	92 cm	320
Standard box stitching machine arm (foot operated)	51 cm	440
Office furniture and equipment		125
Transport, erection and installation, etc.		600
		2,445

3. LEVEL OF OUTPUT

The specified output of the project is 2,500 paperboard boxes per day, which over a 5 1/2 day week for 48 weeks of the year gives an annual output of 660,000 boxes of various sizes. The throughput of paperboard of various thicknesses is at the rate of approximately 2 tonnes per month or 22 tonnes per annum.

4. EMPLOYMENT

The following employment is required to maintain production over 11 months of the year:

			$
1	Supervisor	at $2,400 per annum	2,400
2	Operators	at $1,920 " "	3,840
5	Helpers	at $ 720 " "	3,600
1	Watchman	at $ 720 " "	720
1	Part-time clerical assistant	at $ 720 " "	720
	Other labour costs		1,128
10			$12,408

5. DATA FOR ECONOMIC ANALYSIS

A. INVESTMENT COST

i) Fixed Investment:	$
Machinery and Equipment	2,445
Building Costs (covered area 50 m^2)	2,500
	4,945

ii) Working Capital:	$
3 months' materials	3,245
iii) Residual value:	495

B. ANNUAL OPERATING COSTS

		$
i)	Materials:	
	Craft paperboard of various thicknesses - 22 tonnes at $500 per tonne	11,000
	Stitching wire and gluing chemicals	900
ii)	Wages and Salaries:	12,408
iii)	Water and Fuel:	600
iv)	Motor and Transport:	150
v)	Repairs and Maintenance:	150
vi)	Overheads:	2,500
		27,708

C. EVALUATION (Values in US $)

This is based on a 10 year operating life, 2 year build-up to full capacity production, and a 10 per cent residual value for the fixed investment cost. Initial investment cost is $4,945, working capital in 2 instalments of $1,623 each in the 1st and 2nd years of operation; residual value in the 10th year of operation of $495, together with working capital of $3,245 returned.

Thus, production costs build up as follows:

	1/2 Capacity	Full Capacity
Materials	5,950	11,900
Wages and Salaries	12,408	12,408
Water and Fuel	300	600
Motor Transport	150	150
Repairs and Maintenance	75	150
Overheads	2,500	2,500
	$21,383	$27,708

The following are the results of NPV analysis :

Discount Rate	Present Value of Total Costs	Annual Revenue Required for Given Discount Rate	Revenue required per tonne of Processed Board
10%	170,805	30,016	1,364
20%	117,701	31,175	1,417
30%	87,664	32,384	1,474

20. CORRUGATED BOARD SHEET PLANT

(ISIC Code 3411 - produced 1980)

This profile describes a relatively labour intensive method of manufacturing corrugated board sheets at the rate of 1000 tonnes per annum, or approximately 1.7 million $1m^2$ sheets. The initial investment required is $326,755 and 49 people are employed.

1. PRODUCT DESCRIPTION

The project described in this profile is designed to manufacture corrugated board sheets one metre square from Kraft liner and fluting medium.

2. DESCRIPTION OF TECHNOLOGY

The technology evaluated in this profile is the least capital intensive currently used for the scale of production selected. Greater labour intensity would entail replacing the single facer machine with wholly manual single facing.

Adhesive: In the technique presented here the adhesive used at the single facing sub-process is not suitable for use on double-facing machines due to its low consistency. The adhesive is transferred to the single facer manually by buckets and its level in the tray needs to be kept at the indicated level.

Single facing: The single facer corrugates the fluting medium, glues the flute tips and binds it to one liner. The output from this sub-process is single faced corrugated paper. Given the width of the single facer, average width utilization, average speed per minute, and effective hours per working day the average capacity of the machine may be calculated. In this case the plant efficiency level has been taken as half of the maximum speed of the machine. The effective working hours per shift are determined by the duration of the lunch break, and by stoppages necessitated by the changing of the paper rolls, removal of the finished roll, and by other factors such as machine breakdowns or power failures. (Developed country equipment manufacturers give an effective working time for continuous corrugators in developed country conditions of about 80 per cent of shift time).

The rate of production of a single facer is calculated from the average working speed of 15 metres per minute, an effective working day of 4 hours and one-metre average width utilization. The rate of production of one single facer is 3,600 m^2 per day and 1,080,000 m^2 per year. It is further assumed that the average weight of CB sheet per m^2 is 0.6 kg. This gives an annual production of 648 tonnes for one single facer.

Heating is necessary because a satisfactory bonding of flute and of the liner takes place at high temperature. Steam also 'conditions' the paper (i.e. opens the pores of the paper) so that the required amount of adhesive is absorbed.

Cutting machines: The number of cuts per machine per shift has been assumed to be 3,000. Given the average width of the corrugated board of one metre, and that the sheets are each of 1 m^2, the number of cuts required per day is 5,500 for CB and 5,500 for the liner. The number of machines required has been based on these figures.

Double facing: The sub-process of manual double facing is performed in two steps : (i) application of glue to flute tips of the single faced paper, and (ii) placing of the liner sheet on the glued sheet. The first step is performed by passing the sheet through the pasting machine. The machine itself consists of a metal frame with a glue applicator roll, a 'doctor' roll and a pressure roll. The glue applicator roll revolves in an adhesive tray to which glue is transferred manually. The 'doctor' roll which revolves against the glue roll removes any excess glue. The liner sheet is taken manually and placed on to the glued flute tips of the single faced paper sheet and secured. As the pile of complete double faced sheets reaches a certain height, the operation is suspended and the pile removed by the two operators.

The modern continuous double facing operation (with theoretical speeds of up to 200 lineal metres per minute on the latest models) is performed at high temperatures (up to 150°C) which facilitates quick bonding and aids the drying process. In manual double facing, the board must be kept for at least four hours for adequate bond formation and natural drying. It is normal practice for the boards to be left overnight, the natural pressure of the stack itself aiding board formation.

The following list outlines the production sub-processes together with the equipment required and expected operating life.

i) Unloading of paper rolls and other materials and their transport to the roll and material storage area; transport of rolls from storage to the single facer.
   - 2 Trolleys $100 (3 years)

ii) Adhesive preparation and its transport to the single facer.
   - 1 Metal drum with electric motor drive and 5 Buckets $150 (5 years)

iii) Single facer (the production of single faced paper entails the corrugation of the paper called the medium and its bonding with another sheet of paper called the liner).
   - 2 Single facer (155 cm) $ 29,138 (10 years)

iv) Transport of single faced paper rolls to storage cutting machinery and transport of liner rolls from storage to cutting machines.
   - Trolleys $100 (3 years)

v) Cutting of single faced paper and liner from rolls into sheets of the required size and transport to pasting machines.
- 4 Manually operated cutting machines (including the table on which the sheets are placed) $1,896 (10 years)
- 4 Trolleys $ 200 (3 years)

vi) Glue preparation (for double facing) and its transport to the pasting machines.
- 1 Metal drum with electric motor drive and coal burner $ 230 (5 years)

vii) Double facing (this operation binds the single faced paper with the second liner and thus completes the making of the corrugated board (sheet).
- 2 Pasting machines (183 cm) and 2 tables $3,356 (10 years)

viii) Sheet pressing (natural from the pressure of the stack)

ix) Transport of sheets to sheet storage
- 2 Trolleys $ 100 (3 years)

x) Counting, tying into bundles and despatch (no equipment)

xi) Waste collection and disposal
- 2 Trolleys $ 100 (3 years)

xii) Workshop
- Equipment $2,000 (10 years)

xiii) Laboratory
- Equipment $1,871 (10 years)

xiv) Offices and Vehicles $12,468 (5 years)

xv) Pre-production expenses $10,256

The cost of equipment is based on the ex-works price plus 18 per cent for freight, insurance, etc., plus, where necessary, 12 per cent installation charges.

Initial equipment cost (installed and including pre-production expenses) is $61,965.

The total equipment cost (including discounted replacement costs and pre-production costs) are as follows for an operating life of 20 years:

5% discount rate - $95,941
10% discount rate - $83,348
20% discount rate - $71,058

3. LEVEL OF OUTPUT

The plant is designed to produce 1000 tonnes of corrugated board sheet per annum. The number of days worked per annum are 300 of 8 hours each. With an average weight of CB sheets of 0.6 kg per m^2 this gives a total output of 1,666,667 sheets per annum, each of 1 m^2.

4. EMPLOYMENT

A. Production Labour

			$
1	Plant supervisor	at $2,400 per annum	2,400
6	Skilled Workers	at $1,920 " "	11,520
6	Semi-skilled Workers	at $1,200 " "	7,200
26	Unskilled	at $ 720 " "	18,720
39			$39,840

B. Administrative and Other Labour

1	General Manager	at $4,000 per annum	4,000
1	Production Manager	at $3,000 " "	3,000
1	Accounts Clerk	at $1,200 " "	1,200
2	Secretaries	at $1,200 " "	2,400
1	Laboratory Technician	at $1,920 " "	1,920
2	Drivers	at $1,200 " "	2,400
2	Security Men	at $1,200 " "	2,400
10			$17,320

Total Employment Cost (annual) -

Production Labour	39,840
Administrative and Other Labour	17,320
Supplementary Labour Costs	5,716
	$62,876

5. DATA FOR ECONOMIC ANALYSIS

A. INVESTMENT COST

i) Fixed Investment:

	$
Initial Equipment Cost	51,599
Pre-production Expenses	10,256
Land and Buildings	
Total Land (2,235 m^2)	44,700
Buildings (1,835 m^2)	220,200
Roll storage (427 m^2)	
Sheet storage (528 m^2)	
Production area (700 m^2)	
Offices, workshop etc. (180 m^2)	
	$326,755

ii) Working Capital:

	$
Paper (2 months stock)	51,500
Other materials(2 months stock)	1,108
Finished product (1 month)	34,006
Work-in-Progress (7 days)	9,522
	$96,136

iii) Residual Value:

	$
Land and Buildings	154,800
Equipment	5,160
	$159,960

B. ANNUAL OPERATING COSTS

	$	$
i) Materials:		
Paper, 1050 tonnes (Kraft liner 650 tonnes at $324; fluting medium 400 tonnes at $246 per tonne)	309,000	
Adhesives	5,260	
Tying string	1,386	
Coal	70	
		315,716
ii) Wages and Salaries:		62,876
iii) Water and Fuel:		
Electricity (Production)	2,964	
Electricity (Lighting)	239	
		3,203
iv) Motor Transport:		2,500
v) Maintenance Cost:		
Equipment	5,111	
Buildings	4,404	
		9,515
vi) Overheads:		10,000
Total		$403,810

C. EVALUATION (Values in US $)

This is based on a 20 year operating life, 3 year build-up to full capacity production, and a residual value for buildings and equipment. Investment costs have been taken for the initial year and periodic replacements in subsequent years for equipment with a specified operating life, and then discounted to a present value for the indicated interest rates. Initial investment is $326,755; working capital in 3 instalments of $32,045 each in the 1st, 2nd and 3rd years of operation; with the residual value ($159,960) and working capital returned ($96,136) in the 20th year of operation.

Thus, production costs build up as follows:

	1/3 Capacity	2/3 Capacity	full Capacity
Materials	105,239	210,477	315,716
Wages and Salaries	62,876	62,876	62,876
Water and fuel	1,068	2,135	3,203
Motor transport	2,500	2,500	2,500
Repairs and Maintenance	3,172	6,343	9,515
Overheads	10,000	10,000	10,000
	$184,855	$294,331	$403,810

The following are the results of the NPV analysis:

Discount Rate	Present Value of Total Costs	Annual Revenue Required for Given Discount Rate	Revenue required per tonne of processed board
10%	3,626,159	475,151	475.15
20%	2,187,897	535,960	535.96
30%	1,497,467	574,623	574.62

21. CORRUGATED BOARD BOX PLANT

(ISIC code 3412 - produced 1980)

This profile describes a relatively labour intensive method of manufacturing corrugated board boxes of various sizes, using 1000 tonnes of board per annum. Initial investment required is $373,493, and 65 people are employed.

1. PRODUCT DESCRIPTION

The project described in this profile is designed to manufacture a range of different sizes of boxes from corrugated board. Since the range of sizes, shapes and strength characteristics required by customers differs considerably from one order to another, the product has not been defined very distinctly.

2. DESCRIPTION OF TECHNOLOGY

Creasing and scoring are defined, respectively, as the making of indentations in corrugated board sheet parallel to the flutes, and perpendicular to the flutes, and is accomplished on machines called "bending machines" or "bar benders". A "bar bender" basically consists of two heads, and the bend (crease or score) is made by pressing the sheet between the two heads. One of the heads is equipped with an adjustable control with the aid of which the depth of the crease or score can be varied according to the thickness of the board. These machines can be manually or electrically powered. The former type is normally used at the cottage scale with a production of around 50-60 tonnes per annum. The machines adopted in this profile are electrically powered though manually operated with a foot pedal. The machine is of course manually fed. The blank is fed and then manually moved for each score required. It is then taken out and fed back for creasing.

Slotting of Blanks is accomplished by the use of machines called slotters which may either function independently or may be combined with other sub-process machines to constitute compound machines such as creaser-slotters, printer-slotters etc. In this profile the power operated manually controlled slotter has been selected. It is claimed to have a maximum speed of 60 strokes per minute, however, an average speed of 30 strokes per minute has been assumed. The number of slots required per box has been taken as six. On this basis three slotters are required at the 1000 tonnes per annum scale.

Printing involves a variety of methods. Some small plants do no printing and the customer pastes printed labels onto the box. Other small plants have their printing done by printing firms; blanks being transported to the printer and then returned to the box manufacturers. In screen printing the screen is made of nylon on which the design is made according to the principle of block making. This screen is fitted into a frame. The screen, except the pattern, is coated with chemicals so that the ink penetrates only through the pattern. Ink is manually spread by a brush. The sheet is pressed under the screen with a roller. The utilization of the printing screen depends very much on the size of each order. The estimate of screen input use is based on the assumption of average order size of 1,000 boxes each using one square metre of board.

The stitching technique was the first method of box closure adopted in the industry, and is highly labour intensive. Stitching is superior to gluing and taping in certain respects. This is the only method in which all the laminations are pierced through and closing is thus very firm. It also gives greater protection against pilfering during transit for it is possible to open the glued and taped boxes and then retape or reglue them. However, during the last two decades gluing and taping have considerably increased in popularity. This is partly due to the improvements in glue and tapes. The requirement of three manual stitchers is based on the assumption that one machine will stitch 2,000 boxes per shift.

The following list outlines the production sub-processes together with the equipment required and expected operating life.

i) Handling and storage of sheets and other materials
- 2 Trolleys $100 (3 years)

ii) Sheet cutting
- 7 Manually operated Cutting Machines
$3,321 (10 years)

iii) Transport of blanks to the Scoring Machines
- 4 Trolleys $200 (3 years)

iv) Scoring and Creasing
- 3 Bar benders (1575 mm wide)
$9156 (10 years)

v) Transport of Scored Blanks to the Printing Machines
- 2 Trolleys $100 (3 years)

vi) Printing
- Screen frame, buckets, etc.
$100 (5 years)

vii) Transport of Printed Blanks to Slotting Machines
- 2 Trolleys $100 (3 years)

viii) Slotting of Blanks
- 3 Slotters $1593 (10 years)

ix) Transport of Slotted Blanks to Flap Cutting Machines
- 2 Trolleys $100 (3 years)

x) Flap Cutting
   - 4 manually operated cutting machines
   $944 (10 years)

xi) Transport of Flap-cut Blanks to Stitching Machines
   - 2 Trolleys $100 (3 years)

xii) Stitching
   - 3 Manually operated Stitching Machines (914 mm)
   $5072 (10 years)

xiii) Transport of Stitched Cases to Warehouse
   - 2 trolleys $100 (3 years)

xiv) Counting, tying and Despatch
   - no equipment required

xv) Waste Disposal
   - 2 Trolleys $100 (3 years)

xvi) Office Equipment
   - $2868 (10 years)

xvii) Working Equipment
   - $2000 (10 years)

xviii) Laboratory Equipment
   - $1871 (10 years)

xix) Vehicles $10,000 (5 years)

xx) Pre-production Expenses $10,048

The cost of equipment is based on the ex-works price plus 18 per cent for freight insurance etc., plus where necessary, 12 per cent installation charges.

Initial equipment cost installed and including pre-production expenses is $47,973.

The total equipment cost (including discounted replacement costs and pre-production costs) are as follows for an operating life of 20 years:

5% discount rate - $73,593
10% discount rate - $64,097
20% discount rate - $54,865

3. LEVEL OF OUTPUT

The plant is designed to process 1000 tonnes of corrugated board per annum, manufacturing boxes of various sizes. The number of days worked per annum are 300 of 8 hours each.

4. EMPLOYMENT

A. Production Labour.

			$
1	Plant Supervisor	at $2,400 per annum	2,400
2	Skilled Workers	at $1,920 " "	3,840
11	Semi-skilled Workers	at $1,200 " "	13,200
40	Unskilled Workers	at $ 720 " "	28,800
54			$48,240

B. Administrative and Other Labour.

1	General Manager	at $4,000 per annum	4,000
1	Production Manager	at $3,000 " "	3,000
1	Marketing Assistant	at $2,700 " "	2,700
1	Accounts Clerk	at $1,200 " "	1,200
2	Secretaries	at $1,200 " "	2,400
1	Laboratory Technician	at $1,920 " "	1,920
2	Drivers	at $1,200 " "	2,400
2	Security Men	at $1,200 " "	2,400
11			$20,020

Total Employment Cost (annual) -

Production Labour and Other Labour	48,240
Administrative and Other Labour	20,020
Supplementary Labour Costs	6,826
	$75,086

5. DATA FOR ECONOMIC ANALYSIS

A. INVESTMENT COST

i) Fixed Investment:

	$
Initial Equipment Cost	37,925
Pre-production expenses	10,048
Land and Buildings	
Total land (2,668 m^2)	53,360
Buildings (2,268 m^2)	272,160
Sheet storage (10.09 m^2)	
Box storage (629 m^2)	
Production area (420 m^2)	
Workshop and Laboratory(50 m^2)	
Ink and stitching wire storage(30 m^2)	
Services (80 m^2)	
Office (50 m^2)	
	$373,493

ii) Working Capital:

	$
Corrugated Board (2 months)	89,167
Other Materials (2 months)	799
Finished Product (1 month)	55,700
Work in Progress (7 days)	15,596
	161,262

iii) Residual Value:

Buildings	136,080
Equipment	3,793
	139,873

B. ANNUAL OPERATING COSTS

		$	
i)	Materials:		
	Corrugated Board Sheets 1070 tonnes	535,000	
	Printing Ink	690	
	Printing Screens	29,559	
	Stitching Wire	1,897	
	Tying String	2,204	
			569,350
ii)	Wages and Salaries:		75,086
iii)	Water and Fuel:		
	Electricity (motors)	178	
	Electricity (lighting)	316	
			494
iv)	Motor transport:		2,500
v)	Maintenance cost:		
	Equipment	2,831	
	Buildings	5,443	
			8,274
vi)	Overheads:		10,000
		Total	$665,704

C. EVALUATION (Values in US $)

This is based on a 20 year operating life, 3 year build-up to full-capacity production, and a residual value for buildings and equipment. Investment costs have been taken for the initial year and periodic replacements in subsequent years for equipment with a specified operating life, and then discounted to a present value for the indicated interest rates. Initial invesment is $373,493: working capital in 3 instalments of $53,754 each in the 1st, 2nd and 3rd years of operations; with the residual value ($139,873) and working capital ($161,262) returned in the 20th year of operation.

Thus, production costs build up as follows:

	1/3 Capacity	2/3 Capacity	Full Capacity
Materials	189,783	379,567	569,350
Wages and Salaries	75,086	75,086	75,086
Water and fuel	365	435	494
Motor transport	2,500	2,500	2,500
Repairs and Maintenance	2,758	5,516	8,274
Overheads	10,000	10,000	10,000
	280,492	473,104	665,704

The following are the results of the NPV analysis:

Discount Rate	Present Value of Total Costs	Annual Revenue Required for Given Discount Rate	Revenue required per tonne of Processed Board
10%	5,645,983	739,816	739.8
20%	3,278,190	803,045	803.0
30%	2,273,171	872,284	872.3

22. LAUNDRY SOAP PRODUCTION

(ISIC code 3523 - produced 1979)

This profile deals with the processing of oils and fats into laundry soap, using locally produced raw materials unlike the production of detergents which is based on mineral oils. The principal oils which may be used are derived from coconut, palm kernel, groundnut and soya-beans: where modern meat factories exist, tallow will also be available. The process splits the fats and oils into their component parts of fatty acids and glycerol. The fatty acids combine with caustic soda, to yield a sodium soap.The particular process described in this profile is semi-boiled, and utilizes specialized plant and equipment of well tried design. Annual output is 350 tonnes produced in single shift working over 300 days. The investment cost is approximately $80,000 and the plant provides employment for 12 persons.

1. INTRODUCTION

This profile deals with the processing of oils and fats into laundry soap. The choice of product reflects the fact that processes for making this type of soap are simpler than those used for toilet soap. Although the use of laundry soap has fallen in recent years as a result of competition from synthetic detergents, the production of laundry soap rather than detergents in many developing countries has the advantage of utilizing more locally produced raw materials in the shape of vegetable oils and, in some areas, tallow. Soap manufacture is also viable on a small-scale, while synthetic detergents are based on mineral oil and are only economic if produced on a large scale requiring heavy capital expenditure. The production of laundry soap rather than synthetic detergents may thus result in saving foreign exchange for the purchase of both raw materials and capital equipment.

2. RAW MATERIALS

Ordinary soap is made by the action of caustic soda or caustic potash on fats, the process of saponification giving the soap. Glycerol is a potential by-product, although its recovery requires use of a more complex production process.

For a number of technical reasons, and for economic reasons such as price and availability, the number of fats and oils available to the soap-maker is limited. Some fatty materials used in soap manufacture are listed in Table 1 which gives information on the characteristics of the soaps which can be made from each material in combination with caustic soda.

Table 1

Imparted properties of some fatty raw materials for soap manufacture

Oil or fat	Consistency	Odour	Foam	Detergent	Skin reaction	U s e
1. Coconut	Very hard, brittle	Slight odour of nut	Quick, big bubbles, short-lasting	Good in hot and cold water	Makes skin rough	All kinds especially toilet soap
2. Palm kernel	As above	As above	As above	As above	As above	Household and toilet soap, soap powder
3. Refined palm oil	Very hard	Original oil	Slow, small bubbles, lasting	Very good	Very mild	As above
4. Groundnut	Firm	Original oil	Fairly good	Fairly good	Very mild	Household, textile and toilet soap
5. Soya-bean	Soft	Original oil	Mediocre	Mediocre	Very mild	As above
6. Cotton seed	Fairly soft	Original oil	Mediocre but lasting	Good	Mild	Household soap
7. Tallow	Very hard	Neutral	Slow, small bubbles, lasting	Good	Very mild	Household, textile, toilet, shaving soap

Coconut oil which is pale yellow or white in colour has been decribed as the most valuable fat raw material for the soap maker. It belongs to the group of lauric oils of which palm kernel oil is also a member and has similar properties. Both have tended to be priced higher than other oils, and their price is subject to violent fluctuations.

Palm oil in crude form is red but can be used for yellow laundry soap without having to be bleached. A good soap can be produced from palm oil alone but it is normal to combine it with some lauric oil. Palm oil can be used as a substitute for tallow providing it is bleached but the bleaching process is expensive on a small scale.

Groundnut oil is easily saponified, but its price is usually considerably higher than that of other oils, as is that of cotton seed oil. Additionally cotton seed oil is difficult to saponify, and is normally used in combination with tallow or coconut oil.

The soyabean is essentially a sub-tropical plant, but its cultivation extends to tropical areas. The pale yellow oil is used for soap manufacture in both crude and refined forms and is easily saponified. Because of its weaknesses it has to be blended with other oils.

Tallow is a fat obtained from the tissues of beef and mutton by heat treatment. Only a small proportion of the tallow produced is edible, thus causing the price of tallow to be lower than those of other fatty soap materials which may also consumed. Tallow is generally used in combination with other fats; it can be produced in developing countries where modern meat factories exist.

The blending of soap materials depends on the qualities they impart to soap and their relative prices. Thus, in a combination of tallow and coconut, the latter will contribute lathering quality and solubility while the former will contribute mildness and long-lasting lather. Palm oil imparts qualities similar to those produced by tallow and may be substituted when its price is lower.

Caustic soda, or sodium hydroxide, is the major caustic alkali used in converting the fatty raw materials into soaps which are therefore known as sodium soaps, as distinct from potash soaps made from potassium hydroxide, a more expensive chemical. Caustic soda may be manufactured from common salt, but the plant for this process is complex, requiring a substantial capital outlay. Caustic soda is consequently imported into most developing countries. For soap making it should be of high quality : it absorbs water from the atmosphere and it is necessary to store it in sealed containers.

Caustic soda is the most hazardous material used in soap manufacture, and the solutions are very corrosive, so that it is necessary to provide personnel dealing with the solutions with protective clothing, gloves and goggles.

The corrosive nature of caustic soda necessitates care in the choice of plant-material. Caustic soda solutions dissolve tin, zinc, aluminium, and alloys containing these metals, such as brass. At room temperatures iron and steel are little affected by caustic solutions, but they become corroded at higher temperatures, causing impurities to enter the soap mixture. Storage tanks are usually constructed of welded steel plates, while standard black iron pipe is satisfactory for pipelines transporting caustic solutions at low temperatures. Nickel steel should be used for high temperatures.

Water is used in large quantities in soap manufacture. Hardness is not regarded as a disadvantage in manufacturing sodium soaps because the calcium carbonate is absorbed harmlessly into the product. However, its absorption causes a small loss of soap. Soft water is required for the boiler feed.

3. OUTLINE OF THE MANUFACTURING PROCESS

The prime reaction in soap production is that of converting fats and oils into soap by reaction with caustic soda. This process is termed saponification, and is defined as the splitting up of the esters of the fats and oils into their component parts of fatty acids and alcohol (glycerol). The fatty acids combine with the sodium element of the caustic soda to yield a sodium soap.

The saponification process may be carried out in a number of ways, some simple, some technologically complex. Three different types of process are associated with plants which are simple and involve relatively little capital outlay, viz the cold, semi-boiled and full-boiled processes.

This profile concentrates on the semi-boiled process. In it, the liquid fat is first raised to the required temperature either by steam pipes or merely by placing the reaction vessel over a source of heat. Pre-heated caustic is added to the fat, and stirring carried out until the reaction is complete.

The hot soap-mix is then moved to cooling frames. These are box-type structures, usually made of wood or metal. They are designed to contain the molten soap during the cooling process, and the sides are detachable to facilitate removal of the cooled, solid soap block.

As well as the primitive method of production using the semi-boiled process, it is possible to make use of special process or packaged soap plants. These plants are formulated by the machinery manufacturer, based on well tried and proven designs. They are sold in package form and can be easily transported to any desired location. The plants operate with a certain degree of technological complexity and heating is by means of a steam boiler. A piece of apparatus containing feed pipes, drain pipes, and electrically operated stirrers is specifically designed for the saponification reaction. Transport of materials is carried out partially by means of pipes and pumps.

4. PLANT SPECIFICATION

The economic analysis contained in this profile relates to a plant producing laundry soap by means of the semi-boiled process using the machinery described below. It is assumed that the plant will operate for 1 shift of 8 hours per day over 300 working days per annum. Annual output is taken as 350 tonnes of soap.

	List of equipment	Number of items	Capacity per item
1.	Steam boiler	1	175 lb/hour (2 hp)
2.	Crutching pan	1	600 lb
3.	Soap frames	12	560 lb
4.	Fat storage tanks	2	150 gal
5.	Fat melting tanks	2	150 gal
6.	Caustic mixing tank	1	200 gal
7.	Caustic storage tank	1	200 gal
8.	Fat measuring tank	1	30 gal
9.	Caustic measuring tank	1	30 gal
10.	Soap slabbing machine	1	560 lb block
11.	Bar and tablet cutting machine	1	560 lb/hour
12.	Hand stamper	1	16-20 gal/min
13.	Hand pumps	2	60 gal/min

Notes : 1 long ton = 1.01605 metric ton; 1 lb = 0.4536 kg; 1 gal = 4.546 litres; 1 hp = 0.746 kw.

5. INPUT REQUIREMENTS

The plant provides employment for 12 people, whose designation and assumed rates of pay are as follows : manager ($8260 p.a.); 1 skilled operative ($3150 p.a.); 5 unskilled operatives ($2065 p.a.); 2 warehousemen ($2065 p.a.); 3 packers ($2065 p.a.).

All cost figures given in this profile are in mid-1976 prices.

The cost data for raw materials have been based on the following formula:

Material	% by weight	Cost per ton ($)
Coconut oil	39.5	350
Tallow	22.6	420
Caustic	10.1	330
Water	27.8	0.1225

The amount of scrap produced in this special process is about 12.1% of the total fresh raw materials; however the scrap from each batch is reboiled with a succeeding batch, with no loss.

Electricity requirements have been calculated on the basis of total annual output of 350 tons being produced in 1400 batches, each producing 560 lb. of soap.

Item of equipment	Operating hours	Horsepower hours	kWh	Notes
Steam boiler	1850	3700	2760	1 hr/batch + 1 1/2 hrs/day for start up
Crutching pan	1400	5600	4180	1 hr/batch

Requirements for fuel oil and water are given as follows:

		Units	Number
1.	Number of batches per year	560 lbs	1400
2.	Steam required for saponification at 65 lb per batch	tons	41
3.	Steam required for start-up per day	lb	200
4.	Steam required for start-up per year	tons	27
5.	Total steam required per year	tons	68
6.	Fuel oil required at 27.78 gal per tons of steam	gal	1889
7.	Cost of oil at $0.4725 per gal	$	892.5
8.	Water for steam	'000 gal	15.2
9.	Water for personnel, and space cleaning	'000 gal	36
10.	Loss 15% on total water used	'000 gal	7.7
11.	Total water required	'000 gal	58.9
12.	Cost of water at $0.91 per 1,000 gal	$	53.6

6. ECONOMIC EVALUATION

A. INVESTMENT COST

Item	$
Land (0.1 hectare)	2,150
Civil works	31,000
Plant and equipment (including spares)	30,600
Insurance and freight (10% row 3)	3,060
Installation costs (5% row 3)	1,530
Contingencies at 15%	10,250
Total (rounded)	78,600

B. ANNUAL OPERATING COSTS

	$	Total $
i) Materials:		
Raw materials (including process water)	93,300	
Packaging (2% raw materials)	1,865	
		95,165
ii) Labour:		
Wages and salaries	32,060	
Social security (5% wages and salaries)	1,605	
		33,665
iii) Water and Fuel:		
Electricity	810	
Water	55	
Fuel oil	895	
		1,760
iv) Repairs and maintenance:		
(4% civil works and installed plant & equipment)		2,650
v) Overheads:		
1.5% civil works and installed plant & equipment	990	
$17.5 per ton of output	6,125	
		7,115

C. WORKING CAPITAL

25% annual operating costs	35,090

D. EVALUATION (values in US $)

This is based on 15 year operating life, a 3 year build up to full capacity production, and a residual value for land. Fixed investment is 78,600. Working capital, 35,090, is taken in 3 instalments. On year 1 : 11,696; on year 2 : 11,697; on year 3 : 11,697. The residual value, 2,150, and working capital 35,090, are returned in the 15th year of operation.

Thus, production costs build up as follows :

	Year 1 capacity (1/3)	Year 2 capacity (2/3)	Year 3 capacity (full)
Materials	31,722	63,443	95,165
Wages and salaries	33,665	33,665	33,665
Fuel, water and electricity	587	1,173	1,760
Repairs and maintenance	883	1,767	2,650
Overheads	7,115	7,115	7,115
	73,972	107,163	140,355

The following are the results of NPV analysis :

Discount Rate	Present value of total costs	Annual revenue required	Revenue required per kilo
10%	1,078,806	160,449	0.45
20%	678,920	174,651	0.49
30%	551,303	215,521	0.61

23. PHARMACEUTICAL TABLET PLANT

(ISIC Code 3522 - produced 1981)

This profile describes the technology required to tablet and pack five types of pharmaceuticals commonly found in developing countries for sale through retail outlets. The pharmaceuticals are (a) acetylsalicylic acid (analgesic); (b) tetracycline hydro-hydrochloride (antibiotic); (c) chloroquine phosphate (anti-malarial); (d) piperazine adipate (antihelminthic) and (e) vitamin C. The investment cost is about $598,000 and 32 people would be employed.

1. PRODUCT DESCRIPTION

The products considered in this profile are five, non-patented medicines which are widely distributed and normally found in wholesales or retail chemist's shops. These are:

(a) acetylsalicylic acid (analgesic, anti-inflammatory, commercial packaging of 20 tablets of 500 mg. active substance each);
(b) tetracycline hydrochloride (antibiotic, boxes of 16 tablets of 250 mg.);
(c) chloroquine phosphate (anti-malarial, boxes of 20 tablets of 300 mg.);
(d) piperazine adipate (antihelminthic, boxes of 25 tablets of 500 mg.); and
(e) vitamin C (boxes of 20 tablets of 500 mg.)

2. DESCRIPTION OF TECHNOLOGY

The active substances for each product are incorporated - in strictly controlled proportions - with binders, ballast and preserving agents in a quick-action, mixer-granulator. This gives a perfectly homogeneous blend which is then dried, sifted and pressed into tablet form in an automatic die press.

Throughout the process, quality control is essential and a fully equipped laboratory is included in this profile. Local climatic conditions should be taken into account for preservation and storage life of active substances.

The tablets produced are automatically counted. Manual packaging is normally carried out into labelled bottles and sealed with desiccating stoppers.

Nevertheless a strip conditioning machine has been provided in the investment, to meet packaging needs in humid regions.

Equipment Requirements and Costs

Tablet Manufacture:			
Mixer-granulator,	150 l/batch	15 kW	33,300
Tray desiccator	250-500 kg	6 kW	23,300
Universal sifter	150 kg	4 kW	6,600
Rotary die press,	22 stations		
16,500 to 132,000 tablets per hour		4 kW	40,000
Stainless steel storing			
bins with covers	500 l		6,000
Scales	1 x 10 kg,		
	1 x 300 kg		5,000
Small transport equipment			2,000
Packaging:			
Tablet counting machine 2,500 tablets/minute			7,000
Semi-automatic strip conditioning			
machine 10,000 tablets/hour			10,000
Labelling machine			3,300
Quality control:			
Precision scales; small oven; vacuum pump; pH meter			
colorimeter; refrigerator, miscellaneous			26,900
Miscellaneous equipment & furniture (laboratory,store)			15,500
Workshop			11,300
Spare parts			11,000
		Total	201,200

3. LEVEL OF OUTPUT

TABLET (UNITS)	Year 1	Year 2	Year 3
(a) acetylsalicylic acid (20)	450,000	820,000	1,200,000
(b) tetracycline hydrochloride (16)	140,000	200,000	250,000
(c) chloroquine phosphate (20)	230,000	300,000	500,000
(d) piperazine adipate (25)	-	160,000	270,000
(e) Vitamin C (20)	-	150,000	250,000
	820,000	1,630,000	2,470,000

4. EMPLOYMENT AND EMPLOYMENT COSTS

				$
1	Manager/Pharmacologist	at $4,200	per annum	4,200
5	Administration	at $1,200	" "	6,000
1	Pharmacologist	at $4,000	" "	4,000
3	Skilled (manufacturing)	at $1,920	" "	5,760
15	Semi-skilled(packaging)	at $1,200	" "	18,000
1	Quality Control Supervisor/ Chemist	at $4,000	" "	4,000
1	Assistant Chemist	at $3,000	" "	3,000
1	Skilled Laboratory worker	at $1,920	" "	1,920
1	Storekeeper	at $2,400	" "	2,400
1	Semi-skilled	at $1,200	" "	1,200
1	Mechanic	at $1,920	" "	1,920
1	Electrician	at $1,920	" "	1,920
32				$54,320
	Other Annual Labour Costs:			5,432
	Total Annual Labour Costs:			$59,752

Training

The manager-pharmacologist and quality control supervisor should each receive 6 months training in the country providing the technology and know-how. Technical assistance should also be provided in the first 2-6 months of the project by specialists in management, manufacturing and maintenance.

5. DATA FOR ECONOMIC ANALYSIS

A. INVESTMENT COST

i) Fixed Investment :

	$
Machinery and Equipment	201,200
Freight and insurance(15%)	30,180
Installation (20%)	40,240
Land and Buildings (2500 m^2 land at $20/$m^2$ and 1200 m^2 buildings at $120/$m^2$)	194,000
Pre-operating expenses	12,000
Training	120,000
	$597,620

ii) Working Capital :

	$
Stock of materials(3 months)	198,750
Wages and Salaries(2 months)	9,958
	$208,708

iii) Residual Value :

	$
10% of Equipment Costs(cif)	23,138
50% of Building Costs	97,000
	120,138

B. ANNUAL OPERATING COSTS

	$
Materials	795,000
acetylsalicylic acid at $3/kg	
tetracycline at $72/kg	
chloroquine at $38.8/kg	
piperazine at $7/kg	
Vitamin C. at $13.2/kg	
Bottle, stopper, label etc. at $0.12 per unit.	
Wages and Salaries	59,752
Water and Fuel	15,000
Motor Transport	5,000
Repairs and Maintenance	15,000
Overheads	70,000
Total Annual Operating Costs:	$959,752

C. EVALUATION (Values in US $)

This is based on a 10-year operating life, a 3-year build up to full capacity production and a residual value for equipment and buildings. Fixed investment is $597,620. Working capital is taken in three equal instalments over the first three years of operation and the residual value ($120,138) and working capital ($208,708) is returned in the 10th year of operation.

Thus production costs build up as follows over three years :

	Year 1 (1/3)	Year 2 (2/3)	Year 3 (Full Capacity)
Materials	265,000	530,000	795,000
Wages and Salaries	19,917	39,835	59,752
Water and Fuel	5,000	10,000	15,000
Motor Transport	1,667	3,334	5,000
Repairs and Maintenance	5,000	10,000	15,000
Overheads	23,334	46,668	70,000
	$319,918	$639,837	$ 959,752

The following are the results of NPV analysis :

Discount Rate	Present value of total costs	Annual revenue required for Given Discount Rate	Revenue required per pack
10%	5,694,492	1,082,056	0.43
20%	3,960,098	1,163,253	0.47
30%	2,985,123	1,253,253	0.50

Due to the diversity of the items manufactured, revenues required per pack are to be considered as purely indicative. Annual revenues are more significant in this case.

24. USED OIL REGENERATION

(ISIC code 3530 - produced 1979)

Regeneration of used lubricating oil has been increasing in recent years, partly on grounds of environmental protection, partly in order to reduce oil import requirements. The plant described in this profile is based on the acid/clay process, which has been successfully applied in many countries. Input capacity is 1,200 kg per hour of used oil, and resultant output - based on a 7 hour day, 250 days per year - would be around 1,500,000 kg of blended oils and 170,000 kg of gas oil. The plant has a capital cost of $1,564,150 and would employ 22 persons.

1. INTRODUCTION

The technology of used lubricating oil regeneration has been utilized for many years in industrialized countries and more recently in developing countries. This development has occured for two main reasons :

(i) to prevent pollution of ground and water by waste oil;

(ii) to reduce the need to import fresh crude oil or lubricating oils and hence diminish the national dependence on foreign sources.

The second reason is especially true for those developing countries which have no oil reserves.

2. TECHNOLOGY

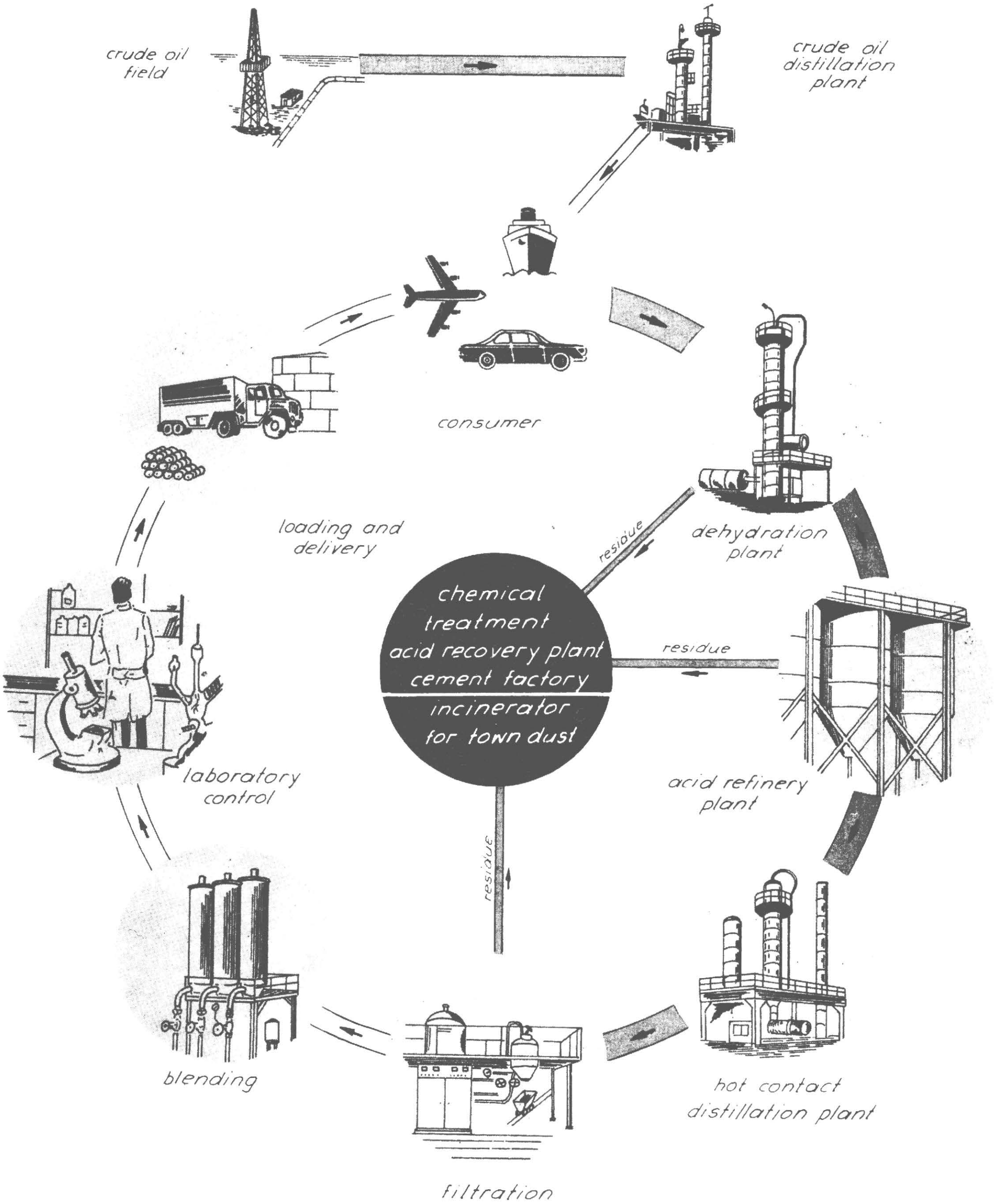
A. INPUT MATERIALS

The used oil regeneration plant is suitable to treat the following oils:

motor car oils (engine & gear); transformer oils; industrial oils (excluding steel-hardening oil and mixture of grease/oil); aviation lubricants; railway oils; and marine oils (bilge oils from ships).

In order to determine whether the waste oil is suitable for the treatment or not, laboratory tests have to be carried out.

CIRCULATION OF LUBRICATING OIL



B. PROCESS DESCRIPTION

The plant presented in this profile is based on the acid/clay process. After a coarse filtration, collected oils flow into storage tanks, and then pass through different phases of the following processes.

dehydration at 160°C under normal pressure; neutralization by sulphuric acid; decolourization by activated bleaching clay; vacuum distillation at 260°C-280°C, according to the oil viscosity intended; filtration through filter press to produce neutral lubricating oil; blending with additives and finally packaging.

The plant can be started within one hour and reaches after this time its full throughput capacity; it can be shut-down within 30 minutes, thus allowing a flexible scheme of operation.

C. OUTPUT PRODUCTS

The acid/clay process is producing a regenerated oil that meets all characteristics required for virgin lubricating oils and from which many types of lubricating oil can be produced : crankcase-motor oils, gear-box oils, hydraulic equipment, industrial oils, etc.

Gas oil can be recovered at the end of the dehydration and the distillation phases, and can be used in the production process.

Residues from the process are waste water, acid tar, and filter cake. The waste water can be fed into an oil/water separator and afterwards channeled into the sewerage system. The filter cake can be dumped in any refuse pit, and the acid tar can be stored in a refuse pit for chemicals, neutralized with lime or burnt in the rotating kiln of a cement plant.

D. REFERENCES

The acid/clay process in the method of oil regenration what has been most successfully applied in many countries : about 40 plants are operating or under construction units with a throughput capacities varying from 1,000 to 16,000 kg/hour.

3. PLANT CAPACITY

The plant described below is a small unit, the capacity of which can meet the requirements of many ACP countries, taking into account the size of markets and the transportation problems for collected oils.

A. TREATMENT CAPACITY

1,200 kg/h of used oil containing less than 2.5% water, i.e. 2,100,000 kg/year (7 h/day, 250 d/year).

B. OUTPUT CAPACITY

(i) 884 kg/h of blended oil, i.e. 1,547,000 kg/year; the blended oil contains 6.3% additives in average.
(ii) 100 kg/h of gas oil, i.e. 175,000 kg/year.

C. WASTE MATERIALS

(i)	waste water 170 kg/h	300,000 kg/year
(ii)	acid tar 245 kg/h	430,000 kg/year
(iii)	filter cake 65 kg/h	114,000 kg/year

The cost of disposal of waste material is taken as $0.012 per kg.

4. MATERIALS AND UTILITIES

Item	Consumption/hour	Annual consumption	Unit price ($)
Used oil	1,200 kg	2,100,000 kg	0.027
Sulphuric acid 98-99%	112 kg	196,000 kg	0.61
Bleaching clay	42 kg	73,500 kg	0.49
Lime	1 kg	1,750 kg	0.65
Ammonia water 23%	6 kg	10,500 kg	1.23
Salt	0.5 kg	875 kg	0.28
Hydrazin	10 g	17.5 kg	0.001
Filter paper 70 g/m^2	4 m^2	7,000 m^2	0.25
Gas oil	140 kg	245,000 kg	0.25
Electric power 500 V	110 kW	192,500 kW	0.018
City water	3 m^3	5,250 m^3	0.37
Additives (aver. quantity)	56 kg	98,000 kg	1.59
210 litre drums (used several times)		4,000	30.00

Packaging can also be made according to the specific needs of the market.

5. WORKFORCE REQUIREMENTS

The following table shows personnel requirements for 1 shift production.

If it is necessary to produce on 2 shifts, there will be an additional demand of 3 operators and 8 unskilled workers.

Position	Number	Salary per year ($)
Commercial Manager	1	15,000
Production Manager	1	15,000
Chemist	1	9,300
Office clerk	1	2,250
Secretary	1	3,000
Operators	3	1,750
Welder	1	750
Fitter	1	750
Electrician	1	750
Unskilled workers	8	375
Total	19	

In addition 3 truck drivers will be needed in connection with the collection of used oil. Their salaries have been included in the cost of the used oil.

6. INVESTMENT COST

The following figures have been extracted from a feasibility study done in 1978 for an ACP country in Africa, and, especially figures corresponding to local costs, must be considered only for guidance.

A. FIXED INVESTMENT

Item	Local $	Imported $
Site preparation	11,350	
Buildings	189,000	
Waste oil acceptance	32,750	4,550
Dehydration plant	137,350	34,450
Acid treatment	40,300	15,000
Distillation plant	144,900	85,000
Filtration plant	44,100	69,000
Intermediate tanks	71,800	22,050
Blending plant	50,400	66,350
Filling station	6,800	13,650
Laboratory equipment	5,300	47,250
Auxiliary equipment	85,700	117,900
3 trucks with $5m^3$ tanks	-	60,400
Trailer with intermediate tanks	-	6,300
Freight and insurance	-	52,500
	819,750	594,400

Local part	$ 819,750
Imported	$ 594,400
	$1,414,150

B. PRE-INVESTMENT EXPENSES

This item amounts to $150,000 and comprises cost for:

- engineering works
- assistance to the plant erection and the start-up
- training of the Production Manager in Europe
- training of the local staff

C. WORKING CAPITAL

This can be estimated according to the following requirements.

Item	Required stock	Cost ($)
Used oil	6 weeks	6,800
Local raw materials	2 weeks	7,780
Imported raw materials	8 weeks	25,200
Finished products	4 weeks	65,220
Drums	5 weeks	12,570
Debtors	4 weeks	105,130
Personnel cost	1 month	4,500

In the case of the specific ACP country concerned, the working capital amounts to $227,200.

D. TOTAL CAPITAL REQUIREMENTS

		$
Fixed investment		1,414,150
Pre-investment cost		150,000
Working capital		227,200
	Total	1,791,350

7. ANNUAL OPERATING COSTS

A. OPERATING COSTS

		$
Materials and utilities		570,800
Salaries		55,050
Repairs and maintenance (2% fixed capital)		28,300
Disposal of waste materials		10,200
Overheads (1% fixed capital 5% working capital)		25,500
	Total	689,850

B. PRODUCTS OBTAINED

As mentioned earlier, the capacity output of the plant is 1,547,000 kg of blended oil and 175,000 kg of gas oil per annum. In the economic evaluation reported below it is assumed that annual sales comprise 1,500,000 kg of blended oil and 170,000 kg of gas oil.

8. EVALUATION (values in US $)

This is based on 10 year operating life, a 3 year build up to full capacity production, and a residual value for land, building and equipment. Fixed investment is 1,414,150 and pre-investment cost is 150,000. Working capital, 227,200, is taken in 3 instalments. On year 1 : 75,734; on year 2 : 75,733; on year 3 : 75,733. The residual value, 300,000, and working capital, 227,200, are returned in the 10th year of operation.

Thus, production costs build up as follows :

	Year 1 capacity (1/3)	Year 2 capacity (2/3)	Year 3 capacity (full)
Materials + fuel + water + elect.	190,267	380,533	570,800
Wages and salaries	55,050	55,050	55,050
Waste disposal	3,400	6,800	10,200
Repairs and maintenance	9,433	18,867	28,300
Overheads	25,500	25,500	25,500
	283,650	486,750	689,850

The following are the results of NPV analysis :

Discount Rate	Present value of total costs	Annual revenue required	Revenue required per kilo of oil
10%	5,250,366	997,664	0.63
20%	4,051,433	1,190,091	0.76
30%	3,351,046	1,406,820	0.91

As 170,000 kgs of gas-oil ($ 0.25/kg) is obtained per year, a constant value of $42,500 is substracted from annual revenues to get the sum which divided by 1,500,000 gives the revenue per kilo in the last column.

9. TECHNOLOGY TRANSFER CONDITIONS

The technology offered is not subject to a patent registration, thus there are neither any royalties nor licensing agreement for the exploitation, and the know-how is supplied as a part of the whole offer.

10. TIME SCHEDULE FOR ERECTION OF THE PLANT

Engineering works can be completed 3 months after the order, and equipment delivered 5 months later. The start up of the plant can be expected 12 months after the order.

11. SPECIFIC ASPECTS

The problem of collection of used oil must be considered with particular attention : infrastructure aspects, quantity available, incentives or assistance to the storage of used oil, all require careful consideration.

The efficiency and the cost of collection will determine the success and the profit-making capacity of the project.

25. COLD-CURED SANITARY WARE PLANT

(ISIC code 3610 - produced 1980)

This profile describes and evaluates a technique for the manufacture of sanitary ware and furniture parts from marble powder and synthetic resin. In particular, the evaluation concentrates on wash-basins produced at the rate of 7,920 per annum at full capacity capacity. Initial fixed investment is $118,800 and the plant employs 6 people.

1. PRODUCT DESCRIPTION

The plant considered in this profile manufactures a luxury wash-basin of 1 m x 0.53 m dimensions, weighing 39 kg. The finish may be to a standard colour or veined (as a marble imitation). The materials used are marble powder and synthetic resin, and the production process uses a special mould. Since these moulds may be locally manufactured to any shape, the same technology may be used to produce any sanitary article (bath, bidet, WC, shelf, bowl, etc.) as well as any other part of furniture (for example an extension to a table).

The advantages claimed for this technology over conventional ceramics manufacture are:

(a) Minimum energy required due to absence of firing;

(b) Seven to eight times stronger than china with the same thickness and specific weight;

(c) The material may be sawn, drilled or screwed;

(d) The moulded parts are strictly identical as their size and shape are not influenced by firing.

2. DESCRIPTION OF TECHNOLOGY

The production process involves four stages:

(a) Preparation and mixing of the plastic resin with the marble powder;

(b) Spraying of a "demoulding agent" onto the moulds;

(c) Casting of the material with the first mould, followed by the fitting of the second mould;

(d) Demoulding, cooling and storing.

The time taken for each wash-basin is approximately 30 minutes. The raw materials include imported plastic resin, demoulding agent and the synthetic material for the manufacture of the moulds. Marble powder should be available from local sources.

This technology is already in use by license-holders in the several parts of the world.

3. LEVEL OF OUTPUT

Although each basin takes 30 minutes to produce, because of the overlapping of the four processes several sets of moulds may be used simultaneously, so that a capacity of 30 basins per day may be achieved. For a 5 1/2 day week and 48 week year this gives an annual output of 7,920 units at full capacity.

4. EMPLOYMENT

			$
1	Managing Director (in charge of sales and production)	at $4,000 per annum	4,000
1	Clerk	at $1,200 per annum	1,200
1	Secretary	at $1,200 " "	1,200
1	Skilled Worker	at $1,920 " "	1,920
2	Unskilled Workers	at $ 720 " "	1,440
6			9,760
	Miscellaneous		976
	Total Annual Labour Costs:		10,736

5. DATA FOR ECONOMIC ANALYSIS

A. INVESTMENT COST

i) Fixed Investment:

	$
Machinery and Equipment	59,000
Land and Building (400 m^2)	22,800
Pre-operating expenses	12,000
Licence fee	25,000
	$118,800

ii) Working Capital:

	$
Stocks of raw materials	72,000
Stocks of packing materials	10,800
Stocks of finished products	60,000
	$142,800

iii) Residual Value: $ 16,000

B. ANNUAL OPERATING COSTS

		$	
i)	Materials:		
	Marble powder 186 tonnes	18,600	
	Plastic resin 124 tonnes	248,000	
	Demoulding agent 3.96 t.	15,840	
	Packing material	39,600	
			322,040
ii)	Wages and Salaries:		10,736
iii)	Water and Fuel:		
	Electricity (30 kWh per day)	2,376	
	Other	500	
			2,876
iv)	Motor Transport		5,000
iv)	Repairs and maintenance		10,000
v)	Overheads		5,000
	Total Annual Operating Costs:		$ 355,652

C. EVALUATION (Values in US $)

This is based on a 10 year operating life, a 3 year build-up to full capacity production, and a residual value for buildings and equipment. Fixed investment is $118,800. Working capital is taken in 3 instalments : on year 1 : $47,600; on year 2 : $47,600; on year 3 : $47,600. The residual value of $16,000 and working capital of $142,800 are returned on the 10th year of operation.

The production costs build up as follows:

	Year 1 (1/3)	Year 2 (2/3)	Year 3 (3/3)
Materials	107,347	214,693	322,040
Wages and Salaries	10,736	10,736	10,736
Transports	5,000	5,000	5,000
Water and energy	2,876	2,876	2,876
Repairs and Maintenance	3,333	6,667	10,000
Overheads	5,000	5,000	5,000
	$134,292	$244,972	$355,652

The following are the results of NPV analysis :

Discount Rate	Present Value of Total Costs	Annual Revenue Required for Given Discount Rate	Revenue Required per item
10%	2,068,324	393,019	49.62
20%	1,423,364	418,104	52.79
30%	1,057,221	443,838	56.04

26. CERAMIC SANITARY WARE PLANT

(ISIC code 3610 - produced 1981)

This profile describes the production of sanitary ware by the "Casting Slip" method using blended clays. This involves a simple firing which ensures that the glaze and body are are fired at the same high temperature forming a dense, vitrified mass with a high gloss, durable craze-free surface, highly resistant to acids and alkalis, providing the most hygenic surface for sanitary fixtures. The investment cost is about $762,000 and employment would be provided for 31 people.

1. PRODUCT DESCRIPTION

The sanitary ware described in this profile is made from blended clays silica and glass minerals (e.g. feldspar) with a white glaze. The type of items include W.C.'s and tanks, wash basins and pedestals, bidets and urinals.

2. DESCRIPTION OF TECHNOLOGY

The flow diagram below, summarizes the process.

The clay materials are mixed together with water to form a high-density "Casting Slip" in the following proportions:

* 25% China-clay (white-firing, kaolinitic clay)
* 25% Ball clay (plastic clay for strength and workability)
* 24% Quartz (silica sand as a filler)
* 26% Feldspar as a fluxing agent forming glasses during firing for minimum porosity.

Water is added until there is a specific gravity of 1.8. The prepared "slip" is refined through sieves and electro-magnets. Chemical electrolytes are also used to keep the water content to a minimum while retaining the required texture (e.g. Sodium silicate or carbonate). The slip is then poured into a pre-formed plaster of paris mould. Plaster usage is in the region of 7% of body weight. When sufficiently rigid, the clay item is removed from the mould so that seams, holes etc. can be marked or punched as necessary. The surface is also smoothed before drying. Dried items are checked for flaws before being sprayed with the glaze. This consists of slurry of powdered silica glass minerals and its use amounts to about 10% of body weight of the clay ware.

The items are then fired in either a continuous tunnel kiln or an intermittent kiln to a temperature of 1200°C. The sanitary ware shrinks 11-12% in the firing. The glaze is permanent.

Equipment Requirements and Costs

		$	$
(a)	Raw Material Preparation:		
	Body:		
	Heavy duty scales	2,000	
	Medium speed blunger	6,748	
	Circular screen	1,924	
	Agitation unit for underground work	3,120	
	Diaphragm pumps	9,936	
	Vibro-energy separator and magnet	11,472	
	GRP tanks	8,868	
			44,068
	Glaze:		
	Porcelain-lined glaze mill	18,926	
	Circular screen	3,090	
	Agitator for underground work	2,484	
	Diaphragm pump	4,964	
			29,464
(b)	Mould-Making:		
	Plaster blender	5,892	
	Water tanks and benches	1,600	
	Drier	8,000	
	Miscellaneous tools	7,588	
			23,080
(c)	Casting:		
	Casting guns	420	
	Benches, lines etc.	4,400	
			4,820
(d)	Glazing and Inspection:		
	Glaze trucks and benches	7,200	
	Extraction booths for inspection	2,800	
	Compressor	4,152	
	Spray booth	8,784	
			22,936
(e)	Drying and Firing:		
	Drying area and trucks	12,800	
	Kiln	80,640	
			93,440
(f)	Other requirements:		
	Mother mould and cases	96,800	
	Hand operated pallet lifting truck	900	
	Water tank and treatment	16,000	
	Effluent treatment	7,000	
	Office equipment	24,000	
	Vehicles	14,000	
			158,700
			376,508

3. LEVEL OF OUTPUT

This profile is based on a plant capable of producing about 84 items of sanitary ware per day. This should give 20,160 saleable items per annum.

4. EMPLOYMENT AND EMPLOYMENT COSTS

			$
1	Manager	at $4,000 per annum	4,000
1	Assistant Manager	at $3,000 " "	3,000
3	Office staff	at $1,200 " "	3,600
8	Supervisors	at $2,400 " "	19,200
16	Skilled workers	at $1,920 " "	30,720
2	Unskilled workers	at $ 720 " "	1,440
31			$61,960
		Other Annual Labour Costs:	6,200
		Total Annual Labour Costs:	$68,160

5. DATA FOR ECONOMIC ANALYSIS

A. INVESTMENT COST

		$
i)	Fixed Investment:	
	Machinery and Equipment	376,508
	Land and Building ($930m^2$ x $\$200/m^2$)	186,000
	Pre-operating expenses	164,000
	Installation etc.	36,386
		762,894
ii)	Working Capital :	
	Stock of materials(3 months)	50,376
	Wages and Salaries(2 months)	11,360
		61,736
iii)	Residual Value :	
	10% of Equipment Costs(cif)	37,650
	50% of Building Costs	93,000
		130,650

B. ANNUAL OPERATING COSTS

		$
i)	Materials:	
	Clay 428.4 t at $250/t	107,100
	Glaze 38.4 t at $1,300/t	49,920
	Stains etc. 3.8 t at $1,022/t	3,884
	Refractories	2,400
	Plaster 33 t at $80/t	2,640
	Tools	960
	Packaging	14,520
		181,424
ii)	Wages and Salaries	68,160
iii)	Water and Electricity	27,410
iv)	Repairs and Maintenance	1,000
vi)	Overheads	8,000
		$285,994

C. EVALUATION (Values in US $)

This is based on a 10-year operating life; on a 3-year build-up to full capacity production and a residual value for buildings and equipment. Fixed investment is $762,894. Working capital is taken in 3 instalments of $20,579 in the first three years of operation and the residual value ($130,650) and working capital ($61,736) are returned in the 10th year of operation.

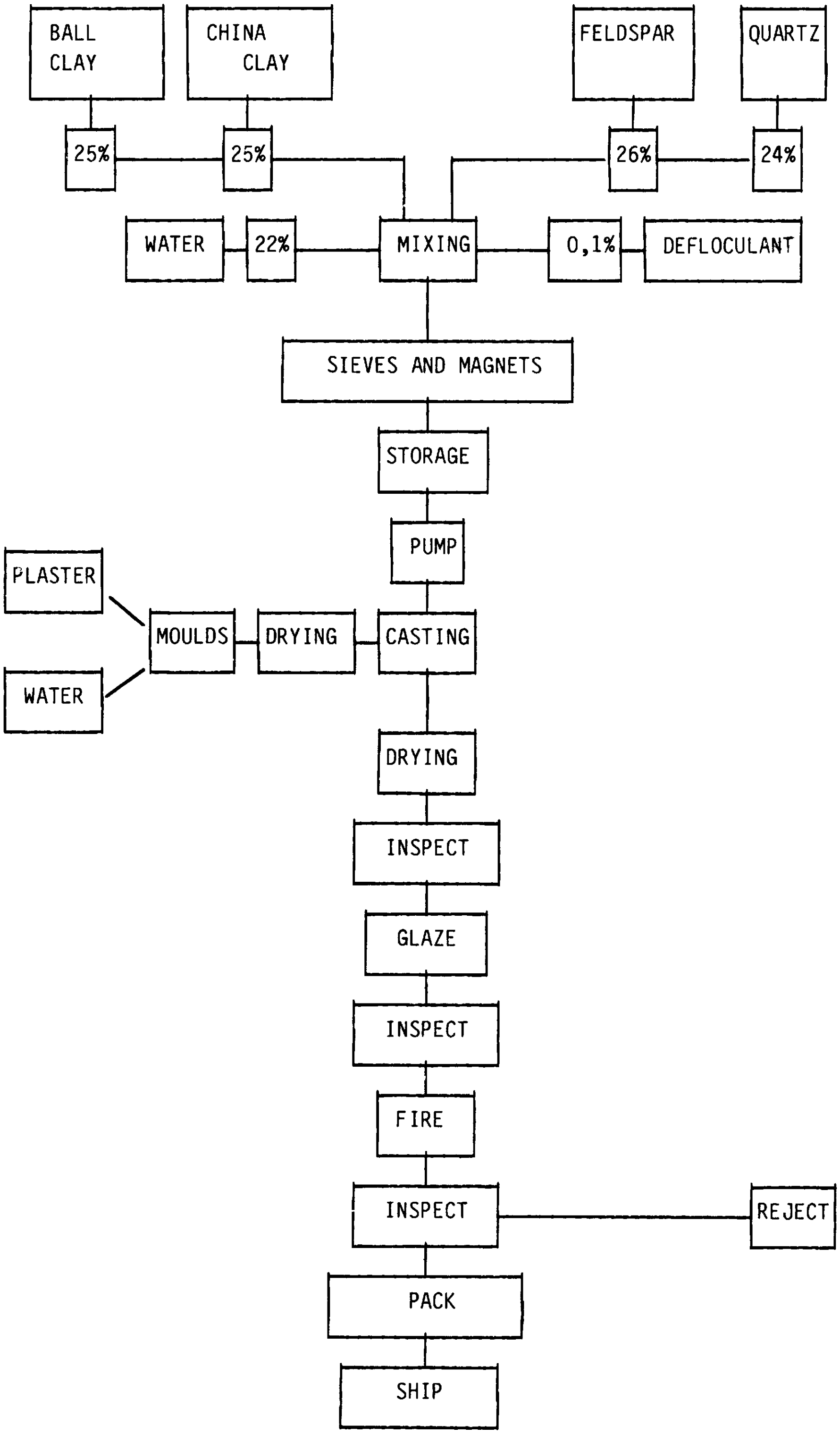
This production costs build up as follows:

	Year 1 (65%)	Year 2 (75%)	Year 3 (100%)
Materials	117,926	136,068	181,424
Wages and Salaries	44,304	51,120	68,160
Water and Electricity	17,816	20,558	27,410
Repairs and Maintenance	650	750	1,000
Overheads	5,200	6,000	8,000
	$185,896	$214,496	$285,994

The following are the results of NPV analysis:

Discount Rate	Present Value of Total Costs	Annual Revenue Required for Given Discount Rate	Revenue Required per item
10%	2,346,993	417,645	20.72
20%	1,841,238	494,166	24.51
30%	1,551,211	597,079	29.62

FLOW DIAGRAM



27. TABLEWARE PRODUCTION

(ISIC Code 3610 - produced 1981)

This profile describes the production of stoneware which is formed by (a) hydraulic press into flan or casserole shaped dishes; (b) slip casting into sugar bowls, teapots etc; and (c) jiggering and jollying into plates, cups and saucers.Stoneware is a clay-based material with a relatively high strength and durability which makes it suitable for "every-day" tableware. The investment cost is about $1 million and employment is provided for 44 people.

1. PRODUCT DESCRIPTION

This project is intended to be used for production of stoneware.

Stoneware products are dense relatively impervious opaque ceramics usually off-white in colour; however by glazing with an opaque white glaze a product suitable for institutional use can be effected.

The fired material is strong, and the resulting body/glaze system has high thermal shock resistance free from crazing under standard conditions. The body was traditionally made from inexpensive naturally vitrifying clays, and generally fired once from 1200°C - 1300°C. In recent years finer stoneware products have been produced from carefully selected clays to which fluxes such as nepheline syenite or feldspar are added together with quartz or grog to adjust the reversible thermal expansion of the body and to reduce drying and firing shrinkages.

Generally stoneware bodies have the following physical characteristics:

Reversible Thermal Expansion of body - 0.33-0.38% to 500°C.
Reversible Thermal Expansion of glaze - 0.30-0.35% to 500°C.
Modulus of Rupture Biscuit - 12,000 psi.
Modulus of Rupture Glost - 15,000 psi.
Porosity (water absorption) less than 2%.

The reason for the choice of stoneware for this particular project is the relatively high strength and durability of the product compared with the traditional porous earthenware products whose glazed strength is usually of the order of 7,000 psi. The strength compares favourably with bone china or porcelain cf. 16-18,000 psi; however the cost of the raw materials is considerably lower.

Due to the current trends in the potential export market for ceramic products they should conform to certain internationally acceptable standards of both aesthetic and technical qualities. The increasing use of culinary aids such as dishwashers, microwave cookers, etc. and the increasing use of the more casual oven to tableware products has placed severe limitations on the use of earthenware as a tableware product. Stoneware products have effectively filled this need and considerable expansion in sales has been effected in both Europe and North America at the expense of standard porous earthenware products.

The product to be produced in the plant will conform to the following standards:

1) Vitreous to both United Kingdom and American standards.
2) Decoration will be dishwasher proof.
3) The glaze/decoration system will conform to the American F.D.A. Standards for lead and cadmium release.
4) The thermal shock resistance of the product will enable the product to be used for oven to tableware applications.
5) The product will be suitable for microwave cooking applications.
6) The strength of the product for hotel application will be comparable to US Vitreous Hotelware.

2. DESCRIPTION OF TECHNOLOGY

The basic inputs for stoneware production comprise a mixture of 30-70% stoneware clay, 30-60% quartz, and 5-25% feldspar. Stoneware clay is of the kaolinitic type with high plasticity and green strength. It is usually blue/black in colour until fired when it dries to off-white. Quartz is the principal constituent of silica sand and is used as a filler. Feldspar is an alumina-silicate mineral used as a gloss-forming flux for minimum porosity of the final product.

Three manufacturing techniques can be employed and may be introduced in sequence to allow for growth and improvement in production.

(a) Production by Pressing.

A heavy duty hydraulic ram press machine is used to shape de-aired, pugged clay in a die in order to produce large, eccentric oval, or rectangular shapes e.g. flans, casseroles etc. A measured amount of clay is placed on a lower die and the press is fitted with the top die to complete the shape under pressure. The clay item is then carefully removed, dried, inspected, tanned and smoothed ready for glazing.

(b) Production by Slip Casting.

This involves the clay being prepared in a liquid suspension with the addition of small amounts of deflocculants, and poured into plaster moulds. Plaster use is about 7% of the weight of each item. This process is most suitable for covered sugar bowls, creamers, teapots, etc. Again when the article is sufficiently dry it is removed from the mould and prepared for glazing.

(c) Plastic-Making by Jiggering and Jollying.

This method is used for making cups, saucers, plates etc. A pugged clay segment of suitable size is mechanically spread on a plaster bat into a disc-shape. The disc is removed and pressed onto a mould of the required shape. The mould is mechanically rotated and a steel profile introduced to form the underside of the item. Differing profiles are used while the mould is rotating to form cups and other hollow shapes. When dry enough to handle the items are prepared for glazing. Cups and mugs have handles fixed by a suitable bonding agent before the final drying.

Glazing involves each item being sprayed with or submersed in a bath of powdered silica and feldspar in water. The use of glaze amounts to about 10% of the weight of each item.

The glazed tableware is placed on refractory supports on kiln cars. The kiln used is of $14m^3$ capacity and would consume about 280,000 litres of diesel oil per annum. The final surface is durable, high gloss and craze-free. Each item is inspected and graded before being packed and fired in a kiln to 1150-1200°C.

Equipment Requirements and Costs

	Import	Local	Total
	$	$	$
12" diameter pug mill	21,320	-	
Clay transport equipment	-	1,600	
Pumps and pipe work	-	8,000	
Technical control equipment	3,000	-	
0.5 t Ball Mill	17,000	-	
20 gal Ball Mill	2,000	-	
Technical Control Equipment	2,000	-	
Glaze containers	-	600	
Pump and pipework	-	4,000	
Mould-making equipment	-	2,000	
Casting equipment	-	7,000	
Ram Press	24,000	-	
Glazing equipment	-	26,400	
Plastic jollying/jiggering	51,000	-	
Kiln ($14m^3$)	100,000	-	
Miscellaneous	-	10,000	
	220,320	59,600	279,920
Freight + insurance 15%	33,048	-	33,048
Installation costs 20%	44,064	11,920	55,984
Administration	-	35,000	35,000
	297,432	106,520	403,952

3. LEVEL OF OUTPUT

The plant described in this profile is designed to handle annually up to 864 tonnes of the clay body material and 87 tonnes of glaze. On a single-shift, 48 week year a possible combination of outputs would be:

Flan dishes etc.	116,928
Coffee pots	9,936
Tea pots	9,936
Sugar bowls	29,232
Creamers	29,232
Tea cups	280,704
Saucers	280,704
Side plates	299,424
Dinner plates	140,352
Mugs	187,104
Total	1,383,552

Additional shifts could be considered over time until throughput became limited by kiln capacity.

4. EMPLOYMENT AND EMPLOYMENT COSTS

		Rate per annum	Total $
1	Manager	at $4,000	4,000
2	Supervisors	at $2,400	4,800
1	Accountant	at $3,000	3,000
3	Typists	at $1,920	5,760
1	Office Junior	at $ 720	720
1	Engineer	at $1,920	1,920
1	Fitter	at $1,200	1,200
3	Clay and glaze prep.	at $1,920	5,760
2	Mould makers	at $1,920	3,840
1	Ram Press operator	at $1,200	1,200
2	Casters	at $1,920	3,840
6	Spongers	at $1,200	7,200
1	Handle maker	at $1,920	1,920
1	Cup maker	at $1,920	1,920
1	Cup Sponger	at $1,920	1,920
2	Plate makers	at $1,920	3,840
1	Trimmer	at $1,200	1,200
2	Handle attachers	at $1,200	2,400
6	Glaze sprayers	at $1,200	7,200
2	Kiln attendants	at $1,200	2,400
2	Warehouse/packing	at $1,200	2,400
2	Labourers	at $ 720	1,440
44			69,880
	Other Annual Labour Costs:		6,988
	Total annual labour costs		76,868

5. DATA FOR ECONOMIC ANALYSIS

A. INVESTMENT COST

i) Fixed investment :

	$
Machinery and Equipment	314,920
Freight and insurance	33,048
Installation costs	55,984
Land and Building ($2300m^2$ at $200)	460,000
Pre-investment costs	150,000
	$1,013,952

ii) Working Capital :

	$
Stock of materials and fuel (3 months)	88,659
Wages and Salaries(2 months)	12,680
	$101,339

iii) Residual Value :

10% of Equipment Costs(cif)	34,797
50% of Building Costs	230,000
	$264,797

B. ANNUAL OPERATING COSTS

i)	Materials :		$
	Clay 864 t at $140	120,960	
	Glaze 87 t at $600	52,200	
	Stains etc. 8.8 t at $1022	8,994	
	Refractories	2,400	
	Plaster 96 t at $80	7,680	
	Tools	2,400	
	Packing	48,000	
			242,634
ii)	Fuel		112,000
iii)	Wages and Salaries		76,868
iv)	Water and Electricity		18,882
v)	Repairs and Maintenance		1,400
vi)	Overheads		9,600
	Total annual operating costs		$ 461,384

C. EVALUATION (Values in US $)

This is based on a 10 year operating life; a 3-year build up to full capacity production, and a residual value for buildings and equipment. Fixed investment is $1,013,952. Working capital is taken in 3 instalments of $33,780 in the first three years of operation. The residual value of $264,797 - and working capital $101,339 - are returned in the 10th year of operation.

The production costs build up as follows:

	Year 1 (55%)	Year 2 (75%)	Year 3 (100%)
Materials	133,449	181,976	242,634
Fuel	61,600	84,000	112,000
Wages and Salaries	42,277	57,651	76,868
Water and Electricity	10,385	14,162	18,882
Repairs and Maintenance	770	1,050	1,400
Overheads	5,280	7,200	9,600
	$253,761	$346,039	$461,384

The following are the results of NPV analysis :

Discount Rate	Present Value of Total Costs	Annual Revenue Required for Given Discount Rate	Revenue Required per item
10%	3,507,339	634,416	0.45
20%	2,707,362	743,240	0.53
30%	2,287,363	880,069	0.63

28. BRICK MANUFACTURE

(ISIC code 3691 - produced 1980)

This profile evaluates two small-scale brick-making plants with identical production technologies but operating on seasonal and on all-year-round bases. The level of output in both cases is approximately 4 million bricks per annum. In the seasonal example the initial investment is $ 145,796 and 130 people are employed. In the all-year-round example the initial investment is $ 93,436 and 99 people are employed.

1. PRODUCT DESCRIPTION

The standard work size for a brick is 215 x 102,5 x 65 mm. A brick of this size may be of four types - solid, perforated, hollow or cellular - according to the volume, shape and distribution of recesses, holes and pores in the fired product. The product described in this profile is a solid fired clay common brick of ordinary quality, with a density within the range 1.6 - 2.4 grammes per cm^3, weight within the range 2.3-3.5 kg and with a crushing strength which should be greater than 5.2 Newton per mm^2.

Note : The technical description and most of the technical and economic data in this profile have been adapted from a David Livingstone Institute study Brick Manufacture in Developing Countries by James Keddie and William Cleghorn, published by Scottish Academic Press, Edinburgh, 1980.

2. DESCRIPTION OF TECHNOLOGY

All processes for making fired clay bricks share the same broad outline. The basic raw material is clay, which must be 'won' from the earth. After preparation of the clay, it is formed into undried 'green' bricks, which must be dried before they are finished by firing them, using a very considerable energy input, in kilns.

The occurrence and availability of clays, sands and silts, their physical properties and chemical constitution, are subject to specialized study. Each must be given proper attention before the commercial production of bricks is contemplated. Once formed the green brick must be strong enough to resist cracking during drying and handling before the process of firing develops in it the microscopic web of ceramic bonds that gives the finished brick its strength. Problems of non-uniform shrinkage or warping during drying and firing must also be solved by adapting the design of the product and the manufacturing process to the raw materials available.

(a) Production Process

(i) Winning Clay - Loading - transportation to works
Methods - hand-winning plus tractor/trailer transport

Assuming that the clay is close to the surface, winning starts with the removal of topsoil and overburden. Winning methods are influenced by technical factors which include the hardness, water content and thickness of the clay deposits. On flat sites a high water table may restrict the depth of winning if drainage is not practicable. The depth of winning may also be legally restricted by the requirement that the land must be readily redeemable for agricultural use. The method of transporting the clay may be influenced by factors such as the difficulty of traversing sodden ground with laden vehicles during the wet season. The won clay is usuallly allowed to weather before being prepared - this allows the clay to mix before use and also provides a buffer stock for the brickworks.

(ii) Clay Preparation - Brick forming
Methods - labour-intensive clay preparation plus hand press

Clay preparation is designed to provide the brick forming stage with a constant supply of uniform plastic clay. Clay that still contains stones, pebbles, lumps, roots, etc.., or varies significantly in its plasticity, will make inferior bricks.

(iii) Drying (including handling before and after drying)
Methods - drying in open sheds plus manual handling

Drying stiffens the bricks to the point where they can be set in the kiln without deforming under load. It also reduces to a minimum the amount of evaporation that has to take place at the start of firing, and this reduces fuel costs. In open shed driers - at their simplest no more than thatched roofs on poles - it is difficult to control the drying process, and the principal precaution against cracking caused by rapid or uneven drying is to control the movement of air with outside shielding walls and by appropriate laying out of the bricks, singly or in open stacks through which air can circulate freely.

(iv) Firing (including setting and drawing)
Methods - Intermittent chamber kiln plus manual setting/drawing of kiln

The main technical aspects of kiln choice are the characteristics of the clay, the scale of output, and the available fuels. Returns in fuel economy might be expected to favour tunnel and continuous chamber kilns rather than trench or intermittent kilns. Observation suggests that in developing countries the skilled and experienced staff needed to run relatively sophisticated kilns are either unavailable or overworked.

Intermittent chamber kilns can be large and technically sophisticated, but are often small and simple in design. Their use is favoured in circumstances where continuous kiln operation is impracticable, either because demand is below the level at which a continuous kiln can be economically run, or because demand itself is only intermittent.

Setting involves the stacking of bricks in a kiln, and drawing removing the fired bricks from the kiln. As elsewhere, this operation is done manually aided by handcarts for internal transport.

b. Machinery and Equipment

	Life	Seasonal	All-Year-Round
Stage 1			
Tools	5 years	25 x \$ 17	18 x \$ 17
Handcarts	7.5 years	8 x \$ 90	4 x \$ 90
Tractors	7.5 years	2 x \$ 16,500	1 x \$ 16,500
Trailers	7.5 years	4 x \$ 2,640	2 x \$ 2,640
		\$ 44,705	\$ 22,446
Stage 2			
Handcarts	7.5 years	14 x \$ 90	10 x \$ 90
Handpress	7.5 years	14 x \$ 132	10 x \$ 132
		\$ 3.108	\$ 2.220
Stage 3			
Handcarts	7.5 years	5 x \$ 90	5 x \$ 90
		\$ 450	\$ 450
Stage 4			
Intermittent chamber kiln	15 years	Capacity 37.000 bricks per week 3 x \$ 3.300	Capacity 27.000 bricks per week 3 x \$ 2,520
Handcarts	7.5 years	3 x \$ 90	2 x \$ 90
		\$ 10.170	\$ 7.020
	Total :	\$ 58.433	\$32.136

c. Land Requirements for Clay Supply

Clay consumption is 2.4 m^3 per 1000 green bricks, being won up to a depth of 2m, so that the area required per 1.000 green bricks is 1.2 m^2. The land value for material supply can be calculated on the basis of the purchase of 6 years' supply of land (31,000 m^2) at a time at \$ 0.28 per m^2, and resale of used land simultaneously at \$ 0,19 per m^2.

d. Land and buildings for brick-making

The land requirements for the brick production activities have been based on the following data :

	Seasonal	All-Year-Round
Stockpile area	750 m^2	550 m^2
Clay preparation	350 m^2	250 m^2
Open shed drying	3,350 m^2	2,400 m^2
Kiln area	795 m^2	600 m^2
Finished brick storage	1,900 m^2 (max. 104 days output)	550 m^2 (max. 30 days output)
Access, offices, etc.	650 m^2	650 m^2
Total :	7,795 m^2	5,000 m^2

On this basis the estimated initial building costs are as follows :

	Seasonal	All-Year-Round
Clay preparation	$ 10,500	$ 7,500
Open shed drying (15 year life)	33,500	24,000
Finished goods stack (15 year life)	19,000	5,500
Office (incl. fittings, etc.)	13,500	13,500
	$ 76,500	$ 50,500

3. LEVEL OF OUTPUT

The pattern of output of brickmaking is determined in many developing countries by the weather, since building activity, and therefore the production of bricks and other building materials, slows down or even comes to a halt with the advent of the rainy season. Irrespective of demand, brickmaking itself may be difficult, the fire in the kiln may be extinguished, vehicles may stick fast in deep mud. For present purposes it has been assumed that there are environments permitting all-year-round production unimpeded by the vagaries of the weather or by fluctuating demand. The alternative Seasonal production environment has a 3 1/2 month (16 week) shut-down of the works, with output correspondingly increased during the production season (36 weeks) to meet current demand and to stockpile for a reduced demand during the wet season.

On the basis of a 6 day week and a 36 week (seasonal) and 50 week (all-year-round) year the required daily output of finished bricks are 18,520 and 13,333 respectively to meet the level of 4 million per annum. The technologies evaluated actually produce 17,575 and 12,825 bricks, the limiting factor being the capacity of the 3 intermittent chamber kilns, capable of handling 74,000 and 54,000 bricks every two weeks. It will be appreciated that output is flexible up to this capacity.

The plants are evaluated on the basis of single-shift working with 7-8 hours per shift, with 6 hour actual production time per day, allowing for stoppages.

4. EMPLOYMENT

a. Production Labour

	No.	Seasonal	No.	All-Year-Round
		$		$
Stage 1				
Supervisory to 2,400	1	2,400	1	2,400
Skilled à 1,920	2	3,840	1	1,920
Unskilled to 720	54	29,908	39	28,080
Stage 2				
Unskilled to 720	33	18,276	23	16,560
Stage 3				
Unskilled to 720	5	2,769	4	2,880
Stage 4				
Skilled to 1,920	5	9,600	5	9,600
Unskilled to 720	30	16,615	26	18,720
Totals	130	83,408	99	80,160

Note : Unskilled production workers have been taken as working for 40 weeks of the year in the seasonal variant, so the annual rate of pay of $ 720 becomes effectively $ 543,85

b. Administrative and Other Labour (including workshop)

			$	$
1	General Manager	at	4,000	4,000
2	Supervisors	at	2,400	4,800
1	Accounts Clerk	at	1,200	1,200
2	Secretaries	at	1,200	2,400
3	Security men	at	1,200	3,600
3	Skilled maintenance workers	at	1,920	5,760
3	Unskilled maintenance workers	at	720	2,160
				23,920

Total Employment Cost (annual)	Seasonal	All-Year Round
Production labour	83,408	80,160
Administrative and other labour	23,920	23,920
Supplementary labour costs	10,733	10,408
	118,061	114,488

5. ECONOMIC ANALYSIS

A. INVESTMENT COST

		Seasonal	All-Year Round
i)	Fixed Investment		
	Initial Equipment Cost	58.433	32.836
	Land and Buildings (initial)		
	- Total Land Material supply (31,000m^2)	8,680	8,680
	- Production (7,795/5,000m^2)	2,183	1,400
	Total buildings	76,500	50,500
		145,796	93,416
ii)	Working Capital		
	Clay stockpile	4,000	2,600
	Firewood and diesel oil	8,150	5,970
	Stocks of spares	7,000	4,000
	Work-in-progress	8,000	8,000
	Stocks of finished bricks	46,338	12,826
		73,488	33,396
iii)	Residual Value		
	Equipment	5,843	3,286
	Land	8,073	7,290
	Buildings	19,125	12,625
		33,041	23,201

B. ANNUAL OPERATING COST

		Seasonal	All-Year Round
		$	$
i)	Materials		
	Clay supply costed into remainder of operation		
ii)	Wages and Salaries	118,061	114,488
iii)	Water and Fuel		
	Firewood	58,320	59,280
	Water (1m^3 per 1000 green bricks)	1,000	1,000
	Other	300	300
iv)	Motor transport		
	Diesel for tractors	350	243
	Other	350	350
v)	Maintenance		
	Equipment spares	7,000	4,000
	Buildings, etc....	1,000	750
vi)	Overheads	10,000	10,000
		196,381	190,411

C. EVALUATION (Valeur en U.S. $)

Seasonal work

This is based on 30 year operating life, a 3 year build up to full capacity production, and a residual value for land, building and equipment. Fixed investment is 145,796.

Working capital, 73,488 is taken in 3 instalments. On year 1 : 24,496; on year 2, 24,496; on year 3, 24,496.

The residual value, 33,041, and working capital 73,488 are returned in the 30th year of operation. The production costs build up as follows :

	Year 1 Capacity : 1/3	Year 2 Capacity : 2/3	Year 3 Capacity : 3/3
Materials	-	-	-
Wages and Salaries	118,061	118,061	118,061
Water and fuel	20,773	42,547	59,620
Motor transport	470	590	700
Repairs and maintenance	2,667	5,333	8,000
Overheads	10,000	10,000	10,000
	151,971	176,531	196,381

The following are the results of the NPV analysis :

Discount Rate	Present value of Total Costs	Annual Revenue Required	Revenue Required per 1,000 bricks*
10%	2,046,875	239,550	63.10
20%	1,146,807	273,615	72.08
30%	759,226	318,735	83.96

* based on 3.795.896 bricks per year.

Annual work

This is based on 30 year operating life, a 3 year build-up to full capacity production, and a residual value for land, building and equipment. Fixed investment is 93,416.

Working capital, 33,396 is taken in 3 instalments. On year 1; 11,132; on year 2; 11,132; on year 3; 11,132.

The residual value, 23,201, and working capital 33,396 are returned in the 30th year of operation.

Production costs build up as follows :

	Year : 1 Capacity : 1/3	Year : 2 Capacity : 2/3	Year : 3 Capacity: 3/3
Materials	-	-	-
Wages and salaries	114,488	114,488	114,488
Water and fuel	20,393	40,487	60,580
Motor transport	431	512	593
Repairs and maintenance	1,583	3,167	4,750
Overheads	10,000	10,000	10,000
	146,895	168,654	190,411

The following are the results of NPV analysis :

Discount Rate	Present value total costs	Annual Revenue required	Revenue required per 1000 bricks *
10%	1,895,533	221,840	57.65
20%	1,027,096	245,072	63.69
30%	660,157	277,144	72.03

* based on 3,847,596 bricks per year.

29. CEMENT-BASED TILE PLANT

(ISIC code 3692 - produced 1979)

The profile describes a process for making floor and wall tiles from cement using a portable installation. The example presented has a production capacity of 55,000 m^2 tiles per annum, requiring an initial investment of $342,424 and a labour force of 12. The average sales price used is $13.30 per m^2.

1. INTRODUCTION

The "Lenoble" process for manufacturing floor and wall tiles from cement was perfected by a Belgian engineer. From 1964 until the present day, the "Lenoble" process has undergone considerable technical development and is used in more than 40 factories.

The material used is extremely simple and comprises rubber moulds (patented), vibrating tables (patented), base plates in asbestos cement and mixers. The installation is mobile, which allows the licensee to set up his production on the site where the tiles will be used. The material is adapted to each licensee's requirements and production can be increased by the simple acquisition of additional rubber moulds and vibrating tables.

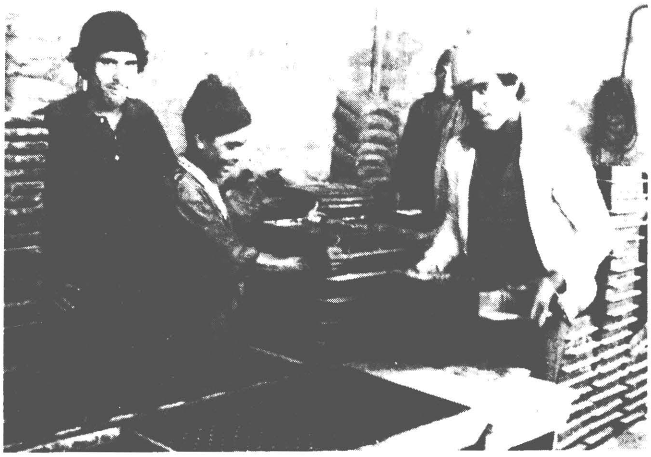
2. TECHNOLOGY

A. PRODUCTION PROCESS

The wearing surface of the tile is made first. After mixing the raw materials, measured amounts are poured into the flexible moulds either manually or automatically. Each mould then travels the length of the vibrating table for approximately 60 seconds.

An exceptionally high compaction of the aggregates and fine cement is obtained by eliminating air bubbles and water veins within the mix through the first vibration. After a period of time varying from one to two hours, depending on climatic conditions, a second and thicker layer of ordinary concrete is added to the first, and the moulds are vibrated again. The result of the vibrations is a perfect compaction and hold between the two layers. The tile hardens in the mould and is demoulded on the following day without the need of any demoulding products. The concrete then dries in controlled conditions of temperature and humidity.

Filling moulds



Deloading moulds from the vibrating table

In comparison with the traditional press system, this system obtains good results.

	Products
Compression	650 kg/cm^2
Wear (depends on the aggregates)	2 mm (AMSLER test)
Porosity	2.5%

B. MATERIAL INPUTS

The raw materials used are:

(a) those of local origin:
- sand
- gravel
- grey cement
- marble chips (optional)

(b) those of foreign origin:
- white cement
- pigment (iron oxide)
- acrylic resins

C. CHARACTERISTICS OF PRODUCT

The "Lenoble" process allows the manufacture of :

a) all types of decorative tiles in cement for floor covering from 20 x 20cm to 60 x 40cm
b) all types of tiles in industrial cement with a strong resistance to wear and shocks
c) tiles imitating certain ceramics for floor or wall covering (without the need for an oven)

d) floor and wall tiles for exterior decoration
e) granito tiles known on the market
f) shiny wall tiles (imitating ceramics)

More than 40 factories throughout the world use this process with a production capacity varying from 50,000 to 600,000 m^2 per year.

3. PLANT CAPACITY

The plant presented hereafter is a small one whose annual capacity is approximately 55,000m^2 and which can meet the requirements of many ACP countries, taking into account the size of the market.

4. RAW MATERIALS AND UTILITIES

Raw materials used in one year by a plant with a capacity of 55,000 m^2 producing tiles whose thickness varies from 1 to 3cm and whose surface varies from 20 x 20cm to 60 x 40cm:

a)	sand	843 tonnes	
b)	grey cement	477 tonnes	
c)	gravel	1650 tonnes	
d)	pigment	24 tonnes	
e)	white cement	53 tonnes	(providing one third of the production is of light-coloured tiles, these 53 tonnes should be substracted from point b))
f)	marble chips and powder	324 tonnes	(in the event of 50% of production being composed of granito tiles, this would involve a considerable reduction in the amount of sand and gravel given in points a) and c))
g)	cement additives (as a reminder)		
h)	other products (as a reminder)		
i)	electric power		4 kW per hour (a standard 3 phase -50 or 60 cycles- supply is required)
j)	water supply		5 m^3 per day (for mixing, washing down and curing)
k)	resins (depending on the quantity of tiles to be produced).		
l)	packaging (depending on the specific needs of the market).		

5. WORK FORCE REQUIREMENTS

The following table shows the personnel requirements for the production of 55,000 m^2.

Position	Number	Monthly cost US $
Managing Director also responsible for business and production	1	1,083.3
Office clerk	1	233.3
Secretary	1	183.3
Skilled workers (foreman)	1	433.3
Unskilled workers	8	1,066.6
Total	12	$3,000.0

6. INVESTMENT COST

The following figures have been extracted from a study carried out in 1978 for an ACP country in Africa and should be considered as a guideline.

A. FIXED INVESTMENT

	$ Local	$ Imported
Land (1200 m^2)	16,666.6	
Site preparation and building	51,666.6	
2 vibrating tables		14,000
4500 rubber moulds		223,425
2 mixers plus extra pans		16,666.6
2 fork-lift trucks plus pallets		3,333.3
Freight and insurance		6,666.6
Training (optional)		3,333.3
Miscellaneous		6,666.6
	68,333	274,091

B. WORKING CAPITAL

This can be estimated according to the following requirements:

	Required stock	Value ($)
Stock of raw materials	2 months	20,333
Stock of finished products	1 month	16,667
Various debtors (= 2 months of production, i.e. 10,000 m^2 x selling price of $13.3 per m^2	2 months	133,000
Personnel cost (in accordance with the outline in point 5)	2 months	6,000
Water and electricity (= 5% of the cost price of 1 m^2 of tile; therefore, for 2 months at a cost price of $3.3 per m^2, this gives: $\frac{5 \times 100 \times 5000 \times 2}{100}$ = $1,667	2 months	1,667
Packaging and miscellaneous		1,667
		179,334

7. **ECONOMIC EVALUATION**

A. INVESTMENT COSTS

i)	Land	16,666.6
ii)	Building	51,666.6
iii)	Machinery and equipment (includes freight and insurance)	270,758.1
iv)	Training of personnel	3,333.3
		342,424.6

B. OPERATING COSTS

	Year 1 1/3 capacity	Year 2 2/3 capacity	Year 3 full capacity
i) Raw materials (at $1.964 per m^2)	36,007	72,013	108,020
ii) Electricity and water (at $0.16 per m^2)	2,933	5,867	8,800
iii) Wages and salaries (for 12 persons)	36,000	36,000	36,000
iv) Maintenance (at 5% of machinery cost at full capacity)	4,513	9,025	13,538
v) Overheads (1% of investment cost + 5% of working capital)	34,936	35,337	35,745
vi) Distribution & sales costs	88,889	177,778	266,667
Total	$203,278	$336,020	$468,770

C. RESIDUAL VALUE

0.5 (16,666.6 + 51,666.6) + 0.1 X 270,758 = 61,242

D. EVALUATION (values in US $)

This is based on 10 year operating life, a 3 year build up to full capacity production, and a residual value for land, building and equipment. Fixed investment is 342,425. Working capital, 179,334, is taken in 3 instalments. On year 1 : 59,778; on year 2 : 59,777; on year 3 : 59,779. The residual value, 61,242, and working capital 179,334, are returned in the 10th year of operation.

The following are the results of NPV analysis :

Discount Rate	Present value of total costs	Annual revenue required	Revenue required per m^2
10%	2,927,309	556,241	10.11
20%	2,081,613	611,460	11.11
30%	1,599,635	671,551	12.21

30. CHALK CRAYON PRODUCTION

(ISIC code 3699 - produced 1980)

This profile describes a method of producing chalk sticks for use in schools and elsewhere. An initial investment of $ 9,255 is required for an annual output of 53,460 boxes of 144 sticks. The project employs 12 people.

1. PRODUCT DESCRIPTION

Chalk sticks are used for writing on blackboards and are made out of plaster of Paris. For educational institutions they are indispensable. The process described is designed to manufacture standard chalk sticks in different colours, packed in boxes of 144 pieces.

2. DESCRIPTION OF TECHNOLOGY

Lumps of gypsum are broken into small pieces and washed thoroughly to remove clay and other impurities. The washed gypsum is then roasted at a temperature of about 120°C to 140°C and converted into plaster of Paris. The white material so obtained is pulverized and sieved through a 60 or 80 mesh sieve. This powder is the main ingredient for the manufacture of chalk crayons.

The mould used for casting chalk crayons is made of gun metal, and prior to filling, the mould is coated with a lubricant consisting of kerosene and groundnut or other oil in the proportion 4:1. The powder is then mixed with water in an enamelled basin and brought to the consistency of a thick slurry. This slurry is slowly poured into the mould perforations where it sets and gets hard in about 10 minutes. The sticks are taken out from the mould by gentle hammering with a wooden mallet and placed in trays for drying.

The addition of a small quantity of ultramarine blue or Chinese blue dye to the water used in the slurry will help to bleach the yellowish white or grey colour of crayons. If desired about 5 per cent china clay may be added to make chalk sticks softer than those made exclusively with plaster of Paris.

Coloured chalks are prepared by dissolving colour in water and then mixing the solution thoroughly with the plaster of Paris. 100 grammes of colouring agent will be sufficient for 1 box of chalk crayons. After casting, the sticks are allowed to dry in the hot sun for a whole day. Coloured crayons are preferably dried in shade, as drying in the sun makes certain colours fade.

Machinery and Equipment		$
1	Gypsum calcination furnace including roaster of 50kg. capacity	190
5	Sets gun metal chalk crayon moulds - each 72 sticks capacity, each with perforations on one side only, complete with base plate and wooden frame	625
1	Flour mill (30 cm size) with 5 H.P. motor and accessories	500
2	Wooden tubs (76 cm bottom; 92 cm top and 76 cm height)	65
	Tools, thermometer, hammers, buckets, storage containers, wire mesh sieves, chalk carrying trays, etc.	125
	Furniture for office and workshop	250
	Transport, erection and installation, and other miscellaneous expenses	500
		2,255

3. LEVEL OF OUTPUT

The projected level of output is at the rate of 225 boxes of 144 sticks per day. At the rate of 5 1/2 days per week for 48 weeks of the year, with a 10 per cent allowance for rejection and breakage, this gives an annual net production rate of 53,460 boxes.

About half of the output is of white chalk and half coloured chalk. The selling price of coloured chalk can be twice that of white chalk, but the economic evaluation has been limited to cost of production estimates and implied selling prices.

4. EMPLOYMENT

The following employment is required to maintain full production over 11 months of the year :

1	Supervisor	at $ 4,000	4,000
2	Skilled workers	at $ 1,920	3,840
3	Helpers	at $ 720	2,160
2	Furnace workers	at $ 1,200	2,400
2	Sorters and packers	at $ 720	1,440
1	Clerck	at $ 1,200	1,200
1	Watchman	at $ 1,200	1,200
		Other costs	1,624
12			$ 17,864

5. ECONOMIC ANALYSIS

A. INVESTMENT COST

i) Fixed Investment	$
Machinery and Equipment	2,255
Building Costs (i.e. covered space 200 m^2)	7,000
	9,255
Residual Value	925

ii) Working Capital (Equivalent of 3 months' materials)	
Raw Materials	2,000
Others	200
	2,200

B. ANNUAL OPERATING COSTS

i) Materials

120 tonnes gypsum at	$ 18.75	2,250
120 tonnes firewood at	$ 18.75	2,250
6 tonnes china clay at	$ 31.25	188
Lubricating oil		150
120 kg. Water soluble colours to	$ 1.25	150
55000 Packing Boxes and Labels to	$ 0.05	2,750
		7,738

ii) Wages and Salaries 17,864

iii) Water and Fuel 320

iv) Motor Transport 125

v) Repairs and Maintenance 230

vi) Overheads - postage, stationery, publicity and contingencies 300

C. EVALUATION (Values in U.S. $)

This is based on a 10-year operating life. 2-year build-up to full capacity production, and a 10 per cent residual value for the fixed investment cost.

Initial investment cost is $ 9,255; Working capital is taken into in 2 instalments of $ 1100 each in the 1st and 2nd years of operation; the residual value of $ 925 together with the working capital of $ 2200 are returned in the 10th year of operation.

Thus production costs build up as follows :

	Year 1 (50%)	Year 2 (100%)
Materials	3,869	7,738
Wages and Salaries	17,864	17,864
Water and Energy	160	320
Transport by road	63	125
Repairs and Maintenance	115	230
Overheads	300	300
	22,371	26,577

The following are the results of NPV analysis :

Discount Rate sation	Present value	Annual Revenue required	Revenue required per box
10%	169,422	29,773	0.55
20%	118,335	31,343	0.58
30%	89,439	33,040	0.61

These revenues per box are for the whole production.

31. WOOD WOOL/CEMENT SLAB MANUFACTURE

(ISIC code 3699 - produced 1980)

This profile deals with a process for the manufacture of wood wool/cement slabs, involving minimum use of machinery and maximum use of labour. The slabs are useful for various types of building and have the properties of lightness, sound proofing and resistance. The investment cost is about $280,000 and 28 people would be employed

1. PRODUCT DESCRIPTION

Wood wool/cement slabs are a product of the mixture of shredded timber (wood wool) and cement, formed by pressure into the required dimensions. This low cost product is used for building and has useful qualities such as relative lightness, insulation, sound absorption and fire resistance; it can also be nailed and sawn. The basic raw materials are ordinary Portland cement, water, chemicals and wood.

2. DESCRIPTION OF TECHNOLOGY

This process reduces machinery to a minimum and is fundamentally labour-intensive.

The stages in the process are as follows:

a) Logs are debarked and stacked in the open air for about 3 months, for conditioning and fermentation of sugars which inhibit the setting of cement;

b) The logs are cut into 50 cm lengths, and shredded by machine to produce wood wool;

c) The wood wool is forked into a wire basket which is transferred to a tank containing a weak solution of the preferred chemical (calcium chloride, magnesium chloride, sodium silicate, etc.);

d) Soaked wood wool is transferred into an adjoining centrifuge, where the excess solution is spun off;

e) A slurry of two parts cement to one of water is prepared, and transferred to a mixer with the spun wood wool;

f) The mixture is emptied into a mould and pre-pressed to the approximate required dimensions, after which, still in their mould basis, the pre-pressed slabs are stacked in batches of one tonne;

g) The batches are finaly pressed to required dimensions and lashed to prevent re-expansion, after which each batch is removed from the press and left for about 16 hours to allow the slabs to cure;

h) Straps are removed and the slabs demoulded and stacked for about 4 days to continue curing. Battens are put between each pair of slabs; and

i) Battens are removed and slabs close-stacked or stored for a minimum of 10 days for final curing.

Equipment Requirement

De-barker with motor
Cross-cut saw with motor
Wood wool shredding machine
Compressor
Electric automatic cutter grinder for sharpening
Preparation tools
Protective creams and clothing
Mixing and soaking tanks and drums
Glass fibre for container fabrication and repair
Centrifuge with wire baskets
3 Electric hoists and slings
Runway systems with brackets and track
Platform scale
2 Trolleys
Cement slurry mixer with motor and pump
Wood wool and slurry mixer with motor
Platform and access way with hand rails
Conveyor
Hydraulic pre-pressing machine
Hydraulic final pressing machine
540 Moulds with surrounds and pistons
6,000 Battens
400 Spacers
50 Pallets
2 Pallet trucks
60 Mould straps or lashings
Moisture Metre
Maintenance and repair kit
Spares kit.

3. LEVEL OF OUTPUT

The level of output envisaged is 160 slabs per day. For a 6 day week and a 48 week year this gives an annual output of 46080 slabs. If each slab weighs 16.5 kg, the output will be about 760 tonnes. This gives a total surface area of 691 m^2 with slabs 15mm thick.

Typical slab is 2.4m x 0.6m.

4. EMPLOYMENT AND EMPLOYMENT COSTS

			$
1	Manager	at \$4,000 per annum	4,000
1	Foreman	at \$2,400 " "	2,400
1	Clerk	at \$1,200 " "	1,200
6	Skilled Workers	at \$1,920 " "	11,520
12	Semi-skilled Workers	at \$1,200 " "	14,400
7	Unskilled workers	at \$ 720 " "	5,040
28			\$38,560
	Other Annual Labour Costs:		3,856
	Total Annual Labour Costs:		\$42,416

5. DATA FOR ECONOMIC ANALYSIS

A. INVESTMENT COST

i) Fixed Investment :

	$
Machinery and Equipment	100,000
Land and Building ($2000m^2$ x \$20; $1000m^2$ x \$120)	160,000
Pre-operating Expenses	20,000
	\$280,000

ii) Working Capital :

	$
Stock of materials(3 months)	28,816
Wages and Salaries(2 months)	7,069
	\$35,885

iii) Residual Value :

	$
10% of Equipment Costs	10,000
50% of Building Cost	80,000
	\$90,000

B. ANNUAL OPERATING COSTS

		$
i) Materials :		115,264
Wood (261kg. per tonne of output)	49,590	
Cement (524kg. per tonne of output)	59,736	
Water (262 l.per tonne of output)	876	
Chemicals (5 l.per tonne of output)	5,062	
ii) Wages and Salaries		42,416
iii) Electricity (30 kWh per tonne of output)		912
v) Maintenance		3,000
vi) Overheads		1,500
Total Annual Operating Costs:		\$163,092

C. EVALUATION (Values in US $)

This is based on a 10 year operating life, a 2 year build-up to full capacity production and a residual value for buildings and equipment. The fixed investment amounts to $280,000. Working capital is taken in two equal instalments in the first two years of operation, and the residual value ($90,000) and working capital ($35,885) are returned in the 10th year of operation.

The production costs build up as follows:

	Year 1 (65%)	Year 2 (100%)
Materials	74,922	115,264
Wages and Salaries	27,570	42,416
Electricity	593	912
Maintenance	1,950	3,000
Overheads	975	1,500
	$106,010	$163,092

The following are the results of NPV analysis:

Discount Rate	Present Value of Total Costs	Annual Revenue Required for Given Discount Rate	Revenue Required per slab
10%	1,212,688	208,121	4.52
20%	923,137	236,674	5.14
30%	755,452	282,043	6.12

32. SMALL-SCALE IRON FOUNDRY

(ISIC code 3710, produced 1979)

The foundry specified in this profile produces grey iron castings for a variety of of uses such as components, agricultural implements, etc. It is designed to produce 350 tonnes of castings per year and employs 31 people (of whom 27 are production workers). The initial fixed investment is $53,160

1. INTRODUCTION

Founding, or casting, is the process of forming metal objects by melting metal and pouring it into moulds, the shape of the object being determined by the shape of the mould. The moulds are usually made of sand.

In iron founding, cast iron is the metal used. Cast iron accounts for a large proportion of the metal cast in both developed as well as developing countries : about 76% in the U.K. and U.S.A., about 80% in India. Cast iron finds wide applications and in varied products such as agricultural implements, motor car components, etc.

2. PRODUCTS

The products that could be produced by a small-scale foundry are varied. Some commonly produced products are listed below :

(a) Sanitary fittings and municipal items such as rainwater pipes and pipe fittings for domestic plumbing, manhole covers and fixtures for sewerage systems, flushing cisterns, etc.;

(b) weights and measures, large weighing scale components, etc.;

(c) domestic cooking utensils;

(d) agricultural implements such as plough shares, and irrigation pumps (the casting and components), and;

(e) spare parts for electrical machinery, construction machinery, tractors, trucks, etc.

3. THE FOUNDING PROCESS

Figure 1 shows schematically the iron founding process using green sand moulding. The various stages are now described briefly.

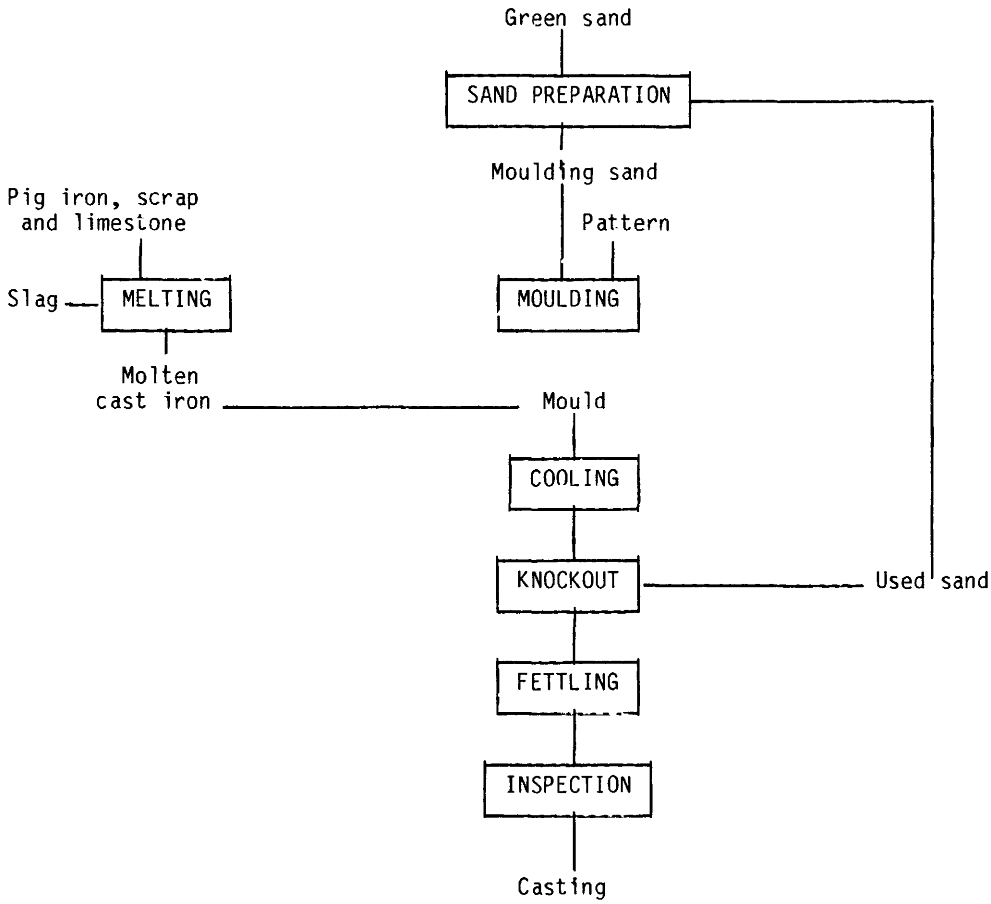


Figure 1 : Schematic illustration of the iron founding process.

A. SAND PREPARATION

The preparation of moulding sand involves basically the blending of sand with bonding materials to obtain a mixture that has the required properties of good green and dry strength, flowability, collapsibility, permeability, appropriate grain size and distribution, etc. All natural moulding sands possess these qualities in varying degree, and, by suitable blending of sands and of any additions, the required properties can be obtained. The chief constituents in sands are silica grains (80-90 per cent) which are refractory, bentonite (clay) which serves as a binder (6-10 per cent), and small quantities of other ingredients such as lime, magnesia and metallic oxides.

Sand is prepared for moulding by blending, mixing in "used" sand which has been broken up and tempering with water to the appropriate moisture content, grain size, permeability and bond strength. The mixing can be carried out by hand with the aid of hand tools; traditionally foundrymen have tested the prepared sand using the feel of their hand. Mixers and mullers (which provide a kneading action on the sand) are available in both fixed and portable versions.

Facing sand is used on the mould surface that faces the metal; parting sand is used to enable the two mould halves to be separated easily.

B. PATTERNS

A casting duplicates the dimensions of an original object, which is used as a pattern to shape the casting cavity of sand mould. Wood is usually chosen as a convenient and relatively cheap material for making patterns; when it is intended to produce a single casting type in high volume, metallic patterns are used. Brass, aluminium alloys, magnesium alloys and ferrous alloys are used for metallic patterns.

Because all metals contract when they solidify from the molten state and as they cool from the solid state, an allowance for the shrinkage has to be incorporated into the pattern dimensions. The pattern must be of such a shape that it can be withdrawn with little effort and without damaging the mould. This is helped by providing a slight taper on all vertical faces of the pattern which come in contact with the mould.

Several types of patterns are available; the three that are most likely to be used at small levels of scale are single piece or solid patterns, split patterns and loose-piece patterns. Solid patterns are one-piece patterns and their use is feasible when a limited number of castings of each type is to be produced. Split patterns are made in two parts, one part producing the lower half of the mould, and the other, the upper half. Splitting of the patterns (along the parting line) is usually arranged along the joint of the mould. Loose-piece patterns are patterns produced as assemblies of loose component pieces; this is to allow easy withdrawal of the pattern from the mould and is used only where the casting design makes this necessary.

C. CORES

Cores are used in moulds to form cavities or recesses in the casting. A pattern may be so designed that it forms a core as an integral part of the mould, in which case the entire mould including the core will be made of green sand. More often, cores are moulded to the desired shape in a core box from dry sand, rammed in and baked in an oven to a hard form. There are a variety of core mixtures (and processes); for small cores clean silica sand with linseed oil is commonly used because of the high strength that they provide. For large cores and heavy castings, dextrin is added to improve the hot strength.

Although core-making machines are available, these are unlikely to be warranted at the low scales being considered here. When cores are made manually, they are usually formed in the core boxes on a bench, and put in a low-temperature oven (at 175-250°C).

The carbon dioxide process uses carbon dioxide to harden the core by a chemical reaction; although it is more expensive, harder cores are obtained.

D. MOULDING

The general procedure followed in moulding is as follows. This description is for a split pattern. A moulding box consists of two rectangular frames of equal horizontal dimensions, usually made of metal. The bottom (drag) box is first put on a flat board. The drag half of the pattern is then placed on the board, with the parting line facing the board. Facing sand is then sprinkled on to the board, followed by the moulding sand until the box is almost full. The sand is then compressed hard with a rammer. Any excess sand is scraped from the surface. The upper (cope) half of the pattern is then placed on the half that is already in the mould, being aligned properly. The top half of the moulding box is positioned on to the bottom half and parting sand is dusted over the joint. Moulding sand is then added to this half of the moulding box, rammed and then scraped. The moulding box is then split, and placed side by side on the board with the patterns exposed. The two half patterns are removed from the moulds by driving a small metal rod into the patterns and gently tapping until they are loosened, so that they can be carefully drawn out. Any repairs to the mould are carried out, channels and runners are cut into the horizontal faces of one or both of the moulds. A sprue and a riser (vertical channels) are cut at opposite ends of the cope, the sprue connecting with the horizontal channel. A pair of bellows is used to blow away any loose sand and then the cores are placed in the required positions. The top half of the mould is then replaced onto the bottom and the two boxes are clamped together. The gate, which is the opening in the mould through which metal is poured, is then cut or shaped near the runner cavity. The mould is then vented with a thin rod.

E. MELTING

Melting is carried out in a coke-fired cupola (an oil-fired furnace is also available).

The cupola consists of a vertical cylindrical shell lined with refractory brick. The charge is dropped through a hole in the upper section. Metal is tapped at the bottom through a spout and slag runs out through a hole at the back, above the metal tapping hole. Air is blown through nozzles (tuyeres) in the lower half.

The charge into a cupola is composed of foundry grade pig iron, scrap iron, coke and limestone (which acts as a flux).

Because of the time required to start it up, the cupola is usually operated on a continuous basis. For small scales, melting may be carried out only twice or three times in a week.

Metal is run from the cupola into ladles from which it is poured into the moulds. Any slag floating on the metal is skimmed off before pouring.

F. KNOCKING-OUT AND FETTLING

The castings are knocked-out of the moulds after cooling. Surplus iron pieces like the runner and riser are knocked-off with a hammer and chisel; any sand or clay left adhering is cleaned with the aid of wire brushes, and; any irregularities at the mould joints are trimmed with a file or grinder.

After inspecting the casting for flaws, any finishing operations (such as coating with tar for some sanitary fittings) is carried out. Rejects are returned to the cupola to be used in the charge.

4. ECONOMIC EVALUATION

In this section, the requirements for a foundry designed to produce 350 tonnes of castings per year are specified. The prices indicated (all in U.S.$) are those obtained in India; for use in any other country, the prices prevailing can be substituted.

The capital and operating costs are first set out and the sales revenue is calculated on the basis of an average price per tonne. All prices are assumed to remain constant in real terms over the life of the project (that is, the relative prices are assumed to remain unchanged).

The equipment, manning and raw material requirements are set out in detail in an appendix.

A. CAPITAL COSTS

i) Fixed Capital:

	$
Plant and equipment basic price	27,300
Freight and installation at 20%	5,460
Furniture and fittings	1,000
Factory building 700m^2 at $18	12,600
Offices and laboratory 200m^2 at $24	4,800
Land 2000 m^2 at $1	2,000
	$53,160

ii) Working Capital:

	$
1 month's raw materials requirements	6,134
1 month's wages and salaries	2,532
	$8,666

B. ANNUAL OPERATING COSTS

	$
Raw materials	73,604
Wages and salaries	28,224
Electric power	2,800
Water and other utilities	1,000
	$105,628

* * *

APPENDIX 1 : PROJECT SPECIFICATIONS

1. PLANT AND EQUIPMENT INVENTORY

		Basic price ($)
(a)	Melting shop	
	1 m.ton/hour cupola with blower and charging platform	5,000
	Oil fired ladle pre-heater with oil burner and blower	1,000
	20 ladles of varying capacities	500
	Weighing scale, 500 kg. capacity	500
		7,500
(b)	Moulding shop	
	Sand mixer-muller, 750 kg. capacity	1,200
	65 mould boxes of varying sizes	1,800
	Moulding tools (rammers, etc.)	100
		3,100
(c)	Core shop	
	Auto sand riddler with tripod	500
	Core drying oven with accessories	4,000
	4 coremaking benches	1,200
		5,700
(d)	Fettling shop	
	Pedestal grinder	2,000
	Heavy duty portable hand grinder	700
		2,700
(e)	Laboratory	
	Precision balance	250
	Rapid moisture tester	300
	Permeability tester	300
	Green sand strength testing apparatus	250
	Sand sieve shaker	300
	Portable core hardness tester	200
	Portable mould hardness tester	200
		1,800
(f)	Common services	
	Water pump with tubewell and overhead tank	2,000
	Oil storage tank	2,000
	Electricity switchboard and power distribution system	2,000
		6,000
(g)	Maintenance and pattern shop	
	drill machine	500
	TOTAL	27,000

2. EMPLOYMENT

(a) Staff	Basic salary (p.m.)
Manager	250
Accountant	140
Accounts clerk	90
Storekeeper	70
(b) Labour	
14 skilled workers	60
5 semi-skilled workers	50
8 unskilled workers	40

Other benefits amount to 20% of the basic salary.

3. RAW MATERIALS (annual costs)

Items	Price/m.ton	Quantity (t.)	Cost (US $)
Pig iron	150	270	40,500
Cast iron scrap	110	116	12,760
Limestone	20	19.2	384
Hard coke	80	77	6,160
Moulding sand	5	700	3,500
Bentonite	60	35	2,100
Other raw materials and consumables			8,200
		Total	$73,604

(A 10% melting loss has been assumed).

4. ELECTRIC POWER (p.a.)

Demand charge 60 kVa at $30	1,800
Consumption charge 25,000 kWh at $0.04	1,000
	$2,800

5. EVALUATION (Values in US $)

This is based on 20 year operating life, a 2 year build up to full capacity production, and a residual value for land, building and equipment. Fixed investment is $53,160. Working capital, $8,666, is taken in 2 instalments. On year 1 : $4,333; on year 2 : $4,333. The residual value, of $10,000, and working capital $8,666, are returned in the 20th year of operation.

Thus, production costs build up as follows :

	Year 1 capacity (50%)	Year 2 capacity (full)
Materials	36,802	73,604
Wages and salaries	28,224	28,224
Water and other utilities	1,000	1,000
Electricity	1,600	2,800
	67,626	105,628

The following are the results of NPV analysis :

Discount Rate	Present value of total costs	Annual revenue required	Revenue required per m.ton
10%	922,564	114,469	327.05
20%	541,833	121,665	347.61
30%	380,003	129,650	370.43

33. FOUNDRY FOR PIPES AND PIPE FITTINGS

(ISIC code 3710 - produced 1980)

This profile describes a foundry project for producing 900 tonnes per annum of pipes and pipe fittings. The initial fixed investment is $129.540 and the level of employment 61 people.

1. PRODUCT DESCRIPTION

The proposal in this profile is based on a foundry designed to produce 900 tonnes per annum of soil pipes and pipe fittings made of cast iron. Such a foundry can be adapted to produce most types of castings in grey cast iron.

2. DESCRIPTION OF TECHNOLOGY

Casting is the process of forming metal objects by melting metal and pouring it into moulds, the shape of the object being determined by the shape of the mould. The moulds are usually (as in this profile) made of sand. Floor moulding (by hand) is used; and simple sand preparation equipment for reclaiming used sand. Melting of cast iron is carried out in a coke-fired cupola. The cores, which are placed in the moulds to form cavities or recesses in the casting, are made manually in core boxes and baked in a low temperature oven.

3. LEVEL OF OUTPUT

The equipment is designed to produce about 3-4 tonnes of castings each year. An annual output of 900 tonnes has been assumed.

4. EMPLOYMENT

The following manning structure has been used:

(a) Staff and Non-Production Employees

			$
1	Manager	at $4,000 per annum	4,000
1	Assistant Manager	at $3,000 " "	3,000
1	Foundry Engineer	at $2,800 " "	2,800
1	Foreman	at $2,600 " "	2,600
1	Accountant	at $2,800 " "	2,800
2	Clerks	at $1,500 " "	3,000
3	Supervisors	at $2,400 " "	7,200
10			25,400

(b) Direct Production Employees

17	Skilled workers	at $1,920 per annum	32,640
22	Semi-skilled workers	at $1,200 " "	26,400
12	Unskilled workers	at $ 720 " "	8,640
51			67,680

Total wages and salaries costs $93,080

5. DATA FOR ECONOMIC ANALYSIS

A. INVESTMENT COST

i) Fixed Investment:

	$
Plant and equipment	82,000
Freight and installation at 20%	16,400
Factory building 1230 m^2 at $18	22,140
Offices and Laboratory 200 m^2 at $24	4,800
Land 4,200 m^2 at $1	4,200
	129,540

ii) Working Capital:

	$
1 month's raw materials requirements	20,000
2 months wages and salaries	15,513
	35,513

Total investment : $165,053

B. ANNUAL OPERATING COSTS

	$
Wages and Salaries	93,080
Raw Materials	229,610
Power, water and other utilities	7,200
Total	$329,890

C. EVALUATION (Values in US $)

This is based on a 20 year operating life, a 3 year build-up to full capacity production, and a residual value for building and equipment. Fixed investment is $129,540. Working capital, $35,513, is taken in 3 instalments : on year 1 : $11,838; on year 2 : $11,838; on year 3 : $11,837. The residual value, $12,954, and working capital, $35,513, are returned on the 20th year of operation.

Thus, production costs build up as follows:

	Year 1 (30%)	Year 2 (60%)	Year 3 (100%)
Materials	68,883	137,766	229,610
Wages and salaries	93,080	93,080	93,080
Energy, water and others	2,160	2,160	2,160
	164,123	235,166	329,890

The following are the results of NPV analysis :

Discount Rate	Present Value of Total Costs	Annual Revenue Required for Given Discount Rate	Revenue Required per m.ton
10%	2,702,353	358,070	397.85
20%	1,530,121	381,767	424.18
30%	1,039,183	408,966	454.41

<u>Note</u>

An extended description of the founding process and technology appears in the profile n°31 of this inventory. The project described and evaluated there was for a smaller (350 tonnes per annum), general-purpose foundry producing a non-specific product range.

34. SMALL-SCALE KNIFE PRODUCTION

(ISIC code 3811 - produced 1979)

The profile describes a relatively labour intensive method of producing multi-purpose knives using scrap or band iron, and considers three scales of output 100, 200 and 300 knives per day. Fixed investment ranges from US $43,478 to $76,087, and employment from 26 to 69.

1. INTRODUCTION

This profile was obtained from the experience gained over a number of years with a co-operative society in East Africa, working at traditional small scale level, with an output of approximately 31,200 knives per annum.

Production was increased to 93,600 knives per year in 1978 using a minimum of mechanization.

In 1979, equipment was being obtained to increase production to 500,000 knives per year. This is achieved by mechanizing part of the production process, notably sub-processes 1 to 8, under 3 (b). The basic sub-processes, material, energy requirements, labour and fixed investment requirements are summarized. Data on operational costs for the mass-production up to 500,000 knives per year are not yet available as a case study. One definite advantage of the mass-production is that other items, such as e;g. cane knives, sisal knives and simple tools can be manufactured with relatively small additional capital investment (cutting tools for the press).

2. GENERAL ASPECTS

A. PRODUCTION METHOD

The proposed production method is related to the current philosophy in various developing countries regarding small-scale industrial development. Production is not export-orientated but is designed to neet local requirements. Capital investments are kept at a minimum and employment aspects are important. The proposed production method can be employed by co-operative societies, with limited know-how.

B. BASIC SUB-PROCESSES

Depending on whether scrap or band iron is used, 14 or 13 sub-processes are distinguished, ranging from cutting scrap or band iron to packing of the knives.

C. SCALE OF PRODUCTION

Three production levels have been considered : 100, 200 and 300 knives per day.

D. MATERIAL REQUIREMENTS

For each of the three production levels, the scrap, band iron, wood and galvanized iron-wire requirements have been calculated.

E. ENERGY REQUIREMENTS

Energy requirements expressed as kWh were calculated for the three production levels and ranged from 21,600 to 64,800 kWh per year.

F. WORK FORCE REQUIREMENTS

All production levels will require 11 managerial and administrative staff.

When using scrap, the production staff will range from 25 to 58 depending on the production level. In case of band iron production staff will range from 16 to 37.

G. INFRA-STRUCTURAL REQUIREMENTS

These relate particularly to the local availability of raw materials, repair and maintenance facilities for equipment and machines and the existing system of market distribution.

H. MARKET SIZE

In the country under consideration there is an estimated market for approximately 500,000 knives and more per annum. All knives are presently imported from the Far East and the Government is keen to have co-operatives to start knife-making.

If these can prove to be reliable suppliers, the Government guarantees a market for knives, by cutting imports accordingly.

I. FIXED INVESTMENT REQUIREMENTS

Specific and general equipment requirements are listed for the three production levels together with the required investments. The total investments range from US $43,478 to $76,087. Machine and raw material costs, if applicable, include freight, insurance and transportation.

3. BASIC DATA

A. PRODUCTION METHOD

The multi-purpose knives are made from carbon steel (067-C75) and have wooden handles. As raw materials, scrap or band iron can be used or a combination of both. The handles consist of two parts riveted with galvanized iron-wire.

B. BASIC SUB-PROCESSES

	Using scrap:	Using band iron:
1.	cutting and trimming scrap	cutting band iron
2.	forging	-
3.	cutting contours	cutting contours
4.	punching holes for handles	punching holes for handles
5.	shaping (grinding)	shaping (grinding)
6.	grinding surface	grinding surface
7.	hardening	hardening
8.	grinding surface	grinding surface
9.	polishing medium	polishing medium
10.	polishing fine	polishing fine
11.	fitting handles	fitting handles
12.	polishing handles	polishing handles
13.	varnishing handles	varnishing handles
14.	packing knives	packing knives

C. SCALE OF PRODUCTION

Production:	per day:	per month:	per year:
A.	100	2,600	31,200
B.	200	5,200	62,400
C.	300	7,800	93,600

D, E, F will be used for band iron.

D. MATERIAL REQUIREMENTS

STEEL:

scrap (per knife : 0.35 kg)

Quantity (in kgs)	per day:	per month:	per year:
A.	35	910	10,920
B.	70	1,820	21,840
C.	105	2,730	32,760

band iron (per knife : 300 X 30 X 1.50 mm, 0.36 kg/m = 0.12 kg)

Quantity (in kgs)	per day:	per month:	per year:
A.	12	312	3,744
B.	24	624	7,488
C.	36	936	11,232

WOOD: (per knife: 0.25 X 0.03 X 0.01 m)

Quantity in m:	per day:	per month:	per year:
A.	25	650 (0.195m^3)	7,800 (2.34 m^3)
B.	50	1,300 (0.390m^3)	15,600 (4.68 m^3)
C.	75	1,950 (0.585m^3)	23,400 (7.02 m^3)

GALVANIZED IRON-WIRE: (0.06 m at 5 mm per knife, 0.157 kg/m)

Quantity (in kgs)	per day:	per month:	per year:
A.	1	25	300
B.	2	50	600
C.	3	75	900

E. ENERGY REQUIREMENTS

Quantity in kWh	per day:	per month:	per year:
A.	70	1,800	21,600
B.	140	3,600	43,200
C.	210	5,400	64,800

F. WORK FORCE REQUIREMENTS

Managerial and administrative staff	$ per month
General Manager	96.50
Accountant	123.90
Personnel manager	78.30
Production manager	78.30
Stores manager	75.70
Cashier	70.40
Typist/telephone operator	58.70
Office supervisor	62.60
Watchman (3 X)	109.60
	$754.00

Production staff (using scrap):			$ per month
A.	100 knives/day:	1 foreman	63.90
		7 forgers	447.40
		17 labour	465.70
			977.00
B.	200 knives/day	2 foremen	127.80
		14 forgers	894.80
		24 labour	657.40
			1680.00

			$ per month
C.	300 knives/day	2 foremen	127.80
		21 forgers	1342.00
		35 labour	958.70
			2428.50

Total per year:
A. $1731.00 X 12 = $20,772
B. $2434.00 X 12 = $29,208
C. $3182.50 X 12 = $38,190

Production staff (using band iron):

			$ per month
A.	100 knives/day	1 foreman	63.90
		15 labour	410.90
			474.80
B.	200 knives/day	1 foreman	63.90
		23 labour	630.00
			693.90
C.	300 knives/day	2 foremen	127.80
		35 labour	958.70
			1086.50

Total per year:
A. $1228.80 X 12 = $14,745.60
B. $1447.90 X 12 = $17,374.80
C. $1840.50 X 12 = $22,086.00

G. INFRA-STRUCTURAL REQUIREMENTS

Major infra-structural facilities relate to regular raw material supply. Scrap and other material can be supplied by local industries. Band iron might have to be imported in most of the developing countries. Repair and maintenance facilities have to be available. Market distribution is very often state-regulated.

H. MARKET SIZE

The size of the market can differ from country to country, but depends on the price, quality, production scale, competition, import and export restrictions.

I. FIXED INVESTMENT REQUIREMENTS

Basic sub-processed	equipment	number required: A.	B.	C.
1-2	**using scrap**			
	forging fires with blowers	2	2	3
	avails	8	16	24
	set of hand-tools	8	16	24
1	**using band iron**			
	metal cutter	1	1	1
3	metal cutter	1	1	2
4	puncher	1	2	2
5	grinder/2 stones	1	2	2
6	grinder/2 stones	1	1	2
7	hardening oven	1	1	1
	oil-tank	1	1	1
8	grinder/2 stones	1	1	2
9	polishing machine/2 rolls	1	1	1
10	polishing machine/2 rolls	1	1	2
11	circle saw	1	1	1
	drill	1	1	1
12	grinder for handles	1	2	3

General equipment requirements (including buildings, etc.)

1 welding unit electrical
1 welding unit autogenous
hand-tools, work-benches, spare parts for specific equipment
buildings
office furniture.

Total investment

(a)	Production 100 knives/day	buildings:	21,739	
		electrification:	8,696	
		machines:	13,043	
				43,478
(b)	Production 200 knives/day	buildings:	32,609	
		electrification:	10,870	
		machines:	15,217	
				58,696
(c)	Production 300 knives/day	buildings:	43,478	
		electrification:	13,043	
		machines:	19,565	
				76,086

J. ANNUAL OPERATION COSTS

Using scrap:	Scale A	Scale B	US $ Scale C
scrap	4,087	8,174	12,261
wood	4,087	8,174	12,261
materials, electricity a.o.	16,087	32,174	48,261
occasional expenses	3,913	7,826	11,739
wages/salaries	20,772	29,208	38,190
repairs and maintenance	4,348	5,870	7,609
	53,294	91,426	129,961

Using band iron:	Scale D	Scale E	Scale F us $
band iron	6,522	13,043	19,565
wood	4,087	8,174	12,261
materials etc.	13,043	26,087	39,130
occasional expenses	3,913	7,826	11,739
wages/salaries	14,744.8	17,374.8	22,086
repairs and maintenance	4,348	5,870	7,609
	46,657.8	78,374.8	112,390

K. PATENT POSITION

Location dependent.

L. OPERATING COSTS (US $ 000)

	33.33% capacity operat.			66.66% capacity operat.			100% capacity operation		
	A	B	C	A	B	C	A	B	C
i) Using scrap									
Scrap	1.36	2.73	4.09	2.73	5.45	8.17	4.09	8.17	12.26
Wood	1.36	2.73	4.09	2.73	5.45	8.17	4.09	8.17	12.26
Materials, electricity, etc.	5.36	10.73	16.09	10.73	21.45	32.17	16.09	32.48	48.27
Occasional exp.	3.91	7.83	11.74	3.91	7.83	11.74	3.91	7.82	11.74
Wages/salaries	20.77	29.21	38.19	20.77	29.21	38.19	20.77	29.21	38.19
Repairs & maint.	1.45	1.96	2.53	2.90	3.91	5.07	4.35	5.87	7.61
Sales & Commission (15% of sales)	4.89	9.78	14.67	9.78	19.57	29.35	14.67	29.35	44.02
Total	39.10	64.97	91.40	53.55	92.87	132.86	67.97	120.76	174.35

	D	E	F	D	E	F	D	E	F
ii) Using band iron									
Band iron	2.17	4.35	6.52	4.35	8.70	13.04	6.52	13.04	19.57
Wood	1.36	2.73	4.09	2.73	5.45	8.17	4.09	8.17	12.26
Materials, electricity, etc.	4.35	8.70	13.04	8.70	17.39	26.09	13.04	26.09	39.13
Occasional exp.	3.91	7.83	11.74	3.91	7.83	11.74	3.91	7.83	11.74
Wages/salaries	14.74	17.37	22.08	14.74	17.37	22.08	14.74	17.37	22.08
Repairs & maint.	1.45	1.96	2.53	2.90	3.91	5.07	4.35	5.87	7.61
Sales & Commission (15% of sales)	4.89	9.78	14.67	9.78	19.57	29.35	14.67	29.35	44.02
Total	32.87	52.72	74.67	47.03	82.22	115.54	61.32	107.72	156.41

Note : D, E, F are for band iron what A, B, C are for scrap iron.

M. WORKING CAPITAL (US $ 000)

		US $ Scale A	US $ Scale B	US $ Scale C
(i)	Using scrap iron			
	Iron and wood for 3 months	2.05	4.09	6.13
	Other expenses for 1 month	4.99	8.69	12.49
	Credit for 3 months to the retailer	24.46	48.91	73.37
	Total	31.50	61.69	91.99
	Year 1 :	10.50	20.56	30.66
	Year 2 :	10.50	20.57	30.67
	Year 3 :	10.50	20.56	30.66

		Scale D	Scale E	Scale F
(ii)	Using band iron			
	Scrap and wood for 3 months	2.65	5.30	7.96
	Other expenses for 1 month	4.23	7.21	10.39
	Credit for 3 months to the retailer	24.46	48.91	73.37
	Total	31.34	61.42	91.72
	Year 1 :	10.45	20.47	30.57
	Year 2 :	10.44	20.48	30.58
	Year 3 :	10.45	20.47	30.57

4. EVALUATION (Values in U.S. $)

This is based on 15 year operating life, a 3 year build-up to full capacity and a residual value for land, building and equipment.

Six possibilities are analyzed :	Fixed investment :	Working capital :
A : 100 knives/hour - 31,200/year	46,960	31,500
B : 200 " - 62,400/year	63,480	61,690
C : 300 " - 93,600/year	82,390	91,990
D : 100 " - 31,200/year	46,960	31,400
E : 200 " - 62,400/year	63,480	61,420
F : 300 " - 93,600/year	73,190	91,720

Working capitals are taken in three instalments as follows :

	Scrap iron			Band iron		
	A	B	C	D	E	F
Year 1	10,500	20,560	30,660	10,450	20,470	30,570
Year 2	10,500	20,570	30,670	10,450	20,480	30,580
Year 3	10,500	20,560	30,660	10,450	20,470	30,570

Residual values are considered as one tenth of the fixed investment. They are returned, with the working capital, at the end of the 15th year.

Note : D, E, F are for band iron what A, B, C are for scrap iron.

The following are the results of NPV analysis :

Discount Rate		Present value of total costs	Annual revenue required	Revenue required per knive
10%	A	543,129	80,779	2.58
	B	943,964	140,394	2.24
	C	1,350,925	200,921	2.14
	D	492,992	73,322	2.35
	E	846,334	125,874	2.01
	F	1,215,943	180,845	1.93
20%	A	350,457	95,250	3.05
	B	602,052	163,631	2.66
	C	857,822	233,147	2.49
	D	319,735	86,900	2.78
	E	542,379	147,413	2.36
	F	775,199	210,690	2.25
30%	A	256,730	100,364	3.21
	B	490,485	191,745	3.07
	C	696,999	272,478	2.91
	D	263,228	102,904	3.29
	E	443,061	173,206	2.77
	F	631,330	246,806	2.63

Note : D, E, F are for band iron what A, B, C are for scrap iron.

35. METAL COATING WORKSHOP

(ISIC code 3822 - produced 1980)

> This profile describes a process designed to add surface metal coatings to new and used parts. The Electrolytic Coating method used produces decorative and/or industrial coatings, specifically of chromium. The workshop requires initial investment of $813,000 and employs 19 people.

1. PRODUCT DESCRIPTION

Surface coatings are used to confer a number of properties to treated parts which strengthen the qualities of the base metal itself. They require a wide range of techniques from which the specific choice varies with the application. The techniques may be divided into two main categories:

(a) Electrolytic Coating.

(b) Non-electrolytic Processes.

The first of these may be broken down into:

Decorative coatings which protect parts against atmospheric corrosion whilst imparting an attractive look: examples include decorative chromium, nickel, zinc, cadmium, and pewter.

Industrial "thick" coatings which increase the mechanical properties and corrosion resistance of treated parts: examples include hard chromium, thick nickel and thick copper.

In the second category the main divisions are:

- Heat treatment and similar processes (carbonizing, nitriding, sulphonating, chromizing, etc);

- Spray metal coating (gas, wire, powder, plasma etc.); and

- Chemical metal coating or immersion coating (immersion in an aqueous solution of the metal to be used for coating) - for example, chemical nickel plating.

Some of these processes are applied only to new parts, but in developing countries a particularly valuable use can be in the re-conditioning of used parts.

Mechanical parts can be re-metalled in two ways: electrolytically (specifically hard chromium plating); and spraying (metal coating using a spray gun). Hard chromium plating gives better molecular adherence than spray coating and it also possesses a number of valuable properties, such as increased wear resistance, increased corrosion resistance, and (in some cases) thermal protection. Hard chromium plating is therefore able to contribute to the characteristics of both new and used parts through improvement of their looks, an increase in manufacturing speeds and a decrease in maintenance and production costs.

2. DESCRIPTION OF TECHNOLOGY

(a) Process

After mechanical preparation of the part (very precise working or rectifying and polishing) which is needed to obtain an even surface, there are several preparatory operations in a series of tanks prior to actual treatment. Most of these operations involve the passage of current through the bath. The equipment required consists, therefore, of electrolysis tanks and current rectifiers, the size of which is related to the dimensions of the parts to be treated.

After the preceding mechanical operations, the part goes through a series of baths which have a specific composition of the base metals which are to be used, but which are mostly of the following types:

- Degreasing Baths - to soap the surface (removing grease)
- Etching Baths - to eliminate metallic oxides by dissolving them
- Rinsing Baths - after each operation and before the following treatment
- Treatment Baths - with temperatures not exceeding 55°C.

The part - which has not been subject to heat or deformation - is suspended from a conducting hook. Chrome is deposited as a result of electrolytic decomposition following the passage of current between the part (cathode) and the insoluble anodes. The difference in potential amounts to 8-12 Volts and the average current strength is 30 Amps per dm^2.

Hard chromium is then deposited. The thickness of the layer varies from a few microns to several millimetres, depending on the intended use of the part and, of course, on the conditions of the treatment (depositing time).

Its low friction coefficient gives excellent results in all friction problems, since after hard chromizing this coefficient is 40% less than for steel.

This electrolytic coating adheres perfectly (molecular adherence), it can be selectively applied (excluding parts which need not be treated), it can be machined to the required tolerances and can be removed by electrolytically without affecting the original material.

Waste liquids are collected and treated in a battery of mobile ion exchangers for regeneration. Chromic steam is filtered and the condensation is recovered for re-use in the baths.

(b) **Equipment required**

The complete line comprises 17,000 litres of baths and a capacity of 20,000 Amps installed in two lines.

(i) a line of vertical tanks with a depth of 3m and a diameter of 1 m, which can treat cylinder type parts up to 2.5 m long and with a diameter of 0.7 m;

(ii) a line of horizontal tanks of 4 m long, 1 m wide and 1.5 m deep which can handle more repetitive series of small- and medium-sized parts.

Each line consists of:

1 degreasing tank
1 rinsing tank (after degreasing)
1 etching tank
1 rinsing tank (after etching)
1 chromizing tank
2 rinsing tanks;

To the tanks are added:

6 current rectifiers corresponding to 20,000 installed Amps
Aspiration and Ventilation Equipment
Purification by mobile ion exchangers for the liquids (pollution control)
Purification by filters for the vapours (pollution control).

3. LEVEL OF OUTPUT

It is impossible to express the output in terms of a quantity of finished products since the process adds value to a wide range of parts. The value added depends on the nature of the work done (surface to be coated) and the deposit added (thickness of the coating). If the output is expressed in terms of amperes/hours, the installation is capable of 15,000 amps/hr, 15 hours per day (taking account of time spent filling and emptying the baths) and 20 days/month. The costing included in the economic evaluation is based on 8 working hours per day for 200 working days in the year.

According to the kind of part treated, the number of parts (single items, medium or long series), the thickness of the coating required etc. ... the work is done by one or two teams (for example, 1 x 8 or 2 x 8) or sometimes even three.

4. EMPLOYMENT AND EMPLOYMENT COSTS

A workshop of this type, working with 2 x 8 persons, i.e. two teams, needs the following personnel:

1	Workshop Manager	at $4,200 per annum
1	Equipment and Maintenance Manager	at $2,400 " "
2	Team Managers	at $1,920 " "
4	Bath Fillers	at $1,920 " "
4	Engineers and fitters	at $1,200 " "
2	Tool makers	at $1,920 " "
1	Controller	at $1,200 " "
2	General Labourers	at $ 720 " "
1	Clerk/Clerkess	at $1,200 " "

Total Annual Labour Costs (including overheads) $36,000/annum

5. DATA FOR ECONOMIC ANALYSIS

A. INVESTMENT COST

i) Fixed investment:

	$000
Construction Site and Buildings (1000-1200 m^2 covered area)	170
Civil Engineering (pits)	24
Electrolysis Tanks and Ventilation	61
Current Rectifiers	61
Electric Transformer Stations(350 KVA)	37
Electric Equipment	37
Pollution Control Equipment	48
Handling Equipment (cranes, pulleys, etc.)	48
Control and Regulation Equipment	12
Vehicles	12
Miscellaneous	24
Allowance for insurance, freight, etc. on imported equipment	72
	606

ii) Other initial costs:

	$
Engineering works with supply of a complete set of plans enabling assembly of the unit	61
Personnel Training	22
Technical assistance on site	15
Working capital	109
Total Investment Cost	813

Note: For these estimations it has been assumed that there is already a mechanical workshop (lathes, maintenance equipment...)

B. ANNUAL OPERATING COSTS

		$000
i)	Materials: (including 2 tonnes chromic acid; 2 tonnes sulphuric acid; and 1 tonne caustic soda per annum)	100
ii)	Wages and Salaries:	36
iii)	Water and Fuel: (including water at 25 m^3 per month; electricity at 50,000 kWh per month and fuel at 15,000 litres per annum)	70
iv)	Motor Transport	6
v)	Repairs and Maintenance	30
vi)	Overheads (including outside work, fees, rent, commercial costs)	140
	Total Annual Operating Costs:	382

C. EVALUATION (Values in US $)

This is based on a 10 year operating life, a 3 year build-up to full capacity production, and a residual value for buildings and equipment. Fixed investment is $689,000. Working capital is taken in 3 instalments : on year 1 : $37,000; on year 2 : $36,000; on year 3 : $36,000. The residual value of $61,000 and working capital of $109,000 are returned on the 10th year of operation.

Thus, production costs build up as follows :

	Year 1 (1/3)	Year 2 (2/3)	Year 3 (3/3)
Materials	33,000	67,000	100,000
Wages and Salaries	36,000	36,000	36,000
Transports	6,000	6,000	6,000
Water and Electricity	23,000	47,000	70,000
Repairs and Maintenance	10,000	20,000	20,000
Overheads	140,000	140,000	140,000
	$248,000	$316,000	$382,000

The following are the results of NPV analysis :

Discount Rate	Present Value of Total Costs	Annual Revenue Required for Given Discount Rate	Revenue Required per hour
10%	3,045,558	578,711	361.69
20%	2,256,406	662,805	414.25
30%	1,793,291	752,851	470.53

36. GENERAL PURPOSE WORKSHOP

(ISIC code 3822 - produced 1979)

This profile provides an inventory of equipment which would be required by a rurally based general engineering workshop serving around 2000 farm families. The principal types of equipment services by such a workshop would include various kinds of agricultural and transport equipment, but domestic equipment could also be repaired. The associated work force requirement would be 14 persons, including 6 skilled workers. The fixed investment of the workshop would be approximately $26.000.

1. INTRODUCTION

In many developing countries there is a need for good facilities to repair and maintain mechanical equipment not only in cities but also in market towns and among groups of villages occupied by farm families remote from urban areas.

The main types of equipment needing such services are as follows:

(i) Equipment used for cultivation, harvesting and preliminary processing of the main crops grown for subsistence or cash; whether man, animal or machine powered.

(ii) Transport equipment; again man, animal or machine powered with emphasis on bicycles and motor trucks.

(iii) Equipment for repairs to minor roads and tracks; picks, mattocks, shovels, wheel-barrows and mobile concrete-mixers.

(iv) Domestic equipment; cooking utensils, stoves and oil lamps.

(v) Water pumping equipment for domestic use and for small-scale irrigation.

(vi) Taps and fittings for domestic water supplies.

Ideally, the workshop should have 2,000 farm families, 12,000 to 18,000 persons, living and working within a 5 km range; the workshop would thus be within about a one hour walk. The area served would be about 80 square kilometres of farm-land.

2. WORKSHOP EQUIPMENT SPECIFICATION

(a)	Power driven tools: Drilling machine, floor standing, 25 mm Small lathe, screw cutting Bench grinder, double ended Hack saw, 150 mm. capacity Hand-held electric drill, 13 mm Hand-held grinder (angle) Each item complete with spares, auxiliary equipment and tools		
		f.o.b. price	$ 7,000
(b)	Hand powered tools and fitters' tools: Bench-type metal shearing machine Block and tackle, 6 tonnes Set of pipe-benders Fly-press		
		f.o.b. price	$ 2,200
	Fitters' tools; e.g. files, hammers, spanners, calipers, steel rules, etc.		$ 1,000
(c)	General engineering equipment		
	(i) Oxy-acetylene cutting and welding Equipment (excluding gas bottles, hired)		$ 1,000
	(ii) Blacksmiths' equipment		
	Anvil, hammers, tongs, etc.		$ 1,000
	Bench tools and equipment		$ 1,700
	(iii) Battery charger (transformer) up to 24 V. and jump-leads		$ 120
(d)	Power supply Electric power - 12 HP; either a diesel set or an electric motor for mains use, with switchgear and wiring		$ 2,500
(e)	Buildings		
	Building, on concrete plinth and open-sided; local construction 100 m^2		$ 5,000
	Concrete ramp, rising to 1.6 m., for under-body repairs to vehicles; local construction		$ 500
(f)	Work-benches, desk, stools, cupboards, fencing, etc; local construction		$ 1,000
			$23,020
(g)	Miscellaneous		2,980
	Total (1978 prices)		$26,000

3. EMPLOYMENT

It is envisaged that the workshop would employ 14 persons, including six skilled workers, one machinist, four fitters and one blacksmith, plus six semi-skilled helpers. In addition there would be one literate foreman and one clerk.

In the economic evaluation, average annual wages and benefits are taken as $1,000 per capital.

4. MATERIAL AND FUEL REQUIREMENTS

A. DIRECT MATERIALS

Steel bar, rod, angles and sheet		
Gasket and gland packing materials		
Oil seals and rubber O rings		
Electric wire and cables		
Fasteners (nuts, bolts, screws, rivets, pins, etc.)		
Steel, scrap, (free)	Total	$ 10,000

B. INDIRECT MATERIALS AND FUEL

Power (electricity or diesel oil), 3.7 kW for 2,000 hours/year, 7,400 kWh at $0.10 per kWh	$ 740
Lubricants, cutting oils, cleaning materials, paints	$ 100
Miscellaneous items	$ 160
Total indirect materials and fuel	$1,000

5. ECONOMIC ANALYSIS

A. ANNUAL OPERATING COSTS

Wages and salaries	14,000
Direct materials	10,000
Indirect materials and fuel	1,000
	$25,000

B. EVALUATION OF THE PROJECT

As the workshop is selling a service rather than a product, the economic evaluation is concerned with calculating the hourly charge for this service in order to earn a particular rate of return. It is assumed that the hourly rate is expressed per hour of skilled work. If the six skilled workers are each employed for 1500 hours per annum, this means that annual workshop revenue is based on 9,000 hours of chargeable work.

It is assumed that 3,000 man-hours of operation is feasible in the first year and 9,000 man-hours in the subsequent 14 years. Annual operating costs are assumed to be pro rata.

6. EVALUATION (Values in US $)

This is based on 15 year operating life, a 2 year build-up to full capacity production, and a residual value for land, building and equipment. Fixed investment is 26,000. Working capital, 6,000, is taken in 2 instalments. On year 1 : 3,000; on year 2 : 3,000. The residual value of $5,000 and working capital, 6,000, are returned in the 15th year of operation.

Thus, production costs build up as follows :

	Year 1 capacity (1/3)	Year 2 capacity (full)
Materials	3,333	10,000
Wages and salaries	14,000	14,000
Indirect materials and fuel	470	1,000
	17,803	25,000

The following are the results of NPV analysis :

Discount Rate	Present value of total costs	Annual revenue required	Revenue required per hour *
10%	218,522	32,630	3.62
20%	146,577	38,151	4.23
30%	122,812	44,578	4.95

* It is considered only 9,000 hours are paid, at full capacity, per year.

37. GRINDING DISC AND CUTTING WHEEL PRODUCTION

(ISIC Code 3823 - produced 1981)

This profile describes the production of grinding discs which are used to grind wwelding seams and polish metal or stone; and cutting wheels which can cut for example, iron, steel, marble, glass, stone and plastics. Fixed investment amounts to $502,570 and 12 people are employed.

1. PRODUCT DESCRIPTION

The plant considered in this profile would manufacture grinding discs and cutting wheels. Grinding discs are used to grind welding seams and polish metal and stone. Cutting wheels are used to cut iron, steel, plastic, marble, stone, glass, etc. Only a few standard sizes would be manufactured at first, with diversification possible in the later stages.

The main raw materials are mineral abrasive products, resins, filling and stabilizing agents.

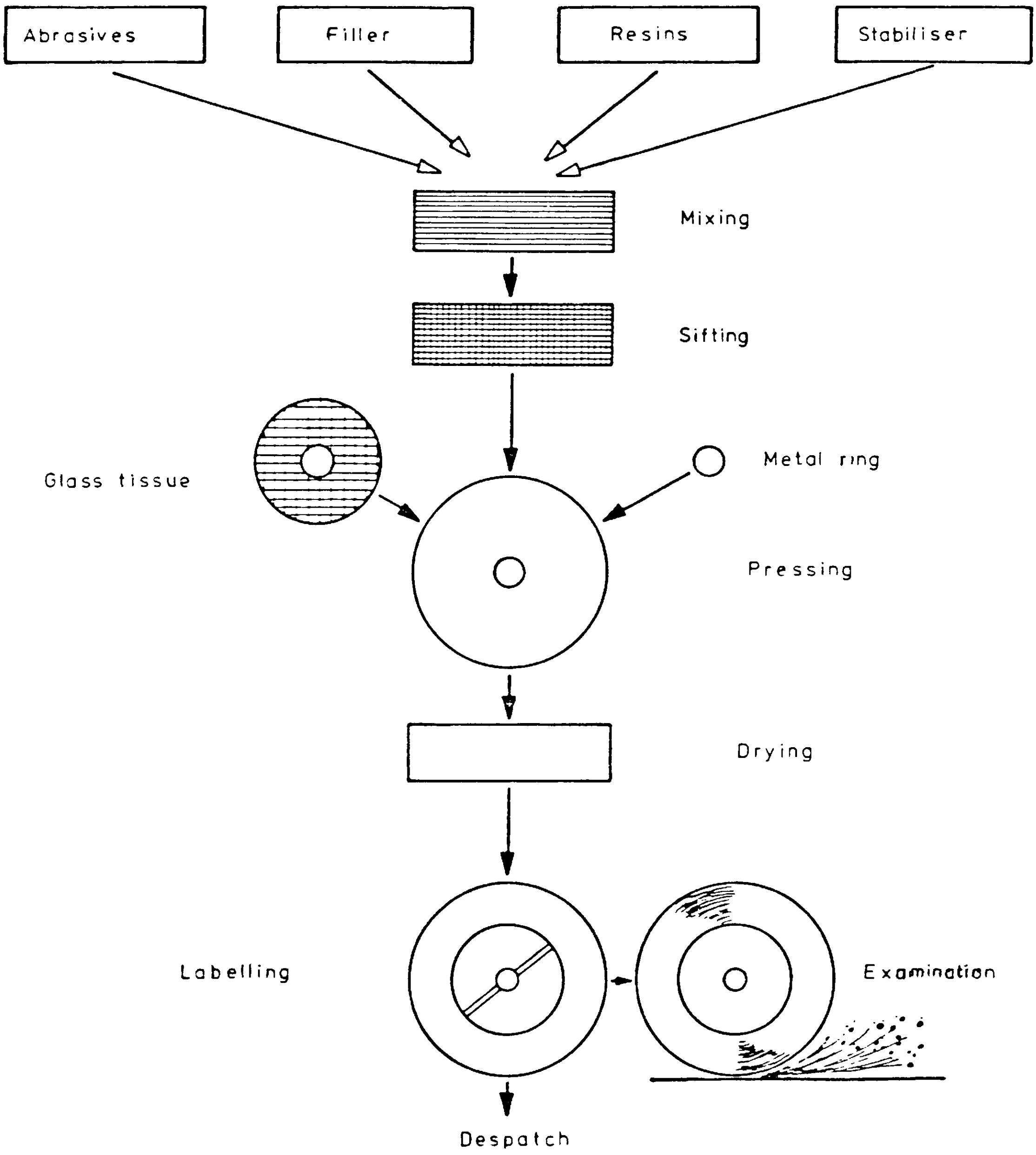
2. DESCRIPTION OF TECHNOLOGY

There are six stages in the process:

a) The raw materials are weighed and mixed to precise formula;
b) The mixture is sifted several times to separate coarse grains and dried;
c) The mixture together with 2 glass tissues and one metal ring is put in a special mould of hardened steel and formed under high pressure to "green wheels";
d) The wheels are dried in electrically heated curing ovens with electronic temperature controls;
e) The discs and wheels undergo quality tests; and
f) The discs and wheels are labelled and packed.

3. LEVEL OF OUTPUT

The plant considered here would have an annual capacity of 87,500 grinding discs and 315,000 cutting wheels.



MANUFACTURING PROCESS

4. EMPLOYMENT AND EMPLOYMENT COSTS

			$
1	Manager	at $4,000 per annum	4,000
1	Foreman	at $2,400 " "	2,400
10	Unskilled workers	at $ 720 " "	7,200
12			$13,600
		Other Annual Labour Costs:	1,360
		Total Annual Labour Costs:	$14,960

5. DATA FOR ECONOMIC ANALYSIS

A. INVESTMENT COST

i) Fixed investment :

	$
Machinery and Equipment	392,570
Pre-operating expenses	80,000
Buildings (250m^2 at $120)	30,000
	$502,570

ii) Working Capital :

	$
Stock of materials(3 months)	73,100
Wages and Salaries(2 months)	2,493
	$75,593

iii) Residual Value :

	$
10% of Equipment Costs(cif)	39,257
50% of Building Costs	15,000
	$54,257

B. ANNUAL OPERATING COSTS

			$
i)	Materials :		292,400
	Grinding materials	80,000	
	Resin	44,800	
	Filler	12,400	
	Stabiliser	1,600	
	Glass tissues	96,000	
	Central metal rings	6,400	
	Black cover paper	35,200	
	Labels, cardboard tape	16,000	
ii)	Wages and Salaries		14,960
iii)	Water and fuel		
	Electricity(20,000 kWh p.a.)		1,440
	Water (not required for manufacturing)		400
iv)	Servicing and Maintenance (3% of machine value)		10,000
vi)	Overheads		5,000
	Total annual operating costs		$325,640

C. EVALUATION (Values in US $)

This is based on a 10 year operating life, a 3 year build up to full capacity production and a residual value for buildings and equipment. The fixed investment amounts to $502,570. Working capital is taken in each of the first three years of operation; and the residual value of ($54,257) and the working capital ($75,593) are returned in the 10th year of operation.

Production costs build up as follows over 3 years.

	Year 1 (65%)	Year 2 (75%)	Year 3 (100%)
Materials	190,060	219,300	292,400
Wages and Salaries	9,724	11,220	14,960
Water and Fuel	1,196	1,380	1,840
Maintenance	6,500	7,500	10,000
Overheads	3,250	3,750	5,000
	$211,666	$244,230	$325,640

The following are the results of NPV analysis :

Discount Rate	Present Value of Total Costs	Annual Revenue Required for Given Discount Rate	Revenue Required per item
10%	2,344,975	417,304	1.03
20%	1,748,571	469,295	1.16
30%	1,409,562	527,166	1.31

38. AUTOMOBILE SILENCER PRODUCTION

(ISIC code 3843 - produced 1980)

This profile outlines a method of producing automobile silencers using a simple technology. An initial fixed investment of $11,025 is required for an annual output of 1,650 silencers. The project employs 5 people.

1. PRODUCT DESCRIPTION

Automobile silencers have to be replaced fairly frequently due to wear and tear, and, of course, different models of cars have different shapes and designs of silencers. Many developing countries import silencers for replacement from the same source as the original automobiles. This profile is designed to meet the replacement requirements using a technology for moulding the silencers which does not involve costly dies and a power press.

2. DESCRIPTION OF TECHNOLOGY

In the initial stages of such an investment project certain work may be done outside for payment, so that all the equipment need not be purchased at the outset. However for the purposes of this profile a complete technology has been described and evaluated.

To some extent the creasing and bending of mild steel sheets can be managed on the guillotine shearing machine itself, in which case the purchase of an edge folding machine may be delayed.

The equipment for bending pipes may be locally devised. Two 150 mm bolts may be fixed at the required spacing on a strong old table. A small pulley wheel (commonly used to draw water from wells in developing countries) may be fixed to form the third corner of the triangle. The actual bending of the pipe will take place around the wheel, and the bolts and the wheel should be positioned to meet requirements.

If gas cylinders are not easily available electric welding may be used, although in time both gas and electric welding techniques should be installed.

After cutting and bending the sheets to approximate size it is to be shaped in the form of a silencer. To do this an old silencer of the required design may be taken to a local foundry and filled with molten scraps, which when cool will make the old silencer a hard and heavy block. This block may then be used as a prototype for shaping the sheets.

(a) **Machinery and Equipment**

	$
Guillotine shearing machine with capacity to cut mild steel sheets 1200 mm x 16 SWG	1,500
Bending machine with rollers (hand operated)	375
Edge fold machine (1200 mm) (hand operated)	375
Pipe bending machine (hand operated)	250
Fly press (n° 12)	750
Gas welding set	250
Electric arc welding set (250 Amps)	500
Flexible shaft grinder (1 HP)	250
Dies, punches, press tools, hand tools	375
Transportation and installation of equipment	1,400
Total equipment cost (installed)	6,025

(b) **Materials**

On average 3 kg. of mild steel sheets of 16 SWG and 3 m of mild steel tube to make one silencer. For 150 silencers the following materials are needed:

Mild steel sheet 16 SWG - 450 kg. at $750 per tonne	340
Mild steel tubes of various sizes - 450 m at average of $1.50 per metre	675
Miscellaneous items such as sandpaper, red oxide, etc.	100
	1,115

3. LEVEL OF OUTPUT

The technology has been designed to produce 150 silencers per month of 25 working days. For single shift working, with an 8-hour day over 48 weeks of the year this would give total production of approximately 1,650 silencers of various dimensions per year.

4. EMPLOYMENT

The technology is a fairly simple one, and the number of operatives required to maintain operations steadily over the entire year consists of two skilled and one unskilled workers.

			$
1	Manager	at $4,000 per annum	4,000
2	Skilled Workers	at $1,920 " "	3,840
1	Unskilled Worker	at $ 720 " "	720
1	Part-time clerical assistant	at $ 500 " "	500
			9,060
		Supplementary labour costs	906
		Total Annual Labour Costs:	$9,966

5. DATA FOR ECONOMIC ANALYSIS

A. INVESTMENT COST

i) Fixed Investment:

	$
Machinery and Equipment (installed)	6,025
Building costs (i.e.covered space)	5,000
	11,025
Residual Value	1,103

ii) Working Capital:

	$
Spare parts etc.	300
Equivalent of 3 months' materials	3,000
	3,300

B. ANNUAL OPERATING COSTS

		$
i)	Materials	12,265
ii)	Wages and Salaries	9,966
iii)	Water and Fuel	500
iv)	Motor Transport	350
v)	Repairs and Maintenance	340
v)	Overheads:	1,200
		24,621

C. EVALUATION (Values in US $)

This is based on a 10 year operating life, a 3 year build-up to full capacity production, and a 10 per cent residual value for buildings and equipment. Fixed investment is $11,025. Working capital is taken in 3 instalments : on year 1 : $1,100; on year 2 : $1,100; on year 3 : $1,100. The residual value of $ 1,103 and working capital of $ 3,300 are returned on the 10th year of operation.

The production costs build up as follows:

	Year 1 (1/3)	Year 2 (2/3)	Year 3 (3/3)
Materials	4,088	8,177	12,265
Wages and Salaries	9,966	9,966	9,966
Water and Fuel	167	333	500
Motor Transport	117	235	350
Repairs and Maintenance	113	227	340
Overheads	1,200	1,200	1,200
	15,651	20,138	24,621

The following are the results of the NPV analysis:

Discount Rate	Present Value of Total Costs	Annual Revenue Required for Given Discount Rate	Selling price required per silencer
10%	146,270	27,604	16.73
20%	100,510	29,524	17.89
30%	79,278	33,282	20.17

39. SMALL-SCALE WHEELCHAIR PRODUCTION

(ISIC code 3844 - produced 1979)

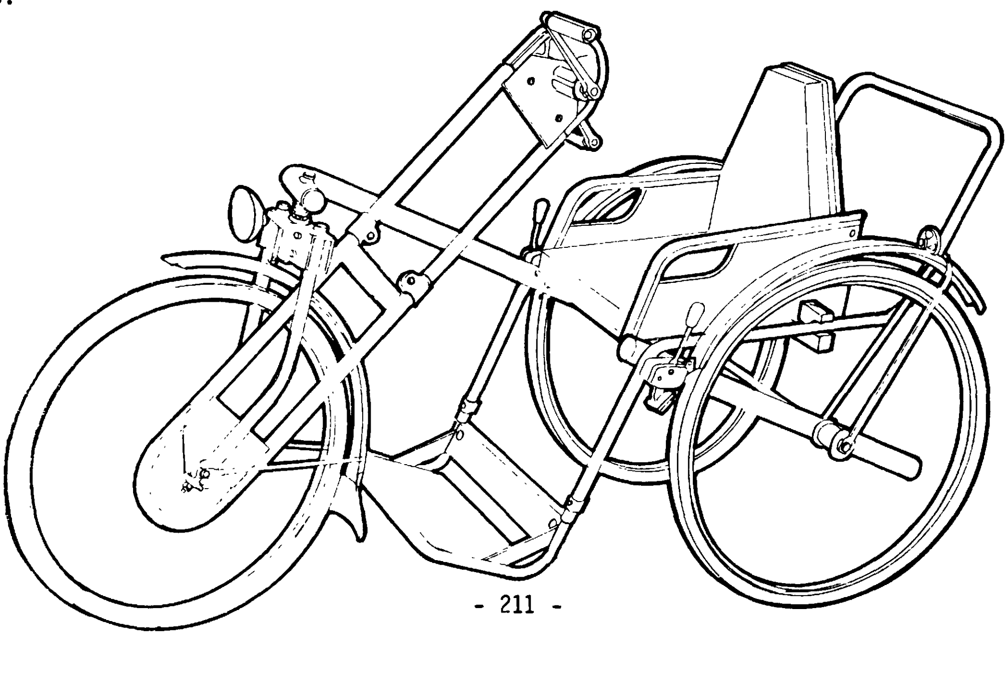
This profile describes the design of a hand-driven wheelchair based on bicycle technology. A production level of 2000 wheelchairs per annum is considered. Total investment is $284,566 and the employment level is 60 people.

The project began in 1977 with a request from an Asian government for help with the resettlement of handicapped people. It was decided that an appropriate wheelchair was needed for handicapped persons to travel up to 10 km from their homes to the workshops.

Since a suitable wheelchair was not available, one had to be designed before a produc-production system could be developed.The design started from basic principles and some interesting innovations have been introduced. They open prospects for other applications such as bicycle trailers and carrier-tricycles.

1. DESIGN

A prototype wheelchair was designed that conformed to the medical and rehabilitation requirements, and to the facilities available for manufacturing it. Also, the needs for a low capital investment and manual labour were taken into account. The wheelchair design is based upon bicycle technology and assembly in local workshops and is appropriate to most developing countries.



The basic design comprises an asymmetrical tubular frame that incorporates a new method for joining the tubes. Complicated techniques are avoided. The components that are subject to wear are standard bicycle parts and can be easily replaced.

The shape and construction of the wooden chair can be adapted locally to individual requirements.

The wheelchair weighs approximately 35 kg, it can be fitted with a luggage carrier and it is hand-driven. Three methods of drive are possible:

- front-wheel-drive model with hand-driven cranks and chain.
- single rear-wheel-drive model with lever-operated crank of the "flying dutchman" type.
- double rear-wheel-drive model through hand-operated levers.

2. BASIC SUB-PROCESSES

The most important sub-processes are:

for the frame (steel):	sawing, shearing
	tube bending
	drilling
	tube shoulder pulling
	brazing (hard soldering)
	welding
	cold riveting
	galvanizing
	varnishing
for the chair (wood):	sawing
	drilling
	sanding
	varnishing
for the cushions (cotton, etc.)	cutting
	sewing
for the wheelchair:	packing
	transporting
	assembling

3. SCALE OF PRODUCTION

A production level of 2000 wheelchairs a year has been considered, based upon a central manufacturing unit and five workshops near local rehabilitation centres.

The frame components are manufactured in the central workshop, but standard bicycle parts and other accessories are purchased.

The wheelchairs are assembled in local workshops in close co-operation with the medical staff of the rehabilitation centres.

4. MATERIAL REQUIREMENTS

The main material requirements are (per wheelchair):

		$
steel tube	15.0 kg	32.60
steel strip and plate	2.2 kg	
accessories	2.3 kg	30.40
standard bicycle parts	6.7 kg	108.70
plywood (1 m^2)	7.5 kg	11.70
canvas and foam rubber	1.3 kg	12.70
varnish	0.5 kg	4.40
	35.5 kg	200.00

5. ENERGY REQUIREMENTS

The main energy requirements are for :

lathes and other machine tools	16 kW
galvano	12 kW

which means about 20 kWh per wheelchair	$ 1.30
brazing gas 0.6 kg per wheelchair	$ 3.57
oxygen 0.8 kg per wheelchair	$ 0.78

6. LABOUR REQUIREMENTS

The manufacture of components for 2000 wheelchairs a year in a well-equipped central workshop will require the following skilled workers:

		$/year
turning	5 lathe operators	7,826
fitting	12 mechanics	18,348
joining	3 welders (brazing)	4,696
painting	2 painters	3,130
To be assisted by	6 labourers	3,913
	28	$37,913

Additionally, it will be necessary to employ other staff to supervise the work and keep records:

		$/year
supervision	1 manager	2,348
	4 foremen	6,261
records	1 toolroom clerk	1,826
	1 warehouse clerk	1,826
	5 bookkeepers	913
	12	$21,391

The central workshop requirement is 40 men. If in the central workshop machine tools are scarce, a work on the shift system may be considered.

The assembling, chairmaking and adaptation of wheelchairs in each of the five local workshops will require 4 mechanics/fitters.

At least one of them has to be trained to co-operate with the medical staff.
Cost for the mechanics/fitters : $6,261 X 4 = $31,305

Total personnel cost for the five workshop :
$37,913 + 21,391 + 31,305 = $90,609/year.

7. INFRASTRUCTURAL REQUIREMENTS

The basic materials and accessories can be imported from the manufacturers. The choice will determine the location for the central workshop which needs to be well-equipped.

From the central workshop, the components have to be sent to the local workshops; transportation is an important aspect of manufacturing wheelchairs.

In the local workshops, they will be assembled and adapted to the requirements of local handicapped people and this will need close co-operation with the medical staff of the rehabilitation centre concerned.

Maintenance and repairs will have to be done locally, but they will be similar to those for ordinary bicycles.

8. FIXED INVESTMENT REQUIREMENTS

The central workshop equipment contains among others:

hand tools, fitter tools, jigs,
sawing machine, bench drill, vertical spindle driller,
bench grinder,
bending machine,
lathes, tool grinder,
brazing and welding equipment,
galvanising equipment.

The local workshops are equipped with carpentry and assembly tools.

		$
Total investment of the central workshop:		
	building	43,478
	electrification	21,738
	tools and machines	34,784
		100,000
Total investment of one local workshop:		
	building	variable
	electrification	variable
	tools	1,304
	motor-lorry	30,435
For the 5 workshops :		158,695

9. ECONOMIC EVALUATION

A. INVESTMENT COSTS

Central workshop	100,000		
Five local workshops	158,695		
		Sub-total	258,695
For land and other assets (10% of sub-total)			25,870
		Total	$284,565

B. OPERATING COSTS

	Year 1 capacity (1/3)	Year 2 capacity (2/3)	Year 3 capacity (full)
Raw materials (at $200 per chair)	133,000	267,000	400,000
Energy (at $5.652 per chair)	3,768	7,536	11,304
Wages and salaries	90,609	90,609	90,609
Maintenance	4,710	9,420	14,130
Overheads	13,716	13,716	13,716
Packaging, desp. sales and Commission (5% of sales)	11,667	23,333	35,000
	257,470	411,614	564,759

C. EVALUATION (values in US $)

This is based on 10 year operating life, a 3 year build-up to full capacity production, and a residual value for land, building and equipment. Fixed investment is 284,565. Working capital, 217,391, is taken in 3 instalments. On year 1 : 72,464; on year 2 : 72,464; on year 3 : 72,463. The residual value, 56,913, and working capital 217,391, are returned in the 10th year of operation.

The following are the results of NPV analysis :

Discount Rate	Present value of total costs	Annual revenue required	Revenue required per wheelchair
10%	3,380,185	642,296	321.15
20%	2,398,515	704,548	352.27
30%	1,815,401	762,133	381.07

40. SOLAR ENERGY DRYING UNIT

(ISIC code 4101 - produced 1979)

The term solar drying is used here to describe a process where solar heated air is is passed over or through the material to be dried, as distinct from "sun drying" in which the material is simply exposed to the sun. Two important products which may be obtained by solar drying are magnesium carbonate (used by the cosmetic and pharmaceutical industries) and aluminium hydroxide (a pharmaceutical chemical). The dryer described in this profile can be operated by a single labourer whose jobs include filling and emptying the trays on which the material is laid, controlling moisture content and doing repairs such as replacing broken glass frames. The capital investment is only $3000, and in the climate conditions outlined in the profile the dryer can produce 30 tonnes of magnesium carbonate or 10 tonnes of aluminium hydroxide.

1. INTRODUCTION

The use of solar energy for drying is one of the most ancient and widespread applications of solar energy, although the customary techniques have a lot of disadvantages. These techniques are commonly known under the name of "sun drying".

The necessity for the installation of a dryer may arise from different reasons:

- Drying is necessary in the production of high quality marketable raw materials, e.g. sisal, silk, leather, wood.
- Drying improves the storage of materials, etending the storage life and diminishing losses during storage (e.g. grains).
- Air drying is a very slow process in cold and humid climates and a drying device accelerates this process.
- Drying facilitates storage of agricultural products which cannot be stored as fresh material (e.g. fruit and vegetables).
- Drying with special devices prevents deterioration of the product by insects, rodents, bacteria, etc. (e.g. all harvested goods).
- Drying devices shorten drying time and thus increase cash-flow (e.g.wood).

- Drying is necessary to eliminate excessive shipping costs, because it is cheaper to remove water by thermal means than to ship it when distribution is charged by weight.

The term solar is used the process where the material is not simply exposed to the sun, but where solar heated air is passed over or through the wet material.

There is no significant commercial manufacture of solar dryers in any country, but experiments have led to a number of dryer designs. Because of the wide variety of circumstances encountered, the potential economic advantages of solar drying must be assessed on an individual basis. The choice of solar dryer design depends on:

- type of material to be dried (size, initial and final moisture content, etc.)
- rated capacity (ton/day of material or kg/h of water to be evaporated)
- local climate.

Special designs are available for a wide variety of materials predominantly for crops or other agricultural products but also for chemicals. Batch capacity of single units range from 20 kg to 3 tonnes and drying rate from 1 kg/h to 30 kg/h of water to be evaporated. Temperatures of up to 95°C can be achieved.

Two main types of solar dryers are to be distinguished:

(a) With direct coversion: solar radiation is absorbed by the material to be dried, and the energy gained evaporates the moisture. This method is highly effective, but temperature control is difficult to establish. Evaporation rate is in the range of 0.4-0.7 kg/h per m^2 dryer area.

(b) Ambient air is heated in a specially designed solar air collector and then passed through the drying bin by means of a ventilator. High drying rates can be achieved since the collector area and thus the heat input can be chosen independently from the bin volume.

Installation costs of solar dryers are very low and vary between $20 and $700, when constructed with local materials.

It must be stressed that running costs of solar dryers are very low, since no fuel costs arise. Thñqe are designs where the ventilation is maintained by natural convection; to achieve high drying rates a fan-forced ventilation is necessary but electrical energy consumption is below 1 kW in most cases. So the operation cost of a solar dryer comprises mainly maintenance cost and labour cost of loading and unloading. A more detailed commercial analysis of one specific dryer is given below.

2. SOLAR DRYING OF CHEMICALS

A. MATERIALS TO BE DRIED

The salt industry in India is a major user of solar energy. In the process of winning salt bittern is left as a by-product which is usually taken as raw material for the production of magnesium carbonate. This is used as filler in rubber, cosmetic and pharmaceutical industries.

The ordinary filler has a selling price of about $375 per tonne and is dried in the open using bright sunshine during the summer months when the bittern is also available. The cost of sun drying is about $25 per tonne. The sun dried product is rejected for cosmetic and pharmaceutical use due to impurities caused by open drying.

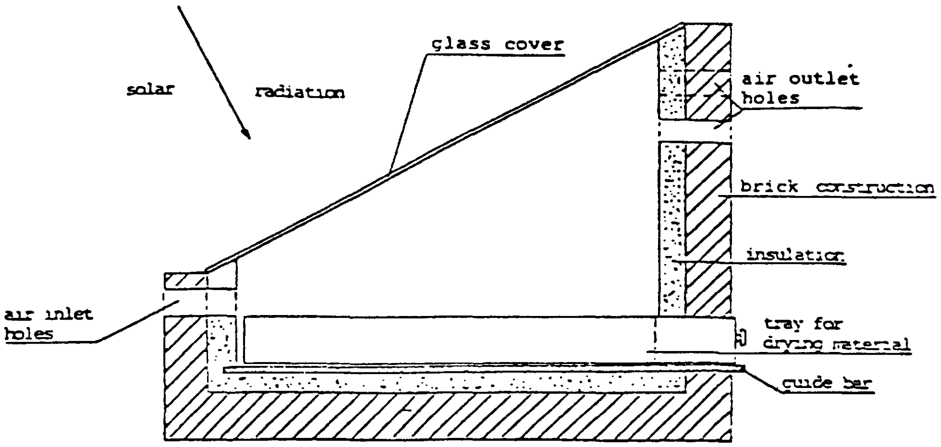
Magnesium carbonate which is used in the cosmetic and pharmaceutical industries is normally dried in electrically or steam heated tray dryers. Here the drying cost is in the range of \$90-\$100 per tonne. Selling prices are about \$525 and \$750 respectively. With the use of a closed solar dryer drying cost can be reduced and thus the profit margin improved.

Aluminium hydroxide, a pharmaceutical chemical, is another case of interest for solar drying. In the normal process a slurry containing about 8% Al_2O_3 (700% moisture content on dry base) is dried to 60% Al_2O_3 (10% moisture) in electrically heated tray dryers. The reported cost of drying is about \$190-\$250 per tonne.

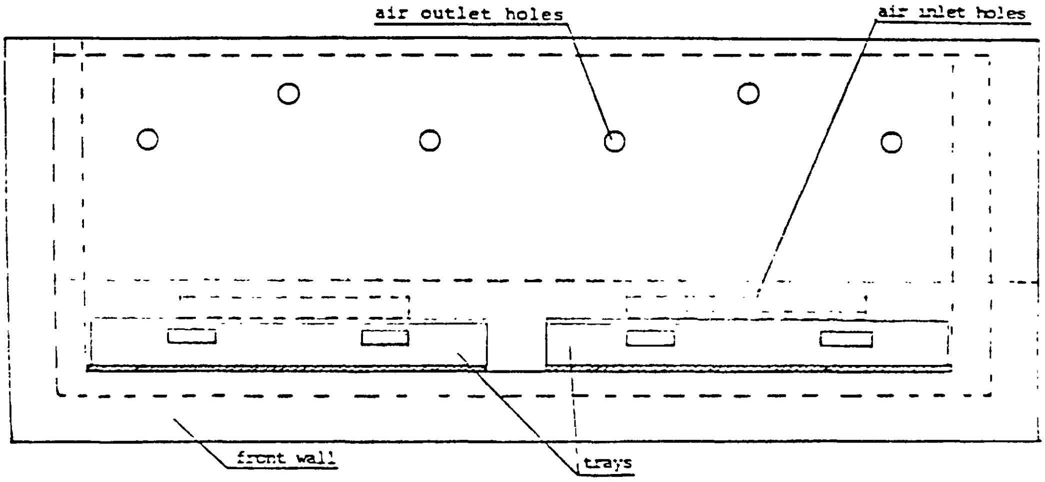
Gujarat is the region of India which is most favoured by the sun, with an average daily solar radiation of 6 W/m^2 day and with 3,000 sunshine hours per year. A solar dryer is operated on 200 days per year.

B. DESCRIPTION OF DRYER

The figure below shows the basic design of the dryer; the one actually used in Gujarat has a length extension of 7.5m and 8 trays with about 8 m^2.



cross section



front view

Masonry walls provide the internal structures. An insulation of magnesia-asbestos powder is applied to reduce conduction loss from the wall and bottom of the dryer. The inside wall is painted with dull black paint to facilitate good absorption.

For circulation of air by natural convection eight windows are provided with wire mesh strainer as air inlet in the front wall of the dryer and for escape of humid air 45 holes of 5 cm diameter are placed in the upper part of the rear wall. Air inlet and outlet areas at 2.5% and 1.4%. Eight units are placed parallel providing 66 m^2 of drying area. The overall batch capacity is 200-300 kg of dried product.

3. ENERGY GAIN BY THE DRYER

Within 4 days aluminium hydroxide is dried from 700% moisture content to 10% (dry base) and 200 kg of dry material is produced, that is 50 kg per day. 310 kg/d of water are evaporated requiring 207 kWh/d or about 4 kWh to get 1 kg of dry material. If the material were dried by means of electrical energy at 80% efficiency, the consumption would be 5,000 kWh/tonne or at energy cost of $200/tonne.

The daily energy input from solar radiation on the whole dryer area is about 400 kWh/day of which about 50% are converted in the dryer to evaporate the water, this is a rather high efficiency.

As regards the drying of magnesium carbonate the efficiency is lower, since the initial moisture content and the final moisture content are lower, 70% and 3% respectively. As much less water has to be evaporated drying is achieved faster and 150 kg/day of dry material are produced. The evaporation rate is 97 kg of water per day for which 65 kWh/day are required. So the efficiency in this case if 16%.

4. WORK FORCE REQUIREMENTS

The dryer can be operated by a single labourer. Tasks to be carried out are charging the trays and unloading the dry material, controlling moisture content, doing repairs including replacement of broken glass panes. A skilful and very reliable person has to be put in charge of the drying unit.

5. COST OF DRYING

Capital investment :	$
land 100 m^2 at $2.50	250
masonry drying unit 65 m^2 at $40	2,600
moisture meter, tools	100
	$2,950
Annual operating cost:	
labour	1,200
replacement of glass	100
other repairs and maintenance	295
	$1,595

The annual output is 30 tonnes of magnesium carbonate or 10 tonnes aluminium hydroxide. The dryer is expected to last ten years.

6. EVALUATION (values in US $)

This is based on 10 year operating life, a one year build up to full capacity production, and there is no residual value. Fixed investment is 2,950. Working capital is not necessary.

Thus, production costs build up as follows :

	Year 1 capacity (100%)
Salaries	1,200
Replacement of glass	100
Other repairs and maintenance	295
	1,595

The following are the results of NPV analysis :

Discount Rate	Present value of total costs	Annual revenue required	Revenue required per tonne	
			A	B
10%	12,751	2,075	69.16	207.5
20%	9,636	2,299	76.63	229.9
30%	7,882	2,549	84.97	254.9

A : 30 tonnes of Magnesium carbonate per year.
or
B : 10 tonnes of Aluminium hydroxide per year.

41. SOLAR RICE DRYER

(ISIC code 4101 - produced 1980)

This profile describes a 1 tonne solar dryer which has the capacity to dry approximately 20 tonnes of rice per harvest. The initial cost is $300 and one man is required to operate the dryer.

1. PRODUCT DESCRIPTION

The introduction of new high-yield varieties of rice has made increased outputs possible by multiple cropping. The second crop sometimes has to be harvested during the wet season when the grain has a high moisture content. Drying is necessary because, while a high moisture content in the grain is desirable during harvesting to minimize losses, the moisture content must be low during storage to prevent the grain from being spoiled by fungi and insects, which thrive in warm moist conditions. Sun drying in the open air is the traditional method, and can be done before or after threshing. Untreated paddy is sun dried by spreading it out on mats or on a concrete floor in a layer 1-2 cm thick. Periodic stirring is necessary to obtain uniform drying. Considerable losses, ranging from 10-25 per cent, can occur during natural sun drying due to various causes, such as rodents, birds, spillage, and contamination. Moreover, rewetting and overdrying in variable weather can producer cracking of the rice grains and a poor yield of full sized kernels after the milling process. The alternatives to natural sun-drying are mechanical drying or the use of a solar dryer. Mechanical drying is subject to breakdown and possible irregularity of energy supply at the crucial times of the year.

The benefits from solar drying of rice include a higher market price (or longer storage period for own-consumption by farmers) and lower wastage due to breaking or other causes experienced with natural drying. In tests the head yield, namely the weight of unbroken kernels obtained per unit weight of paddy, was 58 per cent. This is equal to the head yield from mechanically dried paddy, and is superior to the maximum head yield of 46 per cent obtainable from paddy sun dried in the open air.

The dryer could be used for other crops besides rice, such as peppercorns, shrimps, chillies, coffee beans, etc., and it is likely to find many applications in ACP countries.

2. DESCRIPTION OF TECHNOLOGY

Figure 1 shows how the dryer works. Sunlight passes through the clear plastic sheet and warms the air inside with the help of a layer of burnt rice husks covering the ground below to absorb the radiation. The warm air passes up through the bed of paddy and dries it. The chimney provides a tall column of warm air to increase the air flow through the bed by natural convection. If possible the air inlet at the bottom of the dryer should face the direction of the prevailing wind so as to further increase the air flow.

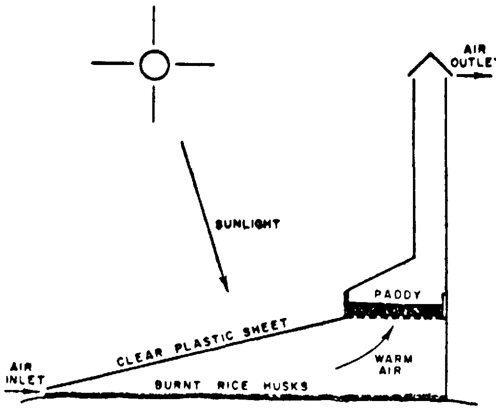


Fig. 1 - Cross-section of dryer

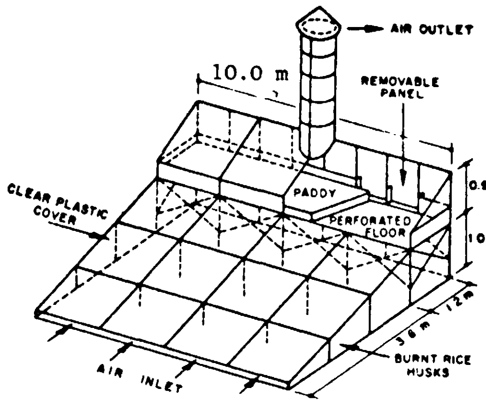


Fig.2 - Design of dryer

To dry paddy by the slow method one requires an air flow in the range of 1 to 5 m^3 per minute per m^3 of grain. The temperature of the air should not exceed 45°C otherwise cracking of the kernels will lower the head rice yield. If the ambient air temperature is 30°C and the temperature of the air inside the dryer is 40°C then a simple calculation shows that for a total height of the column of warm air inside the dryer of 4 metres, the pressure difference across the bed of paddy is 1.46 pascal. The air flow through paddy is known to be 3 m^3 per minute for a pressure drop of 100 pascal per metre depth of grain at low air flows. One finds that grain depths of 209 mm to 94 mm are feasible for air flows in the range 1 to 5 m^3 per minute per m^3 of grain. Tests show that a bed of depth 150 mm can be dried satisfactorily.

The amount of energy required to dry the paddy, and the intensity of the solar radiation determine how big the solar air heater must be. On a poor day in the wet season the insulation is typically 15 megajoules per m^2. To dry 1 tonne of paddy from an initial moisture content of 22 per cent wet basis to a final moisture content of 14 per cent wet basis for safe storage requires about 240 megajoules of energy to evaporate the water.

For batches of 1 tonne of paddy rice the area of the rice bed should be in the order of 12 m^2 and the area of the solar air heater (collector area) should be in the order of 36 m^2.

The bed of paddy is contained in a shallow box (dimensions 1.2 m x 0.3 m x 10.0 m). The bottom of the box is made of sheet steel 0.8 mm thick perforated with holes 1.5 mm diameter, the holes occupying 30 per cent of the floor area. The sides of the box are made of plywood. Removable panels at the back of the box allow the farmer to load and unload the paddy. The box is supported 1.0 m above the ground on a strong wooden frame with secure foundations in the earth.

The area of ground covered with burnt rice husks in front of the rice bed is 3.6 m x 10.0 m. This area should be made convex so that pools of water do not collect there during rain. A drain cut around the dryer helps rainwater to escape.

The air spaces above and below the rice bed, and over the area of ground in front, are enclosed by clear plastic sheet 0.15 mm thick. The plastic sheet is supported by a framework of bamboo poles and wire. There should be no air leaks in the plastic cover; leaks will reduce the air flow through the rice bed.

The chimney consists of a bamboo frame covered with plastic sheet, which should be dark in colour to absorb heat from the sun. A cover over the chimney keeps out rain.

The newly threshed paddy is first cleaned to remove straw and chaff. It is then loaded into the box to make a layer 150 mm deep. The rice bed should not be deeper than 150 mm otherwise insufficient air will flow through it for satisfactory drying. The paddy will dry better if it is stirred several times during the day. If the paddy has already become partly dried during threshing and the weather is fine, drying will take one day. If the initial moisture content of the paddy is high and the weather is cloudy, drying may take several days. Even in dull weather the air inside the dryer will be warmer than the outside air, and slow drying will take place. During periods of rain the paddy in the dryer is safe and will not be spoiled.

If the total amount of paddy to be dried is several tonnes and only a single dryer of 1 tonne capacity is available, the paddy should be harvested and dried in batches every few days. If all the paddy is harvested at the same time it cannot all be dried at once, and wet paddy waiting to be dried may be spoiled.

The cost of constructing the solar dryer is as follows :

		$
(a)	Perforated steel sheet	90
(b)	Wooden posts, plywood and bamboo poles	90
(c)	Plastic sheet	40
(d)	Wire nails, paint etc.	20
(e)	One skilled, one unskilled worker for one week	50
		290

The plastic sheet has to be replaced each year, and general maintenance of the framework of the dryer will be needed in each year. The annual maintenance cost may be assumed to be $70 inclusive of labour.

3. LEVEL OF OUTPUT

It may be assumed that the rice harvesting season extends for a period of 10 weeks, or 70 days. If each batch of 1 tonne of rice takes an average of 3 days to dry to the required extent then the capacity of the dryer is in the order of 20 tonnes per harvest (which we take as one year).

It should be noted that the dryer may be used at other times of the year for other crops. Increasing the throughput will, of course, to some extent reduce the unit cost of drying.

4. EMPLOYMENT

Apart from construction and annual maintenance, labour is required to load and unload the rice, and to oversee the dryer (for example, if the inside of the dryer becomes too hot on a bright day the cover can be shaded). It may be assumed that this requires one semi-skilled man half-time for about 10 weeks, which may be taken as costing approximately $230.

5. DATA FOR ECONOMIC ANALYSIS

A. INVESTMENT COST

		$
i)	<u>Fixed Investment:</u>	
	Solar dryer	290
	Land area (say 50 m^2)	10
		300
ii)	<u>Working capital:</u>	Nil
iii)	<u>Residual Value:</u> Land and perforated steel sheet	100

B. ANNUAL OPERATING COSTS

i)	<u>Materials</u>	Nil
ii)	<u>Wages and Salaries</u>	230
iii)	<u>Water and Fuel</u>	Nil
iv)	<u>Motor Transport</u>	Nil
iv)	<u>Repairs and Maintenance</u>	70
v)	<u>Overheads</u>	Nil
		300

C. EVALUATION (Values in US $)

It has been assumed that the basic framework has a 10-year life, and that the full capacity can be used throughout this period. The final column of the following table indicates the cost of drying each quintal of rice.

The following are the results of NPV analysis:

Discount Rate	Present Value of Total Costs	Annual Cost for for Given Discount Rate	Cost per Quintal of dried paddy
10%	2,105	342	1.71
20%	1,542	368	1.84
30%	1,221	395	1.97

D. ALTERNATIVE EVALUATION

An alternative evaluation of the solar dryer could assume that there is sufficient drying of crops other than rice (together with the other rice harvest) to maintain operations for the equivalent of 6 months of the year (say 180 days). The labour cost may be increased to $600 per annum and repair and maintenance costs doubled for comparison.

The following are the results of NPV analysis:

Discount Rate	Present Value of Total Costs	Annual Cost for for Given Discount Rate	Cost per operating day	Cost per Quintal of dried paddy
30%	2,549	824	4.58	1.60
10%	4,639	755	4.19	1.47
20%	3,315	791	4.39	1.54

On this basis it may be estimated that the cost of drying paddy rice under the conditions set out in this profile may be taken as lying between $1.47 and $1.60 per quintal.

This profile is based extensively on a published paper: R.H.B. Exell; Sommai Komaskoo and Sombat Thiratrakoolchai; "A Low Cost Solar Rice Dryer for Farmers in South East Asia", in **Agricultural Mechanization in Asia,** Autumn 1979. A more technical paper was also referred to : R.H.B. Exell : "Basic Design Theory for a Simple Solar Rice Dryer", **Renewable Energy Review Journal,** Vol. 1, N° 2, January 1980.

42. SOLAR COOKER PRODUCTION

(ISIC code 4101 - produced 1980)

Whilst there are three general types of solar cooker, only the reflector cooker can cook all types of meal; furthermore its handling is similar to that of a gas or electric stove. The plant described in this profile is capable of producing 10 reflector cookers per one-shift day. The fixed investment cost is almost $17,000 and employment comprises 25 production workers and 4 administrative staff.

1. INTRODUCTION

In rural areas over 50 per cent of present fuel consumption is spent on cooking, so that it is worthwhile to seek for an alternative energy source for this purpose. Non-commercial fuels like firewood, animal dung and agricultural wastes are presently the main sources in rural districts and for low-income groups in the cities. One alternative to cover the energy demand for cooking purposes is to harness solar energy in a solar cooker. Since the 1960s there have been efforts to design suitable cooking units.

Three general types of solar cookers can be distinguished:

(i) Box type cookers : low efficiency, low maximum temperature, difficult handling, small price, local materials;

(ii) Steam cookers : low efficiency, temperature up to 100°C, easy handling, medium price, mainly local materials;

(iii) Reflector cookers : high efficiency, high temperature, easy handling, high price, mainly imported materials.

Only with a reflector cooker can all types of meals be cooked, and handling is more like that on a gas or electric stove. Since cooking habits have to change anyhow, when using solar energy, reflector cookers are expected to have the higher marketing potential.

2. PRODUCT DESCRIPTION

The cooker consists of a parabolic reflector - with a focal length of 0.26 m and an aperture of 1.4 m^2 - and a steel frame to pivot the reflector and to hold the cooking vessel. Materials are reinforced polyester lined with aluminized mylar foil for the reflector and galvanized steel pipes for the frame. With fairly good sunshine (800 W/m^2 direct insolation) the cooker delivers 600 W effective cooking power. This is comparable to the effective heat output of a 1.5 kW electric stove. The maximum temperature obtainable is 350°C in the focal point. Up to 5 ltr. of food can be cooked at one time. The cooker has to be adjusted towards sun position every 20 minutes. The service life of the cooker is 10 years; every 2 years lining with new aluminium foil is necessary.

3. LOCATION

Two aspects must be considered which affect the successful implementation of the new technology:

(i) Climatological aspect: reliable sunshine during most of the year, that is either more than 250 days of sunshine per year or more than 2,400 sunshine hours per year. About two-thirds of other cooking fuels can be saved, when using the solar cooker;

(ii) Socio-economic aspect : only if the fuel shortage is very serious, can a positive attitude towards a change of cooking habits be expected.

The Sahel region of Africa seems to have a potentially high market demand. In any case a thorough market analysis has to be carried out prior to investment. At present the cooker exists only in a few demonstration models. Production data are taken from a proposal for small-scale production in an African country.

4. PRODUCTION PROCESS

A. SCALE OF PRODUCTION

The smallest scale of production is 10 units per day in one shift; in that case the only expensive machine is employed permanently. If full productivity is achieved on 300 days per year the annual output is 3,000 units. If the market can absorb more than 10,000 cookers per year, a completely different technology can be applied.

B. SUB-PROCESS OF PRODUCTION

	sub-process	equipment	number of workers
(i)	reflector		
	1 cutting of glass fibre	scissors	1
	2 manual lamination of polyester with glass fibre reinforcement	negative form brush roller	5
	3 polishing	electric polisher	1
	4 cutting of mylar foil	stencil, knife	4
	5 lining reflector with foil	-	4
(ii)	frame		
	6 pipe cutting	pipe cutter	
	7 pipe bending	hand operated hydraulic pipe bender	2
	8 press pipe	vice	
	9 drilling	bench drill	1
	10 wire cutting	wire cutter	
	11 wire bending	-	2
	12 welding	electric welding unit	
	13 assembly, finishing	spanners	3

5. **CAPITAL REQUIREMENTS** (all prices in US dollars)

A. INVESTMENT COST

i) Fixed investment:

	local	imported
Land and Buildings	10,000	
Equipment	2,550	3,250
Freight and installation	250	850
	12,800	4,100
Total		$16,900

ii) Working Capital:

	$
1 month's raw materials	14,200
1 month's wages and salaries	1,600
	$15,800

6. OPERATING CHARACTERISTICS

The set up of the production line can be completed in the first year; the life time of the plant is expected to be 10 years.

(a) Material requirements

	per day	per year	US $ per year
polyester	80 kg	24,000 kg	60,000
glass fibre	40 kg	12,000 kg	40,000
mylar foil self adhesive	30 m^2	9,000 m^2	27,000
steel tubing, 1 inch	60 m	18,000 m	36,000
miscellaneous and consumables			7,000
			$170,000

(b) Energy requirements

Necessary electrical power supply installed is 3 kW.

	per day	per year	US $ per year
Energy	16 kWh	4,800 kWh	1,000

(c) Work force requirements

(i) **Labour**

	US $ per year
4 skilled at $660	2,640
5 semi-skilled at $540	2,700
16 unskilled at $480	7,680
25	$13,020

(ii) **Staff**

general manager	3,000
accountant	2,400
clerk	1,000
storekeeper	800
	$6,200

(d) Repairs and maintenance

10% of fixed capital $1,690

(e) Overheads

1% fixed capital	170
5% working capital	790
	$ 960

7. ECONOMIC EVALUATION

In order to simplify the economic evaluation described in this section a number of assumptions have been made.

As mentioned earlier it has been assumed that the plant will produce 3,000 cookers per year. In the economic evaluation of the project it has been further assumed that in years 1 and 2 output will be 1,000 and 2,000 cookers respectively. A breakdown of annual operating costs in the early years is shown below.

Item	1/3 rate	2/3 rate	full rate
Materials	56,667	113,333	170,000
Energy	333	667	1,000
Wages and Salaries	20,220	20,220	20,220
Repairs and Maintenance	564	1,127	1,690
Overheads	960	960	960
	78,744	136,307	193,870

On the basis of a 10 year operating life, the working capital, $ 15,800, being obtained the first year of production and the recovery of the working capital and half of the cost of land and buildings in the final year, the following are the results of the NPV analysis (values in US $):

Discount Rate	Present Value of Total Costs	Annual Revenue Required for Given Discount Rate	Required Revenue per cooker
10%	1,062,174	201,832	67.28
20%	703,546	206,662	68.89
30%	504,368	211,741	70.58

43. SOLAR DESALINATION UNIT

(ISIC code 4200 - produced 1979)

> The solar still is used as a source of distilled water for both industrial and domestic domestic purposes. In many parts of the world the supply of drinking water during the dry season is a problem of vital concern. The size of still described in this profile is sufficient to cater for the needs of up to 250 inhabitants. The plant requires only one attendant and has a capital cost of less than $18,000.

1. INTRODUCTION

By means of solar energy potable water is produced from seawater or brackish well water in the process of desalination or distillation.

The solar still consists of a shallow pool of brine covered by sloping panes of glass. The water is evaporated by absorbed solar radiation and the vapour condenses on the underside of the glass covers, which are cooled at the outside by convection. The water droplets trickle down the glass to be collected in narrow drains along the bottom.

2. LOCATION

The solar still is used as a source of distilled water for battery maintenance in garages and analytical laboratories in hospitals and schools. In many parts of the world, supply of drinking water during the dry season is one of the most crucial problems for villages.

Solar stills offer a solution for the problem of potable water supply first in places near the sea, using saline seawater; secondly in places which are rich in underground water, but when the water is unfit for human consumption; and thirdly, where only brackish or polluted surface water is available.

Furthermore on small islands distilled water may be the only source of fresh water.

Installations of solar desalination plants are widely used in the USA, Greece and Australia.

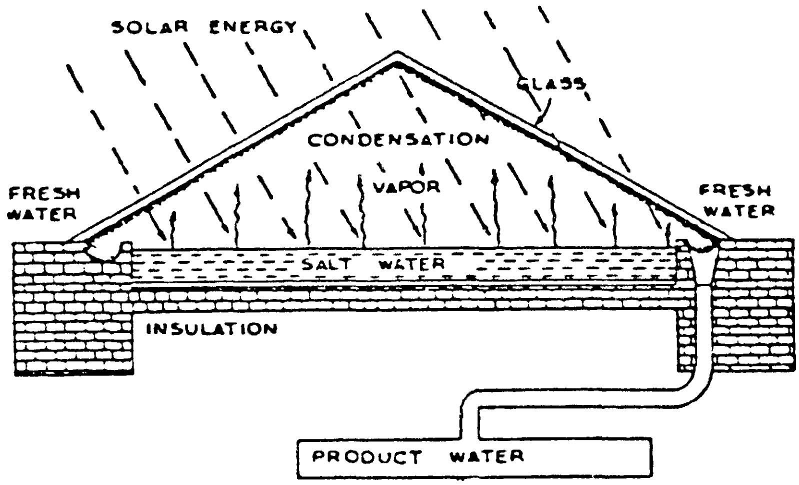
A large number of stills have been built in Niger and Mali. The great advantage of the solar still is the flexibility it offers in choice of size. The output of the still is above all a function of its area - typically 2-4 l/m^2 day or about 1 m^3/m^2 year. Durable stills have been built for a unit cost of 15-30$/$m^2$ dependent on design and local circumstances. Solar stills can be built in any size from a few square meters area up to some 100,000 m^2. If the output has to be greater than 1,000m^3/day, conventional fuel fired desalination plants are more economical today.

3. DESIGNS OF SOLAR STILLS

Although small community-scale stills are competitive with other desalination systems, the process must be regarded as experimental. New plants have to be designed according to local conditions rather than being chosen from standardized units.

The variation in designs is mainly in the use of materials, so that one can distinguish between permanent and semi-permanent constructions. The basic design is shown in the figure below.

Figure 1



The most durable stills use concrete for the trough painted with asphalt. The cover is glass in aluminium frames; aluminium is also taken for the collection drains. Cheaper and less durable stills take plastic foils for the trough and the cover and frames are made of wood. Single slope roofs are used in off-equator regions whereas gable roofed stills are more common in equatorial areas.

The following section describe a solar still, which has been erected in Haiti, on a small island which during the dry season has only a saline water well as its water source.

4. WATER PRODUCTION BY A SOLAR STILL

(a) Capacity

The components of the desalination plant are:

- the saline well with a windmill driven pump and a standby handpump;
- upper feed tank for saline water;
- the fresh water reservoir.

The schematic concept is shown in figure 3, and the design of the still itself in figure 4.

The water output from the still is 1,250 l/day on an average including rain water catchment. This is sufficient for about 250 residents in the community.

The area of the still is about 400 m^2 (25m x 16m), giving an average production rate of 3 l/m^2 day, out of which 10% comes from rain water (precipitation is only 100 mm/year).

(b) Material requirements

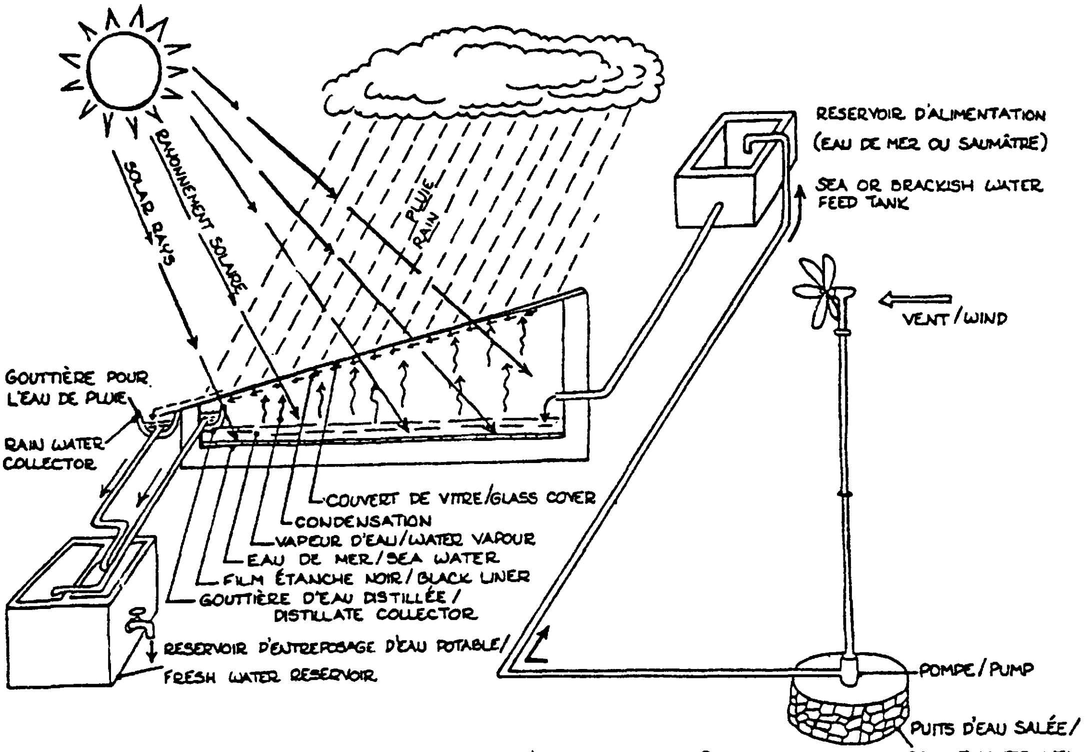
Locally available materials were used as much as possible, that is bricks, cement, sand and concrete blocks for the basic construction. The drain troughs for the distillate and the rainwater are cast in the wall structure, so that no material is used for this. As insulation material dried coffee husks were used. If no very cheap insulation material is available, insulation can be excluded, since it improves the efficiency of the still only slightly.

Imported items are the glass panes (400 m^2), the rubber basin liner (400 m^2) and the sealing compound to hold the glass in place. The pumps, PVC-pipes and fittings were also imported.

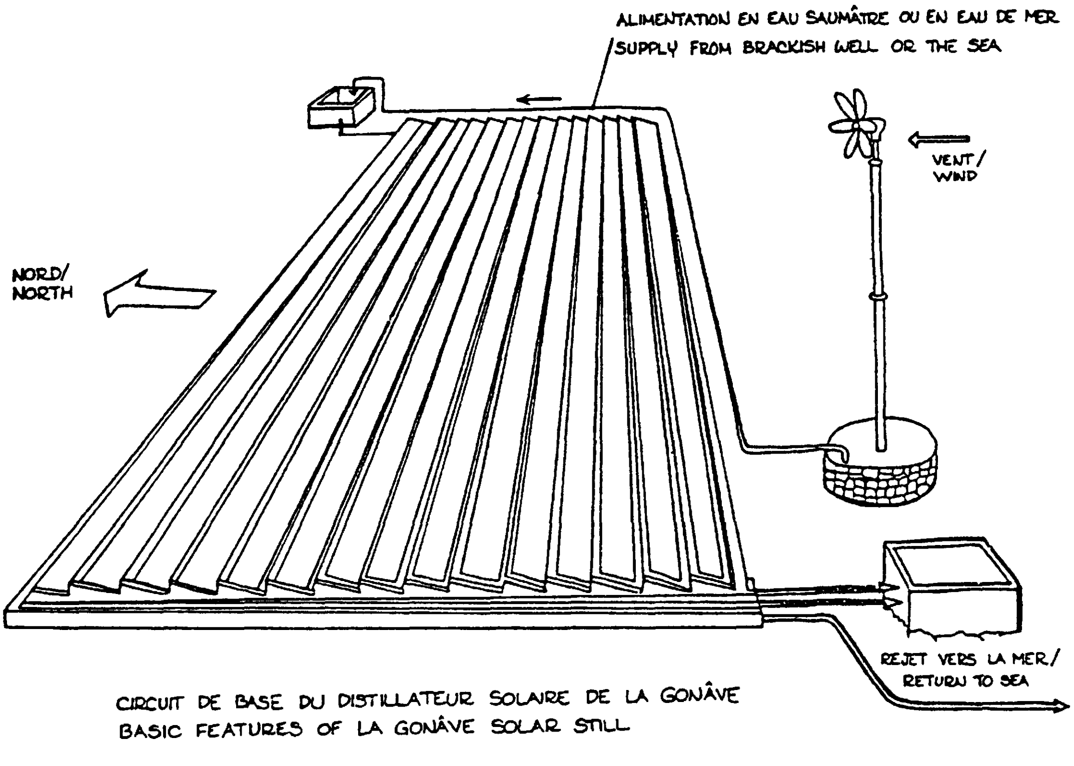
(c) Work force requirements

Various levels of skills and capabilities are necessary to install the desalination plant. Carpenters are required to build the concrete formers. Bricklayers and masons are needed for construction of the solar still basin; basic plumbing and tinsmith work is also required. All these skills were available within the community. An engineer is needed for supervision and management during installation, which can be carried out in one year.

Figure 3

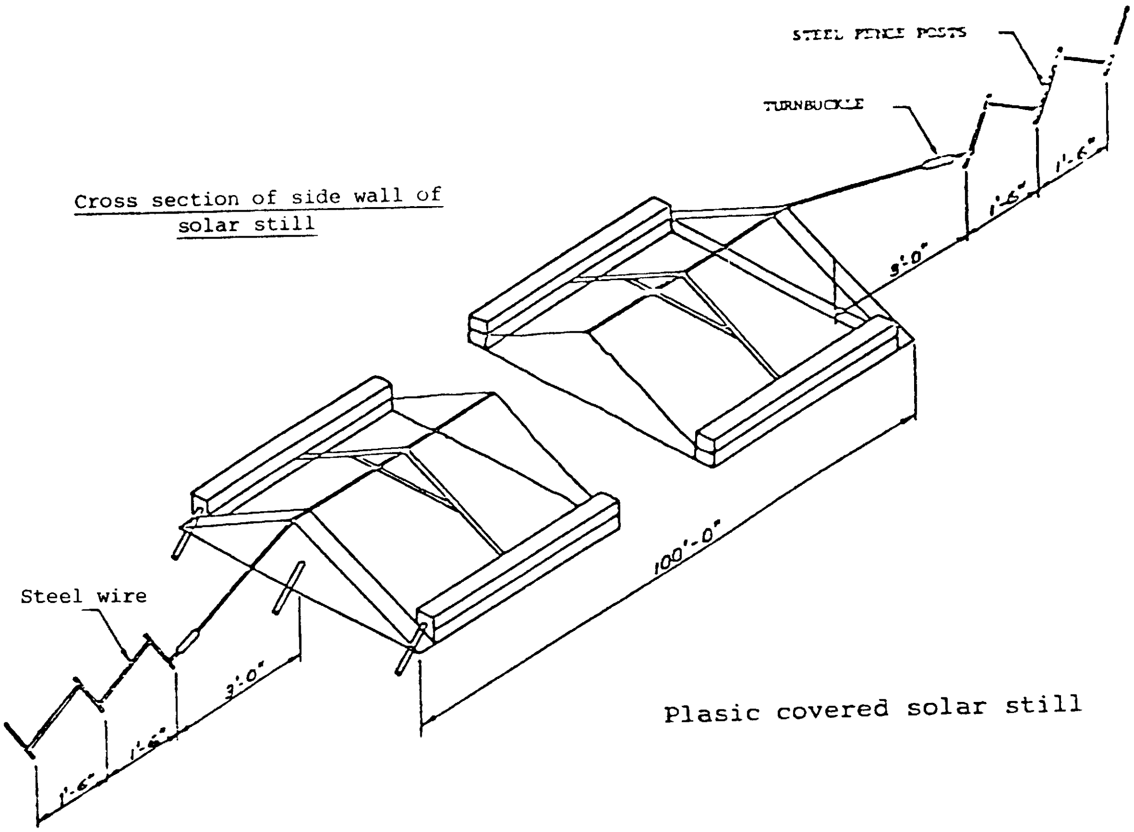


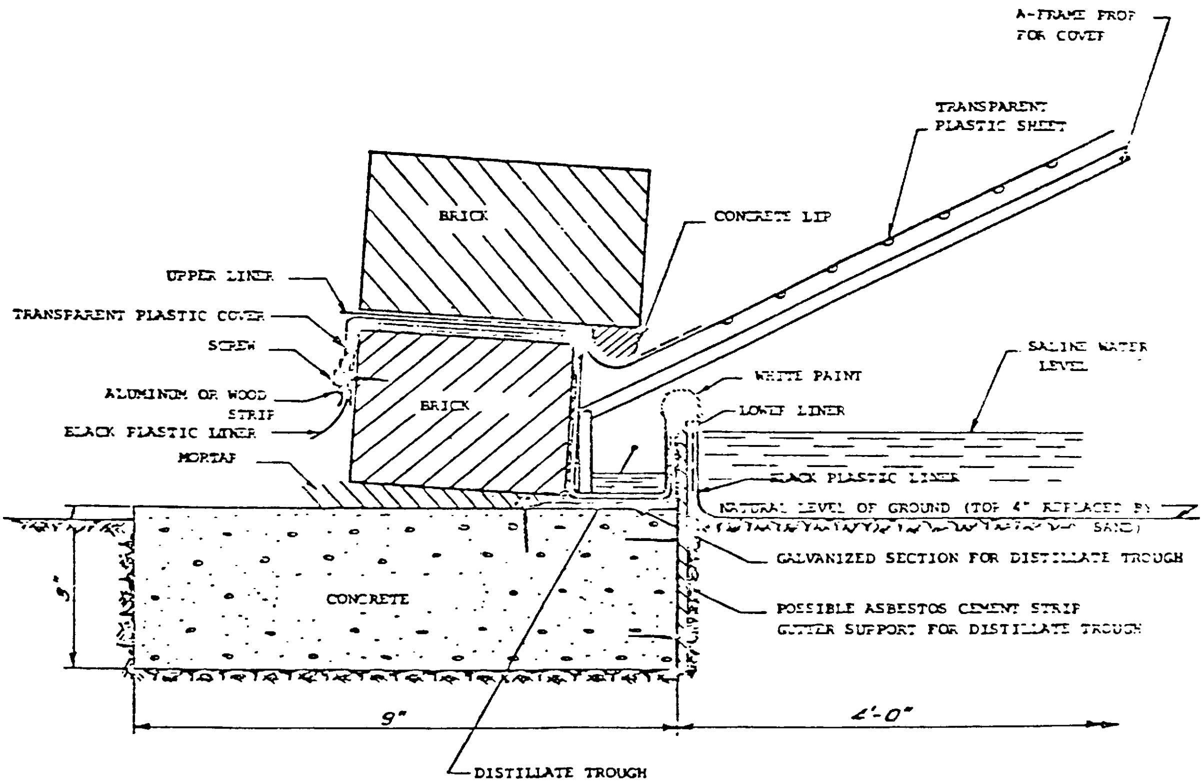
VUE SCHEMATIC DU FONCTIONNEMENT D'UN DISTILLATEUR SOLAIRE
SCHEMATIC CONCEPT OF SOLAR STILL OPERATION



CIRCUIT DE BASE DU DISTILLATEUR SOLAIRE DE LA GONÂVE
BASIC FEATURES OF LA GONÂVE SOLAR STILL

Figure 4


STEEL FENCE POSTS
TURNBUCKLE
Cross section of side wall of solar still
1'-6"
1'-6"
3'-0"
100'-0"
Steel wire
3'-0"
1'-6"
1'-6"
Plasic covered solar still


A-FRAME PROP FOR COVER
TRANSPARENT PLASTIC SHEET
BRICK
CONCRETE LIP
UPPER LINER
TRANSPARENT PLASTIC COVER
SCREW
ALUMINUM OR WOOD STRIP
BLACK PLASTIC LINER
MORTAR
BRICK
WHITE PAINT
LOWER LINER
SALINE WATER LEVEL
BLACK PLASTIC LINER
NATURAL LEVEL OF GROUND (TOP 4" REPLACED BY SAND)
GALVANIZED SECTION FOR DISTILLATE TROUGH
POSSIBLE ASBESTOS CEMENT STRIP
GUTTER SUPPORT FOR DISTILLATE TROUGH
CONCRETE
9"
9"
4'-0"
DISTILLATE TROUGH

(d) Capital requirements

Fixed Investment:	$
land 800 m^2 at $1,00	800
materials	14,000
labour	3,000
	$17,800

The cost/area of $44,5/$m^2$ is above the elsewhere reported figures of $16-32/$m^2$, because all supplementary installations like the windmill etc. are included.

Working capital is not required.

(e) Operating characteristics

The plant needs little maintenance. The still has to be flushed once a day in the morning with fresh saline water, the windmill pump has to be serviced regularly and broken glass panes have to be replaced after heavy storms. So only one attendant is employed to run the whole plant.

The solar still has now been in operation for 10 years and is expected to last 20 to 30 years.

(f) Annual operating cost	$ per year
labour, one attendant	1,000
materials, replacement of glass	500
maintenance and repairs other than glass	200
	$1,700

(g) Evaluation (values in US $)

This is based on 25 year operating life, with neither build-up to full capacity production, nor residual value. Fixed investment is 17,800. No working capital is necessary.

Thus, production costs are as follows :

	Year 0, full capacity
Materials (to replace glass)	500
Wages and salaries	1,000
Other repairs and maintenance	200
	1,700

The following are the results of NPV analysis :

Discount Rate	Present value of total costs	Annual revenue required	Revenue required per 1000 litres
10%	33,233	3,661	8.03
20%	26,212	5,297	11.62
30%	23,459	7,047	15.45

5. ALTERNATIVE STILLS

(a) Small still for a single household

From India the design of a small still with gabled roof is reported with 10 m^2 area. It is also a concrete and glass system but without any delivery piping. The still has to be filled daily by hand and therefore installation and running costs, are much lower. The installation cost is $200 and the still can deliver 25 l/day on an annual average, ranging between 7 and 37 l/day according to season.

(b) Plastic covered still

From Canada the design of a 40 m^2 solar still is available which can be erected at a price of $450. Production rate is about 120 l/day or 44 m^3 per annum. The economic life of the still is 15 years, but the transparent plastic cover has to be renewed every two years.

44. SOLAR WATER HEATER PRODUCTION

(ISIC code 4200 -produced 1980)

This profile analyses the operation of a plant which can produce daily 5 solar water heaters designed on the thermosyphon principle by which circulation of water between between the collector and the storage tank is by natural convection. The plant had a fixed investment cost of $22,140 and employs 31 production workers and 7 administrative staff.

1. INTRODUCTION

The conversion of solar radiation energy into heat energy is the direct process of absorption and it does not require a complicated technology to exploit solar energy in this way. Solar heated water is used for domestic purposes like showers, baths, washing, etc. and also for space heating. Larger installations are used for hotels, hospitals or schools. Smaller units are available for the domestic hot water demand of a single household.

A solar water heater consists basically of a flat plate collector and an insulated storage tank. The collector is commonly a blackened metal plate with attached metal tubing and is usually provided with a glass cover and a layer of insulation beneath the plate. To store the hot water produced in the collector its tubing is connected by piping to the storage tank, and from there to the hot water piping system of the building.

Solar water heaters are quite commonly used in Israel, Australia, Japan and parts of the U.S.A. Sales in Israel are in the range of 10-15,000 units per year and about 20% of the households have solar water heaters. The manufacture of solar water heaters has been undertaken in a number of ACP countries.

2. CHOICE OF TECHNOLOGY

(a) Water circulation

Water may be circulated between the collector and the storage tank in two different ways: by forced circulation by means of an electric pump and by natural convection from the collector towards the tank.

The advantages of the forced circulation are:

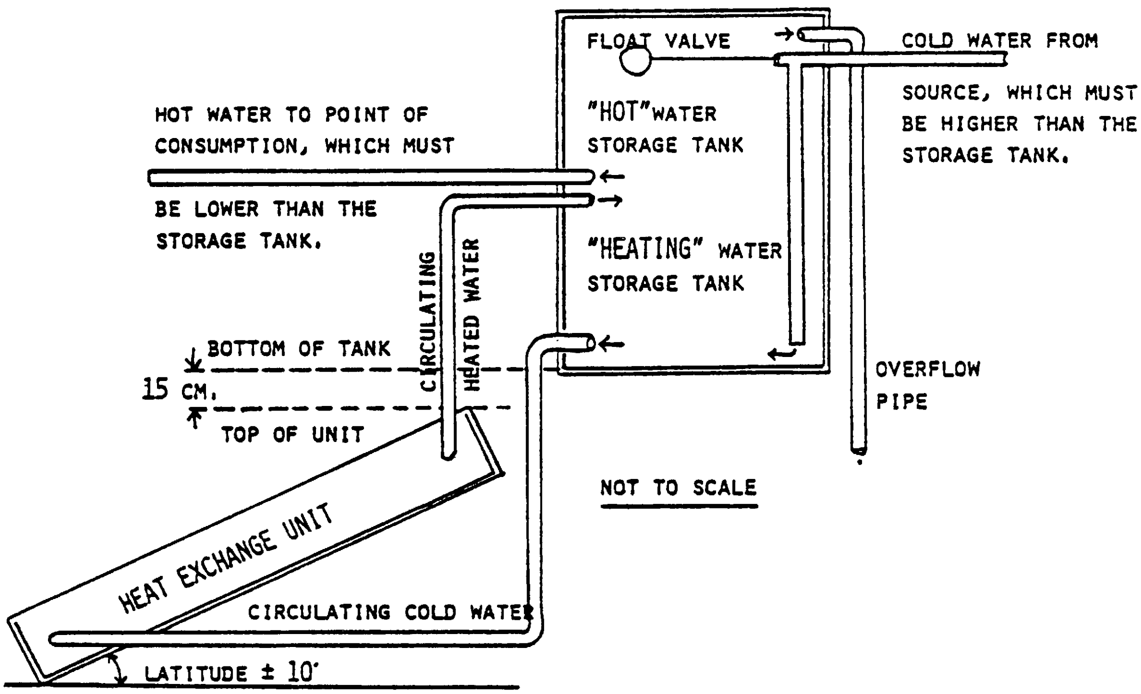
(i) higher energy gains can be achieved through a control via temperature sensors in the storage tank and the collector outlet; and

(ii) the storage tank can be positioned at any place in the building. In Europe it is commonly placed in the basement, where the auxiliary heater is usually situated.

The disadvantages include higher installation cost, frequent maintenance, and the necessity to be linked to an electricity supply.

Circulation by natural convection - often referred to as the thermosyphon principle - is shown in Figure 1 below.

Figure 1



FLOW DIAGRAM SHOWING RELATIVE POSITIONS OF PLUMBING AND PARTS OF THE SOLAR WATER HEATER

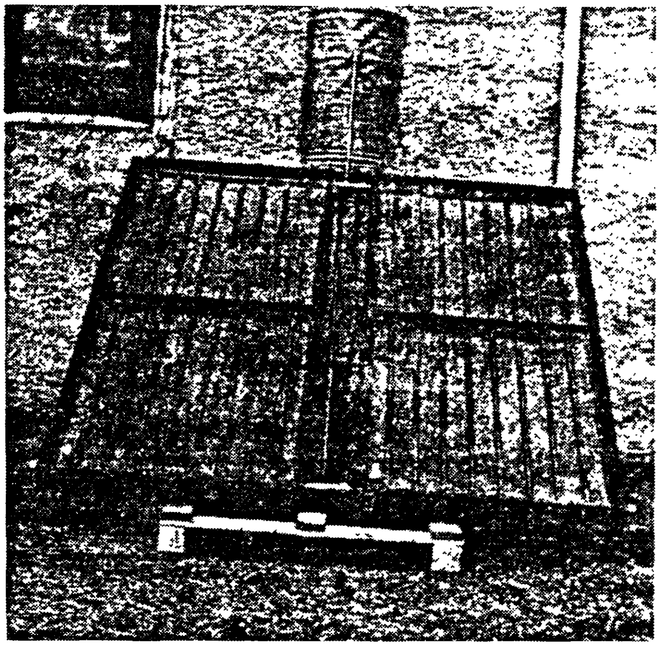
In its favour are the facts that no electricity is required for the pump, it is self-regulating and almost no maintenance is necessary.

The disadvantages comprise lower efficiency and the need for the tank to be installed above the collector. When the solar heater is placed on a flat roof, tank and collector are permanently connected on a single frame.

In hot climates the thermosyphon principle should be preferred, because of its simplicity, since there is no need to protect the storage tank from heat losses to ambient air, as it is the case in cold climates.

There is a wide variety of collector designs. One unit, which is commonly used in Israël, is shown in Figure 2 below. This type has proven its reliability over 20 years.

Figure 2



II

(b) **Collector design**

There is a wide variety of collector designs. Collector plates can be made of aluminium after the Roll-Bond principle as a tube-in-sheet plate. Another type consists of a copper plate with a copper pipe soldered on it. These types are highly effective, because of the good thermal conductivity of materials involved.

Due to the high cost of these materials steel sheets with steel pipes welded on it forming a grid are preferred nowadays. Selective surfaces are necessary in places with low average insulation; in locations with high solar radiation, dull black paint will serve sufficiently for proper absorption. In cold climates collectors have double glazing, but in hot climates single glazing gives higher efficiency, apart from the high temperature range (above 90°C).

The energy gain from solar radiation in the collector is a function of about 20 parameters, the most crucial being the difference (Δ T) between the mean water temperature in the collector and the ambient temperature. Most collectors have an efficiency in the range of 50% at Δ T = 40°C. For example: at a global insulation of 1,000 W/m^2 (bright sunshine) a collector with 1 m^2 absorption area will deliver 500 W of heat energy, that is it can heat up to 10 litres of water within one hour from 20°C to 60°C.

The most surprising fundamental rule for solar water heaters is that the more hot water is consumed, the greater is the energy gain from solar radiation.

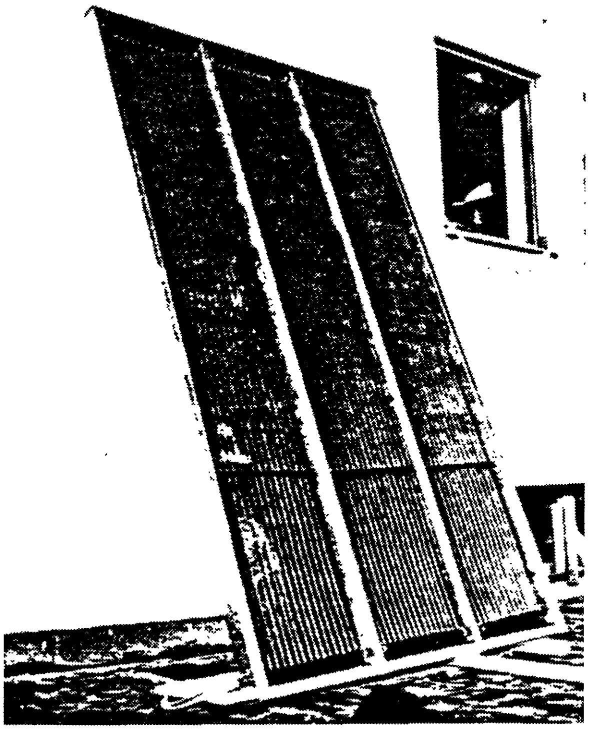
Since the ambient temperature plays a great role in the collector performance, less efficient collectors in hot climates can easily deliver water of 80 or 90°C. A low cost collector, which can be produced with only little equipment is described in the following sections. Only a few demonstration units have been produced so far; the service life of at least 10 years is verified.

3. PRODUCT DESCRIPTION

The collector has an absorption area of 4.5 m^2 and is designed to load a storage tank of 360 l capacity. It would serve the domestic hot water demand of a 5-person household. The main difference from other collector designs is that the absorber consists of an absorber plate and a narrow grid of thin black plastic tubing.

In the self-supporting wooden frame the necessary layers are arranged: 4 cm glass-wool insulation, black painted steel sheet, PVC-tubing grid, spacers and polyester plate. The collector is shown in the photograph below.

Figure 3



The collector is designed to be used in connection with a thermosyphon tank, since it can withstand only little water pressure.

As connections between collector and storage tank will be carried out by the plumbing contractor on the site, only the manufacture of the collector is described. Materials involved are processed, so that production line has to be located in an industrially developed environment.

4. PRODUCTION PROCESS

(a) Scale of production

The production process is described for a team which can manufacture 5 collectors per day or 1,500 per year, using mainly hand operated equipment.

(b) Sub-processes of production

	Sub-process	Equipment	Number of workers
(i)	**frame**		
	1 cutting wood		)
	2 cutting harboard and polyester sheet	circular saw	(1
	3 drilling holes	electric hand drill	1
	4 assemùbly of frame		2
(ii)	**absorber plate**		
	5 cutting steel sheet	steel cutter	-
	6 polishing	electric polisher	1
	7 cleaning		1
	8 priming	electric paint-spray	1
	9 spray painting	electric paint-spray	1
(iii)	**tubing grid**		
	10 cutting copper pipe.	hand oper, pipe cutter	2
	11 drilling hole	drill press	1
	12 brazing	welding torch	1
	13 cutting of PCV - and rubber tubes	scissors	1
	14 connecting PVC - tubes and copper-pipe distributor	screw driver	2
(iv)	**assembly**		
	15 assembly	elec. screw-driver	2
	16 cutting aluminium	shears	1
	17 bending aluminium	bending manchine	1
	18 testing and finish		2
			21

5. CAPITAL REQUIREMENTS

A. FIXED INVESTISSEMENT

	$
Land	1,000
Buildings	12,500
Equipment	4,700
Freight and installation	940
Workbenches, fittings, furniture, etc.	3,000
	22,140

	$
One month's raw materials	15,820
One month's salaries and wages	2,565
	18,385

6. OPERATING CHARACTERISTICS

A. MATERIAL REQUIREMENTS

material		per unit		US $ per year
wood beam	40x80 mm	14.5 m	21,780 m (69.6m^3)	17,400
wood ledge	15x30 mm	25 m	37,500 m (18.88)	11,250
hard board	3 mm	5 m^2	7,500 m^2	15,000
glass wool	40 mm	4.5 m^2	6,750 m^2	20,250
steel sheet	0.8 mm	4.5 m^2	6,750 m^2	10,125
copper pipe	ø 18 mm	3 m	4,500 m	6,750
copper pipe	ø 8 mm	4 m	6,000 m	3,900
rubber tube	ø 22 mm	2 m	3,000 m	4,500
tube clamps		100	150,000	7,500
aluminium strips 120x0.5 mm		9.4	14,100 m	21,150
polyester plate UV resistent	1 mm	5.4 m^2	8,100 m	60,750
paint		1 kg	1,500 kg	3,750
miscellaneous		-	-	3,000
consumables (solder, gas, solvents, etc.)				4,500
				$189,825

B. ENERGY REQUIREMENTS

Power installations of 10 kW are required, consumption is 60 kWh per day.

Annual consumption 18,000 kWh at $0.08 per kWh $1,440

C. WORKFORCE REQUIREMENT

Labour	
8 skilled workers at $660	5,280
11 semi-skilled workers at $540	5,940
12 unskilled workers at $480	5,760
31	$16,980
Staff	
general manager	3,000
accountant	2,400
production manager	3,000
personnel manager	2,400
storekeeper	1,000
cashier	1,000
clerk	1,000
	$13,800

D. REPAIRS AND MAINTENANCE

10% of fixed investment	$ 2,200

E. OVERHEADS

1% fixed capital	$ 220
5% working capital	920
	$ 1,140

7. ECONOMIC EVALUATION

In order to simplify the economic evaluation described in this section a number of assumptions have been made.

As mentioned earlier the annual output is presumed to be 1,500 collectors. In years 1 and 2 of the project, however, annual output is taken as 500 and 1,000 collectors respectively. The breakdown of annual operating costs in the early years is given below :

Item	Year 1 1/3 rate	Year 2 2/3 rate	Year 3 full rate
Materials	63,275	126,550	189,825
Energy	480	960	1,440
Wages and Salaries	30,780	30,780	30,780
Repairs and maintenance	733	1,467	2,200
Overheads	1,140	1,140	1,140
	96,408	160,897	225,385

On the basis of a 20 year operating life, the working capital - $18,385 being obtained the first year of production - and the recovery of the working capital plus the cost of land in the final year, the following are the results of the NPV analysis (Values in US $):

Discount Rate	Present Value of Total Costs	Annual Revenue Required for Given Discount Rate	Revenue required per collector
30%	646,198	247,965	165.31
10%	1,784,159	233,773	155.85
20%	981,933	240,552	160.37

45. SMALL-SCALE CHARCOAL PRODUCTION

(ISIC code 1210 - produced 1979)

Charcoal is a fuel which has important industrial as well as domestic uses. Being made from wood, potentially a renewable resource, the environmental implications of charcoal production require careful consideration. The process described in this profile operates with two kilns which are loaded and fired alternately. The basic sub-processes involved involved are wood preparation, carbonization and packing of the finished product. A team of 5 workers should be able to produce 12 tonnes of charcoal per month. The fixed investment cost is under $5000.

1. INTRODUCTION

The art of making charcoal is at least 6,000 years old. Interest in charcoal as a fuel, both for domestic use and for industrial purposes, has recently increased because of a steep rise in the prices of all fuels and power.

Charcoal is made from wood, a renewable resource. It should be noted that charcoal industries have caused large-scale environmental damage. The ecological effects of removing trees must be understood and measures be taken to prevent such damage, prior to starting a charcoal industry.

The reason for the use of charcoal instead of wood is that the heat value of charcoal is twice as high as that of wood (1,700 kJ/kg compared to 850 kJ/kg). Therefore the shipping cost of fuel is reduced. Charcoal burns without smoke and can be used in smaller and more efficient stoves.

Charcoal is also used in industry in the process of manufacturing lime and cement, for the extraction of metals, particularly iron, from their ores. Iron and steel made with charcoal are of higher quality than that made with coal. Charcoal is used for forging and producing high quality castings. Activated charcoal is produced by treatment with zinc chloride; it is used as absorbent in chemical processes and medicine.

2. PRODUCTION PROCESSES

Charcoal is produced when wood is burned under limited supply of air. Gaseous components and water are removed, so that charcoal consists of about 90% carbon. The yield should be 50-70 kg of charcoal out of 1 cubic mètre of wood.

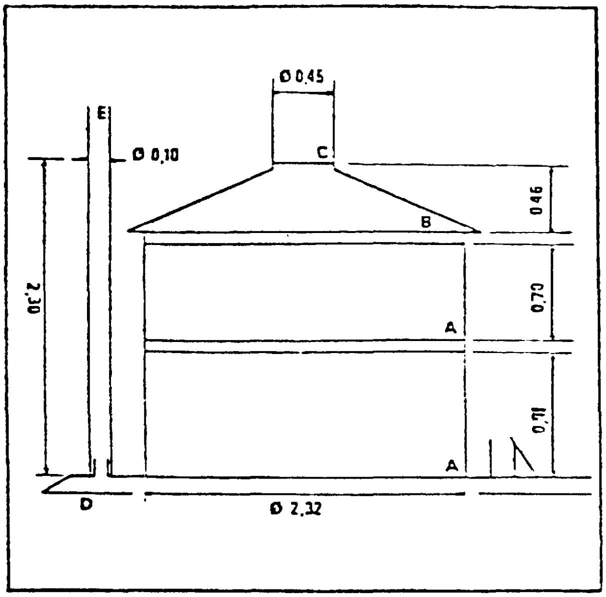
The simplest way of making charcoal is in pits of earth kilns. Fixed kilns can be made of brick, cement or clay.

As it can be very expensive to bring wood from the forest, fixed kilns should be located at places with abundant and continuing supplies of wood, e.g. at saw-mills.

Portable kilns can easily be taken to the wood and assembled on the spot.

(a) Production of charcoal in a portable steel kiln.

The most popular, easily usable kiln consists of two inter-locking cylinders, which can be rolled from one place to another. The figure below shows the basic outline of the kiln. Wood cut into 0.5 m lengths is left to dry for 6 weeks. The full size version shown takes 6 m^3 of wood.



Components of the kiln :

2 cylinders A, 2.3m diameter, 0.9m and 0.8m high

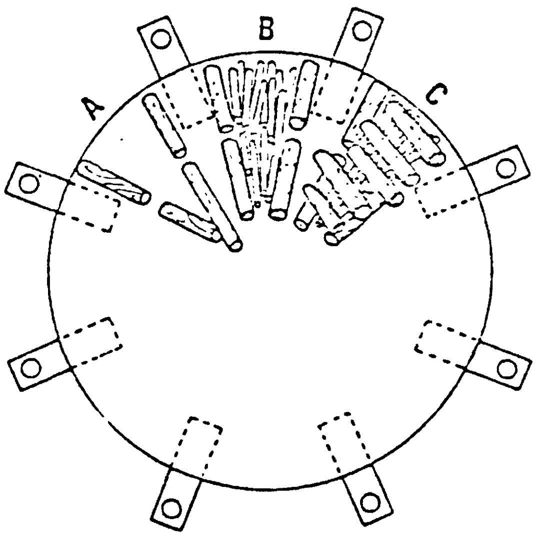
1 cover B, 2.3m diameter, 0.5m high

1 cap C, 0.45m diameter

8 smoke boxes D, 0.15 X 0.9 X 0.7m with closable caps and collars

4 chimneys E, 0.1m diameter and 2.3m high

First, an appropriate site free from stumps is selected near the wood supply. Vegetation is removed and the place levelled roughly to produce a platform of 3 m diameter. The bottom cylinder is placed on the ground and the 8 smoke boxes fitted underneath at equidistant intervals. Then the cylinder is loaded with wood as shown in the following figure.



The hollow rim at the top of the bottom cylinder is filled with sand and the second cylinder lifted on. Loading continues until the wood forms a conical shape above the top cylinder. Its rim in turn is filled with sand and the cover placed on it, still leaving 10 cm of space. With all lids of the smoke boxes open fire is set to the 8 lighting points between them. When the kiln becomes sufficiently hot, the lighting holes are covered with soil. After 30-60 minutes the cover will settle into the hollow rim of the top cylinder, thus sealing the kiln. Now the 4 chimneys are fitted to the collars of the 4 alternate smoke boxes and the top is covered with the cap. The air can now enter by 4 smoke boxes and smoke can escape by the chimneys. Thus a reverse draught is established. The operation can be controlled by closing a chimney or removing soil from the bottom to increase temperature. After 8-10 hours the chimneys should be moved to their neighbour smoke boxes. After 16-24 hours the carbonization is completed, the chimneys are removed and all air entrance holes at the bottom are covered with soil. Cooling down needs 8-12 hours and then the charcoal can be packed.

(b) Scale of production

The smallest scale of production operates with two kilns, which are loaded and fired alternately. Operation costs increase proportionally to the number of kilns. At full productivity 12 tonnes of charcoal per month are produced by a team of 5 workers. It is assumed in the analysis below that the product is sold ex site, so that transportation and wholesale functions are the business of another entrepreneur. Charcoal is usually sold in 25kg gunny bags.

(c) Sub-processes of production

The basic processes are wood preparation, carbonization and packing.

Wood preparation	Equipment
(1) fell wood	axe, saw
(2) cut wood	bush saw, cross-cut saw
(3) split wood	wedges, hammer
(4) maintenance of tools	sharpening stone, sharpening file, saw setting pliers
(5) stacking of pieces	
(6) air drying for 6 weeks	
Carbonization	**Equipment**
(7) clear and level site	hoes, shovels, spades, matchets, axes, rakes
(8) installation of kiln	portable kiln
(9) loading of kiln	crow-bar, ladder
(10) lighting the kiln	-
(11) control during 2 days of carbonization	-
(12) packing	spring balance, sacks, needle, string
(13) transfer to new site	

Three workers are required for the wood preparation stage and two required for carbonization.

3. CAPITAL REQUIREMENTS

A.	FIXED INVESTMENT	$
	2 kilns at US $2,000	4,000
	various tools	250
		4,250
B.	WORKING CAPITAL	
	One month's wages	425
	One month's raw materials	106
		531
	Total	$4,781

4. OPERATING CHARACTERISTICS

A. MATERIAL REQUIREMENTS

Nearly any wood can be taken for charcoal production; commonly used species, which are fast growing, are Eucalyptus and Wattle trees. 6 steres are needed to load one kiln. Working 300 days a year, the annual requirement is :

1,800 cu.m. of wood at $0.25	$ 450
sacks, string	816
	$1,266

B. WORK FORCE REQUIREMENTS

	US.$/year
5 semi-skilled workers	3,300
Management, supervision & office work	1,800
	$5,100

C. ANNUAL OPERATING COST

Material requirements	$1,266
Wages	5,100
Maintenance and replacement of tools	425
	$6,791

Production can start two months after investment. The first month should partly be taken for training of the labourers if necessary.

5. EVALUATION (values in US $)

This is based on 5 year operating life, a one year build-up to full capacity production, and a residual value for tools. Fixed investment is 4,250. Working capital, 531, is taken in one instalment on year 0. The residual value, 1,000, and working capital 531, are returned in the 5th year of operation.

Thus, production costs build up as follows :

	Year 1 capacity (50%)	Year 2 capacity (100%)
Materials	633	1,266
Salaries	5,100	5,100
Repairs and maintenance	213	425
	5,946	6,791

The following are the results of NPV analysis :

Discount Rate	Present value of total costs	Annual revenue required	Revenue required per kg of charcoal
10%	24,575	8,621	0.059
10%	23,678	9,202	0.063
20%	20,132	9,820	0.068

46. BRIQUETTES FROM AGRICULTURAL WASTE

(ISIC Code 1210 - produced 1981)

This profile describes the production of fuel briquettes from agricultural waste. This involves two main operations - compaction of the raw material into briquette and the carbonization of these to charcoal. An evaluation is carried out for each of an automated and a non-automated technology. Fixed investment is about $197,750 for the automated unit and 8 people are employed. Fixed investment for the non-automated unit is about $184,250 and 10 people are employed.

1. PRODUCT DESCRIPTION

Waste from agricultural production has long been used as fuel, by direct combustion. This method could be improved by converting the waste into briquettes, and converting the briquettes into charcoal by carbonization.

The advantages claimed for briquetes over unconverted waste used as fuel are :

a) easier handling;
b) easier storage and smaller storage area requirements;
c) lower transport costs : better loading of lorries;
d) more rapid ignition;
e) higher heat value : up to 4,500 kcal/kg according to moisture content of the waste;
f) slower combustion; and
g) lower ash content.

The advantages of converting the briquettes into charcoal by carbonization are:

a) heat value may reach 7,500 kcal/kg;
b) combustion time is three times slower;
c) ash content reduced to about one-tenth; and
d) less smoke in combustion.

2. DESCRIPTION OF TECHNOLOGY

Five basic steps are involved. These are:

a) screening the waste to remove foreign bodies such as sand, pieces of metal, etc;

b) crushing is required for hard materials such as bark, wood waste, coconut shells etc;

c) drying is necessary for materials with high moisture content. Moisture content should be less than 15%. This can sometimes be done by spreading the material in the open air, but may require equipment such as solar heating installations, or a rotary drier;

d) briquetting - the material, crushed and dried if necessary, is fed into a briquetting machine and comes out as a cylindrical briquette. It is cut automatically by a special cutting device; and

e) carbonization of the briquettes takes place in a kiln. Time and output will vary greatly according to the different waste materials used. This profile will concentrate on material which is of fine or medium granulometry and of low moisture content. In this case crushing is not necessary and a simple solar drier installation is satisfactory.

3. LEVEL OF OUTPUT

Approximately 110 tonnes of briquettes per month can be produced from 120 tonnes of raw material (depending on moisture content). This will give an output of roughly 1,320 tonnes per year.

The carbonisation kiln has a capacity of 6 tonnes, and 40 hours are required for each batch of briquettes. About 110 tonnes, or 18 batches, of briquettes are available per month and the output of charcoal briquettes will be about 38 tonnes per month, or 456 tonnes per year.

4. EMPLOYMENT AND EMPLOYMENT COSTS

		Automated Unit	Non-Automated Unit
1	Manager	$ 4,000	$ 4,000
1	Clerk	1,200	1,200
1	Lorry driver	1,920	1,920
1	Foreman	2,400	2,400
2	Skilled Workers at $1,920	3,840	3,840
2	Unskilled Workers at $720	1,440	-
(4)	Unskilled Workers at $720	-	2,880
8 (10)		$14,800	$16,240
	Other Annual Labour Costs:	1,480	1,624
	Total Annual Labour Costs:	$16,280	$17,864

5. DATA FOR ECONOMIC ANALYSIS

A. FIXED INVESTMENT	Automated Unit	Non-Automated Unit
i) Investment Cost:	$	$
Machinery and Equipment	105,000	95,000
Land and Building		
(700m^2 x $20; 350m^2 x $120)	56,000	56,000
Freight and Insurance	15,750	14,250
Installation	21,000	19,000
	197,750	184,250

ii) Working Capital :

	Automated Unit	Non-Automated Unit
	$	$
Stock of materials (3 months)	3,500	3,500
Wages and Salaries (2 months)	2,713	2,977
	$6,213	$6,477

iii) Residual Value :

	Automated Unit	Non-Automated Unit
	$	$
10% Equipment Cost (cif)	12,075	10,925
50% Building Cost	28,000	28,000
	$40,075	$38,925

B. ANNUAL OPERATING COSTS

		Automated Unit	Non-Automated Unit
		$	$
i)	Raw Material (1,400 tonnes at $10/t)	14,000	14,000
ii)	Wages and Salaries	16,280	17,864
iii)	Electricity	4,800	4,000
iv)	Fuel	8,000	8,000
v)	Water	176	176
iv)	Maintenance(3% Investment)	5,933	5,528
v)	Overheads	2,000	2,000
		$51,189	$51,568

C. EVALUATION (Values in US $)

This is based on a 10 year operating life, a 2 year build up to full capacity production, and a residual value for buildings and equipment. The fixed investments amount to $197,750 and $184,250 for automated and non-automated units respectively. Working capital amounts to $6,213 and $6,477 respectively taken in the first year of operation. The residual value of $40,075 and $38,925 respectively, and the working capital are returned in the 10th year of operation.

i) Non-Automated Unit

Production costs build up as follows over 2 years:

	Year 1 (65%)	Year 2 (100%)
Materials	$ 9,100	$14,000
Wages and Salaries	11,612	17,864
Electricity	2,600	4,000
Fuel	5,200	8,000
Water	114	176
Maintenance	3,593	5,528
Overheads	1,300	2,000
	$33,519	$51,568

The following are the results of NPV analysis on Non-Automated Unit.

Discount Rate	Present Value of Total Costs	Annual Revenue Required for Given Discount Rate	Revenue Required per tonne
5%	543,537	73,562	161.32
10%	473,064	81,187	178.04
20%	383,455	98,310	215.59

ii) Automated Unit

Production costs build up as follows over 2 years:

	Year 1 (65%)	Year 2 (100%)
Materials	$ 9,100	$14,000
Wages and Salaries	10,582	16,280
Electricity	3,120	4,800
Fuel	5,200	8,000
Water	114	176
Repairs and Maintenance	3,856	5,933
Overheads	1,300	2,000
	$33,272	$51,189

The following are the results of NPV analysis on automated unit.

Discount Rate	Present Value of Total Costs	Annual Revenue Required for Given Discount Rate	Revenue Required per tonne
10%	483,801	83,030	182.00
20%	395,137	101,305	222.13
30%	331,410	117,444	257.55

47. FUEL ALCOHOL PRODUCTION

(ISIC code 3511 - produced 1981)

This profile describes a small, village-scale plant for the production of fuel alcohol from sugar cane. The alcohol can be used to run engines such as trucks, tractors and stationary pumps or generators. Fixed investment is about $44,400 and 13 people are employed.

3. PRODUCT DESCRIPTION

The purpose of the plant is to produce ethyl alcohol from locally available raw materials, in this case sugar cane. The plant would be suitable for small rural cummunities which want to produce their own fuel for trucks, tractors, etc. rather than rely on diesel oil which may be expensive or difficult to obtain.

2. DESCRIPTION OF TECHNOLOGY

There are four main operations:

a) Sugar cane is crushed in a grinding mill, and the juice is conveyed to juice tanks. The bagasse (cane fibre) can be fed into a boiler to reduce the necessity for outside energy sources.
b) The fermentation phase consists of loading the vats, inoculation utilizing pressed yeast, nutrients supplementation consisting of adding ammonium sulphate and tribasic super phosphate. The yeast must be added before the juice is put in the vat, and the nutrients are also placed in the juice tank. After supplementation and inoculation, the fermentation takes 24-30 hours, after which the wine flows into the wine tank.
c) The regeneration treatment consists in adding sulphuric acid to the inoculum (yeast) which remains in the vat. After 90-120 minutes, the vat is again loaded with juice.
d) The wine is pumped into the still and is distilled. The residue from distillation, stillage, can be used in the fields as fertilizer.

The equipment is as follows:

a) Wine masonry tanks are used for fermentation, juice storage, wine, stillage storage, and cooling water.
b) The bagasse burning is done in a grate-type furnace with a 45% slope, made with refractory bricks (38% alumina) and common bricks. The bagasse is loaded manually.
c) The grinding mill for crushing the sugar cane has a capacity of about 1 tonne of cane per hour yielding 500 litres of juice per hour. The mill is driven by a three-phase, 5 HP electric motor.
d) Pipes, valves and other piping accessories will depend on the equipments physical arrangement.

e) The alcohol storage vertical tank is built using the reinforcing techniques which consist in covering a screened wire frame with mortar. The tank's nominal capacity is 25,000 litres.

f) The column for distillation of the alcohol is made of wood. A packed column with bamboo Raschig type rings is specified.

g) The still is made of wood with a volume of about 2,154 litres. The wine is heated by steam passing through a 3/4" diameter copper coil with a length of 30 metres.

h) The condenser is made of wood, and is 0.5 metre long. The vapours condense outside the coil while the cooling water circulates inside the coil. The coil is made of copper, with a 2 cm diameter and a length of 12 metres.

i) The vertical cooler is made of wood, and is 0.4 metre long. The 2 cm diameter copper coil is 8.5 metres long. The distillate passes through the coil while the cooling water is outside the coil.

j) Four circulating pumps are required to:
transfer the juice from the tanks to the vats;
transfer the wine from the wine tank to the distillation column;
transfer the syrup from the syrup tank to the general syrup reservoir; and
pump the cooling water from the tank to the condenser.
The pumps are each driven by 3/4 HP motors.

k) The boiler produces about 210 kg of steam per hour at 8 atmospheres. It has a $15m^2$ heating surface, with vertical fire boilers and 58 2" size pipes.

3. LEVEL OF OUTPUT

The plant in this profile produces 50,000 litres of alcohol per annum, assuming a single shift, 8 hour day, a 5 day week and operation during 6 months of the year.

4. EMPLOYMENT AND EMPLOYMENT COSTS

			$
1	Manager	at $4,000 per annum	4,000
4	Supervisors	at $2,400 " "	9,600
8	Semi-skilled Workers	at $1,200 " "	9,600
13			$23,200
		Other Annual Labour Costs:	2,320
		Total Annual Labour Costs:	$25,520

5. DATA FOR ECONOMIC ANALYSIS

A. FIXED INVESTMENT

	$
i) Investment Cost :	
Machinery and Equipment	24,000
Land and Building ($100m^2$ x \$120)	12,000
Freight and insurance	3,600
Installation	4,800
	\$ 44,400
ii) Working Capital :	
Stock of materials(3 months)	2,080
Wages and Salaries(2 months)	4,253
	\$ 6,333
iii) Residual Value :	$
10% of Equipment Costs(cif)	2,760
50% of Building Costs	6,000
	\$ 8,760

B. ANNUAL OPERATING COSTS

	$
i) Materials :	
Sugar cane	4,160
ii) Wages and Salaries	25,520
iii) Maintenance (6% of machine value)	720
vi) Overheads	500
Total annual operating costs	\$ 30,900

C. EVALUATION (Values in US \$)

This is based on a 10-year operating life, a 2-year build up to full capacity production and a residual value for buildings and equipment. The fixed investment amounts to \$44,400. Working capital amounts to \$6,333 taken in the first year of operation, and the residual value of \$8,760 and the working capital are returned in the 10th year of operation.

The production costs build up as follows:

	Year 1 (65%)	Year 2 (100%)
Materials	\$ 2,704	\$ 4,160
Wages and Salaries	16,588	25,520
Maintenance	468	720
Overheads	325	500
	\$ 20,085	\$ 30,900

The following are the results of NPV analysis:

Discount Rate	Present Value of Total Costs	Annual Revenue Required for Given Discount Rate	Revenue Required per litre
10%	224.381	38.508	0.77
20%	167.785	43.017	0.86
30%	135.362	47.969	0.95

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