Cochetopa Biomass Energy
Saguache, CO

Wood-chip Gasification for Irrigation:
Feasibility Study

Colorado Department of Agriculture
ACRE Grant Program
Saguache County Renewable Energy Sales Tax Grant Program
10/29/08

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Pictures 1 & 2 from cover: One of five diesel powered gensets at Cochetopa Farm (top), and the by-product biomass of Mountain Valley Lumber's milling operation (bottom).

1.0 Project Overview

Cochetopa Land and Cattle is a 1200 acre certified Organic farm working in alfalfa, cattle, and commercial compost (Colorado Natural Compost). The farm presently has no substantial grid connection and has been running the three center pivot irrigation systems on diesel-powered gensets. With the rise of diesel fuel costs and the inherent maintenance requirements, this approach has become very costly, unsustainable, and an unnecessary contributor of greenhouse gases.

The Cochetopa Biomass Energy (CBE) project was formed to assess the viability of utilizing the wood-chip residues from the owners' lumber mill, Mountain Valley Lumber, to power the farm's irrigation energy needs. The wood chips would be converted into a syngas through the established technology of biomass gasification. The syngas could then be used to power internal combustion engines to produce electricity to run the irrigation pumps and pivot-arm tower motors.

The first realization from pursuing this goal was that in order to make small scale biomass gasification (less than 1 megawatt) perform economically, we needed to value to thermal energy of the exhaust gas and genset engine coolant. The capitol costs for a biomass gasifier, genset, and related infrastructure were simply too high to simply be used for electricity alone at utility prices of $0.075 kWhr. Thus, we were not just evaluating the electricity from biomass gasification, but rather both the heat *and* electricity produced from wood chips. With this goal in mind we were looking at efficiencies of up towards 80 percent. As such, we began investigating what industries we could co-locate with a biomass gasifier genset that could pay a wholesale rate year round for thermal energy. The industries considered were:

1) Biodiesel Production
2) Greenhouses
3) Lumber Drying Kiln
4) Offices
5) Mechanics Shop

As a result, Cochetopa Biomass Energy was exploring the role of an Energy and Enterprise Development project for Saguache County, which is the second poorest county in the state with a very high unemployment rate. The Saguache County commissioners, local residents, and San Luis Valley native, US Representative John Salazar, who all are eagerly working toward local economic and renewable energy development, welcomed this role.

The second main task was the analysis of a gasification technology provider ready to deploy a field-proven unit for our purposes, at our scale, and within a budget that is feasible. With the global assessment conducted by CBE's project partner Community Energy Systems, we had the opportunity to evaluate the state of biomass gasification worldwide and, at this point, are not prepared to invest in anyone's system. As a result, CBE is looking to implement an interim strategy by installing a district heating system at the lumber mill to serve the heating loads already existing. The system would be fired off of a wood-chip boiler resulting from an exclusive relationship CBE has with a proven manufacturer from Prince Edward Island, Canada. There are presently no technology providers of this type in the United States. This strategy would:

1) Establish the infrastructure for utilizing the thermal energy from a wood-chip boiler now, and a wood-chip gasifier when CBE has found a reliable technology provider
2) Develop a market for a non-fossil, economically competitive, and efficient agricultural heating fuel and system throughout the San Luis Valley and beyond

3) Displace diesel, propane, and grid electricity heating demands at the mill while demonstrating a whole-systems industrial model of operation
4) Alleviate the volatility in operating costs for Mountain Valley Lumber, one of Saguache County's largest employers

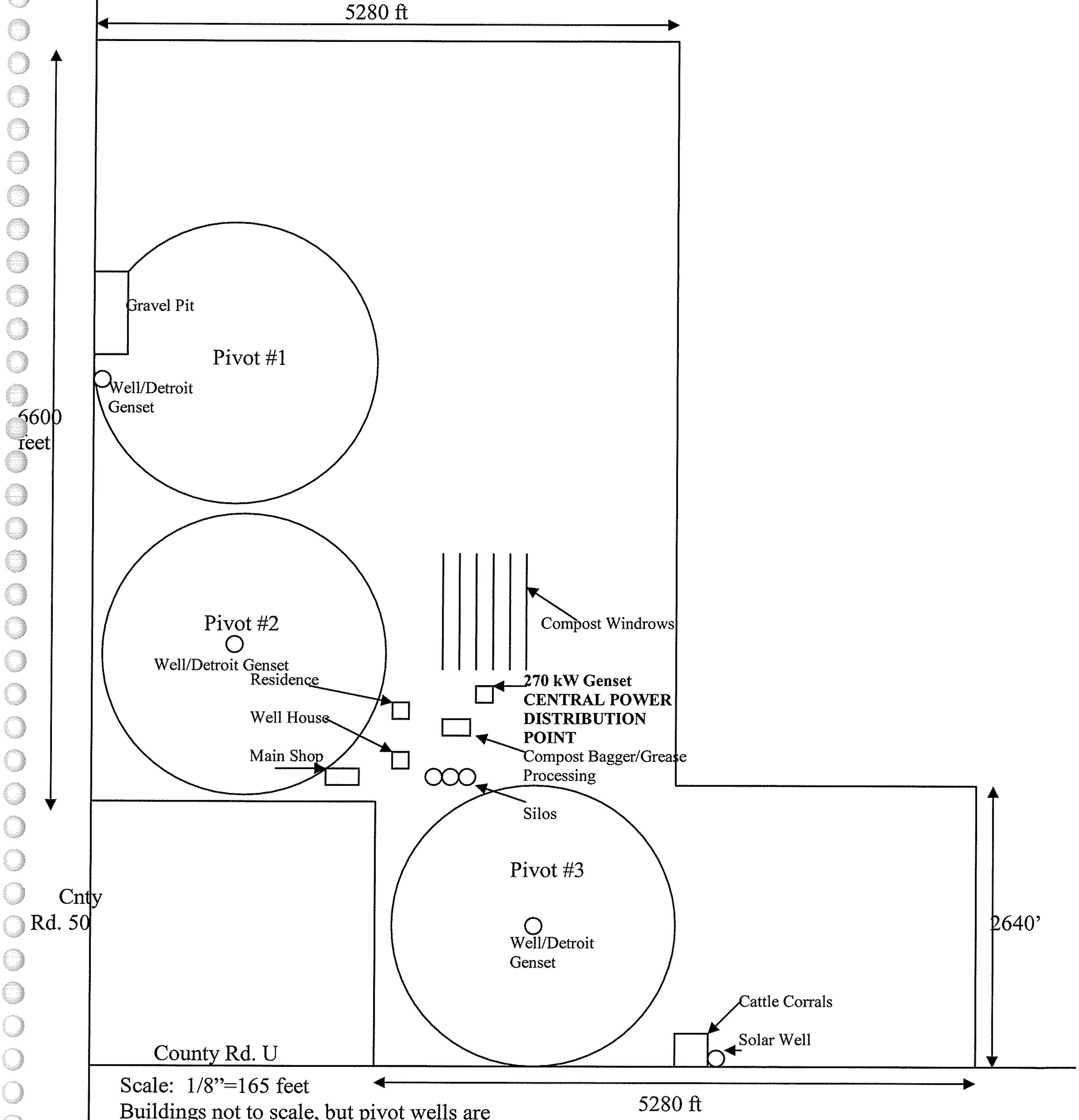
Thirdly, CBE realized that the thermal requirements at Mountain Valley Lumber itself were some of the most ideal and immediately compatible heat loads that were also conveniently co-located right next to the source of the wood-chips. The lumber-drying kiln also had the advantage of a heat user that is operated in both winter and summer while presently being powered by diesel and grid electricity. The thermal requirements at Mountain Valley also simplified the recruitment for a new heat-using industry because they were already established and under the operation of John and Cathy Baxter, owners of Cochetopa Farm and Mountain Valley for the last thirty years. With this approach, the wood-chips were being utilized right at their source while the savings of displaced diesel and grid electricity were also being accrued for the owners without involving new industries and entities. This simplified the project greatly as well as helped fast-track its implementation.

As a fourth point, CBE was forced to recognize that the production of *biochar*, the wood-chip remnants after gasification (7-17%), could prove to be an extremely valuable co-product in contemporary biomass gasification. This carbon material could revolutionize agricultural soil science management, help produce higher yields, and aid water conservation while contributing to fixing atmospheric carbon in agricultural and forest soils. These effects together had the potential to make biomass gasification a potentially carbon-negative renewable energy resource.

As a final product of the feasibility study, and a result of the above considerations, CBE is focusing the development of biomass energy on two fronts. The first is the interim strategy summarized above, and the second is a pilot test of a small scale gasifier genset at Cochetopa Farm by a leading gasifier expert from Golden, CO. This pilot is utilizing one of the Detroit gensets that are used on the center pivots to be retrofitted to accept syngas from a small 60 kW gasifier. It is believed this test will produce significant activity in the field of small-scale biomass gasification in the States since WWII.

With funding from Saguache County and the Colorado Department of Agriculture's ACRE program, the Cochetopa Biomass Energy Project has learned a lot about rural agricultural energy supply and demand. We have chosen to focus on biomass because it is what the owners of Cochetopa Farm has in abundance as a by-product of their milling operation, but also because of the several nascent opportunities that exist within that approach. CBE hopes that this feasibility report will not only help Cochetopa and Mountain Valley Lumber in finding ways to stay competitive in a rapidly evolving and challenging marketplace, but also serve as a resource that many other agricultural entities throughout Colorado and beyond may stand upon for their own evaluation of biomass energy.

Cochetopa Land and Cattle Site Map
Living Arts Systems, LLC October 2008



Scale: 1/8”=165 feet
Buildings not to scale, but pivot wells are

2.0 Considerations in the Development of Biomass Energy

1. Efficiency factors in wood energy conversion
2. The essential role of heat use/sales for economic viability
3. Power sales factors
4. Wood fuel type consideration

2.1 Energy Efficiency Factors

The conversion of wood to electricity has typically been accomplished through using conventional combustion-steam turbine systems that have been in operation for nearly 100 years. This system has a number of advantages, most significant of which is the well established reliability of the system in thousands of installations. As a result of this proven effectiveness, this approach has the other critical advantage of being readily able to be financed through many conventional capital sources.

However, there are several major disadvantages to this approach that will increasingly limit its utilization in biomass energy applications.

Steam system inefficiency—First, the system has inherit inefficiencies intrinsic to steam-based systems. The maximum efficiency of wood energy to electricity conversion in this type of system is unlikely to exceed 20-22% (and is frequently less than 20%). This suggests that of every 10 units of energy inherent to the wood fuel, only 2 or less are converted to electricity. The remaining energy is lost as heat. In many installations, some of this heat is captured and used on site. However the dynamics of steam management and control make this process both complex and expensive. The effort to improve overall system efficiency was a primary factor in considering emerging wood gasification systems.

Emissions—Another consequence of the relatively high inefficiency of wood combustion-based systems is their much higher levels of air emissions. Effectively reducing these emissions creates significant additional costs for these systems.

The efficiency of wood heating—In contrast, systems that use wood primarily as a heat source can operate at over 80% efficiency. This higher efficiency also translates into much lower emissions and emission reduction related costs. Although gasification systems avoid this emission issue, they are still significantly less efficient in energy conversion.

System cost—A significant issue in evaluating the potential for developing a wood energy project is the substantial initial investment required. The 250 kW gasification system considered in this analysis would cost a minimum of $1,000,000 for installation. The cost/kW would improve at larger scales of implementation. In contrast, a wood heating system would likely have an implementation cost of less than 30% of this cost and could have a much faster payback period given likely increases in heating oil, natural gas and other sources of heating energy.

High Cost of Steam System Maintenance—The generation and control of steam requires high specification steel systems and fittings and special knowledge and training for operators. Consequently the ongoing operations and maintenance costs for this type of system are substantial.

Project Scale—Given the significantly higher operation costs, conventional biomass power systems typically do not achieve economic viability at scales smaller than 10-15 megawatts. Systems of this size will require over 200 tons of woody fuels per day to sustain operations.

Substantial Water Use—A third disadvantage to conventional steam-based systems is the significant volumes of water necessary as part of the steam cycle. For even smaller systems like the one contemplated in this project, this would require over 50,000 gallons of water daily to sustain operations.

2.2 Essential Role of Heat Use/Sales

The financial analysis conducted in this project clearly demonstrated that heat utilization and sale is essential for the project to be economically viable. For this aspect of the project to be successful, the gasification project will need to have co-locating heat users that require a consistent supply of low quality (not steam) heat. If the heat users have a strong seasonal variation in their uses (only need heat in winter), additional uses will need to be found that create a relatively stable year-round heat demand.

2.3 Power Sales Factors

One of the initial impetuses for this evaluation was the Cochetopa Farm owner's strong motivation to replace existing diesel-based irrigation pumping with an energy source that utilized locally available wood resources. Another revelation in the economic analysis of this project was the significance of the off-season grid-power sales factors in determining the economic viability of the project. Despite the significant savings potential during the on-site growing season demand, the relatively low market value of wholesale power sold back to the utility during the off-season limited the overall revenue potential of the project. To this is added the significant liabilities that are assumed in a long-term power sales contract. Unlike many agricultural production systems that can vary depending on time of year or the climatic factors in a particular season, energy production contracts require a consistent and unchanging production 24/7, often for as much as 330 days out of the year. This contractual obligation places makes any grid tied biomass system a significant legal and financial consideration.

2.4 Wood fuel type consideration

A significant development that emerged as part of the Cochetopa assessment was the identification of a wood fuel issue that has become an unforeseen opportunity for biomass development that addresses many of the issues identified above. The core of this issue is the logistical challenges that must be addressed in preparing and transporting wood residue as a fuel source for either a gasification or a wood heating system. Given its relatively low density (imagine a handful of sawdust or wood chips), the volume to weight ratio is high, making this form of wood fuel costly to transport.

This same bulkiness also creates logistical costs for the potential user. This material must be stored in covered buildings that take up significant space. The material must also be conveyed from storage to utilization system, a process that adds additional costs and space needs.

One of the common solutions to this set of limitations is the conversion of bulky wood residues to pellets. This fuel type is in wide and increasing use in residential pellet stoves and increasingly in commercial applications.[1] This approach is significantly more efficient in material transport and also reduces the end-users space and handling costs.

The major disadvantage of this system is the significantly higher cost of the wood fuel. Prevailing costs for wood chips for heating or other applications is in the range of $25-$60 per ton (depending on moisture content). In contrast, the conventional ¼" residential grade wood pellet will cost over $150/ton. There are also not yet well developed systems for delivering these pellets in bulk to large commercial users. The recognition of this particular wood energy dynamic stimulated the consideration of a series of options, which have come together as a new biomass opportunity. This opportunity is described as part of the concluding Next Steps section of this report.

3.0 Cochetopa Electrical System Analysis

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[1] Colorado has two new pellet mills coming on-line in Kremmling and Walden. A number of commercial or public buildings are installing wood pellet heating systems including the South Routt Schools in Oak Creek, CO and the Mountain Parks Utility Building expansion in Granby, OR.

3.1 Table 1: Existing Electrical Loads

		Motor HP	Phase	Voltage	Amps	Watts Con.
Irrigation Pivot						
	Pump	50	3	460	65	29,900
7 towers per pivot		1 ea/ 7 hp total	3	460	13.3	6118
	TOTAL	71	3	460	78.3	36,018
	(x3)	**213**	**3**	**460**	**234.9**	**108,054**
Compost Bagging						
Compost Hydraulic Motor		7.5	3	460	10.3	4738
Bagging Shed Conveyor		3	3	460	4.4	2024
Hammer Mill		15	3	440	20	8800
Post Screen Conveyor		5	3	460	6.5	2990
	TOTAL	**30.5**	**3**	**460**	**41.2**	**18552**
Compost Screener/Sifter						
In-Take Conveyor		2	3	440	2.68	1179.2
Main Tumbler		20	3	440	27.9	12,276
Waste Conveyor		1	3	380	1.9	722
Compost Outload Conveyor		2	3	460	3.4	1564
Truck Loader Conveyor		3	3	460	4.3	19,780
Cat		15	3	440	20.25	8910
	TOTAL	**43**	**3**	**460**	**60.43**	**44431.2**
COMPOST TOTALS		**286.5**	**3**	**460**	**336.53**	**171,037**
Gravel Quarry Estimate						
(based on Skoglund Pit for Screening/Sifting)		**45**	**3**	**460**	**33.75**	**15,525**
Existing Electrical Load					**TOTAL**	**187 kW**
Biodiesel Plant						
Pumps		5	3	460	6.5	2990
(x5)		25	3	460	32.5	14,950
Reactor Agitator		5	3	460	6.5	2990
(x2)		10	3	460	13	5980
Air Compressor		10	3	460	7.5	3450
Pressure Washer		5	1	230	30	6900
	TOTAL	**55**	**3**	**460**	**96**	**37260**
Greenhouses 3 30x96'						
Exhaust Fans		.75 HP	1	240	2.34	563
	x6	**4.5**	**1**	**240**	**14.04**	**3378**
HAF Fans		.25 HP	1	115	1.6	188
	x12	**3**	**1**	**115**	**19.2**	**2256**
Evaporative Cooling Pumps		**.75 HP**	**1**	**115**	**4.9**	**563**
	TOTAL	**7.5**	**1**	**115/ 240**	**38.14**	**6197**
TOTAL ELECTRIC CONSUMPTION W/ BIODIESEL AND GREENHOUSE		**394**	**1,3**	**115/ 240/ 460**	**504.42**	**230019**

The first step in evaluating the viability for locating a heat and electricity producing gasifier on Cochetopa Farm was an analysis of the heat and electrical requirements of the operations that were already there, along with the requirements of the operations that were being considered to accompany. According to these numbers, Cochetopa has an existing peak electrical load of about **187 kWhr** when all the electrical loads are being used at one time. As such, CBE has been planning for a 250 kW gasifier. This would enable present loads to be accommodated while allowing for expanded opportunities, such as a biodiesel and greenhouse operation. Any remaining electricity would be sent to the grid in a power purchase agreement with the utility.

Under these circumstances, this electrical load schedule would be seasonal and quite complementary. The pivots only run from April-May through October, the compost is quite variable mostly through the summer, the gravel quarry is also variable, and the biodiesel plant and greenhouse would be fairly constant throughout the year. This would enable the revenues from a grid connection to be accrued through the winter when other income streams are at a low.

CBE had several phone conversations with both Xcel Energy and the San Luis Valley Rural Electric (SLVREC) and a meeting with each utility, SLVREC's Operations Manager Terrel Jensen on 3/10/08 and Xcel's Engineer Brad Meininger on 6/5/08. Cochetopa Farm lies right on the edge of both territories. It is presently hooked up with the SLVREC with a single phase line while Xcel has a three phase line just across the road. The challenge was to decipher which utility was more willing to accommodate a biomass generation facility and what benefits they could bring to the table. In the end, Xcel prepared a bid for line extension at **$55,476** (see appendix) and seemed eager to have an interconnection with a biomass energy production facility. The SLVREC submitted a territory invasion agreement for Xcel to come into their territory. In general, Xcel has been more aggressive with renewable energy grid ties, particularly wind and solar.

4.0 Gasification Technology Assessment

Development of a micro-grid system to provide agricultural power at the Cochetopa farm site using wood biomass required the evaluation of non-conventional biomass gasification systems that can provide electricity at higher levels of conversion efficiency than conventional combustion-steam generation approaches. This evaluation included both an assessment of the technical viability and the economic sustainability of these technologies.

4.1 Description of the Assessment Process

Project partner Community Energy Systems conducted an extensive worldwide technology sweep to identify the most suitable technologies for consideration at the Cochetopa site. The field of biomass gasification is changing rapidly and assessments conducted even 12-24 months ago are likely to miss recent developments in new technology. Through a combination of evaluating other technology assessments, contacting leading experts in the field, engaging technology blogs and listservs, and reviewing other technology solicitations, CES compiled a list of appropriate technologies for initial review. CES leveraged assessment resources being provided in other CES projects to substantially expand the technology sweep conducted for the Cochetopa project.

4.2 List of Technologies Evaluated

Table 2 shows the full set of technologies initially considered in this evaluation. The technologies initially considered potentially suitable are highlighted.

4.3 Table 2: List of Gasification Systems

ABGT (Advanced Biomass Gasification Technology)	Downdraft	0.5-50 tpd	pilot
Agni	using Ankur, no power production	1.0-15	commercial
Ankur	updraft gasifier	0.1-1	commercial
BCT	gasifer w-20,000 GPD of ethanol from 400 (200 dry) tons/d	200	
Babcock & Wilcox Vølund ApS	custom biomass gasification solutions	3.5-20 Mwe	pre-commercial
BGP, Inc	batch/ starved air gasifier	1 Mwe modules	
BESI	updraft gasifier	250 kw - 1MW	demo
Biomass CHP	downdraft, zero liquid waste	100 kw - 5 Mwe	commercial
Biomass Engineering Ltd	downdraft, batch	250 kWe	commercial
Bioten	biogas turbine	5 Mwe	demo
Carbon Sequestration, LLC	?		
Condens Oy	novel fixed bed updraft gasifier with CHP, no fuel densification	1-3 Mwe	commercial
CPC	small packaged downdraft	0.5-1.5	5-100 kwe
Cratech	syngas to gas turbine	1-20MW	demo?
Emery Energy Co.	fuel densified updraft gasifier	2-500	pilot
Energreen Power LTD	using Ankur		
Energy Products of Idaho (EPI)	gasifiers/boilers for ST - Design, Engineering, Fabricate	custom	commercial
Entimos Oy Ltd	downdraft, decommissioned due to poor operation	2-15 Mwe	demo in Finland
GEM America	thermal cracking (no oxygen)/gas engine or CT or ST	55 wet tpd/module	commercial
Heuristic Engineering Inc.	large scale EnviroCyclers	48-480	commercial
IES	pyrolysis/TO/WHRB/ST	8-125	commercial
Nexterra	fixed-bed updraft gasifier with ST		commercial
Phoenix Energy	using Ankur?	250 kw e	pilot
PRM Energy	fixed-bed, updraft with ST; or Gas Engines	20-2000	commercial
Puhdas Energia Oy	downdraft gasifier	6 (0.25 tph)	pilot in CT
Pyromex	electric induction heated pyrolysis/gas engines	1.2 Mwe/10 tpd	
Radhe	using Ankur	900-7500 kw(th)	
Westwood/Coaltec Energy	downdraft/fixed bed		commercial
Xylowatt - Swiss	using Ankur or IISCe	150-200 kW	pilot
Xylowatt - Belgian		0.3-1.5 Mwe	commercial
Zilkha Biomass	1.5 Mwe unit gasifer with gas turbine	1.5 - 10 Mwe	pilot
Zero Point Clean Tech	2 Mwe skid mounted engine units	2 Mwe	demo

4.4 Preliminary Findings

According to the Mountain Valley Mill owner (also owner of Cochetopa Land and Capital), the amount of consistently available wood resource potentially available for a field-based gasification unit would be 10-20 tons/day. Taking a conservative approach to the amount of materials that could be consistently provided, the project team recommended that only technologies capable of operating with 10 tons/day or less were considered for use in this project. These are highlighted in yellow in the table.

As will be noted, a number of these firms base their technology around a proven gasifier produced by an Indian firm called Ankur. Consequently, CES conducted additional due diligence to evaluate these companies to identify the firm with the best capacity to deliver this technology in the US (a number of these firms are in Europe and most have indicated they are not prepared to support technology deployments in the US). One Ankur-based firm—Phoenix Energy—was then selected for comparison to the other small-scale gasifiers being considered.

These four finalist technologies are compared in the matrix in Table 6.

Based on this analysis, the Phoenix/Ankur technology was identified as the most suitable technology for further consideration at the Cochetopa incubator site. The modest fuel requirements—approx. 10 tons/day—make it reasonable to presume that sufficient material will be available to sustain operations. The nameplate power output of the unit, 300kW nominal, 220 kW after parasitic loads, qualify it for "production metered" power sales. As is noted in the power sales analysis below, this was determined to be the most advantageous arrangement for power sales marketing for this project.

The Phoenix/Ankur system was also one of the few systems with demonstrated commercial deployments. The Ankur gasifier has been used in many successful projects in India for over two decades. A number of these systems are now also in operation in Europe. Phoenix has enhanced the basic gasifier system by adding additional controllers and emissions clean-up systems that improve both operational efficiency and ease of operations.

Appendix A includes substantial information on the Phoneix/Ankur system including a basic system layout. One substantial advantage to the Phoenix system is its small footprint—less than 40' by 60' for the entire gasification and power production line. This size should be well suited to the incubator site identified as the preferred location for the facility.

4.5 Table 3: Technology Evaluation Matrix—Cochetopa Biomass Energy

Firm	Phoenix (Ankur)	Biomass Engineering	Community Power Corp	IES
System Cost (30%)	9	5	9	5
System Scale (20%)	9	9	4	7
Commercial Demonstration (20%)	8	9	7	7
O/M (10%)	9	6	5	6
Fuel Flexibility (10%)	7	7	7	9
Company Credibility (10%)	8	9	6	7
Overall (100%)	**50**	**45**	**38**	**41**

4.6 Financial Analysis

The financial analysis for this project was developed using the proprietary financial modeling software provided by the selected technology vendor—Phoenix Energy. While many potential variables could have an impact on project viability, three were identified as having the most significant impact. These are:

1. Initial capital cost of equipment
2. Cost of feedstock
3. Percentage of heat sold for ancillary uses

The financial modeling tool was constructed to enable these three variables to be easily changed and sensitivity analysis was conducted to determine the best to least suitable scenarios within the realm of what was considered possible in the near and longer term. The results of the sensitivity analysis are listed in the Table 4 below.

4.7 Table 4: Sensitivity Analysis for Key Economic Variables

Parametric Results

Run #	Feedstock Cost	Capital Cost	Thermal Sales	IRR (%)
1	30	750	100%	2.90%
2	40	750	100%	-4.00%
3	40	650	100%	2.00%
4	30	650	100%	14.00%
5	35	650	100%	7.50%
6	30	650	80%	-3.00%
7	30	550	50%	-6.00%
8	25	550	50%	8.50%
9	20	550	80%	28.90%

Assuming 15 yr debt, 7% interest, 60,000 partners equity
Thermal sales at $7.69/therm or $3.00/gal propane equivalent

The results indicate that the project is most sensitive to heat sales followed by feedstock costs and finally by total capital costs. Obviously the most ideal scenario includes buying down the capital costs by at least $100,000, reducing feedstock costs modestly and having full heat utilization. Alternatively, additional capital buydown and further reductions in feedstock costs could provide flexibility as heat utilization is gradually expanded over time.

Snapshots of the financial tools used in this analysis are included in the Appendix. Additional evaluations can be conducted after Cochetopa and other interested parties have reviewed the initial results and determined the most likely capital and ownership structures.

4.8 Summary of Findings

The extensive assessment of small-scale biomass gasification units now available indicates that there are now units available that are commercially demonstrated and are appropriately configured for deployment at the Cochetopa site. A more detailed financial analysis of the Ankur technology indicates that economic viability depends on the enterprise capitalizing the facility being able to capture and sell the excess heat produced by these units (up to 65% of the energy produced). For the investment to yield attractive returns, at least 80% of the heat produced would need to be sold. This return also depended on a relatively low cost for the wood feedstock.

The other factor that could substantially improve the economic viability of the project is the increase in the sales rate for wholesale power to the Utility. At the present time, it is unclear which utility—Xcel or San Luis Valley Electric—would be the power purchaser due to the property being in a boundary area between the two utilities. Currently both have relatively low wholesale power purchase rates (less than $.075/kWh. However, recent changes energy costs could result in significant cost increases in electric power over the next 3-5 years, substantially improving the economic returns for the project.

Based on these findings, the project team recommended to the Cochetopa owners that successful implementation of a gasification unit at the Cochetopa site will require one or both of the following:

1. Identification of established enterprises with a substantial year-round heat need that can be co-located at the Cochetopa farm site.
2. Market prices for wholesale power increase to over $.09/kWh before inclusion of REC's carbon credits, or other "green" power premiums.

At the same, several immediate short-term opportunities have been identified that can both address existing energy needs at the Mountain Valley Sawmill and potentially substantially expand the potential benefits of woody biomass energy to the larger agricultural community in the San Luis Valley. These are described and discussed in the concluding segment of this report.

5.0 Heat Users

It is clear that a small scale gasification system needs to attain maximum efficiency of the process through capturing and making value of all the latent heat coming off the genset exhaust and engine coolant. To value only the electricity from the genset results in longer returns from high capitol costs. Competing with coal-powered electricity at $0.07-$0.12 kWhr is difficult with a small biomass generation site.

In general, we were looking at a 250 kW gasifier producing about 750,000-1,000,000 BTUs per hour. As a nominal base rate for calculations we were using $8.00 per mmBTUs. This equates to $192 per day, $5760 per month, and $69,120 per year that CBE could be generated in thermal sales. This is assuming we have a co-located heat user(s) that is contracted to be buying heat year round. A biodiesel plant would be buying heat year round, for instance, but a greenhouse operation would not. The heat users that we considered were biodiesel processing, greenhouses, lumber drying kiln, office spaces, and mechanics shop.

5.1 Biodiesel Processing

Biodiesel was considered as a viable heat user because of the existing waste vegetable oil processing (1500 gal/day) and small biodiesel reactor (100 gal/day) infrastructure on Cochetopa Farm. John Baxter is the owner of this infrastructure. We conducted a heat use analysis to determine how much heat a small commercial plant would use (winter and summer) and designed and budgeted the building of a 250,000 gallon per year plant with a capacity to be producing up to a million gallons per year. (See appendix for full design, schematic, and budget.)

250k-1 MGY Biodiesel Plant Capitol Cost: $406,669

Peak Thermal Demand: 1,057,500 BTUs/hr

Peak Electrical Demand: 37 kW

The thermal energy requirements from this facility using 1000 gallon reactors would have used all of the available 1 mmBTUs coming off the gasifier, however, this heat demand would be during the daytime when greenhouse heating would be at its minimal. This heat requirement is also if all the heat loads were demanded at the same time, which would not happen, and this facility could utilize other approaches (such as vacuum methanol recovery) to reduce its thermal demand.

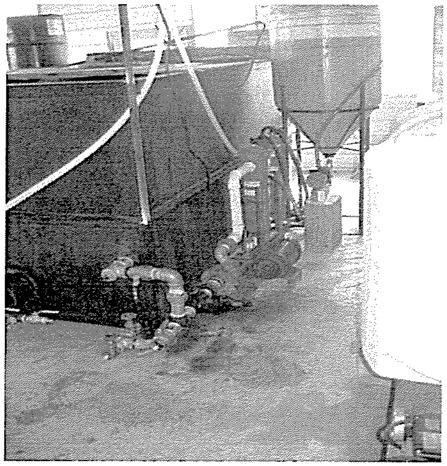


Photo 3: The existing grease processing and small biodiesel plant on Cochetopa Farm.

This could have been a viable avenue to pursue being that Cochetopa Farms and Mountain Valley Lumber both use a lot diesel fuel for transportation and equipment, these entities already own existing high-volume grease handling infrastructure as well as many tanks and equipment, and they were working with experienced operators of biodiesel plants, such as then VP of Production for Biodiesel Industries of Denton, TX Bob Armantrout. Saguache County also expressed interest in buying locally made fuel from CBE. The main problem was that when Cochetopa first installed its grease handling infrastructure yellow grease was selling for \$0.12/lb or \$0.90 per gallon. One year later yellow grease was \$0.36/lb or \$2.70 per gallon. This increase in price, the rising cost of shipping it from the Front Range, and the processing costs made it extremely unattractive for Cochetopa to pursue yellow grease biodiesel, or even straight vegetable oil (SVO) applications. The pressing of virgin oil from seed was also considered, however, a plant capable of 1 million gallons per year was at least a \$1 million investment while the San Luis Valley is a Canola Use District limiting the growing of only canola spec seed. With this regulation, other varieties of high yielding or dryland mustards such as *Camelina or Brassica juncea* could not be legally grown and thus CBE would be limited with marginal 3500 lb/acre (186 gallons oil/acre) seed yields.

The final point indicating biodiesel was not a viable enterprise to invest in was the status of the industry around Colorado. In 2004, there was three commercial biodiesel plants in Colorado: Biodiesel Industries in Berthoud, AgriDiesel in Burlington, and Bioenergy of Colorado in Denver, plus there was two feasibility studies going on: Alta Energy in Monte Vista and San Juan Bioenergy in Bayfield. By the end of 2007, all three commercial plants were closed and the latter two feasibilities turned out a red light for progressing. The price of feedstock, the price of methanol, and the transitioning regulatory market were all making biodiesel development an uneconomical undertaking. As such, CBE is not presently pursuing any biodiesel development.

5.2 Greenhouse Operations

Greenhouses pose a very likely opportunity to have a high value agricultural activity coupled with a biomass energy facility. The rising interest in local food production by consumers and the need for jobs in this sector makes this pursuit a likely candidate for a CBE partner. CBE has also made the fortunate acquaintance with veteran greenhouse manager Nitschka Terkquile, presenting working with

Photo 4: Nitschka Terquile with John Baxter at the Summit Farms Potato Seed Greenhouse

Summit Farms in Center, CO. This greenhouse carries a rather unrecognized role in the valley's vital potato industry as a certified disease-free potato seed production facility. Without greenhouses of this nature, there simply would not be any potato industry due to the excessive diseases that happen around potatoes.

In essence, Nitschka and her staff receive orders from the farm owner/manager about how many potato seeds they will need in two years. Then, they acquire disease free potatoes from the extension office or similar and begin cloning through a highly-sterile tissue culture process. After 18 months or so of tissue culturing in the lab, they transplant seedlings into the greenhouses to be grown out into a G-1 nuc seed potato. These highly valuable seed potatoes cost about $0.50-$1.00 each and the entire greenhouse full can have $400,000 worth of seed. After the greenhouse is harvested, the seed is then ready for the field. When that field is harvested that next fall, whatever seed potatoes (G-2) are separated out can be grown again for only another year or two (G-3, G-4) and then they have to go back to the G-1 seed from the greenhouse.

Many farmers have their own greenhouse and labs for this process and many use the facility at Summit Farms for their seed. Nitschka is well-networked within this community and has had interest from farmers to have an independent farmer's cooperative greenhouse that could grow seed for many farms while not being owned by anyone exclusively. With this premise, CBE and Nitschka felt there was a tremendous opportunity to build a greenhouse lab in Saguache County, which is more isolated from the heart of the potato industry, and Nitschka would manage the staff and farmers' cooperative.

Based upon the facilities at Summit Farms, CBE came up with these calculations:

5.3 Table 5: Greenhouse Heat Loss

Summit Farms 8784 sq ft Greenhouse, 1200 sq ft Headhouse, and Lab

Peak Thermal Demand: 1.2mmBTUs/hr

	Year	Peak Month	Heating Month Average
Present Propane Expenditures: (@$27.17/mmBTUs)	$46,690	$15,000	$5,187
CBE Thermal Sales* (@ $8.00/mmBTUs)	$13,745.60	$4,416	$1,520
CBE Wood Chip Supply Service $80/ton (@$4.76/mmBTUs)	$8178	$2627	$904

*This represents a 70% reduction in fuel costs

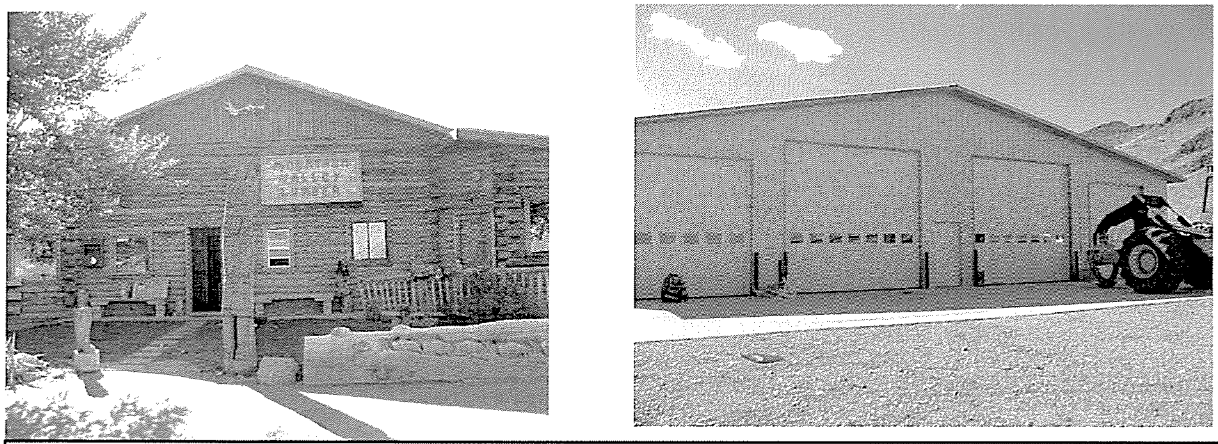
The CBE wood chip supply service is a scenario we are looking at where Summit Farms would install their own wood chip boiler as a substitute for their propane boiler and thus be able to purchase wood chips at an extremely competitive rate over propane. This margin is very valuable for the agricultural community with the present market of fluctuating fuel prices as well as very attractive to a wood chip producer such as Mountain Valley Lumber.

5.4 Lumber Kiln

Photo 5: Mountain Valley Lumber Kiln

In looking at all the opportunities to co-locate a heat user with a woodchip energy production facility, it was interesting to look at what heat users are situated right next to the source of the wood-chips themselves. The lumber drying kiln at Mountain Valley Lumber is located about 500 feet from the main mill and associated wood chip pile. The kiln building is a 45x68' building with a 36x15.5' machine room currently housing a diesel/waste oil burner and electric blower for heating the kiln. The preferred specs for a 250 kW gasifier genset facility are about 25x60 or with adaptation 25x47. In building off the west side of the building, there could easily be suitable space to house this equipment. Additionally, a wood-chip boiler firing a district heating system for the mill would also find suitable space here. The other noteworthy point here is that the kiln is a heat user that will consume heat in 24/7 stints both winter and summer.

5.5 Mountain Valley Lumber Offices and Mechanic Shop



Photos 6 & 7: Mountain Valley Lumber Main Offices (left) and new mechanics shop (right)

The other two heat loads at Mountain Valley Lumber are the mechanics shop and main office and retail space. The shop has in floor radiant heating tubes and is ready for hook-up while the office would need to be retrofitted for hydronic heating. A simple district heating system radiating out from the kiln building would serve these other two buildings and thus displace propane and electrical energy that would otherwise serve this purpose.

Lumber Mill Peak Electrical Demand: 41 kW (with high demand/start-up surges)

Mechanic Shop Peak Thermal Demand: 80,000 BTUs/hr

Office/Retail Thermal Demand: 100,000 BTUs/hr

5.6 Thermal Use Conclusion

In conclusion of the thermal utilization of a biomass energy facility, it is clear that brining in and/or starting up a heat-using new enterprise out on Cochetopa Farm itself has a whole set of challenges, capitol costs, and time constraints that complicate the initial goal of biomass electricity and heat. While we have considered many, it is clear that the farmer's cooperative disease-free potato seed greenhouse managed by Nitschka Terquile is the most suitable, high value, and most likely to happen. The relationship developed between CBE and Nitschka has been very encouraging.

Secondly, the existing operation of Mountain Valley Lumber has sufficient thermal loads that are extremely suitable for biomass heating while they are already existing and under the ownership of Cochetopa's owner, John and Cathy Baxter. Whether it is from a wood-chip boiler producing only heat, or a gasifier producing heat and electricity, Mountain Valley is ideally suited to utilize this biomass energy through a district heating system serving the kiln, offices, and shop. This is the next phase of CBE contingent of funding from ACRE.

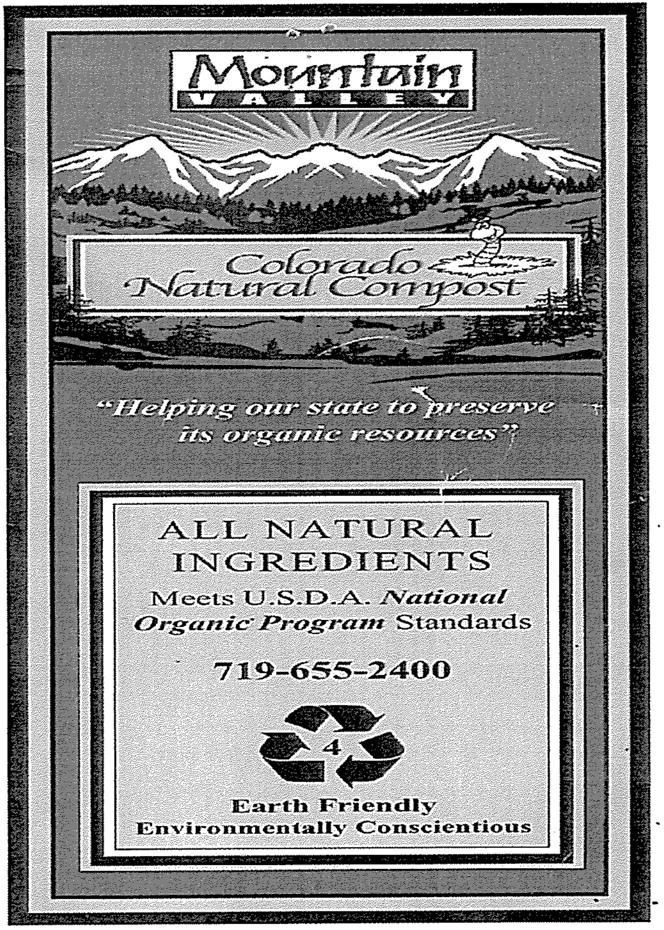
Mountain Valley Lumber Heat Loads:

1.	**New Mechanic's Shop**	**80,000 Btu/h**
2.	**Retail Building**	**100,000 Btu/h**
3.	**Machine/Kiln/Greenhouse**	**530,000 Btu/h**
4.	**Totals**	**710,000 Btu/h**

This would suggest a 1 million BTU/hr burner from our vendor from Prince Edward Island.

6.0 Biochar

Photo 8: Mountain Valley's Award Winning Compost



Biochar is the name of the carbon by-product that results from pyrolysis of biomass. There can be from 5-17% biochar produced from a biomass gasifier. For a 250 kW gasifier consuming 10 tpd of wood chips, that's 1000-3400 lbs per day in biochar production. For every pound of char that is taken out of the fuel cycle by adding it to soils, there are 2.5 lbs of CO2 that are taken out of the atmosphere in a long-term, genuine carbon sequestration. CBE could be in a position to be sequestering 2500-8500 lbs of CO2 *every day.* Furthermore, the carbon trading value of this practice alone is about $75/ton, or $37.50-$319 per day.

Much of the data that is coming out about biochar was inspired by the Terra Preta soils of the Amazon where we see thousands of years worth of charcoal additions to soils. Researchers at Cornell University have described biochar soils to have "the potential to revolutionize the concepts of soil management." Having both this affinity for nutrients plus its long stability could be invaluable to address the problems such as soil degradation and food security, water pollution from agro-chemicals, and climate change. In essence: "Soils with biochar addition are typically more fertile, produce more, and better crops for a longer period of time." Char additions of 4 to 20 tons, sometimes 160 tons, per acre have been reported to yield up to three to four times the yield in crops. (Biomass gasification is already a carbon-neutral renewable energy process. This means no more CO2 is released in the process of capturing energy than was absorbed during the prior biomass life cycle. Adding the char to soils banks up to half of the original feedstock carbon as a solid soil catalyst and prevents it from becoming a greenhouse gas. Biomass gasification already has many potential derivatives such as electricity, hot water, and liquid fuels, and now it has the ability to fix carbon, contribute to sustainable agriculture, and promote soil remediation.

In Colorado, eleven out of the twenty-two rural electric co-ops lie within regions severely affected by the current and massive beattle-kill epidemic. Reducing this tremendous wildfire hazard by removing the substantial timber resources, creating value-added wood products, and generating negative-carbon electricity with the by-products could prove to be a productive management solution. The ability to then return at least some of the resulting biochar to the forest soils could promote healthy new stands of resilient timber and undergrowth.

CBE has the existing asset of a commercial compost facility, Colorado Natural Compost, with a 5000 bag per day bagger. Producing compost blends with a biochar addition as well as producing bags of biochar for the home gardener are areas of huge potential that CBE is considering in relation to its eventual gasifier development.

7.0 Next Steps

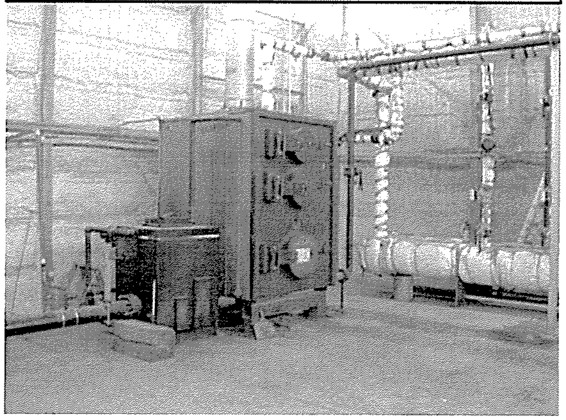
The ACRES funded biomass feasibility evaluation for the Cochetopa Farm site has generated a number of valuable products for both the project sponsors and for the larger agricultural community of Colorado. First, the project has significantly expanded the baseline information available about the relatively new field of small-scale biomass gasification. This information will assist other agricultural enterprises considering biomass gasification as a part of an integrated diversified farm or ranch operation.

Second, the study has identified an interim biomass thermal technology that could significantly reduce the heating energy costs of farming or ranching operations within 30-50 miles of biomass resources. These two project outcomes are summarized below.

6.1 Biomass fuel supply, Densification, Boiler Manufacturing

One of the distinguishing features of small-scale down-draft wood gasifiers is their need for a "chunky" fuel (chips with a minimum average size of 1" x 1"). As a consequence, one of the major forms of sawmill residue—sawdust and small chips/shavings—is not suitable in its raw form as a fuel for these systems. Given the significant portion of wood byproduct this material represents at most mills, the project analysis require identification of systems and technology that could convert this material into a suitable fuel form.

Photo 9: Grovewood boiler in a greenhouse



Wood Densification—A common approach to reducing the bulk of either agricultural feed or wood waste are machines called variously "briquettes" or "densifiers".

Machines of this type produce the 1/2" to 1" agricultural feed pellets that are common in the agricultural industry. Although similar in principal to a residential wood pellet manufacturing machine, simple forms of this technology are relatively low cost (less than $200,000) and have simple, low-cost operation.

In considering the installation of a densifier system for the Cochetopa gasifier, the project team realized that it may have discovered a new fuel form that could be used in wood heating systems. By densifying the fuel, it could be transported much more cost effectively and stored and conveyed on site in much more space and cost efficient methods by the end-user.

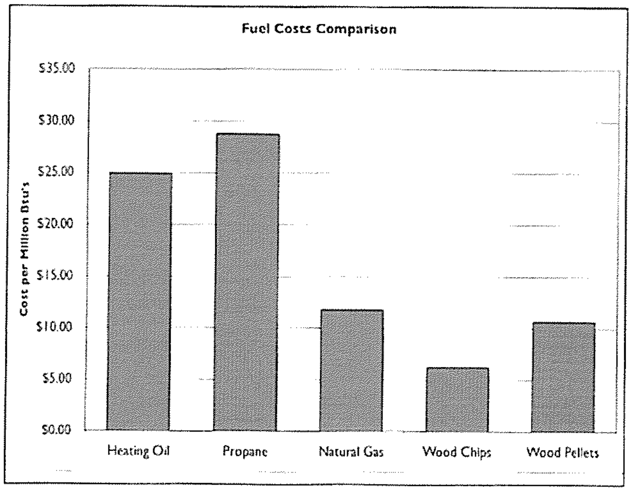
Mountain Valley Lumber currently has resources with which it may make the purchase of a densification unit suitable for piloting a briquette/cube scale wood heating system as part of the wood heating enterprise described below.

Local Manufacturing of Wood Boilers—Simultaneous to this realization, the project team's heat load analysis of the Mountain Valley sawmill site was revealing a number of heat load needs that could be combined to form the basis for a small central district heating system that could use the sawmills existing residues to displace a significant annual expenditure on energy for both heating and wood drying.

This led the project team to look for a smaller scale wood boiler system that would be well suited to the mills needs. Most US wood heating system vendors have focused on systems over 1 million btus/hr in size. Community Energy Systems was aware of a small boiler manufacturer in Canada that produced a modular commercial wood heating system that could be sized from 300,000 Btu to over 1 million btu/hr. As the operator of both a sawmill and an agricultural operation, John Baxter was immediately aware that a wood heating system of this sort could be of substantial interest to many of his farm and ranch colleagues.

After extensive discussions with the Canadian firm, a preliminary agreement was developed to explore the possible purchase of a manufacturing license for the Canadian firms technology. A consortium of partners is now forming to explore this opportunity with the intended outcome being the development of a wood heating company firm based in Saguache County. This company would provide biomass-based heating services to agricultural and commercial customers throughout the San Luis Valley. The new firm would manufacture and install the systems and provide both fuel and ongoing service/maintenance as part of long-term stable heating contracts at rates below existing fossil-fuel dependent systems. This would bring much needed new employment and revenue opportunities for one of the poorest Counties in the state.

7.2 Table 6: Cost comparison of various heating fuels



Note: cost calculations assumes bulk delivery to institutional scale applications

source: Biomass Energy Resource Center

One of the significant opportunities imbedded in this potential relationship is the possibility of developing a new type of wood heating system that an use the larger "briquettes" that small wood processing firms like Mountain Valley Lumber can produce from their sawmill residues. With the increased efficiency of handling and transportation, this could open up opportunities for many small enterprises around the valley to access this less expensive form of heat energy.

In so doing, this enterprise would also recirculate a substantial flow of dollars that otherwise leave the community. Every dollar not spent on natural gas, propane or electricity for heat would be a dollar retained in the community and recirculated at least several times through the economic multiplier effect.

Over the next three months, Mountain Valley Lumber and its partners will be initiating negotiations with the Canadian firm to finalize the terms of their license agreement. At the same time, Mountain Valley Lumber will proceed with the design of a district heating system utilizing the Canadian technology as the first pilot project and demonstration of this approach. The goal will be to manufacture and install the first demonstration unit by spring of 2009.

7.3 Micro-scale biomass gasification pilot

As part of its research to identify biomass gasification alternatives, the research team was contacted by a Colorado firm interested in piloting a 40 kW mobile biomass unit suitable for deployment in rural agricultural settings. Green Solutions and Agua Das agreed to retrofit a Detroit diesel genset that is currently used on Cochetopa for powering the center pivot irrigation systems. The genset was delivered to Golden on October 22 and should be ready for field trials sometime in late fall of 2008 to evaluate the viability of this approach. This will be some of the most significant small scale gasification work since WWII.

Agua Das has been working in biomass gasification for over 25 years as a researcher, inventor, designer, manufacturer, consultant, troubleshooter, and strategist. He is a pioneer in ultra low tar gasification and simplified effective gas cleanup with no liquid discharge. He and Dr. Tom Reed wrote the book updating gasification from the World War II Gengas era to the present. Das is a co founder with Tom Reed and Jim Fournier of Biomass Energy and Carbon Inc., Golden, CO, suppliers of biomass equipment. His books are Handbook Of Biomass Downdraft Gasifier Engine Systems and Contaminant Testing Method for Gasifier Engine Systems. He holds three US patents regarding methods for making and using fuel gases, a phase responsive control circuit, and a variable frequency pulse generating circuit. With the consultation of Agua Das, CBE will be greatly empowered and capable in the gasification industry. If this pilot is successful and a solid working relationship is developed CBE will be in a position to:

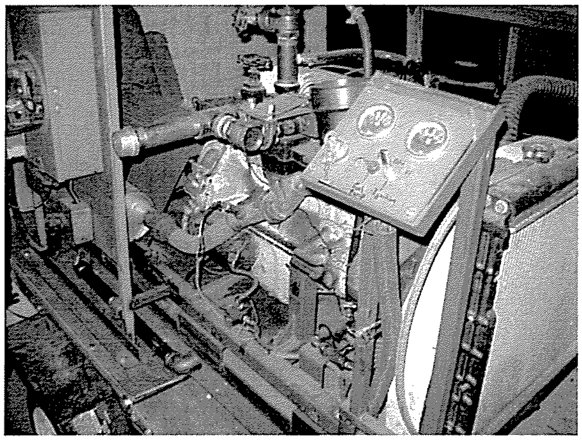


Photo 10: One of Agua Das' small gasifier gensets at his lab/shop in Golden, CO.

1) Build a 250 kW gasifier to supply the entire farm's electricity requirements (from existing 250 kW Allis Chambers diesel Genset
2) Provide heat for a 90x120 commercial greenhouse operation
3) Produce significant biochar to be included in its Colorado Natural Compost bagging operation
4) Be knowledgeable about purchasing another vendor's gasifier

Next steps on larger gasifier—Although the project team determined that a ¼ MWe gasifier was not currently the best first step in developing a wood energy system, actions were still undertaken as part of this grant to lay the groundwork for a potential biomass combined heat-power facility at the Cochetopa or Mountain Valley Lumber sites sometime in the near future. In addition to the technical and financial assessments of technology and initial price negotiations with the vendors, the project team has also contracted with electrical engineers to design and specify the basic elements of a micro-distribution grid at the Cochetopa site. This would streamline the development process for a power unit if conditions become suitable. In addition to the technical development steps, the project team and Cochetopa and its business partners are currently in discussions over the possible development of year round greenhouse operations that could co-locate with the gasification facility and provide one of the consistent heat users necessary to make the project economically viable.

8.0 Conclusion

The ACRE feasibility assessment grant has provided vital resources in evaluating the potential for wood energy development in the San Luis Valley. First, we know how important full heat utilization is for an economical gasifier project and have decided to focus on the lumber mill for the heat loads already present. As such, we are recommending the interim strategy of installing a district heating system at the mill. When we have found a suitable gasifier technology provider, we will be able to conveniently plug the heat supply into this system. Likewise, we are proceeding with a micro-grid layout at Cochetopa Farm so that when the gasifer is installed we will be able to hook it right in. The relationship for a competent greenhouse operator has also been established and will most likely be the heat-user/partner that will make the economics function well. Secondly, we are wanting to explore the less expensive, more accessible, and potentially more opportunistic approach of biomass energy through wood-chip boilers to initially serve the district heating system at the mill. As a result, a consortium of partners is forming to develop of a biomass heating system manufacturing, sales and service enterprise. This district heating system fired from a wood-chip boiler is currently the subject of an ACRE implementation grant now being considered by the ACRE board.

We deeply appreciate the foresight of the Colorado Department of Agriculture in providing resources to the agricultural community to identify bio-energy opportunities. These will not only support and help diversify the economic opportunities of resource-based communities, but will provide an important contribution to increasing our State and Nation's energy self-reliance.

Appendix A

Phoenix-Ankur System Description

Company Name: Phoenix Energy
Contact Name: Greg Stangl
Address: 1800 Scott St
San Francisco
Phone 415.286.7822
Email: stangl@phoenix.energy.net

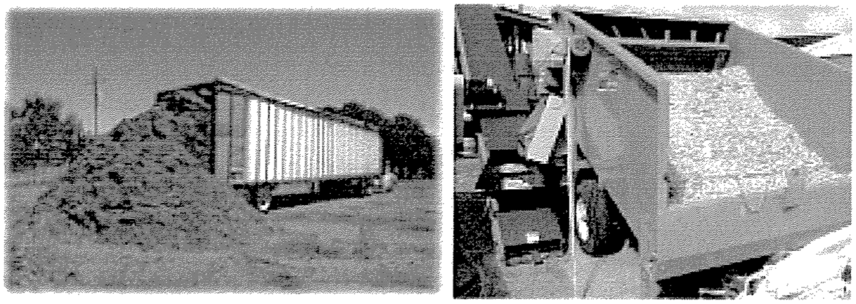
The Phoenix/Ankur systems represents an intriguing potential for small scale projects (<1MWe) that have a fuel supply of at least 8-10 tons/day of low or now cost fuel and a relatively high electrical cost (>$.10/kWh) or substantial avoided costs as a substitute for installing or hooking to grid-based power. This system combines Ankur's long record of successful deployments in a relatively low-tech gasifier with modest quality syn-gas, with a set of high efficiency controllers and emissions clean up systems developed by the US firm Phoenix Energy. Phoenix has nearly completed its first installation of its new modified system at a furniture site in Poland. Several other systems are now in the planning phases. Described below are some of the basic features of this system.

System Components

The primary components of the system include: 1) fuel storage and conveying, 2) gasification, 3) gas cleaning, 4) power production, and 5) ash and liquid handling. The following provides the detail of these components.

Fuel storage and conveying

Fuel storage options are determined based on site logistics. Management believes that hydraulic walking floor trailers (Figure 1) or agricultural silage wagons are some of the better options to accommodate storage and automated conveying. The wagons are mobile, with quick disconnect provided to an automatically controlled hydraulic power unit for unloading. The trailers convey to a platform feeder (Figure 1). The platform feeder can handle a wide range of material and provide transfer to an 18-in.-wide inclined belt conveyor. If fuel size may not be readily assured it may be necessary to include a grinder. Assuming oversized material (over 1 ft in length) is minimized, process design should consider a simple means to eliminate oversized material or grind separately versus automation of grinding.



Figurel – Walking floor trailer (left), fuel feeder and conveyor (right)

Figure 2 shows the gasifier and general arrangement of the drying, pyrolysis, combustion, and char reduction zones in the gasifier. Downdraft gasifiers of this type (Imbert) produce low gas contaminants for two reasons.

The bed is fixed (not fluidized), allowing for low carryover of particulates, and hydrocarbon vapors produced in the pyrolysis zone are drawn down through the high-temperature zone and cracked to lower hydrocarbons (less tar). The gasifier is under vacuum drawn by a high-pressure blower.

Gas cleaning

Wet scrubbing has several advantages with respect to cooling, cleaning, and maintenance. Producer gas must be clean and cooled for engine application. Various options include cyclones, shell and tube heat exchange, moving bed filters, precipitators, etc. The venturi scrubber is the most compact, most effective, and least expensive gas-cleaning option. Venturi scrubbers can remove particles of less than 10 μm at high efficiency and simultaneously cool the gas. Other options are more expensive, less effective, and must be cleaned to remove deposits that inhibit heat exchange and performance. The filtration system downstream of the scrubber is simple, inexpensive, and provides additional cleaning to push contaminant levels below 200 ppm and down to 10 ppm. The first filter is a coalescing filter comprising wood blocks. The filter only requires periodic wash down and very limited media changes. The second filter uses sawdust and is actively stirred on a timer to prevent restriction to flow. The media requires replacement once a week. The remaining filters require minimal maintenance. The third filter is the same as the second without a stir. The final filter is a fabric bag, in service as a final safety catch, and is normally installed in proximity to the engine.

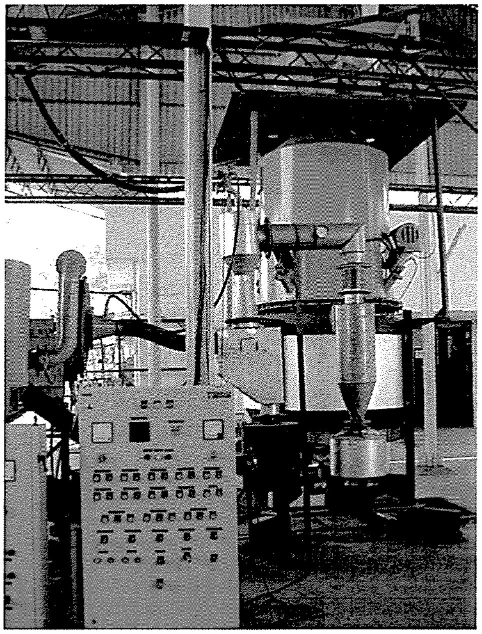


Figure 2 – The gasification column

Power production

Currently, the product is based on a spark-ignited Cummins Model GTA-3067-G engine. The engine is capable of providing 250 KW operating on producer gas. The GTA-3067-G is a four-stroke, turbocharged, natural gas engine. It is likely the best scenario would be to use a cheaper rebuilt engine, since the standard manufacturer's warranty would be voided by using syngas. By using a household engine name, Phoenix Energy ensures reliability, readily available spare parts, and qualified mechanics. Phoenix Energy will customize the producer gas carburetion for this engine and provide standard paralleling switchgear for electric grid interconnection. Jennbacher, Caterpillar and others produce suitable engines, which could be used instead of Cummins if desired.

Ash and liquid handling

Charcoal/ash is removed from the gasifier using pumped water flow (slurry). Scrubbed particulate is combined with the charcoal stream. Water is used to provide a seal to the bottom of the gasifier. This method simplifies maintenance by eliminating the need for valves and quenching the charcoal to prevent dust and the potential for fires. Water/slurry level is maintained in a tank and pumped to an automated filter. The automated filter is typical for river sludge treatment and separates the solids from the recirculated water. The solids and a percentage of water may be conveyed to a thermal oxidizer primarily fueled by burning approximately 5% of the produced syngas. In some localities, sewer disposal is also available. The thermal oxidizer will provide clean disposal of all produced charcoal and process liquids. Water leaving the filter is passed through a final stationary filter prior to heat exchange. The scrubbing water is absorbing heat from the product gas and must be cooled prior to returning to the scrubber. Closed-loop ground-source heat exchange may be proposed to eliminate the need for a cooling tower and water evaporation, although either method may suffice.

Emissions and Mass Energy Balance

Expected emissions are shown in the table below.

	Emission Rate (lb/KWh)
NOx	0.006
CO	0.024
Total Hydrocarbons	0.060
CO2	4.2
SO2	minimal

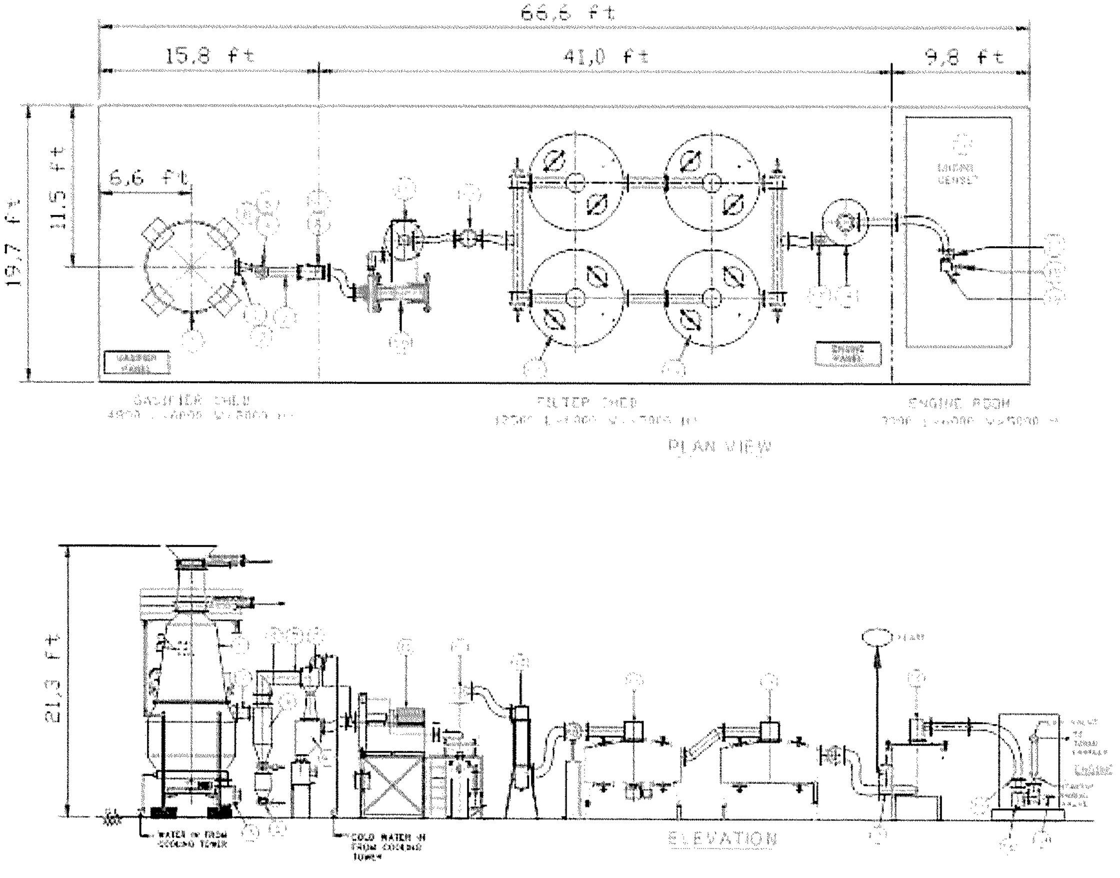
(tons/year)	Estimated Emissions	Non Major Threshold	Notice of Proposed Action Threshold
CO	5.260	70	10
NOx	0.490	50	20
VOC	0.188	50	20
HAPs	0.188	25	10
PM	0.778	70	15
SO2	<1	100	40

Modularity

There are a couple of rough schematics attached below, however, while this is our preferred layout our first project looked nothing like this with components scattered and the engine in a completely separate part of the customer's facility so we are pretty flexible. Essentially what is needed is a 25 x 60 feet footprint for the essential components including the genset, plus an area for fuel handling, storage and loading. Elevators can be used (if space is cramped or conveyers if it is not. If the genset is placed elsewhere the foot print can be reduced to 25 x 47 feet

Appendix B

Schematic of Phoenix System Configuration



LEGEND

S.NO.	DESCRIPTION
1	GASIFIER WITH AUTOMATED DOOR
2	GASIFIER DISTANCE PIECE
3	DRAIN TUB
4	CYCLONE
5	AUTO ASH COLLECTION BOX
6	BELLOW
7	BELLOW DISTANCE PIECE
8	VENTURI SCRUBBER
9	DRAIN BOX
10	WET BLOWER
11	SEPERATION BOX
12	HEAT EXCHANGER
13	ACTIVE FILTER-02NOS
14	PASSIVE FILTER-02NOS
15	FLARE WITH PNEUMATIC VALVE
16	SAFETY FILTER
17	MOTORISED VALVE
18	WATER SEPERATION BOX
19	PNEUMATIC VALVE
20	ENGINE GENSET

Other components

Our method is usually to go in with a turn-key quote we find this works the best for people who are not in the energy producing businesses.

That said site specific work should be left to the client if it is anything more than putting down a pad for the engine block. If the electrical interconnect is not immediately near the unit, the customer should incur an upcharge related to the additional electrical work.

If the customer cannot supply the required fuel and therefore we need to add grinding and fuel handling capability.

Equipment
Portable Storage (4 silage wagons) modified
Conveyor to Grinder
Grinder
Inclined Conveyor
Rotary Valve
Gasifier & Filtration System + Controls
Sludge Tank
Pumps (gasifier pump, scrubber pump, filter pump)
Auto-Filter
Thermal Oxidizer
Engine Generator
Catalytic Converter
Carburetor
Switchgear
Jib Crane
Piping
Electrical
Cooling Tower
Misc.
Freight

Appendix C: Samples of Financial Modeling System

Customer produces tons per year of forest waste	3,300	tons/yr
customer's cost to dispose	$(25.00)	per ton

Technical Data

gasifier parameters	704-880	lbs/hour
operating hours per year	8,000	hours
electric production	1,928	MW/year

Economic Data

Inflation rate	3.00%
Business growth rate	5.00%
Tax rate	38.50%

Revenue/Cost Data

Renewable energy credit (REC) price	$2.50	per MW		
Production tax credit (IRC §45) - power sold to 3rd parties	$10.00	per MW		
Average wholesale elec price	$70.00	per MW		
Average standby demand		per MW		
Utility users tax	1.00%	of bill		
Total Project Cost	750,000			
Grant Contribution	(150,000)			
Project costs	600,000			
tax depreciable life (MACRS)	5			
Debt	540,000			
interest rate (prime rate + 0)	7.00%	IRR	7.5%	equity
term in years	15			
Equity	60,000			

Drying Energy

Recovered heat available	10,231	MMBTU/yr	
Incubator Zone heat (Ph 1 & 2)	179	MMBTU/yr	
Dry Kiln (ea)	1,440	MMBTU/yr	
Greenhouse	1,487	MMBTU/yr	
Subtotal known uses	3,106	MMBTU/yr	
Remaining heat	7,125	MMBTU/yr	
Value of the thermal energy	$23,889		30%
	$78,692		100%
Thermal Energy Sales %	0.8		
First yr value at input % sales	$78,692		

Heat capture

theoretical calculation of syngas

660	lbs of wood per hour
6,930	BTU/lbs of @ 20% moisture
4,573,800	BTU of wood @ 20% moisture
75%	thermal effiency of gasifier

observed calculation of syngas

300	kg wood per hour
2750	kCal (net) per kg of wood
3.965667	BTU per kCal
3,271,675	BTU per hour

observed calculation of waste heat from engine

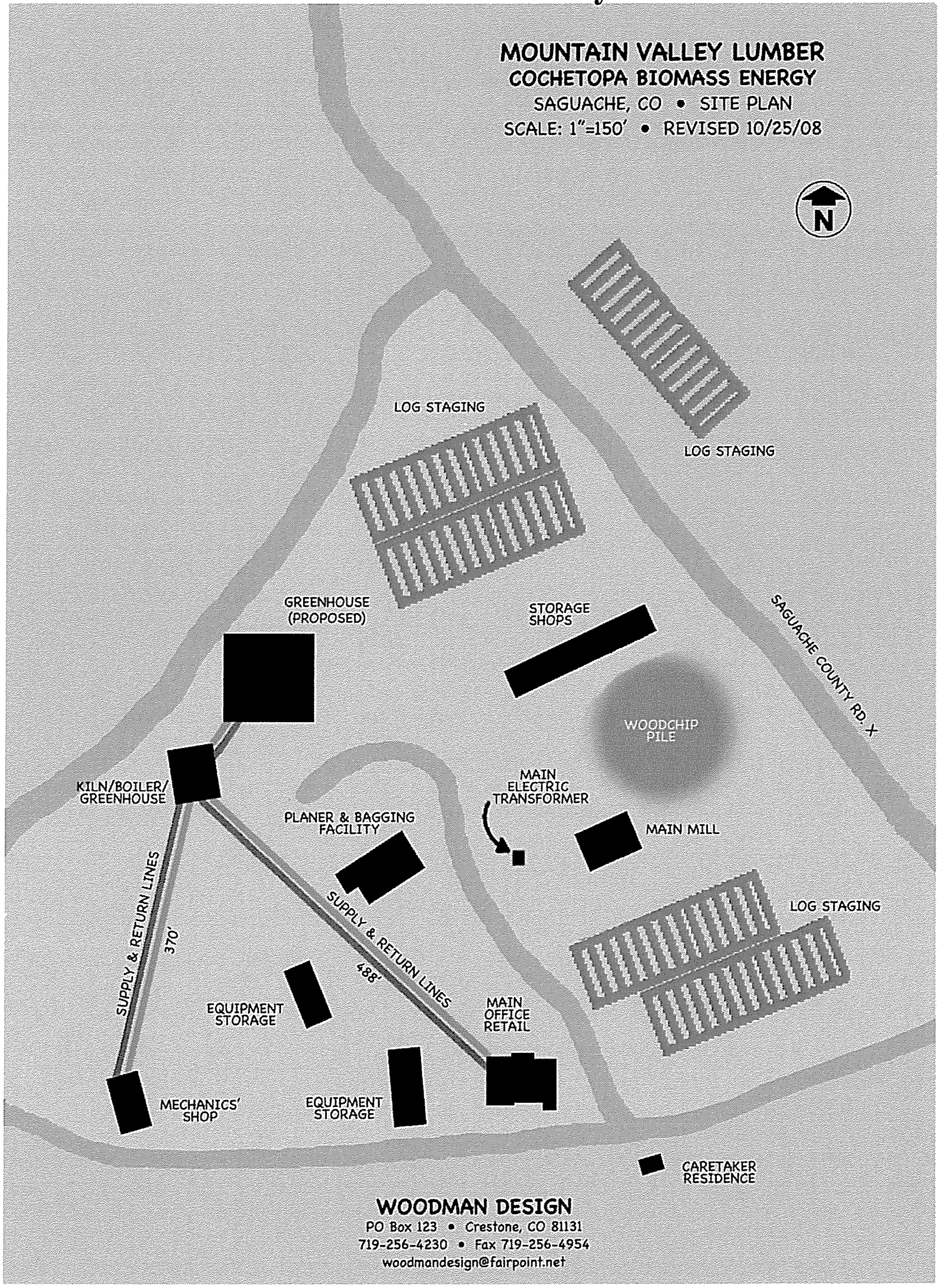
kCal of heat per hour	322,500	from jacket & exhaust
BTUs per Kcal	3.965667	
BTUs per hour of recoverable heat from engine	**1278927.61**	
	1.28	MM Btu/hr

Appendix D

Preliminary Proforma for Biomass Systems

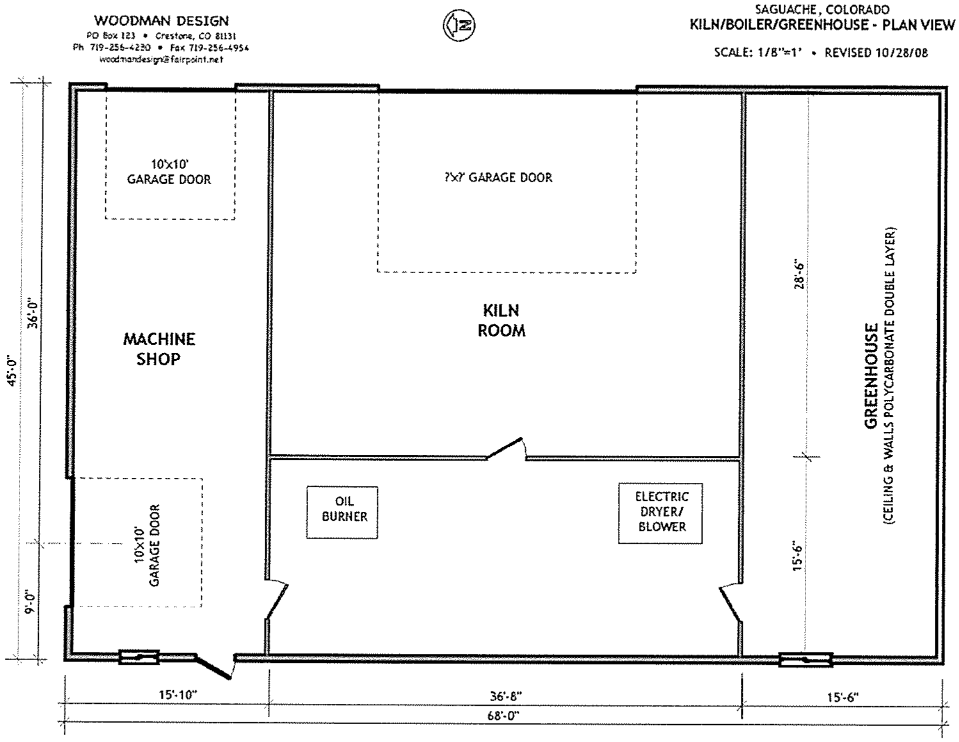
Project Income Statement		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Income		-	-	-	-	-	-	-	-	-	-
Feedstock Cost		(104,566)	(107,703)	(110,243)	(113,551)	(116,957)	(120,466)	(124,080)	(127,802)	(131,636)	(135,586)
Sale to Grid		119,504	119,504	119,504	119,504	119,504	119,504	119,504	119,504	119,504	119,504
REC's		4,850	5,093	5,347	5,614	5,895	6,072	6,254	6,442	6,635	6,834
Value of heat		78,693	81,054	83,485	85,990	88,569	91,227	93,963	96,782	99,686	102,676
Federal Carbon Credits		0	0	0	0	0	0	0	0	0	0
Other state & local incentives		0	0	0	0	0	0	0	0	0	0
Gross Revenue		98,481	97,947	98,093	97,558	97,011	96,337	95,642	94,926	94,188	93,429
Expenses											
Less operating expenses		(20,000)	(20,600)	(21,218)	(21,855)	(22,510)	(23,185)	(23,881)	(24,597)	(25,335)	(26,095)
Gross Cash Flow		78,481	77,347	76,875	75,703	74,501	73,151	71,761	70,328	68,853	67,333
Deprecation		(130,000)	(130,000)	(130,000)	(130,000)	(130,000)	0	0	0	0	0
Interest expense		(40,950)	(39,320)	(37,577)	(35,711)	(33,715)	(31,579)	(29,293)	(26,847)	(24,231)	(21,431)
Pre tax income		(92,469)	(91,973)	(90,702)	(90,008)	(89,213)	41,572	42,467	43,481	44,622	45,903
(Tax)/tax rebates		35,601	35,410	34,920	34,653	34,347	(16,005)	(16,350)	(16,740)	(17,180)	(17,673)
Tax credit (IRC §45)		19,400	19,982	20,581	21,199	21,835	22,490	23,165	23,860	24,575	25,313
Net income	-60000	(37,469)	(36,582)	(35,200)	(34,156)	(33,031)	48,057	49,282	50,600	52,018	53,543

Appendix E: Mountain Valley Site Map & Building Plans for Heat Loss Analysis



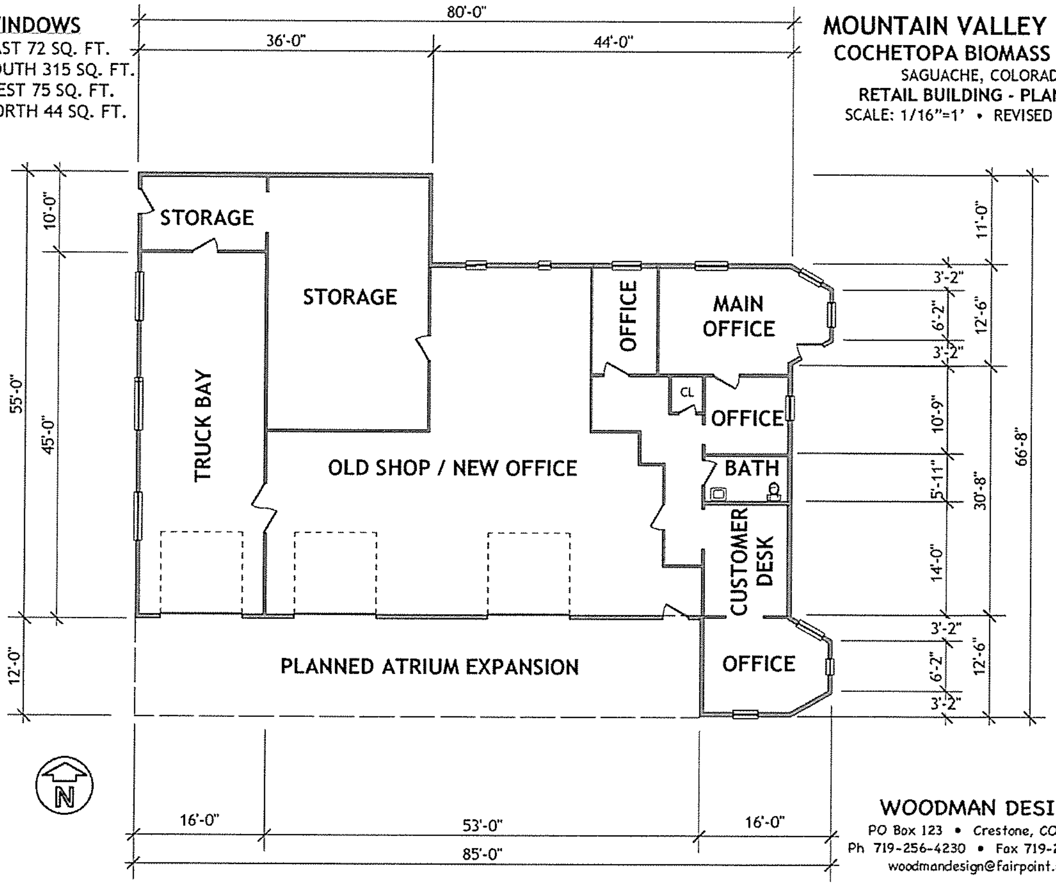
MOUNTAIN VALLEY LUMBER
COCHETOPA BIOMASS ENERGY
SAGUACHE, COLORADO
KILN/BOILER/GREENHOUSE - PLAN VIEW
SCALE: 1/8"=1' • REVISED 10/28/08

WOODMAN DESIGN
PO Box 123 • Crestone, CO 81131
Ph 719-256-4230 • Fax 719-256-4954
woodmandesign@fairpoint.net



WINDOWS
EAST 72 SQ. FT.
SOUTH 315 SQ. FT.
WEST 75 SQ. FT.
NORTH 44 SQ. FT.

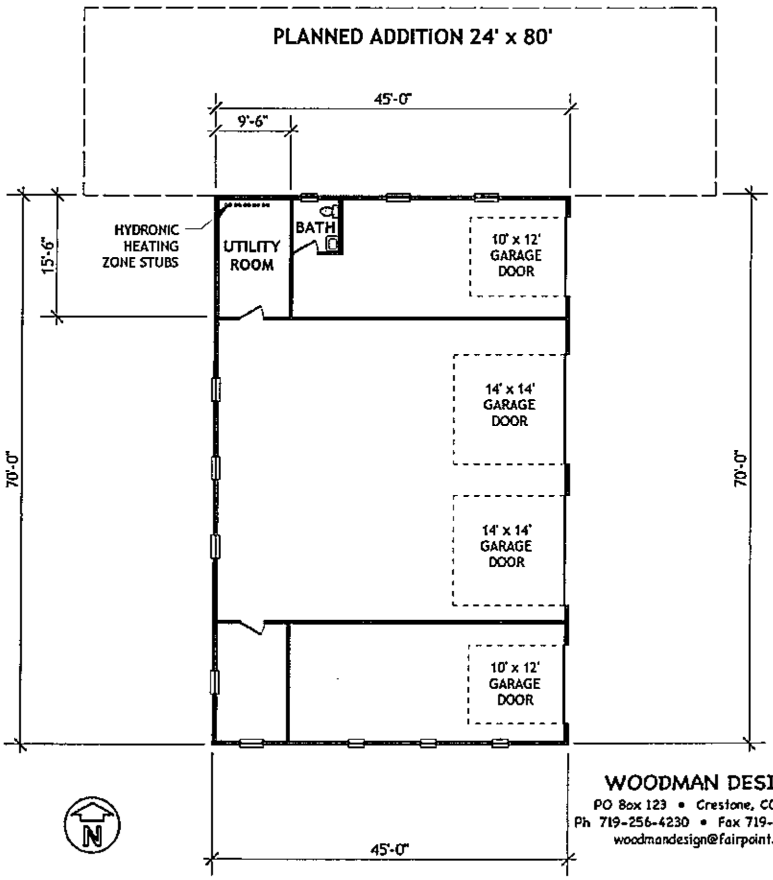
MOUNTAIN VALLEY LUMBER
COCHETOPA BIOMASS ENERGY
SAGUACHE, COLORADO
RETAIL BUILDING - PLAN VIEW
SCALE: 1/16"=1' • REVISED 10/29/08



WOODMAN DESIGN
PO Box 123 • Crestone, CO 81131
Ph 719-256-4230 • Fax 719-256-4954
woodmandesign@fairpoint.net

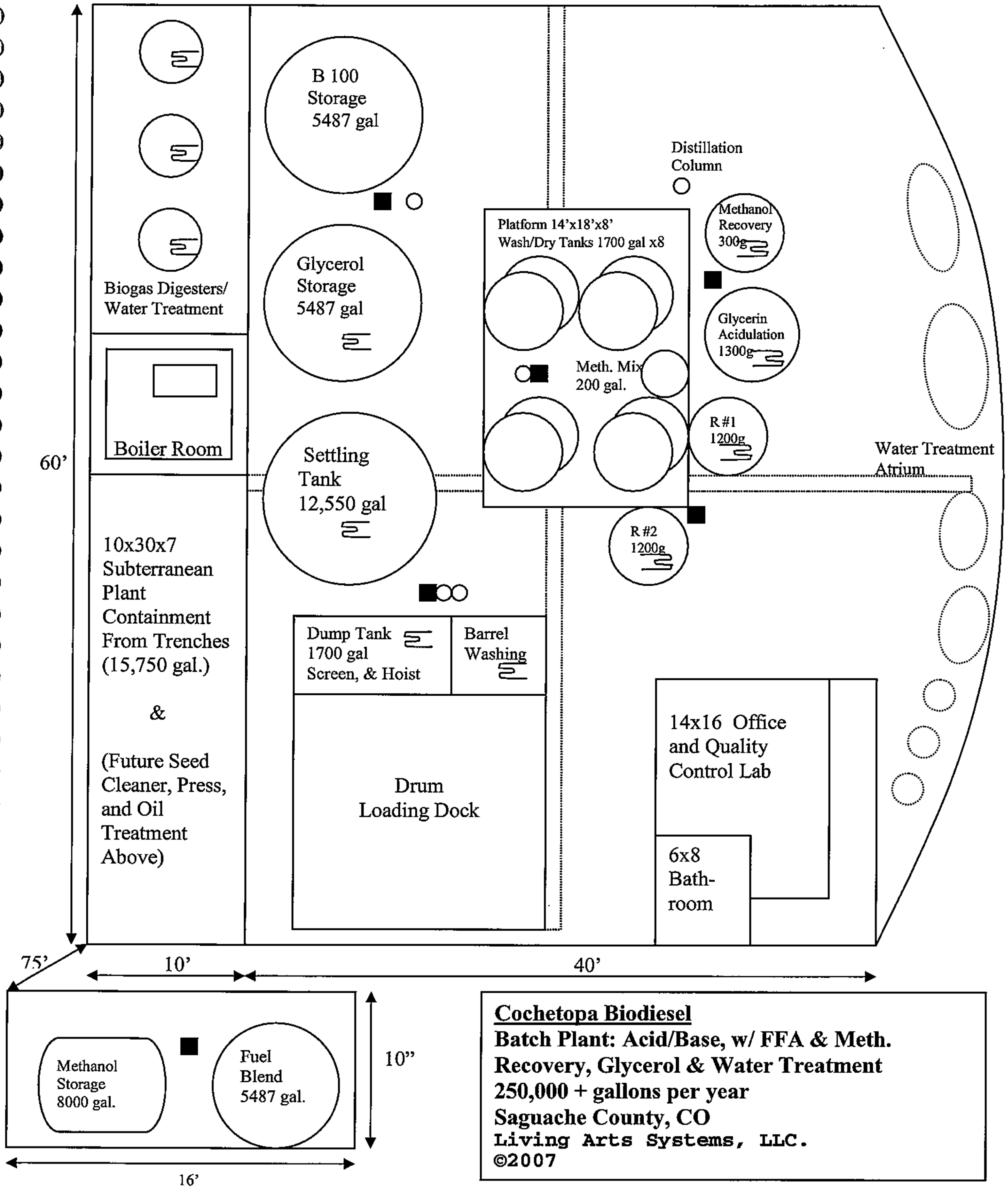
WINDOWS
EAST 632 SQ. FT. GARAGE DOORS
SOUTH 30 SQ. FT.
WEST 48 SQ. FT.
NORTH 28 SQ. FT.
TOTAL WINDOWS & GARAGE DOORS = 738 SQ. FT.
TOTAL SQUARE FOOTAGE = 3150 SQ. FT.
WITH ADDITION = 5070 SQ. FT.

MOUNTAIN VALLEY LUMBER
COCHETOPA BIOMASS ENERGY
SAGUACHE, COLORADO
NEW MECHANICS' SHOP - PLAN VIEW
SCALE: 1/16"=1' • REVISED 10/29/08



WOODMAN DESIGN
PO Box 123 • Crestone, CO 81131
Ph 719-256-4230 • Fax 719-256-4954
woodmandesign@fairpoint.net

Appendix F: Biodiesel Plant Layout, Capitol Costs, and Operating Budget



<u>Cochetopa Biodiesel</u>
Batch Plant: Acid/Base, w/ FFA & Meth.
Recovery, Glycerol & Water Treatment
250,000 + gallons per year
Saguache County, CO
Living Arts Systems, LLC.
©2007

Biodiesel Equipment

Transfer Pump #1	Roper 60 gpm		$2,000
Dump Tank & Screen*	1700 gal Steel w/ Hoist, Trolley & H.E.		$7,500
Barrel Washer	Contained Steel Bin, Semi-Auto.		$5,000
Filter Assembly	FSI X-100 or similar, Steel		$1,600
WVO Storage Tank*	12,550 gal, Steel Vertical w/ H.E.		$5,500
Methanol Storage	8000 gal, Steel Horizontal		$10,000
Methanol Pump	Pneumatic, 20gpm		$800
Esterification Reactor #1	1200 gal. SS Jacketed, Agitator		$17,500
Methoxide Mix, SS	200 gal. SS Agitator		$2,500
Transesterification Reactor #2	1200 gal SS Jacketed, Agitator		$17,500
Transfer Pump #2	Roper 60 gpm, 2AM32		$2,000
Decanter, Wash/Dry Tanks (x8)	1700 gal HDPE ($599 ea.)		$4,792
Transfer Pump #3	Roper 60 gpm 2AM32		$2,000
Glycerin Acidulation Tank	1300 gal HDPE		$549
Transfer Pump #4	Roper 60gpm, 2Am32		$2,000
Glycerin Storage*	5487 gal Steel		$2,500
Methanol Recovery Tank/Manifold	400 gal. Steel		$400
Methanol/Water Distillation Column	Charles 803, Copper		$1,000
Biodiesel Storage*	5487 gal, Steel		$2,500
Biogas Digesters/Water Treatment	Puxin Casted Ferro Cement (3 in series)		$25,000
Water Treatment Atrium Tanks	Steel, HDPE, Piping, Pumps		$7,500
2 Boilers	Clean Burn 350,000BTU		$21,800
Air Compressor	Ingersoll 10 HP 35 cfm @ 175 psi		$2,500
Pressure Washer	NorthStar 2700 PSI 2.5 gpm, 5 hp		$2,500
Piping, Fittings, Valves, Gauges, etc.			$20,000
Lab Equipment	Gas Chromotograph, scale, etc		$20,000
Lab, Safety Supplies, Misc.			$5,500
		Total	**$192,441**

Building

40'x60' Eccentric Concrete Slab with Hydronic Tubing and Drainage Trenches		$19,500
Turn Key 40'x60' Insulated Steel Building w/ 14'x16' Office/Lab/Bthrm.		$75,000
10'x30'x6' Stem Wall on North Side for Containment/Truck Bay		$2,000
Liner or Concrete for Containment		$2,000
Cinder Block Boiler Room		$3,000
Post and Beam Platform		$4,500
Plumbing		$2,500
	Total	**$108,500**

Labor

Groundwork & Excavating		$4,200
Biodiesel Processor Tank Installation		$10,000
Plumber: Building and Biodiesel Tanks, Boiler Runs		$6,000
Electrician: Building and Biodiesel Pumps, Motors		$4,000
Welding and Fabrication		$6,500
	Total	**$30,700**

Consulting, Permitting and Fees

Bob Armantrout, Consulting		$1,500
Building and Septic Permit		$450
Conditional Use Permit		$800
National Biodiesel Board Registration (EPA Tier 1 Data)		$2,500
Misc.		$1,500
Air Pollution Emmisions Notice-CDPHE		$500
	TOTAL	**$7,250**

TOTAL	**$338,891**
Contingency 20%	**$67,778.20**
TOTAL PROJECT	**$406,669**

Batch Pilot Production Cost (100 gal Batches) 53k GPY

	Best Case Scenario			**Worst Case Scenario**		
	Cost/Unit	Cost/Batch		Cost/Unit	Cost Batch	
Feedstock	$0.12/lb	$81		$0.35/lb		$236.25
Methanol	$3.00/gal	$22.77		$3.50/ gal		$69.30
KOH	$0.65/lb	$6.96		$0.99/lb		$7.28
Electricity	$0.05/kwh	$1.00		$0.10/kwh		$1.70
Propane	$22/mmbtus	$2.20		$26/mmbtu		$2.60
Labor	$20/hr	$60		$20/hr		$60
Expenses		$5.00				$10
Maintenance		$2.00				$4.00
	.66 meth / gal biodiesel	$181				$391.13
		/81 gallon yield			/70 gallon yield	
		$2.23 per gallon/			**$5.59 per gallon/**	
		$1.49 w/o labor			**$4.73 w/o labor**	
			Median Cost $3.91 per gallon/$3.11 w/o labor			
Profit/Loss						
Selling for $3.00/gal		$0.77	Loss $0.91		Loss$2.59	
Selling for $3.50/gal		$1.27	Loss$0.41		Loss$2.09	

Small Commercial Biodiesel Production Cost (1000 gal batches) .5 MGY

	Best Case Scenario				**Worst Case Scenario**		
	Cost/Unit	Cost/Batch	232 gal batches		Cost/Unit	Cost Batch	
Feedstock	$0.12/lb	$750	$0.29/lb	464	$0.35/lb		$2,186.63
Methanol	$1.15/gal	$210.75	$3.14	$160	$3.50/ gal		$641.41
KOH	$0.95/lb	$7.35		$2.00	$0.99/lb		$7.66
Electricity	$0.05/kwh	$10.00		$2	$0.10/kwh		$17.00
Propane	$22/mmbtus	$22.00		$5.00	$26/mmbtu		$26.00
Labor	$20/hr	$60			$20/hr		$60
Expenses		$10.00		$5.00			$10
Maintenance		$6.00		$3.00			$12.00
Admin.		$60		$5.00			$80
		$0.01					$0.04
		$1,136		646			$3,040.74
		/750 gallon yield			$3.23/gallon	/666 gallon yield	
		$1.51 per gallon/				**$4.57per gallon/**	
		$1.43 w/o labor				**$4.48 w/o labor**	
			Median Cost $3.04 per gallon/$2.96 w/o labor				
Profit/Loss							
Selling for $3.00/gal		$1.49		Loss$0.04		Loss$1.57	
Selling for $3.50/gal		$1.99		$0.46		Loss$1.07	

APPENDIX G: HEAT/LOSS DATA FOR MILL

GEORGE T. SANDERS CO. INC.

HYDRONIC HEATING SALES COORDINATOR
BARRY ENGLEMAN
PO BOX 169
SILVERTHORNE, CO. 80498
970-262-0196 HOME OFFICE
970-262-0209 HOME OFFICE FAX
970-904-0167 CELL PHONE
barryengleman@comcast.net
bengleman@gtsanders.com

To:	NICHOLAS CHAMBERS	Re:	MOUNTAIN VALLEY LUMBER
Attn:	NICK	Date:	11/3/08

I am going to see if I can get the heat loss calculation software I use downloaded into my laptop so I can get the detailed heat losses down for the various buildings at Mountain Valley Lumber. In the meantime, I have prepared some estimated heat losses for the various buildings. Those estimates are as follows:

1. New Mechanic's Shop	**80,000 Btu/hr**
2. Retail Building	**100,000 Btu/h**
3. Machine/Kiln/Greenhouse	**530,000 Btu/hr**
4. Totals	**710,000 Btu/h**

The Kiln building is broken down as 30,000 Btu/h for the Machine Shop and Greenhouse and 500,000 Btu/h for the Kiln Room. I will discuss the Kiln Room further on in this memo.

The new Greenhouse is also shown piped this new central heating plant on the site plan but I do not have any information on this building right now so I can't include it.

The supply and return lines from the boiler location to the New Mechanic's Shop will need to be 40mm (1-1/4") pipe size. The supply and return lines from the boiler location to the Retail Building will also need to be 40mm (1-1/4") pipe size. I recommend using a product called Ecoflex which has two 40mm Pex pipes in one 7" sealed polyethylene jacket. The 40mm supply and return pipe is insulation within the 7" jacket. This pipe is available in maximum 328 foot lengths. It is not inexpensive pipe but it can be bedded very quickly in the ground keeping

installations costs to a minimum. You can see information on this pipe at www.uponor-usa.com. An uncoiler, which can be mounted on a backhoe bucket, is available to borrow for the installation of the pipe.

Since the Kiln Room is the largest heating load it is good to keep the boiler plant close to it. After reviewing the different ways of heating a wood drying kiln, I think Mountain Valley Lumber is currently doing it the best possible way. We can replace the existing waste oil boiler with the central wood-fired boiler for pre-heating the kiln room. If they have a heating phase for sap setting, the new central boiler plant could be used for that also.

The biggest problem with kiln drying lumber is getting the moisture created out of the kiln room. If it is removed by exhausting the heated air in the room to outside, the heating loads can become very large. The air brought in from outside to replace the exhausted air now has to be heated to the same temperature as the exhausted air. The heating load will increase as the outdoor air temperature decreases. Energy use can increase dramatically when the kiln room is used in the winter months.

The existing electric blower/dryer recirculates the heated air in the kiln room and condenses the moisture out of this heated air before returning the same air to the kiln room. The electric heater in this unit then just has to maintain the air temperature required for the kiln room when the air temperature drops from normal building and evaporative heat losses. From an energy usage standpoint, maintaining the air temperature from building and processing losses is much less expensive than heating the room volume of outside air from as low as -20°F back up 110°F or 160°F or whatever air temperature they maintain in the kiln room.

I don't know anything about the existing electric unit they have now. You may have sent me some information on it but that e-mail would be stored in Outlook Express in my disabled computer. It may be time to look at whatever new heat pump technology is available for kiln drying wood which could replace the existing unit if it is not operating in a very efficient manner. Modern heat pumps can provide up to 3 and 4 times the efficiency of standard heating equipment for homes and businesses. I will make some inquiries regarding heat pumps and kiln drying wood.

I will also make some inquiries as to the feasibility of placing a hydronic heating coil in the air handler to see if the new central boiler system might have some significant use for reheating the kiln room air in conjunction with a heat pump system. In order to make these inquiries, I am going to need more information regarding the operation of the kiln room:

1. **How long does the kiln drying process currently take? Is the timeframe any different from summer months to winters months?**
2. **What is the air temperature in the kiln room kept at during the drying process? Does it vary during the process?**

3. I believe we were told the pre-heat process handled by the waste oil burner brought the kiln room to 85°F before the dryer was turned on. Is this correct? Does they use a sap setting heating process?

I would appreciate answers to these questions.

Summary:
The new greenhouse appears on the site plan with a fairly large footprint compared to the other building shown. If we estimate a required heat load of 200,000 to 300,000 Btu/h for this building, the total heat output of the new central boiler heating plant is going to be 900,000 to 1,000,000 Btu/h if we use this boiler for pre-heating the kiln room and possible sap setting of the wood after drying. This heating load could increase if we do find it feasible to assist the existing dryer or future heat pump drying unit with a hydronic heating coil.

The pipe size required for both the Retail Building and the new Mechanic's Shop is 40mm (1-1/4") Pex pipe. The size of these pipes will not change after a detailed heat loss of the structures is completed as long as the future size of these structures is not increased dramatically. If necessary, this pipe could be installed now using the 40mm (1-1/4") pipe size.

Thanks,
Barry

Appendix H: Gasifier Pilot Proposal

Proposal for
Joint Development Agreement
for 40 kw Gasifier Pilot Project
September 2008

Technology Designer: Green Sources (GS) Agua Das, Golden, CO
Pilot Host: Cochetopa Biomass Energy (CBE), Saguache, CO

Proposal Summary: This proposal is for a sequence of tests of wood chip gasifier provided by the Technology Designer first in Golden, then on the site of the Pilot Host.

Phase I: Initial Gasifier Technology Testing

Phase I will focus on tests of liquid diesel fuel flow, wood gas flow, wood consumption rate, engine speed, power increase, all will be measured. Performance, fuel savings, fuel equivalence conversion ratio, power increase, and other benefits will be calculated and evaluated.

Preliminary tests at Green Sources Golden facility

Prepare the engine supplied by CBE to for tests to

-measure diesel fuel and fuel gas flow
-RPM
-Manually adjust injector setting
-Exhaust Manifold temperature
-Intake Manifold boost pressure

Prepare the test facility to apply measured engine loads.

Measure baseline diesel fuel flow vs RPM over a safe range of speeds from no load to various intermediate loads.

Modify air intake system to create suction to draw fuel gas into the intake air.

Measure combined diesel fuel flow and gaseous flow and wood fuel consumption vs RPM and load as before.

Calculate the fuel saving value of gaseous fuel inputs (gallons diesel fuel saved per dry ton wood Chips)

CBE will furnish a wood chip dryer to supply 200 lb/hr of bone dry chips from 50% wet chips with heat from engine exhaust and radiator.

Once the dryer is ready, then the gasifier and engine modification parts will be installed at the irrigation pumping site on Cochetopa Farms, near Saguache, CO.

This short term preliminary test will determine the fuel savings rate of gasified wood chips for diesel dual fuel operation using a small on hand gasifier for the operation of an existing 50 horse power Detroit diesel engine coupled to an electrical generator and PTO propelled pump for running a center pivot irrigation system.

This information will be used as the basis to decide to advance to phase II.

This gasifier equipment is pre commercial. Operation is a combination of automated and manual controls. Phase one tests are about fuel savings not the degree of automation.

The service interval for fuel supply, char removal, and the likes is site and application specific employing hour bin, day bin, 3 day (weekend bin), week bin, etc.

Fuel input requirement: We anticipate that to save 100 gallons liquid fuel is one ton dry ton chips with no char production or two dry tons at 30% char production. Practical operation will be between these limits.

The practical limits of truck/wagon/container/conveyor size determine operator attention provided jam free materials handling which, of course CBE has great experience.

Phase I operations will provide both valuable operations data for the Technology Designer and viability verification for the Pilot Host. The Pilot Host will contract the Technology Designer to perform this test run including all installation, start-up, and monitoring activities during the test period.
Both parties will actively gather and share all operations data gathered during the pilot test. Phase I will also provide the Technology provider with a high profile pilot test site that enhances the credibility and viability of the technology for agricultural applications.

Phase II: 40 kw Gasifier on Single Pivot arm irrigation
CBE will order or contract a lease of a 40 KW rated wood chip gasifier system
System will be operated at CBE 2009 growing season

Phase III: Technology Replication
Based on successful outcomes of Phase II, CBE will enter into negotiations with GS and BEC to secure a manufacturing license for production of these units for joint distribution and sales.

Proposal Outcomes: The following outcomes are anticipated for the two participating entities:

GS

1. Real world operations data in a high value application (agricultural/irrigation)
2. High profile exposure of technology to both public officials and private industry
3. Relationship building with a prospective manufacturing and marketing partner

CBE

1. On-site evaluation of the viability of a small-scale gasifier system for agricultural applications.
2. Reduced cost irrigation pumping for a high value agricultural product
3. Evaluation of economic and logistical viability for implementation of a manufacturing operation in Saguache County, Colorado (2nd poorest County in Colorado)
4. Agricultural char for improved compost product.

Present Assumptions: In communication thus far, it has been stated that:

1) The 40 kw gasifier would reduce diesel consumption down to 10% and consume about 1 to 2 ton per day of wood chips depending on char production.
2) The turn-key price of said gasifier would cost about $2000 per kW, or $80,000 for the 40 kW

Compensation

Technical services will be provided to CBE by GS on a time, materials, travel, expenses, profit, and discount basis.
Rates are $30 to $120/hour depending on staff.
Orders: Terms 50% deposit. Balance on delivery. 1.5%/mo over 60 days past due
Profit keystone materials & expenses
Discount no profit for prepaid retainer
Jurisdiction: Golden, Colorado, USA
Disputes both parties agree to arbitration.

Appendix I: Current Accounting (as of 11/4/08)

Date	Payable to:	Amount	Comment
1/4	**CBE**	**+$5000**	**Saguache County Grant**
1/15	LAS	-$559	Grant Writing
2/19	LAS	-$1100	Biodiesel design & budget, elec.analysis
2/25	CES	-$647.50	Biomass Tech. Assess., meetings, travel
4/28	CES	-$637.55	Biomass Tech. Assess., travel
5/25	CES	-$325	Biomass Tech Assess., travel
6/15	CES	-$240.40	Biomass Tech Assess., meetings, travel
7/12	LAS	-$525.60	Meetings, thermal study, accting., corres.
7/14	CES	-$340.40	Biomass Tech. Assess.
9/17	ACRE	-$50	Application Fee
11/4	LAS	-$30	Computer Support
11/5/08	Woodman	-$481.25	Mtn. Valley Building Plans for heat/loss
11/5/08	O & V Print	-$47.14	Printing & Binding of Final Report
	TOTAL	**$4983.84**	
	BALANCE	**$16.16**	

Billable to ACRE ($20,000)

7/31	CES	$565.40	Biomass Tech
8/31	CES	$240.40	Biomass Tech
9/30	CES	$1329.73	Biomass Tech
11/5	LAS	$2610.20	Corres., mtngs, pilot, final report, mileage
11/5	Agua Das	$7000	40 kW gasifier pilot test
11/5	John's Travel	$3000	Grovewood Boilers due diligence
11/4	Engineering	$3500	Design, CAD, and budget of micro-grid
11/5/08	CES	$246.72	Truck Milegae to Golden w/ Detroit for pilot
	Total	$18,492.45	

Balance due:
Brett's Oct and Nov hrs, Nick's last Nov hours, printing supplies, postage