BIOCHAR FEASIBILITY STUDY

EXPLORING THE ENVIRONMENTAL, SOCIAL AND ECONOMIC VALUE OF A BIOCHAR BUSINESS IN THE METHOW VALLEY

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MKTG 591: Sustainable Business Practicum

This is an excerpt of our full study. Key financial projections have been removed.
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EXECUTIVE SUMMARY

As part of the Seattle University MBA Sustainable Business Practicum course, our team of three students – Mike Baranick, David McElwee and Maria Zazycki (The Team) – conducted a feasibility study researching the environmental, social and economic value of a biochar business for our client, Hanz Scholz (The Client). Our client, who lives in the Methow Valley of North Central Washington, was primarily interested in converting slash piles from forest management activities in the Okanogan National Forest into a biochar product that could be exported from the valley.

Over the course of 10 weeks, we researched the product potential of biochar, analyzing its benefits as a soil amendment, alternative energy source and climate offset market investment. Our investigation took us from Seattle to the Methow Valley, where we obtained a better understanding of the forest management activities and the community in which our client resides. Biochar has many benefits (carbon sequestration, soil amendment and clean energy) and thus has many potential revenue sources. While it is part of an emerging industry, it is also very diverse, with active companies, universities and non-governmental organizations located around the world. Through extensive interviews with biochar advocates and experts as well as business leaders in the timber and forest service industries, we narrowed our research on the feasibility of marketing biochar solely as a soil amendment product.

While some biochar soil amendment companies market their product as a mixed biochar compost product, for simplicity sake, we focused on the other model – marketing 100% biochar. We analyzed two business models for selling 100% pure biochar. The supply business model factors all the feedstock available from the Okanogan National Forest on an annual basis. Because this would require a large investment and produces more biochar than we think there is a market for, we also created a second business model from the demand side. This model factors in the current sales volume of the existing competitors based on industry demand.

Recommendation
Both of our business models prove that a biochar business in the Methow Valley will not be easy to implement primarily due to the lack of consumer demand relative to the supply of feedstock. To overcome this, we recommend our client build partnerships throughout the Methow Valley in order to leverage resources among the existing businesses throughout this region. We also advise he build alliances within the biochar industry in an effort to capitalize on the efforts to build project demand. Furthermore, we recommend that our client implement a short-term pilot study of a small scale biochar operation. This should include producing biochar, testing it in a variety of soils and conducting consumer market studies.
PROJECT OVERVIEW

Project Description
Based in the Methow Valley of North Central Washington, our client was interested in developing a business model that would take advantage of waste biomass produced through forest management practices in the Okanogan National Forest. The U.S. Forest Service (USFS) creates piles of slash – small-diameter limbs, tops and miscellaneous residue left over from forest management activities, such as thinning, pruning and timber harvesting. The piles of slash are then treated and safely burned as a way of disposal. The burning of slash piles is not only expensive for the USFS, but it also emits harmful carbon dioxide into the atmosphere. Additionally, slash burning can significantly change soil processes, plant establishment and adjacent vegetation.\(^1\) While the USFS is interested in finding alternative ways to remove the slash piles, they face several challenges including an established market, safe access to the piles and federal regulations.\(^2\)

By converting this product into biochar, our client proposed that we could not only avoid the harmful effects from burning slash piles, but also create an agricultural amendment product that safely sequesters carbon. Furthermore, our client was interested in creating an exportable product that could provide living wages and improve the quality of life for members of the Methow Valley. Finally, as business students, we discussed framing the study around the potential for this biochar business to be profitable. In short, our client charged us with exploring the possibilities of creating a truly sustainable business – one that combines the aspects of environmentally, socially and financially sound strategies into a successful business model.

Because this study was part of our MBA coursework, we had only 10 weeks to complete the project. As such, we narrowed the scope of our project to solely focus on the value of a biochar soil amendment start-up business located in the Methow Valley. The intent is not to provide our client with a full business plan, but rather to understand the commercial value of biochar as a soil amendment product, including market considerations and financial investments.

Description of the Methow Valley
The Methow Valley is located in North Central Washington, approximately 200 miles east of Seattle, where the team is based. Tucked away in the North Cascades, the valley has a population of approximately 5100, including approximately 400 residents of Winthrop and 900 residents of Twisp.\(^3\) The Methow Valley is located within Okanogan County, of which 80% is rural.\(^4\) Agriculture/Forest/Fishing/Hunting is the primary industry in the Methow Valley (14.0%), followed by Accommodation and Food Services (12.9%), Educational Services (10.3%), and Construction (9.8%).\(^5\) While tourism drives some of the economy in Winthrop, drawing in outdoor enthusiasts who travel year round to hike, bike and ski, our client indicated that few exportable products are created in the Methow Valley.

Project Methodology and Obstacles
Our methodology included Interviews with biochar experts, advocates and business owners; research scientists; USFS employees; and residents of the Methow Valley. We also conducted
extensive online research. To understand the market, we studied many different components of the biochar industry – including diverse feedstock, conversion processes and marketable product types.

Through our research process, we faced several unavoidable obstacles. First, was the limited timeframe of the project. Ten weeks is a short amount of time, especially considering the Team consists of only three part-time graduate students. Second, we started with no understanding of what biochar is, nor did our professor and peers in the MBA class. In fact, we had never heard of biochar prior to this project. This is not surprising, since biochar is an emerging industry – which is part of the reason our client was drawn to the project. As a result, we faced a lot of scattered and somewhat contradictory information about biochar, its application and its commercial value. Our final challenge was the fact that our team is not from the Methow Valley but instead we live 200 miles away in Seattle. Working remotely on a business feasibility study is challenging, especially when one of the goals of the study is to create a business that promotes the social and economic sustainability of the community in which it will reside.

**PRODUCT POTENTIAL ASSESSMENT**

**Marketable Products**

*Biochar*

Biochar has been around for thousands of years, dating back to the pre-Columbian Amazonian natives between 450 BC to AD 950. Modern day researchers were fascinated by the dark, nutrient-rich soil that these Amazonian natives left behind. This Amazonian soil has since been referenced to as “Terra Preta,” which translates to *black earth*.

Biochar is produced using a technique called pyrolysis, in which biomass is heated in the absence of oxygen to temperatures between 300-800 deg C. The chamber in which the pyrolysis process occurs is referred to as a kiln. There are three major outputs produced from the pyrolysis process, a solid (biochar), a liquid (oil) and a gas (syngas). The quantity of each output is determined by four key variables of the pyrolysis process: input material, water content, operating temperature and process time. Biomass that is heated between temperatures of 300-600 deg C typically is referred as a “slow” pyrolysis product, as the process time can take many hours. The benefit of the slow pyrolysis process is that up to 40% of the biomass input can be converted to biochar. The “fast” pyrolysis process occurs at temperatures above 600 deg C and can be completed in minutes; however, this process produces higher ratios of oil and syngas and less biochar.

Exhibit 1 provides a high-level overview of the pyrolysis process.

The primary application of biochar is to be used as a soil amendment in agriculture. Biochar can either be applied directly to agricultural crops or used as a supplement in fertilizer or compost. When used as a supplement to fertilizer or compost, biochar can reduce the inputs of these products by 25-30%. The advantages of using biochar for agriculture applications will be further explored below.

Biochar can also be used as an alternative fuel source, as many developing countries are using the charring process as a method to cook. These countries use specifically-designed stoves to
char the biomass input, releasing enough heat to cook food. Additionally, the biomass input is charred throughout the cooking process, producing a biochar product equivalent to that produced within a kiln.\(^9\) Therefore, the advantages to this process variation are three-fold: this method (1) provides a means for developing countries to cook, (2) utilizes a renewable resource as the fuel source, displacing the need for fossil fuels like natural gas, and (3) produces biochar as a byproduct.

**Byproducts (syngas and oil)**

Pyrolysis of biomass produces two primary byproducts: syngas and oil. Both byproducts can be used as fuel, providing clean, renewable energy. The syngas byproduct is a mixture of hydrogen, carbon dioxide, carbon monoxide and hydrocarbons.\(^{10}\) The primary application of syngas is to be used as an input in the pyrolysis process, either as a heating source in the drying process or in the kiln itself. Depending on the climate and geographical location, biomass typically has to be dried in order to reduce the water content, as biomass with greater than 20% water content is difficult to create biochar.\(^{11}\) Therefore, this syngas byproduct can become an essential piece of the pyrolysis process. Furthermore, syngas does not have to be processed or refined before reusing, thus creating yet another advantage of this byproduct. Many kilns are able to capture the syngas and immediately reuse the byproduct as an input into the process, and as a result the production of biochar is a closed-loop process. Excess syngas that is not reused in the pyrolysis process can be sold, which can be used to generate electricity or as a low grade fuel in boilers or cooking stoves.

The second byproduct of the pyrolysis process is oil. This byproduct is not as beneficial as syngas, as the oil must be refined before using. The oil can be used as a standalone product; however, the emissions can be heavy in particulates and black carbon. Therefore, it is best practice to upgrade the oil to a biodiesel, which can then be used as a fuel for transportation. This application can be very beneficial, especially when the biochar production process requires delivering the feedstock to a central processing plant or if the biomass product is exported. This oil byproduct contains approximately 55% of the energy content by volume as diesel fuel.

**Pelleted Biochar**

Biochar can also be pelletized, in which the primary application is to be used as residential or commercial energy production. This pelletized biochar can be used as either a direct heat source or as an input to produce steam for electricity. Biochar pellets are advantageous in that the overall density is increased, thereby reducing transportation costs.\(^{12}\) The pelleting process takes place after pyrolysis and requires a pellet mill or press, along with a series of steps depending upon the size and amount of substrate.\(^{13}\) Before a mill can be used, woody substrates should pass through a wood chipper and a "hammer mill" in order to create smaller pieces. Pellet mills are varied in their design and size, with larger engines necessary for commercial processes.\(^{14}\) Despite the potential market opportunities for pelleted biochar, the application of using the material as an energy producing resource will not be further explored in this feasibility study.

**Product Value (Qualitative)**
 Soil Amendment

One of the primary advantages of biochar is to be used as a soil amendment in agriculture. As stated above, biochar can be applied as a standalone product or by combining with fertilizer or compost, which reduces these inputs by up to 30%. The benefits of using biochar as an agricultural product are immense. Biochar has an extremely high surface area – a gram of biochar can have approximately 25 square meters of surface area.\textsuperscript{15} As a result of this high surface area, biochar acts as a “carrier” that can hold and retrain nutrients within its porous structure. Therefore, when biochar is mixed with a fertilizer or compost it is able to store the nutrients in the ground for longer periods of time, thus reducing the future annual applications of fertilizer or compost.\textsuperscript{16} Figure 1 provides an illustration of biochar’s porous structure.

Reducing the quantity of fertilizer used in agricultural operations has enormous benefits, as the fertilizer emissions can often produce detrimental effects of the surrounding ecosystem. Figure 2 provides an illustration of the “dead zone” in the Gulf of Mexico as a result of the high levels of fertilizer runoffs that are transported by large rivers like the Mississippi.

Another benefit of biochar when used in the agricultural industry is its ability to capture nitrogen and methane. High levels of nitrogen in the ground are problematic in that it can leach into nearby groundwater. With regard to methane, one of the leading causes of global warming, biochar is able to sequester this gas and restrict its ability to enter the atmosphere. Additionally, biochar is also able to simulate mycorrhizal fungi colonization, which has the capacity to deliver nutrients, especially phosphorous, to plants for increased nutrient uptake and root growth.\textsuperscript{17} Furthermore, Ponderosa pine and Douglas-fir trees, abundant within the Methow Valley, can produce relatively high pH biochar. Biochar with higher pH levels increases the char’s electrical charge and can therefore attract even more nutrients, greatly improving the soil’s health.\textsuperscript{18} Centuries of agricultural operations has caused detrimental affects to the world’s soil quality – the majority of the world’s soil is considered degraded, very degraded or without vegetation (See Exhibit 2). Biochar – with its ability to retain nutrients – is a solution to this agricultural problem.
Finally, biochar used as a soil amendment can also increase water retention. Like nutrients, water is attracted to biochar’s high surface area and porous structure. The benefits of water retention are twofold. The first is the reduction of the water needed to maintain agriculture lands. With rising costs of water – a direct result of the world’s diminishing supply of fresh water resources – amending biochar in soils can reduce utilities costs for agricultural operations. Secondly, many farmers tend to overwater their fields, which can cause nutrients and fertilizers to leave the soil and pollute nearby groundwater.

When using biochar as a soil amendment, it is best to incorporate the char using mechanical machinery, as the biochar is most effective when applied at plant root depths. Alternatively, the biochar can be placed in pre-tilled soil; however, this incorporation method is less desirable as it may increase soil disturbance and decrease the overall biochar coverage. Biochar is also effective when mixed with either compost or organic fertilizer, as previously noted.

The amount of biochar that is necessary to significantly alter the soil density and nutrient levels is dependent upon the existing soil condition, and researchers have yet to agree on a set of standards regarding soil types. However, experiments have shown that there is a positive correlation between the amount of biochar applied and the resulting increase in the nutritional and water retention characteristics of the soil. For instance, in an experiment on plots of Savannah terra preta soils in Columbia, biochar was added by varying amounts per hectare of soil (0, 8 and 20 tons), with the most significant increases in nutrient retention occurring at the 20 tons/hectare scenario. Furthermore, in an experiment with typical Midwestern soils from the U.S., biochar was tested in an isolated container in the amounts of 0, 5, 10 and 20 grams per one kg of soil. The results indicated that the 20 gram biochar scenario raised the soil’s pH by 1 unit, while also increasing its water retention potential by 15%.

**Carbon Credits**

Biochar also has the future potential of participating in the very lucrative carbon offset market. The carbon offset market is divided into two distinct segments: a compliance market and a voluntary market. A compliance market is utilized by companies that purchase carbon credits in order to comply with mandatory emissions caps. Conversely, carbon offsets in a voluntary market are typically purchased by governments, NGOs, individuals, or even environmentally-conscious businesses that do so in order to reduce carbon emissions. Biochar is currently not recognized as an official method of producing carbon credits, although many researchers believe its entry into the carbon credit market is imminent. For this reason, the selling of carbon credits from biochar production will not be further explored in this feasibility study.

**Environmental Value**

The environmental benefits that biochar presents are potentially its greatest product value. The most significant environmental benefit is biochar’s ability to sequester carbon. To better understand the carbon sequestration process, it is helpful to first recognize how the standard carbon cycle functions. Exhibit 3 illustrates a comparison between a standard carbon cycle and
one including the biochar pyrolysis process. During a standard carbon cycle, a forest of trees will sequester carbon dioxide throughout its lifetime, releasing the oxygen back into the atmosphere and retaining the carbon molecules within the biomass. When a tree dies off, the woody biomass is left to decompose on the ground or to be used as fuel to produce energy. Whichever method is used, the biomass ultimately releases all of the carbon that it previously sequestered. Therefore, this process would be considered a carbon neutral system, in which the biomass releases the same amount of carbon that it originally sequestered. The right side of the figure in Exhibit 3 represents biomass that underwent the pyrolysis process. Instead of letting the biomass decompose or be used as a fuel source, the biomass instead can be pyrolyzed. The advantage of pyrolysis is that the sequestered carbon is retained in the newly formed biochar and is therefore not released back into the atmosphere. Research indicates that biochar can retain its carbon when buried in the ground for hundreds to thousands of years.

As stated above, the syngas and oil byproducts can be used as an energy source. Although the carbon molecules within the syngas and oil will be released, no “new” carbon is being released into the atmosphere since this is where the carbon was originally sequestered from. Conversely, fossil fuels release carbon that has been stored underground for millions of years, thus releasing “new” carbon into the atmosphere. Furthermore, by using renewable energy like syngas and bio-oil in lieu of fossil fuels, the demand for these fossil fuels will decrease, as well as the dirty carbon emissions that they release.

The biochar process provides additional environmental benefits. For instance, biochar created from the pyrolysis process creates very little ash and therefore does not contribute to air pollution. Finally, the biochar process can reduce water consumption used in agriculture, as explained above (See Exhibit 4).

**Social Value**

One of the major considerations for starting a biochar production operation would be the opportunity to support the local Twisp/Winthrop community by creating highly valued employment positions. The social goal of this biochar operation is four-fold:

1. Provide livable wages to its workers;
2. Provide year-round employment;
3. Provide workers with the opportunity to work outdoors in the beautiful Methow Valley; and
4. Create partnerships with Methow Valley business (e.g. composters, nurseries and farms).

Two operational models were constructed to better understand the social benefits of initiating a biochar operation. The first model explored is considered the “demand scenario,” in which a market research analysis was performed to better understand the current sales volume of the existing competitors based on industry demand. The second model, the “supply scenario,” is based on the available supply of local feedstock, which assumes that all of the biochar produced can be sold. As a result of the initial assumptions, the models lead to significant
differences in terms of their social impact to the community. The Financial Assessment section of this report provides quantitative information on the number of employment positions, wages and feasibility of potential partnerships (See Appendices B and C).

The other significant benefit of producing a biochar production operation within the Twisp/Winthrop community is the ability to produce a highly-valued product that can either be used by the local community or exported out of the Methow Valley. Currently, the Methow Valley receives 14 shipments from full-size semi-trucks on a daily basis, and all of these trucks leave the valley empty.24 There may be the potential to form a partnership with the trucking industry in order to export the biochar in these outgoing trucks. As we will describe in the next section, the costs related to the exporting of biochar can prove to be a challenge for a successful business model.

**Market Potential Assessment**

**Product Life-Cycle Considerations**

The biochar industry is in the first phase of a product life-cycle – the *market introduction* stage. During this phase, costs are very high and sale volumes slow to start. While competition is generally low, so is demand. In essence, demand must be created, which will require educating the potential consumer base to try the product and then working to retain them as a customer. Scaling a smaller production model to a larger one is required if a biochar business is to be profitable, although at that point, the firm would risk attracting competition. This would be considered the *growth stage* in a product life-cycle. Production costs will decrease, but due to increased competition, so would prices.25

As we saw above, biochar has many benefits (carbon sequestration, soil amendment and clean energy) and thus has many revenue sources (GHG credits, agricultural fertilizer and alternative energy). While it is part of an emerging industry, it is also very diverse, with active companies, universities and non-governmental organizations located around the world. In short, we see a great potential for the biochar industry to continue to grow and expand beyond the market introduction stage. However, we are not able to discern this rate of growth or size of expansion.

**Industry Competition**

Despite using a technology that has been around for more than 2000 years, the nascent biochar sector is faced with some challenges, including:

1. *High start-up costs* associated with biochar production, particularly compared to the composting sector.26
2. *Lack of consensus among the scientific community* on how biochar achieves its range of benefits, especially over the long-run. This is critical to convincing the possible market sectors of biochar’s benefits.27
3. With so few operations up and running, *it is hard to test the benefits on a commercialized scale*. For now, industry pioneers rely on the research community to prove the benefits. This makes it hard for potential investors – especially risk-adverse investors – without which a large-scale biochar business is unlikely.28
4) In the long-run, if biochar becomes a profitable industry it runs the risk of over competition for feedstock sources, which could lead to land misuse, thus reversing the benefits of the process.29

These obstacles create a high barrier to entry for biochar companies. However, there are many biochar organizations working around the world to move the industry forward. For this reason, it is important to understand the competition within the biochar industry, which includes both commercialized biochar businesses and not-for-profit or university-related organizations. The following table includes the top competitors for a Twisp/Winthrop-based biochar business.

<table>
<thead>
<tr>
<th>Organization</th>
<th>Profile</th>
<th>Product Lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>EcoTrac Organics30 (Wenatchee, WA)</td>
<td>• Just went to market and is the strongest competitor due to location</td>
<td>• EcoFeed (HyperGrow): pine-based biochar fertilizer, low in nitrogen</td>
</tr>
<tr>
<td></td>
<td>• Sold online and at Molback's Nursery in Woodinville, Magnolia Nursery in Magnolia and West Seattle Nursery</td>
<td>• EcoFeed Plus (HyperGrow Plus): low in phosphate – ideal for municipals (parks, golf courses, etc.)</td>
</tr>
<tr>
<td>Biochar Merchants31 (Mentor, OH)</td>
<td>• Small firm</td>
<td>• 100% pure hardwood biochar in 2#, 10#, 40# as well as by the pallet (50 bags). Truckloads also available.</td>
</tr>
<tr>
<td></td>
<td>• Is looking for regional re-sellers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Sold on Ebay and directly from the business owner</td>
<td></td>
</tr>
<tr>
<td>BioCharm32 (San Rafael, California)</td>
<td>• BioCharm Biochar is a soil amendment product of Energy Anew, Inc.</td>
<td>• Biochar “Pre-charged” Biochar Soil Amendment: only product being sold, but expect more products coming to market soon</td>
</tr>
<tr>
<td></td>
<td>• Has experienced leadership team</td>
<td></td>
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<tr>
<td></td>
<td>• Sold online or via 2 stores in CA</td>
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<tr>
<td>Biochar Solutions33 (Golden, Colorado)</td>
<td>• Biochar Solutions was created after Biochar Engineering Corporation sold its IP and R&amp;D facility to a private company committed to quickly scaling up new biochar technology</td>
<td>• 100% pure biochar in bulk amounts.</td>
</tr>
<tr>
<td></td>
<td>• Has experienced leadership team</td>
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<tr>
<td></td>
<td>• Holds patent for high-processing pyrolysis kiln</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Sold online only</td>
<td></td>
</tr>
<tr>
<td>New England Biochar34 (Eastham, Massachusetts)</td>
<td>• Small not-for-profit</td>
<td>• Terra Codda: Inoculated biochar compost mix</td>
</tr>
<tr>
<td></td>
<td>• Sells finished biochar mixes as well as equipment and consulting/educational services</td>
<td>• Dark Matter: 100% Pure Biochar</td>
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</tbody>
</table>
There are dozens of other direct and indirect competitors within the industry, including:

- **BuyActivatedCharcoal**, located in Crawford, Nebraska, sells a variety of charcoal based products, including air filters, textiles, medicinal products and pet care items like digestive aids, as well as biochar.  

- **Avello Bioenergy** is a commercializing proprietary technology developed at Iowa State University. Avello has transformed fast pyrolysis into a platform that is versatile and offers a low-cost solution to biomass conversion. Their biochar line has not gone to market, but their technology poises them for long-term success.

- **Josh Frye of Frye Poultry** (West Virginia): Poultry farmer-turned small biochar business owner, Josh Fry has successfully modeled a way to use grants to propel a start-up biochar business using 100% chicken waste. He also is the recipient of government grants to help him conduct biochar benefits research through his operations.

This list is by no way exhaustive. Universities all over the world are doing research into the benefits of biochar. Non-profit organizations and international government agencies are also working on biochar solutions. In the commercial sector, clean energy businesses have started to incorporate the powerful benefits of carbon into their business model. Furthermore, an established investor base is critical to biochar’s success. Currently, there are few investors willing to commit to this endeavor. One is Canada-based Moneda Resources Limited, who acquired alternative energy leaders, Sapphire Technologies, in 2008, and has shown interest in investing in biochar.

**Marketing Mix**

**Product and Price**

There are two basic ways to market a biochar soil amendment product: 100% pure biochar that needs to be measured and mixed with other fertilizers by the consumer and biochar compost/fertilizer mixes, which are formulated to meet specific soil amendment needs.

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>PROS/CONS</th>
<th>PRICE POINTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model A:</strong> 100% pure biochar&lt;br&gt;(See Exhibit 5)</td>
<td>• Less costly to produce, but sold at a lower price point&lt;br&gt;• Geared towards the “educated” consumer&lt;br&gt;• Can be sold in large bulk amounts – great for B2B&lt;br&gt;• Delivery outside of the Methow Valley is costly</td>
<td>• Average is $1/# for a 40-pound box&lt;br&gt;• Smaller quantities have higher price points (up to $5.00/#)&lt;br&gt;• Larger quantities have lower price points (as low as $0.60/#)</td>
</tr>
</tbody>
</table>
| **Option B:** Biochar Compost/Fertilizer Mixes<br>(See Exhibit 6-A and Exhibit 6-B) | • More expensive to produce, but can be sold at a higher price point<br>• More convenient for the “less educated” (home gardeners) | • Varies widely according to size and mixture<br>• EcoTrac sells EcoFeed for $25 for an 8-pound bag, while BioCharm is sold for
Delivery outside of the Methow Valley is costly

- Offers more options for expansion of product lines

$15 for a 33-pound bag, before shipping

**Placement (Distribution)**

Distribution of biochar is a large expense for any biochar business. Both models face similar concerns when it comes to the packaging and shipping of biochar.

For long-distance shipping, the mark-up is approximately 100% due to the weight of the product. Special arrangements with shipping firms would need to be arranged to reduce this. Biochar Merchants sells their product on Ebay, using the U.S. Postal Service for most shipments. Recently, there has been a demand for larger bulk orders of their biochar – bags shipped on pallets – which they ship using an LTL freight hauler.39 Local and regional shipping avoids some of these challenges. Some biochar sellers are willing to pay house calls to interested customers. While this is much more cost-effective, it does require a business model that can ensure the sporadic nature of the requests is managed for efficiency.

Long-distance shipping requires more intensive packaging that will protect the product from moisture and damage. Most biochar mixtures are sold in wax-coated, heavy boxes or plastic bags. The designs mimic those of any other compost mixture or fertilizer on the shelf. Inclusion of soil benefits and other marketing design elements are common. Figure 3 shows EcoTrac Organics’ EcoFeed biochar mixture on the shelf at Magnolia Garden Store in Seattle, Washington.

![Figure 3: EcoFeed Biochar Fertilizer Mix](image)
**Promotion**

Through our research, we found that there are mixed opinions on who is driving the market for biochar: home gardeners and managers of city parks, golf courses and university campuses or large-scale farmers and wineries.

Jessica Leber, a *New York Times* journalist warns that the largest hurdle for biochar firms is finding a market, citing that the biggest revenue source is with farmers, who are also driving the development of technology. Conversely, Mike Urban, owner of Biochar Merchants, indicates that his best market is not with farmers who till acres of land, but rather with the home and small organic gardener with raised beds or pots that is looking for a fertilizer that also sequesters carbon.

Regardless of who is the driver, our research indicates that lack of awareness by the consumer is the number one hurdle for a successful biochar business. All biochar firms we researched have active websites, with varying levels of sophistication. Many of these sites include product testing results conducted by the firm themselves and/or testimonials from users of their product. Some offer a fair level of education – including links to scientific research or popular media articles touting the benefits of biochar. Other firms have added an awareness-raising component as part of their business model, offering personalized biochar consulting services and/or classes on biochar application.

In addition to a strong web presence, getting involved in biochar organizations is an important part of promotion in this emerging industry. The International Biochar Initiative, a non-profit organization dedicated to “supporting researchers, commercial entities, policy makers, farmers & gardeners, development agents and others committed to sustainable biochar production and use,” is not only an excellent resource, but they are also working on a buy/sell biochar portal to better connect buyers and sellers. Furthermore, there is an active Biochar Discussion List Website ([http://biochar.bioenergylists.org/buy_biochar](http://biochar.bioenergylists.org/buy_biochar)) that offers a place for buyers and sellers to communicate. These provide accessible options to market to the educated biochar consumer, as well as to stay informed of competitors and potential partners.

**Challenges with the Market Model**

Though many people around the world are actively researching, producing, selling and buying biochar, there has yet to be any individual or organization to prove a clear market demand for the product. While this may be exciting to a more risk-oriented entrepreneur, we found several challenges with the market models we analyzed. First, more research must be done to convince farmers of the benefits of biochar. While home gardeners may be more easily persuaded to purchase their first bag of biochar, farmers and other large-scale agricultural companies have a greater risk involved in trying new soil amendments geared toward increasing crop yields. Regardless of how “natural” a fertilizer is, farmers may be slow to displace traditional chemical fertilizers where the added yields are uncertain. Until then, market price is hard to pin down.

A second challenge that cannot be overlooked is the lack of regulation for biochar. This stems from the lack of consensus among scientists of the immediate and long-term benefits of
biochar, as well as a clear understanding of the optimum composition of biochar for maximum carbon sequestration. Market regulation is also critical for biochar to be considered as a high quality offset in carbon credit programs.44

As a result of these issues, we find that entering the biochar industry requires a firm to not only develop their own pilot testing models, but also get involved in advocacy efforts to increase funding for research and build alliances with other groups in the industry.

**BUSINESS MODEL OPTIONS**

Two operational models were constructed in order to better understand biochar’s sales potential. The models represent a wide range of sales, in that each model forecasts the extreme high- and low-ends of product’s sales potential. The first model explored is considered the “demand scenario,” in which a market research analysis was performed to better understand the sales volume of the existing competitors based on current industry demand. This model forecasts sales at the lower end of the range. The second model, the “supply scenario,” is based on the available supply of local feedstock and assumes that all of the biochar produced can be sold. This model forecasts sales at the higher end of the range. The team believes that obtaining annual sales within this range is feasible; however, consumer awareness of biochar’s benefits must be increased to bring these sales volumes to fruition.

*Demand Model*

As stated above, the annual sales volume for this scenario is based on current industry demand. An annual sales volume of 10,000 lbs was assumed, which is based on Biochar Merchant’s (based in Mentor, Ohio) sales forecast, and this scenario would require approximately 50 working days per year.45 This demand scenario yields annual sales of $25,000 and provides positive net income in year 1. Initial financing of $12,500 is required to offset the capital equipment cost and to produce positive monthly cash flows throughout the five year pro-forma analysis. The operating equipment used in this scenario utilizes (4) sets of 55/110-gallon steel drums – as depicted in figure 4 – as well as other machinery like a wood chipper, bagger/labeler, and truck with trailer. Furthermore, this scenario provides approximately 9 tons of carbon sequestration per year. Unfortunately, this scenario provides limited social benefits, as the low annual sales cannot support the justification for paid employees. Appendices B-1 and C-1 provide a detailed account of the input variables and financial statements for this scenario.
Supply Model:
This supply scenario is based on interviews with the Okanogan National Forest staff, who projected out the average annual slash that is burned for forest management. The model forecasts an annual sales volume of 15.75 million lbs of biochar, which would require a year-round operation to produce. The forest service manages 3,000 to 5,000 acres of forest per year, which contains approximately 35 gross tons of residual biomass per acre. Only 30% of this available residual biomass was used in the financial calculations in order to account for unknown circumstances, such as poor road access, weather, competition, permit issues and fires. After accounting for the fact that only 25% of biomass actually produces biochar, annual sales revenue of over $16 million is still achievable. The financial models indicate that a positive net income can be obtained by year 2. An initial investment of $25 million is required to offset the capital equipment costs and to produce positive monthly cash flows throughout the five year pro-forma analysis.

The operating equipment required for this scenario would be (67) portable kilns – such as the one in Figure 5 – as well as other machinery like bulldozers, chippers, utility loaders, baggers/labelers, and flatbed trucks. The number of kilns required is based on the unit’s input capacity and the number of operational hours per year. Additionally, a large warehouse would be required to bag and label this massive quantity of material. Furthermore, this scenario provides significant environmental benefits, sequestering approximately 14,000 tons of carbon per year. Finally, this scenario also provides impressive social impacts by employing close to 170 full-time employees. Appendices A, B-2 and C-2 provide a detailed account of the process, input variables and financial statements for this scenario.

Recommendations & Conclusion
After analyzing both of these business models, we conclude that there is no easy “over-night” way to set up a biochar business in the Methow Valley. Our conversations with the USFS confirm that while they eagerly support alternatives to burning slash piles, no business has been able to successfully transform the slash into a profitable product – despite the fact that many have tried. We recommend following the four essential building blocks to constructing a sustainable biochar business model:

1. Justification of demand: A successful business model must truly understand the market and be able to discern long-term interest. The conflicting opinions surrounding who makes up the potential biochar market – large-scale farms or home gardeners – is a challenge that must be overcome. We recommend additional research in this area.
2. **Demonstrable markets and growth opportunities through a Pilot Testing Model:** Because there is also disagreement on the benefits of biochar on specific soil types, it is important to create a pilot testing model. Marketing “pull” strategies are vital tools for a successful business in an emerging industry, so involving consumers in the testing and application process will be critical. Biochar Engineering is one firm that is helping to advance their own biochar sales by offering a joint product-service business model, working with clients to test their soil and establish the right amount of biochar and other supplements for their particular soil and regional needs (See Exhibit 7).

3. **Realizable and sustainable biomass supply and yield:** By far the most important building block is an established long-term feedstock supply that can be timed to meet business demand. While slash may appear readily available, the challenge thus far has been creating an application that is worthy of the investment. Understanding this and planning for long-term feedstock supplies is critical.48

4. **Partnerships:** As we have pointed out throughout this report, partnerships are an important component to a biochar start-up business in the Methow Valley. While a competitor on one level, Wenatchee-based EcoTrac Organics is a likely future partner due to their close geographical proximity and early entry into the market. Our client also has a great resource in SeaChar, a Seattle-based grassroots non-profit whose mission is to “promote the widespread use of biochar as a sustainable tool to fight climate change, build a healthier environment and reduce waste.”49 Their programs include biochar research, educational outreach and technology development geared toward promoting biochar as a solution to global environmental challenges and thus should help our client develop market demand. Furthermore, local partnerships with the USFS, TwispWorks and the many local businesses who seek to improve the economic vitality of the Methow Valley are important for a successful biochar firm.

Understanding these four building blocks will help define the risk-reward profile of a company. While neither business model we explored is necessarily feasible, we believe that there is room for a successful biochar business model of some type to exist in the Methow Valley. Like all sustainable business models, it will take time, persistence and a creative way of approaching the traditional business model. Yet if done properly, the reward will be a profitable business that is truly integrating itself into the natural ecosystem of our planet for decades to come.
EXHIBITS

Exhibit 1

The Biochar Pyrolysis Process

Biomass
- manure
- organic wastes
- bioenergy crops (grasses, willows)
- crop residues

Pyrolysis

Biofuel
- bio-oil
- hydrogen

Transport
Energy
Coproducts
Industry

Return to soil as biochar

Residual heat

Optionally, N₂, NOₓ, SO₂, CO₂ can be added to increase C sink and nutrient content.
Exhibit 2

Global Soil Degradation\textsuperscript{51}
Exhibit 3

Standard Carbon Cycle vs. Carbon Cycle including Biochar Sequestration

[Diagram showing carbon cycle with and without biochar sequestration]
Exhibit 4

Biochar’s Environmental Benefits\textsuperscript{53}
Exhibit 5

Product Model Option A: 100% pure biochar

The Biochar Engineering (now Biochar Solutions) Sales Sheet exhibits a model for marketing pure biochar.
### Exhibit 6-A

**Product Model Option B: Biochar Compost/Fertilizer Mixes**

**EcoTrac Organics (Wenatchee, WA)**

<table>
<thead>
<tr>
<th>EcoFeed is sold in a XX pound bag for $24.95 at three garden stores in Seattle and online.</th>
<th>EcoFeed (HyperGrow Plus) is a Washington State approved Commercial Fertilizer. EcoFeed (HyperGrow Plus) is also currently seeking Washington State approval for Organic certification.</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Image of EcoFeed product]</td>
<td>[Image of EcoFeed application result]</td>
</tr>
<tr>
<td><em>EcoFeed applied to bare spot in playground at Chelan Park.</em></td>
<td><em>Grass filled in 6 weeks later.</em></td>
</tr>
</tbody>
</table>
| Testimonial from Consumer: **Judy Marsalis** of Wenatchee Washington  
"I used HyperGrow Plus (EcoFeed) on my tomatoes at the beginning of August and within a week they had grown 10 more inches and had many new branches and flowers and fruit. I also applied a handful to each of my rose bushes that were otherwise stagnant and 10 days later they had new growth of approximately 12 inches with numerous new buds. HyperGrow Plus (EcoFeed) is a very good product and all natural. I would recommend HyperGrow to any homeowner or backyard gardener." |
Exhibit 6-B

Product Model Option B: Biochar Compost/Fertilizer Mixes

Biocharm Biochar Soil Amendment

15-quart bags sold in Marin County, CA at two nurseries. Also sold online for $15 plus $14.50 shipping.

How to Use
Apply Biocharm™ Biochar Soil Amendment in a layer one to two inches thick, then blend well into soil. Ensure Biocharm™ does not sit on top of soil but is blended in deeply to help plant roots.

Water thoroughly after application. Use in vegetable beds, flower beds, potted plants, agricultural fields, orchards, etc.

Using two inches of Biocharm™ Biochar Soil Amendment sequesters more carbon and has a greater impact on your garden.

To amend each 10 square feet of garden:

<table>
<thead>
<tr>
<th>Depth to Apply</th>
<th>Amount to Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 inches</td>
<td>4 bags</td>
</tr>
<tr>
<td>1 inch</td>
<td>2 bags</td>
</tr>
</tbody>
</table>
As a hybrid product/research firm, Biochar Engineering is able to provide more precise estimated benefits of their products.57
APPENDIX A

TECHNICAL AND OPERATIONAL ASSESSMENT

The Technical and Operational Assessment will cover the logistics of a biochar operation. For simplification purposes, we have focused on a mobile operations scenario where feedstock is chipped, pyrolyzed and bagged on site. Mobile operations will provide flexibility in the short term. Mobile equipment may be re-purposed for a centralized operations scenario with minimal financial and performance cost.

Equipment and Machinery
The mobile biochar operations process described below is intended to provide flexibility in terms of scale and potential seasonal limitations. There are other biochar processes available, but given the geographic landscape of the Methow Valley, we determined that this approach was more in-line with the long-term goals of the client.

A typical mobile operation would involve: Three flatbed trucks, one chipper, one mobile pyrolysis unit, one mobile bagger and one utility loader.

1. Flatbed/Stake truck pulling the mobile Pyrolysis unit
2. Flatbed/Stake truck pulling the chipper
3. Flatbed truck with Mini-loader pulling the bagger
4. Slash feedstock will be chipped onsite
5. Chipped feedstock will be pyrolyzed onsite. We estimate 500lbs of feedstock will be processed per hour.
6. Biochar will be bagged onsite
7. Bags will be loaded onto the trucks

The scale of operations will vary depending on the targeted biochar production level

<table>
<thead>
<tr>
<th>Item</th>
<th>Use</th>
<th>Possible Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flatbed/Stake Trucks</td>
<td>Transport/Towing</td>
<td>Various</td>
</tr>
<tr>
<td>Chipper/Grinder</td>
<td>Chipping Slash</td>
<td>RotoChopper</td>
</tr>
<tr>
<td>Mobile Pyrolysis Kiln</td>
<td>Pyrolysis</td>
<td>Biochar Solutions</td>
</tr>
<tr>
<td>Mobile Bagger</td>
<td>Bagging Biochar</td>
<td>RotoChopper</td>
</tr>
<tr>
<td>Utility Loader</td>
<td>Lifting/Storage</td>
<td>New Holland</td>
</tr>
</tbody>
</table>

*The Equipment and Machinery table is tied to our financial model. Noted prices are not exact and are provided as a guide to initial equipment needs and costs. A chipping service (assumed rate of $500/ton) may replace the chipper/grinder. This may also limit the flexibility of mobile operations.

Raw Materials (feedstock collection)
Forest Service: The area surrounding the Methow Valley is part of the Okanogan National Forest consisting of roughly 1.2M acres of managed forest. The initial vision of creating biochar in the Methow Valley was based on using large piles of harvest-related slash (small-diameter
material left over from USFS timber sales) as the primary source of biomass feedstock. In addition, there may be access to “Fuels-Treatment” slash. Slash from fuels treatment is generally small material removed from the forest to limit the risk of forest fire.\textsuperscript{58}

For the purposes of this feasibility study, our expectation is that we will be able to buy existing slash from the USFS at a rate between .25 cents and $1 a ton. Based on current fuels treatments contracts, the USFS is paying $9/ton to remove the slash. This translates to a net reduction in costs and ensures access to small-diameter biomass. The per-ton price of slash is variable and dependent on the timber market. If there is a market for slash, then slash costs will increase.\textsuperscript{59}

Following a timber sale, slash piles are often burned as a fire reduction measure. As a result, the USFS is interested in developing a more consistent small-materials (slash) market. Additionally, and in line with the goals of this project, the USFS is interested in developing the local market and economy.\textsuperscript{60}

Mobile Operations Challenges
A mobile operations strategy provides some flexibility to our operations given current market conditions and our Supply and Demand scenario modeling. Based on existing research of the Okanogan National Forest, there appears to be plenty of small-diameter biomass available. The following challenges may impact the efficient harvesting of that biomass:\textsuperscript{61}

- Environment Assessments: For every contract there is a one to two year environmental assessment performed.
- Soil Disturbance: The Okanogan National Forest is sensitive to soil disturbance and compaction. When this occurs, Water absorption is decreased and roots don’t grow.
- Terrain: Steep terrain may prohibit access to some sites.
- Fish habitat corridor protection: regulations may limit access to sites.
- Weather:
  - During periods of high temperature, clearing and biochar operations may be halted periodically to evaluate fire risk and will be stopped completely if too high.
  - During periods of very cold temperatures, access to soil sensitive areas may be improved because cold temperatures will prevent soil damage.

Cycle of collecting the wood
Based on USFS interviews, the timing delay between timber sales and contract execution (when trees are cut) can be as much as five years. For the purposes of this feasibility study, we have noted this time delay as a potential risk. In addition we have also assumed that even with the time-delay, there will be enough harvest-related slash biomass to sustain operations. \textsuperscript{62}

Quantity of biomass
The quantity of harvest-related biomass will vary depending on the type of tree being processed, tree-stand density and the manner of processing. Typically, Douglas Fir will produce more biomass compared to Ponderosa Pine because they have higher branch loading. The
density of the tree stand will also impact the amount of biomass and the way in which it is processed. Whole tree yarding is the process of cutting down a tree, but processing it in a central location (site of slash pile), which will increase the size of the slash pile. The USFS has estimated one slash pile per 10 acres of green harvest. The average slash pile, depending on the aforementioned variables, is estimated at 35ft high by 50ft long by 25ft wide.63

Transportation to and from biomass
Transportation costs to and from slash piles will greatly influence operations. For the purposes of this operational assessment, we’ve estimated that most operations will occur within a 50-mile radius of Twisp. As fuel costs increase, or as the miles traveled to access slash piles increases, additional operational costs may be incurred.

Private Landowner Partnerships
Partnerships with private landowners may be a source for biomass. Additional research and relationship building will be needed.

Storage Facility
Location: Availability of industrial property and potential zoning restrictions for future industrial property may prove problematic. As of the writing of this Feasibility Assessment, there were no industrial, light industrial or commercial properties available in Twisp.64
Appendices B and C (Financial Projections) have been removed from this document.
ENDNOTES

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63 Trebon.