

INTRODUCING BIOMASS ENERGY AT FERRUM COLLEGE: THE CHALLENGE OF INTRODUCING NEW TECHNOLOGY

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INTRODUCTION

Ferrum College and English Biomass Partners have been working together for nearly five years to design, build, and operate a biomass plant that will provide almost all of the thermal energy and a portion of electricity requirements for the campus. The biomass plant began full operation in 2014. This is the story of what they have learned.

Introducing new technologies into existing systems to achieve strategic sustainability goals often create unexpected challenges that threaten hoped for benefits and leave participants wondering what went wrong. Yet even projects that present these challenges are also great sources of encouragement and learning. Many projects begin with a focus on the promise of a particular technology, (in this case using biomass for fuel), and while the prospects can be exciting, it can obscure the hard work of preparing the existing system for change. Moreover, the “systems” that frequently present the most difficulty are the human systems and behaviors that influence implementation. Because these are not well-understood or documented they are “uncovered” during implementation. The purpose of this article is to identify critical success factors and provide insight about processes that enhance the likelihood of success.

KEYWORDS

biomass plant, thermal energy, college sustainability, district heating, alternative biomass fuels, forest sustainability

SUSTAINABLE ENERGY AT FERRUM COLLEGE

Beginning in February of 2014, the Ferrum College Biomass Energy and Research Facility began supplying thermal energy to the college campus. The facility designed and installed by English Biomass Partners allows Ferrum College to provide “low-cost, green energy” to its campus and achieve its sustainability goals. In addition to becoming “green” through carbon reduction, the college will become more energy efficient with reduced energy costs. Located in the foothills of the Blue Ridge Mountains of Southwestern Virginia, Ferrum is a four-year residential college surrounded by mountains, lakes, rivers and state parks. Ferrum offers 33 areas of study ranging from business and environmental science to teacher

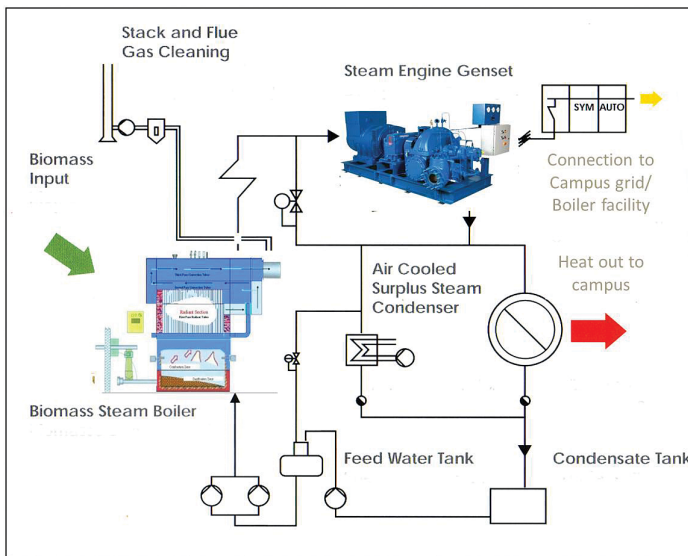
1. Managing Partner of Ascent Energy Partners (AEP, <http://www.ascentenergypartners.com>). AEP is an energy efficiency consulting firm dedicated to designing solutions for businesses that make efficient use of energy resources while simultaneously reducing the impact on people and the environment. AEP was engaged by Ferrum College and English Biomass Partners to assist with the implementation of the Biomass Energy Plant project.

education and criminal justice with small class sizes, and a dedicated faculty. The 1,500 men and women who attend Ferrum come from 25 states and a dozen countries, and more than 80 percent live on Ferrum's 700-acre campus.

FIGURE 1. Campus map.



FIGURE 2. Biomass System Description.



boiler system in selected buildings. Like many district energy systems, some of the infrastructure was aging and the system grew incrementally as the college matured. With limited funding available for infrastructure, the college worked hard to maintain and upgrade key systems.

BIOMASS SYSTEM DESCRIPTION

In 2010, English Biomass Partners approached the college and offered to provide a total “Turnkey” solution, including engineering, design, fabrication, construction and installation of a new biomass fired power plant for the college. The new power plant was to consist of two separate operating systems.

The campus uses a central hot water system for space heating and domestic hot water typically during the months of October through April. The Biomass Plant produces saturated steam to run an electric turbine that will produce electricity for the college and supply thermal energy to heat the campus hot water loops.

The overall project cost, financed by English Boiler Partners, is more than \$5 million for the Biomass plant. Currently 16 buildings are served by the hot water loop, and the college will consider adding others in the future.

During the spring of 2014, the Biomass Energy and Research Facility began operations. During this period it provided supplemental heat to the campus hot water loop to test and commission the basic operations prior to full load commencement in the fall heating season. The new biomass system is anticipated to provide an overall thermal efficiency of approximately 85%.

Prior to the Biomass boiler startup, Ferrum College was using a vintage oil-fired boiler to provide for the bulk of its thermal energy requirements. Propane was used to supplement the main

Main Boiler System

The main boiler system (MB1) is designed to provide the energy needed for the high temperature hot water district heating and domestic hot water systems. The new system consists of a steam generator; designed for an input of 30 mmBtu/hr, firing biomass consisting of wood waste procured from local lumber suppliers. In addition, the system is designed to maximize overall efficiency by installing new heat recovery systems, including combustion air and boiler feedwater pre-heating systems. The new steam generating system is also designed to meet and exceed new boiler emission limits. This system also provides steam to a steam turbine generator. The new steam turbine generator supplies the electrical energy needed to operate the new steam generator and support the fuel handling and emission systems. In addition, the excess power generated by the steam turbine generator is to be used by the college. The MB1 will provide 100% of the thermal energy required for the campus hot water loops. The main boiler presently uses wood chips from local suppliers as its primary fuel.

FIGURE 3. Biomass Main Boiler.



FIGURE 4.. Steam Turbine.

FIGURE 5. Research Boiler.



Research and Development Boiler

The second system, the research and development boiler (RB1), is a much smaller steam generating system, designed to produce up to 6.8 mmBtu/hr. RB1 is designed to combust not only wood waste, but agricultural crop waste or other alternative energy fuels, grown specifically for use as an alternative fuel. Both systems, MB1 and RB1 are installed within the same building, but each system has a separate control room. In addition, the control room for boiler RB1 is to be used to provide instruction for environmental science students; students from local community colleges, and provide outreach to farmers and land owners interested in growing alternative biomass fuels. Students will be able to gain substantial first-hand experience from wide-ranging topics, including the proper relationship between fuel and air for combustion and emission control; design considerations for district heating systems; and power generation using available steam. The college also anticipates using the plant to educate farmers and land owners regarding the effects of fertilizers and chemicals used during the growing season on combustion within the steam generator. These instructional sessions would help farmers choose applications that could provide the protection that they need for their crops, but would then provide the farmer the additional income derived from the selling of the crop waste stream for use as an alternative energy fuel.

Some of the unique features of these boilers include (1) an extended combustion zone that enables more complete combustion of fuels, (2) precast refractory-lined combustion chambers, (3) fully automated controls, (4) auto de-ash systems, and (5) completely modular design. The benefits can be seen in improved efficiency even when operating substantially below design capacity, automatic self-cleaning with very low levels of ash, minimal manual intervention, and safer operating conditions.

STRATEGIC INTENT

The Biomass Energy and Research Facility highlights the importance of shared vision between Ferrum College and English Biomass Partners. This is particularly important because of the nature of long term agreements for distributed power generation between customers and developers. In this case the term of the agreement is for a minimum of ten years.

“We are proud to be building a facility that serves as an example of Ferrum’s commitment to sustainable initiatives,” says the college’s president, Jennifer Braaten. This statement made at

the project commencement clearly articulates the importance of sustainability at the highest levels of the college. Likewise, English Biomass Partners has demonstrated a commitment to sustainability by their commitment to the industry and their extensive biomass boiler design and fabrication experience.

FIGURE 6. Research Boiler.

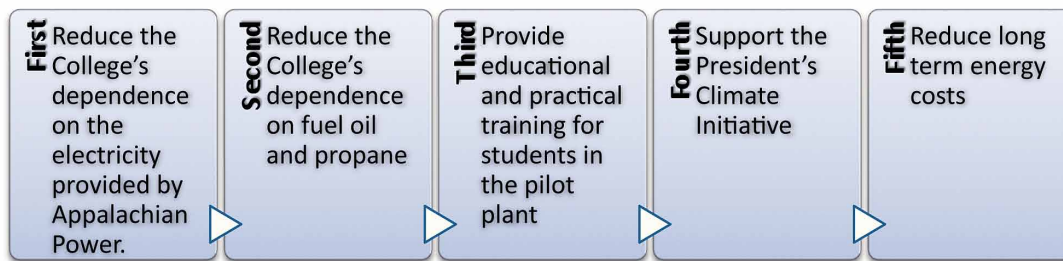


BIOMASS PLANT STRATEGIC OBJECTIVES

Even before the final decision to build a biomass energy plant, the following objectives were developed to create the proper focus for the development team.

In addition to the college goals and objectives, what other factors were considered in the decision to pursue a biomass energy plant? Three of the most important factors include access to renewable fuel resources, reasonably predictable fuel pricing, and the ability to achieve emissions expectations. In a nutshell, as outlined in the chart below, the right conditions and readiness to build a biomass plant had to be present.

FIGURE 7. Strategies 1.



Renewable Resource

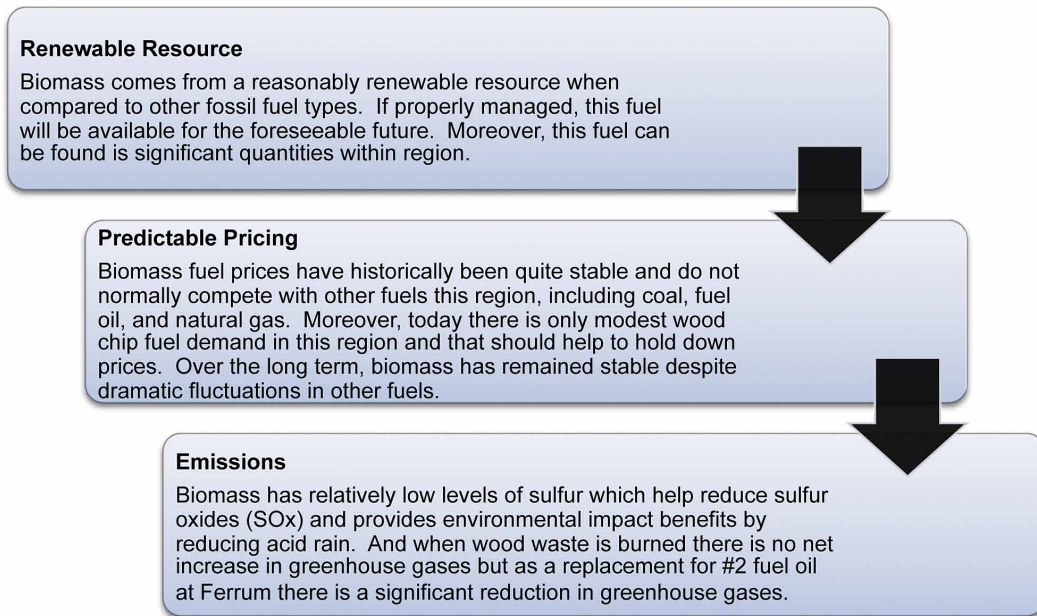
Determining the potential of the renewable resource meant assessing its availability and predictability in the long term. It also required evaluating the potential to create sufficient usable energy through combustion in the Biomass Plant.

Biomass is a well-established renewable resource in the region where Ferrum College is located. The forest products industry in Virginia is a significant part of the economy generating more than \$24 billion annually.

The Virginia Forest Products Association reports that over 27% of industrial companies within the state manufacture forest products. Currently, there are more than 140 sawmills that can provide fuel for the industry. In the area surrounding Ferrum College, many mills have been in operation for many years and are expected to continue.

Virginia's forests contain a variety of timber types with hardwoods making up 80% of the forest with the rest in pine types. Of the 25.4 million acres in Virginia, 60% is classified

FIGURE 8. Renewable Resources Predictable Pricing Emissiona.



as commercially productive woodland and has among the largest hardwood inventories in the country. Perhaps most important is that the Virginia forest products industry grows twice as much hardwood as it harvests annually, evidence of a commitment to sustainability. Overall the forest products industry consumes enough of its own “by-products” each year to save over 2,000,000 barrels of oil.¹

Predictable Pricing

In light of the historic drop in oil pricing during the end of 2014, it is difficult to predict with confidence future fuel pricing, especially over the ten year term of the agreement between Ferrum College and English Biomass Partners. However, in order for both parties to manage fuel pricing risk (either for wood or #2 fuel oil), the college agreed to a minimum payment for thermal energy usage based on a market price/gallon and a minimum quantity of fuel oil per year. It also has a provision for a floor usage and price/gallon based on 2010 performance. The actual quantity of thermal energy used is converted to a comparable quantity of fuel oil

FIGURE 9. Sawmill locations.

Situated in the middle of the U.S. Atlantic Coast, Virginia is an ideal location for trade. Its vast, abundant timber resource grows in three geographically distinct areas of the state, from the Coastal Plain, through the Piedmont, to the Appalachian Mountains. In fact, Virginia is located in the US Southern Forest Region which has been called “America’s wood basket.”

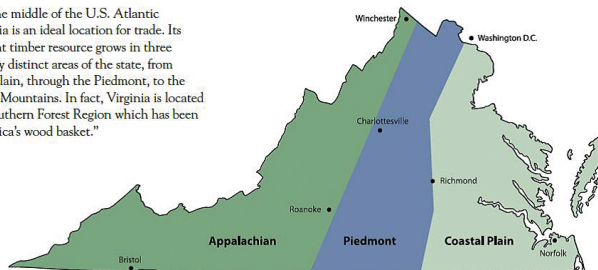


FIGURE 10. Wood Chips.



1. Published on the Virginia Forest Products Association website <http://www.vfpa.net/index.html>. 2014.

based on 134,700 Btu/gallon. English Biomass Partners in turn agreed to assume the pricing risk of wood waste and chips over the course of the agreement and the operational risks associated with converting the wood chips to thermal energy. While this solution does not completely eliminate pricing risk, it does establish a clear methodology for shared risk critical to any long term agreement.

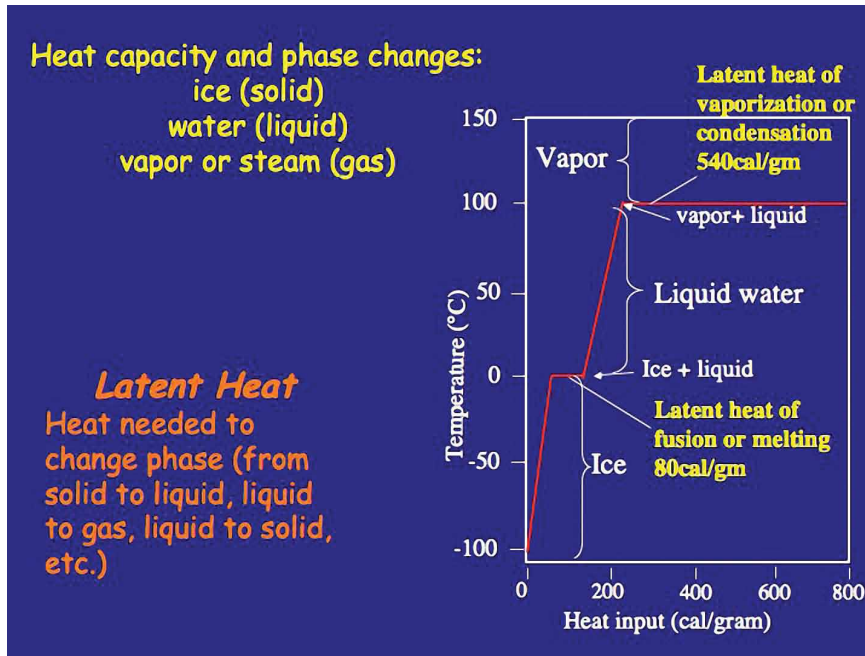


FIGURE 11. Latent Heat Chart.

Heating Values

In addition to assessing fuel supply and pricing, an understanding of the heating values in biomass is important. Quite simply, heating values represent the amount of heat generated from the combustion process in a biomass plant. But with wood byproducts heating values can vary quite dramatically by wood type and their specific moisture content.

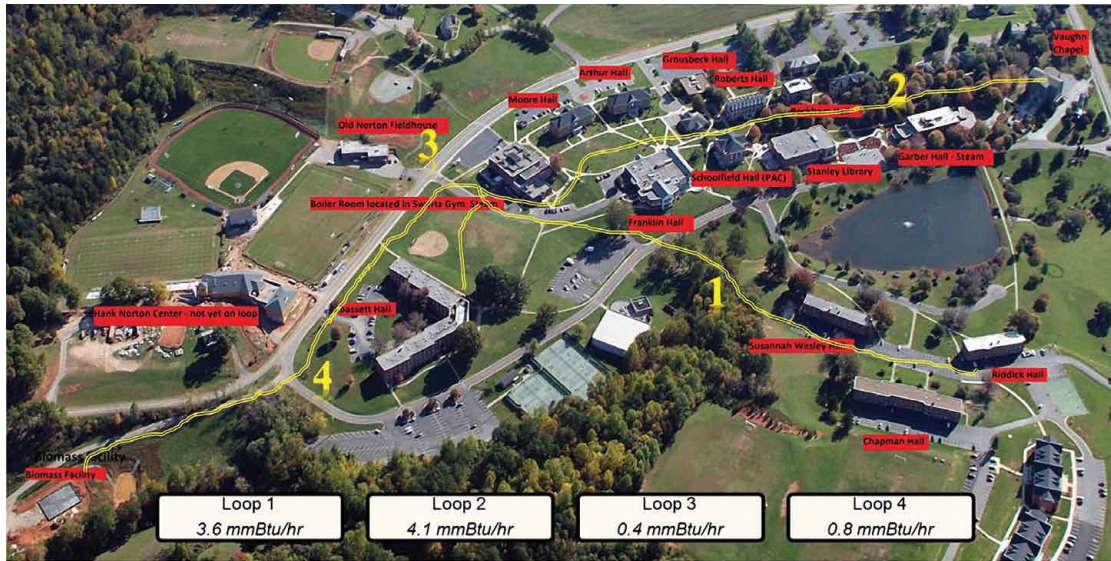
In order to establish the expected useful energy of any fuel like wood that contains water, the latent heat of vaporization must be determined. As the figure to the right illustrates, the heat required to change water from a liquid to vapor state is the latent heat.² Water content in a living tree can make up 30-60% of the raw weight of the tree. Hence, when wood is burned, energy is required to change that water into vapor. In every biomass plant design, the process of combustion requires that some energy in the fuel is used to change water into steam. The amount of energy required is dependent on the moisture content of the biomass. If the biomass is dry, less energy is required than when it contains higher quantities of water. Based on initial assays and a conservative estimate of heating values, the wood supply is assumed to have 45-50% moisture. This information was critical to designing the Biomass Plant.

2. Authors: Michael Arthur and Chris Marone, Department of Geosciences, College of Earth and Mineral Sciences, The Pennsylvania State University; Published on web @www.e-education.psu.edu/earth540/content/c3_p3.html ; © 2014 The Pennsylvania State University. This courseware module is part of Penn State's College of Earth and Mineral Sciences' OER Initiative. Except where otherwise noted, content on this site is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 3.0 Unported License.

OPERATING CONDITIONS BEFORE BIOMASS PLANT STARTUP

The campus heating system generated hot water (HW) at 325-340°F and circulated the HW at an estimated rate of 400 gallons per minute through approximately 12,000 feet of underground insulated pipe. The current campus heat load (space heating and domestic hot water) was met with a single 10 mmBtu/hr fuel oil fired boiler. However, the aging boiler, pumps, and heat exchangers required continuous manual intervention and a bit of creativity by facility engineers to achieve desired performance. Relatively little process performance data was

FIGURE 12. Renewable Resources Predictable Pricing Emissiona.



available and a plan was developed to begin data collection and analysis for the entire system and each individual building.

There are four loops linking the campus, served by a central plant main boiler as shown in the campus layout below.

Early Operational Findings

Energy consumption in building heating systems can be complex and depends on a variety of factors. The following is a short list of key findings:

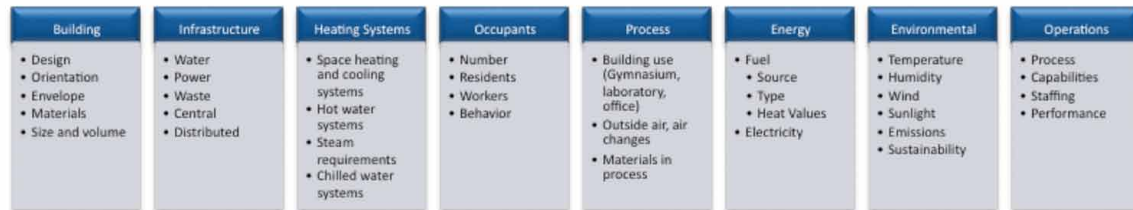
1. The least efficient buildings dictated the heating demand for the entire campus.
2. Few measurement and operational tools to fine tune the system performance existed.
3. Student and faculty behavior had a significant impact on overall thermal demand.
4. Performance of the Biomass Plant forced unexpected changes in operations elsewhere on campus.
5. Initiating other energy efficiency projects adversely affected the hoped for performance of the Biomass project.
6. Insights gained from this project have strengthened the commitment to sustainability at all levels.

The factors considered in the analysis of the Biomass plant design are shown on next page.

For example, people can easily understand that environmental conditions influence the amount of heating required. *Essentially, the colder the outside air temperature, the more energy*

it takes to heat a building. But the outside temperature doesn't just vary from one location to another - it varies all the time, wherever you happen to be. It's usually colder at night than it is in the day, and any single day/week/month/year is usually at least a little bit warmer or colder than the day/week/month/year before it.

FIGURE 13. Biomass Plant Design.



In general, Ferrum College uses the heating system to keep buildings at a constant temperature, therefore the amount of energy that the heating system uses will vary from one day/week/month/year to the next, just like the outside air temperature does. Understanding actual individual building performance is critical because it can reveal, as it did in this case, that one or two buildings drive the thermal energy required for the whole system. Heating degree days are a reasonable way to quantify all of this.

The base temperature of a building

With regard to heating degree days, the base temperature of a building is the temperature below which that building needs heating. All buildings have a core or base temperature - it can vary from building to building, but it most critically depends on two things:

- What temperature is set for each building? Typically the point at which the thermostat is set?
- How much free heating comes from the people, process, environmental conditions (e.g. solar gain) and equipment inside the building? In other words, what's the average internal heat gain?

Heating degree days were a simple way to quantify all of this. The idea is that the amount of energy needed to heat a building in any day/week/month/year is directly proportional to the number of heating degree days in that day/week/month/year. The base temperature for most of the buildings at Ferrum College was established at 65°F, though as a practical matter, the base temperature varies by building. In its simplest form:

$$\mathbf{1 \text{ degree (below } 65 \text{ }^\circ\text{F)} * 1 \text{ day} = 1 \text{ heating degree day}}$$

Interestingly, in the process of evaluating the impact of heating degree days, we discovered that it has increased by more than 47% during the last three heating seasons!

Early Testing

The early testing and operation of the Biomass Plant revealed further important issues requiring attention and modification before the commencement of a full heating season. These included both technical and operational considerations that could only be uncovered during the testing period. Some of the items were intuitive but others revealed information that could

FIGURE 14. Biomass Main Boiler.



only be determined accurately through operation. Important answers like how quickly could the system respond to thermal demand changes were confirmed. In addition, integrating the Biomass Plant operations with other energy efficiency strategies adopted by the College was crucial to achieving desired objectives. Some examples follow:

Hot Water Supply Temperature

The establishment of a target supply water temperature is critical to the effective management of any district hot water system. But the historical information for the Campus Hot Water Loop was based on completely different design parameters. Not only did the total mass flow of the system change, but coincidentally the college had decided to change the existing high temperature hot water system (330°) to a lower temperature system (190°) in hopes of reducing costs. This change was much more significant than might first appear. Fortunately, EBP and Ferrum jointly created test protocols and shared all of the data and worked collaboratively to develop a proper strategy.

It appears that the optimum supply temperature for the Biomass System is now approximately 250°. This temperature allows the Hot Water Loop to provide the necessary thermal energy to keep even the most inefficient of the buildings properly heated. Furthermore, at this

temperature, heat recovered from steam used to generate electricity could be used to preheat condensate thereby increasing the overall efficiency of the plant.

Having a firm target supply temperature allowed the Biomass Plant to tune its operations and achieve the highest fuel efficiency possible. In fact, it has resulted in some modifications to the biomass plant that, at present, yield efficiency results greater than 77%. It is expected that hoped for efficiencies in excess of 80% are achievable.

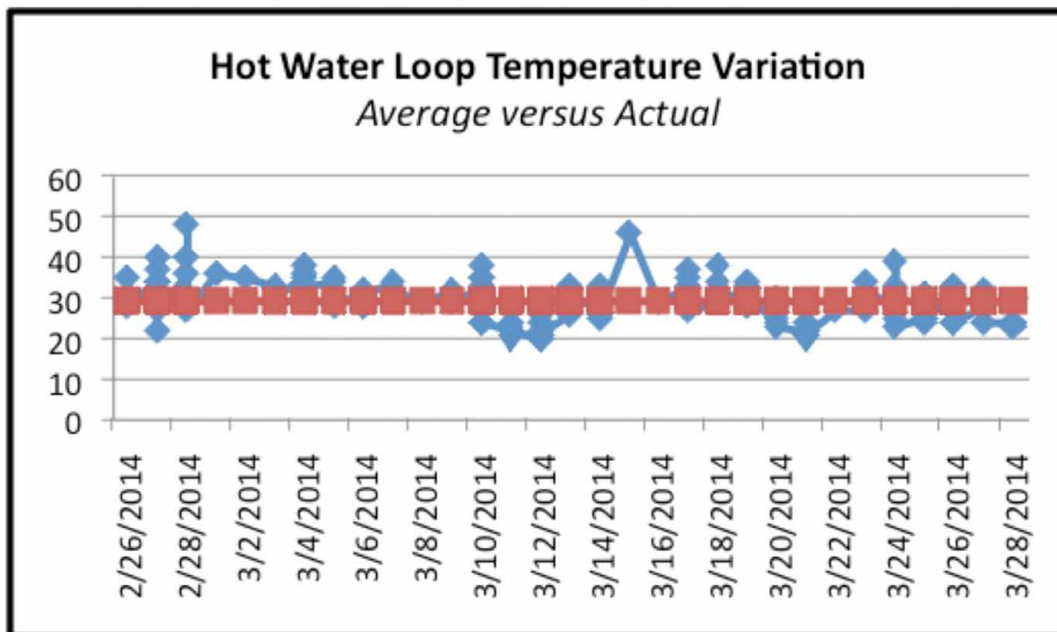
In the future, it may be possible to reduce the propane gas demand with heat from the biomass system.

Data Collection and Monitoring

Few tasks are more important to effective operations as is analysis of critical performance information. This is an aspect of design that is often overlooked. In fact, monitoring devices for biomass systems are frequently limited to the biomass plant itself. While proper controls and monitoring are essential in biomass plants, Ferrum and EBP have discovered together the power of appropriate information throughout the rest of the campus.

Perhaps the most important is the recognition that cooperation, information sharing, and joint problem solving between the biomass plant staff and the college facility staff is absolutely essential for success. This required a complete review of operating procedures for both the college and biomass plant. Procedures related to data collection included accurate, timely information has helped to overcome unexpected problems. For example, understanding temperature differences at various locations in the Hot Water Loop revealed faulty sensing devices (either not calibrated or inaccurate) that obscured or were misleading with respect to changes introduced into the system. The chart below illustrates this point. During a one month testing period, the difference between biomass plant supply and hot water loop temperatures were remarkably different. The culprits included measurement devices requiring recalibration or replacement.

FIGURE 15. Temperature Variation Chart.



When implementing a change this significant, one should anticipate making wholesale changes to the monitoring system for the entire campus in order to take advantage of the benefits.

Moreover it is clear that new controls and instrumentation will be necessary to manage the systems productively.

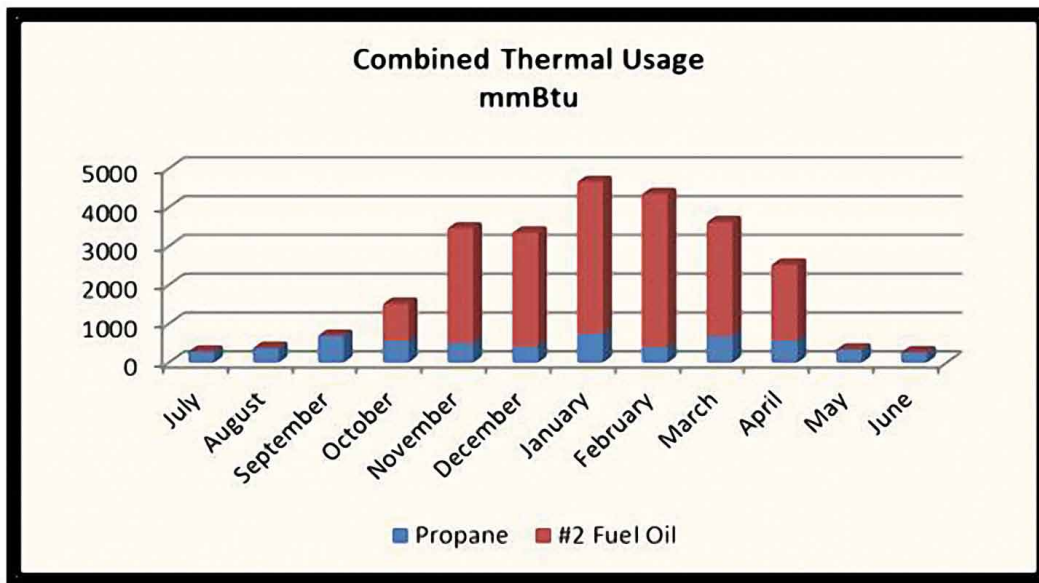
System knowledge

A third observation is that all operators and supervisors must clearly understand the entire system so that unintended and adverse consequences will be minimized.

Since the project was based on replacing #2 fuel oil with wood byproducts as the primary source of thermal energy, it required a thorough understanding of how #2 fuel oil was used to provide thermal energy. In many cases, information was readily available to answer key questions. However, in others, it did not exist and relevant data had to be identified, produced, collected and analyzed.

One of the annoying problems with older oil fired central heating systems is that there is often no gauge on the storage tank to indicate how much oil has been used or remains. If there is a gauge, frequently it is inaccurate or not properly calibrated. Often the only alternative left is to visually inspect the tank or rely on the oil delivery company to keep the tank topped up at their convenience.

FIGURE 16. Thermal Usage Chart.



In this case, determining expected use of #2 fuel oil for domestic hot water and space heating could only be deduced from oil delivery tickets over several years. While a seemingly simple task, linking fuel use to actual thermal demand proved more difficult than anticipated because of the absence of reliable performance data from existing systems. The table above shows the average thermal demand based on the amount of fuel oil and propane purchased for the campus hot water system. While a simple concept, developing accurate demand models can be very challenging.

Energy efficiency initiatives

During the implementation of the Biomass project, Ferrum College like other responsible owners continued to aggressively pursue other high priority energy efficiency initiatives affecting their entire campus. They included efforts to upgrade equipment, install new monitoring devices, and to improve performance of the existing hot water distribution system by operating at lower temperatures and flow rates. In addition, the college converted steam heating to hot water systems in two remaining buildings. While quite appropriate, these efforts sometimes obscured the true benefits of the biomass plant and required operational changes and coordination. Finally, when considering new initiatives, care must be taken to insure that benefits are not “double-counted”. This can happen when two or more initiatives claim the same benefits.

Biomass research and development

The college is excited about their investment in the research boiler and its potential to educate students and provide economic stimulus to the region. While the research program utilizing this new capability is still in its formative stage, with specific research to begin in 2015, an example of the potential is described below.

Biomass Feedstock Innovations

The combustion of agricultural crop waste or agricultural crops grown specifically for use as an alternative fuel to natural gas, fuel oil, or other fossil fuels, such as coal, can present a challenge to a steam generator. The use of an agricultural waste stream without first analyzing the chemical makeup of the waste stream may potentially increase fouling and corrosion of the heat transfer surfaces. This is mainly due to the fuels inorganic constituents, in particular the elements of potassium (K), chlorine (CL), and sulfur (S). These elements are naturally abundant in agricultural biomass. Upon combustion, these elements are partly released in the gas phase. Once released CL, K, and S are responsible for deposition of non-combustibles, commonly known as ash, on the heat transfer surfaces of the steam generator by decreasing the ash fusion temperature of the other constituents that make up the flue gas. These three inorganic elements in combination with the heat of combustion will cause excessive ash deposits on the heating surfaces of the steam generator.



The scientific community has developed an Alkali Index that helps predict the potential to cause increased fouling and or corrosion and thereby decreasing the heat transfer and efficiency of the steam generator. Generally, agricultural crops or other alternative energy fuels that have an Alkali Index from 0.1 to 0.4 can be combusted without causing fouling; 0.4 to 0.8 will have the potential to cause fouling; 0.80 to 1.0 will cause significant fouling and should be used with caution; 1.0 and greater should be avoided and not used for combustion.³

TABLE 16. Alkali Content and Slagging Potential of Various Biofuels.

Alkali Content and Slagging Potential of Various Biofuels						
Fuel	Btu/lb (dry)	Ash %	Total Alkali		lb/MMBtu	
			% in Ash	lb/ton		
WOOD						
Pine Chips	8,550	0.70%	3.00%	0.4	0.07	
White Oak	8,165	0.40%	31.80%	2.3	0.14	
Hybrid Poplar	8,178	1.90%	19.80%	7.5	0.46	
Urban Wood Waste "Clean"	8,174	6.00%	6.20%	7.4	0.46	
Tree Trimmings	8,144	3.60%	16.50%	11.9	0.73	
PITS, NUTS, SHELLS						
Almond Shells	7,580	3.50%	21.10%	14.8	0.97	
Refuse Derived Fuel	5,473	9.50%	9.20%	17.5	1.60	
GRASSES						
Switch Grass	7,741	10.10%	15.10%	30.5	1.97	
Wheat Straw-average	7,978	5.10%	31.50%	32.1	2.00	
Wheat Straw-hi alkali	7,167	11.00%	36.40%	80.0	5.59	
Rice Straw	6,486	18.70%	13.30%	49.7	3.80	
Bagasse - washed	8,229	1.70%	12.30%	4.2	0.25	
Source:						
Thomas R. Miles, Thomas R. Miles Jr., Larry L. Baxter, Bryan M. Jenkins, Laurance L. Oden. Alkali Slagging Problems with Biomass Fuels, First Biomass Conference of the Americas: Energy, Environment, Agriculture, and Industry, Volume 1, 1993.						

This research facility can provide unique opportunities to examine questions like:

- What combination of fuels with a low alkali index (such as waste wood) can be mixed with other biomass fuels with a high alkali index, (those normally not used for combustion), and successfully proven to be combusted generating meaningful thermal energy and not cause increased fouling and corrosion within the steam generator?

This can lead to the capability to

- Analyze local agricultural waste streams to determine their organic and inorganic components.

3. Thomas R. Miles, Thomas R. Miles Jr., Larry L. Baxter, Brian M. Jenkins, Laurance L. Oden, Alkali Slagging Problems with Biomass Fuels, First Biomass Conference of the Americas: Energy, Environment, Agriculture, and Industry, Volume 1, 1993.

- Calculate their alkali index ratio and determine if the waste stream product can potentially be used for combustion.
- Based on the alkali index and through laboratory combustion analysis calculate the ash fusion temperature of the biomass.
- If the results of the laboratory testing indicate that the ash fusion temperature and the alkali index will not cause increased fouling with the boiler, then combust the biomass waste stream in a steam generator for an extended period of time to verify the laboratory analysis.
- If the results of the laboratory testing indicate that the ash fusion temperature and the alkali index will cause increased fouling with the boiler, then experiment with other biomass fuels in combination that do not increase the ash fusion temperature or have a lower alkali index. Through laboratory combustion analysis of the combined fuels, calculate the new combined alkali index and ash fusion temperature.

The overall result of the research will be to create an alternative fuel or combination of fuels that can be combusted within a boiler that will not cause significant fouling and corrosion within the steam generator. This biomass fuel could then be used to replace conventional boiler fuels of natural gas, fuel oil, and/or coal.

Research job creation

There are no local laboratories within the region that can provide similar analysis of the potential biomass fuels that can be grown in the market. This facility/laboratory will be capable of performing all of the essential analysis described above. Even with a modest research program, it is quite possible that five full time personnel would be needed to support laboratory testing.

Commercialization

Biomass fuel harvesting normally occurs in the fall and winter months as the biomass fuels, other than wood waste, would be in the dormant state and dry. The analysis of previous alternative biomass fuels has shown that the nitrogen content of the biomass fuel is considerably less at this time of the year; therefore, the fuel would not significantly increase the formation of nitrous oxides during combustion. The harvesting of the biomass fuels would require farm workers who are usually not employed during the fall and winter months. This facility at Ferrum College would require 1500 to 2000 acres of crop residue to replace the conventional boiler fuel used during their heating season. The creation and cultivation of new and potential fuel streams could create many new full time positions just within the southwest region of Virginia and not necessarily just for the college but for new and existing commercial and industrial manufacturers. These new biomass fuels could provide the cost savings that existing commercial and industrial facilities require to remain competitive.

Educational Value

Ferrum College has one of the oldest environmental science programs in the country, and the only agriculture program in the local area based at a small liberal arts college. A hallmark of both the environmental science program and the agriculture program is the many opportunities provided for experiential learning and faculty-student research. Ferrum has a strong track record training graduates in the fields of forestry, wildlife, water quality, and soil and land conservation; the property already incorporates biomass plantings at the Titmus Agricultural Center.

This project will allow Ferrum College to expand student training, developing a strong and effective program related to biomass energy use and production. As the nation considers new models of securing low-carbon, low-pollution energy, the ability to train students in the collection and analysis of important data on factors such as the energy yield of different fuel sources, smokestack emissions, and economic uses of byproducts such as ash represents an emerging opportunity.

This proposed project will greatly expand opportunities at Ferrum College for student training in the emerging field of energy production. The boiler facility includes the only solid-fuel “research” boiler licensed to test new biomass energy feed stocks – this might include new fuels such as pressed algal byproducts, along with blends of various biomass feed stocks (wood and switchgrass, for example) and/or blends of biomass feed stocks with traditional fossil fuels such as coal.

Biomass energy is increasingly recognized as an important driver of local economies, and this region of Virginia and North Carolina is widely recognized as a “biomass sweetspot.” Nearby facilities such as Piedmont Geriatric Hospital in Blackstone, VA, are making significant investments in the purchase of both wood and native grasses for biofuel, and localities are making infrastructure investments in recognition of the local economic benefits of powering facilities from locally-sourced biofuels. Having the opportunity to provide hands-on training for students in all aspects of this biomass economy, including establishment, harvest, and boiler operation, provides a unique opportunity to truly see the “whole picture.”

DEAL STRUCTURE

As a small, independent college, Ferrum does not have the luxury of a huge endowment or deep funding sources. Hence, a project of this size, \$5,000,000, was not able to be reasonably funded by the college under normal circumstances. In this case, English Boiler and Tube, Inc. Partners was able to provide the capital to design and build the biomass plant in exchange for a 10 year energy purchase agreement.

Energy Purchase Agreement

English Boiler and Tube, Inc. provided all project funding, through their wholly owned subsidiary, English Biomass Partners. In December 2010, Ferrum College entered into an agreement with English Biomass Partners for the development of the biomass system and purchase of thermal energy and electrical power beginning on the date of commercial operation for a period of ten years.

The key components of the agreement include:

Land Lease	Operations	Fuel	Pricing	Taxes & Credits
<ul style="list-style-type: none"> • Duration • Terms and Conditions 	<ul style="list-style-type: none"> • Maintenance • Monitoring • Ash handling • Backup systems 	<ul style="list-style-type: none"> • Biomass purchases • Thermal and electrical calculations 	<ul style="list-style-type: none"> • Thermal energy • Electricity 	<ul style="list-style-type: none"> • Renewable Energy Credits • Rights • Ownership

In order to sell electrical power to Ferrum College, English Boiler Partners obtained a **competitive service provider** (CSP) license from the Virginia State Corporation Commission specifically for this project.

Risk Management

For both parties, there are risks associated with pursuing this strategy. However, the parties have worked to mitigate the risks and have developed reasonable solutions. A few samples of risks that have been addressed include the following:

1. Loss of thermal energy production from the biomass plant: The college has agreed to maintain the existing fuel oil main boiler for emergencies and the research boiler can be used to supplement the thermal needs of the college. The hot water loop continues to run through the existing main boiler in order to retain this capability.
2. Loss of electrical power production from the biomass plant: The college will continue to receive the bulk of its electricity requirements from the local utility and the power required to operate the biomass plant can be supplied by the utility as well.
3. Loss of local biomass fuel supply: There are a large number of wood chip suppliers within Virginia outside of the local area. There are more than 140 lumber mills in the state. Other fuels including wood chips are available for short term use.

Other risks or conditions may be unavoidable, for example, a continued trend toward lower heating season temperatures. However, the college has several initiatives to improve the performance of individual buildings aimed at making them more thermally efficient. And the biomass plant has been designed to be able to provide substantially more heat to the heating loop if necessary.

CONCLUSION

As noted at the beginning of this article, the purpose was to identify critical success factors and provide insight about processes that enhance the likelihood of success.

The critical success factors begin first and foremost with an alignment of purpose. Clearly, Ferrum College and English Biomass Partners are aligned in their big picture view of this project. Creating clear agreements about critical issues and assumptions reinforce understanding and the potential for success. Secondly, a close working relationship between Ferrum College and EBP was forged early, and they worked hard to maintain it. This was essential when challenges were uncovered that no one anticipated. In fact, as the project progressed, individual problems began to be viewed as everyone's concern. Thirdly, understanding the strengths and weaknesses of the existing system provided insight that improved the performance of the biomass plant. The best example was that as result of the college's decision to adopt a low temperature hot water system a modification to the original concept was incorporated so that both ideas could be executed successfully.

Notwithstanding all of the positive accomplishments, continued commitment to one another is absolutely essential for the long term success of the biomass plant system.

