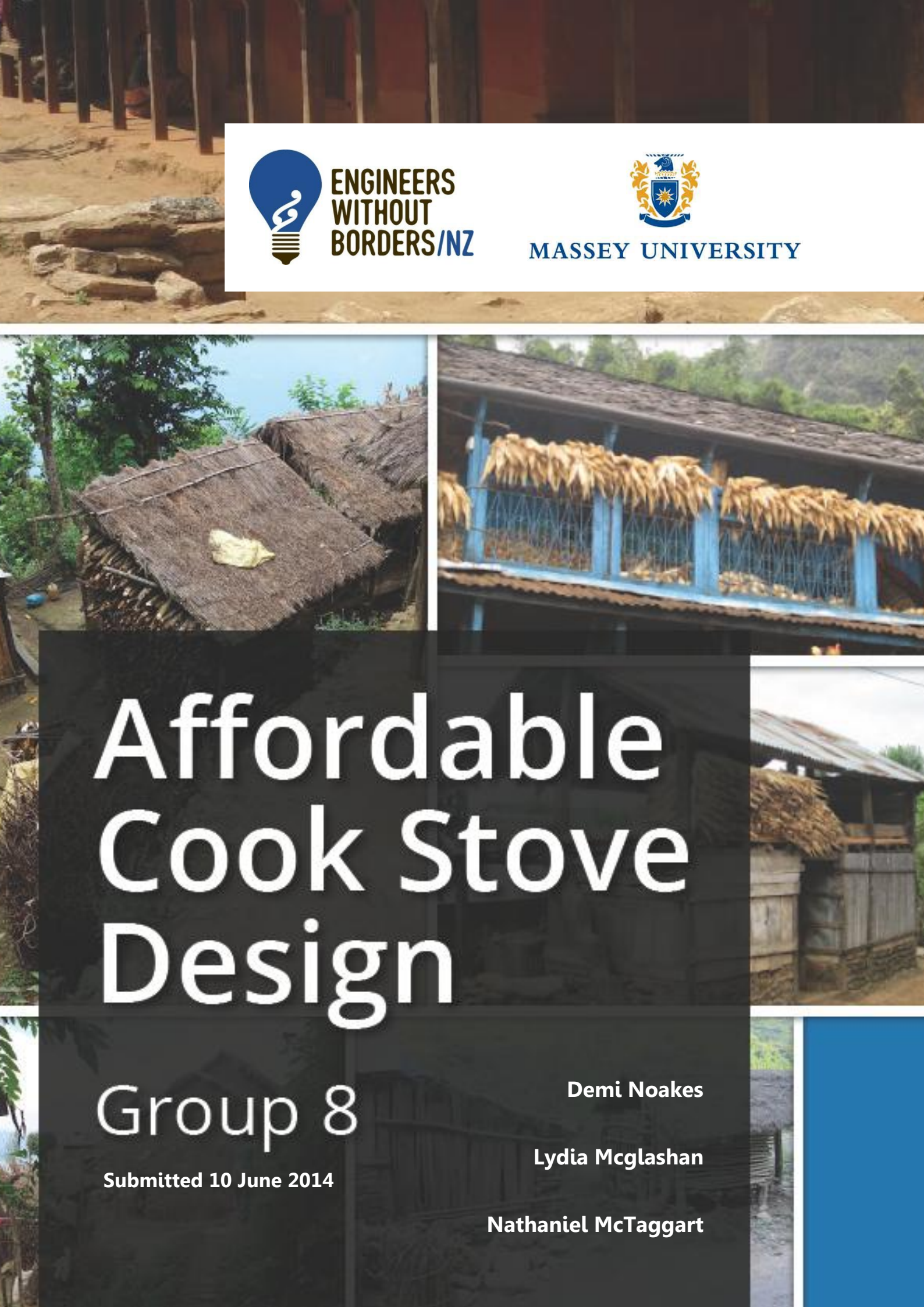

ENGINEERS WITHOUT BORDERS/NZ

MASSEY UNIVERSITY

Affordable Cook Stove Design

Group 8

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Executive Summary

Sandikhola, a hilltop community in the Gorkha District, is one of the many villages in rural Nepal whose people are suffering from the effects of poor cooking technologies. Cooking is primarily done by the women over a smoky open fire inside their poorly ventilated homes. The fires are inefficient and produce large amounts of smoke. Current alternative cooking methods are inaccessible to the majority of rural Nepalese due to economic issues.

The objective of this project was to develop a better cooking method which reduces or eliminates the negative aspects of their current method, and is affordable and accessible for all Nepalese in these rural communities. The solution would provide the rural hilltop communities with a cooking method that requires less wood to be gathered and doesn't smoke out their homes. Research into their current cooking methods highlighted the main issues which need to be resolved. Research into current improved methods used around the world shows that these alternatives are impractical to be implemented in these villages. After creating a list of alternative solutions and using decision making methods to compare their potential, it was concluded that the most effective and viable solution would be to develop a new design. A design criteria was put together from the client brief supplied by EWB to make sure the design satisfied the requirements of the villagers.

The proposed solution is made from mainly local materials; a recycled 60 litre barrel, clay and chimney pipe. These can be sourced cheaply, which makes the design affordable for even the poorer villagers. The barrel acts as a heating element for the villagers to place their cooking pots on to cook the food. Clay is packed around the inside edge of the barrel to insulate the fire which helps to contain the heat, improving the efficiency, this also keeps the sides of the barrel from getting too hot. The chimney directs the smoke outside and also the draft that is created draws air into the fire, which improves the efficiency of the wood burning. As testing of the prototyped solution proved, the cookstove uses less wood than the traditional open fire cookstoves, and eliminates the accumulation of smoke inside their homes.
An instruction manual will be provided for implementation so the villagers can be trained to make the cookstove themselves, making it affordable for them.

The solution is not just specific for Sandikhola, it can also be implemented in other hilltop communities in Gorkha, and countries with similar cooking issues as well. This is because of the widespread availability of the materials used, and the adaptability of the design.

Table of Contents

List of Figures

List of Tables

1.0 Introduction

1.1 Problem Description

The Engineering Without Borders (EWB) organisation has teamed together with Nepal Water For Health (NEWAH) to create solutions to be implemented into Nepal. They have chosen to focus on hill districts and in particular the Sandikhola village situated in the Gorkha District. Residents of the village are predominantly subsistence farmers therefore rely on their own produce and have an inability to earn money. This is the cause of many problems that exist within the village and the level of poverty that they live at.

A serious issue with their way of living is the method used to cook their foods. This is done over an open fire situated within the house that requires large amounts of fuel and produces dangerous levels of smoke into the house. The firewood takes three hours to collect each day, creating a large workload. The smoke produced from the open fire is emitted into the room which causes severe health problems.

1.2 Subject of Report

This report serves the purpose to show the exploration of the issues surrounding their cooking methods and the materials and construction of an affordable and sustainable solution for the villagers.

1.3 Objectives

The project ultimately seeks to improve the living conditions of poor Nepalese hilltop residents. Therefore the specific objective is to create a solution allowing the villagers to cook their food with less fuel and little or no harmful emissions into the house.

1.4 Scope

Despite the client, Engineers Without Borders, providing a large brief with seven design areas to be addressed, this report only addresses the housing and construction aspect. The objective of the project is to provide a solution in this area that improves the apparatus currently used for cooking in Sandikhola. Also documented is the possibility of implementing our design into other hilltop communities in Nepal.

1.5 Limitations

Due to 50% of Sandikhola villagers being ranked as living well below the poverty line and the majority of the villagers being subsistence farmers, it is necessary for the solution to cost little or no money to produce and be cheap to run. It requires a similar technique of cooking as the one already used in order for it to be accepted by the community. It must also use local materials as transport into the village is very limited.

1.6 Issues Raised by Charter

Various issues were identified:

- Sandikhola has such a small population that no search engine returns any results

- Any data used relates to the Terai region and Gorka district and not specifically the Sandikhola village
- Information regarding the availability of materials is limited for the above reasons
- Exact transport issues are not clearly defined

2.0 Background

2.1 Location

Nepal is located in Asia between India and China. It is a landlocked country, with terrain ranging from the low lying fertile land to the treacherous Himalayan mountain ranges. The village of Sandikhola is a hilltop community in the Gorkha District, which is located in the Terai region in Nepal. This area is particularly fertile which provides the locals with the ability to grow their own food and raise livestock.

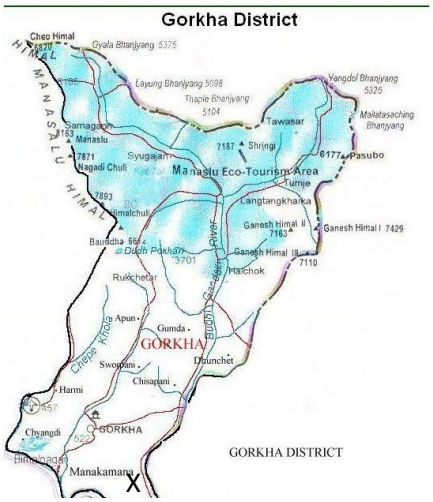


Figure 1. Location of Sandikhola in Gorka district. Retrieved from ncthakur.itgo.com/districtmaps/gorkha_district.htm

2.2 Climate

The climate consists of five seasons; summer, winter, autumn, spring and monsoon season. The climate varies so much due to the location and topography of the hilltop communities. In the Terai region, summer temperatures can exceed 37 degrees Celsius and winter temperatures range from 7-23 degrees Celsius (Gurung, 2008).

2.3 Living Conditions

The living conditions in Sandikhola, as with many hilltop communities, are inadequate because the villagers are predominantly subsistence farmers and have no means of earning money to improve their conditions.

Housing in these hilltop communities is generally made from locally sourced materials, such as clay, stone and mud bricks, which are made by the villagers. It is difficult to transport in new materials because of the conditions of the road, hence the use of local materials. Also the locally sourced materials are cheap and readily available for the villagers to use.

2.4 Economy

Nepal's economy is unstable. Agriculture constitutes 40% of their gross domestic product income (The World Bank Group, 2008) which is an unreliable source of income due to the unpredictable weather conditions. The majority of the population in Nepal live in rural areas with approximately 80% of families relying on subsistence farming (New Agriculturalist, 2009). This creates an issue for national economic growth because, "The absence of economic opportunities outside subsistence agriculture keeps most Nepalese poor." (The World Bank Group, 2008). In Sandikhola, fifty percent of the population are categorised as "poor" or "ultra poor" (NEWAH, 2014).

2.5 Diet and Food Cultivation

The villagers have a simple diet with pulses and rice being their main staple food. Bread, roti, churra, curried vegetables and milked tea are eaten between these meals, with meat only being eaten on special occasions. All of this food is cooked over the open fire in pots or directly over the flame. Beef is never eaten by the Nepalese people due to the predominant Hindu religion.

2.6 Cooking Methods

Figure 2. Current cooking method. Retrieved from http://ucrtoday.ucr.edu/6664/woman-child-cooking

The main cooking method of poorer villagers are open biomass (wood) burning fires. The open fires are used inside the home on the lower level. The only ventilation available are the tiny windows in the walls of the home. However, this is not sufficient ventilation and much of the smoke emissions lingers inside the home creating a dangerous and unhealthy environment. Those who use this method of cooking are four times more likely to develop smoke related illnesses such as chronic bronchitis than those who use improved stoves with adequate ventilation (Ban et al, 2004).

Some improved cookstoves such as the rocket stove have already been implemented in Nepal but can be expensive and out of reach for poorer families such as the majority of the villagers in Sandikhola.

3.0 Discussion

3.1 Generating Alternative Solutions

Four possible design solutions were researched and weighted against the selection criteria to identify the most suitable solution for the Sandikhola villagers.

3.1.1 Biogas

Biogas systems use animal and human waste in an air-tight chamber that ferment resulting in methane gas. The methane gas can then be used for cooking. Biogas produces the second least amount of pollutants during cooking than any other fuel, behind electricity (Wilkie, 2013). It reduces workload as no firewood is collected, is cheap to run, and also has other uses such as for lighting. However, it is expensive to install which makes it out of reach for many subsistence farmers in Nepal. Culture may inhibit the handling of animal and human waste and their use in cooking. There are also issues associated with the lack of individual household livestock and toilets.

3.1.2 Cookstove

The cookstove is the most similar of the four alternative solutions to their current cooking method. It uses the burning of wood as energy for cooking. The cookstove is enclosed with a combustion chamber, increasing the efficiency of wood burning, and has a chimney which directs the smoke outside, improving the air quality indoors. Firewood would still need to be collected, but the amount required is less, and therefore villagers would not have to make the trip every day.

3.1.3 Smoke Filter

The smoke filter is a catalytic combustor that uses a chemical reaction which converts the harmful gases from the wood smoke to water vapour and carbon dioxide. It needs a high temperature to work, which ranges at around 270 degrees Celsius and requires to be running at that temperature for 20 to 30 minutes to work effectively (Fire Cat, 2014). An issue with this is that a lot of smoke is produced in the starting of the fire, before this temperature is reached so the system wouldn't work. The metals used in this system are palladium and platinum. These metals are very costly, therefore making the solution expensive and unsuitable for implementation in Nepal.

3.1.4 Solar Cooker

Solar cooking works by sunlight energy being converted into heat energy then used to cook. This is a very economical way of cooking, as there are no other running costs involved, once the cooking apparatus is set up. Solar cooking is reliant on sunlight, and therefore can only be used when there is sufficient sunlight. In the Terai region, where Sandikhola is located, there is monsoon season from June to September, which means there is limited sunlight during these periods. Also transportation to the village of Sandikhola is a major issue, which would make importing in the solar cooking apparatus difficult and costly.

3.2 Summary of alternative solution selection

Table 1: Solution Weighting Criteria Chart

Note: Each score is marked out of 5 based on research conducted on each design.

	Biogas Stove	Solar Cooking	Cookstove	Smoke Filter
Efficiency	4	2	4	3
Fuel Accessibility Weighting 1.5x	3.5	2	2	2
Cost Efficiency Weighting 1.5x	3	4	4	4
Environmental Sustainability	4	5	3	5
Indoor Pollution Weighting 1.5x	5	5	5	4
User Friendliness	3	3	4	3.5
Cultural Acceptability	5	5	5	5
Implementation	1	1	3	2
Total	34.25	32.5	35.5	33.5

From the above information we have concluded that the cookstove is the most effective design to solve the previously identified ventilation problem in Sandikhola. This is because it is cheap and easy to make using materials already used to construct their homes, and will be efficient to use with minimal indoor pollution.

3.3 Material Availability

3.3.1 60 Litre Barrel

A 60 litre steel barrel is used for transporting flammable liquids, like petrol and diesel, into small villages where it is inaccessible for large trucks. Due to the poor conditions of the roads to these hilltop communities, the fuel is required to be delivered in these steel barrels.

Once the fuel inside the drums has been used up, the empty drum can be reused in our design. As our design uses half a barrel, one barrel would make two

cookstoves, and with the number of households in Sandikhola being 66, this would take approximately 33 barrels to provide the whole community with this new design (NEWAH, 2014).

3.3.2 Mud Bricks, Clay and Stone

Mud Bricks and clay are used to build their homes, so these are readily available and are cheaply sourced material, in which the villagers are accustomed to using. This will help the acceptance of the design in the community, as they are more likely to accept something that they are familiar with using. The clay and stone are a natural resource in the village, and are known to and can be sourced by the locals.

3.3.3 Metal Chimney

The cookstove design uses a 1.25m long 4'' Galvanised Iron pipe for a chimney. The design of the chimney was discussed and a conclusion was made that it would be necessary to use this 4'' pipe for the chimney, even though it is not locally sourced in the village. It is still relatively cheap and other materials for the design will be at no charge, therefore the overall cost will remain low. These 4'' Galvanised Iron pipes are available in Nepal, as specified as by NEWAH (NEWAH, 2014). This pipe was chosen as it was the most easily resourced pipe to fit the necessary requirements.

3.4 Benefits of Suggested Solution

Testing of the final design prototype confirmed the desired results of the cookstove. The smoke was directed out through the chimney, which means that the design does reduce the indoor smoke levels, with almost no smoke being released into the room. The prototype was also tested against an open fire, using the same amount of wood. The fire in the cookstove was observed to have a longer burning time, as well as the flame being much cleaner, indicating higher efficiency and having a more complete combustion, which has both environmental and social benefits.

3.4.1 Environmental

There are a number of environmental benefits with the solution. One of these is that the rate of deforestation of their local and community forests will be reduced. This increases the sustainability of the forests and the security of the crops.

Another benefit is the improvement of the indoor air environment. The smoke generated by the fire goes out the chimney in the design, rather than left to accumulate inside their homes as their current methods cause. This will significantly improve the quality of the air inside their homes.

The smoke emissions produced will also be less due to the decreased amount of wood needed to fuel the stoves. This will decrease the amount of carbon monoxide released into the atmosphere.

The design also supports recycling, which is a huge environmental benefit. Oil barrels are a waste product as a result of containing oil needed for transport. Instead of creating a product which requires new materials and energy to produce it, an existing product is used for a new purpose.

3.4.2 Social and Cultural

The main social benefit of this design is that the people will no longer have to suffer the adverse effects of smoke inside their homes, and the time spent on wood collection per week will be reduced. These lead to an overall improvement in their quality of life.

The implementation process and maintenance of the design will bring the community closer. Villagers will together learn new skills to be able to build and maintain the cookstove. They will also rely on others' skills for cutting barrels which will encourage the villagers to support each other.

However an issue that has been considered is that this cooking method is different to the way they've traditionally cooked for generations. Some people may not want to change their way of cooking, or may not see any need to change. A design limitation identified to reduce this impact was choosing a design that was similar to their current method of cooking.

3.4.3 Economic

The cookstove design is very cost effective, and will not be a financial burden to the people. It has a small cost of $21.86 NZD for implementation, and from this point will operate at no cost to the families other than the eight-twelve monthly replacement of the barrel in which import costs into the village will apply.

It will decrease the amount of illness in the village; this is not only a social benefit, but also an economical benefit. The villagers will not have to get in debt for using health care when they can't afford it. Also with improved health they can work more and their work will be more efficient, increasing the crop capacity and allowing for cash crops to be grown additional to the subsistence crops.

3.4.4 Sustainability

Sustainability is a key factor to take into consideration in any engineering project. The proposed design is sustainable, with considerations for the economic, environmental and social aspects for both the current and future generations. The clay and clay bricks do not have to be remade when the barrel is replaced and are both also made from a readily available material. The barrel is a waste product used by the transport industry that is growing in demand.

3.5 Selected Design and Justification

The selected design consists of a half barrel, a clay mould and a chimney. 'Design Principles for Wood Burning Cook Stoves' lists ten design principles to increase the combustion efficiency of cook stoves (Bryden et al, 2004). Several of these are:
- Insulate around the fire to help it burn hotter (Principle One)
- Use of a chimney increases the draft (Principle Two)
- Feed Sticks into the fire as needed (Principle Three)
- Maintain a good draft into the fire (Principle Five)
- Constant Cross-Sectional Area (Principle Seven)
- Lift the burning sticks off the ground for air flow (Principle Eight)

It is important to respect the locals' culture and appreciate their own knowledge, therefore a design has been chosen that is similar to their existing method.

Taking these principles and incorporating them into our design helped us to develop a better cookstove that reduces harmful smoke emissions inside the home and requires less fuel.

3.5.1 Clay mould

The clay mould around the fire corresponds to Principles one and eight, from 'Design Principles for Wood Burning Cookstoves'. The clay mould is for the interior of the barrel. It provides insulation to help the fire burn hotter and contain the heat inside the cookstove (Principle one). This insulation also ensures the safety of the cookstoves, as the sides of the barrel won't get too hot and become a health safety risk. To make the clay mould, clay is packed inside the edges of the barrel, to be 50mm thick. As the clay dries, it shrinks in size leaving a gap between the sides of the barrel. The clay mould can then be removed from the barrel (see figure 3 and figure 4). The sides of the clay mould allow the wood to be leant up against it. This increases the efficiency according to Principle eight, as air flow is allowed underneath the fire, helping to drive the fire.

Figure 3. Clay before drying. Original image.

Figure 4. Clay shrinkage after drying. Original image

3.5.2 Barrel

The Nepalese cook using pots only, not in an oven. The barrel provides the cookstove with an element that will heat up with the fire underneath it, where the pots can be placed on to cook the food. Using the barrel means that the Nepalese can still cook their food traditionally in a pot, with the benefit of no harmful smoke emissions, rather than having to adapt to oven cooking as other 'improved' designs may require. This will enable the design to be accepted into the community. The barrel would need to be cut in half and a hole for the chimney be made in the side of it. (See Appendix A for instructions).

3.5.3 Base

Figure 5. Correct way to feed in wood. Original image.

The base design of our cookstove corresponds to Principles three and five. Principle three states that the feeding of sticks into the fire improves the efficiency of the fire, as well as reducing emissions. Figure 6 shows the comparison of feeding the wood into the fire and not feeding them in.

As shown in our design there is a fixed opening to the fire so that wood can be fed into the fire as needed (see figure 5). Principle five states that a good draft is required for the fire to work efficiently. The bricks at the base are arranged so there are small gaps allowing for air to be drawn into the fire. The base for the cookstove is made out of mud bricks, the same material used to build their homes. These are made by the locals, and hence are cheap and readily available. These mud bricks are dried and can withstand the temperatures of fire.

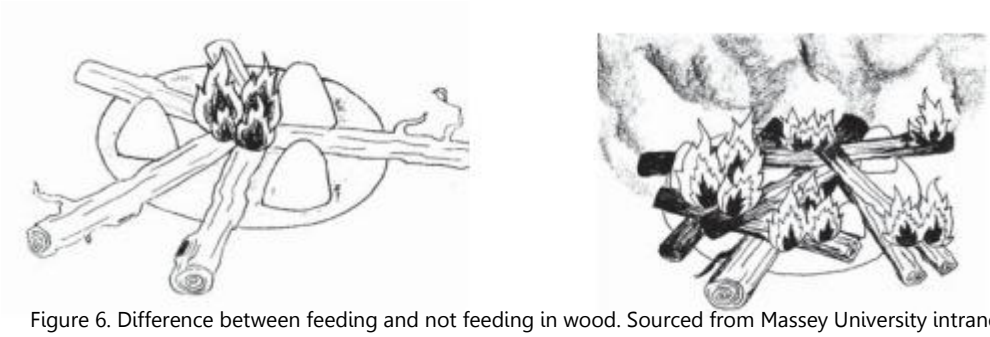


Figure 6. Difference between feeding and not feeding in wood. Sourced from Massey University intranet.

3.5.4 Chimney

Figure 7. The working chimney. Original Image.

The use of a chimney is necessary to extract the smoke outside. Not only does the chimney allow the smoke to be drawn from the fire, but it also increases the draft in the fire, which drives the fire and ultimately increases the efficiency, according to Principle two. When testing our prototype it was clear that the chimney was working as there was a good draft of smoke drawing out the top. (See figure five). This showed that there was a decrease in pressure in the chimney, which is the result we were hoping for.

3.6 Costing

3.6.1 Materials

The material costing includes the purchasing/acquiring of clay, clay bricks, empty 60L barrel and the 1.25m 4" galvanised iron pipe. The clay and clay bricks are assumed to be at no cost to the household as the clay is a natural resource in the village and the villagers can make the clay bricks themselves. It is also assumed that the barrel can be sourced at no cost because it is a waste product that would otherwise be sent to the landfill. The only material cost involved with the solution is the cost of the 1.5m galvanised iron chimney pipe, which costs 1594.71 Nepalese Rupees (NPR), which equates to $20 NZD.

3.6.2 Tools

The only tool that is required to be bought by the village for the cookstove, is the 4.5 inch (115mm) angle grinder that is required to cut the barrel. Only one of these would be required to be bought by the village, as it can be used many times. The angle grinder can be purchased from a hardware store for 1244.72 NPR, which equates to $90 NZD. Divided between the 66 households in Sandikhola, this would be $1.36 NZD per household. The grinding disks would need to be replaced every five barrels and these cost around $5 NZD.

3.6.3 Labour

The proposed solution can be predominantly made by the locals, once the materials are there for them. This means that labour costs are at a minimum. However, due to safety, untrained villagers cannot cut the barrels themselves. As stated earlier in the document, two or three villagers would need to be trained to use the angle grinder and to do so safely. Therefore, the labour cost involved is the cost for getting the barrel cut. Skilled labour work is paid at 600 NPR ($7.45 NZD) per day (NEWAH). The barrel cutting would take 30mins, which equates to about $0.50 NZD, based on an eight hour work day.

Table 2: Summary of Total Costs

Type of Cost	Running Costs (NZD) per cookstove per year	Start up Cost (NZD) per cookstove
Materials	$0.00	$20
Tools	$1.00	$1.36
Labour	$0.50	$0.50
Total (NZD)	$2.86	$21.86

3.7 Affordability

The running costs for the cookstove solution is $2.86 NZD per year per cookstove which equates to 230.22 NPR. The start up cost per cookstove is $21.86 NZD which is 1759.64 NPR. Data collected from NEWAH shows that the wage for working one day as a skilled labourer is 600 NPR, and as an unskilled labourer is 400 NPR (NEWAH, 2014). Using this information, for the villagers to get the 1759.64 NPR start up cost, as an unskilled worker would need to work four and a half days, or as a skilled worker, for three days. This is assuming no subsidy from associations. The yearly running cost, is almost negligible considering it would take less than a day's work, per year for both skilled and unskilled labourers, to earn this.

Another option available for the villagers to afford the costs associated with the cookstove is to extend their crops slightly above their own living means and use this extra produce as a cash crop. This addition money can then be used to contribute to the start up and running costs.

4.0 Conclusions

From this report it can be concluded that the current method of cooking over an open biomass fire is not sustainable nor efficient for the villagers. It requires large amounts of fuel and is a serious risk to their health. In the report the improved cookstove design has been proven to be the most effective solution for solving the issues surrounding their current cooking methods for the Sandikhola people. This is because it is cheap, made out of readily available materials, and most importantly creates a healthier home free of smoke emissions.

4.1 Recommendations

Before the design is implemented into the village, a few recommendations have been made to ensure its design is the most effective. Time and resource constraints of the project have prevented these procedures from being completed. These are:

- Community consultation to ensure the design will meet their specific needs. This will include their opinion on the ease of use and cultural acceptability.
- Accurate and substantiated research on the availability of resources. Due to the lack of specific information about Sandikhola available this has not been confirmed.
- Communication with the appropriate transport agencies would be required to negotiate an agreement for acquiring the barrels.
- Further testing of the cookstove to ensure it has been designed effectively to prevent smoke from being emitted inside the home.

4.2 Implementation

One of the key attributes of our design is that the majority of the implementation of the solution can be done by the villagers themselves. An instruction manual is provided (see Appendix A) which contains a step by step guide on how to make the cookstove. This is written in a way that is easy for the NEWAH volunteers to interpret for the villagers. It is suggested that the village have two or three trained people who know how to cut the barrels safely, and who can do this for the village, as this is something that not everyone can do themselves.

Once the barrel and chimney are ready the villagers can make the cookstove themselves using their local materials, and the instruction manual as an aid.

When the barrel wears out, which we predict to be 8-12 months, the design of the cookstove allows for easy replacement of the barrel, without damaging any other part of the cookstove. It is simply pulled off the clay mould and a new barrel replaces it, then using clay to fill in any gaps.

The suggested design is not just specific for the village of Sandikhola, it can be implemented across any of the hilltop communities of Gorkha, or in any developing

country in need of improved cooking technologies. This is because the materials used are widespread, and not just specific to one area.

4.3 Community Consultation

The process of community consultation has not been possible for the duration of the project as it has been conducted in New Zealand with no contact with any volunteers currently working in the village. This is not the usual practice. It would be beneficial to continue the refinement and progress of the design from within the village in order to work closely with the community to ensure their participation is maximised. This will ensure the success of the project for many years after the presence of EWB has gone.

Allowing the village people to become involved in the final stages of design and the implementation process will provide them with a sense of achievement and input. This will encourage them to feel more positively about the new design and increase the likelihood of it being successfully integrated.

4.4 Difficulties in Communication

The language barrier will be the greatest difficulty to overcome, with Nepali being the most predominately spoken mother tongue. There is also a risk that the idea and design given to the village is not accepted due to lack of trust. Both of these difficulties can be overcome by the existing presence of the Engineers Without Borders and Nepal Water for Health organisations. NEWAH has been working in Nepal since its establishment in 1992, therefore the team has invaluable experience and presence in the village. The villagers are more likely to accept a change in lifestyle encouraged by volunteers who they know well and have learnt to trust, rather than from an engineering company who has bombarded them with technology they are unfamiliar with.

4.5 Ethical Considerations

There are a number of responsibilities and ethical considerations that arise when undertaking an engineering project. In this project, measures were made to ensure the ethical obligations required by engineers is followed diligently.

The main focus of this project was to make an improvement in the lives of the people in the hilltop communities of Gorkha. Throughout the project, thought and consideration was made about all aspects of the design, ensuring that it doesn't compromise other aspects of their lives, is equally serving to the whole community and doesn’t introduce negative effects. This was done by having regular checks of the developing design against the design criteria, and ensuring that it met the brief provided by the client.

These communities have a vastly different culture to any first world country culture. It was vital to take into consideration the culture and traditions of these people. In doing this, extensive research was conducted in order to gain understanding of their culture and ways of living. For example, the most important design constraint was that the design had to be a cookstove, not an oven. This was necessary to acknowledge their culture and the way they have cooked food for centuries.

5.0 Team Processes

5.1 Challenges and Successes

There were many up and downs experienced in the duration of this project. A significant challenge was the loss of the fourth team member in week eleven. This was difficult to overcome so close to the end of the project but with some testing and a lot of report writing still to be done. The rest of the group had no choice but to continue on by reallocating his sections of the report, which created an increased workload for the group.

Another challenge was the interference of personal schedules with group meetings and allocated project days. All members of the group had busy schedules with sport, work and living away from home. This made it difficult for meetings to be planned and full attendance at all project days to be achieved. This caused setbacks.

A success that arose from the above mentioned challenge was the use of social media platforms to communicate within the team. At the beginning of the project a private Facebook page was made where members could post ideas, agendas, meeting notes and other project related material. It enabled the group to communicate and make progress when face to face meetings weren't possible. Google Docs was also used to share report material that had been written.

5.2 Team Roles

Demi Noakes	Nepal general research, existing material and natural resource research, charter drafting, charter editing, biogas stove research, cookstove prototype one construction, cookstove prototype two construction, cookstove prototype two development, exhibition material, report drafting, report content editing, report final editing
Lydia McGlashan	Nepal general research, ventilation system research, charter drafting, identifying selection criteria, cookstove research, solar cooking research, cookstove prototype one construction, cookstove prototype two construction, cookstove testing, scale model construction, report drafting, report content editing
Nathaniel McTaggart	Nepal general research, diet and alternative cooking method research, identifying selection criteria, smoke filter research, cookstove prototype one construction, cookstove prototype two construction

5.3 Team Reflections

5.3.1 Demi Noakes

Overall the project has been a huge learning curve but has taught me many invaluable skills. For Group 8 the project started off very slow and did not really gain much momentum until right at the end. With so much else going on in other papers the project was put out of mind to start with.

Sandikhola is a very small village with little to no information being available. This made it very hard for the group to source any specific or reliable information about the locally available materials. We had to overcome this by using research about the district and region that it is situated in, however this will make some of our information inaccurate. This information would need to be confirmed and design specifications rectified before the design was implemented.

We also lost a member very late into the project which gave us each more workload. Problems did not arise due to differences in skill levels, but more due to differences in effort put into the project. I have always had high expectations of myself and my work so to work in a team where others' work ethic and expectations are lower than mine is challenging. This was an issue when it came to writing the report. The workload could have been more evenly shared but the final report is to a high standard which is most important.

The solution itself proved to be very successful. It requires less wood and any emissions from the stove are directed out through the G.I. pipe. However, it still requires more work before it can be implemented into Sandikhola. The availability of the resources would need to be confirmed and community consultation would need to take place. Being on site in the village a few weeks before the full implementation would be beneficial to gain the support and trust of the villagers and receive their ideas in order to produce a design that is going to work best for them, as ultimately this is the main objective of the project.

5.3.2 Lydia McGlashan

Reflecting on this project, I feel that our group did well at coming together and completing this project. Everyone in the team contributed fairly evenly to different aspects of the project, and on the whole everyone got on well. We had regular team meetings which was definitely helpful in keeping communication up and ensuring that the project was on track. I feel that we could have improved on the communication, as there was a lack of communication at times, which resulted in confusion and lack of understanding in which direction the project was going in. We were also disadvantaged as four weeks out from the report due date, one of our members dropped out. This made it hard as we were in the process of compiling the group's individual research together for the final report, and we were unable to get hold of his research. This also meant that we had lost a quarter of our workforce, so we had to pick up those dropped responsibilities as well as continue with our own. However, our team did well at handling this and were able to pick up this extra workload and finish and complete the project. Overall, I was happy with the way the team worked together.

The process that we followed throughout the project was the engineering method, and I feel that we followed this well which helped us produce our final solution. It took a while for us to get going with the project, as it took a few weeks to settle on an issue to focus on. However, once this was decided on, our team worked well, each using our strengths to benefit the team and our project.

The aspect that I found hard about this project was that at times the instructions given were a bit vague, so we were unsure as to what was expected in terms of assessment. The mentor we had was helpful in making sure we were on track with the project, however we missed a few meetings with him, because we were away prototyping one week, then the next week he was away, so he didn't have much input in our final solution.

The final solution was successful with a full size prototype to show, which achieved the outcomes of the project.

5.3.3 Nathaniel McTaggart

At the beginning of the project we made quite a lot of progress on the project by firstly by researching general information about Nepal to give us a better understanding of the problems. The decision for which problem to choose was fairly hard to make as we all had different views on what problems we wanted to solve. We then had a meeting and got delegated an problem to look at and did research on that problem and made a table to show where each area excelled or not of the different problems we came to an agreement on cooking methods. Although it was my second choice in the problems to solve I went with it because the majority thought that it was a good idea and to keep the peace in the group. I feel that the group was working well together apart from a few heated discussions here and there between fellow group members.

The final product turned out to be quite good and I am fairly pleased with it although if I was more assertive with some of my ideas on the prototype and spent more time discussing it the end design might have been better. I think that the team meetings that we had were more productive towards the end of the project because we had a better and more detailed outline as to what needed to be discussed. I think everyone pulled their weight fairly evenly and managed to get all the work done by the dead line although there was one team mate who has dropped out of the course just before we started the report who had struggled to sometimes get the work done in time.

I believe overall the solution that we have come up with addressed our main problem of having too much smoke inside the house but I think it fell slightly short of being a very fuel efficient design. Things that I would improve for myself would be to try to express my thoughts more during the meetings and to discuss other people's points more thoroughly also to manage my time better. Having access to cheap electricity and having biogas facilities would make making cooking methods with these a better choice but because implementing cheaper electricity and biogas plants is not a cheap and easily viable solution we chose to do an improved cook stove.

6.0 References

Ban, A., Gallo, P., Gouws, J., Gros, J., Guy, K., Schneider, E. (2004). *Alternative cooking technology: New stoves solving old problems.* Chapel Hill, NC: Kenan-Flagler Business School. Retrieved from www.cse.unc.edu/knowledge

Bryden, M., Still, D., Scott, P., Hoffa, G., Ogle, D., Bailis, R., Goyer, K. (2006.). Design *Principles for Wood Burning Cook Stoves.* Eugene, OR: Aprovecho Research Centre. Retrieved from http://www.pciaonline.org/design-principles

Fire Cat. (2014). *What is a catalytic combustor?* Retrieved from http://www.firecatcombustors.com/Articles.asp?ID=250

Gurung, H. (2008). Nepal Atlas & Statistics. *January and July Mean Temperatures* (pp. 48-51). Kathmandu, Nepal: Himal Books. Retrieved from http://www.ewbchallenge.org/nepal-water-health-newah/resources

New Agriculturist. (2009). *Country profile-Nepal.* Retrieved from http://www.new-ag.info/en/country/profile.php?a=935

NEWAH. (2014). *Sandikhola Demographics.* Retrieved from http://www.ewbchallenge.org/nepal-water-health-newah/resources?keys=&field_tags_tid=All&page=1

NEWAH. (2014). *Tools, materials and labour costs in Nepal.* Retrieved from http://www.ewbchallenge.org/nepal-water-health-newah/resources?keys=&field_tags_tid=All&page=2

Wilkie, A.C. (2013). *Biogas: a renewable biofuel*. Retrieved from http://biogas.ifas.ufl.edu/ad_development/faqs.asp

The World Bank Group. (2001). *Nepal: Priorities for Agriculture and Rural Development*. Retrieved from http://go.worldbank.org/D9M3ORHVL0

7.0 Bibliography

Agenbroad, J., DeFoort, M., Kirkpatrick, A., & Kreutzer, C. (2011). A simplified model for understanding natural convection driven biomass cooking stoves – Part 1: Setup and baseline validation. *Energy for Sustainable Development, 15(2), 160-168.* doi: http://dx.doi.org/10.1016/j.esd.2011.04.004

Bogdanowics, A. (2010, August 6). A Cleaner Cooking System for Developing Countries. *The Institute.* Retrieved from http://theinstitute.ieee.org/people/students/a-cleaner-cooking-system-for-developing-countries538

countryeconomy.com. (2012). *Nepal - Population.* Retrieved from http://countryeconomy.com/demography/population/nepal

Duzgun, M. (2013, November 22). New cookstoves clear the air in Nepal: Case studies. *The Guardian.* Retrieved from http://www.theguardian.com/global-development-professionals-network/2013/nov/22/new-cookstoves-clear-the-air-in-nepal-case-studies

Global Alliance for Clean Cookstoves. (2014). *Cookstove Fuels.* Retrieved from https://docs.google.com/document/d/1_GAC_2wh_dXHK3Ihrox-HnqHPUjcnq0ut37AwiL9_Qg/edit

Hayes, R.E., & Kolaczkowski, S.T. (1997). *Introduction to Catalytic Combustion.* Amsterdam, The Netherlands: Gordon and Breach Science. Retrieved from http://books.google.co.nz/books?hl=en&lr=&id=pN_gprEVyMAC&oi=fnd&pg=PR17&dq=plastic+catalytic+combustion&ots=8jehiF3hKr&sig=IUYVROcMJ-fgDI-eWmfM4R2qDXw#v=onepage&q=plastic%20catalytic%20combustion&f=false

IEA. (2006). *World Energy Outlook 2006*, OECD Publishing. doi: 10.1787/weo-2006-en

Kenny, C. (2011, October 16). From Dung Power to Solar Power. *Slate.* Retrieved from http://www.slate.com/articles/technology/future_tense/2011/10/alternative_energy_will_benefit_billions_in_the_developing_world.html

Manisha UK. (n.d). *Agriculture of Nepal.* Retrieved from http://www.mcwfnepal-uk.org/about-nepal/agriculture-of-nepal

McCausland, A. (2013, February 14). Working With Principles for Creating More Efficient Cooking Stoves (Ethiopia). *The Permaculture Research Institute.* Retrieved from http://permaculturenews.org/2013/02/14/working-with-principles-for-creating-more-efficient-cooking-stoves-ethiopia/

Naturally Nepal. (2012). *Climate.* Retrieved from http://welcomenepal.com/promotional/know-nepal/climate/

Practical Action. (n.d.). *Biogas.* Retrieved from http://practicalaction.org/biogas-fuel

SimGas. (2011). *Benefits of Biogas.* Retrieved from http://www.simgas.nl/benefits-of-biogas

Shrestha, S. K. (2002). Improved cookstoves in Nepal: challenges and strategies. *Energy for Sustainable Development,* 6(2), 60-63. doi: http://dx.doi.org/10.1016/S0973-0826(08)60315-4

Solar Cookers International. (2010). *How Solar Cookers Work.* Retrieved from http://www.solarcookers.org/basics/how.html

8.0 Appendix

Group Eight Cookstove Assembly Instruction Manual

This manual outlines the materials and tools needed to make the cookstove.

Equipment Needed

Materials required:

- 60L empty metal drum
- Clay (as necessary)
- 12 bricks
- 1.25m 4 inch diameter galvanised pipe

Tools required:

- 115mm Angle grinder
- Grinder disk

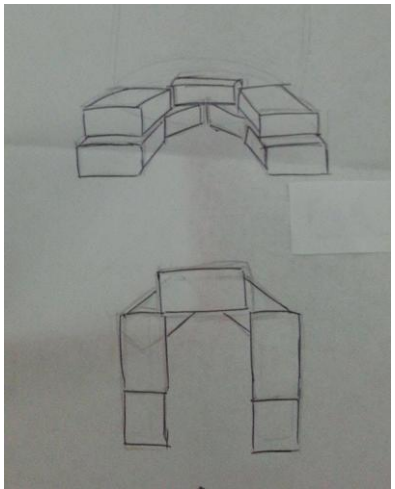
Assembly

Barrel Preparation

Due to the high risk when cutting the barrel, only those who are trained can do this task. The barrels are cut in half using an angle grinder. This is done by making a cut at the middle of the barrel, cutting around until it is separated into two equal halves. A square hole is then cut 75mm below the uncut end of the barrel with dimensions 125mm x 150mm. See safety precautions on measures to prevent accidents when using the grinder.

Cookstove Method

1. Once the barrel is acquired, initially burn off the leftover residue using an open flame outside of the home. This is necessary to ensure no oil remains.
2. With the barrel placed cut side up, line the inside of the barrel with clay 50mm thick. Ensure the layer is even.
3. Leave the barrel in a dry place with good airflow but out of direct sunlight to dry. This will take approximately 5 days depending on the humidity. The clay will noticeable shrink inwards, this is a good sign.
4. Construct the base according to figure 1. The base needs to be placed in the area used for cooking or



near one of the small windows. Gaps between the bricks are to increase the flow of air through the cookstove. Clay may be used to secure the bricks into place but gaps should be left between each brick. Only use the clay as an adhesive between two layers.

5. Once the barrel has dried place it cut side down onto the base.
6. See the additional notes on preparing the home for chimney placement.
7. Attach the pipe to the pre-cut hole in the barrel and secure using clay. The other end is directed either through the wall or out of one of the small windows.

Figure 1. Brick Arrangement

Barrel Replacement

To replace the barrel, detach the pipe and lift the existing one off the clay mould and slide the new pre-cut one down over the clay. Reattach the pipe using clay.

Pipe Placement

The pipe may be extended through the wall of the home or out through one of the small windows.

If the chimney is extended through the wall, a hole of minimum 4 inch diameter is made in the wall using a hammer or any other effective method. The pipe will then be directed through this hole before being connected to the barrel and secure at both ends with clay. The hole will be filled in to ensure the home is watertight and that the pipe will remain in place.

If the chimney is to be directed through a window, the cookstove will be placed near the window so the pipe can reach through the window.

Safety Precautions

Some precautions are necessary to ensure that all health hazards are controlled:

- Burning the residue in the barrel must be done outside in a controlled situation with a minimum amount of material to ensure it does not get out of control.
- When using the angle grinder, eye protection and gloves should be worn.
- To avoid kickback, the grinder must only be used with the correct cutting disks
- When handling the cut barrels, care must be taken as the cut edge is very sharp. Do not carry the barrel by holding the cut edge and take care when applying the clay.