Commercial production of energy efficient biomass stoves for the commercial and institutional sector

Manual for producers, promoters and users

Contents

1 WHY IMPROVED COMMERCIAL AND INSTITUTIONAL WOOD STOVES?

Cooking in large catering establishments such as restaurants and hotels, and schools and hospitals, is a large user of energy. In many parts of the World this cooking is fuelled primarily by wood - gas and electricity supplies being either unavailable, unreliable or too expensive. East Africa is no exception and this manual is one of the outputs from a project for the UK Government's Department for International Development to promote energy efficient wood stoves in commercial and institutional kitchens in Ethiopia, Kenya, Tanzania and Uganda.

By way of a regional example, about 11% of commercially traded wood fuel in Uganda is used in commercial establishments and government and private institutions[1]. This amounted to 384,000 tonnes of wood in 1994. Similar figures are found throughout East Africa and other parts of the World. The rest of the traded wood fuel is used by industries, for whom many of the stove designs are also suitable, particularly for food processing, and by households particularly in urban and peri-urban areas.

The cost of this wood can be 15 – 20% of the kitchen budget for institutions and restaurants so by using wood more efficiently significant running cost savings can be made. There are other benefits from the use of well designed fuel efficient stoves in large catering establishments, they include:

- removal of smoke and gases from the kitchen
- a cleaner kitchen environment
- reduced risk of burn injuries
- more control of the cooking temperature
- reduced kitchen air temperature
- improved kitchen layouts and working positions for staff

In addition there is an environmentally driven agenda for the promotion of improved stoves. Deforestation is a continuing problem in many parts of Africa. The trade in commercial wood fuel is one factor putting pressure on wood resources. If the wood fuel can be used more efficiently at its end-use point the overall effect is to reduce the amount of deforestation for this purpose.

It was this environmental agenda which drove research and development in institutional stoves in Kenya in the 1980s with NGOs such as Kengo and the Bellerive Foundation developing stove models to suit the cooking needs of Kenya. It was found that suitable designs could reduce wood fuel use by half, a 50% saving on fuel bills. This showed that improved stoves have payback periods of less than two years in institutions such as schools and under a year in commercial restaurants, hotels and bakeries.

Other NGOs, such as those concerned with health, education and other social needs have focussed on stove development as a way to reduce the running costs of institutions and to improve the kitchen environment.

[1] EC funded "Woody Biomass Derived Energy Study" – Forest Dept., Min. of Nat. Resources, Uganda, 1995

2 COMMERCIALISATION

2.1 WHY COMMERCIALISE PRODUCTION?

Early work to produce institutional stoves came through NGOs and Government programmes. These were necessary to carry out the required design, laboratory testing and field work to develop the new products. Promotion and dissemination were also activities where NGOs and government were able to assist the programmes. Once the benefits these products delivered became clear the private sector began to take an interest, particularly in Kenya. With fuel savings of 50% and firewood prices remaining fairly constant it made financial sense for institutions and businesses to invest in the improved stoves. Good quality production finish also gave the products a modern image thereby breaking down the old fashioned image wood stoves usually have. At first the subsidised NGO programmes tried to compete with the private sector market entrants but this could not be justified and now in Kenya there are around 20 private manufacturers of commercial/institutional stoves. The rational for this is why should NGOs and governments become involved in what are commercially viable activities. By allowing the private sector to operate freely the production of the stoves does not rely on foreign donor inputs or government expenditure. Both these sources are always at risk from changing priorities and budget cuts. Where governments, NGOs and other donors can have a role is in the following activities:

- Technical training of stove producers
- Promotion and dissemination
- Monitoring and quality control
- Business training
- Assistance with provision of loan finance

2.2 STEPS TO COMMERCIALISATION

Figure 1 is a flowchart setting out the steps required by a government or donor funded programme to set up commercial manufacture of institutional stoves. In fact this process can also be used for the commercialisation of household stove production or any other renewable energy or energy efficiency product which has an economically viable market.

2.2.1 Needs assessment

Are improved institutional or commercial wood stoves actually needed in the area where the programme is planned? In many areas this is likely to be the case but some preliminary investigation is required to find out if wood is being used widely as a fuel in these sectors and whether the businesses and institutions are paying for their fuel. This is not the same as “perceived need” as many of the users of traditional stoves will not be aware that alternatives are available. Improved stoves to them may just mean changing to gas, electricity or kerosene. Improvement of the kitchen environment may not be a priority to school heads or restaurant owners while it may be to staff. Potential fuel purchasers may be unaware of the savings they could make by reducing their wood consumption or switching from charcoal to efficient wood use.

Flowchart

Widespread use of wood or charcoal in the sector is often a good enough indication that an improved stove market exists or can be developed.

2.2.2 Market Assessment

A vital stage of the commercialisation process, this will be dealt with in more detail in Chapter 3. The market survey needs to identify the present users of large scale cooking stoves, what they cook, how they cook, how much they spend on fuel, and their willingness to invest in new stoves. The size ranges of restaurant and institution need to be surveyed and the size range of cooking pots used and quantity of food cooked daily. The results will provide input into the selection of stoves to design, test and manufacture, the target cost and hence quality of the stoves. The survey results will also assist in planning a marketing and promotion campaign for the stoves.

2.2.3 Producer surveys

This survey is to identify those who could produce the stoves. Firstly the group of artisans or groups most suited to producing the stoves should be identified. These will be the people with whom to concentrate training and support efforts. Secondly, it is important from the outset to involve more than one producer as this encourages competition and cost reduction. Time spent here understanding the dynamics and skills within the informal manufacturing sector will be rewarded later by greater project success. Chapter 4 describes these surveys more fully.

2.2.4 Product design

Designing the right product(s) for the market will make or break a stove commercialisation process. Information from the market survey on existing stoves being used will feed in here but do not be afraid to think originally, a different design from that normally accepted can also attract users to take it up. You do not have to start from scratch, stoves already used in other parts of the country, region or the world can be adapted for local conditions. In this project many of the designs promoted had already been marketed successfully in Kenya. In the household stove market the Lakech charcoal stove now highly successful in Ethiopia was an adaptation of the Kenyan Ceramic Jiko which itself had been developed from the Thai Bucket Stove. An important point to think about at this stage is why customers choose a stove, energy efficiency is not the only factor though it is a large one in the commercial institutional sector. Table 1 shows the results from the consumer needs and preferences section of the Ethiopia market survey.

Table 1 Consumer needs and preference survey

Preferences	Number of responses	Percent
Energy Saving	19	19
Smoke Removal/Chimney	12	12
Multi-sized Pots	10	10
Convenience	9	9
Speed (Fast Cooking)	6	6
Compact (in terms of space)	6	6
Clean/easy to clean	6	6
Portable	4	4
Health/Protection from heat	4	4
Heat Retaining	4	4
Durable	4	4
Multi-purpose (hot water)	3	3
Affordable	3	3
Attractive	2	2
Good Combustion	2	2
Others	4	4
Total	**98**	**100**

Other very important aspects to be dealt with at the design stage are ease of construction, availability of materials and cost of manufacture. Chapter 5 will look at this subject in more detail.

2.2.5 Laboratory Testing

It is important to know the combustion efficiency of the stove designs for the following reasons:

- To select the best design options
- To compare with the efficiency of the existing stoves
- To be able to assess the environmental impact of the promoted stoves
- To use this information for marketing purposes

Laboratory tests are not just about efficiency, ease of use and practicality need to also be assessed at an early stage. A highly fuel efficient stove is not much use if it goes out all the time or fails to bring a pot of water to the boil within a reasonable time. Field trials will further highlight such points but it is better to start identifying them at an early stage. Chapter 6 discusses stove testing methods.

2.2.6 Pilot production

This is where the producers are really brought into the process. Once a design has been developed and tested the next stage is to make a pilot production run of a few stoves. It is a good idea to commission two or three producers to make these. This should be seen as part of the producer training process. The project team work alongside the selected producers to explain the design and monitor the production. Financial assistance would be given possibly in the form of a direct purchase of a number of stoves, say 3 –10 per producer in the case of commercial stoves which are expensive items. Having the producers work closely with the

design team is important as there will be feedback from the producers on ways to make production easier and reduce cost while the design team will want to maintain efficiency and quality.

2.2.7 Field trials

Field trials take place in selected institutions or commercial establishments that have shown an interest in the stoves. Stoves would normally be installed free but for a limited period or with an option to purchase a stove at a reduced price once the trials have been completed. Monitoring of fuel use (wood, charcoal, kerosene, electricity etc.) will take place before the trials with the existing cooking facilities. Interviews with staff should take place at this point regarding their satisfaction with the stoves they are presently using. Once the stoves are installed the fuel use is again monitored, staff satisfaction is also surveyed throughout the trial which should be continued for 1 month. It is very important that staff are given full training in the use of the stoves before the trials. This includes wood preparation and storage. Often wood for improved stoves needs to be cut to a smaller size and stored in a dry place. It is important that owners and managers also appreciate the importance of a quality fuel and that this may mean more time being required by cooks to prepare fuel or the purchase of fuel readily prepared. Neglect of this aspect can lead to disaffection by staff due to increased workload or poor performance of stoves due to wet or overlarge firewood. Results from the field trials will feedback into the final design of the stove.

2.2.8 Market trials

Once the field trials are completed and any design defects identified and rectified, the improved stove is ready for market trials. The producers are responsible for conducting these with support from the project team. At this point the stoves should be sold on an open market to real customers, these may include those who were involved with the field trials but also new customers who purchase the stoves. This does not mean that innovative financing mechanisms such as credit or free trial periods cannot be used at this stage to encourage purchasers to try out the stoves. Commercial/ institutional stoves can be expensive items (e.g. $500-$1000) so incentives such as this are often necessary to get customers to try them out. The new customers will also be monitored closely, though in their eyes this will be presented as after sales service. This is a crucial stage as the perceived success of the product can make or break it. The satisfaction of the new customers and the word of mouth review they give to others will count for a lot at this stage. Those who buy the stove at this stage are called the “early adopters” and are only a small fraction of the total market. Those more cautious will be watching carefully to see the reaction of the first customers to the product. It is, therefore, even more crucial to give full training to staff and managers at this point to ensure the stoves are used correctly. One rule used by the Kenyan manufacturer who provided technical input to the project is to refuse to commission new stoves until correct wood storage systems have been put in place and training given to staff.

2.2.9 Acceptability assessment

The final stage of the commercialisation project is to carry out an acceptability assessment with the original customers of the new stoves. This will generally take place some time after the market trials (3-6 months) and new customers who have purchased stoves since the

market trials as well. This will pick up more long term problems such as durability of stove components, persistent incorrect use by catering staff and seasonal variations. A good example from the Ethiopian commercial injera cooker acceptability assessment was identifying a rain water leakage problem where the chimney exited through the kitchen roof, this problem only surfaced during the rainy season and was easily rectified.

2.2.10 Next steps

The completion of the commercialisation process is not the end of the work of a stove development team. Continuing assistance should be given to producers to:

- Attract new producers
- Improve production techniques and reduce production costs
- Maintain quality
- Promote and market the stove to new markets and new regions
- Help producers access finance to grow their businesses
- Provide further business training to producers

The following chapters go into some of the steps in the commercialisation process and other issues in more detail.

3 MARKET ASSESSMENT

As mentioned earlier the market assessment provides information which can assist several of the subsequent stages of a commercialisation process. These include:

- the producer survey - current users of large cooking stoves may be able to supply information on the current manufacturers;
- product design- the survey should identify the requirements of stoves for the market, this information will feed into stove design;
- field tests – institutions and establishments contacted during the market survey may be suitable for field tests;
- market trials – the marketing approach to be adopted during market trials will be developed using information from the market survey

In addition to the commercialisation process the market survey will feed into general awareness and promotion campaigns.

Commercial and institutional kitchens should be covered

To avoid focus on one particular type of user, kitchens to survey should be drawn from the following non exhaustive lists.

3.1 COMMERCIAL SECTOR

- Bakeries
- Restaurants
- Hotels
- Bars
- Small food processing industries

3.2 INSTITUTIONAL SECTOR

- Hospitals
- Schools
- Prisons
- Military
- Religious missions

Stratify the sample to cover small, medium and large commercial and institutional users

3.2.1 Data to collect

(A fuller survey is attached in Appendix 1)

1. Details of the establishments - size, no. of staff, meals served, etc.
2. Details of cooking utensils – pot sizes. material of manufacture, cost, etc.
3. Details of energy sources used – fuel, quantity, cost, end use
4. Details of appliances used – type, fuel, number
5. Details of energy efficient appliances used – wood, charcoal, perception
6. Consumer needs and preferences – staff, owner, priorities

4 PRODUCER SURVEYS

The groups from which possible stove producers may come include:

- Existing manufacturers of commercial/ institutional stoves
- Manufacturers of household stoves
- General metalwork fabrication shops
- Bricklayers and masons who may install permanent masonry stoves
- Appropriate technology workshops

If you do not know where to identify possible producers you could try some or all the following channels:

- Shops marketing household stoves may be able to tell you about suppliers or the area in town where most stove manufacture is located
- Schools with large catering requirements may have been approached by stove suppliers before
- Restaurants will have several large stoves, find out where they got them from
- Development agencies such as Oxfam, GTZ and others may have been involved in the past with stove manufacture and may have contacts with interested producers
- Advertise in the newspaper and hold a meeting for interested persons

Once you have contacted potential producers a survey is required to establish for each of the groups:

- Present models produced
- Present production capability
- Training needs
- Interest in the programme

In the present project the Ethiopian team used a selection process to identify the most suitable group of producers (Table 2) and then the producers themselves (Table 3) they thought most likely to make a success of the commercialisation training. See Tables 2 and 3 below:

Table 2 Metal workshop Group Selection Criteria.

Key:
High: Highest quality office furniture, hospital beds, file cabinet, …etc.
Medium: Doors, windows, water tankers, …etc from sheet metal.
Small: Domestic utensils (stoves, plates, and pots) production (scrap) & repair.
Micro: Subsistence: Most of Lakech Mirte Producers are in this category.

Criteria	%	Sectors			
		Formal		Informal	
		High	Medium	Small	Micro
Interest in the Project	**30**	**5**	**10**	**20**	**30**
Relevant Experience:	**15**	**5**	**8**	**14**	**10**
Metal Works	5	5	5	4	1
Previous Project Stoves	5	0	1	5	5
Non-project Stoves	5	0	2	5	4
Level of Support Required:	**25**	**25**	**20**	**10**	**5**
Space/Workshop/Location	10	10	10	5	4
Working Capital	5	5	3	1	0
Equipment and Tools	5	5	5	2	0
Technical Assistance	5	5	2	2	1
Quality Standards	**10**	**10**	**9**	**7**	**5**
Reliability (to stay with project)	**10**	**1**	**3**	**7**	**10**
Overhead Cost (profit margin)	**10**	**0**	**2**	**7**	**10**
Total	**100**	**41**	**52**	**65**	**70**

Table 3 Producers Selection Criteria

Selection Criteria	%	Producers											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Interest	**15**	15	10	15	15	10	15	10	8	15	10	15	15
Business Skills	**15**	15	10	13	13	10	10	15	12	10	15	12	10
Technical Skills	**15**	12	15	12	10	10	15	15	12	15	12	12	10
Workshop & Location	**15**	10	15	10	15	10	10	15	10	15	10	10	10
Level of Support	**15**	10	12	10	10	8	12	10	10	12	12	10	10
Project Experience	**10**	10	10	10	10	8	8	10	8	6	9	8	8
Reliability	**10**	10	5	10	9	9	8	5	8	6	8	6	8
Full Time Job	**5**	5	2	5	5	4	3	4	4	2	2	2	5
Total	**100**	**87**	**79**	**85**	**87**	**69**	**81**	**84**	**72**	**81**	**78**	**75**	**76**

5 PRODUCT DESIGN

- What does market (cook) want?
- Who can produce it?
- How can it be produced easily, more cheaply, better?
- How can the new or improved product be linked from producer to market with minimum intervention?
- How can readily available materials, existing skills, etc. be used?

Product design relies upon information gathered during the previous assessment phases.

The **Market Assessment** will provide information on:

- What the market place expects
  - Stove types
  - Pot sizes
- The cost that is acceptable
- Quality and finish
- Expected environmental improvements

The **Producer survey** will have established what, with any required training, the local manufacturers can produce. How existing manufacturing methods, traditions can be exploited.

A third source of information and expertise are **external inputs.** These can have a large impact and should be brought in by the project team. Stove designers or manufacturers from neighbouring regions or countries or with experience in the types of stove the project is to promote should be brought in to give design advice. This may of three kinds:

- to transfer a technology already developed and proven elsewhere;
- to adapt a design from elsewhere for local use and manufacture
- to assist in designing a new stove from scratch but building on their knowledge of combustion processes and other stoves

5.1 TARGET DESIGN CRITERIA

It is s good idea to set down the expectations you feel the market has for the stove before the design is made, these are the design criteria. Example 1 below, from this project, can illustrate the point. The Ethiopian team set out to introduce a new “Wot” stove (a stove for cooking sauces and stews) to be used primarily by restaurants and bars. The existing stoves had the following failings identified in the market assessment. These and their resulting design criteria are copied here from their technical report.[2]

[2] Report on technical issues of commercial”injera” and “wot” stoves, Megen Power, June 1988

Example 1 - THE TRADITIONAL ETHIOPIAN " WOT" STOVES:

It is understood that the traditional institutional stoves are inefficient from the point of view of performance. Performance here manifests altogether the power output of fire, the range of power output, efficiency, ease of starting, tar formation, maintenance and life expectancy. The efficiency of these stoves varies with such factors as power out put, moisture and density of fuel, and pan base area to mention a few.

The inefficiency in traditional commercial and institutional stoves in Ethiopia in general is attributed to:

A. There is no control mechanism of airflow through the door.
B. Very wide combustion volume (not proportional to other stove sections)
C. In most cases the pots are resting on the top of the stove (no shielding) which enhances the energy loss through radiation
D. The stoves have unbalanced designs between the different features & sections which makes them uncomfortable.
E. They are very risky of fire burns and are unhealthy due to smoke emissions and generally are not safe for cooking.

Design criteria for improved Ethiopian institutional "WOT" stoves.

1 - The stoves should not cost more than 1500 EB.
2 - The stove design should be able to accommodate 2 - 6 pots based on the customers interest.
3 - The savings on fuel should be 50% over the traditional and/or the open fire.
4 - Stoves should have long lifetime, low maintenance, cleaning and repair requirements.
5 - Stoves should put maximum length of 0.5m
6 - It should be easy to light and should heat up very quickly
7 - The stove should be powerful enough to boil water in maximum of 45 minutes.
8 - Smoke should go out of the kitchen
9 - Fire require minimum attendance.

5.1.1 Design considerations

- Cost
- Will stove save money/time?
- Ease of use
- Comfort
- Lighting difficulties
- Different sizes of pot
- Height
- Safety
- Durability
- Maintenance
- Portability
- Fabrication
- Available materials

5.2 DESIGN ASPECTS

It is not intended that this manual be a comprehensive technical design manual for commercial stoves, a manual dedicated to that purpose would be more appropriate. However, it is worth indicating a few of the design issues surrounding the major components with examples from the project.

5.2.1 General design

5.2.1.1 Built-in or portable designs?

Built in stoves

Both multipot and the large single pot institutional stoves can be built as permanent kitchen features with masonry stove bodies and chimneys. Stoves of this design can be found in many parts of the world in institutions.

Advantages
- They are durable
- They can be built by local masons.

Disadvantages
- They are expensive to build
- Each stove is a one off so there are no economies of scale.
- They are of a massive construction and can take a long time to heat up.
- Chimney cleaning can be difficult.
- The manufacturers, being masons, may not be well trained in stove design.
- If fire boxes and chimneys are not correctly sized the stoves may not be fuel efficient or easy to use.
- There is a lot of disruption in the kitchen during installation
- They take up a lot of space in the kitchen

Portable stoves

These stoves provide the same service as the built in stoves but have a different construction approach. They are fabricated from steel with insulation provided by bricks or lighter insulation material such as mineral wool or vermiculite. They are manufactured in a workshop and then transported to the point of use for assembly. Chimneys are generally made of metal.

Advantages

- They can be produced on a batch or production line process, reducing costs
- They heat up quickly being less massive than built-in stoves
- Chimneys can be easily dismantled for cleaning
- Spare parts can be easily supplied and fitted
- They are produced by dedicated stove producers who know about stove design
- They can be assembled and installed quickly
- They can be moved to another place if necessary
- They can be made with an attractive modern appearance

- They can be transported to remote areas fairly easily

Disadvantages

- Expensive
- Training of kitchen staff is required

The project is generally in favour of the more portable metal and insulation style of designs because of the above listed benefits. However, some built in designs can be perfectly functional and save fuel. The following design information will be based around the portable models.

5.2.2 Materials

5.2.2.1 Stoves

The primary construction material defining the shape of the stove is steel, this can be mild, galvanised or stainless depending on cost and function. Painted mild steel can be a suitable material in some situations as can galvanised steel. For the best finish and durability stainless steel can be used but this is often not available or very expensive. It is important that the gauge of material used matches the function of that component, material too thin will corrode and be damaged quickly but material that is not load bearing and simply there to present a good appearance should not be of too heavy gauge as this adds unnecessarily to cost. Consider using scrap material where possible, recycling of stainless steel is particularly worthwhile.

5.2.2.2 Pots

Pots can be made from aluminium,(cast, spun, pressed or welded), cast iron, steel (mild or stainless) or ceramic. The most common choices for institutional stoves are aluminium or stainless steel. Aluminium are cheaper but less durable. Stainless steel pot manufacture requires inert gas welding equipment.

5.2.3 Insulation

Bricks are the most commonly used material. If stoves are being installed some distance from the place of manufacture it may be best to purchase the bricks locally and install them in the stove on site. Other suitable materials, especially for stoves that need to be particularly portable or need to be supplied in a finished condition are mineral wool and vermiculite. Vermiculite cement is also a useful insulating material.

5.2.4 Fuel and air inlet

This needs to be correctly sized to allow fuel of the correct size into the firebox. If it is too large it will encourage kitchen staff to feed in large logs and even whole uncut poles. This will also prevent the fire door from being shut. The fire door design should be such that it closes automatically unless deliberately propped open. Vents in the door should be adjustable to allow regulation of air to the firebox.

5.2.5 Combustion chamber

This should be sized and positioned carefully. Two large a firebox will encourage excessive fuel use. Multipot stoves only need a single firebox. Under this project we have manufactured and supplied 12 pot stoves with a single firebox! Four have been supplied so far responding to demand. It is not necessary for each pot to have firebox. The combustion chamber should be positioned so that the flames pass around the pots before reaching the chimney. Fireboxes too close to the chimney will cause flames to pass directly up the chimney, this is energy inefficient and damages the chimney.

5.2.6 Grate

A grate used in institutional stoves improves the performance of the stoves. The principal reason being that the primary air enters from under the grate and passes through the fuel bed. Thus a grate combined with a regulated air system produces considerable improvements in fuel economy. Grates can be made from fired clay, steel bar or cast iron. Cast iron are the most durable but the most expensive. A grate made from welded reinforcing bar is perfectly functional but will require replacement on a regular basis depending on use.

5.2.7 Chimney

Chimney design is crucial for good combustion and fuel efficiency. Advice from an experienced stove manufacturer is invaluable here. Too small a diameter will lead to a lack of draw making the stove difficult to light and smoky. Too large a diameter will give too much draw making the stove energy inefficient and it could lead to combustion in the chimney itself causing damage. Often stoves are arranged in groups of 2,3 or 4 with the flues feeding into a single chimney. Sizing is crucial here particularly as sometimes not all the stoves will be operated and sometimes they will. Be prepared to experiment with chimney size in the workshop to find the optimum diameter for the stove,

5.2.8 Dampers

Dampers are fitted in the chimney to give some regulation of the effect of the chimney on the stove. These features can compensate for some of the problems listed above in 5.2.7 but they should not be used to make up for bad chimney design as cooks may not use them. They can also help compensate for varying external windspeeds.

5.3 GENERAL DESIGN SUMMARY

Design is always an optimisation process involving the efficiency and performance of the stoves, material selection and possibilities and skills of construction. Good design enables operational convenience and also considers socio - economic matters. Diverse stove designs and methods of production should be investigated. Costs and benefits of each method should be analysed. Then determine whether stoves can be produced that will technically perform to satisfy the defined felt needs and/or problems at affordable prices. The basic principles in designing stoves are the same everywhere. However, it is necessary to modify as to the needs and local conditions.

6 PHOTOGRAPHS

7 STOVE TESTING

This manual is intended to fill an information gap on how to commercialise the production of fuel efficient wood fuelled commercial and institutional stoves. As noted in the design section it is not intended to become a detailed technical manual. However, it is necessary to give some information on stove testing so that producers, and those supporting projects to train and assist producers, have an idea of what priority they should put on stove testing and where information can be found.

There is a wealth of information on stove testing, mainly carried out for household stove testing it is usually directly relevant for larger comm./inst. stoves also. Publications include:

1. Improved wood waste and charcoal burning stoves, Bill Stewart – IT Publications. 1987.

2. Testing the efficiency of wood-burning stoves, VITA 1985.

The following section will give an introduction to stove testing explaining why and how it is done.

7.1 WHY CARRY OUT STOVE TESTS?

As listed in Section 2 it is important to know the combustion efficiency of the stoves being manufactured for the following reasons:

- To select the best design options
- To compare with the efficiency of the existing stoves
- To be able to assess the environmental impact of the promoted stoves
- To use this information for marketing purposes
- To be able to evaluate the effect of future modifications on efficiency
- To monitor the quality of future stoves production in terms of efficiency by comparison with the first pilot production.

Tests are usually of two types **laboratory testing** and **field trials.**

7.1.1 Laboratory tests

Do not be put off by the term “laboratory “ – these tests are usually carried out in the workshop or a small structure erected for the purpose. The most important items needed are a stop watch and a reasonably accurate balance.

Laboratory tests are themselves of two types:

7.1.1.1 Water boiling tests

Water boiling tests use simple methodologies involving boiling fixed volumes of water over periods of time and measuring the quantity of wood used. Comparison can be made between traditional stoves and improved designs. Overall stove efficiency can also be calculated if required.

7.1.1.2 Controlled cooking tests

In these tests, instead of water, the kind of food the stove is designed to cook is prepared under controlled conditions. A trained cook is needed to carry out the test as they can judge that the food has been prepared properly. The amount of fuel required by different types of stove to prepare the same amount of an identical meal can then be compared.

7.1.2 Field trials

- Choose "representative" institutions based upon needs & market surveys
- Choose control & test groups to test appliances "objectively"
- Introduce appliances & gauge responses
- Encourage ruthless critique & criticism
- Take results & reapply them to design
- Get "go", "no go" signals

Once laboratory testing has been completed and any required modifications to the design made the next stage is to try out the stoves in representative kitchens. These kind of trials are not complicated but careful planning is required so that meaningful results can be obtained. The establishments to be used in the trials should be identified some time before the trial so that existing fuel use with their current stoves and cooking methods can be measured. They should be shown how to weigh their wood and measure how much they use on a daily basis. Other details such as number of meals served should also be recorded. They should be encouraged to use air dried wood for both the period before the new stoves are installed and afterwards so that comparison is of like with like. Once the new stoves are installed it is necessary to know if all the cooking is now to done on these stoves or only a proportion. If only a proportion, the comparison must be made with the stoves that have been replaced.

To be statistically significant a certain number of tests must be performed. The following table, Table 4 gives the number of tests required relative to the expected differences in fuel use between the traditional and new improved stove.

Table 4: Minimum numbers of kitchens to be included in trials relative to expected difference in fuel use for different stoves

Expected difference in fuel use (%)	10	20	30	40
Minimum number of kitchens in trial*	54	14	7	5
* Corresponds to a Coefficient of Variation of 0.4; 10% level of significance				
From *Testing efficiency of wood-burning stoves, international standards, VITA, 1985*				

Fortunately in the case of the institutional and commercial stoves improvement in efficiency of greater than 40% can generally be expected meaning that trials in about 5 kitchens or less should be sufficient.

The additional advantage of field trials is that a large amount of the information needed for the acceptability assessment can be collected at the same time.

7.2 COMMENTS ON STOVE TESTS

It is should be kept in mind that while tests are important and need to be carried out carefully and thoroughly so that like is compared with like and the results are meaningful, we should not get too theoretical. If a highly complicated stove testing programme is initiated in a commercialisation process it could alienate both the producers and the potential customers volunteering for the trials.

The water boiling test can be quite sufficient to highlight clear benefits of improved stoves over the traditional design. In this way you can measure the relative amount of fuel used by each stove to boil the same amount of water. Rather than being fixed on the idea of overall efficiency, which is a difficult concept for many users, the concept can be the saving achieved by the improved stove over the original stove. For example " In a test bringing 50 litres of water to the boil and then boiling off (evaporating) 10 litres of water the improved stove used half the amount of wood as the traditional 3 stone fire".

Example 2 below is from Ethiopian stove tests on the Commercial "Wot" stoves used for sauces and stews. The report describes their laboratory water boiling tests.

Example 2 TESTS ON COMMERCIAL WOT STOVES:

OBJECTIVE:
The objective of the test was to determine the performance of commercial wot stove with the existing or traditional open fire stoves. Tests were conducted on both open fire as well as commercial wot stove. The result of this test would help us to measure up the performance with open fire.

OBSERVATION OF THE TEST:
Seven tests were performed on the commercial wot stove and four tests on the open fire. The test results on Commercial Wot Stove have exhibited an increase in efficiency. The main reason is attributed to the possibility of cooking using four pots at the same time with only one fuel inlet, in which case it was possible to see improvements in the modes of heat transfer i.e radiation, convection and convection.

POSSIBLE IMPROVEMENTS:
- The stove brought all 4 pots to the boil in 17 minutes. The idea suggested here is that to minimise the time it would be necessary to take the grate to the middle of the combustion chamber and lower the angle of the brick wall at the back of the stove.
- It would be necessary to see the effect of the height of the combustion chamber by lowering it to 75% of the existing height. We believe that this would improve the power of the stove during simmering.
- The grate holes size should be minimised by half so that embers and unburned wood can not fall down to the ash box with out giving their total potential energy.
- The fire went off when the main door was closed and the secondary air inlet was open. One of the probable reasons for this is because of the small amount of air introduced to the existing volume of combustion chamber. It is therefore important to widen the area of the secondary air inlet.
- There should be a small pot sink in the middle of the stove in order to exploit the use fuel energy that is dissipating through radiation at the center of the stove.

The following table explains the performance of the stoves.

Stove Type	Ignition Time (min)	Time to boil (min)	Ave.time/pot to boil 6 lit water (min)	Efficiency (%)
Commercial wot stove	2 - 3	24 lit - 17	6	12
Open fire	2 - 3	6 lit - 32	32	8

It is possible to deduce from the above table that Open Fire stove has a similar starting time with Commercial stove. Presumably, this is the only point where the open fire is competing with the commercial stove. Generally the Commercial Wot Stove will create a significant improvements to fuel saving and in general improves the kitchen drudgery in Ethiopian small and medium hotels and hotel and restaurants. A fuel saving of over 50% was achieved compared to the traditional three stone fire. Also other improvements like smoke withdrawal, safety, hygiene (health), comfort and speed are the advantages observed during the test.

8 PRODUCTION

Production has two phases, **pilot production** followed by field tests, market trials and an acceptability assessment and then **full production** once the results of the pilot production and trials have been assimilated into design. An important aspect of the production phase as far as the project is concerned is that this is when the closest involvement with and training of producers takes place.

8.1 PILOT PRODUCTION

- Go back to the market
- Choose your producers
- Make links between producers & market
- Ensure materials are available
- Ensure producers understand consumers
- Produce cheaply, easily
- Learn by pilot production

The purpose of this phase is to produce a batch of prototypes which are to be used for field tests and market trials. They will incorporate improvements that were required as a result of the laboratory testing. At this point it the producer and project team will be looking at ways in which cost of production can be brought down by batch processes, bulk purchase of materials and use of substitute cheaper materials. However, it is important that quality is not compromised at this point. These are the first products to go out into the market place and they need to make a good impression. It is likely that some project funds are available at this point to subsidise production and it is well worth while spending a little more than the target price of the production model to ensure these stoves:

i) have an attractive finish
ii) are strongly made and will not fail during the field tests and market trials

8.2 FULL PRODUCTION

Once the field tests and market trials have been completed and further improvements suggested by users and producers the workshops can move on to full production. There are some decisions to be made here, do you:

- produce only to order
- produce models to keep in stock?

Is production:

- on a one off basis
- a batch process
- a production line?

These options will be decided by the demand for the stoves in the market place and the resources the producer has in terms of manpower, workshop space, materials, cash in the form of capital or loans.

A this point the production cost of the stove must be examined in detail. The entire cost of production must be broken down into its integral parts of labour, materials, transport, power etc. for each process in manufacturing the stove. It is very important that the producer knows the full cost of the stove they are producing. It is very easy to look at what they think the market will bear or at the cost of another product and think that is therefore the price that their stove must be. This may not be the case at all, it could be cheaper for them to produce it and therefore they can undercut other products. It may also be that their production costs are more expensive. In this case you either need to present the advantages of your product to the customer and explain why they should pay more or reduce your costs so that you can still sell the stove at the perceived market price, cover your costs and make a small profit.

The Example below from Ethiopa below shows the breakdown of costs for the two stoves developed by the Ethiopian project team.

Example 3 Cost break down for the inst. Mirte and commercial Wot stoves.

INSTITUTIONAL MIRTE		**COMMERCIAL "WOT" COOKERS**	
Raw Materials	**Et.birr Amount**	**Raw Materials**	**Et.birr Amount**
Main body	51	Sheet metal	200
Door section	20	Angle iron	60
Chimney box sec.	23	Bricks	75
Flat iron	3	Cement	30
Mirte Stove	25	Sand	30
Mtad	7	Flat iron	30
Hinges	4	Round bar	20
Chimney	30	Pots	400
Sand & Cement	7	Welding materials	22
Welding materials	4	Paints and thinner	15
Paints & thinner	4	Hinges	15
Labor		Labour	
Direct	43	Direct	125
Indirect	50	Indirect	150
Overhead		Overheads	
Workshop Rent	15	Workshop Rent	60
Electricity	5	Electricity	20
Water	1	Water	5
Transport	5	Transport	50
Depreciation	9.25	Depreciation	92.5
Profit	60	Profit	350
TOTAL	**366.25**	**TOTAL**	**1749.5**

9 MARKETING AND PROMOTION

Marketing and promotion strategies will vary from place to place and country to country. The ideas presented here come predominately from the project workshops in Kenya, Ethiopia, Tanzania and Uganda. The one thing that is sure is that the producers will have to do some marketing and promotion. Most methods are mentioned here but the task of the producers or sales rep is to identify the most suitable for their area. One way to do this is to see how other products are typically marketed locally.

There will be two main customer bases:

i) Commercial establishments: Hotels, bakeries, restaurants, bars, food processing industries, etc.
ii) Institutions: Schools, hospitals, prisons, refugee camps, military camps, etc.

For both you need to assure:

- Quality
- Price competitiveness
- Guarantees & follow-up

9.1 MARKETING METHODS

9.1.1 Literature

- Brochures
- Posters
- Newsletters
- Periodic letters to institutions/ mailshots
- Calendars

9.1.2 Demonstrations

- Trade fairs, shows
- Large meetings of prospective clients e.g. National school heads meetings
- Special request exhibitions
- Market place demonstrations
- Exhibit on prominent junctions

9.1.3 Direct marketing

- Visit establishments
- Telephone establishments

9.1.4 Media advertisement

- Newspapers
- Trade and Telephone Directories
- TV programmes

- Radio programmes
- Bill boards

9.1.5 Financial inducements

- Credit, higher purchase
- Money back guarantees
- Strategic price cuts, sales
- Bulk discounts

9.2 COMMERCIAL ESTABLISHMENTS

Marketing and promotion methods suitable for commercial clients:

- Credit (instalment payments)
- Media (newspaper, tv, radio)
- Money back guarantees
- Market demonstrations
- Shows, trade fairs, etc.
- Price cuts
- Leaflets
- Display stoves at key junctions
- Calendars

9.3 INSTITUTIONAL ESTABLISHMENTS

Marketing and promotion methods suitable for institutional clients:

- Workshops (different people from different agencies to learn from one another, gain information, exchange ideas, etc.)
- Trade fairs, exhibitions
- Donors
- NGOs
- PVOs
- Mail shots
- Personal visits
- Periodic letters
- Newsletters
- Calendars
- Credit
- Government promotion campaigns

10 FINANCIAL ISSUES

When in the introductory workshop for the commercial stoves project, producers in Ethiopia, Tanzania and Uganda all identified working capital and credit for purchasers as either their first or second highest priority.

It is vital that producers can get access to some form credit. Many producers are moving up from domestic stove production to larger stove production. They do not have the sort of capital in-hand to manufacture a large stove costing $ 200-500 or more.

The technology is new and the customer wants to see it work first. They are much more likely to agree to some form of instalment payment scheme or money back guarantee. These can win a producer a sale but they need the capital in hand to manufacture the stove and wait for the customer to pay them.

There are loan funds available from commercial banks but in most countries they are not suitable for small stove producers due to:

1. Requirement for collateral
2. High interest rates, 25%
3. Unproven, unknown products, lack of track record
4. Need for a commercial licence in some places

However, all is not lost, there are other sources of credit that can be assessed by producers:

1. Informal borrowing from friends and family
2. Traditional local credit schemes ("Ekub" in Ethiopia)
3. Charitable trusts such as the Gatsby Trust in Uganda and Kenya make small loans to manufacturing businesses
4. NGOs and other donors can provide revolving funds dedicated for stove producers
5. Revolving funds and credit unions aimed at stimulating small enterprise are ideal for stove manufacturers
6. Producers can form associations to help each other, raise funds and disburse small loans.
7. Producers can help each other by combining forces to supply large orders.

To enable loans to be received small producers need to prepare simple, but sensible and realistic business and marketing plans. Those controlling the source of funds need to see clearly what they plan to do and that is achievable.

11 ROLE OF GOVERNMENT AND DONORS

The theme of this project is that stoves should be manufactured and promoted through the private sector as viable commercial products. In the past governments and donors have subsidised stove manufacture but this has led to unsustainable production and a perception among some possible customer groups that these products are received “free” and should not be paid for. The role of government and donors should be enabling, removing barriers and impediments but it should not be over involved.

11.1 SUITABLE GOVERNMENT SUPPORT

- Formulation of appropriate energy policy and environmental protection creating the necessary awareness
- Fiscal & monetary policy in favour of promoting energy conservation
- Energy & environment in national curriculum
- Promote energy conservation to be taken up by NGO's and donors
- Import duty and tax
- Create a favourable environment - easier financial access/credit
- Applied research and development
- Promote/support energy related S&T activities (R&D, institutionalisation, information, training, technology etc.)
- Favourable policy ground to support = producers (association), consumers(quality; standardisation/labelling; credit; organisation)
- Promote/facilitate the dissemination of technologies
- Inter-ministerial steering committee on Energy

11.2 SUITABLE NGO AND DONOR SUPPORT

11.2.1 SUPPORTIVE

- Promote energy conservation and efficiency improvement
- Efficient forest management practices
- Facilitation for the development of the informal sector - community organisations
- Contribute towards the legalisation of credit facilities and guarantees

11.2.2 FACILITATIVE

- Support not compete with the private sector
- Assist with credit schemes
- Training and commercialisation programmes
- Help create the environment for business
- Reflect on government policies - lobby/advocacy function
- Promote networking amongst stakeholders
- Play a role in capacity building and training/workshops

11.2.3 INNOVATIVE

- Take the energy sector/energy conservation more seriously - clearly defined activities leading to some tangible impacts

- Play a role in monitoring and reiterative learning
- Bringing about innovative ideas/technologies

12 BUSINESS PLANNING

A commercial stove business is like any small business, it requires careful planning, hard work and continuous monitoring of performance, costs and profitability. Preparation of a simple but thorough business plan is one step towards making long term plans for the business. The section below gives some of the main sections that should go in a business plan.

12.1.1 Business plan format

1 Mission Statement
2 Background
3 Product description
4 Market Potential
Clients today
Clients tomorrow - Firm, likely, possible
5 Your products
6 Resource requirements
7 Funding/ loan requirements
8 Financial Analysis (including cash flow)

Year 1
Year 2
Year 3
Expenditures
Revenues
Product sales

It is not the intention of this manual to give detailed business plan development guidelines as there are plenty of generic books and information on the market dealing with this subject. In Appendix 2 there is an example financial analysis, profit and loss, balance sheet and cash flow, for an example stove business.

13 USING INSTITUTIONAL/COMMERCIAL STOVES

13.1 FIREWOOD PREPARATION AND STORAGE

One of the main differences that comes about when switching from a three stone fire to an improved stove is the preparation of the wood fuel. An improved stove must have chopped and dry fuel for the following reasons:

- Wet wood will deposit tar on the pots and in the chimney causing smoke and air flow problems
- Wet wood burns less efficiently
- Uncut wood prevents closure of the firebox door
- Uncut wood is not sized to suit the stove
- Uncut wood will lever and damage the stove

Ideally fuel should be chopped and stored in a ventilated but covered wood shed. This allows air drying and can prevent theft of wood if kept locked. Wood should be dried for at least 3 months after chopping.

13.2 USING THE STOVE

13.2.1 Lighting

Small pieces of dry wood should be used for initial lighting. The firebox dictates the size and amount of wood which should be used. The firebox door can be left open during initial firing to allow a flow through of air. Once burning well, larger cut logs can be added.

It is usually not necessary to have more than 3 or 4 pieces of wood in the firebox of a fuel efficient wood stove at a time. Once the stove is fired up the addition of a single piece of wood from time to time is sufficient.

Once larger wood has been added and the fire is burning well the door to the firebox should be closed and ventilation adjusted. The door should only be opened for the addition of more fuel.

13.2.2 Cooking and care of saucepans

Saucepans should always have liquid in them when on the stove. In some kitchens, once the food has been served the empty pans are replaced on the hot embers, this reduces the life of the pan. Large stainless steel and aluminium pans are expensive items. Pans should be cleaned after use outside and inside. A wood burning stove burning efficiently does not leave much soot on a pan.

13.2.3 Chimney cleaning

A good manufacturer of commercial/ institutional stoves will allow the chimney to be assessed easily. Soot can be scraped out of the chimney with a long stick or brush. This should be done regularly, every 2 weeks to 1 month.

13.2.4 Problem solving

1. Pans become black and covered in a thick tar - *Reason - wet wood is being used*

2. Chimney is too hot and becoming damaged by flames – *Reasons–I) too much draw on the stove, chimney incorrectly sized, too high or too large a diameter, OR ii) the firebox is too big and located next to the chimney. Both these faults as well as damaging the chimney will cause the stove to be inefficient.*

3. Kitchen is smoky – smoke leaking from the sides of the pans – *Reasons – I) wet wood is being used, clogging the air passages with tar, ii) chimney needs cleaning, iii) insufficient draw on the stove, chimney too narrow or too short*

Appendix 1 Market survey questionnaire

I. IDENTIFICATION

1.1Name of Interviewer .....
1.2 Interview Number .....
1.3 Date .....
1.4 Name of Establishment .....
1.5 Address .....
1.6 Tel .....
1.7 Name of Owner .....
1.8 Interviewed Person .....
1.9 Position/Rank .....
1.10 Address .....
1.11Tel .....

1.12 Physical Address: Building..... Rd/Street..... Town.....
Country.....

1.13 Year of Registration .....
1.14 Number of Years in Operation .....
1.15 Main Operations
i .....
ii .....
iii .....
iv .....

II. DETAILS OF ESTABLISHMENT

2.1 Number of Employees .....

2.2 Number of meals/people served per week: .....

III. DETAILS OF COOKING UTENSILS

				Sizes of pot		
Pot type	**Number used**	**How often replaced**	**Cost of pot**	**Diameter/cm**	**Height/cm**	**Volume /l**
Aluminium						
Cast Aluminium						
Stainless Steel						
Clay pots						
Others Please specify						

IV. TYPES OF ENERGY USED

Category	Hours per day	Times per day	Qty	Cost per day
Electricity				
For lighting	.....	.....	.....	.....
For cooking .	.....	.....	.....	.....
For baking	.....	.....	.....	.....
For ironing clothes	.....	.....	.....	.....
Others	.....	.....	.....	.....
Gas				
For cooking	.....	.....	.....	.....
For baking	.....	.....	.....	.....
Others	.....	.....	.....	.....
Kerosene/Paraffin				
For cooking	.....	.....	.....	.....
For Lighting	.....	.....	.....	.....
Others	.....	.....	.....	.....
Charcoal				
For cooking	.....	.....	.....	.....
For baking	.....	.....	.....	.....
For heating/Roasting	.....	.....	.....	.....
Others	.....	.....	.....	.....
Wood				
For cooking	.....	.....	.....	.....
For baking	.....	.....	.....	.....
For heating/Roasting	.....	.....	.....	.....
Others	.....	.....	.....	.....

V. LIST OF APPLIANCES USED

Category	Description of Appliance	Number of units
Electricity	i.....	....
	ii.....	....
	iii.....	.....
	iv.....	.....
Gas	i.....	.....
	ii.....	.....
	iii.....	.....
	iv.....	.....
Kerosene	i.....	.....
	ii.....	.....
	iii.....	.....

	iv.....	.....	
Charcoal	i.....		.....
	ii.....		.....
	iii.....	.....	
	iv.....	.....	
Wood	i.....		.....
	ii.....		....
	iii.....	.....	
	iv.....	.....	

VI. PREVIOUS EXPERIENCE OF ENERGY EFFICIENCY/IMPROVED APPLIANCES

(Complete for wood and charcoal improved appliances the kitchen or staff have used or have experience of - use a new sheet for each appliance)

i) Name of Appliance .....
ii) Improved by .....
iii) Improved unit bought from .....
iv) Name of Producer (if different from seller) .....
v) Date of purchase .....
vi) Purchase prices .....
vii) Efficiency rate .....
vii) Does the improved appliance save energy Yes..... No.....
viii) If yes, what are the savings made:

ix) Running costs

Amount of fuel Used /day,week,month	Length of time Stove is used	Cost
No. of bags.....	Hours/day.....	Per day.....
No. of lorries.....	Hours/week.....	Per week.....
No. of tons.....	Hours/month.....	Per Month.....
No. of Kgs.....		

VII. CONSUMER NEEDS AND PREFERENCES

Without prompting ask the responder to state up to 5 qualities they would expect from new stoves.

	Quality
1	
2	
3	
4	
5	

VIII. INTEREST IN IMPROVED APPLIANCES

(The person interviewed)

Is s/he interested in energy efficient appliances Yes..... No.....

If yes, specify the type s/he is interested in:

Ovens	……..
Institutional Stoves	……..
Multi-pot stoves	……..
Grills	……..
Other	……..

Comments/ Observations from the interviewer:

Appendix 2

Example financial analysis for a stove business

			1998	1999	2000	2001	2002
A	**Profit and loss**						
	1 Revenues						
	Stove sales units		100	150	200	250	250
	Stove sales income		$15,000	$22,500	$30,000	$37,500	$37,500
	Stove cost	150					
	Total Turnover		$15,000	$22,500	$30,000	$37,500	$37,500
	2 Expenditure						
	2.1 Production costs						
	Direct Labour		$3,000	$4,500	$6,000	$7,500	$7,500
	Raw materials		$1,500	$2,250	$3,000	$3,750	$3,750
	Factory overheads (rent,bills,etc)		$2,250	$3,375	$4,500	$5,625	$5,625
	2.2 Marketing and Admin costs						
	Salaries		$2,000	$2,000	$2,000	$2,000	$2,000
	Communications (tel, post)		$500	$500	$500	$500	$500
	Advertising and promotion		$500	$500	$500	$500	$500
	Transport		$500	$500	$500	$500	$500
	Water and electricity		$200	$200	$200	$200	$200
	Office supplies		$200	$200	$200	$200	$200
	Depreciation (equipment)		$4,000	$3,200	$2,560	$2,048	$1,638
	Insurance premiums		$200	$200	$200	$200	$200
	Miscellaneous		$200	$200	$200	$200	$200
	Total Expenditure		$15,050	$17,625	$20,360	$23,223	$22,813

3 Profit/loss

Gross profit	($50)	$4,875	$9,640	$14,277	$14,687
Interest @10%	($400)	($607)	($200)	($100)	$0
Profit before tax	($450)	$4,268	$9,440	$14,177	$14,687
Tax (@35%)	$0	$1,494	$3,304	$4,962	$5,140
Profit /loss after tax	($450)	$2,774	$6,136	$9,215	$9,546

B Balance sheet

Fixed assets					
Equipment	$16,000	$12,800	$10,240	$8,192	$6,554
Total fixed assets	$16,000	$12,800	$10,240	$8,192	$6,554
Current assets					
Debtors	$1,250	$1,875	$2,500	$3,125	$3,125
Bank Account	$0	$1,180	$8,167	$17,731	$27,882
Stock	$625	$938	$1,250	$1,563	$1,563
Current liabilities					
Creditors	($1,254)	($1,469)	($1,697)	($1,935)	($1,901)
Bank loan	($7,071)	($3,000)	($2,000)	($1,000)	$0
Net Current Assets	($6,450)	($476)	$8,220	$19,483	$30,668
Net Worth	**$9,550**	**$12,324**	**$18,460**	**$27,675**	**$37,221**
Financed by:					
Equity	$10,000	$10,000	$10,000	$10,000	$10,000
Reserves	($450)	$2,324	$8,460	$17,675	$27,221
Net Worth	**$9,550**	**$12,324**	**$18,460**	**$27,675**	**$37,221**

C **Cashflow**

Increase in capital	$10,000				
Sales	$13,125	$21,563	$29,063	$36,563	$37,500
Cash expenditure	($9,796)	($14,210)	($17,572)	($20,936)	($21,209)
Interest	($400)	($607)	($200)	($100)	$0
Tax	$0	($1,494)	($3,304)	($4,962)	($5,140)
Loan Repayments	($1,000)	($1,000)	($1,000)	($1,000)	($1,000)
Capital					
Over draft	$5,000				
Assets	($20,000)				
Net Cashflow	($3,071)	$1,180	$8,167	$17,731	$27,882
	($13,071)	$1,180	$8,167	$17,731	$27,882
Loan Balance	4000	3000	2000	1000	0
Interest	400	300	200	100	0

13.2.4.1.1 IRR Calculation

Trading outflows					
General purchases	($9,796)	($14,210)	($17,572)	($20,936)	($21,209)
Interest	($400)	($607)	($200)	($100)	$0
Tax	$0	($1,494)	($3,304)	($4,962)	($5,140)
Loan repayments	($1,000)	($1,000)	($1,000)	($1,000)	($1,000)
Assets	($20,000)				
Total Trading Outflows	**($31,196)**	**($17,311)**	**($22,076)**	**($26,998)**	**($27,349)**
Income	**$13,125**	**$21,563**	**$29,063**	**$36,563**	**$37,500**
Net cashflows	**($18,071)**	**$4,251**	**$6,986**	**$9,564**	**$10,151**
IRR Calc.	22%				

IRR rule is to accept a project if its opportunity cost of capital is less than the IRR.