Development of the Bushblok Industry in Namibia

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Abstract

Bush encroachment is a cause of desertification in Namibia and contributes to the decline of the cheetah's habitat. In an effort to combat bush encroachment and habitat loss, the Cheetah Conservation Fund's subsidiary company CCF Bush Pty. Ltd. has developed the Bushblok product, a compressed wood fuel log created from processed invader bush. Through market research, we made recommendations to CCF Bush to develop domestic usage of the product, including a business plan to enter the residential wood fuel market.

Executive Summary

Namibia's savannah is currently infested with thorn bushes, covering an estimated 10 – 12 million hectares representing 12 – 14% of the land. The infestation by this indigenous species is the result of a complex interaction between cattle farming, fire suppression policies, and weather. Unfortunately, once bush takes hold and displaces grass cover, its root system develops and gains a competitive advantage for water, preventing the grass's return. When the acacia thorn bush encroaches, it can cause land to lose up to 100% of its productivity and usefulness. The resulting dense thickets of bush prevent farmers from using the land and disrupt the natural habitat of the Namibian ecosystem. The invasive thorn bush is also known to adversely affect the cheetah by decreasing the cheetah's line of vision during hunting and limiting the proliferation of prey. The cheetah's population nearly halved in the 1980s because of bush encroachment and other factors such as increased levels of poaching, industrial expansion and economic development. Many Namibian conservationists took notice of the cheetah's dramatic recession and the Cheetah Conservation Fund began a campaign to ensure the cheetah's survival.

CCF Bush Pty. Ltd., a subsidiary of the Cheetah Conservation Fund, is dedicated to restoring the savannah to its natural state. Currently, CCF Bush harvests the invasive thorn bush, chips it, and extrudes it into the Bushblok fuel log. At this time, CCF Bush produces a few hundred metric tons of Bushblok fuel logs each year and exports a substantial amount of the product to the United Kingdom. CCF Bush would like to increase sales to domestic markets and substantially increase its production over the next year. CCF Bush's supply line and production capabilities are strong enough to support growth, but new markets are required to sell the product on a larger scale.

The goal of this project was to identify which Namibian energy markets could feasibly utilize the Bushblok product. To do this, we evaluated the social and technological implications of switching from current energy sources to Bushblok. Focusing our investigations on firewood markets in the residential sector and heating applications in the industrial sector, we were able to make recommendations to CCF Bush Pty. Ltd. concerning who can best use their product.

Industrial Market Analysis and Recommendations

The scope of our industrial market analysis was limited to Namibian industries that utilize boiler systems. We identified two major fuel sources used in boiler systems within Namibia, coal and heavy fuel oil (HFO). The most common fuel of the two is heavy fuel oil which accounted for four of the six companies visited. We identified three types of industrial markets which may be suitable for Bushblok to develop. These markets include pure biomass firing, coal co-firing, and HFO co-firing. Caloric property testing was completed on the Bushblok to allow for a comparison between its energy density and that of other fuel sources. To gauge the receptiveness of each company to switch from their current fuel source to a new firing opportunity, we conducted interviews with plant engineers and technical managers. These

interviews were used to gather data about each company's fuel consumption, boiler type, fuel contracts, and their thoughts on biomass and co-firing opportunities.

Based on our findings, we recommend that CCF Bush avoid the industrial energy market at this time, for the following reasons:

- The energy density of the extruded Bushblok log is too low for biomass-only firing. Bushblok logs have a typical value of about 10.5 MJ / kg while coal has a typical energy density of around 26.5 MJ / kg. Switching to biomass-only firing would incur larger transportation and storage costs as well as initial retrofitting costs. There is currently little existing motivation to justify these costs for companies.
- HFO-fired boiler systems are typically compact, computer automated, and allow for strict control of heat produced. Although HFO is more expensive than coal, these systems require little supervision and are more convenient to plant engineers than boilers which use pulverized fuels such as coal. Implementing a co-fired system with this type of boiler would change its automated nature and would also require an extremely expensive retrofit. Precise control with pulverized or partial pulverized systems is not as simple as with a liquid fuel boiler and is often required by industries using HFO-fired systems.
- Boiler systems tend to require a complete-and-quick-burning fuel to produce the desired amount of steam pressure per hour. Extruded Bushblok fuel logs are compact and slow burning in nature. The heat release rate of these logs is not suitable for any type of boiler system.
- The price per MJ estimate of Bushblok raw chip is quite close and possibly less expensive than that of coal depending on the pricing scheme used by CCF Bush. However, the burning properties of raw chip have not yet been investigated. Raw chips are more suitable for coal co-firing applications, but further investigation must be conducted before they can be recommended for use as a co-fired fuel.

Although entrance into the industrial market is not recommended at this time, we have identified a few scenarios which would provide an advantage to CCF Bush. Currently, Namibia has no emissions regulations. In the event that emissions regulations were instituted, industries would be more apt to search for cleaner burning fuels. Use of wood fuels such as Bushblok in co-firing applications may cut down the amount of toxins released in the air during combustion, and co-firing may be a less expensive alternative to purchasing smoke treatment systems. A second scenario involves the predicted energy crisis. It is estimated that in 2007 South Africa will not be able to provide the power Namibia will require. In the event that energy shortages occur, fuel prices may see a substantial rise due to decrease in supply. Rising fuel prices may cause companies to search for alternative energy sources. Because of this, co-firing Bushblok raw chips with coal may become an acceptable option for companies trying to save money on boiler fuel.

Residential Market Analysis and Recommendations

The scope of our residential market analysis was limited to retailers and consumers of wood fuels in the areas of Otjiwarongo, Ongwediva, and Oshakati. We identified three types of users of wood fuels as well as two different types of retailers. Retail establishments were categorized into two types, formal and informal. Formal retailers include gas stations and supermarkets while informal retailers include open air markets and neighborhood sellers of wood fuels. To gauge receptiveness of consumers to switch from their current wood fuels to Bushblok we conducted interviews and held demonstrations of the Bushblok's burning capabilities. These interviews provided us with information regarding each consumer's level of usage as well as their thoughts on Bushblok and willingness to use it. The demonstrations allowed us the opportunity to showcase the Bushblok as a cooking fuel and hold discussions with onlookers. Interviews with retailers allowed us to gather information on the price of wood fuels, the type of market in the area, amount of sales, typical customers, and distribution methods.

Based on our findings, we recommend that CCF Bush attempt to enter the residential wood fuel market due to the following reasons:

- We found through interviews with consumers that they are willing to try a new product. Consumers said that they preferred wood over charcoal because of the price and because of the way it burns. Many consumers often use wood to braai[1] and cook traditional foods; they prefer the open fire that wood provides rather than a flameless charcoal fire.
- We found during demonstrations that onlookers were very excited and interested in the Bushblok product. Although many were skeptical at first, once they watched the Bushblok burn they wanted to know where they could purchase it and how much it cost.
- Through investigations we found that all types of residents use wood at least occasionally for braais. Retailers also provided us with sales data for wood products in their stores. This information shows that a large amount of wood is consumed in these areas each week and there is substantial room for Bushblok to enter this market.
- Through interviews with retailers, we found that they are very willing to sell new products in their stores. In Otjiwarongo, some stores had previously sold the Bushblok and were willing to sell it again.
- There are existing market channels through which Bushblok can be sold. Distribution systems as well as direct sales systems are in place; CCF Bush must only develop a strategy to use these market channels.

[1] Braai is the Afrikaans term for a barbeque which is typically used throughout Southern Africa

Based on our findings, we have created a business plan for CCF Bush Pty. Ltd. to enter the residential market. This plan includes the following recommendations:

- **Marketing Strategy** – We recommend CCF Bush use a direct marketing system. We found through our interviews that most retailers were genuinely excited about a new product and were willing to try if they knew more about it. Using a salesman, CCF Bush would be able to promote the Bushblok product to both independent purchasing establishments and wholesalers.
- **Pricing Strategy –** We recommend CCF Bush price Bushblok between the price of wood and charcoal. In addition, we recommend that the price of Bushblok vary between region, distribution method and type of seller. We found that wood prices are typically quite lower than that of charcoal. Because Bushblok is a compressed wood log which burns longer and more like charcoal, we believe that Bushblok should be priced within the range of these two existing products.
- **Distribution Strategy –** We recommend CCF Bush make use of both direct sales and wholesale distributors to sell their product. Interviews with retailers showed that two different distribution types are currently used, those which purchases are made through wholesale distributors and those which purchases are made directly from the manufacturer. It would be beneficial for CCF Bush to make contact with wholesale distributors in order to reach retailers who only use this system. For retailers willing to make cash purchases and those which only purchase directly, CCF Bush would benefit from a direct sales and delivery approach.
- **Management and Personnel Structure –** We recommend that CCF Bush create two new job positions: a driver and a sales representative. The previous recommendations require dedicated personnel to make sales and to deliver the Bushblok product. The work hours involved as well as the required salary will be dependent on the markets CCF Bush chooses to enter.
- **Financial Analysis –** We recommend CCF Bush enter the residential markets using the financial analysis's we have created as a guide. Market research as well as estimates of transportation, salary, and production costs allowed us to create break-even estimates for each region. We found that for it to be profitable for CCF Bush to enter the market in Otjiwarongo they would need to sell over 1.5 tons of product per month or about 35% of the market we identified. Similarly, if they wish to enter the market in Ongwediva and Oshakati, they would need to sell over 2.5 tons of product per month or 54% of the market. If CCF Bush attempts to enter the market through wholesale distributors stationed in Windhoek, they would need to sell an additional 2.5 tons of product per month or 32% of the market.

The business plan we have developed incorporates the information that is necessary to venture into the domestic firewood market for the areas of Otjiwarongo, Oshakati, and Ongwediva. This plan also incorporates information necessary to expand the market through existing wholesalers located within the country. It is important to recognize the substantial social benefits involved with expansion of Bushblok sales. If CCF Bush enters the residential market in Ongwediva and Oshakati, they may provide a direct solution to deforestation occurring

in the area. At its current production, CCF Bush is not solving the problem of Bush encroachment. Although entrance in the domestic market would still not solve this problem; it may serve to create growth within the company, leading to larger production and eventual restoration of bush encroached land.

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Authorship Page

Throughout the writing process, each team member had an opportunity to work on several different portions of the report. In most cases, writing and editing was done by multiple team members on each section. The authorship of each section outlined below represents the team member who was most influential on that particular section. It is important to recognize that this does not mean each section is the work of that team member alone.

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Glossary

Acacia – Genus of several types of indigenous thorny bushes encroaching on Namibian savannah

Bakke- The Afrikaans term for pickup truck that is commonly used throughout Southern Africa

Braai- The Afrikaans term for Barbeque that is commonly used throughout Southern Africa

Bush Encroachment – Growing infestation of thorny bushes which is detrimental to farmlands and large animal habitats

Bushblok – Wood fuel briquette created from excess biomass in Namibia

Biomass – Any organic, non fossil material, dead or alive

Boiler - An enclosed tank in which water is heated and circulated, either as hot water or as steam, for heating or power.

Caloric - Of or relating to heat

CCF – Cheetah Conservation Fund, established in 1990 to fund conservation programs for the endangered African Cheetah

CCF Bush – CCF Bush Pty. Ltd., a subsidiary company of the Cheetah Conservation Fund, dedicated to production of Bushblok fuel logs

Co-firing – Industry process of burning coal and an alternative fuel together for energy production

Combustion – The process of burning

Desertification – Transformation of habitable land into desert

Ecosystem – (Ecological System), grouping of organisms living together within their environment functioning as a whole community.

Emissions – Substances, often harmful gasses, discharged into the air during combustion

Eskom – South African power company

Extrusion – Process of forcing material through a die to compact and form it to a desired shape

Forest Stewardship Council – International organization which provides a green label certification to companies with environmentally friendly wood products.

Fuel log – Compacted solid mass made from any fuel source suitable for burning in a controlled environment

Hectare – Unit of land measurement, 10,000 sq. meters

Herbivore – Animal which feeds chiefly on plants

Hydrocarbon – An organic compound containing only carbon and hydrogen often occurring in fossil fuels

Indigenous – Originating and living naturally in its current environment

Injection – Process of adding fuel to a boiler during operation

MJ – Abbreviation of Mega Joule

NamPower – Namibian Power company

NAPCOD – Nambian government program, *National Program to Combat Desertification*, created to prevent desertification of land in Namibia.

Poaching – Practice of illegally hunting animals

Proliferation – The act of growing or producing at a very rapid rate

Pty. Ltd. – Proprietary Limited business designation, similar to an American limited liability corporation. Typically this type of business has less than fifty shareholders and is not publicly traded.

Retrofit- To provide (a boiler for example) with parts, devices, or equipment not in existence or available at the time of original manufacture

Ton – See tonne

Tonne – One metric ton, 1000 kg.

Introduction

Namibia's savannah is currently infested with thorn bushes, covering an estimated 10 – 12 million hectares representing 12 – 14% of the land. Indigenous species are responsible for the infestation, the result of a complex interaction between the grass cover, overgrazing, fire suppression policies, and weather. When the acacia thorn bush encroaches, it can cause land to lose up to 100% of its productivity (De Klerk, 2002). Dense thickets of this bush prevent farmers from using the land, displace prey species, and lower the hunting efficiency of predators such as the cheetah. Unfortunately, once bush has taken hold and displaced grass cover, unchecked development of its root system gives the bush a competitive advantage for water, preventing the grass from returning (De Klerk, 2002).

As a threat to the cheetah, bush encroachment is an issue of concern for the Cheetah Conservation Fund (CCF). Founded in 1990 by Dr. Laurie Marker in Namibia, the CCF's stated mission is "to ensure the long-term survival of the cheetah and its ecosystem through a multi-disciplined and integrated conservation programme of research, management and education" (CCF, 2006). The Cheetah Conservation Fund was created because economic development and expansion in Africa began to diminish the cheetah population (Department of Interior, 2000). CCF Bush Pty. Ltd., a subsidiary of the Cheetah Conservation Fund, also carries a similar mission. CCF Bush's vision is to return the savannah to its natural open state by combating the problem of bush encroachment, thereby improving the habitat of the cheetah.

Currently, CCF Bush is harvesting bush and processing it into fuel logs known as Bushbloks. CCF Bush produces a few hundred metric tons of Bushblok fuel logs each year and exports a substantial amount of this product to the United Kingdom for home heating. The log has recently been certified as environmentally friendly by the Forest Stewardship Council, and is advertised as having long burning times at very hot temperatures with low ash output. With an estimated quantity of excess biomass exceeding 100 million tons, it is clear that there is a substantial surplus of raw materials available for Bushblok production (CCF, 2006).

Existing environmental and economic challenges have prompted a need for CCF Bush to look very carefully at expanding their business. CCF Bush would like to increase production of their product to harvest more encroached bush as well as provide more jobs to local Namibians. However, they are currently limited to selling their product in foreign markets as they have yet to

penetrate domestic energy markets. The company recognizes that the pending Namibian energy crisis of 2007 threatens to leave the country in a series of rolling blackouts causing economic depression. Keeping this inevitable energy crisis in mind, CCF Bush would like to explore expansion into this market. The CCF Bush factory is located in the city of Otjiwarongo. Because of this, Otjiwarongo is an acceptable starting point to enter the wood fuel market. Furthermore, the demand for firewood in the North Central Region of the country is causing deforestation in the area and limiting the supply of firewood that its inhabitants depend on. The continued over-harvesting of the limited wood supply in this region as well as clearing land for agricultural purposes is resulting in desertification of the region. Penetrating into the domestic wood fuel market would translate to an increase in production for CCF Bush and could potentially alleviate the wood supply problem. An increase in the wood fuel market knowledge base may allow CCF Bush to increase sales in Namibia, especially in Otjiwarongo and the North Central Region.

The goal of this project was to identify which Namibian energy markets could feasibly utilize the Bushblok product. To do this, we evaluated the social and technological implications of switching from current energy sources to Bushblok. An analysis of the Bushblok's caloric properties was also conducted. Focusing our investigations on firewood markets in the residential sector and heating applications in the industrial sector, we were able to make recommendations to CCF Bush Pty. Ltd. concerning who can best use their product.

Background

In this chapter, we discuss the root causes of cheetah endangerment and the plans of the Cheetah Conservation Fund to restore the cheetah's habitat with the help of CCF Bush Pty Ltd. We consider the technical and economic issues that CCF Bush Pty Ltd faces in creating a viable business that can sell the Bushblok product. The purpose of this new business venture is to not only benefit the CCF, but to benefit all of Namibia by creating another option for energy. Throughout this chapter, we present information on several technical issues and social problems which were investigated during the research phase of this project. The pending energy crisis in Namibia suggests the possibility of implementing Bushblok fuel logs in industrial applications through co-firing techniques already proven in other parts of the world. Deforestation problems leading to desertification in the North Central Region and large percentages of people who rely on wood for cooking suggest that Bushblok fuel logs may be able to penetrate an already large residential wood fuel market.

The Cheetah as an Endangered Species

With its beautiful spotted fur and its blistering speed, the cheetah is well known as the world's fastest land animal. It is also known as one of the most threatened. Between 1900 and 1996, the world's cheetah population diminished from 100,000 animals to just 12,000. This section will explain some of the original causes of cheetah population depletion, and will describe the responses to it.

Economic Development Leading to Bush Encroachment

Constant economic development and expansion in Africa is a contributing factor in diminishing the cheetah population (Department of Interior, 2000). Grazing land is often taken over by industrial expansion, and farmers and ranchers often fence off their remaining lands. This decline in free grazing land is a major factor leading to the problem of bush encroachment within Namibia.

Bush encroachment is one of the most recently studied threats to the cheetah. Bush encroachment refers to the proliferation of thorny bushes, rendering formerly productive land unusable. Nearly 26 million hectares of bush are encroached, 10 – 12 million of which are encroached to the point that the land is useless (De Klerk, 2002). Many studies have analyzed

the economic threat to farmers due to bush encroachment, but all studies recognize that such a dramatic difference between open and closed savannah is causing harm to the ecosystem as well (De Klerk, 2002).

Bush encroachment occurs when the balance between bush and grass in the African savannah is upset. A two layer model of savannah root systems has been proposed with grasses occupying the upper layer and bush roots extending deeper into the lower layer (De Klerk, 2002). Normally, there is heavy grass cover and the grass is the dominant competitor for water, keeping the bush in check. If for some reason the grass layer is damaged, the bush roots grow into the upper soil layer and bush seedlings survive to maturity, resulting in a proliferation of bush (De Klerk, 2002). The establishment of bush in the upper soil layer prevents the grass from reestablishing itself. Farmers and ranchers are often blamed for over utilizing the grass, but other factors such as fire, drought, and displacement of indigenous browsing herbivores affect the savannah's plant balance (De Klerk, 2002).

The Cheetah Conservation Fund and Creation of CCF Bush Pty. Ltd.

After the cheetah population in Namibia nearly halved in the 1980s, many Namibian conservationists took notice of the cheetah's dramatic recession. One organization, the Cheetah Conservation Fund, began to campaign to ensure the cheetah's survival.

Dr. Laurie Marker chose Namibia, home to the largest population of cheetahs, to found the Cheetah Conservation Fund (CCF). The CCF's stated mission is "to ensure the long-term survival of the cheetah and its ecosystem through a multi-disciplined and integrated conservation programme of research, management and education" (CCF, 2006). When Dr. Marker began her campaign in 1990 she stated that "probably 90 percent of the people looked at me and thought I was nuts" (Wines, 2005). These attitudes were due to a nationwide lack of knowledge and care for the dwindling cheetah population. Since its beginning, the CCF has succeeded in bringing the poaching levels down from 800 killings per year in 1980 to 200 per year in 2005 (Wines, 2005). The number of cheetahs eventually stabilized in Namibia and the population even began to rise in the past few years. In addition, Marker stated that "at this point, a good 60 to 70 percent of people within the cheetah's range are very enlightened, and not having any problems with cheetahs" (Wines, 2005).

The work of the CCF is not yet complete. The CCF's current goals include reinstatement of genetic variation in the cheetah, educating farmers on the benefits of cheetahs, and raising awareness of the cheetah's plight. The CCF has implemented genetic studies, ecological studies, rancher education programs, and other programs to succeed in accomplishing its goals (CCF, 2006).

Created by the Cheetah Conservation Fund in 2001, CCF Bush Pty. Ltd. is a for-profit organization dedicated to the development of the CCF Bush Project. CCF Bush was created to manage an effective harvesting process for the undesirable bush which causes encroachment problems throughout the country. In 2004, CCF Bush began producing the Bushblok fuel log (Africa News, 2006). Bushblok fuel logs have been introduced as an environmentally friendly competitor in wood and coal-firing markets. The goal of CCF Bush is to effectively manage this newly developed Namibian industry while providing jobs, reclaiming bush encroached land, and restoring the cheetah's natural habitat. Because Bushblok is a replacement fuel for typical firewood, domestic sales of the product may also alleviate problems of deforestation within the country.

Current Uses for Unwanted Biomass

The term biomass refers to material from organic matter such as animal waste or plant material (Natural Resources Defense Council, 2006). As previously mentioned, CCF Bush is trying to utilize this abundant biomass within the country of Namibia to create a renewable energy fuel log. CCF Bush is not the first company to process unwanted biomass as a fuel log. In order to help CCF Bush grow, it is important to understand which markets have been tapped by competitors, and at what levels. Although CCF Bush's product is very similar to those of its competitors, it does hold the advantage of brand recognition as being cheetah friendly.

Biomass as Fuel

Combustible fuels are made up of hydrocarbon chains which give them a high potential energy that is released when burned. In terms of low emissions and high heat energy (known as energy content), biomass is perhaps the best renewable source of combustible energy. The defining quality of this source is that the hydrocarbons are made through photosynthesis using the power of the sun. Like coal, biomass can be burned to create heat that can be converted into

electricity. Biomass can also be fermented to create ethanol fuel, "digested" by bacteria to create methane fuel, or "gasified" to produce a cleaner gas to replace petroleum products (Natural Resources Defense Council, 2006). The main source of biomass is wood and wood byproducts, which were the main source of energy until the mid 1800s in the United States.

Burning plant-like biomass does give off greenhouse gasses; however, these emissions are comparable to the amount of the carbon dioxide recycled by the plant during growth (Natural Resources Defense Council, 2006). In addition, there are lesser amounts of harmful emissions such as carbon monoxide, sulfur oxides, and nitrogen oxides in biomass than in coal or petroleum based products. When biomass is substituted for fossil fuels, these properties of biomass help to decrease the occurrence of acid rain and smog (Natural Resources Defense Council, 2006).

Bushblok Fuel Logs

With a projected value of over 100 million tons of excess biomass, it is clear that there is a substantial surplus of raw materials available for the production of Bushblok wood fuel log (CCF, 2006). CCF Bush is primarily interested in the use of combustion of the biomass to release the potential energy rather then the possibility of creating a fuel by digesting or gasifying the invader bush.

Bushblok has already proven to be a competitive wood fuel log in the foreign markets. The log is competitively priced with coal and offers benefits such as low ash output and long burning times. Bushblok has entered the market in the UK as a convenience fuel log for home heating. According to *Africa News*, CCF Bush has shipped over 400 metric tons of Bushblok to the United Kingdom from October 2005 to February 2006. Currently, the domestic market in Namibia is not quite as large. CCF Bush would like to promote co-firing processes with Namibian businesses as well investigate other options such as residential use as a cooking fuel.

Bushblok fuel logs, as pictured in Figure 1, are relative in size to a building brick and weigh approximately 0.83 kg each. A single log may burn for up to 1.5 hours at very hot temperatures. Specific heating and emissions characteristic of the wood fuel logs are currently unknown as very few studies on the logs have been conducted. Bushblok fuel logs hold similarities to U.S. products such as the Duraflame™ log which is also made from excess and

otherwise unusable biomass. However, unlike similar U.S. products, Bushblok is not comprised of any wax or tar binder.

Figure 1: Bushblok Fuel Logs

Opportunities in the Residential Market

Two distinct problems within Namibia are bush encroachment and deforestation. Both of these problems lead to desertification causing land to become unusable. The production of Bushblok is helping to alleviate the bush encroachment problem at the moment. However, if transported to and sold in areas of deforestation, it would also curb hard wood usage within the nation and slow the rate of forest loss. In this section we explain the problem of deforestation and the substantial size of the residential wood fuel market. It is important to recognize that if Bushblok enters the residential market on a large scale, it will help to alleviate the problem of deforestation.

Deforestation in the Owambo Region

Although Namibia is the most arid country south of the Sahara Desert, it did possess 15% of the total forest area in Africa as of 1995 (Erkkila, 2001). Most of these forest regions within Namibia are located in the North Central and North Eastern regions of the country near the

Kunene and Okavango Rivers and the border of Angola (Erkkila, 2001). This region consists of 2.3 million hectares of semi-arid land. Located between Etosha and Angola, it completely covers the provinces of Omusati, Oshana, and Oshikoto (Erkkila, 2001). This area holds 44% of the population of Namibia (as of 1991) with a population of 740,000 and a population density of 14 persons per square kilometer (Erkkila, 2001). The people of the Owambo region are Bantu speaking people who typically herd cattle. The Bantu language has taken shape into modern day Oshiwambo; speakers of the Oshiwambo language account for 51% of the total population (Erkkila, 2001).

The Owambo region, also known as the Owambolands to locals, has been plagued by deforestation problems. Between 1990 and 1995, this region lost about 42,000 hectares of forest with an annual rate of deforestation of 0.3%. This is by far the most severe region of deforestation in Namibia (Erkkila, 2001). The earliest concerns of possible wood degradation came to surface in the late nineteenth century when the well wooded areas were cleared for either cattle grazing land or agricultural needs (Erkkila, 2001).

By 1962, the South African government considered deforestation to be a significant environmental threat as well as a substantial economic problem. The current Namibian government still shares these beliefs. The socio-economic problems surrounding deforestation are leading to unsustainable development of the region. Deforestation also directly causes an environmental problem known as desertification. The problem of deforestation leading to desertification was also specifically mentioned in Namibia's Green Plan presented in 1992 (Erkkila, 2001). In this plan, the Directorate of Forestry in Namibia highlighted a need for cross-sectoral cooperation to combat the deforestation problem (Erkkila, 2001). Currently, the situation in Namibia is paradoxical in that there is an abundance of biomass in the Central Region of the country due to the bush encroachment problem and a lack of biomass in the North Central Region due to the deforestation problem.

Namibia Residential Fuel Use

In prior studies, it was found that rural villages harvest hardwood off of their communal lands in order to provide their need of firewood (Food and Agriculture, 2000). In these rural areas of Namibia, 90% of the harvested wood is used for cooking fuel. When wood is purchased by rural villagers, it is regarded as commercial consumption of wood. In 1996, it was estimated

that approximately 1.00 kg of wood is used per day per person in rural villages (Food and Agriculture, 2000).

Residential wood fuel use in Namibia is quite high in comparison with other home fuel usage. In 2003, it was estimated that 62% of all households in the nation use wood fuel for cooking rather than electricity or other sources. This breaks down to 89% of rural households and only 20% of urban households. In comparison, only 25% of all households use electricity with a breakdown of 5% in the rural areas and 56% in the urban areas (Mendelson, 2005). Although a majority of wood use occurs in the rural areas of the country, the densely populated Northern Central Region accounts for much of these households. High wood fuel usage in this area is also causing environmental problems such as deforestation, as previously mentioned.

In suburban settings, wood is supplied by formal retailers such as gas stations and grocery stores. According to the Department of Forestry, wood harvesters in Namibia often collect the wood illegally which they then sell to retailers in either the townships or sometimes to established retailers. In order to harvest and trade wood legally in Namibia one must register with the Department of Forestry, though many retailers disregard this policy (Food and Agriculture, 2000). Due to the limited availability of wood through retailers, access to electricity, and the ability to pay for it, electricity is typically used for cooking in urban households. The convenience of electricity in these urban settings sets the commercial wood fuel usage much lower than rural settings at just about .3 kg per person (Food and Agriculture, 2000).

Annual wood fuel usage in Namibia has been estimated at 152, 864 tons of commercial collected wood and about 519, 467 tons collected off of communal lands for free (Food and Agriculture, 2000). These estimates were made in 1996 by the Namibian Department of Forestry and these numbers may have changed. With a total of 672,331 tons of wood fuel utilized in Namibia per year, this may be a very feasible market for CCF Bush to develop its product.

Opportunities in the Industrial Market

Similar to the domestic residential market, the industrial market provides significant opportunity for CCF Bush to enter as well as the possibility of alleviating a large social problem within the country. In this section we will explain the pending energy crisis in Namibia as well as how Bushblok may provide a partial solution to the problem as a renewable energy source.

We will then explain the concept of co-firing and provide examples of where it has worked elsewhere in the world.

The Pending Energy Crisis

According to NamPower, the southern portion of Africa, which includes Namibia, is facing an energy crisis with the possibility of blackout conditions as early as 2007. NamPower, the national power utility of Namibia, specializes in energy transfer into electric power and is the primary combatant of the energy crisis in Namibia (NamPower, 2006). Right now the Eskom Company based in South Africa is the major electricity provider for Namibia. The current Bilateral Agreement between Eskom and NamPower expires in 2006 (Nam Power, 2006) and there are "no guarantees" for the future. NamPower warns that Eskom might be forced to stop providing the valuable power that it does now (2006).

However, Namibia is not without its own source of electricity. The Ruacana Hydro-Power Station, Paratus Diesel Power Station, and the Van Eck Coal Power Station are able to provide approximately 400 megawatts to the Namibian power grid with a major hydropower development project in the works for 2007 (Nam Power, 2006).

The Van Eck power plant is located in the northern industrial area of Windhoek and is the only coal-fired plant in Namibia, making it the prime candidate for conversion to co-firing with biomass. The plant was opened in the early 1970s and was the first coal powered plant in Southern Africa to use the dry cooling method. The plant can produce 120 MW and uses a Brown Boveri Orsal generator. It currently uses 570 kilograms of coal per hour and 290 liters of water per hour. This input generates approximately 37.79 kilograms of steam per second. The system works by spraying coal onto the moving floor grate and then the coal is fed into the Yarrow Africa, Babcock and Wilcox boilers (Van Eck, 2006).

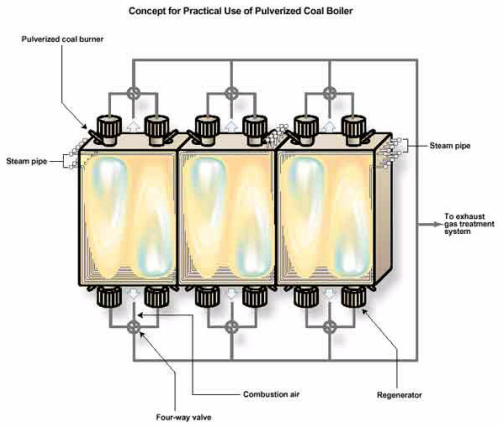
The cost of running the Van Eck plant is too expensive for the Namibian economy because of the high price of coal (Namibian Economist, 2000). Therefore, the plant is not run year round, and is only used when necessary. The plant has been turned on in the past when South Africa's Eskom plant leaks or is shut down.

The Namibian government would like to begin to focus its energy efforts into renewable energy within the country. Sam Nujoma, founding President of Namibia, stated that Namibia has to focus on using its natural resources to help Namibia's economic base. He also has stated

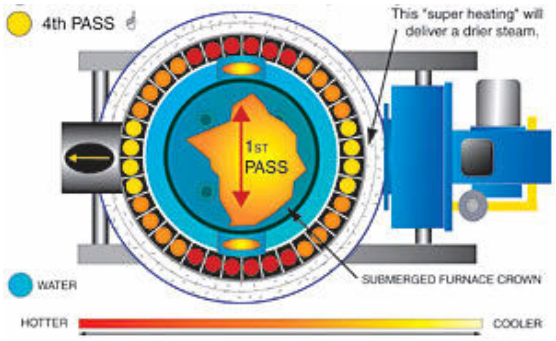
that Namibia needs to use their resources internally to help combat the energy problem and reduce their dependency on imported electricity (Nujoma, 2005).

Co-firing of Coal and Biomass

Co-firing utilizes both the energy from coal and the stored solar energy from biomass. The practice of co-firing implies the substitution of biomass for a portion of a fossil fuel such as coal in a boiler. The practice of co-firing is a "fuel-diversification" strategy which is not a brand new technology. For decades, wood product industries have been using this technology to utilize their scrap materials. Co-firing has been successful in virtually all coal fired boilers such as stokers, fluidized beds, pulverized coal boilers, and cyclones as seen in Figure 2 below (US Department of Energy, 2004,).



Pulverized Coal Boiler
http://www.eccj.or.jp/hicot/eng/pamph/img/et2.jpg



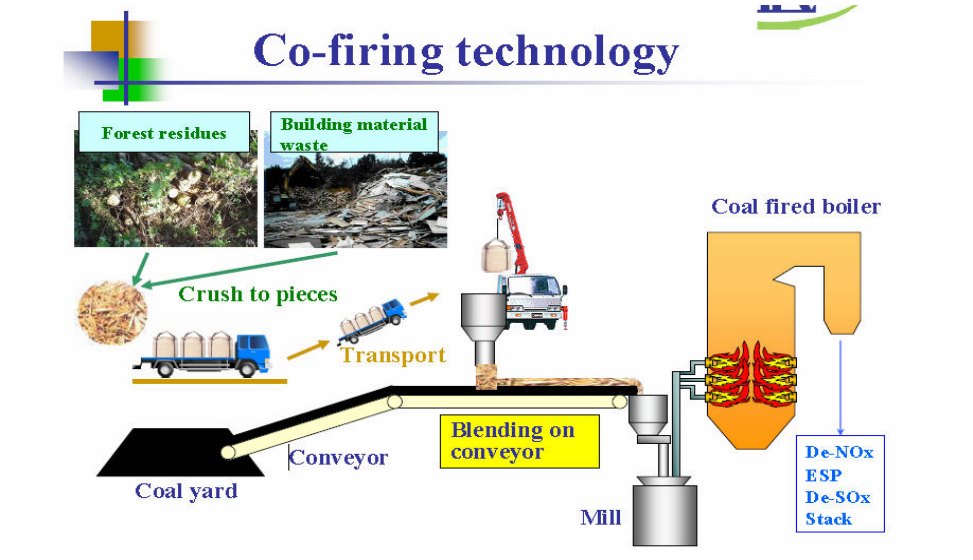
Cyclone Boiler
http://www.hurstboiler.com/images/4vts2.jpg

Figure 2: Pulverized and Cyclone Boiler Systems

Co-firing is becoming a more utilized technique through out the world due to its economic and environmental benefits. With the rising cost of fuels such as coal and petroleum products, biomass is a welcomed cost reducer due to the fact that it is a renewable resource. As mentioned previously, another benefit for environmentally conscious industries is that burning biomass has no net carbon dioxide output as well as helps with limiting sulfur oxides and nitrogen oxides that are released into the air.

A disadvantage of this beneficial technology is that in order to get the best possible reaction within the boiler, there has to be an optimal ratio of biomass to fossil fuel and then the correct air ratio to have ideal combustion. One other possible drawback is the requirement of a

separate pulverizing and/or mixing machine to make sure the process operates without problem. Additional equipment necessary for this process is presented in Figure 3 below.



Co-Firing of Coal with Biomass - Sugiyama, Shirai, and Kimoto

Figure 3: Co-firing Technology

Retrofitting Boilers for Co-firing

If a power plant currently has a coal-fired boiler it is relatively simple to install a biomass co-firing process. If the biomass harvested contains a low enough moisture content, the furnace and boilers do not need to be adjusted. Even though the boilers do not have to be adjusted, the biomass does need to be processed differently for specific boiler types. Table 1 below from the Federal Energy Management Report on Biomass Co-firing in Coal-Fired Boilers shows the relative sizes of biomass that should be used for specific boilers (US Dept. of Energy, 2004). If CCF Bush can produce the biomass in these sizes, industries would require less change to their boiler systems.

Table 1. Biomass sizing requirements.

Existing Type of Boiler	Size Required (inches)
Pulverized coal	≤1/4
Stoker	≤3
Cyclone	≤1/2
Fluidized bed	≤3

Table 1: Biomass Sizing Requirements

Therefore, the only retrofitting equipment needed to update a coal-fired plant to a co-fired plant is a feed system. The preprocessed biomass must be mixed with the coal and fed onto the conveyors that enter the furnace through the boiler's current injection ports. The design of the mixing and injection process will vary with each power plant depending on its current injection process.

Greenidge Co-Firing Power Station, Dresden, New York

A co-firing test program was implemented at the Greenidge Station in 1994 by New York State Electric and Gas (otherwise known as NYSEG). This particular coal fired plant was retrofitted such that a wood fuel feed was conveyed separately to the pulverized coal boiler where it would then meet up with the coal fuel (as seen in Figure 4). After 3-4 years of testing, NYSEG decided that the tests were successful and that this particular technology was able to be sustained on a commercial basis. By 1999, most of the test equipment was substituted with more permanent replacement equipment.

Only a year after this plant became commercial, the 108 MW coal fired boiler burned 11,000 tons of wood, providing about 5% of the total heat output of this boiler. However, as the co-firing concept became more established, a new "hammermill" was installed to help to increase the percentage of total heat output for wood products to be 10%. This new technology helped to implement the co-firing process more effectively.

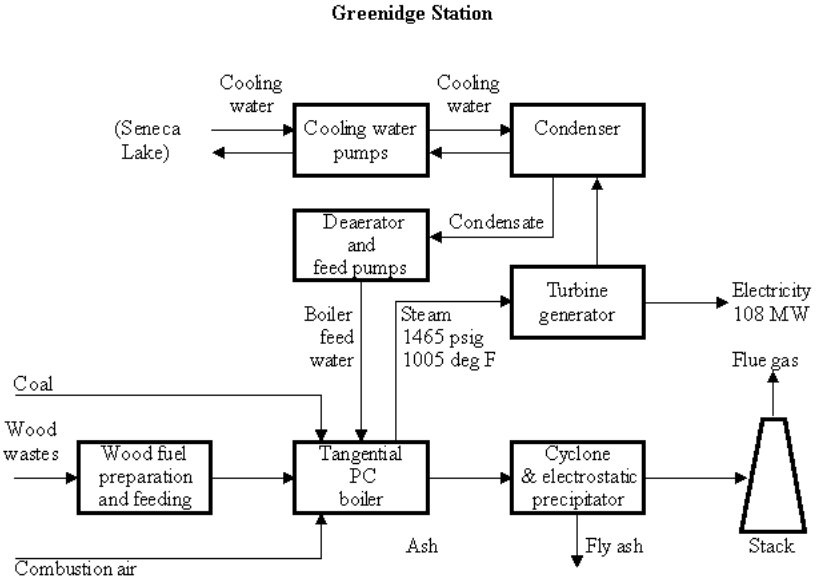


Figure 4: Greenidge Power Generation Flow Chart

Co-firing of Heavy Fuel Oil and Biomass

Co-firing technology can also be used with liquid fuels, such as heavy fuel oil (HFO), and biomass. HFO contains relatively high levels of pollutants, mainly sulfur, which when burned causes the creation of sulfur dioxide (Wikipedia, 2006). Due to its limited refining process, HFO is the cheapest liquid fuel oil on the market (Wikipedia, 2006). A second drawback of this product is its very high viscosity (Wikipedia, 2006). Pumping a high viscosity fuel is very difficult in colder climates because a heating apparatus is needed to warm the oil so that it can be pumped. Because Namibia has a warm climate, this heating apparatus is unneeded.

The co-firing of liquid fuel and biomass has been demonstrated in Denmark at Burmeister & Wain Energy A/S where they were able to utilize a mixture of natural gas, heavy fuel oil and chipped biomass from the area in their boiler system (Bendixen, 2005). In order to retrofit the liquid fuel boiler, the technicians at Burmeister & Wain Energy A/S added a pulverizer to their system that connects to the boiler after the gas stream, as seen in Figure 5 below. After the chipped fuel is added, the boiler operates by combusting both liquid fuel and the biomass. This system shown below was originally running on just a natural gas and HFO stream at 49% efficiency while after adding the biomass, there was a 2% drop to 47% efficiency (Bendixen, 2005). The boiler may lose some efficiency, but in this case, the 2% drop doesn't outweigh the benefits to the environment due to Denmark's high environmental standards (Bendixen, 2005).

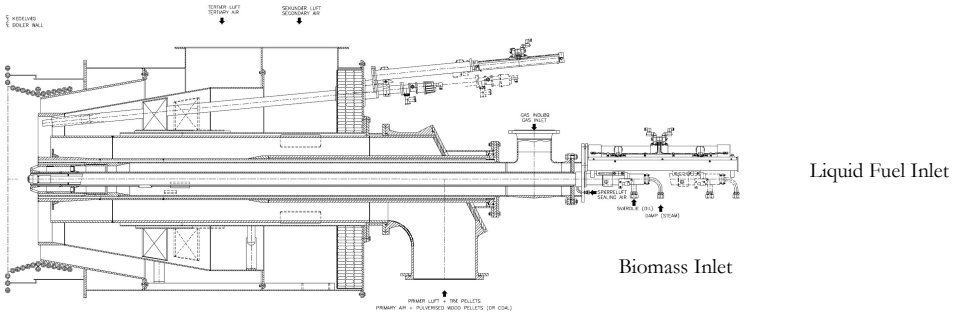


Figure 5: HFO, Natural Gas and Biomass Boiler in Gentofte, Denmark

Methodology

The purpose of our investigation was to gather information so that we could help CCF Bush Pty. Ltd. develop sales within Namibia. CCF Bush sells Bushblok in the U.K., but is interested in entering domestic markets. CCF Bush Project Director Bruce Brewer had identified two areas of interest, residential wood fuel markets and industrial energy markets. In this chapter, we will explain the methodology we used to investigate both. In the residential section, we will describe how we created primary research questions, designed interviews, and sampled retailers and consumers. In the industrial section, we will describe how we created primary research questions, collected technical data on Bushblok and industrial fuels, and interviewed plant engineers.

Researching the Residential Wood Fuels Market

We investigated the residential market because our background research had shown that there were high rates of wood fuel consumption in Namibia. Our sponsor, CCF Bush, was interested in entering the wood fuel market because it could potentially mean an increase in sales, as well as social benefits for Namibia. By increasing production CCF Bush could potentially employ more local Namibians and supply a new wood fuel product to the market to decrease deforestation in the country. The purpose of our research was to gain an understanding of the residential market so that we could recommend a course of action to CCF Bush.

In this section, we will explain the methodology we used to investigate the residential wood fuels market. First, we created primary research questions to guide our investigation. Those questions led us to choose two target populations, consumers and retailers, to gather data from. We then created specific questionnaires for consumers and retailers. Finally, we selected specific regions to evaluate and created plans to conduct investigations within them.

Research Questions

In order to evaluate the residential market we established three primary research questions to direct our investigations:

- ***Is there a need for a new wood fuel product in the residential market?*** Our background research had shown that there were high levels of wood consumption in Namibia, but we wanted to find out if there was a shortage of wood that Bushblok could address. In order to determine if there was a shortage of wood, we chose to evaluate if there was a discrepancy between the supply and demand. If the demand for wood out weighed the supply there would be a need for a new wood fuel product in the residential market.

- ***If there is a need for a new wood fuel product, how should it be sold?*** To find out what is required to sell Bushblok as a substitute for current wood fuels, we sought information on the distributor/retail structure. Along with the market structure, we identified costs incurred through the shipping process. Finally, we decided to requested retail and wholesale price information for current wood fuels in order to recommend a price range for Bushblok.

- ***Will there be social acceptance and willingness to use Bushblok as a new wood fuel product?*** It was essential that we consider the social factors that surround wood use in Namibia. We recognized that people may have traditional reasons for burning wood and therefore switching to Bushblok may have a social impact on the communities. We sought out the reasons why communities burned wood, if they were content using wood as a fuel, and if they were willing to try a new fuel source. In addition, we gathered information on the consumer's receptiveness to Bushblok.

Finding answers to these questions in any wood fuel market would allow us to evaluate the potential for Bushblok to be sold within a market. The ideal market for CCF Bush would have a strong need for Bushblok, retailers that would purchase Bushblok at high prices and consumers that would be willing to use a different wood fuel. The worst case market would have a high supply of wood and low demand, uncooperative or non-existent retailers, and consumers uninterested in trying the Bushblok product.

Interviews with Retailers and Consumers

The purpose of this section is to explain how we developed data collection strategies to address the research questions we identified above. We will first explain why we decided to interview retailers and consumers; next, we will describe the techniques we chose to gather information from them.

We identified retailers and consumers as the most approachable of all the constituents in the wood fuel products economy. We anticipated that suppliers, such as charcoal manufacturers and wood harvesters, would be uncooperative because our research was for a potential competitor. Distributors, which service wide regions, might be hard to locate. Retailers and consumers, however, could benefit from a new product, and would be easy to locate.

After determining the desired data and the target population, we selected a data collection method. We decided to use personal interviews and demonstrations so that we could gather quantitative data, such as price information, and subjective information, such as consumer interest in Bushblok. We created separate sets of questions for consumers and retailers to guide our interviews.

The questions created for retailers, shown in Appendix B: Retailer Interview Questions, focus on volume of sales, wholesale and retail price, and receptiveness to Bushblok. We learned from the general manager of CCF Bush Pty. Ltd., Bruce Brewer, that wood is sold at formal locations such as gas stations and supermarkets as well as informally, in the shack dwellings. In both cases, we conducted the interviews in a semi-formal manner. Our intent was to gather specific, quantitative information, and then to inquire about the retailer's perspective on the feasibility of selling Bushblok. Included in the feasibility of selling Bushblok would be the potential price and delivery aspects of the product.

When we interviewed formal retail managers, our primary concern was to be respectful of their time and position. When we interviewed informal retailers, we had to take extra care to make the purpose of our investigation clear from the outset. We were aware that many informal retailers collected wood illegally, so we did not want people to feel as though we would report them to local authorities.

The questions we designed for consumers, seen in Appendix C: Residential Interview Questions, focus on demand, satisfaction with available wood fuels, and receptiveness to Bushblok. Because wood is sometimes consumed illegally, the consumer interviews needed to be

planned carefully. To show the locals that we were not there to scrutinize their life styles, we had to thoroughly explain the purpose of our study and the data we were looking for. Furthermore, in order to create a friendly environment we brought mints with us for both the children who were not in school and for the interviewees.

In addition, we held demonstrations with the Bushblok to gauge the receptiveness of consumers to the product. We set out to informally ask the people if they would use Bushblok and if they found it more suitable then wood. In order to gain as many opinions as possible on the Bushblok product, we held demonstrations in the open markets and in the informal settlement, where many people would pass during our display of the burning and cooking ability of Bushblok.

Region of Focus

In order to limit the scope of our investigations we only chose to research two regions in Namibia. In this section we describe the two regions of focus for our investigation: Otjiwarongo and the Oshakati / Ongwediva area. In each case we explain why the region was of interest and how contacts were made with retailers and consumers.

The CCF Bush factory is located in the city of Otjiwarongo, so we selected that region to begin our investigations. CCF Bush has a good relationship with the Otjiwarongo Municipality because the company hires so many local constituents to work in the factory. If we did find a market for CCF Bush to enter, it would be a logical step for CCF Bush to further develop its relationship with the town. Our background research had also shown that there was a significant amount of wood fuel use in the region, suggesting that there could be a market for Bushblok.

We took advantage of CCF Bush's relationship with the Municipality and asked CCF Bush General Manager Bruce Brewer to personally introduce us to Manfred Uxamb, the Otjiwarongo City Manager. We desired this introduction so the city manager would help us identify wood retailers and consumers in Otjiwarongo.

Through this interview, we found that gas stations and supermarkets sell wood, charcoal, and charcoal briquettes and these retailers are all located along the main road in Otjiwarongo. We split up into teams of two, so that we could gather data more rapidly, and went to each retailer to gather our desired information.

We also learned during our interview with Mr. Uxamb that there are retailers located within the local settlement of Orwetoveni. The residents in this area did not speak English, so the municipality provided a translator from the Orwetoveni Branch Office to guide us through the settlement and to help us conduct interviews. We believed that having a translator from the municipality would be beneficial, as he already understands the Bushblok product and our intent in interviewing the locals. To not overwhelm the interviewees we had the local translator and only two of our group members travel into the informal settlement. During these interviews we used the previously described questionnaire from Appendix C: Residential Interview Questions.

In order to gain as many opinions as possible on the Bushblok product we held a demonstration after work hours in a very busy area of the informal settlement. Also, because children were present, as it was after school hours, we brought sweets with us as a gift. The CCF provided us with a translator to explain to us the viewers' perceptions and reactions to the Bushblok. We informally asked the people if they would use Bushblok and if they found it comparable to wood.

We chose Ongwediva and Oshakati, located in the North Central region of Namibia, as our second region of study. It may be home to the strongest domestic Bushblok market, because our background research had shown that deforestation and high wood usage were prevalent in the area. More importantly, the North Central Region of the country is also the most densely populated. A CCF employee, Matti Nghikembua was a native of the region and had contacts within both city governments.

Mr. Nghikembua traveled with us to Ongwediva and Oshakati and he was able to identify gas stations, grocery stores, and open markets that sold wood fuels. In addition, Mr. Nghikembua had a contact with the local Director of Forestry who escorted us to the Oshakati open market, provided translation, and informed us of regulations on wood sales in the area.

We split up again into teams of two to interview the retailers in the gas stations and supermarkets. We had no contact information, so we went from store to store without setting up interviews prior to our appearance. The managers spoke English, so we interviewed them ourselves using the questions from Appendix B: Retailer Interview Questions.

When we went to interview consumers we used two translators and were able to split up into two teams of two. Our primary translator, Mr. Nghikembua, had family in the area and requested the help of his sister to translate for the second team. This allowed us to interview two

completely different areas simultaneously. One team went door to door through a formal neighborhood to interview consumers. The other team members conducted interviews in the rural farming homesteads. The interviews were conducted in the same manner as in the Orwetoveni settlement, guided by Appendix C: Residential Interview Questions.

Researching the Industrial Energy Sector

From our background research, we learned that it is possible to burn biomass in a boiler system by substituting it for more common fossil fuels. The predicted energy crisis which may occur as early as 2007 may create a substantial need for renewable energy sources within Namibia. An industrial client could potentially be a large, steady customer for the Bushblok product. The purpose of our research into the industrial market was to gain an understanding of industrial fuel needs and to identify any businesses which would be favorable for CCF Bush to pursue a relationship with.

In this section, we will first describe the research questions we created to guide our investigation into the industrial market. Next, we will describe how we gathered technical information on Bushblok and other boiler fuels. Finally, we will describe the methods we used to collect information from boiler system engineers and plant managers.

Research Questions

We used an approach similar to that used for the residential sector to guide our research into the industrial energy market. We began by preparing two primary research questions.

- ***Is it feasible to use Bushblok as a boiler fuel?*** To assess the feasibility of using Bushblok, we needed to gather information to compare the combustive properties of different boiler fuels. We wanted to know if Bushblok could burn cleanly enough to be used as a boiler fuel and if it had a high enough energy density.

- ***If it is feasible, what incentives and obstacles would there be to using it?*** From our background research, we identified several factors that could prevent a company from switching to Bushblok. We wanted to find out if the supply line and price were stable in order to learn if Bushblok could be a more reliable fuel source. We also wanted to know

if companies were locked into fuel contracts and if they were receptive to co-firing. Technical factors that could prevent a company from switching included difficulty in retrofitting, boiler condition, and emissions requirements.

The best case scenario for CCF Bush would be to find a company with a need for an alternative energy source that could use and benefit from Bushblok. The worst case scenario would be to find a company with well met energy needs that would not benefit from using Bushblok as an alternative fuel source.

Caloric Properties of Bushblok and Other Boiler Fuels

In this section, we describe the methods that we used to obtain information on various fuels used in Namibia. We learned from CCF Bush Project Director Bruce Brewer that coal and HFO are the two boiler fuels predominantly used in Namibia. We will first explain the relevant properties of the two fuels, and then how we conducted testing to measure the Bushblok's caloric properties.

We contacted both fuel suppliers and fuel consumers to ask them if they could supply us with energy density information for their fuel. We contacted Engen Petroleum Ltd. asking for information on HFO and NamPower and Meatco Abattoir for information on coal.

CCF Bush Pty. Ltd. sent us Bushblok samples to conduct testing. When we received the samples we set out to answer two questions: What quantity of energy does Bushblok produce per unit mass (MJ/kg) and does it have any properties that would be detrimental to its use?

To find the energy density of the Bushblok, we approached WPI Fire Protection Engineering Lab Director, Randy Harris, and requested that he run a cone calorimetric test. The test results would include a measure of heat released during burning as well as the mass of the fuel sample. With that information, we could then calculate the energy density of the product. By combining the energy density (MJ/kg) with production cost (N$/kg) we determined the price per MJ of heat released. Bushblok, coal, and HFO all have different energy densities and are sold by the ton or by the liter, so price per MJ provides a common denominator to compare the three. That information was important, because when boiler system operators consider switching or mixing fuels, they are more concerned with how much total heat the boiler must produce than

the physical amount of fuel consumed. By comparing price per MJ, we were able to directly compare the cost of using different boiler fuels.

The cone calorimetric test apparatus could also measure time to ignition, oxygen consumption, carbon dioxide and carbon monoxide emissions, smoke density, and mass loss during burning. The test information would not put us in a position to certify the Bushblok as a clean and safe burning product, but we would be able to say if it *wasn't* a good product. High carbon monoxide emissions would indicate that the Bushblok isn't combusting completely, meaning that the Bushblok isn't burning cleanly and could also make the product deadly for residential use. A high smoke density would mean it is giving off a lot of soot, which is undesirable for a boiler system and for residential use. Finally, a high amount of mass remaining after burning would show that the Bushblok had many incombustible impurities. The testing that was done on Bushblok did not include a chemical analysis that would be necessary to determine whether the product has corrosive or toxic properties that would be detrimental in a boiler system.

Interviews with Plant Engineers

In this section, we will explain the methodology we used to gather information from industry. First, we explain why we chose to interview boiler system operators and plant engineers and we describe the questionnaire we developed to gather data. Next, we show how we created a plan to contact engineers.

We chose to speak with boiler operators and plant engineers because they would have information on their specific company's energy usage and needs as well as opinions on biomass firing, co-firing, and the Bushblok product itself. We chose personal interviews because we believed interviewees would be more responsive to our questions than through e-mails or phone calls. We created a questionnaire to guide our interviews that is found in Appendix D: Industrial Interview Questions. The first half of the questionnaire contained questions about energy needs and sought information about fuel price, fuel consumption, stability of supply, and the nature of the relationship with the supplier. The second half of the questionnaire focused on technical issues such as the boiler fuel energy density and the cost of replacing the boiler. As with the residential methodology, the interviews were conducted in a semi-formal manner. Our intent

was to promote discussion so that we could learn about engineers' perspectives on using the Bushblok product.

We could not obtain a listing of companies with boiler systems, so we had to make a plan to identify them. We decided to use Bruce Brewer's personal contacts, business referrals, telephone books, and internet research to identify businesses and then contact them. After making contact with a business, we asked for referrals to other businesses, making a snowball survey of industry. Dr. Brewer initially directed us towards several companies and organizations including NamPower, MeatCo Tannery, the Namibian Chamber of Commerce, and the Namibian Manufacturers Association. We successfully contacted five companies and one boiler system expert. They included NamPower, Meatco Abattoir, Meatco Okapuka Tannery, Namibia Breweries, Etosha Fisheries, and Anthony Hearn of A.W.H. Engineering. Representatives from all companies scheduled personal interviews, except for the representative from the NamPower, who responded through e-mail.

Market Analysis in the Industrial Sector

In this chapter we consider three potential industrial uses of Bushblok including biomass-only firing, co-firing with heavy fuel oil (HFO), and co-firing with coal. For each of these potential uses we will present information on energy characteristics of the fuels, issues associated with retrofitting of boiler systems to accommodate biomass, and the receptiveness of the industry to new fuels. All of the information presented is based on the information gathered from caloric testing and from conversations with boiler operators. We will first show that only the raw chips that comprise the Bushblok fuel log can be used in a boiler and that they should only be co-fired. We will also describe the two fuels that are predominantly used in industrial boiler systems in Namibia, coal and HFO. We will continue with our analysis of the coal and HFO market assuming the raw chip prerequisites and how Bushblok biomass can be co-fired in these systems.

Biomass Only Firing

Based on our caloric testing and interviews with boiler experts, we have determined that using Bushblok raw chips as a primary boiler fuel would be technically possible, but there are many barriers that make it infeasible for current boiler operators. Furthermore, Bushblok could not be fired in its processed extruded form because it does not have a high enough heat release rate. In this section we explain the challenges with using Bushblok as a primary industry fuel.

We learned from our background research that boilers require a quick burning fuel with a high energy density. Boiler operators raise the heat release rate of solid fuel by pulverizing it before it enters the boiler, increasing the surface area of the fuel. Because Bushblok is compact, it does not burn quickly enough to be used in any firing process. The raw acacia chips which the Bushblok is comprised of have a much higher surface area that can be spread more evenly resulting in a higher heat release rate.

The tests conducted on the product show that the caloric value of the Bushblok fuel log is about 10.5 MJ per kilogram. As a comparison, the caloric value of industrial fuels that are currently used range from 26-42 MJ per kilogram. In order for a boiler to generate the required amount of steam if Bushblok were used as a fuel, the boiler would need to use 2.5 – 4 times the mass of more common industrial fuels.

Rather then replacing a whole boiler system it is common practice in industries to instead adjust their current boiler with a retrofit. During our research, we found that wood fired boilers used before the widespread use of fossil fuels were very large in comparison to modern boilers. The size difference between the boilers accommodates the biomass' bulk as a result of the relatively low density of biomass compared to high carbon fuels. Mr. Anthony Hearn of AWH Engineering Pty. Ltd. added that modern boilers do not have the physical capacity to handle the volume of Bushblok biomass necessary to generate the amounts of heat that are typically required in modern industrial applications. In addition, because more biomass must be burned, there must be more oxygen to complete the combustion process. Biomass-fired boilers must have larger fans in order to feed more air into the system. Therefore, it is not possible to retrofit an existing boiler to a biomass-fired system and produce the same amount of energy desired. In order to be feasible, a company would have to invest in a brand new boiler which we found to cost upwards of N$100,000.

Because of the multitude of barriers surrounding the use of biomass as a primary fuel, the idea of a transition was not well received by the industry professionals in this sector. All of the professionals interviewed were content with the fuel they were currently using. In addition, implementing this option would prove very costly and unbeneficial to these industries.

HFO Industry and HFO-Biomass Co-firing

From interviews with HFO boiler operators and reviews of technical data, we have found that conditions in the HFO market are unfavorable for CCF Bush because the cost of co-firing raw chips with HFO is too high. In this section we will present findings showing that retrofitting is expensive and the price of energy from raw chips does not offset operating costs. We will also show that the stability of the HFO supply line does not put pressure on industry to use biomass, and plant operators are not receptive to the co-firing concept. Even though we did not interview a large sample of boiler operators, our findings draw heavily from technical data which can be considered representative of the entire industry.

The price per unit of energy produced (N$/MJ) is a good comparative measure for fuels. On this basis, Bushblok raw chip would be less expensive than HFO, costing about $N0.02 per MJ compared to $N0.07 per MJ for HFO. However, our findings suggest that companies are not likely to incorporate biomass co-firing for a number of reasons.

Perhaps the most important reason for not utilizing co-firing technology is that HFO can be fully automated and precisely controlled. Liquid fuel feed systems are generally fully automated; this was the case for all of the HFO boilers we were able to investigate. Pumps and valves can precisely fire the fuel directly into the heat exchange pipes. The automated feed system does not need to be continuously supervised by an employee, reducing operating costs. An additional advantage of the liquid fuel is that the valves can be used to quickly start or stop the flow of fuel, reducing waste during startup and shutdown. Even though the price of energy from raw chips may be cheaper, the operating costs of using HFO may still be significantly lower.

A second key characteristic of liquid fuels, such as HFO, is that they combust relatively completely leaving very little soot and ash remaining in the system. Pulverized fuels, such as biomass, leave ash and soot behind that must be cleaned on a regular basis. Therefore, an HFO and biomass co-fired boiler would have to be cleaned much more frequently, increasing maintenance costs.

Additionally, retrofitting an HFO fired boiler to co-fire raw chip would require a major overhaul of the boiler system. Many of the boilers that we viewed were over 10 years old and many were refurbished boilers over 20-30 years old. Retrofitting an HFO system to co-fire the raw chip product would involve purchasing a whole new, additional feed system. This feed system must also be added to the boiler in addition to the automated liquid fuel system, causing a major retrofit. Altering old boilers with such an extensive retrofit may be difficult because of the wear on the machinery.

In addition to the retrofit, new storage facilities must be built to house the raw chips. This facility must be big enough to house the large amount of biomass that will be used for an extended period of time as mentioned in the previous section. This new storage facility may prove to be problematic if the company does not have the funds or space for an additional warehouse.

Another important factor that may cause negative opinions on the co-firing technology is the fact that the supply of HFO is very stable and consistent. This consistency does not put pressure on boiler operators to find a renewable energy source. Representatives from every HFO-fueled company we spoke with said that the price of N$2.94 per liter to $N3.02 per liter was steady between this range because of the contracts they enter into with fuel supply

companies in Namibia such as Engen or Shell. We were also told that supply has been stable except for a fuel shortage in December 2005. This fuel shortage was the only one that the HFO companies have encountered since industries have started using HFO. This small problem has not deterred the enthusiasm surrounding the use of HFO as a primary fuel source in industry.

In addition to our technical research, we also investigated receptiveness to the co-firing technology. We found that most plant engineers did not know that co-firing a solid fuel with a liquid fuel was possible. Even after further explanation of the process, engineers still were not receptive to co-firing. Sean Smith, from the Meatco Tannery, told us that his HFO supplier was responsible for the maintenance and repair of his fuel system all the way up to where it was fired into the boiler. The addition of a new fuel system would be a new responsibility that he was not interested in. Rolf Lukaschik, from Namibia Breweries, was highly skeptical of our research because he thought co-firing with HFO was impossible. Other engineers told us that in order to implement a co-firing process it would cost them too much, it would be too much of a hassle, and it would not be beneficial to their business.

Coal Industry and Coal-Biomass Co-firing

Through interviews with two industry professionals and technical data gathered about coal, we found that retrofitting requirements for co-firing of biomass with coal would be minimal. Additionally, we found that the price of energy from raw chips is comparable to that of coal. We will show that co-firing is very easy to accomplish and may be financially beneficial to coal users. Our information is based on interviews at two of the four coal fired boilers we were able to identify in Namibia which include Meatco Abattoir and Van Eck Power Plant. Again, our conclusions draw heavily from the technical data that we were able to research and collect from the industries.

Using information supplied by operators of coal-fired boilers, we have estimated the price per MJ of energy produced from burning coal. This estimate includes only the purchase price of the fuel and its cost of delivery. An engineer at Van Eck Power Station reported that the grade of coal they use has 26.5MJ/kg of energy while the Meatco Abattoir used a higher grade coal having 28MJ/kg. The price of coal including delivery to Van Eck is $N600/ton while the price of coal delivered to Meatco is $N640/ton. Using the costs given to us by each respective

representative we calculated the price per MJ at Van Eck Power Station to be 2.26 cents while the higher grade coal used at Meatco was determined to be 2.29 cents per MJ.

A similar approximate cost analysis can be applied to the Bushblok raw chips. The raw chips cost N$80/ton at the baseline without any transportation costs factored in. A transport agent at TransNamib Holdings Pty. Ltd. reported to us that they can ship coal from mines for $N155/ton with a 34 ton minimum order. Assuming that the transport costs for coal would apply to transporting wood chip, the delivered cost of the wood chips would be at a baseline of N$235/ton. Making an additional assumption that raw chips have the same energy density of 10.5 MJ/kg as the extruded Bushblok, we calculated the price per MJ of raw chip would be 2.24 cents per MJ which is comparable to that of coal.

Co-firing of biomass with coal also would not substantially affect labor and cleaning costs. For example, when we conducted an interview at Meatco Abattoir, we observed a full time employee spreading coal on the conveyer feed. Because both the pulverized fuels must be fed into the system manually and the boiler cleaned on a regular basis, the additional costs associated with co-firing pulverized fuels would be minimal. For this analysis, we have assumed the additional costs to be zero, making them a non factor in our analysis of coal and Bushblok raw chips.

One other finding that would make the transition from coal firing to co-firing wood chips with coal is that the retrofit of the boiler system would be relatively straightforward to implement. Both coal and wood chips are pulverized solid fuels and have similar handling requirements. The lifts and conveyer systems used to feed coal into a boiler for firing could also carry raw chip. Both coal and biomass have to be pulverized in the same type of grinding process before being fired in a boiler system. This also allows for an inexpensive and easier retrofit because the biomass can be inducted into the system in the same manner as the coal.

Furthermore, the storage facilities used for coal could double as storage facilities for raw wood chips. There are some technical problems to be addressed before utilizing the storage facility. However, it would have to be a dry facility as the raw chips must be dry when fired in the system in order to get the most energy from the fuel. Secondly, the energy per unit volume of Bushblok raw chips is much less than that of coal. Table 2 shown below illustrates that almost six times as much Bushblok raw chips must be used in order to have the same heat released as

coal. Therefore, the storage facility must be large enough to house not only the amount of coal needed to co-fire, but also a larger bulk volume of raw chips used to co-fire.

	Average mass/volume density (g/cm^3)	Average energy density (MJ/kg)	Energy per volume (MJ/m^3)
Coal	1.34	25.8	34,600
Bushblok	0.635	10.5	6,670

Table 2: **Energy per Unit Volume Comparison of Coal and Bushblok**

Considering only the two coal-fired plants that we investigated, a substantial amount of biomass would be used annually with the co-firing technology implemented. Van Eck Power Plant reported an average volume of coal consumption at 115,000 tons per year, although the Quantity has varied widely from only 2,926 tons in 2000 to 294,753 tons in 1979. With prime ratios of 5-10% of biomass to coal as mentioned in our background research, there could be on average between 5,750 to 11,500 tons of biomass used annually at the Van Eck Plant compared to the upwards of 100 million tons of excess biomass in Namibia. In addition, the engineers at the Meatco Abattoir reported that they consumed a relatively consistent and large volume of coal a month as they run 6 days a week continuously.

We also explored industry receptiveness to co-firing with biomass and found that there are some logistical problems associated with the conversion to coal co-firing with biomass. In addition, we found that the plant engineers that we talked to in this section of the industry were open to the idea of co-firing with Bushblok biomass. However, we were unable to gain a full understanding of the receptiveness at Van Eck other than they were very willing to give us information about their running costs. The engineers at Meatco Abattoir were very receptive as they have tried the co-firing option with excess animal fat in the past. We believe that this would be a very good option for CCF Bush to further investigate. More information on energy density and transportation costs would be necessary for a full investigation into the market

Emissions and Regulations Surrounding Boiler Use

An additional finding was information on regulations on boiler emissions and cleaning. Most industrialized nations have air quality regulations. In the United States, for example, 98% of pollutants must be removed from the air released to the atmosphere or it will result in a fine

and clean up costs for the area (Crandall, 2001). However, in Namibia, there are no air quality or emissions requirements. Accordingly, industry operators do not need to treat the smoke that is released that contains particulate pollution as well as toxic gasses into the atmosphere. The only relevant environmental, health and safety regulation in Namibia is that the boilers must be cleaned and inspected once a year. This regulation is controlled by the Ministry of Labor which inspects them yearly to check for corrosion or cracks that might be unsafe. The plant manager at Etosha Fisheries in Walvis Bay explained to us that this was a very strict regulation. At this plant, they had to decommission a boiler due to the corrosion of the water pipes within the system.

The limited regulations within Namibia mean that the companies can use coal and HFO, two of the least expensive fuel source in the world without an additional air abatement process. In addition, the lack of treatment of the smoke released causes a large amount of pollution. One of the more beneficial qualities of the Bushblok product is that it can be cleaner burning than coal or HFO. Our research showed that co-firing coal with biomass will also lower emissions and can generate the same amount of heat energy when co-fired with the prime ratios of 5-10% biomass. Without more comprehensive environmental health and safety codes and the fines that are typically associated with them, some businesses may be less motivated to invest in a change because they cannot justify the costs involved with changing to a co-fired system.

Industrial Market Recommendations

Based on our findings, we recommend that CCF Bush does not enter the industrial market with Bushblok at this time. Although the renewable energy concept that Bushblok embodies is theoretically sound, several obstacles, technical as well as social, prevent its immediate use. In this chapter, we will describe our recommendations regarding each of the three potential industrial uses of Bushblok that we investigated as well as explain the technical and social obstacles we have identified for each. Finally, we will explain circumstances which may make it advantageous to enter industrial markets in the future.

Biomass Firing Opportunities

We do not recommend that CCF Bush promote extruded Bushblok as a standalone replacement fuel for industrial heating applications at this time. The key factor in making this recommendation is Bushblok's low energy density.

Bushblok has a lower energy density than the fuels used by industry in Namibia. Bushblok has an energy density of 10.5 MJ/kg while HFO has upwards of 42 MJ / kg and coal has approximately 26 MJ / kg, depending on the grade. Regardless of fuel type, the same amount of energy needs to be released to generate the same amount of steam. If pure Bushblok were fired, a company would need a boiler 3-6 times physically larger than it currently owns to accommodate the larger mass of biomass. Industries would incur costs building larger storage facilities as well as transporting larger volumes of material.

We recommend that CCF Bush use raw chips rather than extruded Bushblok in any co-firing processes.

In addition to energy density, heat release rate of fuel used is also of particular interest to boiler operators. Although two materials may have the same energy density, the rate at which they release heat may not be the same. Because steam pressure produced is affected by heat released per unit of time it is important that boiler fuels burn as fast as possible. We have found that extruded Bushblok does not have a high enough heat release rate for use in a boiler system. Boilers utilize pulverized or liquid fuels to provide a higher heat release rate. HFO and coal both have quick, consistent and complete firing processes. Bushblok, in its highly compressed, blocky form, does not burn quickly enough or completely enough in the short time necessary.

Raw chips of acacia bush would have a much larger surface area and would burn more quickly. We conclude that the Bushblok fuel logs would be impractical for use in any type of firing process. Although raw chips do not possess the energy density required in a biomass-only firing process, they may be feasibly used in a co-fired process.

Heavy Fuel Oil Co-firing Opportunities

We do not recommend that CCF Bush Pty. Ltd. pursue marketing the Bushblok product as a fuel source for co-firing with heavy fuel oil within Namibian industry. Our research has shown that the difficulty of retrofitting and the loss of automation make conditions in the HFO co-firing market unfavorable for Bushblok.

The difficulty and cost of retrofitting an HFO-fired boiler to a co-fired system is too high for a company to warrant change without any other significant motivation. Because the ignition and feed systems used in an HFO-fired boiler are compact and designed for a liquid fuel, retrofitting the system for use of a non-liquid fuel would require a significant change in machinery. This change may require an entirely new feed system, ignition system, and in certain cases, a new boiler.

HFO systems are typically computer automated and require little or no attention from the plant technical manager. One HFO boiler system we toured had a fully automated system and the fuel tanks, pumps, and ignition system were tended to entirely by the fuel company. This ease of operation is desired by plant managers as it minimizes the number of employees needed to monitor the systems. Although coal is a less expensive fuel, plant operators often prefer HFO systems due to their simplicity, ease of use, and automation. Co-firing HFO with biomass would eliminate this advantage.

Coal Co-firing Opportunities

We recommend that CCF Bush Pty. Ltd. continue investigation into the receptiveness of coal-fired industries in Namibia to the idea of co-firing with Bushblok. In addition, we recommend that CCF Bush Pty. Ltd. further investigate the properties of raw chips including the chips' burning capabilities.

We concluded that the use of raw chips in a coal co-fired process might be beneficial to the industry as well as CCF Bush Pty. Ltd. Through conversations with boiler operators and prior

research, we discovered that in coal-fired boilers, the coal used is already pulverized. The feed system would work for raw chip induction into the system with minimal retrofitting required. Some minor issues involved with retrofitting these systems include addition of equipment designed to help produce the optimal ratios of biomass, coal, and oxygen fed into the system.

However, we believe further investigation is required. Because the extruded Bushblok fuel logs are comprised of the ground raw chips, we assumed that the two materials exhibit the same energy density. The only differences we considered in the two materials were the mass density and heat release rates. We recognize that it is necessary to test the energy density and heat release rate of raw chips to compare them to pulverized coal. Using those assumptions, we concluded that the price per kilo joule of Bushblok and coal are similar. This means that it would cost the same amount per unit energy to fire the bush chips as to fire the coal. However, the necessary volume of raw chips would be much greater, causing an increase in storage and transportation costs. We recommend more investigation on the energy density and heat release rate of the raw chip as well as the cost increases required to switch to a co-fired process.

Although there is a limited coal-fired market within Namibia, a single company with a high fuel consumption rate could provide substantial social and environmental benefits through increased business to CCF Bush Pty. Ltd.

Possible Future Opportunities

We recommend that CCF Bush Pty. Ltd. further investigate the possibility of marketing Bushblok to the industrial sector of Namibia in the future if the energy crisis causes fuel prices to rise significantly or if emission standards are established.

We have concluded that there are two possible scenarios which may provide future opportunities for industrial market penetration. The first scenario that would play out positively for CCF Bush would be for fuel prices to rise significantly. The predicted energy crisis for Southern Africa may cause the price of fossil fuels to rise in the near future. An increase in the price of coal or HFO would provide motivation for industries to search for a less expensive alternative fuel. A great enough difference in the price per MJ comparison of current fuels and Bushblok may provide companies with the motivation to make the initial investment required to co-fire with Bushblok. The Meatco Abattoir was interested in cost-saving changes to their boiling process and the extremely high fuel consumption rate of Van Eck power plant makes it an appealing prospect for the Bushblok product. We recommend that CCF Bush Pty. Ltd. monitor the prices of coal and HFO during the coming years as these two companies may be interested if the price of current fuels rises significantly.

Second, if emissions standards are established within the country Bushblok may become a more feasible product to use in the market. The low smoke and clean burning properties of Bushblok make it an environmentally friendly product in comparison to coal and HFO. Currently there are no emission standards for smoke in Namibia. However, as the nation develops, emissions standards may be established. In the case that emissions standards are established, the receptiveness to firing clean burning biomass may increase. Consequently, CCF Bush should further investigate biomass firing and co-firing if emissions standards are established in Namibia.

Market Analysis of Wood Usage in the Residential Sector

After completing our investigation into residential markets in Otjiwarongo and Ongwediva, we found that Bushblok in the residential market is a competitor with wood, charcoal, and charcoal briquettes. In this chapter we will demonstrate that there are retail channels to enter the market, that there is a demand for wood fuel products, that the scarcity of wood makes wood products a commodity, and that people can afford to pay for that commodity. We shall also show that the quality and supply of the existing wood products do not always meet the demand and that Bushblok is a culturally acceptable substitute.

The findings in this chapter were based on interviews with eight consumers of wood and thirteen retailers of wood fuels in Otjiwarongo and interviews with nineteen consumers and seven retailers in Ongwediva and Oshakati in the North Central region of Namibia. Although we were unable to interview a large sample of consumers and retailers, the high correlation among responses suggests that our findings are reflective of the areas we visited.

Existing Retail Market Channels

In all regions investigated, we found wood fuel product retailers that could potentially sell the Bushblok product. We identified two types of retailers, which we have chosen to describe as informal and formal. We categorized formal retailers as established businesses including grocery stores and gas stations. These retailers typically sell multiple types of goods including wood and charcoal. We categorized informal retailers as smaller businesses which typically only sell wood products and are established only on a local scale. We found that these two types of retailers are existing market channels which CCF Bush may use to penetrate the wood fuel market.

The informal retailers sell wood out of their own homes in the Orwetoveni settlement in Otjiwarongo and in the open-air markets in Ongwediva and Oshakati. These retailers typically purchase wood by the bakke[2] load directly from farmers whenever their stock runs low. Usually, the wood is transported in large logs and must be split into smaller pieces and then bundled for sale. When asked how much profit is made after selling a full load of wood, one retailer replied

[2] Bakke is the Afrikaans term for pickup truck that is commonly used throughout Southern Africa.

that it depends how small the pieces are cut. He explained that the smaller the pieces the more money he can potentially make. Informal retailers typically have less control over their wood supply and therefore prices, and volume of wood sold is often variable.

The formal retailers, in contrast with the independently owned and operated informal retailers, are often franchise or corporation owned. They include service stations such as Shell, Engen, and Total as well as supermarkets including Spar, Pick-n-Pay, OK Grocer, and Shoprite. They sell packaged fuel products, including charcoal and charcoal briquettes in bags sized from 3 – 5kg, and wood in bags sized from 4 - 10kg. Typically, grocery stores use a credit system to make purchases through a distributor from an approved list of products. Although grocery stores typically do not have independent purchasing power, some have the ability to make cash purchases for smaller scale orders. Often, sales representatives from charcoal manufacturers or farmers come by to find out how much the franchise wants to buy and then arrange for delivery.

The existence of established formal and informal wood product retailers suggests that CCF Bush could use existing channels to get their product to consumers, and in some cases, already has. Two retailers in Otjiwarongo and one in Ongwediva reported carrying the Bushblok product before but had sold out their stock and didn't know where to buy more. Evidence of proven market channels supports the use of local retail locations as a selling point for Bushblok.

Current Wood Fuel Demand

We found that there is a significant demand for wood fuel products in the regions we investigated, as evidenced by consumer usage and retail sales. In this section we describe demand by dividing it into three categories according to frequency and nature of wood product use. These categories include occasional use by desire, occasional use by necessity, and daily use by necessity.

The consumer who occasionally uses wood when desired does so for traditional cooking, gatherings, and braais[3]. In Ongwediva, interviewees from formal, fully electrified neighborhoods responded that they only used wood occasionally to cook traditional foods like roasted meat, or to braai on the weekends. Through interviews with formal retailers in Otjiwarongo we found that most wood purchases are from occasional users. During ten different interviews with local retailers, store managers suggested that customers who purchase wood are

[3] Braai is the Afrikaans term for a barbeque which is typically used throughout Southern Africa

using it for weekend braais, and they sell the most wood fuel during holiday seasons. Therefore, the formal retailers were able to confirm our findings that there is a class of occasional users that desire wood for traditional and social motivations. The demand for these braai products is significant; some stores reported selling as much as 300 bags in one week during the winter months.

The other occasional user is from an electrified house, but may not be able to afford using electricity all of the time and uses wood by necessity. A factory worker from CCF Bush who lives in the settlement at Orwetoveni stated that sometimes at the end of the month they may be unsure how much electricity they have used and are forced to buy wood in fear of a high electric bill. This type of user was also prevalent in Ongwediva. Some interviewees responded that although it is available, the high price of electricity often forces them to cook outside on a wood fire.

The third category of consumer, the kind that uses wood every day, typically lives in the informal settlements. Remarkably consistent responses from interviews with factory workers at CCF, on site interviews in the Orwetoveni settlement, and residents from traditional Owambo homesteads in Ongwediva all showed they use wood every day for cooking. One Orwetoveni woman said that if wood ran out, she used an oil stove, but that wood was cheaper and she preferred wood to oil. Another Orwetoveni man said that when it rained and the wood was wet that life was hard because the wood was all they had. The residents reported either purchasing small bundles of wood each day from informal retailers who receive wood from farmers or harvest it illegally and sell it from their homes. Other residents reported that they collected it for free for just their households. Interviews with informal retailers confirmed the residents' statements that wood is used daily in the settlements and that obtaining wood can be difficult. Sales varied widely according to the size of the informal retailer, but one owner had a high enough demand to sell a bakke load of wood that cost him 130 dollars for over 300 dollars in a single week.

Wood Fuel as a Commodity

The demand for wood in Otjiwarongo, Ongwediva, and Oshakati has made wood and wood products a commodity rather than a free resource. In this section we explain that the cost,

price and volume of sales that we discovered in Otjiwarongo and the Ongwediva region correlate with demand in these areas.

Residents in the Orwetoveni settlement have two options for collecting firewood; either they must purchase a single day's supply for N$1-2 or they must travel to collect it illegally off of privately owned land. Several women told us that they harvest it for free but they risk many dangers including: being bit by a snake, being shot by a farmer, being reported to the police, or being physically attacked. Even though some people collect wood for free many people are still able to pay as evidenced by the volume of sales in the informal retail sector. During interviews, consumer responses ranged from the price of wood being fair to the consumer having no choice in the price. The informal retailers themselves are in a similar situation. Because the farmers in Otjiwarongo have rights to the land and the wood on it, the farmers are in a position to sell wood by the bakke-load to the informal retailers. On average a bakke-load can cost a retailer about N$400, and the retailer can sell that load for about N$535, therefore making a profit of N$135.

In Ongwediva and Oshakati, we were told by the local Director of Forestry that the scarcity of wood is a major problem. Ministry of Forestry regulations only permit land owners in the region to harvest wood. Informal sellers at the open air markets are also under strict regulation and must register with the Ministry of Forestry and arrange for transportation to outside locations to purchase wood. One retailer told us that her purchases are made from community projects that are initiated by the Ministry of Forestry. Another retailer told us that he gets permits and travels to a wide range of suppliers. He had stated that wherever there is wood he travels and it is also hard to find. Our translator, who was a native of the region, told us that the region was better developed economically than Otjiwarongo. We found that the informal retailers were selling the same size bundles of wood as in the Orwetoveni settlement, but for N$7-8 instead of N$1-2.

As evidenced by the substantial wood markets already existing in Otjiwarongo, Ongwediva, and Oshakati, it is clear that wood fuel is a commodity which people will pay for. Although supply and prices vary greatly by region, high demand of wood fuel products was a consistent factor in each of these areas.

An Inconsistent Supply of Wood

We found that the supply of wood products does not completely satisfy market demand. Consumers and formal retailers both expressed dissatisfaction with the supply of wood when it rained. Due to the manufacturing process, Bushblok's supply will not be affected by the weather. Bushblok is also packaged in a plastic wrap that will keep it protected before use. This provides Bushblok with a distinct advantage, as wood sold through the informal retailers is sold in bundles tied with string and is very susceptible to rain.

Interviews with retailers showed us that the inconsistent supply of wood often causes sales losses for them. One formal retailer in Otjiwarongo told us that wood was difficult to obtain when it rained. She stated that the farmer who supplies the wood she sells will not package the wood once it is wet so the supply often runs out. In Oshakati and Ongwediva, the Christmas holiday creates a brief and very high demand for wood. Several formal retailers told us that demand may double during this period. One store manager told us that wood is the first product they sell out of, followed by charcoal. While showing us an informal retailer at one of the open-air markets, the Director of Forestry told us that at Christmas time people will point to large logs as they are delivered on bakkes and claim them before they are even unloaded.

Weak supply lines may also leave stores without wood products. One formal retailer in Oshakati said that her store frequently doesn't carry wood. She stated that sometimes her supplier is permitted to go through the gates at Oshivelo and sometimes he can not. Other retailers are supplied directly from the manufacturers or farmers who typically take orders once a month. Shelves will go empty if the supplier does not come to take purchase orders often enough or if the retailer is unable to contact them.

Consumer and Retailer Receptiveness to Bushblok

Because the use of wood for cooking is often for traditional or cultural reasons, we investigated consumer receptiveness of substituting Bushblok in these types of situations. Traditional braais are one of the more popular ways to hold social gatherings and many traditional foods are preferred to be prepared over a wood fire. After demonstrating to cook with Bushblok, our research showed that consumers found it similar enough to regular wood that they are willing to use it when preparing traditional foods. Bushblok is similar to common wood fuels

and creates hot coals that are desired in these social settings. The price of Bushblok is the other most important factor to consumers. Interviews have shown that consumers are willing to purchase and use Bushblok if the price is low enough that it is competitive with wood and they are able to afford it.

Although Bushblok is similar to wood and can be used as a substitute, the consumers we interviewed would not have initially purchased the product on their own. Their willingness to buy the product was hindered by the fact that during our interviews and demonstrations some consumers did not understand directly from the packaging what Bushblok was. One consumer mentioned that she would not purchase Bushblok because of this. One local consumer in the Orwetoveni settlement was skeptical about the Bushblok's burning qualities and asked us to come back for a cooking competition where she would cook with wood and we would cook with Bushblok. Therefore, the Bushblok product may not be able to be sold in its current packaging.

In addition, we found that five retailers wanted to see how the product burned before deciding whether or not it would be profitable to sell. Informal retailers in both Otjiwarongo and Ongwediva were skeptical of the Bushblok product, due to the unknown burning characteristics and the unknown price of the product. However, three retailers were receptive to the idea of the product and were interested in the possibility of selling Bushblok.

In light of the responses to the burning capabilities, we held demonstrations to test the retailer's and consumer's receptiveness to Bushblok. After the demonstrations, we found that locals were receptive to the Bushblok product and generally people wanted to try Bushblok for household cooking. There was one woman who was still unsure if she would purchase Bushblok because she did not know how long the Bushblok will last during burning. This problem arose because we were forced to end our demonstration early. However, the resident who purchased a package of Bushblok during our demonstration mentioned that he found Bushblok to be a better product than the current wood sticks sold by most retailers. Also, the resident who helped to light the fire told us that the coals created by Bushblok were created faster and lasted longer than their normal wood coals. We found that holding the demonstration increased receptiveness greatly in the area and is an effective way to communicate the benefits of the Bushblok product.

From the information gathered we found that there is a market for the Bushblok to enter and that Bushblok has the potential to become a consumer friendly and socially acceptable product. Consequently, based on the market infrastructure, the demand for wood, the ability to

afford wood, the diminishing supply of wood, and the positive receptiveness of the population in Otjiwarongo and Ongwediva we have concluded that there is a potential market for Bushblok.

Framework of a Business Plan Created for CCF Bush Pty. Ltd.

Overview

We recommend that CCF Bush Pty. Ltd. take advantage of the existing wood fuel product market beginning with the areas of Otjiwarongo and Ongwediva. The wood product market in Namibia contains opportunity for expansion due to high demand and an unsteady wood supply. We have proposed a business plan for CCF Bush Pty. Ltd. to introduce its product to the residential market in these two regions. We recommend using direct marketing, pricing Bushblok between wood and charcoal, and selling Bushblok through a sales representative. In addition, we recommend using a combination of direct sales and existing distributors to circulate the product. We have described a management and personnel structure for the business and have provided break-even analyses for the Otjiwarongo, Ongwediva and wholesaler markets. In addition, we have summarized the benefits of implementing the business plan according to the objectives of CCF Bush Pty. Ltd.

Marketing Strategy

We recommend that CCF Bush Pty. Ltd. use direct marketing in order to effectively market the Bushblok product. Namibia is a developing country and though there are large retail chains, the structure of the existing wood fuel market allows for independent purchasing power by retailers. In addition, the strong response to our interviews by retailers during our data gathering suggests that marketing in person is an effective way to promote the Bushblok product.

We recommend that CCF Bush use a salesman to personally visit and make contact with potential retailers and consumers. We found during interviews that consumers could not quickly

identify what Bushblok was and that they were uncertain about the burning qualities of the product. A salesman's duties would include demonstrations of the Bushblok product to educate consumers and retailers as to its burning capabilities and properties.

In addition to this marketing strategy, we suggest that CCF Bush make adjustments to the packaging label for the Bushblok product. As mentioned, consumers could not identify what Bushblok was. We recommend that a slogan or image be added to the packaging that consumers will associate with firewood, trees, or braais.

Pricing Strategy

We recommend entering the existing wood fuel markets with a price that is in between that of wood and charcoal products for each market. Although the Bushblok product is composed of wood, it burns longer and hotter than the same amount by weight of unprocessed wood. The higher burning quality should be reflected in the price of the product.

Through our research we found the average purchase price of wood by formal retailers in the Otjiwarongo area to be N$0.93 per kg and the average purchase price of charcoal to be N$1.50 per kg. We suggest pricing the Bushblok in the middle of this range in the formal markets. The typical purchase price of wood in the informal markets in this area falls between N$0.50-N$1.00 per kg. Because charcoal is not sold in the informal markets in Otjiwarongo and the price per kilogram of wood is low, we recommend that CCF Bush Pty. Ltd. sell the 15 kg bags of Bushblok scrap to the informal settlement retailers. By selling the scraps, CCF Bush Pty. Ltd. will also be enabling the retailers to divide up the product in smaller bundles which the consumers are more familiar with. We recommend that in order to make the price comparable to that of wood, CCF Bush Pty. Ltd. price the 15 kg bags at approximately N$15 dollars.

The average purchase price of wood by formal retailers in the Ongwediva and Oshakati area is N$1.52 per kg and the average price of charcoal is N$2.71 per kg. We suggest pricing the Bushblok in the middle of this range in the formal retail market. These price comparisons are outlined in Table 3.

Otjiwarongo Formal Retailers	
Average Wood Purchase Price per kg	N$0.93
Average Charcoal Purchase Price per kg	N$1.50
Oshakati and Ongwediva Retailers	
Average Purchase Price for Both Fuels per kg	N$2.00
Average Wood Purchase Price per kg	N$1.52
Average Charcoal Purchase Price per kg	N$2.71
Orwetoveni Informal Retailers	
Wood Purchase Price per kg	N$0.50 – N$1.00

Table 3: Retail Wood Fuel Prices per Kilogram[4]

Anticipated Sales

We have included wood fuel sales volume estimates that can be used to prepare a more detailed sales strategy. We organized the market by region and distribution method. The distribution method is split between retailers that purchase directly and through a distributor. We separated retailers into wholesale and direct purchasers through our interview process, those who reported receiving wood from farmers and locals were categorized as direct and those who received wood from a market or store distributor were categorized as wholesale.

We estimated the total volume of wood fuel sales in all the regions' formal markets we investigated to be 16,600 kg per month. We calculated this by multiplying the weight of each wood product unit and the number of units sold in each region. In some cases we estimated data points which we were unable to collect by extrapolating known volumes and prices. We believe our estimates are conservative as we may not have found every formal retailer in each region. The volume and price estimates used to calculate the sales volumes are shown in detail in Appendices Q and R.

We estimated total gross revenue in a similar manner by multiplying price per wood product unit with the units sold in each region. When calculating the gross revenue we used the retailer's purchase price which is the price at which they bought the product. This would be appropriate if CCF Bush was selling directly to the retailer. In instances where a wholesale distributor was involved we had to consider an additional wholesale markup. We found that in

[4] Calculations based on data gathered in formal retail establishments in designated areas, therefore actual average prices in each sector may vary.

Namibia, a typical wholesale markup is around 30%, which we factored in to calculate the gross revenue for CCF Bush in the wholesale calculation.

	Otjiwarongo Direct Sales	Ongwediva / Oshakati Direct Sales	All Areas Wholesale	Totals
Volume by Weight	4270 kg	4550 kg	7764 kg	16600 kg
Gross Sales to Retailers	N$3,830	N$9,840	N$5900	N$20400

Table 4: Monthly Wood Fuel Market Totals[5]

We were not able to conduct enough interviews in the Orwetoveni settlement to create an accurate estimate of the market size. Rather than ignore a large section of the residential market, we combined our findings with background information to create an overall picture of the Orwetoveni settlement.

According to the Orwetoveni town council the Orwetoveni informal settlements contain 2,800 households, each of which consumes an estimated average of one kilogram of wood per day according to Appendix Q. This works out to 84,000 kg of wood a month. We found that some wood is illegally collected for free, which reduces the size of the market that Bushblok could acquire. Due to our limited sampling we cannot estimate how much illegal harvesting will affect the size of the Bushblok market. Figure 6 estimates the volume of sales that Bushblok would acquire by obtaining a percentage of the current wood demand in the Orwetoveni settlements.

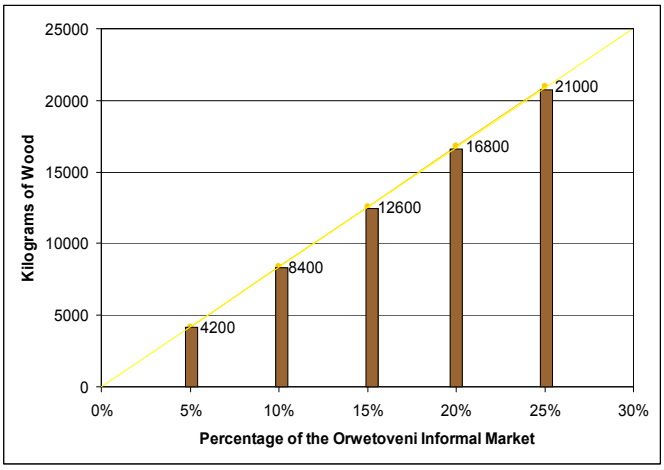


Figure 6: Total Monthly Volume of Sales in Orwetoveni According to Market Percentage

[5] Calculations based on data gathered in formal retail establishments in the areas of Otjiwarongo, Oshakati, and Ongwediva. Data points not available were substituted with the average of remaining data points.

Despite the lack of information from the Orwetoveni settlement, we still believe that CCF Bush will be able to use local retailers to penetrate the market. We found two large retailers that used a supplier/retailer system, rather than an illegal harvest/retail system. One retailer averaged 150 bundles of wood a week. She purchased wood by the bakke load for N$170, equivalent to N$1.13 a bundle, and then resold it at N$2.00 a bundle. The other large retailer sold a similar volume of wood at similar prices over the course of a month. Together, the two retailers alone represent N$750/month in gross revenue. We expect that there are more retailers in the region that CCF Bush will be able to work with to penetrate the market.

Distribution Strategy

We found that there are existing distributors in the formal markets; we recommend that CCF Bush Pty. Ltd. use these existing channels to circulate their product. Currently we have found distributors that CCF Bush Pty. Ltd. should make further contacts with. These include Vimona Markets, the Spar Distributor, Pricemart, Freshmart, and the Ministry of Forestry in Ongwediva. Contact information for these distributors and retail stores can be found in Appendix S: Contact List.

However, only 30% of the retailers we interviewed used distributors, therefore 70% of the retail market we researched will not be accessed through distributors. Consequently, we recommend that CCF Bush Pty. Ltd. also distribute Bushblok to retailers directly from the factory. A direct distributing strategy would involve additional transportation costs and would require hiring additional personnel.

Costs incurred when hiring private cargo transport services have been estimated and displayed in Table 5 below. These costs have been estimated assuming transport with a 3000 cc 4x4 bakke loaded with 100 packages of Bushblok and a petrol price of N$5.50 / liter. Using these figures, we consulted the Automobile Association of Namibia website and used factors provided including maintenance, tyre[6], and petrol costs. The final costs for transport to each city are displayed below. The volume details and estimates are shown in detail in Appendix Q and R.

[6] Tyre is the British term for tire which is commonly used throughout Southern Africa

	Ongwediva	Windhoek	Tsumeb	Grootfontein	Okahandja	Swakopmund	Walvis Bay
Distance from Otjiwarongo	463	237	181	209	143	369	399
Cost / kilometer (delivery)	1.42	1.42	1.42	1.42	1.42	1.42	1.42
Cost / kilometer (return)	1.13	1.13	1.13	1.13	1.13	1.13	1.13
Total cost of travel	N$1,180	N$605	N$462	N$533	N$365	N$942	N$1,020
Packages / truckload	100	100	100	100	100	100	100
Transport Cost / package	N$11.8	N$6.05	N$4.62	N$5.33	N$3.65	N$9.42	N$10.2
Transport Cost / kilogram	N$1.18	N$0.60	N$0.46	N$0.53	N$0.36	N$0.94	N$1.02

Table 5: Estimated Transport Costs by City

Management and Personnel Structure

In order to enter the wood fuel markets that we have outlined above, we recommend that CCF Bush create two new job positions: a salesman / sales representative and a driver.

To begin selling Bushblok we propose that the Bushblok product be sold through a sales representative located at CCF Bush Pty. Ltd. The sales representative's responsibilities would include obtaining contacts with potential customers in Ongwediva, Oshakati and with Windhoek wholesalers. Other responsibilities would be organizing the sales of Bushblok directly to retailers in these regions and through distributors in Windhoek. We recommend that CCF Bush only hire a sales representative if it extends it sales outside of Otjiwarongo. In addition, we recommend that the sales representative only be a part-time employee. We make this recommendation based on the prediction that it will not be necessary to have someone promoting Bushblok full time. The sales representative would be expected to receive a typical workers salary. A typical salary for a CCF Bush Pty. Ltd. worker is N$1500-4500 dollars a month plus N$50 dollars a month for benefits

In order to accomplish direct distributing, we recommend that a driver be hired for deliveries. A standard driver receives a salary that varies from a typical worker. CCF Bush Pty. Ltd.'s minimum workers salary for a driver is N$3,000 a month with N$500 in benefits.

Financial Analysis

By analyzing potential revenue against expenses in the Otjiwarongo, Ongwediva, Oshakati and wholesale markets, we created three different financial analyses. We were able to determine the break-even point in each market where the revenues would begin to exceed the expenses. We calculated the revenue as a function of sales volume based on the recommended price of Bushblok in each region. As mentioned previously the recommended Bushblok price in each region is a price midway between wood and charcoal. The expense analyses are based on the bottom line cost of Bushblok at N$360 per ton which includes the harvesting and manufacturing costs of producing Bushblok. In each region we estimated the expense by adding the assumed transportation costs to the baseline cost of Bushblok. We have also considered salary prices provided by CCF Bush Pty. Ltd. as fixed expenses that CCF Bush would incur each month.

If CCF Bush Pty. Ltd. begins market penetration in Otjiwarongo we suggest that a current representative from CCF Bush contact the retailers we investigated. We suggest that one part time driver is hired for one week out of a month as most retailers accept shipments on a monthly basis. Figure 7 shows a financial analysis of Otjiwarongo sales assuming a baseline driver salary of N$1000 per month. The amount of Bushblok sales necessary to reach the break-even point is approximately 1.5 tons, which is 35% of the market we investigated.

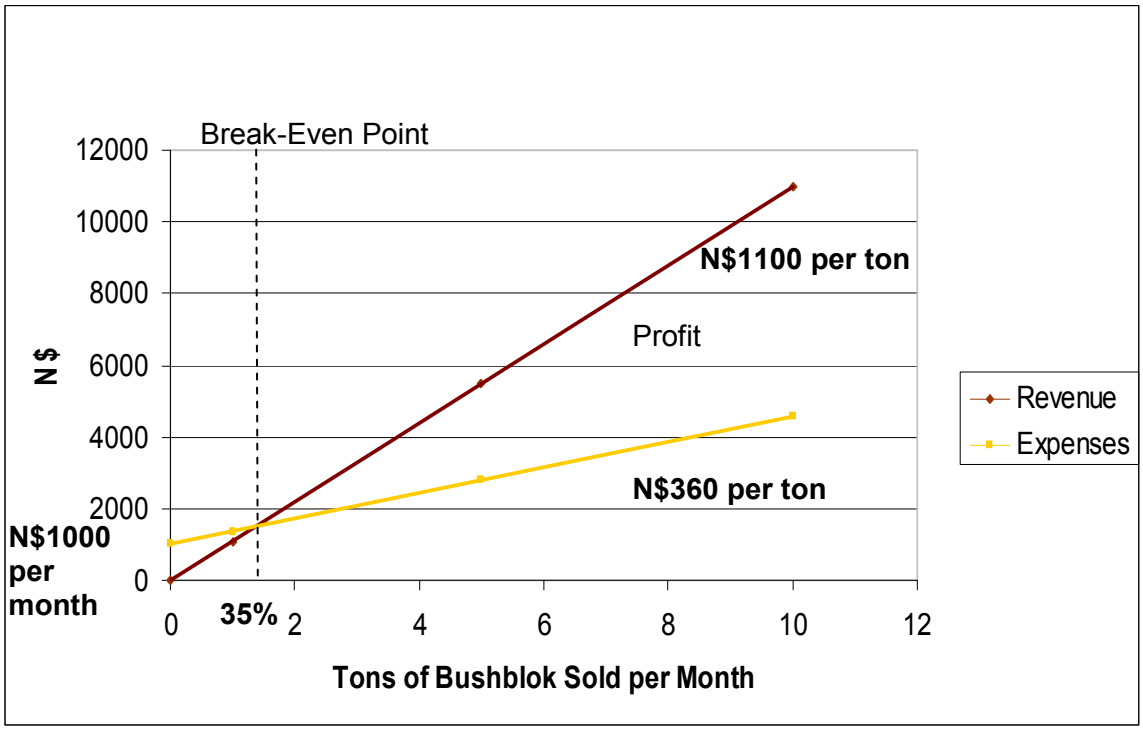


Figure 7: Otjiwarongo Financial Analysis per Month

If CCF Bush Pty. Ltd. then begins market penetration in Ongwediva and Oshakati we recommend that they increase their driver's work to three weeks out of the month. We also recommend that a sales representative be hired for one week out of the month to promote sales in the region. The financial analysis graph for this region, assuming an increased baseline salary cost of N$3015 which is the additional incremental salary expense for the region, can be seen in Figure 8. The revenue assumption for this region is higher then in Otjiwarongo and the wholesale market because the price of wood and charcoal in the region are higher. Also, the volume-dependent expense cost in the region is significantly higher then Otjiwarongo because of the increased transportation costs. The break-even point for this region would be approximately 2.5 tons per month or 54 % of the market we investigated. Due to the scarcity of wood in the region and the unsteady supply 2.5 tons may be feasible.

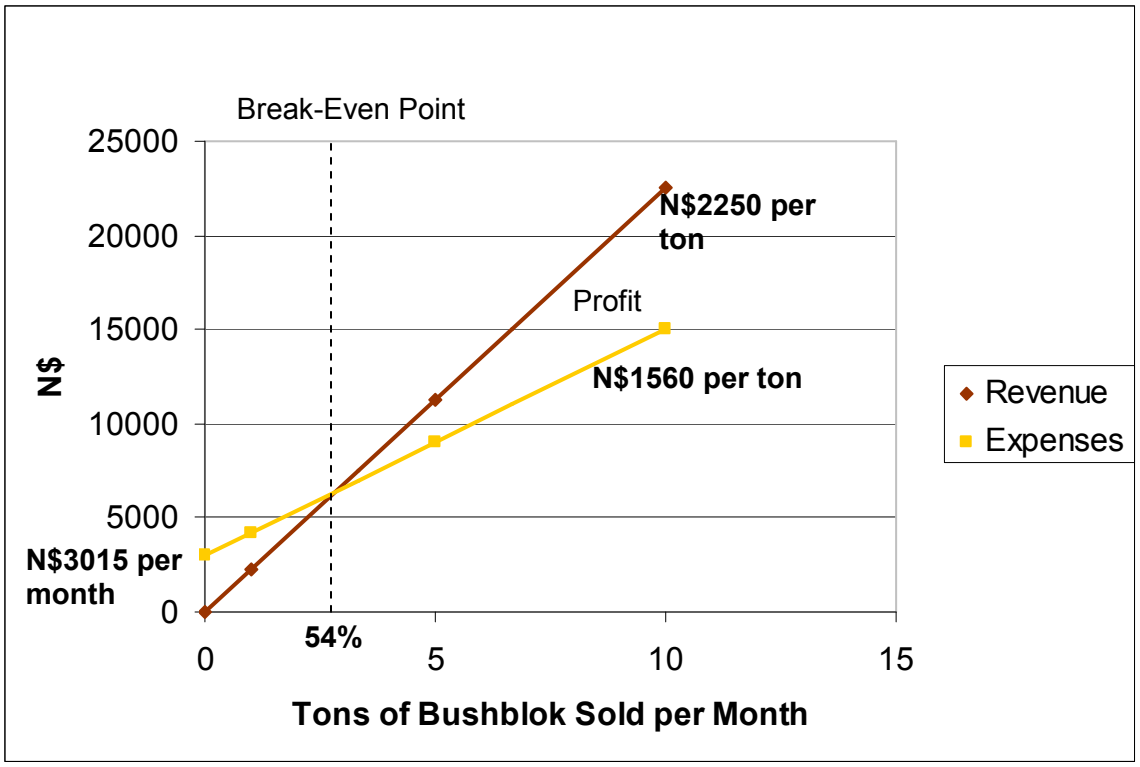


Figure 8: Ongwediva and Oshakati Financial Analyses per Month

If CCF Bush Pty. Ltd. then desires to begin market penetration through Windhoek wholesalers, we recommend they make their driver a fulltime employee. We also recommend that they increase the time the sales representative works from one week a month to two weeks per month. The salary costs associated with initiating this venture would total a N$2015 increase. In order to break-even with these additional salary expenses CCF Bush Pty. Ltd. would need to sell approximately 2.5 tons of Bushblok per month in the Windhoek wholesale market. This is illustrated in the financial analysis graph in Figure 9. By using the previously calculated gross wholesale revenue amounts for wholesalers, this would total 32% of the market we investigated.

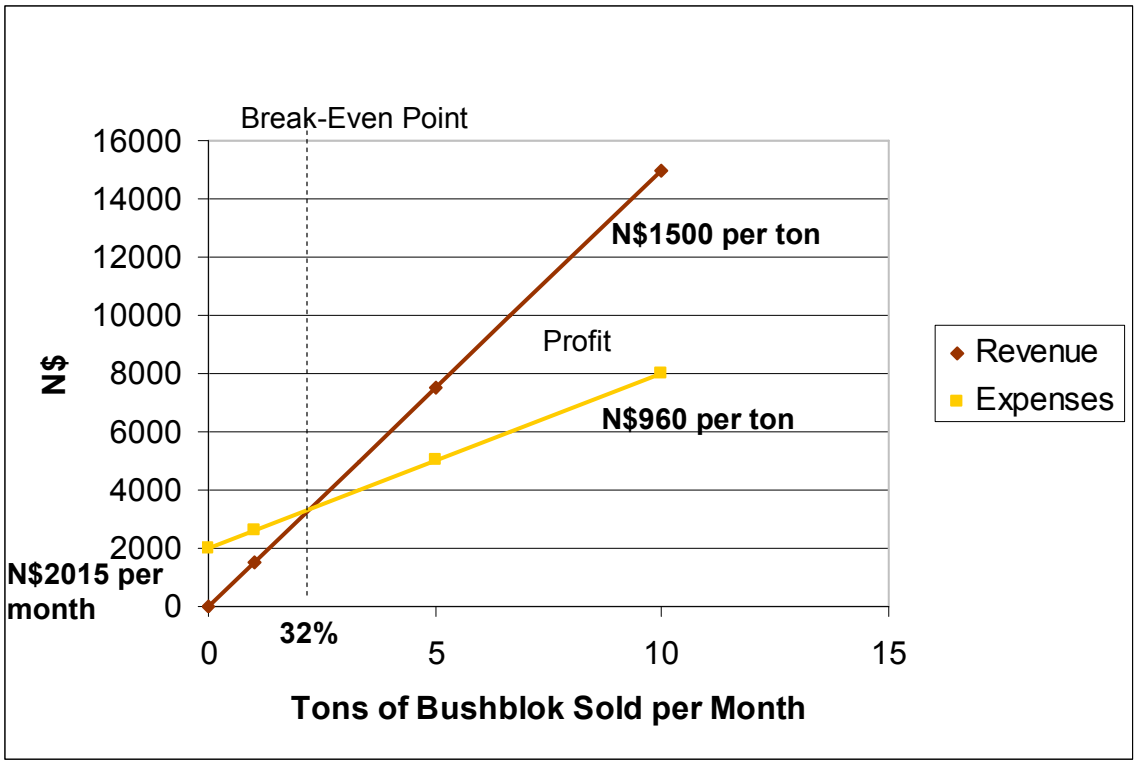


Figure 9: Windhoek Distributor Financial Analysis per Month

Social Impact

By initiating market penetration in Otjiwarongo, Ongwediva, and Oshakati, CCF Bush has the potential to address key issues included in its mission statement. By implementing the proposed business plan, CCF Bush Pty. Ltd. would be addressing the restoration of the savannah, employment of Namibians and alleviation of the over-exploitation of native Namibian trees for firewood.

By reaching the break-even point in each market CCF Bush would be manufacturing a total of 6.5 tons of Bushblok a month. Currently they are manufacturing approximately 288 tons per month for the foreign markets. Although the domestic market may not be increasing production or habitat restoration by a large amount, it would be addressing several other social, economic, and environmental objectives of CCF Bush.

By marketing Bushblok in Otjiwarongo, CCF Bush Pty. Ltd. would be furthering their relationship with the Otjiwarongo Municipality by increasing job opportunities. They would also

be addressing their objective of employing local Namibians by hiring new drivers and sales representatives.

Also, by adding a new wood product into the Namibian market CCF Bush will be helping to alleviate a shortage of wood supply that areas of the country are facing. By initiating market penetration in the areas of Ongwediva and Oshakati they would be helping to ease a seemingly large shortage of wood supply in these areas. By reaching a 50% market penetration, as indicated by our break-even analysis, Bushblok would be making a significant reduction in the amount of hardwood harvested, addressing the severe deforestation issue in North Central Namibia. In addition by using wholesalers to sell Bushblok, CCF Bush Pty. Ltd. would be able to sell large quantities of wood throughout Namibia.

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Appendix A: CCF Bush Pty. Ltd.

The largest remaining cheetah population in the world lies in Namibia, a developing country with a small industrial base. Unfortunately, government initiatives to expand the Namibian economy often conflicted with protection of the cheetah. The problem peaked in the 1980's as more and more ranches were developed encroaching on cheetah territory. Poaching levels increased significantly, and the cheetah population nearly halved.

The Cheetah Conservation Fund (CCF) was then formed in 1990 by Dr. Laurie Marker. It's stated mission is "to ensure the long-term survival of the cheetah and its ecosystem through a multi-disciplined and integrated conservation programme of research, management and education." Because of the CCF's work, the cheetah population in Namibia has stabilized at approximately 2,500 animals. The CCF is now an international organization officially recognized in Namibia, Kenya, the United States, Canada, and the United Kingdom as a Non-governmental Organization (NGO). NGOs typically possess non-commercial goals along with nonprofit status and must also advocate a social, cultural, legal and/or environmental cause. As a nonprofit organization, the CCF has operated primarily as a fundraising organization outside of Africa, while the divisions in Namibia and Kenya appropriate funds for genetic studies, ecological studies, rancher education programs, and other programs in line with the CCF's goals.

The CCF recently spun off a for-profit company, CCF Bush Pty Ltd., created in response to the proliferation of acacia mellifera and dichrostachys cineria**.** The thorny bush, now infesting at least 10 million hectares in Namibia, has reduced cheetah hunting efficiency, prey abundance, and caused economic problems for ranchers. Bush encroachment has also been identified by the Namibian government as a threat and falls under the jurisdiction of the National Programme to Combat Desertification (NAPCOD). CCF Bush Pty Ltd. serves the dual purpose of clearing the unwanted biomass and then processing it into marketable firewood briquettes sold under the brand name "Bushblok." CCF Bush Pty Ltd. is still a very young, very small company. The Proprietary Limited designation limits the company to a maximum of 50 shareholders and they may not be publicly traded. They currently employ only 35 people.

The practice of extruding otherwise useless biomass into fuel logs is not new, and specialized fuel logs such as the Duraflame™ log are commonly used in many U.S. households. Even though there is an estimated 100 million tons of available biomass, CCF Bush is still

operating as a pilot program. There are no direct competitors in Namibia, and it is a complete niche market. CCF Bush currently harvests bush and distributes Bushblok themselves, but depending on the success of the pilot company, CCF Bush intends to grow into a large scale operation. CCF Bush would focus on processing while harvesting and distribution would be contracted to local farmers and entrepreneurs, respectively. CCF Bush has also identified several other crucial areas for study, including product line development, manufacturing efficiency, bush harvesting techniques, job creation, economic impact, and pricing.

Appendix B: Retailer Interview Questions

- Where do you get woodfuel?
- How much do you pay for it?
- How much do you sell it for?
- Is the supply steady?
    - Do you ever run out of product to sell?
- Is the demand steady?
    - Do you have typical customers that purchase regularly?
    - Do you sell more around holidays or other certain times of the year?
- How often do you receive wood to sell?
- Who is your average buyer and do you know what they typically use it for?
    - Local residents?
    - Tourists?
    - Everyday cooking?
    - Weekend braai?
- Bushblok Receptiveness:
    - Have you sold the Bushblok product before?
    - Would you consider trying it in your own home?
    - Would you consider selling it?

Appendix C: Residential Interview Questions

- What do you use for cooking and heating?
- How many people are in your household?
- How much fuel do you use?
- Where do you get your fuel?
- How much do you pay for it?
- Do you feel that the price is fair?
- How often do you purchase it?
- Is it available when you need it?
- Other Comments:

Appendix D: Industrial Interview Questions

ENERGY NEEDS AND COST

How much does fuel cost?

How much fuel do you use?

Are your fuel needs met?

Is the supply of fuel steady?

Is the cost steady?

Are you in a contract for fuel?

Who supplies your fuel?

BOILER NEEDS / TECHNICAL ISSUES

Is it meeting your needs?

What is the energy density of the fuel oil?

How old is your boiler?

How long do you expect it to last / are you thinking of buying a new one?

How much does a new boiler cost?

Do you have emissions requirements?

Appendix E: Cone Calorimeter Test Results – Bushblok Sample

Cone Calorimeter Test Run Data

100 Institute Road
Worcester, MA 01609
Phone: (508) 831-5628
Fax: (508) 831-5680

Test Information

Test Number:	test 01
Specimen Identification:	Specimen 01
Material Name:	Bushblok
Manufacturer/Submitter:	Cheetah IQP Group
Sample Description:	Bushblok sample 1
Raw Data File Name:	022706sample01.txt
Reduced Data File Name:	Bushblok_test1(reduced).xls
Date of Test:	2/27/2006
Tester:	Randy Harris

Test Parameters

Ambient Temperature:	71 F
Relative Humidity:	16%
Heat Flux:	50 kW/m^2
Exhaust Duct Flow Rate:	30 g/s
Orientation:	Horizontal
Specimen Holder:	TRUE
Specimen Preparation:	2 layer foil
Notes:	1” Separation

Specimen Information

Specimen Color:	[]	Brown
Specimen Thickness:	[mm]	20.0
Specimen Test Area:	[m^2]	0.0088
Specimen Initial Mass:	[g]	221.8
Specimen Final Mass:	[g]	45.4
Specimen Density:	[g/cm^3]	1.1
Mass Lost:	[g]	176.5
Total Heat Evolved:	[kJ]	2316

Test Times [s]

Shutter Open:	194
Time to Ignition:	253
Flameout:	2185
Clean Air/End of Test:	2203

Daily C-Factor

0.044

Cone Calorimeter Test Run Data

100 Institute Road
Worcester, MA 01609
Phone: (508) 831-5628
Fax: (508) 831-5680

Test Summary

Test Number:	test 01
Date:	02/27/06
Material:	Bushblok sample 1
Specimen Identification:	Specimen 01
Flux:	50 kW/m2

The Peak, Average and Total parameters are computed over the test period ignition to flame out. There are 4 exceptions. The first three involve initial heat release rate averages for periods after ignition of 60, 180 and 300 seconds. The final involves the average mass loss rate which is computed over the time period from 10% mass loss to 90% mass loss.

Parameter	Unit	Value
Heat Release		
Peak Heat Release Rate	[kW/m^2]	239
Average Heat Release Rate	[kW/m^2]	136
Total Heat Release	[MJ/m^2]	262
Average HRR for the first 60s	[kW/m^2]	218
Average HRR for the first 180s	[kW/m^2]	199
Average HRR for the first 300s	[kW/m^2]	187
Peak Heat of Combustion	[kJ/g]	81
Average Heat of Combustion	[kJ/g]	19
Smoke Obscuration		
Peak SEA	[m^2/g]	0.124
Average SEA	[m^2/g]	0.017

Peak Smoke Yield	[g/g]	0.015
Smoke Obscuration (Cont.)		
Average Smoke Yield	[g/g]	0.002
Peak Smoke Production Rate	[m^2/s]	0.017
Average Smoke Production Rate	[m^2/s]	0.002
Total Smoke Release	[m^2]	3.954
Gas Production Rates		
Peak Carbon Monoxide	[g/s]	0.000
Average Carbon Monoxide	[g/s]	0.000
Peak Carbon Dioxide	[g/s]	0.493
Average Carbon Dioxide	[g/s]	0.220
Mass Loss		
Peak Mass Loss Rate	[g/s]	0.430
Average Mass Lass Rate	[g/s]	0.141
Initial Mass	[g]	221.8
Final Mass	[g]	45.4
Mass Loss Fraction	[]	0.80
Burn Time		
Time to Ignition	[s]	59
Duration of Flaming	[s]	1932
Duration of Test	[s]	2009

Cone Calorimeter Test Run Data

100 Institute Road
Worcester, MA 01609
Phone: (508) 831-5628
Fax: (508) 831-5680

Test Notes

Test Number:	test 01
Date:	02/27/06
Material:	Bushblok sample 1
Specimen Identification:	Specimen 01
Flux:	50 kW/m2

Observations

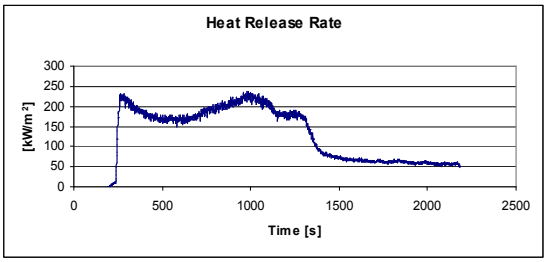
Small amount of light grey smoke
Smoldering occurring, glowing combustion
Light orange flame
Appears to be clean burning, very little smoke with a nice woody aroma
Peak heat release rate is around 230 kw/m2
Little or no CO output

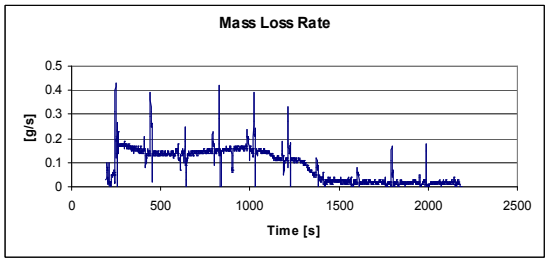
Heat release rate is rising again, probably created from an insulating char layer

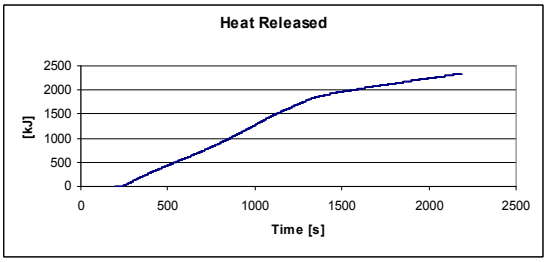
Observations (Cont.)

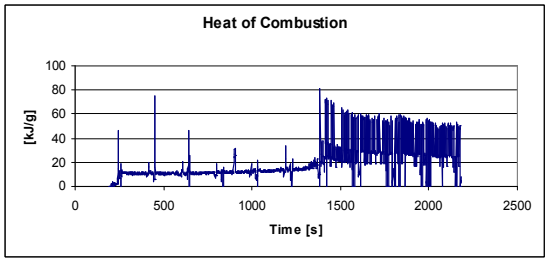
Slightly darker smoke but still very insignificant, no cracking or boiling, very basic flame

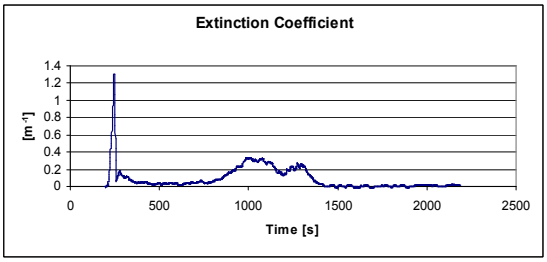
White colored char layer at the end of the test

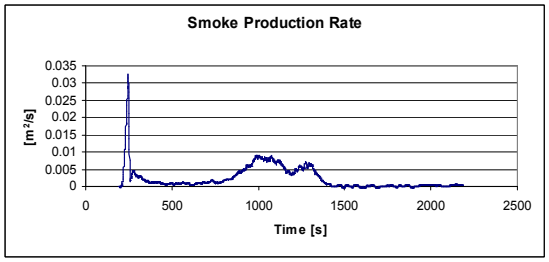


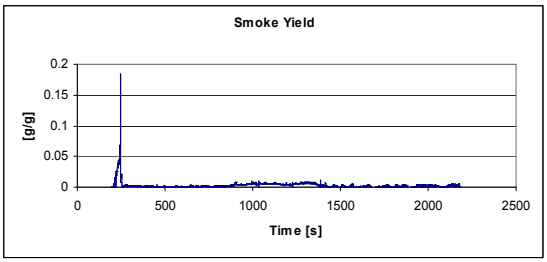


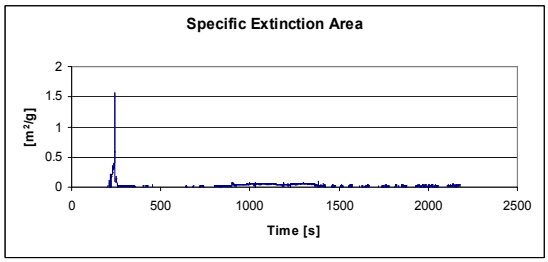


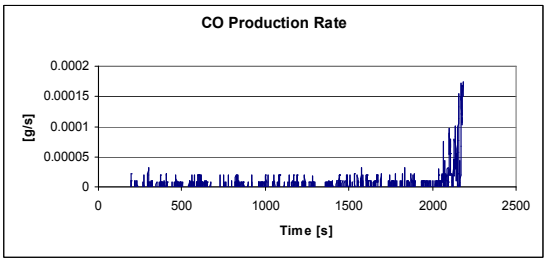


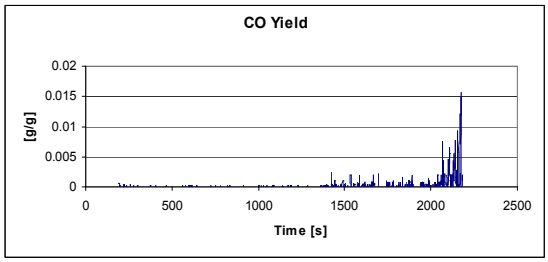


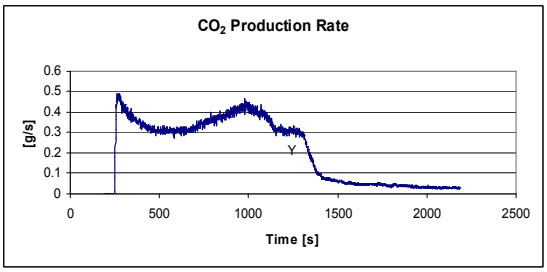


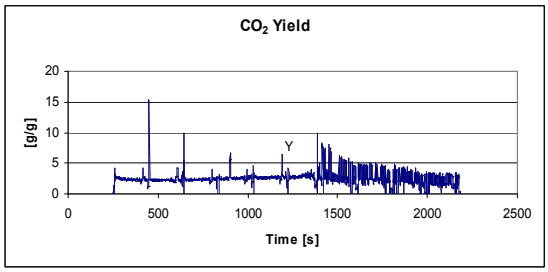

Smoke Yield
[g/g]
0.2
0.15
0.1
0.05
0
0
500
1000
1500
2000
2500
Time [s]


Specific Extinction Area
[m²/g]
2
1.5
1
0.5
0
0
500
1000
1500
2000
2500
Time [s]


CO Production Rate
[g/s]
0.0002
0.00015
0.0001
0.00005
0
0
500
1000
1500
2000
2500
Time [s]

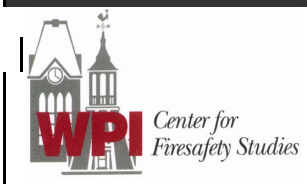

CO Yield
[g/g]
0.02
0.015
0.01
0.005
0
0
500
1000
1500
2000
2500
Time [s]


CO2 Production Rate
[g/s]
0.6
0.5
0.4
0.3
0.2
0.1
0
Y
0
500
1000
1500
2000
2500
Time [s]


CO2 Yield
[g/g]
20
15
10
5
0
Y
0
500
1000
1500
2000
2500
Time [s]

Appendix F: Cone Calorimeter Test Results – Duraflame Anytime Sample

Cone Calorimeter Test Run Data



100 Institute Road
Worcester, MA 01609
Phone: (508) 831-5628
Fax: (508) 831-5680

Test Information

Test Number:	test 05
Specimen Identification:	Specimen 05
Material Name:	Fire Log
Manufacturer/Submitter:	Cheetah MQP Group
Sample Description:	Duraflame sample 1
Raw Data File Name:	022706sample05.txt
Reduced Data File Name:	Duraflame_test1(reduced).xls
Date of Test:	2/27/2006
Tester:	Randy Harris

Test Parameters

Ambient Temperature:	73 F
Relative Humidity:	15%
Heat Flux:	50 kW/m^2
Exhaust Duct Flow Rate:	30 g/s
Orientation:	Horizontal
Specimen Holder:	TRUE
Specimen Preparation:	2 layer foil
Notes:	1” Separation

Specimen Information

Specimen Color:	[]	Brown
Specimen Thickness:	[mm]	20.0
Specimen Test Area:	[m^2]	0.0088
Specimen Initial Mass:	[g]	221.5
Specimen Final Mass:	[g]	19.2
Specimen Density:	[g/cm^3]	1.1
Mass Lost:	[g]	202.3
Total Heat Evolved:	[kJ]	3851

Test Times [s]	
Shutter Open:	181
Time to Ignition:	616
Flameout:	2623
Clean Air/End of Test:	2642

Daily C-Factor
0.044

Test Summary

Test Number:	test 05
Date:	02/27/06
Material:	Duraflame sample 1
Specimen Identification:	Specimen 05
Flux:	50 kW/m2

The Peak, Average and Total parameters are computed over the test period ignition to flame out. There are 4 exceptions. The first three involve initial heat release rate averages for periods after ignition of 60, 180 and 300 seconds. The final involves the average mass loss rate which is computed over the time period from 10% mass loss to 90% mass loss.

Parameter	Unit	Value
Heat Release		
Peak Heat Release Rate	[kW/m^2]	375
Average Heat Release Rate	[kW/m^2]	217
Total Heat Release	[MJ/m^2]	436
Average HRR for the first 60s	[kW/m^2]	350
Average HRR for the first 180s	[kW/m^2]	331
Average HRR for the first 300s	[kW/m^2]	318
Peak Heat of Combustion	[kJ/g]	281
Average Heat of Combustion	[kJ/g]	27
Smoke Obscuration		
Peak SEA	[m^2/g]	3.625
Average SEA	[m^2/g]	0.300
Peak Smoke Yield	[g/g]	0.427
Average Smoke Yield	[g/g]	0.035
Peak Smoke Production Rate	[m^2/s]	0.047
Average Smoke Production Rate	[m^2/s]	0.023
Total Smoke Release	[m^2]	46.960
Gas Production Rates		
Peak Carbon Monoxide	[g/s]	0.000
Average Carbon Monoxide	[g/s]	0.000

Gas Production Rates (Cont.)		
Peak Carbon Dioxide	[g/s]	0.526
Average Carbon Dioxide	[g/s]	0.281
Mass Loss		
Peak Mass Loss Rate	[g/s]	0.390
Average Mass Lass Rate	[g/s]	0.090
Initial Mass	[g]	221.5
Final Mass	[g]	19.2
Mass Loss Fraction	[]	0.91
Burn Time		
Time to Ignition	[s]	435
Duration of Flaming	[s]	2007
Duration of Test	[s]	2461

Observations

Acid filter installed.

Before sustained flaming ignition, flame flash occurred at 560, 580, and 630 seconds.

Just before ignition, specimen intumesced at 15 mm.

Upon ignition, sparker was trapped in intumescent layer. Specimen had to be tilted to remove sparker.

Tilting the specimen at approximately 680 seconds caused the given noise in mass loss rate history.

After ignition, flaming occurred only in a limited area around the center of specimen.

Before ignition, the smoke is light in color, “white”.

After ignition, the smoke is dark in color, “black”.

No smoke leakage from the exhaust hood.

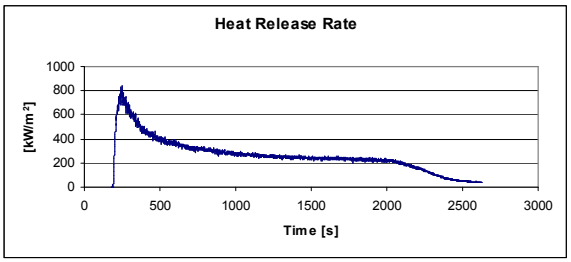
Orange flame is less radiant but quite large

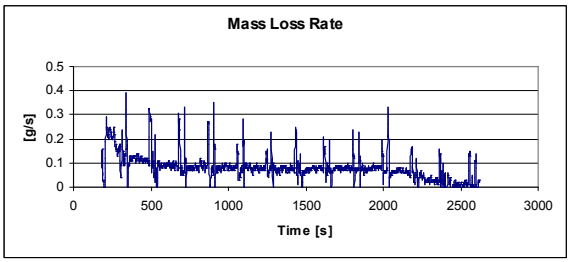
Small bubbles, boiling occurring. Binder probably has a liquid phase

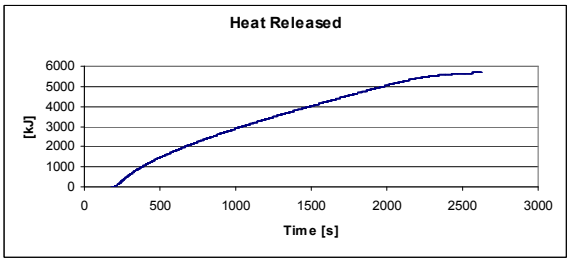
Heat release rate peaked quite high

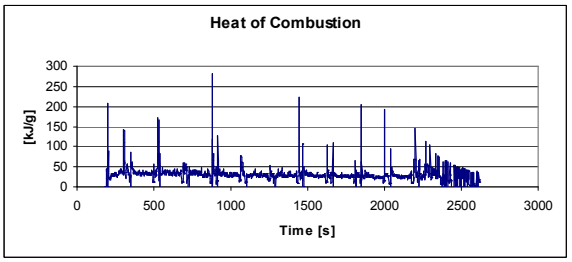
Quite a bit of black smoke towards the end of the burn

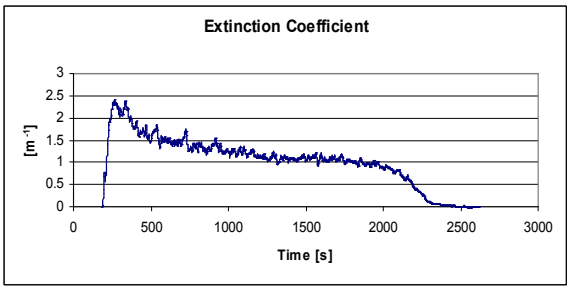
CO2 levels are not that high

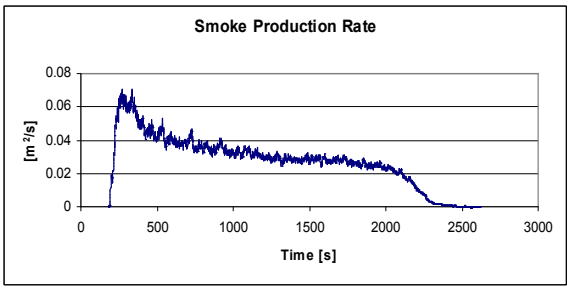

Heat Release Rate
[kW/m²]
1000
800
600
400
200
0
0
500
1000
1500
2000
2500
3000
Time [s]

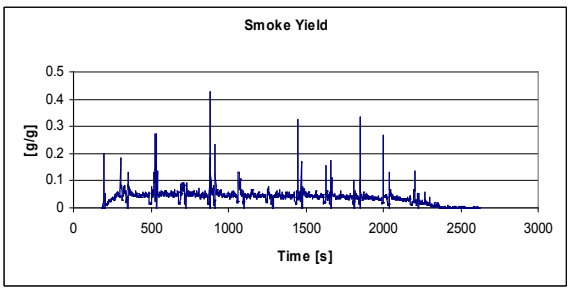

Mass Loss Rate
[g/s]
0.5
0.4
0.3
0.2
0.1
0
0
500
1000
1500
2000
2500
3000
Time [s]

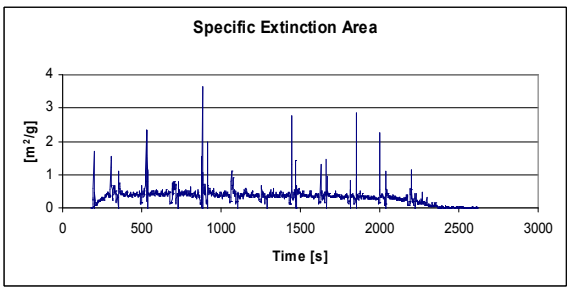

Heat Released
[kJ]
6000
5000
4000
3000
2000
1000
0
0
500
1000
1500
2000
2500
3000
Time [s]

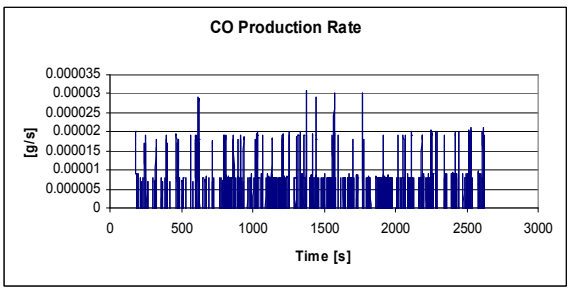

Heat of Combustion
[kJ/g]
300
250
200
150
100
50
0
0
500
1000
1500
2000
2500
3000
Time [s]

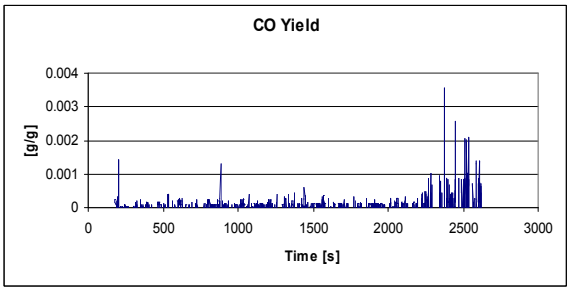

Extinction Coefficient
[m⁻¹]
3
2.5
2
1.5
1
0.5
0
0
500
1000
1500
2000
2500
3000
Time [s]

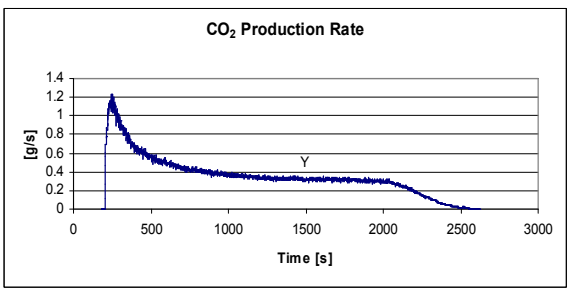

Smoke Production Rate
[m²/s]
0.08
0.06
0.04
0.02
0
0
500
1000
1500
2000
2500
3000
Time [s]

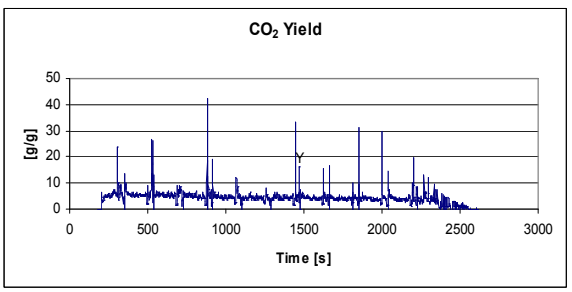

Smoke Yield
[g/g]
0.5
0.4
0.3
0.2
0.1
0
0
500
1000
1500
2000
2500
3000
Time [s]


Specific Extinction Area
[m²/g]
4
3
2
1
0
0
500
1000
1500
2000
2500
3000
Time [s]


CO Production Rate
[g/s]
0.000035
0.00003
0.000025
0.00002
0.000015
0.00001
0.000005
0
0
500
1000
1500
2000
2500
3000
Time [s]

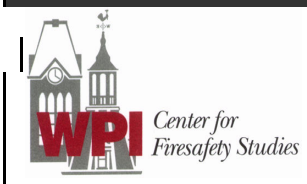

CO Yield
[g/g]
0.004
0.003
0.002
0.001
0
0
500
1000
1500
2000
2500
3000
Time [s]


CO2 Production Rate
[g/s]
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Y
0
500
1000
1500
2000
2500
3000
Time [s]


CO2 Yield
[g/g]
50
40
30
20
10
0
Y
0
500
1000
1500
2000
2500
3000
Time [s]

Appendix G: Cone Calorimeter Test Results – Hardwood Pellets Sample

Cone Calorimeter Test Run Data



100 Institute Road
Worcester, MA 01609
Phone: (508) 831-5628
Fax: (508) 831-5680

Test Information

Test Number:	test 04
Specimen Identification:	Specimen 04
Material Name:	Hardwood Pellets
Manufacturer/Submitter:	Cheetah MQP Group
Sample Description:	Pellets sample 1
Raw Data File Name:	022706sample01.txt
Reduced Data File Name:	Pellets_test1(reduced).xls
Date of Test:	2/27/2006
Tester:	Randy Harris

Test Parameters

Ambient Temperature:	73 F
Relative Humidity:	15%
Heat Flux:	50 kW/m^2
Exhaust Duct Flow Rate:	30 g/s
Orientation:	Horizontal
Specimen Holder:	TRUE
Specimen Preparation:	2 layer foil
Notes:	1” Separation

Specimen Information

Specimen Color:	[]	Brown
Specimen Thickness:	[mm]	20.0
Specimen Test Area:	[m^2]	0.0088
Specimen Initial Mass:	[g]	221.8
Specimen Final Mass:	[g]	46.4
Specimen Density:	[g/cm^3]	1.1
Mass Lost:	[g]	175.4
Total Heat Evolved:	[kJ]	2322

Test Times [s]	
Shutter Open:	188
Time to Ignition:	226
Flameout:	1543
Clean Air/End of Test:	1573

Daily C-Factor
0.044

Test Summary

Test Number:	test 04
Date:	02/27/06
Material:	Pellets sample 1
Specimen Identification:	Specimen 04
Flux:	50 kW/m2

The Peak, Average and Total parameters are computed over the test period ignition to flame out. There are 4 exceptions. The first three involve initial heat release rate averages for periods after ignition of 60, 180 and 300 seconds. The final involves the average mass loss rate which is computed over the time period from 10% mass loss to 90% mass loss.

Parameter	Unit	Value
Heat Release		
Peak Heat Release Rate	[kW/m^2]	517
Average Heat Release Rate	[kW/m^2]	200
Total Heat Release	[MJ/m^2]	263
Average HRR for the first 60s	[kW/m^2]	426
Average HRR for the first 180s	[kW/m^2]	393
Average HRR for the first 300s	[kW/m^2]	344
Peak Heat of Combustion	[kJ/g]	334
Average Heat of Combustion	[kJ/g]	15
Smoke Obscuration		
Peak SEA	[m^2/g]	1.005
Average SEA	[m^2/g]	0.022
Peak Smoke Yield	[g/g]	0.118
Average Smoke Yield	[g/g]	0.003
Peak Smoke Production Rate	[m^2/s]	0.012
Average Smoke Production Rate	[m^2/s]	0.003
Total Smoke Release	[m^2]	4.160
Gas Production Rates		
Peak Carbon Monoxide	[g/s]	0.000
Average Carbon Monoxide	[g/s]	0.000

Gas Production Rates (Cont.)		
Peak Carbon Dioxide	[g/s]	1.034
Average Carbon Dioxide	[g/s]	0.355
Mass Loss		
Peak Mass Loss Rate	[g/s]	0.650
Average Mass Lass Rate	[g/s]	0.147
Initial Mass	[g]	221.8
Final Mass	[g]	46.4
Mass Loss Fraction	[]	0.79
Burn Time		
Time to Ignition	[s]	38
Duration of Flaming	[s]	1317
Duration of Test	[s]	1385

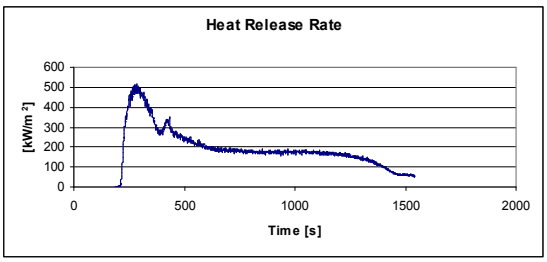
Observation

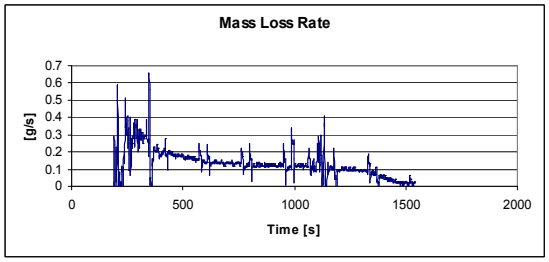
Very intense flame

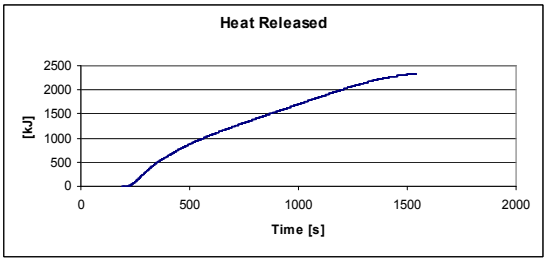
Sample charred very quickly

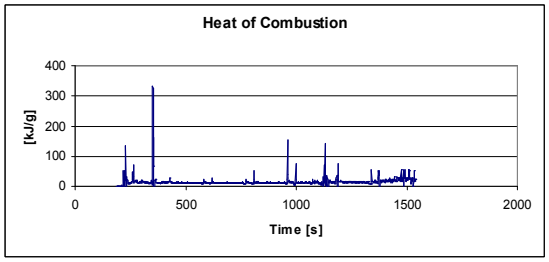
Bright orange flame, very little smoke

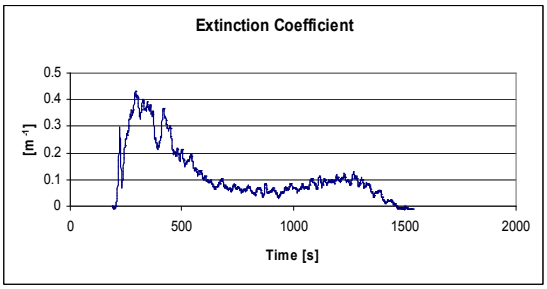
Sample experienced almost a complete burn

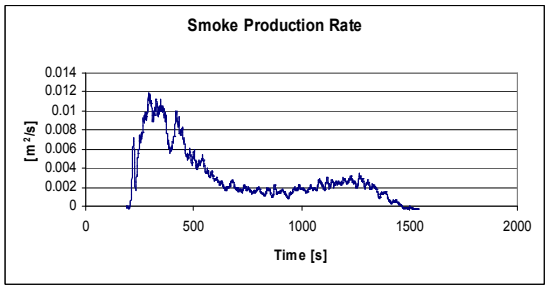


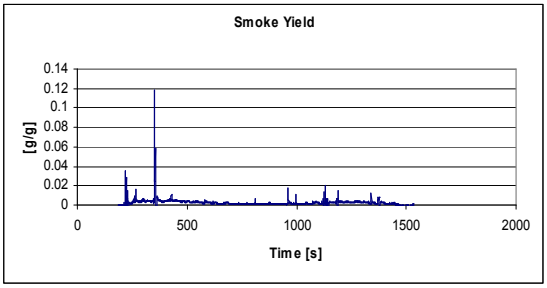


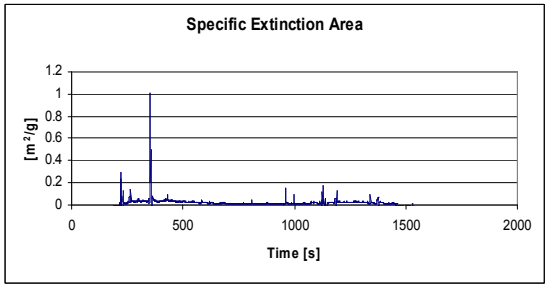


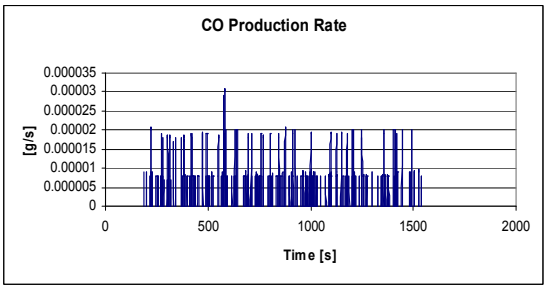


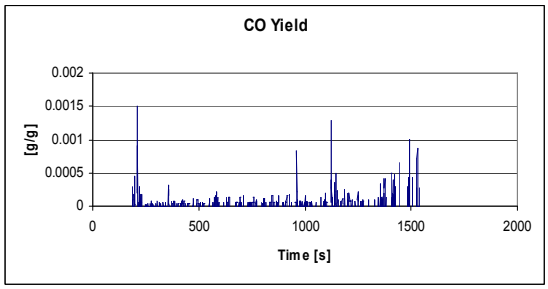


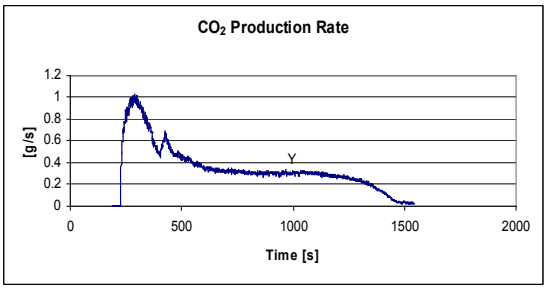


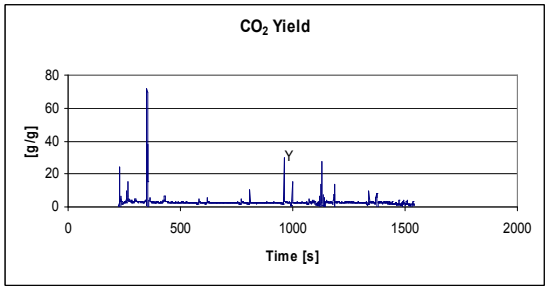

Smoke Yield
[g/g]
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
500
1000
1500
2000
Time [s]


Specific Extinction Area
[m²/g]
1.2
1
0.8
0.6
0.4
0.2
0
0
500
1000
1500
2000
Time [s]


CO Production Rate
[g/s]
0.000035
0.00003
0.000025
0.00002
0.000015
0.00001
0.000005
0
0
500
1000
1500
2000
Time [s]


CO Yield
[g/g]
0.002
0.0015
0.001
0.0005
0
0
500
1000
1500
2000
Time [s]


CO2 Production Rate
[g/s]
1.2
1
0.8
0.6
0.4
0.2
0
Y
0
500
1000
1500
2000
Time [s]


CO2 Yield
[g/g]
80
60
40
20
0
Y
0
500
1000
1500
2000
Time [s]

Appendix H: Cone Calorimeter Test Results – Homelife Sample

Cone Calorimeter Test Run Data

Center for Firesafety Studies

100 Institute Road
Worcester, MA 01609
Phone: (508) 831-5628
Fax: (508) 831-5680

Test Information

Test Number:	test 02
Specimen Identification:	Specimen 02
Material Name:	Fire Log
Manufacturer/Submitter:	Cheetah IQP Group
Sample Description:	Homelife sample 1
Raw Data File Name:	022706sample02.txt
Reduced Data File Name:	Homelife_test1(reduced).xls
Date of Test:	2/27/2006
Tester:	Randy Harris

Test Parameters

Ambient Temperature:	71 F
Relative Humidity:	16%
Heat Flux:	50 kW/m^2
Exhaust Duct Flow Rate:	30 g/s
Orientation:	Horizontal
Specimen Holder:	TRUE
Specimen Preparation:	2 layer foil
Notes:	1” Separation

Specimen Information

Specimen Color:	[]	Brown
Specimen Thickness:	[mm]	20.0
Specimen Test Area:	[m^2]	0.0088
Specimen Initial Mass:	[g]	222.3
Specimen Final Mass:	[g]	19.6
Specimen Density:	[g/cm^3]	1.1
Mass Lost:	[g]	202.7
Total Heat Evolved:	[kJ]	5723

Test Times [s]

Shutter Open:	191
Time to Ignition:	209
Flameout:	2764
Clean Air/End of Test:	2794

Daily C-Factor

0.044

Test Summary

Test Number:	test 02
Date:	02/27/06
Material:	Homelife sample 1
Specimen Identification:	Specimen 02
Flux:	50 kW/m2

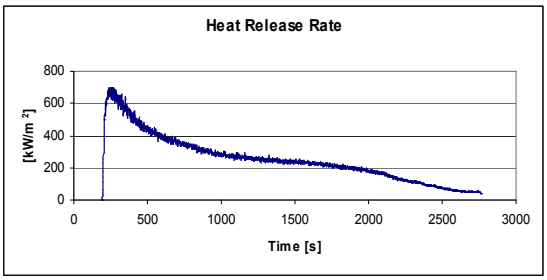
The Peak, Average and Total parameters are computed over the test period ignition to flame out. There are 4 exceptions. The first three involve initial heat release rate averages for periods after ignition of 60, 180 and 300 seconds. The final involves the average mass loss rate which is computed over the time period from 10% mass loss to 90% mass loss.

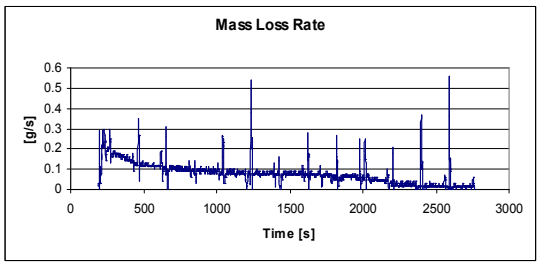
Parameter	Unit	Value
Heat Release		
Peak Heat Release Rate	[kW/m^2]	700
Average Heat Release Rate	[kW/m^2]	254
Total Heat Release	[MJ/m^2]	648
Average HRR for the first 60s	[kW/m^2]	645
Average HRR for the first 180s	[kW/m^2]	611
Average HRR for the first 300s	[kW/m^2]	556
Peak Heat of Combustion	[kJ/g]	234
Average Heat of Combustion	[kJ/g]	31
Smoke Obscuration		
Peak SEA	[m^2/g]	3.456
Average SEA	[m^2/g]	0.342
Peak Smoke Yield	[g/g]	0.407
Average Smoke Yield	[g/g]	0.040
Peak Smoke Production Rate	[m^2/s]	0.081
Average Smoke Production Rate	[m^2/s]	0.030
Total Smoke Release	[m^2]	75.880
Gas Production Rates		

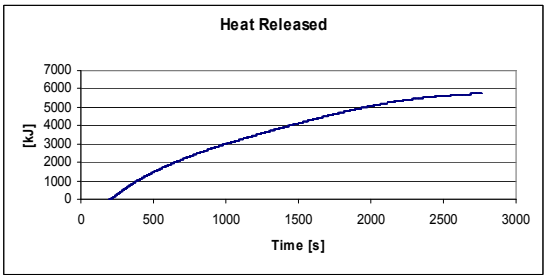
Peak Carbon Monoxide	[g/s]	0.000
Average Carbon Monoxide	[g/s]	0.000
Gas Production Rates (Cont.)		
Peak Carbon Dioxide	[g/s]	1.097
Average Carbon Dioxide	[g/s]	0.346
Mass Loss		
Peak Mass Loss Rate	[g/s]	0.560
Average Mass Lass Rate	[g/s]	0.092
Initial Mass	[g]	222.3
Final Mass	[g]	19.6
Mass Loss Fraction	[]	0.91
Burn Time		
Time to Ignition	[s]	18
Duration of Flaming	[s]	2555
Duration of Test	[s]	2603

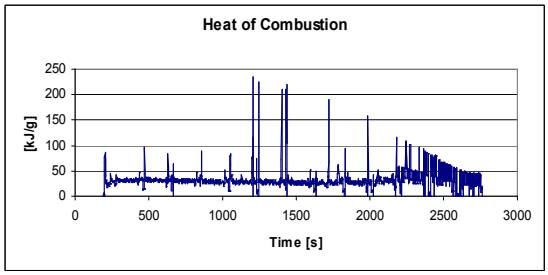
Observations

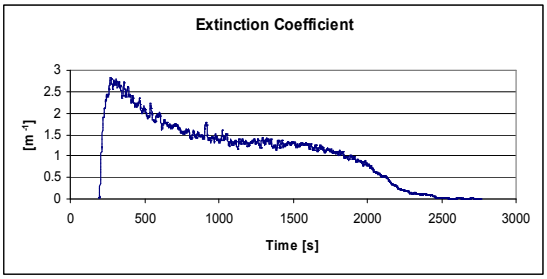
There is a significant amount of grey smoke
The sample ignited fairly quickly
Flame is quite high, this signified a higher heat release rate
Black smoke is beginning to appear rising from the sample
CO2 output level is fairly high
Scale adjustments necessary due to high heat release rate
Flame is orange in color
No crackling or boiling

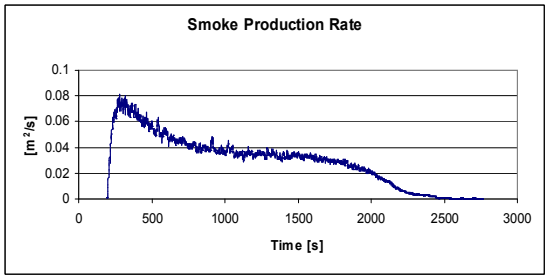


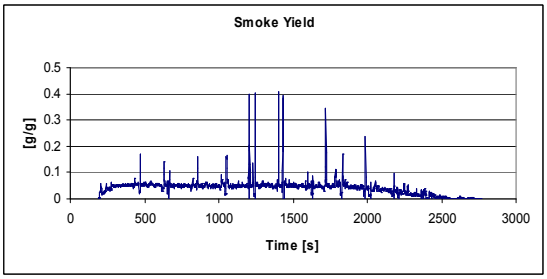


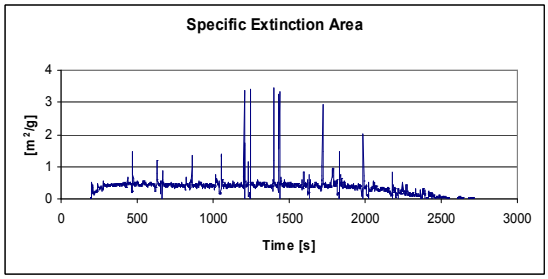


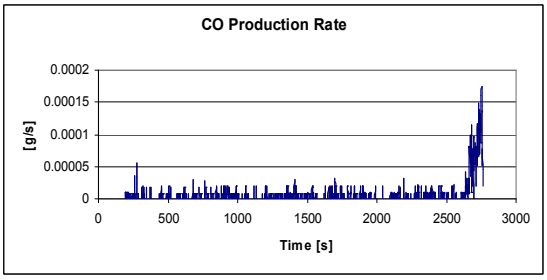


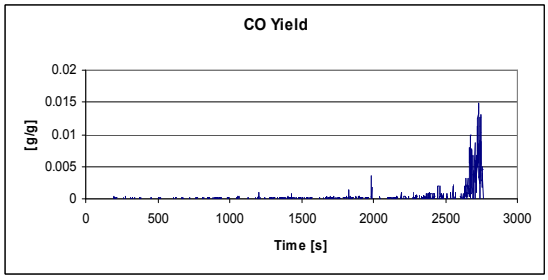

Extinction Coefficient
[m -1]
Time [s]

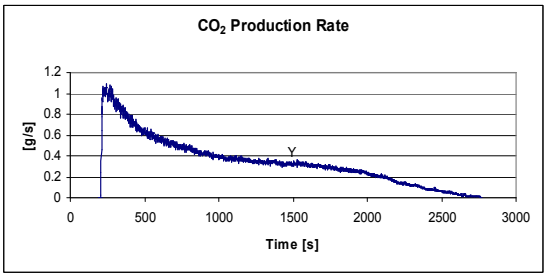

Smoke Production Rate
[m2/s]
Time [s]

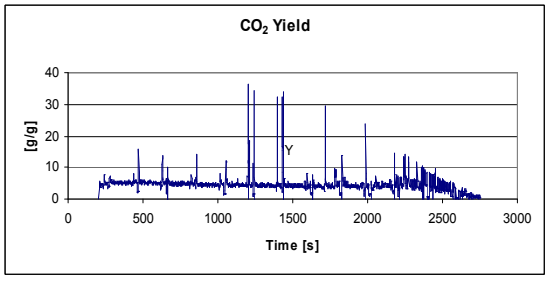

Smoke Yield
[g/g]
Time [s]


Specific Extinction Area
[m2/g]
Time [s]


CO Production Rate
[g/s]
Time [s]


CO Yield
[g/g]
Time [s]


CO2 Production Rate
[g/s]
Y
Time [s]


CO2 Yield
[g/g]
Y
Time [s]

Appendix I: Cone Calorimeter Test Results – Pine Mountain Sample

Cone Calorimeter Test Run Data

100 Institute Road
Worcester, MA 01609
Phone: (508) 831-5628
Fax: (508) 831-5680

Test Information

Test Number:	test 03
Specimen Identification:	Specimen 03
Material Name:	Pine Mountain Superlog
Manufacturer/Submitter:	Cheetah IQP Group Pine Mountain Superlog
Sample Description:	sample1
Raw Data File Name:	022706sample03.txt
Reduced Data File Name:	Pine Mount_test1(reduced).xls
Date of Test:	2/27/2006
Tester:	Randy Harris

Test Parameters

Ambient Temperature:	71 F
Relative Humidity:	16%
Heat Flux:	50 kW/m^2
Exhaust Duct Flow Rate:	30 g/s
Orientation:	Horizontal
Specimen Holder:	TRUE
Specimen Preparation:	2 layer foil
Notes:	1” Separation

Specimen Information

Specimen Color:	[]	Brown
Specimen Thickness:	[mm]	20.0
Specimen Test Area:	[m^2]	0.0088
Specimen Initial Mass:	[g]	222.1
Specimen Final Mass:	[g]	15.2
Specimen Density:	[g/cm^3]	1.1
Mass Lost:	[g]	206.9
Total Heat Evolved:	[kJ]	6026

Test Times [s]

Shutter Open:	204
Time to Ignition:	222
Flameout:	3414
Clean Air/End of Test:	3443

Daily C-Factor

0.044

Test Summary

Test Number:	test 03
Date:	02/27/06
Material:	Pine Mountain Superlog sample1
Specimen Identification:	Specimen 03
Flux:	50 kW/m2

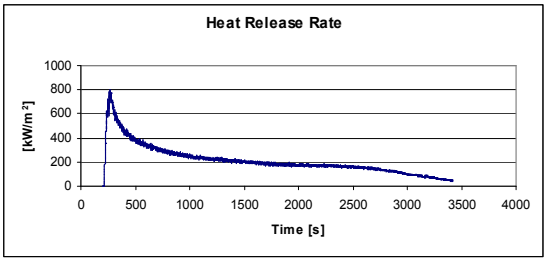
The Peak, Average and Total parameters are computed over the test period ignition to flame out. There are 4 exceptions. The first three involve initial heat release rate averages for periods after ignition of 60, 180 and 300 seconds. The final involves the average mass loss rate which is computed over the time period from 10% mass loss to 90% mass loss.

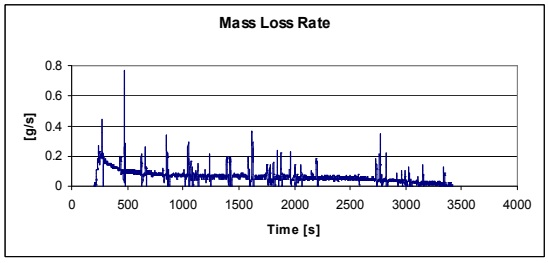
Parameter	Unit	Value
Heat Release		
Peak Heat Release Rate	[kW/m^2]	797
Average Heat Release Rate	[kW/m^2]	214
Total Heat Release	[MJ/m^2]	682
Average HRR for the first 60s	[kW/m^2]	616
Average HRR for the first 180s	[kW/m^2]	573
Average HRR for the first 300s	[kW/m^2]	507
Peak Heat of Combustion	[kJ/g]	299
Average Heat of Combustion	[kJ/g]	28
Smoke Obscuration		
Peak SEA	[m^2/g]	2.929
Average SEA	[m^2/g]	0.241
Peak Smoke Yield	[g/g]	0.345
Average Smoke Yield	[g/g]	0.028
Peak Smoke Production Rate	[m^2/s]	0.063
Average Smoke Production Rate	[m^2/s]	0.018
Total Smoke Release	[m^2]	57.836
Gas Production Rates		

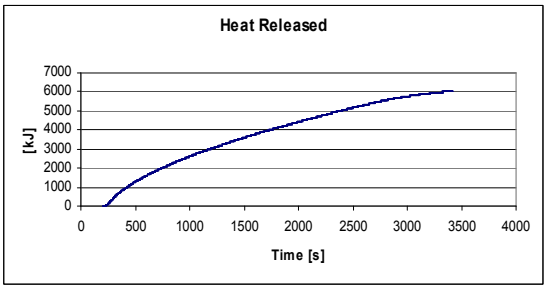
Peak Carbon Monoxide	[g/s]	0.000
Average Carbon Monoxide	[g/s]	0.000
Gas Production Rates (Cont.)		
Peak Carbon Dioxide	[g/s]	1.232
Average Carbon Dioxide	[g/s]	0.283
Mass Loss		
Peak Mass Loss Rate	[g/s]	0.760
Average Mass Lass Rate	[g/s]	0.069
Initial Mass	[g]	222.1
Final Mass	[g]	15.2
Mass Loss Fraction	[]	0.93
Burn Time		
Time to Ignition	[s]	18
Duration of Flaming	[s]	3192
Duration of Test	[s]	3239

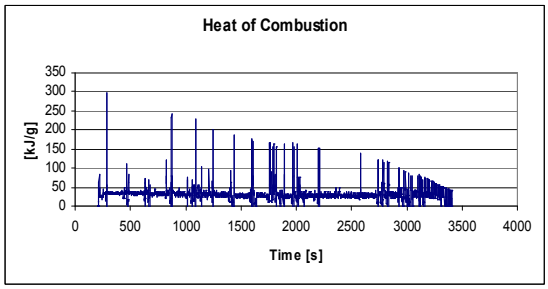
Observations

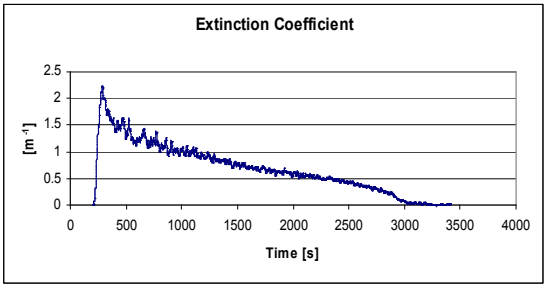
The sample appears to be boiling
Post ignition, flame is dark orange, very bright and radiant, dirtier burn
Black smoke is apparent, very tall flame
Steady heat dissipation
Flame is steadily becoming less intense, very noticeable black smoke
Very long burn, steady decline throughout

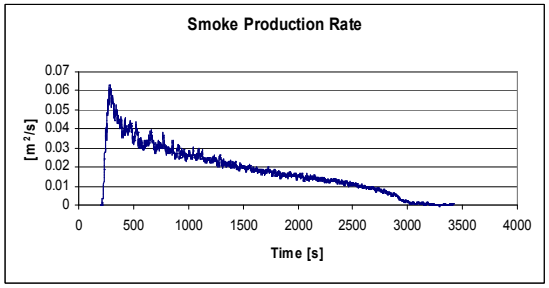


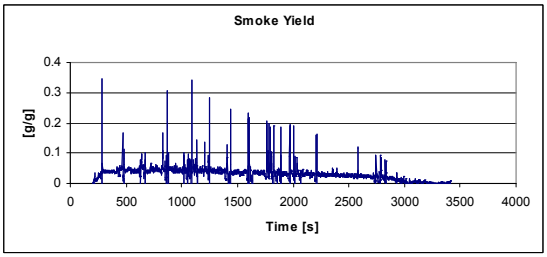


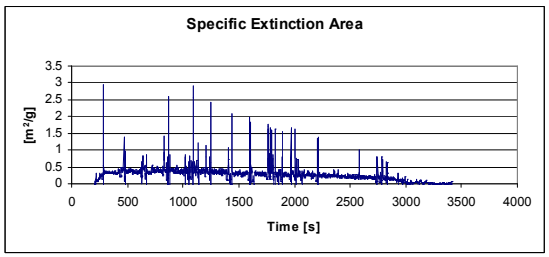


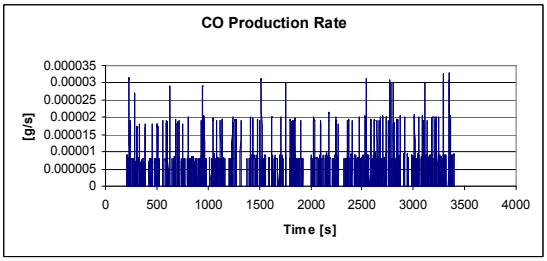


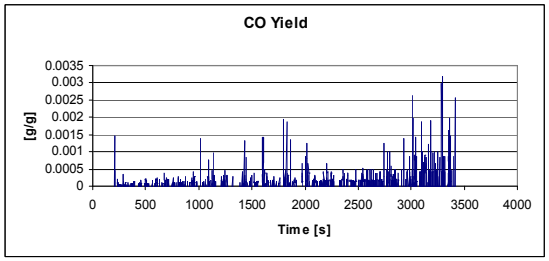

Extinction Coefficient
[m-1]
Time [s]

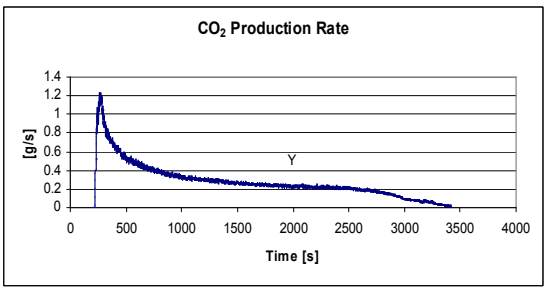

Smoke Production Rate
[m2/s]
Time [s]

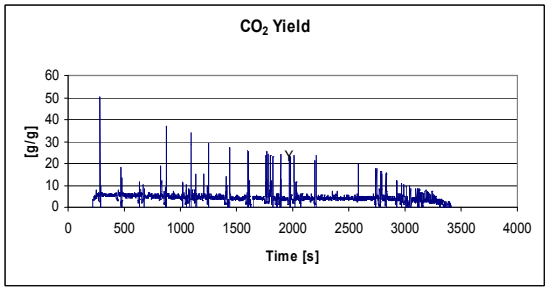

Smoke Yield
[g/g]
Time [s]


Specific Extinction Area
[m2/g]
Time [s]


CO Production Rate
[g/s]
Time [s]


CO Yield
[g/g]
Time [s]


CO2 Production Rate
[g/s]
Y
Time [s]


CO2 Yield
[g/g]
Y
Time [s]

Appendix J: CCF BUSH Pty Ltd Meat Co. Tannery Findings

ENERGY NEEDS AND COST

How much does fuel cost?

N$2.58 / Liter (heavy fuel oil prices haven't increased like other fuel has)

How much fuel do you use?

10,000 liters for 22 days a month

Are your fuel needs met?

Yes

Is the supply of fuel steady?

Yes

Is the cost steady?

Yes

Are you in a contract for fuel?

Yearly Contracts

Who supplies your fuel?

Engen (for 12 Years)

BOILER NEEDS / TECHNICAL ISSUES

How much heat energy does it take to run your boiler?

Is it meeting your needs?

Yes

What is the energy density of the fuel oil?

How old is your boiler?

How long do you expect it to last / are you thinking of buying a new one?

Will last 20-30 yrs. If kept in good condition, 15 yrs on average, but only 5 if something goes wrong

How much does a new boiler cost?

Do you have emissions requirements?

To clean the boiler once a year

Comments:

They have two boilers – one that runs, and a standby one. (2.8 and 1.8 ton boilers)

Boiler can be easily changed to another type of fuel by a exchanging the gas inlet

Asked if he would exchange for cheaper fuel and he stated "there isn't cheaper fuel"

Explosions are the main problem for boiler failure. (YIKES)

Further Contacts:

Namibia Dairies

Windhoek Meat Co. Abattoir

Appendix K: CCF BUSH Pty Ltd Meat Co. Abattoir Findings

ENERGY NEEDS AND COST

How much does fuel cost?

N$640/ton delivered

How much fuel do you use?

Delivered 120 tons 2 times a month

Plant runs 24 hours a day every day except Sundays

Are your fuel needs met?

Yes

Is the supply of fuel steady?

Yes

Is the cost steady?

Yes

Are you in a contract for fuel?

No contract – they buy top quality coal with the best price for transport (transport is the most expensive part of the price)

Who supplies your fuel?

API Walvis Bay – a South African supplier

BOILER NEEDS / TECHNICAL ISSUES

How much heat energy does it take to run your boiler?

Is it meeting your needs?

Yes

What is the energy density of the fuel oil?

18,000-23,000 kJ / kg

How old is your boiler?

20 years old – 1 ton boilers

How long do you expect it to last / are you thinking of buying a new one?

Thinking about refurbishing in the next 5 years

How much does a new boiler cost?

Do you have emissions requirements?

To clean the boiler once a year

Comments:

Further Contacts:

Namibia Breweries

Fish Industry

Hospitals

Appendix L: CCF BUSH Pty Ltd Namibia Breweries Findings

ENERGY NEEDS AND COST

How much does fuel cost?

They're in a contract, but can't share that information

How much fuel do you use?

65 Tonnes

Are your fuel needs met?

Yes

Is the supply of fuel steady?

No problems

Is the cost steady?

It varies with market price, but again, that's confidential

Are you in a contract for fuel?

Yes

Who supplies your fuel?

In a contract with BP

BOILER NEEDS / TECHNICAL ISSUES

How much heat energy does it take to run your boiler?

Is it meeting your needs?

Yes

What is the energy density of the fuel oil?

How old is your boiler?

Boiler was retrofit 2yrs ago and on was retrofit 10 yrs ago

How long do you expect it to last / are you thinking of buying a new one?

How much does a new boiler cost?

Do you have emissions requirements?

There are no emission requirements or chemical treatments. A 2 yr hydraulic test and a 1 yr Cleaning.

Comments:

Further Contacts:

AWH Engineering Anthony Hearn

Appendix M: CCF BUSH Pty Ltd Etosha Fisheries Findings

ENERGY NEEDS AND COST

How much does fuel cost?

$3.02 per liter

How much fuel do you use?

173,000 Liters can fill the Tank. They use 9 tonnes of steam per hour and 13.2 tonnes per hour on fish meal

Are your fuel needs met?

In December there was a fuel shortage and from February 19th to the 8th of March they had to switch to diesel

Is the supply of fuel steady?

Same as Above

Is the cost steady?

Cost has increased from 2.94 to 3.02 but that is pretty steady

Are you in a contract for fuel?

Yes

Who supplies your fuel?

Shell

BOILER NEEDS / TECHNICAL ISSUES

How much heat energy does it take to run your boiler?

Is it meeting your needs?

What is the energy density of the fuel oil?

How old is your boiler?

1 got rejected and needs to be repaired it got rejected in 1994 and it was made in 1977. The other 2 boilers are from 1988 and 1968

How long do you expect it to last / are you thinking of buying a new one?

They Last Forever as long as you treat the water with salt and calcium pellets

How much does a new boiler cost?

2.3 Million w/o installation costs

Do you have emissions requirements?

No

Comments:

They don't run when there aren't fish, He says you can't co-fire with the boilers, the systems are computer operated

Further Contacts:

Appendix N: CCF BUSH Pty Ltd Van Eck Findings

Daily Coal Feed Rate at Maximum Rate Load:

With 4 Units on full load with a coal burnt figure of 0.56 kg/kWh it will consume approximately 1,500 tonnes/day

Average Heating Value of Coal:

26.5 MJ/kg

Bulk Density of Coal:

920 kg per m^3 . It depends on the coal sizing- the figure is for mixed smalls.

Annual Coal Use:

We average approximatel 115,000 tonnes/year over the power stations existence. The most coal consumed was in 1979 at 264,573 tonnes and at the least in 2000 at only 2,926 tonnes.

Unit Cost of Coal Delivered to the Boiler Facility:

It depends from one shipment to another- the latest cost exceeds N$ 600/ton delivered at Van Eck

Tipping Fee for Landfill:

Not applicable- the final dust is being removed by Rent-a-Drum at N$140/container and the rough ash by ourselves

Appendix O: Otjiwarongo Residential Data

Location	TE220	DS340	B Section	B Section
What do you use for Cooking/Heating?	Wood	Wood	Wood	Firewood
How many People are in your Household?	7	5	1	5
How Much Fuel Do you Use?	1 Large Pack of Wood	Cook two times a day and they use tons of little acacia branches	6 pieces for 2 days (bigger then a stick)	4 pieces of wood a day Another person who purchases it from a farm
Where do you get your Fuel?	Collect it illegally	Collect it illegally	From local sellers in the settlements	
How much do you pay for it?	120 for 1 week	Free but dangerous to collect cause it is illegal and there are snakes	1 dollar a pack	1 dollar
Do you feel the price is fair?	No, very expensive	No that is why they collect	Not enough wood and it is not fair for her	It is a fair price Sometimes she has to wander to other sellers
How often do you purchase it?	Sometimes they must pay the farmers	Everyday they go collect it	Every two days	
Is it available when you need it?	When it rains they must try to burn it wet	The cook outside and when it rains it is hard especially when the Bush is wet	When it is rainy it isn't available	Normally
Other Comments:	Don't know how much they would pay for Bushblok		She uses oil when there is no wood for her and the oil cost 1.20 for a little bottle that will last a week	Cooks 3 times a day

Location	Seller TE364	DN237	DN354	Seller
What do you use for Cooking/Heating?	Sells wood to others	Firewood	Wood	Firewood
How many People are in your Household?		4		2
How Much Fuel Do you Use?	Gets a truck full when needed	4 pieces a day		A collection or pack lasts 1 week
Where do you get your Fuel?	A farmer delivers	Local Seller		Collect from the forest for free
How much do you pay for it?	150 dollars a truck load	2 five pieces a day		Nothing

Do you feel the price is fair?	It is Expensive	Sometimes if she doesn't have money she harvests illegally		Sell at their houses 5 pieces
How often do you purchase it?	Normally once a month	Everyday		Once a week collects
Is it available when you need it?	Yes	Yes		Use gas if you can't get wood 2.00 a bottle
Other Comments:	Interested in Selling Bushblok	Cooks Meats and beans	Was Making millets to sell in town	Interested in selling Bushblok depending on price

Location	Seller	DN	TC96 Seller	Sellers	TE263
What do you use for Cooking/Heating?	Firewood	Firewood	Wood	Wood	Wood
How many People are in your Household?	1	9		6	9
How Much Fuel Do you Use?	A collection or pack lasts 1 week	A huge pile (look at picture)	A truck load a week	A bundle a day	a 5 kg package from the farm for a funeral
Where do you get your Fuel?	Collect from the forest for free	Collect illegally an hours walk from home	A famer delivers and she cuts it	They collect it illegally	From a farmer 100, but normally 2 dollars a day
How much do you pay for it?	Nothing	Free	130 Dollars a truck	They sell it 1 dollar for 4 pieces	from a local seller
Do you feel the price is fair?	Sell at house in 5 piece packs	Free	Sells for 1 dollar for 5 pieces	Are not interested in Bushblok	No choice
How often do you purchase it?	Once a week collects	3 days it lasts	Once a week and she has a permit to sell	Everyday they collect it	Everyday, and at funerals
Is it available when you need it?	Uses gas if can't collect	They use gas somedays but prefers wood because of price	Yes	Sometimes they don't get customers, but they can always get it	Sometimes you need to look at other houses
Other Comments:	Interested in Selling		Sells 300-130 a 170 dollar		

	Bushblok depending on price	profit. No one will buy Bushblok if they don't know the product and 15 dollars a pack is too much

Appendix P: Ongwediva and Oshakati Residential Data

Location	Urban	Urban	Urban	Urban
What do you use for Cooking/Heating?	Electricity and Wood	Electricity and Wood	Electricity but they cook meat outside with wood	Wood
How many People are in your Household?	17	27	5	6
How Much Fuel Do you Use?	1 bunch of wood a day	Use wood on the weekends	$50 a month	$60-70 a month
Where do you get your Fuel?	From the Open Market	Buys wood from the farm and houses	they go into the village	Depends
How much do you pay for it?	$7.00 for a bunch	$7.00 for 4 pieces		
Do you feel the price is fair?	It is Expensive but there is no other option	The price is getting expensive	It is expensive and prices are rising	
How often do you purchase it?	Whenever it runs out		They buy it a lot	Once a month
Is it available when you need it?	Sometimes they don't have any	Sometimes they run out	Yes	Yes, but if they forget to buy it they need to go to the Open Market
Other Comments:	Cheaper then Electricity			Only use traditional wood for meat

Location	Urban	Urban	Urban	Rural
What do you use for Cooking/Heating?	Electricity and Wood	Wood and sometimes electricity	Sometimes Wood	Wood
How many People are in your Household?	7	5	6	10
How Much Fuel Do you Use?	They don't use much cause they don't use it often	Do not know		Difficult to say how much because they use different types of wood, but they use it to cook lunch

				and dinners
Where do you get your Fuel?	Open Markets	In the Village	Collect it in the village and it is free	They collect it off of their land, usually tree stumps
How much do you pay for it?	$7.00 a bunch		Free	Free
Do you feel the price is fair?	It is expensive			When they do buy it from the town it is not fair and too expensive
How often do you purchase it?	When the electricity is off	Once a month	Every 2 months	When ever they have the money to, only once in a while
Is it available when you need it?	It is always available	Wood runs out and they do not always have it	Always Available	It is very scarce
Other Comments:		Wood is better then electricity		They collect wood for the other houses, as they are the owner of the homestead

Location	Rural	Rural	Rural	Rural	Rural
What do you use for Cooking/Heating?	Wood	Wood	Wood	Wood	Wood
How many People are in your Household?	10	16	8	6	10
How Much Fuel Do you Use?	They use it two times a day	They use it two times a day	They use it two times a day	They use it two times a day	They use it two times a day
Where do you get your Fuel?	They collect it off of the land usually through Stumps	They collect it off of the land usually through Stumps	They collect it off of the land usually through Stumps	They collect it off of the land usually through Stumps	They collect it off of the land usually through Stumps
How much do you pay for it?	It is free, if they go into town 5-50 dollars	It is free, if they go into town 5-50 dollars	It is free, if they go into town 5-50 dollars	It is free, if they go into town 5-50 dollars	It is free, if they go into town 5-50 dollars

Do you feel the price is fair?	It is expensive but they have no choice	It is expensive but they have no choice	It is expensive but they have no choice	It is expensive but they have no choice	It is expensive but they have no choice
How often do you purchase it?	They collect once to twice a day and buy in town when they have to	They collect once to twice a day and buy in town when they have to	They collect once to twice a day and buy in town when they have to	They collect once to twice a day and buy in town when they have to	They collect once to twice a day and buy in town when they have to
Is it available when you need it?	It is very Scarce	It is very Scarce	It is very Scarce	It is very Scarce	It is very Scarce

Location	Rural	Rural
What do you use for Cooking/Heating?	Wood	Wood
How many People are in your Household?	8	6
How Much Fuel Do you Use?	They use it two times a day	They use it two times a day
Where do you get your Fuel?	They collect it off of the land usually through Stumps	They collect it off of the land usually through Stumps
How much do you pay for it?	It is free, if they go into town 5-50 dollars	It is free, if they go into town 5-50 dollars
Do you feel the price is fair?	It is expensive but they have no choice	It is expensive but they have no choice
How often do you purchase it?	They collect once to twice a day and buy in town when they have to	They collect once to twice a day and buy in town when they have to
Is it available when you need it?	It is very Scarce	It is very Scarce

Appendix Q: Otjiwarongo Wood Fuel Sales

All prices in the following table are in Namibian Dollars

Otjiwarongo Direct

Business Name	Product	Package Weight	Purchase Price[7]	Purchase Price / kg
BP Express	Wood	10.00	$6.00	$0.60
Caltex	Wood	10.00	$11.00	$1.10
Cash and Carry	Wood	6.00	$4.50	$0.75
Shell	Wood	10.00	$9.50	$0.95

Otjiwarongo Direct

Business Name	Retail Price[8]	Retail Price / kg	Markup	Units Sold per Month
BP Express	$6.50	$0.65	8.33%	-
Caltex	$18.00	$1.80	63.64%	50
Cash and Carry	$8.50	$1.42	88.89%	200
Shell	$13.50	$1.35	42.11%	150

Otjiwarongo Direct

Business Name	Units Sold Per Week	Total Units Sold Per Month	Gross Wholesale	Total Unit Volume Sold Per Month
BP Express	-	1070[9]	$958.00	-
Caltex	-	500	$550.00	50
Cash and Carry	-	1200	$900.00	200
Shell	-	1500	$1,425.00	150

Otjiwarongo Distributor

Business Name	Product	Package Weight	Purchase Price	Price / kg
Pick n' Pay	Wood	4.00	$5.48	$1.37
Shoprite	Wood	10.00	$12.99	$1.30
Spar	Wood	6.00	$6.50	$1.08
Spar	Wood	10.00	$7.50	$0.75
Total	Wood	10.00	$4.50	$0.45
Total	Charcoal	3.00	$4.50	$1.50

Otjiwarongo Distributor

Business Name	Markup	Units Sold Per Month	Units Sold Per Week	Total Units Sold Per Month
Pick n' Pay	63.32%	-	-	-
Shoprite	7.70%	-	-	-
Spar	20.77%	-	10	40
Spar	26.00%	-	60	240
Total	97.78%	40	-	40
Total	77.78%	15	-	15

[7] Purchase price refers to the price at which a retailers buys a product
[8] Retail price refers to the price at which the product is sold
[9] Price in red are extrapolated values

Otjiwarongo Distributor (Continued)

Business Name	Total Weight Volume Sold Per Month	Gross Wholesale
Pick n' Pay	647	$492.00
Shoprite	647	$492.00
Spar	240	$260.00
Spar	2400	$1,800.00
Total	400	$180.00

Appendix R: Oshakati and Ongwediva Wood Fuel Sales

All prices in the following table are in Namibian Dollars

Ongwediva and Oshakati Direct

Business Name	Product	Package Weight	Purchase Price	Price / kg
Shell	Wood	7.00	$9.50	$1.36
Shell	Charcoal	4.00	$13.30	$3.33
Engen	Wood	5.00	$11.00	$2.20
Engen	Charcoal	5.00	$10.50	$2.10

Ongwediva and Oshakati Direct

Business Name	Retail Price	Price / kg	Markup	Units Sold Per Month
Shell	$15.35	$2.19	61.58%	50
Shell	$15.00	$3.75	12.78%	50
Engen	$18.50	$3.70	68.18%	-
Engen	$18.60	$3.72	77.14%	-

Ongwediva and Oshakati Direct

Business Name	Units Sold Per Week	Total Units Sold Per Month	Total Weight Volume Per Month	Gross Wholesale
Shell	-	50	350	$475.00
Shell	-	50	200	$665.00
Engen	150	600	3000	$6,600.00
Engen	50	200	1000	$2,100.00

Ongwediva and Oshakati Distributor

Business Name	Product	Package Weight	Purchase Price	Price / kg
Spar	Wood	-	-	-
Spar	Charcoal	-	-	-
Shoprite	Wood	10.00	-	-
Shoprite	Charcoal	5.00	-	-
Pick-n-Pay	Wood	10.00	$9.99	$1.00
OK Grocer	Wood	7.00	-	-

Ongwediva and Oshakati Distributor

Business Name	Retail Price	Price / kg	Markup	Units Sold Per Month
Spar	-	-	-	-
Spar	-	-	-	-
Shoprite	$9.99	$1.00	-	-
Shoprite	$12.99	$2.60	-	-
Pick-n-Pay	$14.00	$1.40	40.14%	15
OK Grocer	$11.99	$1.71	-	-

Ongwediva and Oshakati Distributor				
Business Name	**Units Sold Per Week**	**Total Units Sold Per Month**	**Total Weight Volume**	**Gross Wholesale**
Spar	-	-	647	$492.00
Spar	-	-	647	$492.00
Shoprite	-	-	647	$492.00
Shoprite	-	-	647	$492.00
Pick-n-Pay	-	15	150	$149.85
OK Grocer	-	-	647	$492.00

Appendix S: Contact List

Contacts

Business Name	Name	Phone
Department Contacts		
Permanent Secretary of the Ministry of Trade and Commerce	Andrew Ndishishi	Cell: 264811241412 Work: 264612999000
Head of the Manufacturing Association of Namibia	Hennie Fouier	
Deputy Director of the Ministry of Trade and Industry	Freddie U !Gaoseb	Cell: 0811245508 Work: +264612837348
Director of Economic Statistics		283 4023
Forestry Offices		22 1478
Natural Resource Management		284 2111
Mines and Energy Main Office		284 8111
Director of Energy		284 8322
Min of Trade and Industry		283 7111
Industrial Development		283 7328
Industrial Planning		283 7313
Industrial Smallscale		283 7305
Otji Industrial		(067) 30 3994
Reg of Comp. and Close Corps.		283 7242
Namibian Chamber of Commerce and Industry	Charity	061-228-809
Walvis Bay Chamber of Commerce and Industry		064-20-5578
Orwetoveni Town Council	Andre	0811227645
Soltec	Heinrich Steuber	26461235646 264811243056 h.steuber@soltec.com.na
Otjiwarongo Municipality	Manfred Uxamb (CEO)	0812407658, ts@otjimun.org.na
Distributor Contacts		
AWH Engineering	Anthony Hearn	0811278803, awh@iway.na
Vimona Products CC		304252

Spar Distributor	Pierrie Venter	0811299332
Retail Contacts		
Orweto Shopping Center	Helene Roux	302112
Spar Ongwediva	Christian	232037
Oshakati BP	Lelanie Van Den Heever	0812997858
Shoprite Otjiwarongo (Shoprite Checkers Group)	Bosof “Bossey”	061372408
OK Grocer Oshakati	Stefen	0811285150
BP Express Otjiwarongo	Ethel Lucas	0811271938
Otjiwarongo Cash and Carry	Phunes	08112904280
Otjiwarongo Shell	Julia Ndjadila	067304844 0811292626
Otjiwarongo Engen	Mr. Hanssen	067304229
Otjiwarongo Pick n’ Pay	Mr. Thomas Knopp	
Oshakati Engen	Deon Nagel	065221457 0812840907 oneshila@iway.na
Industrial Contacts		
Meatco	George Kotter	081 128 3428
Meatco Tannery- Technical Manager	Sean Smith	081 124 5416
Meatco Abattoir	Tony Hobling	261361
Van Eck/ Nampower	Reiner Jagau	Reiner.Jagau@nampower.com.na
Etosha Fisheries	Mr. Ferabi	064-21-5600
United Fishing	Mr. Yurgen Berthold	064-21-7500
Gendev Fishing	Francois	francois@gendev.com.na