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Preliminary Feasibility Report

Sullivan County Nursing Home and Department of Corrections Complex Biomass Heating Project

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The Wood Education and Resource Center is located in Princeton, W.Va., and administered by the Northeastern Area State and Private Forestry unit of the U.S. Department of Agriculture Forest Service. The Center's mission is to work with the forest products industry toward sustainable forest products production for the eastern hardwood forest region. It provides state-of-the-art training, technology transfer, networking opportunities, applied research, and information. Visit www.na.fs.fed.us/werc for more information about the Center.

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1.0 EXECUTIVE SUMMARY

The government of Sullivan County, NH (SCNH) operates a nursing home and county jail (DOC) in south central New Hampshire, near the town of Claremont. The two facilities are adjacent to each other on property that once composed the county farm. This preliminary feasibility study evaluates options for SCNH to utilize renewable biomass energy to offset fuel oil use for space and domestic hot water heating as well as the operation of an onsite laundry. The report evaluates biomass utilization in thermal and thermally-led combined heat and power (CHP) options. Installation of a biomass boiler would present SCNH with the opportunity to decrease operating costs, increase heating system redundancy, and reduce CO_2 emissions.

Existing Energy Usage and Systems

SCNH supplied WERC with two years of fuel delivery and electric usage data beginning July 1, 2009 and ending June 30, 2011. Load modeling for the report is based on data from the second year beginning July 1, 2010 and ending June 30, 2011. 124,943 gallons of fuel oil were used by both the nursing home and DOC during this time period at a total cost of $323,178. SCNH estimated the fuel oil price at $3.25/gallon for the upcoming heating season. The last reported price of $3.46/gallon was for a delivery made on June 30, 2011. In addition to the fuel oil, 35,000 gallons of propane were used onsite mainly for air reheat in rooftop units. . As a result, this usage was not included as a potential fossil fuel offset for the biomass system. A more detailed investigation is recommended to determine if a portion or the entire load could be included in the biomass system.

One 3.35 mmBtu/hr input (approximately 2.7 mmBtu/hr output at 80% efficiency) Cleaver Brooks boiler produces 8 psig steam that is distributed for space heating in the office portion of the nursing home and used to generate hot water for space heating in the rest of the building. Steam is also used to heat domestic hot water in a shell and tube heat exchanger located in the boiler room. Two Fulton 1.6 mmBtu/hr output boilers produce steam at 90 psig in the DOC. Steam is distributed throughout the facility at 90 psig and is used for space heating, domestic hot water generation, and operation of four 120 lb capacity steam laundry dryers. Two of the three Cleaver Brooks boilers in the nursing home were installed in 2000 while the third was installed in 1974. All three boilers are in good condition. The two Fulton boilers in the DOC were installed as part of a renovation project completed in 2010. After only a year of operation, they have proven to be maintenance intensive and show considerable wear.

Biomass Availability and Price

Modern biomass combustion systems can burn a variety of fuels with a wide range of moisture content. Wood chips were selected as the basis for analysis because of their availability and price. A survey conducted in the summer of 2011 by the New Hampshire Timberland Owners' Association indicated that wood chips with approximately 40% moisture content by weight are available from $20/ton to $50/ton and that an adequate local supply is available to provide the estimated maximum of 1,916 tons required annually. A cost of $42/ton is used for this prefeasibility analysis, corresponding to a budgetary quotation received September 28, 2011.

Options Evaluated

Three wood fueled biomass boiler system options are evaluated in this report. Option 1 is a system that produces steam to offset the use of fuel oil for space heating at the SCNH complex. Option 2 includes the same boiler capacity as Option 1 and adds the ability to generate renewable electricity from biomass. Energy cost for electric generation will typically cost less than $0.02 per kWh generated with a thermally-led combined heat and power system. Option 3 provides the same capability as Option 2, but in a different configuration. The biomass system options were sized and evaluated using a load model that was developed from the fuel delivery data supplied by SCNH and local weather data. The options include the following equipment:

Option 1 – Steam Only: A 150 hp wood chip fueled biomass boiler (~5,000 lb/hr steam) rated at 150 psig, operated at 90 psig. This system would replace 75% of the fuel oil usage at both the nursing home and DOC with wood chip fuel.

Option 2 – Combined Heat and Power: Biomass Plant and Nursing Home: The addition of a 50 kW backpressure steam turbine/generator in the biomass plant and a 40 kW backpressure steam turbine/generator in the nursing home would replace 90% of the total fuel oil usage and generate 297,100 kWh of electricity. This would replace 18% of the combined nursing home and DOC annual electric usage. The turbine/generator located in the biomass plant would be connected directly to the main electric service that supplies both facilities in the complex. The turbine/generator located in the nursing home would be connected directly to the main service supplying the nursing home. An analysis of the total electric usage for both buildings indicates that the combined capacity of the turbine/generators does not exceed half of the total demand. This suggests that net metering is not required. A more detailed investigation of the electric demand is recommended to confirm if net metering is required and to optimize the interconnection of the turbine/generators.

This option requires a boiler rated at 450 psig operated at 410 psig and a condenser to reject heat during periods of low space heat demand. Including the condenser allows the system to continue to operate at a minimum output of 1.25 mmBtu/hr when space heat demand is below this level. This ability increases both the amount of electricity produced and the fuel oil offset compared to Option 1 by allowing the boiler to run throughout the off-heating season. The difference in cost between fuel oil and wood chips coupled with the current electric cost make this system configuration favorable versus only operating the wood fueled boiler based on heat demand alone. Also, the amount of heat rejected during the periods of low space heat demand is 40% of the total energy usage for that period, maintaining a low generated electricity cost. This energy amounts to less than 10% of the total annual heat generation.

Option 3 – Combined Heat and Power: Nursing Home: This option combines the 150 hp boiler rated at 150 psig operated at 130 psig with the 40 kW backpressure turbine/generator and the condenser in the nursing home. This arrangement generates 137,000 kWh of renewable electricity which is about 9% of the total annual consumption at the complex. Similar to Option 2, this arrangement would also offset 90% of the fuel oil usage at the complex.

All three of the options require a 2,700 sf building located centrally between the nursing home and DOC facilities that include a boiler room, control room, and a fuel storage area.

Biomass Project Costs and Benefits

The capital cost associated with Option 1 is $2.1 million which includes the boiler, boiler housing, fuel storage, underground steam piping, and interconnections with the existing boiler systems. Option 2 would have a net add of $600,000 for increased boiler operating pressure, the turbine/generator equipment, and steam condenser for a total project cost of $2.7 million. Option 3 would have a net add of $200,000 to the cost of Option 1 for a turbine/generator, and steam condenser for a total project cost of $2.3 million. The investment in Option 1 generates a $219,000 first year net operating savings and a 9.6 year simple payback period. The investment in Option 2 provides a $296,000 first year net operating savings and a 9.0 year simple payback. Option 3 generates a first year net operating savings of $281,000 and a 8.3 year simple payback. A summary of the first year net operating savings analyses are shown in Table ES1.

Table ES1 – Nursing Home and DOC Biomass System Potential Net Operating Savings

Option*	Current Fuel Oil Cost	Value of Electricity Generated	Estimated Wood Chip Cost	Estimated Fuel Oil Cost w/Wood System	Additional O&M Costs for Wood System	Potential First Year Net Operating Savings
1 -Steam Only	$406,056	---	$(61,640)	$(101,514)	$(24,264)	$218,638
2 -CHP: Biomass and Nursing Home	$406,056	$39,514	$(80,459)	$(40,606)	$(28,264)	$296,241
3 -CHP: Nursing Home Only	$406,056	$18,260	$(76,774)	$(40,606)	$(26,264)	$280,672

* **All Options include supplying steam to both the nursing home and DOC.**

A cash flow analysis was completed for financing the project over a 20 year term at 4.5% interest. Under this scenario, Option 1 has a 25-yr net present value of $3,499,261 while Option 2 has a net present value of $4,924,844, and Option 3 has a net present value of $4,910,974. Table ES2 shows a summary of the results of this analysis.

Table ES2 – Nursing Home and DOC Biomass System First Year Cash Flow Analysis Summary

Option[1]	Financed Amount	Annual Financing Payment[2]	1st Year Net Cash Flow	25 Year Net Present Value
1 - Steam Only	$2,090,603	$(160,718)	$57,921	$3,499,261
2 - CHP: Biomass and Nursing Home	$2,669,009	$(205,183)	$91,058	$4,924,844
3 - CHP: Nursing Home Only	$2,326,003	$(178,814)	$101,859	$4,910,974

[1]**All Options include supplying steam to both the nursing home and DOC.**
[2]**Assumes 20 year financing at 4.5% interest rate.**

Conclusions and Recommendations

Woody biomass presents SCNH with an opportunity to reduce its operating costs at the nursing home and DOC complex located near Claremont, NH while offsetting a large portion of their fossil fuel use with renewable energy. Option 1, steam only, would produce steam for heat in both the nursing home and DOC for a capital cost of $2.1 million and provide a first year net operating savings of $219,000. Option 2, CHP in the biomass plant and nursing home, would provide steam for space heating offsetting 90% of the annual fuel oil usage as well as generating 18% of the complex's annual electricity demand for a cost of $2.7 million. This option would produce a first year net operating savings of $296,000. Option 3, CHP in the nursing home only, would offset 9% of the annual electric usage with renewable electricity while providing a first year net operating savings of $281,000 for a cost of $2.3 million. These savings provide project simple paybacks of 9.6 years for Option 1, 9.0 years for Option 2, and 8.3 years for Option 3. 20 year financing at a 4.5% interest rate results in a 25 year Net Present Value (NPV) of $3.5 million for Option 1, $4.9 million for Option 2, and $4.9 million for Option 3. Additional benefits that would be provided by a woody biomass project include:

- Support of the local economy through the purchase of a minimum of $61,000 of locally sourced renewable wood chip fuel;
- Decreased dependence on imported oil by replacing 93,000 gallons of fuel oil with renewable wood chip fuel;
- A hedge against volatility of the fossil fuel market;
- A minimum 948 metric ton decrease in CO_2 emissions through the use of renewable wood chip fuel instead of non-renewable fuel oil;
- Increased heating system redundancy for the SCNH complex.

As SCNH continues to pursue biomass renewable energy options, WERC recommends that the next level of evaluation includes detailed consideration of the following items:

- Actual steam consumption at both facilities to determine the optimum biomass boiler size. This will maximize fuel oil offset and annual savings.
- The potential to offset propane used by rooftop heating units with the biomass system.

- Biomass system capital costs based on detailed site investigations, initial plant layout and design, and direct quotes from manufacturers.
- Alternative funding sources (low interest loans, grants, and incentives).
- Local boiler operating and licensing requirements for the recommended boiler operating pressures.

WERC also recommends that SCNH personnel visit existing biomass boiler installations to develop a detailed understanding of the equipment and its capabilities. WERC is available to assist SCNH in arranging tours of existing facilities.

2.0 INTRODUCTION

2.1 WERC PROGRAM

The USDA Forest Service Wood Education and Resource Center (WERC) is providing professional services to promote and support projects utilizing wood energy in a sustainable manner. This is being done through the Wood Energy Utilization Support Program. The goal of the program is to promote the Forest Service's Northeast Area Strategic Plan objective on the sustainable use of forest resources to provide efficient use of renewable energy resources and accomplish greenhouse gas reduction. The services are available to public and private entities (clients) interested in and committed to efficient use of local wood for energy. This report is the result of the feasibility-level study and was developed under the WERC program by Wilson Engineering Services, PC.

2.2 SULLIVAN COUNTY OPPORTUNITY

The government of Sullivan County, NH (SCNH) operates a nursing home and jail (DOC) in south central New Hampshire. The two facilities are adjacent to each other in a rural location outside of the town of Claremont, NH. This location and the close proximity of both facilities provides the opportunity to offset fossil fuel usage with woody biomass fuel for space and domestic hot water heating through the installation of a wood chip fueled biomass boiler. Space is available to construct a building to house the biomass boiler and fuel storage in a central location between the DOC and nursing home. This location would provide easy access for fuel delivery trucks with minimal disruption to the operation of the DOC and nursing home. Underground distribution pipes could deliver steam to the existing boiler rooms in each facility. Nearby forest industry and infrastructure is capable of providing an adequate supply of wood chips at a competitive cost that would significantly reduce the County's heating related expenses at this complex and protect it from volatility in the fossil fuel energy market. The replacement of fuel oil with renewable woody biomass fuel would also decrease the County's carbon footprint and retain fuel expenditures in the local economy.

3.0 EXISTING ENERGY USE AND SYSTEMS

Both the DOC and the nursing home currently have steam distribution systems that provide both heat for building space and domestic hot water. Each building has a boiler room that houses fuel oil fired steam boilers.

3.1 EXISTING SYSTEM

Nursing Home: Steam is produced by one 3.35 mmBtu/hr input (approximately 2.7 mmBtu/hr output at 80% efficiency) Cleaver-Brooks fuel oil boiler. Two of these boilers were installed in 2000 (one is online and the other provides backup) and are only capable of producing 15 psig steam. Steam is distributed in the office portion of the facility at 8 psig. Hot water is distributed throughout the nursing home portion of the facility. A shell and tube heat exchanger in the boiler room converts steam to hot water. Certain areas of the building are heated by propane fueled rooftop air handling units. Inclusion of these heating loads in the biomass system is not likely to be practical and was not included in this analysis. All equipment is in good condition.

DOC: Steam is produced by two 1.6 mmBtu/hr output Fulton fuel oil boilers. Both boilers were installed during a recent renovation project and produce steam at 90 psig. The renovation also included moving the main laundry services for both facilities from the nursing home to the DOC. The laundry includes four 120 lb capacity steam heated dryers that require an estimated peak of 1,000 lbs steam/hr total at 90 psig when operating at full capacity. To service this load, steam is distributed throughout the building at 90 psig for space heating and domestic hot water production; however, all components in the system other than the dryers can operate on 10 psig steam. Domestic hot water production for the facility is generated by shell and tube heat exchangers distributed throughout the building. All heating equipment is generally in good condition except for the two boilers which have proven to be maintenance intensive and show considerable wear after only one year of operation.

3.2 CURRENT ENERGY USAGE AND COST

Sullivan County provided fuel delivery data for both facilities for the two years beginning July 1, 2009 through June 30, 2011. A summary of this data is shown in Table 1. During the fiscal year starting in July 2010 and ending in June 2011, 49,795 gallons of No. 2 fuel oil were used at the DOC and 75,148 gallons were used at the nursing home for a total of 124,943 gallons. The total energy cost for this period was $323,178. The shift in energy use from the nursing home to the DOC between the two years reflects the relocation of the laundry. Table 2 shows an estimated monthly breakdown of the fuel usage based on the delivery data for this same period. SCNH estimated the fuel oil price at $3.25/gallon for the upcoming heating season at the site. The last reported price of $3.46/gallon was for a delivery made on June 30, 2011. In addition to the fuel oil, 35,000 gallons of propane were used with rooftop heating units that are not included in this analysis. A more detailed investigation is recommended to determine if a portion or the entire load could be included in the biomass system.

Table 1 – Nursing Home and DOC Annual Fuel Oil Usage

Heating Season	Nursing Home Oil Usage (gal/yr)	DOC Oil Usage (gal/yr)	Total Complex Oil Usage (gal/yr)	Average Oil Cost ($/gal)	Total Annual Fuel Cost ($/yr)
July '09-June '10	113,625	12,278	125,903	$2.51	$316,016
July '10-June '11	75,148	49,795	124,943	$2.59	$323,178

Table 2 – Nursing Home and DOC Estimated Monthly Fuel Oil Usage

Month	Estimated Oil Usage (gallons)
July 2010	6,773
August 2010	5,258
September 2010	5,384
October 2010	13,835
November 2010	13,234
December 2010	16,031
January 2011	13,005
February 2011	9,045
March 2011	15,164
April 2011	8,175
May 2011	11,613
June 2011	7,426

The July 2010-June 2011 fuel usage was selected to be the basis for load modeling at the facilities. This selection is based on analysis of weather data. Local weather data was obtained from WeatherUnderground reporting station KVSF in Springfield, VT and compared with the average heating season through determination of the number of heating degree days (HDD's). A summary of this data is shown in Table 3. A comparison of the HDD's during July 2010-June 2011 to the long-term average annual HDD's yielded a 6% difference, which indicates that the July 2010 through June 2011 heating season is representative of a typical heating season. Thus, the consumption of 124,943 gallons was used as the typical annual fuel oil consumption for the analysis included in this report.

Table 3 – SCNH Heating Degree Day Summary

Time Period	Heating Degree Days
July 2010-June 2011	7,483
1981-2011*	7,930

**Source: National Weather Service reporting station in Newport, NH.*
Data retrieved from http://nowdata.rcc-acis.org/CTP/pubACIS_results

The average daily boiler output (mmBtu/hr) shown in Figure 1 was developed based on the total fuel usage for both the nursing home and DOC along with daily weather data. On average, a base load of 788,000 Btu/hr exists in the off-heating season, while a peak average load of 3.5 mmBtu/hr occurs during the heating season. The base load corresponds to the average daily fuel usage during the month of August, when little space heating is done. The heating loads were developed using the base load and a fuel oil usage per heating degree day that was adjusted so that the modeled total annual usage matched the reported annual total usage. It is important to note that Figure 1 shows the estimated average output for each day. During each

day, the actual loads will fluctuate. Monitoring of similar facilities has shown fluctuation of loads above or below the daily average by up to 30% during the heating season. During the summer months, this fluctuation will be even greater since the majority of usage will be for occasional hot water demand and laundry operations. Figure 2 contains the load duration curve for the average boiler output data shown in Figure 1.

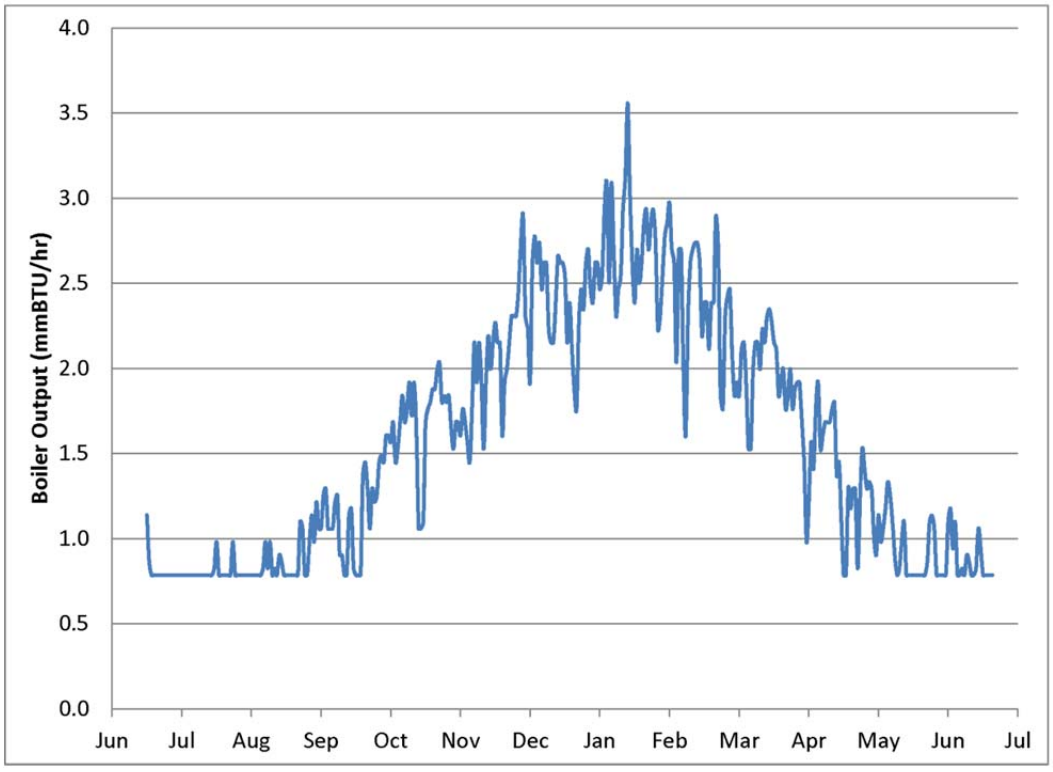


Figure 1 – Nursing Home and DOC Average Daily Boiler Output (July 2010 – June 2011)

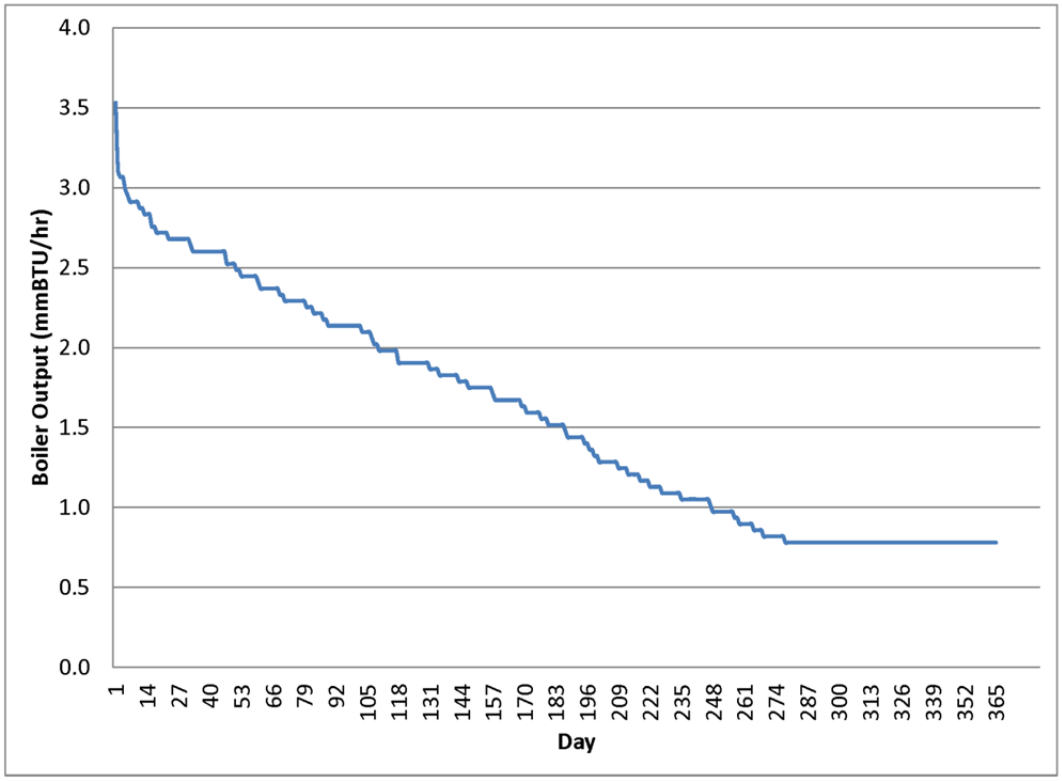


Figure 2 – Nursing Home and DOC Load Duration Curve (July 2010 – June 2011)

4.0 BIOMASS AVAILABILITY AND PRICE

The proposed biomass boiler system can accommodate a variety of different biomass fuels. For the purposes of this study, all values are based on using whole tree wood chips at a cost of $42/ton. This information is based on a budgetary quote received September 28, 2011. A market survey conducted by the New Hampshire Timberland Owners Association that was published in the summer of 2011 indicated wood chips are available for a cost ranging from $20 to $50/ton. This survey indicated that there is adequate supply to provide the estimated maximum usage of 1,916 tons of wood chips annually. The following companies were identified as potential sources of wood chips:

- Cousineau Forest Products, Henniker, NH
- D. H. Hardwick & Sons, Inc., Bennington, NH

Wood chips are transported in walking floor style trailers that have a typical capacity of 22 tons. Deliveries would range from one every other day in the peak heating season to one per week in the off-peak season.

5.0 BIOMASS SYSTEM OPTIONS

Three options are evaluated in this report. Option 1 is a system that provides steam to offset the use of fuel oil generated steam at the SCNH complex. Options 2 and 3 provide the ability to provide steam for heating and generate renewable electricity from biomass at a cost of $0.02/kWh or less through a thermally-led combined heat and power system. The biomass

system options were sized and evaluated based on the load model previously described. The options considered include the following equipment:

Option 1 – Steam Only: A 150 hp (5.0 mmBtu/hr) biomass fired boiler (~5,000 lb/hr steam) rated at 150 psig, operated at 90 psig. This would replace 75% of the fuel oil usage at both facilities with wood chip fuel.

Option 2 – Combined Heat and Power: Biomass Plant and Nursing Home: This option will require a 150 hp boiler rated at 450 psig and operated at 410 psig with a condenser to reject heat at periods of low space heat demand. The addition of a 50 kW backpressure steam turbine/generator in the biomass plant and a 40 kW backpressure steam turbine/generator in the nursing home would replace 90% of fuel oil usage in both facilities and generate 297,100 kWh of renewable electricity. This would replace about 18% of the combined nursing home and DOC annual electric usage.

Option 3 – Combined Heat and Power: Nursing Home: This option combines a 150 hp boiler rated at 150 psig and operated at 130 psig with a 40 kW backpressure turbine/generator and condenser located in the nursing home. This arrangement generates 137,000 kWh of renewable electricity which is about 9% of the total annual consumption at the complex. Similar to Option 2, this arrangement would also offset 90% of the fuel oil usage at the complex.

For each of the options, the boiler will be housed in a newly constructed building of about 2,700 square foot that is centrally located between the nursing home and DOC. The boiler would be interconnected to the steam supply and condensate return headers in each building via underground insulated pipe. A portion of this building would include a wood chip storage facility that would hold 2 days of chip storage at maximum boiler output. Appendix A contains a description of the approximate location and layout of the biomass boiler plant along with a schematic of the biomass boiler system options.

5.1 OPTION 1 - STEAM ONLY

A 150 hp (5.0 mmBtu/hr) biomass boiler rated at 150 psig, but operated at 90 psig will supply steam to both the nursing home and DOC. The 90 psig steam will be piped directly to the supply headers in the nursing home and DOC. This steam will supply heat for domestic hot water, space heating, and steam operated laundry dryers in the DOC. In the nursing home, the pressure will be reduced to 8 psig and distributed for space and domestic hot water heating.

Wood chip fueled biomass boilers operate most efficiently between 25% and 100% (1,250 to 5,000 lbs steam /hr) of their output, which will enable this system to replace 75% of the total fuel oil usage with renewable wood chip fuel. The fuel oil boilers in each facility will operate during periods of low demand. The shaded area in Figure 3 illustrates this operation. It is assumed that for approximately 150 days of the year there will not be enough consistent load to enable the biomass system to operate effectively with this option.

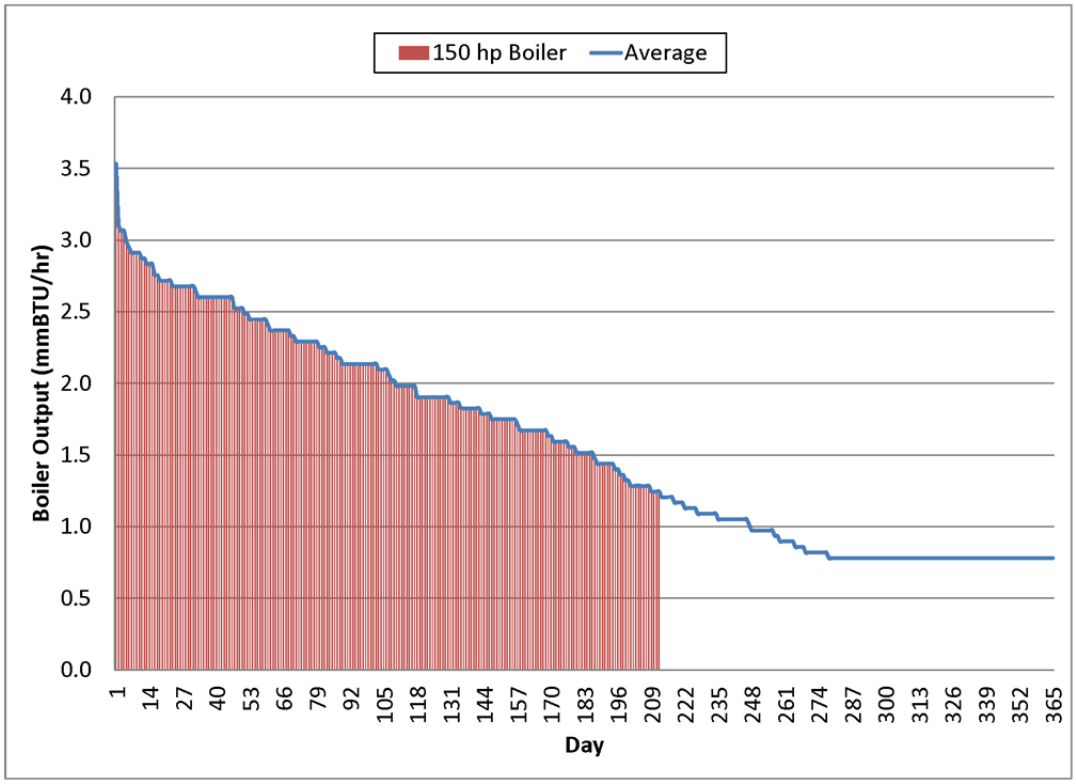


Figure 3 – Biomass Steam Only Average Daily Output Coverage (Option 1)

5.2 OPTION 2 - COMBINED HEAT AND POWER: BIOMASS PLANT AND NURSING HOME

The addition of a backpressure steam turbine/generator would add the ability to generate electricity. The proposed system consists of two turbine/generators. One 50 kW turbine/generator installed in the biomass plant and one 40 kW turbine/generator installed in the nursing home. The boiler supplying the steam would be rated at 450 psig, and operated at 410 psig. The steam produced would flow through the turbine/generator in the biomass plant, expanding from 410 psig to 90 psig before being distributed to the nursing home and DOC to satisfy heat demand. Steam flowing into the nursing home would pass through the second turbine/generator expanding from 90 psig to 8 psig before being distributed in the building to satisfy heat demand.

This configuration is thermally-led, meaning that the output of the turbine/generator generally follows the output of the boiler to meet heat demand. An estimated 14 kW of electricity per 1,000 lbs of steam passing through the turbine would be generated by the turbine in the biomass building. The turbine/generator in the biomass plant is sized to operate efficiently through the same range of steam flow rates as the boiler. The result is the turbine can operate efficiently from 25% to 100% of its rated capacity or 5,000 to 1,250 lbs of steam/hr when coupled with the 150 hp boiler. Only 60% of the total annual steam produced is used in the nursing home. The turbine/generator located in the nursing home is sized to efficiently operate

from 4,000 to 1,000 lbs steam/hr, producing 15 kWh per 1,000 pounds of steam passing through the turbine. After passing through the turbine/generator in the biomass plant, the steam available for heating for the entire complex would range from 4,810 to 1,200 lbs of steam/hr. The amount of steam available to the nursing home after passing through the turbine/generator there would range from 3,920 to 980 lbs of steam/hr.

The addition of a condenser in the nursing home would allow the boiler to continue to operate below its effective minimum output of 1,250 lbs of steam/hr. The result is that both turbine/generators continue to produce electricity when the heat demand is below 25% of the boiler's rated capacity (1,250 lbs of steam) by rejecting a portion of the heat to the atmosphere. This scenario would generate 297,100 kWh annually at an effective cost of $0.02/kWh, replacing 18% of both the nursing home and DOC's combined annual electric usage. Also, it would allow the boiler to operate effectively throughout the year, leading to a 90% replacement of the annual fuel oil usage. The rejected heat does not have a large effect on the system efficiency. The shaded area in Figure 4 illustrates operation with the condenser, while the green line illustrates the anticipated peak heating demands. Note that the shaded area above the average daily steam demand represents the heat rejected throughout the course of the year. A schematic describing this system is displayed in Appendix A.

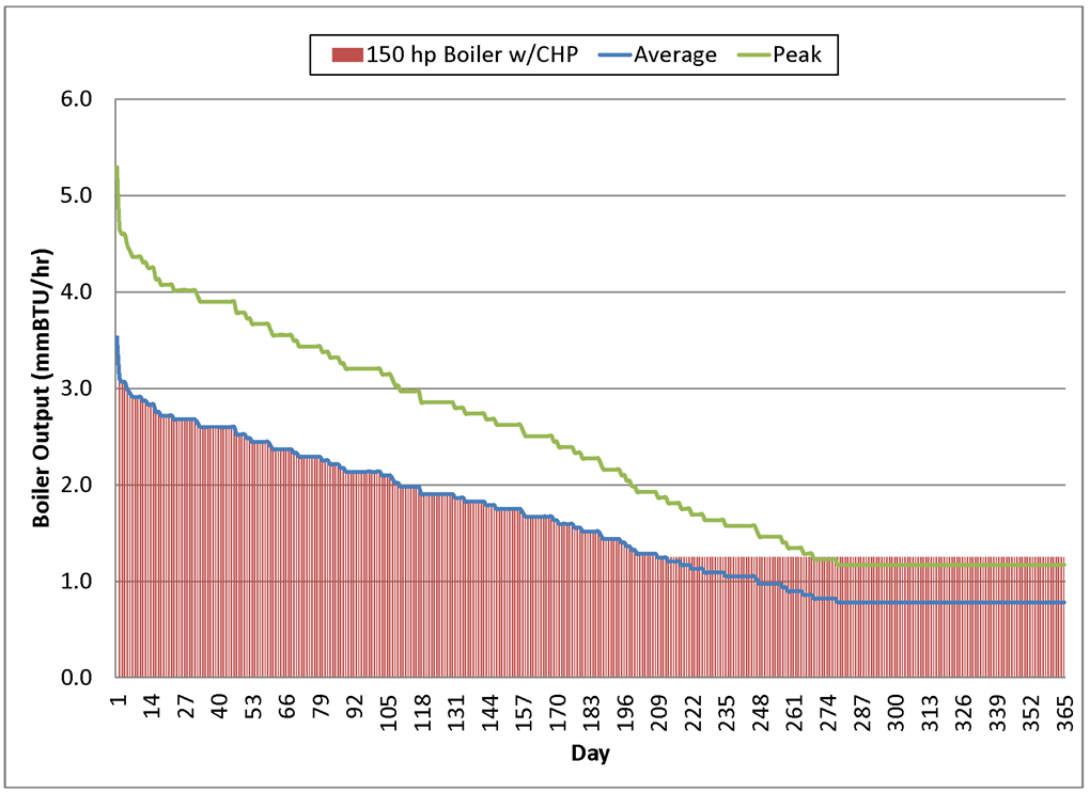


Figure 4 – Biomass CHP Average Daily Output Coverage for Options 2 and 3

The turbine/generator housed in the biomass building would be interconnected through the biomass service entrance directly to the main electric service supplying the entire complex, providing the opportunity to offset electricity purchased from the utility. The turbine/generator

located in the nursing home would be connected to the main nursing home service, providing the same opportunity. An analysis of the electricity usage at both facilities indicated that the combined 90 kW capacity of the two turbine/generators does not exceed half of the average electricity demand. This suggests that net metering may not be required. A more detailed investigation into the electric demand profile of both buildings is recommended to determine the best method of interconnecting the turbine/generators.

5.3 OPTION 3 - COMBINED HEAT AND POWER : NURSING HOME ONLY

This option is similar to Option 2 except it would involve a 150 hp boiler rated at 150 psig that would operate at 130 psig. 130 psig steam would expand to 8 psig through a 40 kW turbine/generator in the nursing home generating 137,000 kWh of renewable electricity at a cost of $0.02/kWh and rate of 18 kWh per 1,000 pounds of steam passing through the turbine. This is 9% of the total complex annual electric usage. Also, it would provide the opportunity to replace approximately 90% of the annual fuel oil usage by including the condenser to reject heat during periods when the heat demand is less than 25% of the boiler's maximum output. The boiler coverage illustrated in Figure 4 applies to the boiler operation in this Option as well as Option 2.

6.0 ANALYSIS OF OPTIONS

6.1 CAPITAL COST ESTIMATE AND OPERATIONAL COSTS

Capital costs for constructing and integrating a woody biomass project into SCNH's existing infrastructure are shown in Table 4 for each option.

Table 4 – Project Capital Cost Estimate Summary

Option	Capital Cost
1-Steam Only	$2.1 million
2-CHP: Biomass Plant and Nursing Home	$2.7 million
3-CHP: Nursing Home Only	$2.3 million

Additional costs for CHP include an increase in the maximum boiler rating from 150 psig to 450 psig for option 2, installed costs for backpressure steam turbine/generators, pressure reducing valves to bypass the turbine/generators for maintenance or emergencies, and the steam condenser. Costs were based on recent quotations and bids provided by boiler and steam turbine/generator manufacturers. Estimates include equipment costs, building costs, and associated professional fees. A multicyclone is included with the boiler to control particulate emissions. A table showing the detailed cost breakdown for each option is in Appendix B.

Table 5 shows an estimate of annual operation and maintenance costs associated with the wood system. The biomass plant may not require the presence of a full-time boiler operator onsite. Local regulations may have special requirements depending on steam pressures. These regulations should be investigated. It is assumed for the purposes of this analysis that the existing staff will operate the system with a negligible increase in labor hours.

Table 5 – Biomass Annual Operations and Maintenance Cost

Item	Annual O&M Cost
Electricity	$14,824
Ash Removal	$2,720
Maintenance Contract/Wear Parts	$5,000
Hearth Grates & Ash Screw (Replaced every 5 years)	$1,040
Stoker & Furnace Screw (Replaced every 10 years)	$680
Steam Turbine/Generator Maintenance (CHP only)	$4,000

6.2 FINANCIAL ANALYSIS

The first year net operating savings were calculated for both biomass system options. The resulting energy profiles for each option are shown in Table 6.

Table 6 – Proposed Biomass System Energy Profile Summary

Option	Current Fuel Oil Usage (gal/yr)	Portion of Fuel Oil Replaced	Estimated Wood Chip Usage (ton/yr)	Estimated Fuel Oil Usage w/ Wood System (gal/yr)	Estimated Electricity Generated (kWh/yr)
1- Steam Only	124,940	75%	1,468	31,235	---
2- CHP: Biomass and Nursing Home	124,940	90%	1,916	12,494	297,096
3- CHP: Nursing Home	124,940	90%	1,828	12,494	137,294

Table 7 contains the estimated net operating savings for each option. All savings values are based on a current fuel oil cost of $3.25/gal. The addition of the electricity generation in CHP presents the greatest net operating savings as the avoided cost from purchasing electricity at the SCNH complex is added to the operating savings. The first year net operating savings for Option 1 are $219,000 annually, while Option 2 provides $296,000, and Option 3 saves $281,000. These operating savings provide a simple payback period of 9.6 years for Option 1, 9.0 years for Option 2, and 8.3 years for Option 3. The sensitivity of the first year net operating savings to fuel oil and wood chip costs is shown in Appendix C for both options.

Table 7 – Nursing Home and DOC Biomass System Potential Net Operating Savings (same as Table ES1)

Option	Current Fuel Oil Cost	Value of Electricity Generated	Estimated Wood Chip Cost	Estimated Fuel Oil Cost w/Wood System	Additional O&M Costs for Wood System	Potential First Year Net Operating Savings
1 -Steam Only	$406,056	---	$(61,640)	$(101,514)	$(24,264)	$218,638
2 -CHP: Biomass and Nursing Home	$406,056	$39,514	$(80,459)	$(40,606)	$(28,264)	$296,241
3 -CHP: Nursing Home	$406,056	$18,260	$(76,774)	$(40,606)	$(26,264)	$280,672

* **All Options include supplying steam to both the nursing home and DOC.**

A cash flow analysis was also completed for financing the project assuming a 20 year financing term at a 4.5% interest rate. Option 1 has a 25-yr net present value of $3,499,261, while Option 2 has a net present value of $4,924,844, and Option 3 has a net present value of $4,910,974. Table 8 shows a summary of the results of this analysis and Table 9 provide the assumptions used in the financial analysis. The detailed analyses are shown in Appendix C.

Table 8 – Nursing Home and DOC Biomass System First Year Cash Flow Analysis Summary (same as Table ES2)

Option	Financed Amount	Annual Financing Payment	20 Year Financing, 1st Year Cash Flow	25 Year Net Present Value
1 - Steam Only	$2,090,603	$(160,718)	$57,921	$3,499,261
2 - CHP: Biomass and Nursing Home	$2,669,009	$(205,183)	$91,058	$4,924,844
3 - CHP: Nursing Home	$2,326,003	$(178,814)	$101,859	$4,910,974

[1] **All Options include supplying steam to both the nursing home and DOC.**
[2] **Assumes 20 year financing at 4.5% interest rate.**

Table 9 – Financial Analysis Assumptions

Item	Value and Unit	Source
Annual energy usage	124,943 gal	2010-2011 SCNH fuel deliveries
Portion fuel oil replaced in Option 1	75%	WERC estimate
Portion fuel oil replaced in Option 2	90%	WERC estimate
Fuel oil boiler efficiency	80%	WERC assumption
Fuel oil heat content	139,000 Btu/gal	WERC assumption
Wood chip heat content	10.0 mmBtu/ton	WERC assumption
Wood chip boiler efficiency (HHV)	71%	WERC assumption
Steam heat content	1,000 BTU/lb	WERC assumption
Fuel oil price	$3.25/gal	Current SCNH estimate
*Wood chip price	$42.00/ton	Budgetary quotation
Electric Value	$0.133/kWh	Current SCNH electric bill

**New Hampshire Timberland Owners Association quarterly market survey published Summer 2011.*

6.3 Additional Benefits of Wood System

The wood chip system will provide additional benefits to SCNH including:

- Support of the local economy through the purchase of a minimum of $61,000 of locally sourced renewable wood chip fuel ;
- Decreased dependence on imported oil by replacing 93,000 gallons of fuel oil with renewable wood chip fuel;
- Protection from the volatility of the fossil fuel market;
- A minimum 948 metric ton decrease in CO_2 emissions through the use of renewable wood chip fuel instead of non-renewable fuel oil;
- Increased heating system redundancy for the SCNH complex.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Woody biomass presents SCNH with an opportunity to reduce its operating costs at the nursing home and DOC complex located near Claremont, NH. Option 1, steam only, would produce steam for heat in both the nursing home and DOC for a capital cost of $2.1 million and provide a first year net operating savings of $219,000. Option 2, CHP in the biomass plant and nursing home, would provide steam for space heating offsetting 90% of the annual fuel oil usage as well as generating 18% of the complex's annual electricity demand for a cost of $2.7 million. This option would produce a first year net operating savings of $296,000. Option 3, CHP in the nursing home only, would offset 9% of the annual electric usage with renewable electricity while providing a first year net operating savings of $281,000 for a cost of $2.3 million. These savings provide project simple paybacks of 9.6 years for Option 1, 9.0 years for Option 2, and 8.3 years for Option 3. 20 year financing at a 4.5% interest rate results in a 25 year Net Present Value (NPV) of $3.5 million for Option 1, $4.9 million for Option 2, and $4.9 million for Option 3. Additional benefits that would be provided by a woody biomass project include:

- Support of the local economy through the purchase of a minimum of $61,000 of locally sourced renewable wood chip fuel;
- Decreased dependence on imported oil by replacing 93,000 gallons of fuel oil with renewable wood chip fuel;
- A hedge against volatility of the fossil fuel market;
- A minimum 948 metric ton decrease in CO_2 emissions through the use of renewable wood chip fuel instead of non-renewable fuel oil;
- Increased heating system redundancy for the SCNH complex.

As SCNH continues to pursue biomass renewable energy options, WERC recommends that the next level of evaluation includes detailed consideration of the following items:

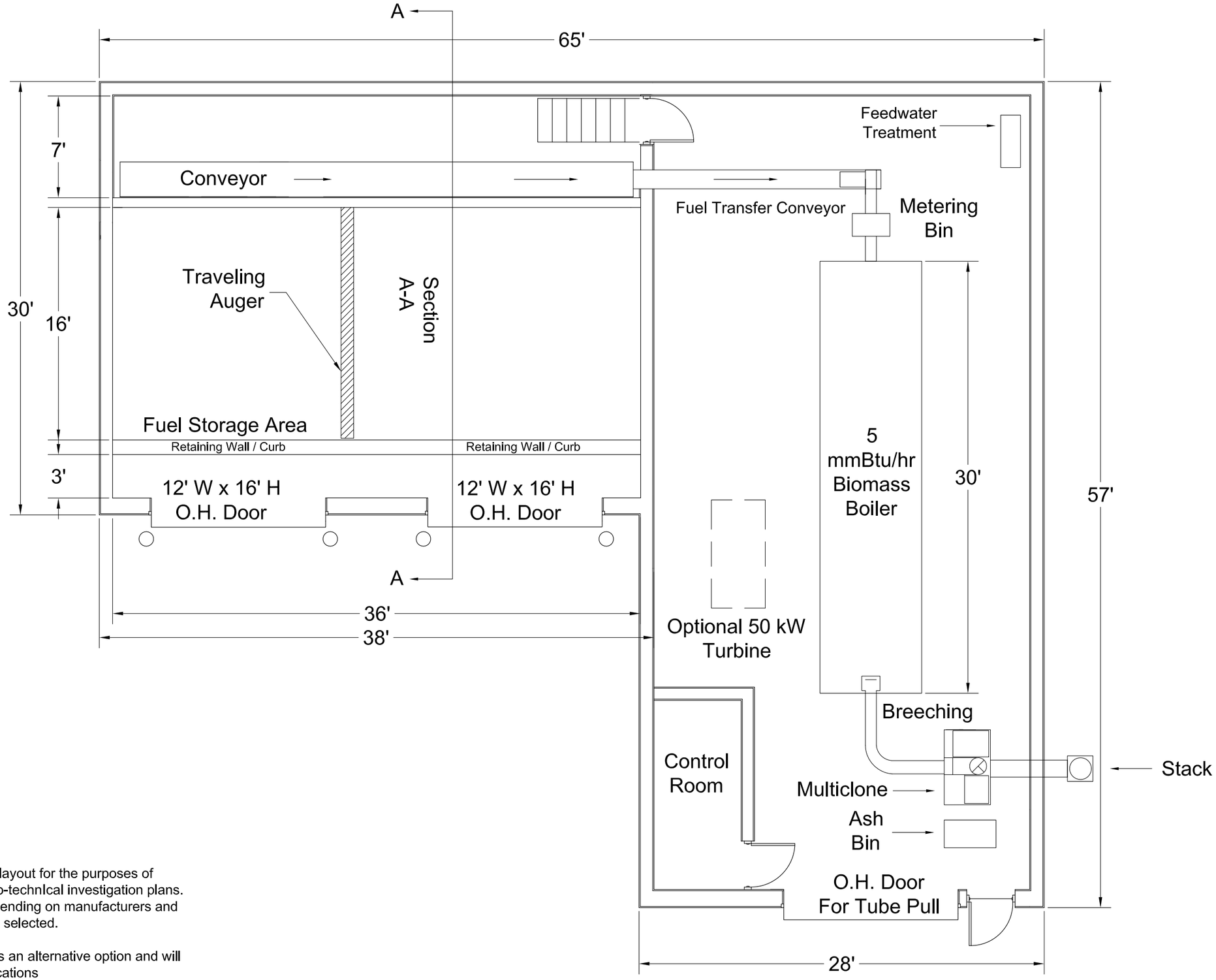
- Actual steam consumption at both facilities to determine the optimum biomass boiler size. This will maximize fuel oil offset and annual savings.
- The potential to offset propane used by rooftop heating units with the biomass system.
- Biomass system capital costs based on detailed site investigations, initial plant layout and design, and direct quotes from manufacturers.
- Alternative funding sources (low interest loans, grants, and incentives).
- Local boiler operating and licensing requirements for the recommended boiler operating pressures.

WERC also recommends that SCNH personnel visit existing biomass boiler installations to develop a detailed understanding of the equipment and its capabilities. WERC is available to assist SCNH in arranging tours of existing facilities.

Appendix A

Drawings

- Conceptual biomass building layout
- Fuel storage building cross section
- Site plan
- Option 1 system schematic
- Option 2 system schematic
- Option 3 system schematic



Notes:

1. This drawing is a conceptual layout for the purposes of developing surveying and geo-technlcal investigation plans. Actual footprints will vary depending on manufacturers and materials handling equipment selected.

2. A rake fuel handling system is an alternative option and will require building layout modifications

Designed DEM 9-23-11
Drawn DEM 9-23-11
Checked DAW 9-27-11
Approved
Date
Title
Job Class

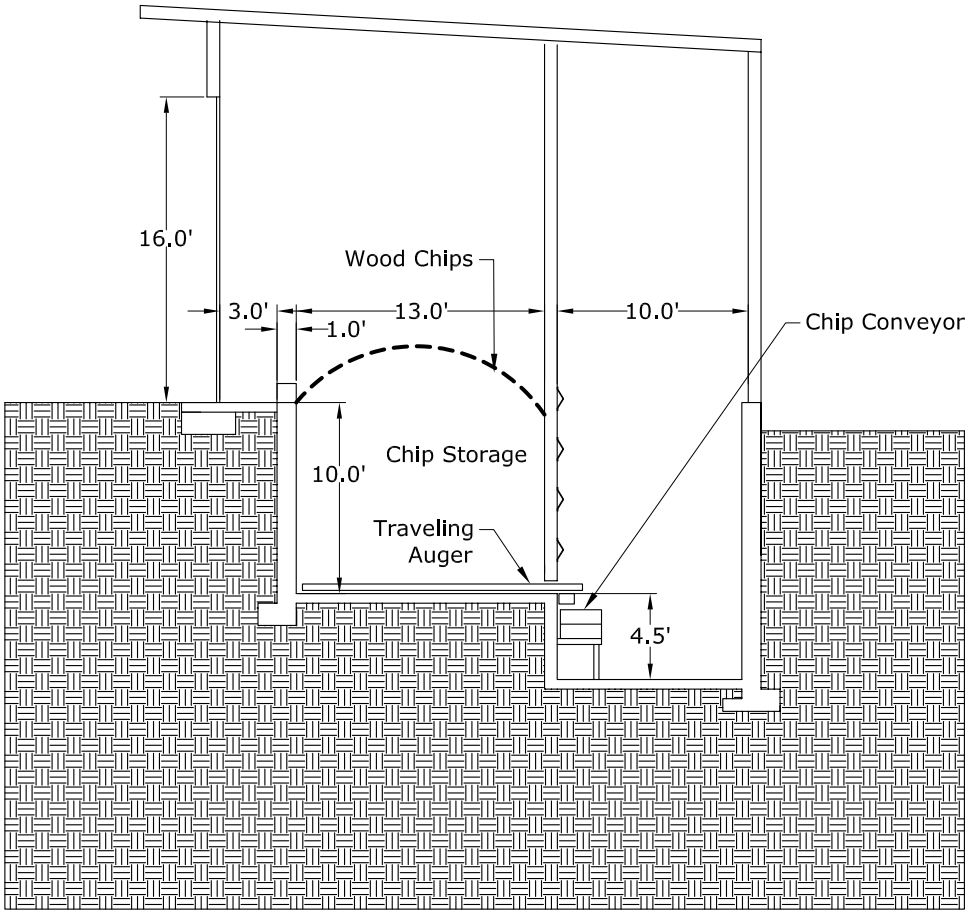
Sullivan County Complex
Claremont, NH

Biomass Building Layout

WERC
Wood Education and Resource Center
United States Forest Service
United States Department of Agriculture

REVISIONS
Date | Description | Approved

Appendix A.1



Note: This drawing is a conceptual layout for the purposes of developing surveying and geo-technical investigations plan. Actual footprints will vary depending on the manufacturer and materials handling equipment utilized.

10' 0' 5' 10'

Scale

Appendix A.2

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Sullivan County Complex

Claremont, NH

Wood Chip Storage Section A-A

Designed	DEM 9–21–11
Drawn	DEM 9–21–11
Checked	DAW 9–27–11

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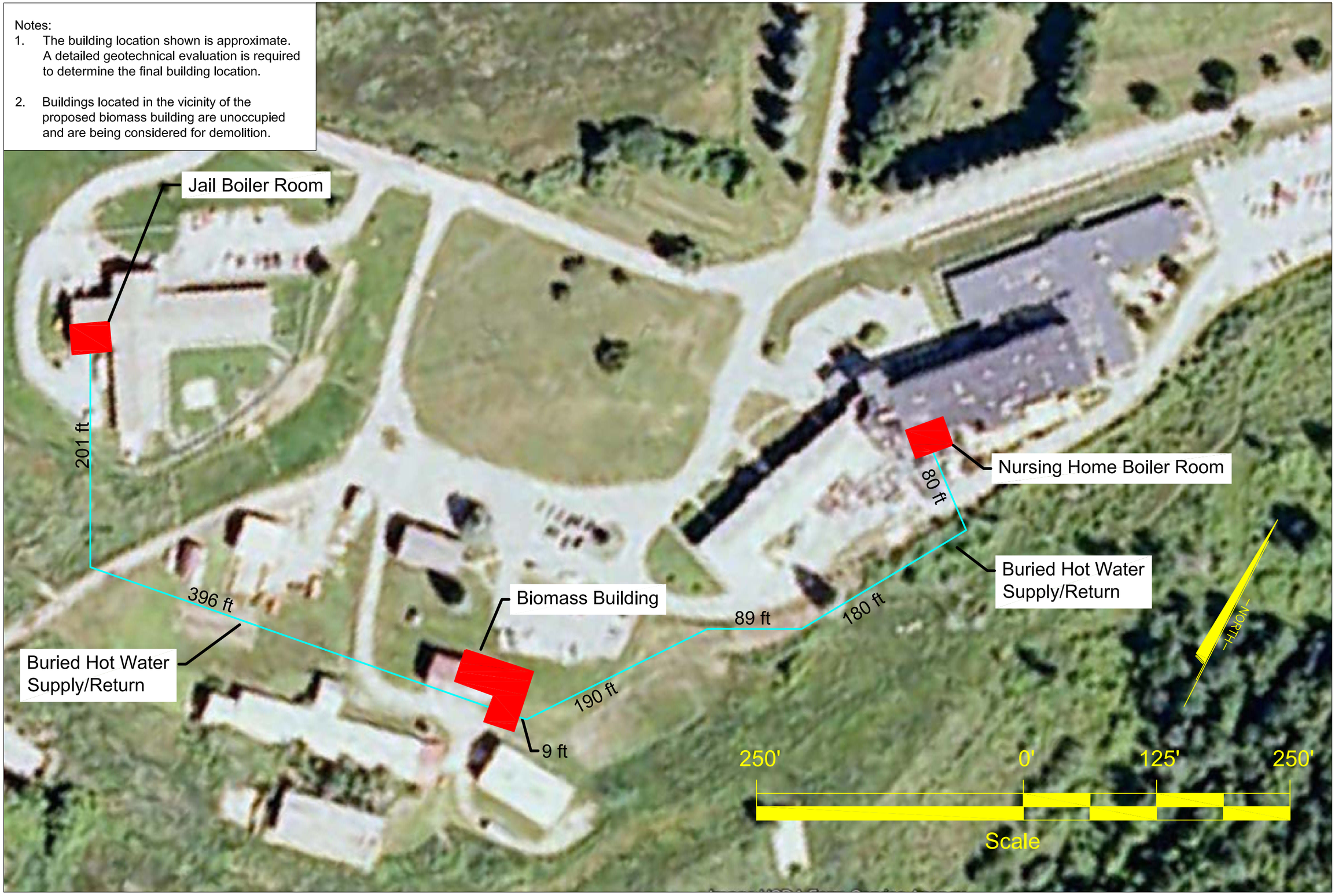
Title _____ Job Class ____

Notes:

1. The building location shown is approximate. A detailed geotechnical evaluation is required to determine the final building location.

2. Buildings located in the vicinity of the proposed biomass building are unoccupied and are being considered for demolition.



Designed	DEM	9-23-11
Drawn	DEM	9-23-11
Checked	DAW	9-27-11

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Sullivan County Complex

Claremont, NH

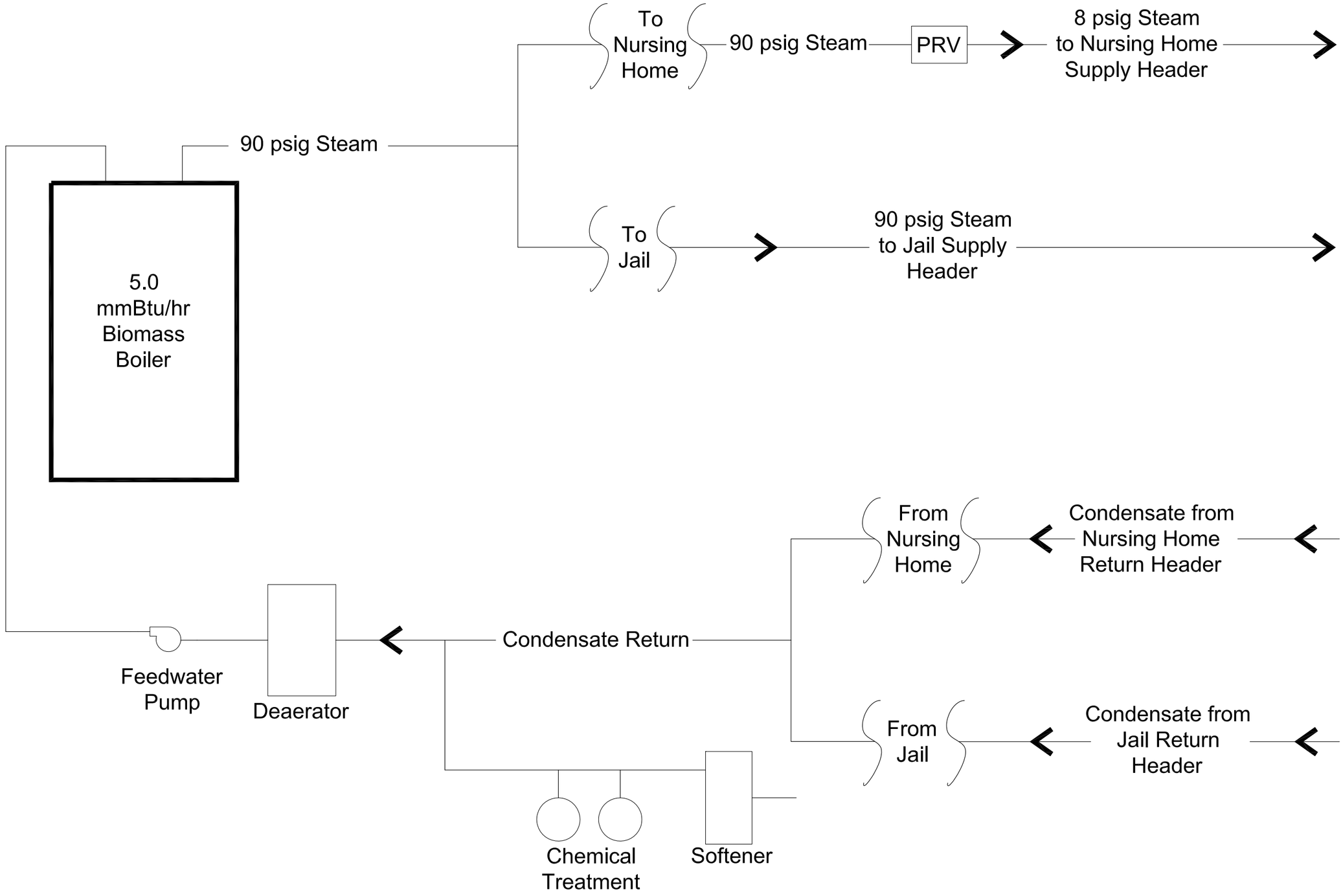
Conceptual Site Plan

WERC

Wood Education and Resource Center
United States Forest Service
United States Department of Agriculture

REVISIONS		
Date	Description	Approved

Appendix A.3



Designed DEM 9-23-11
Drawn DEM 9-23-11
Checked DAW 9-27-11

Approved
Date
Title
Job Class

Sullivan County Complex
Claremont, NH

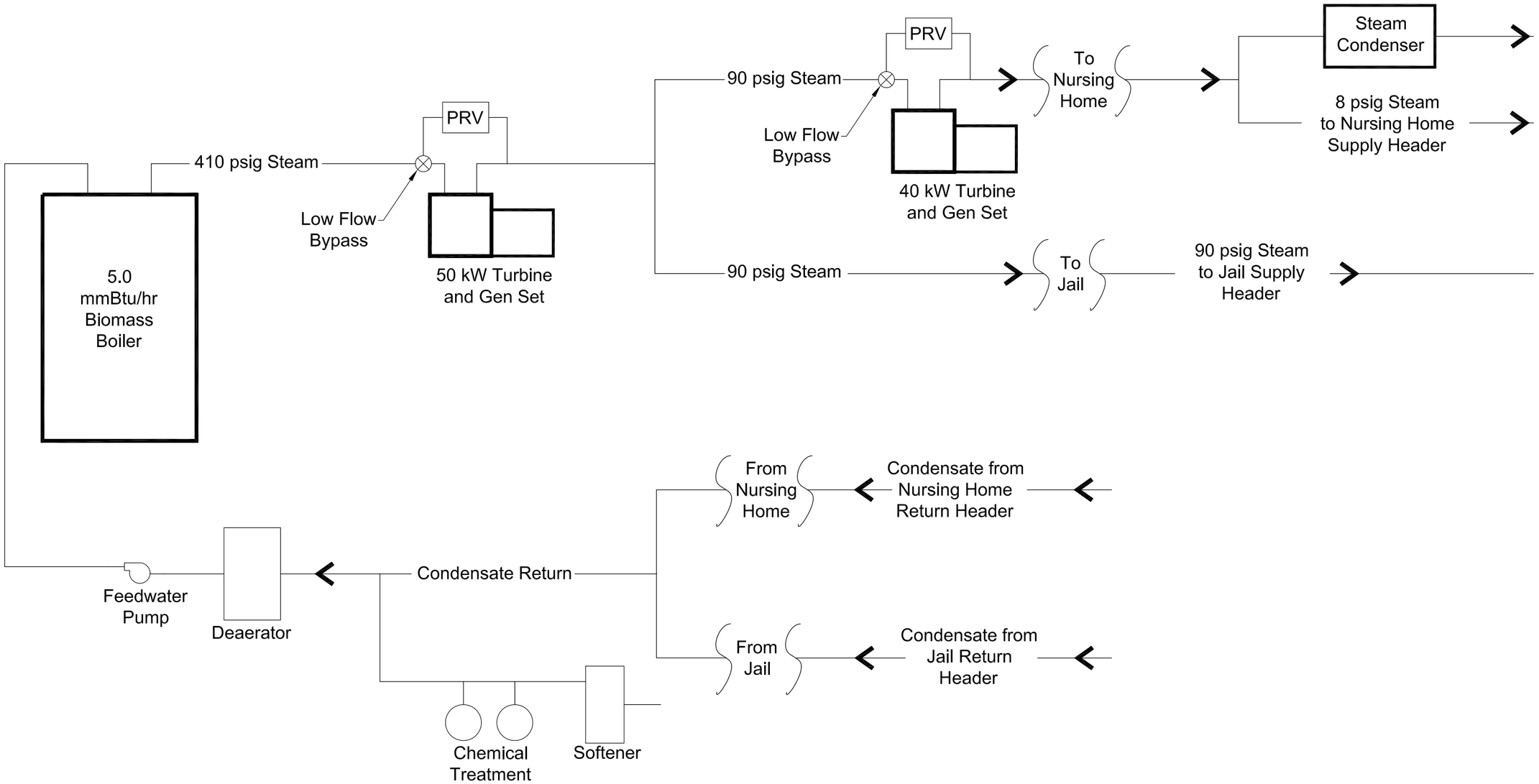
Option 1 System Schematic

WERC
Wood Education and Resource Center
United States Forest Service
United States Department of Agriculture

REVISIONS

Date	Description	Approved

Appendix A.4



Designed	DEM	9-23-11
Drawn	DEM	9-23-11
Checked	DAW	9-27-11

Approved
Date
Title
Job Class

Sullivan County Complex

Claremont, NH

Option 2 System Schematic

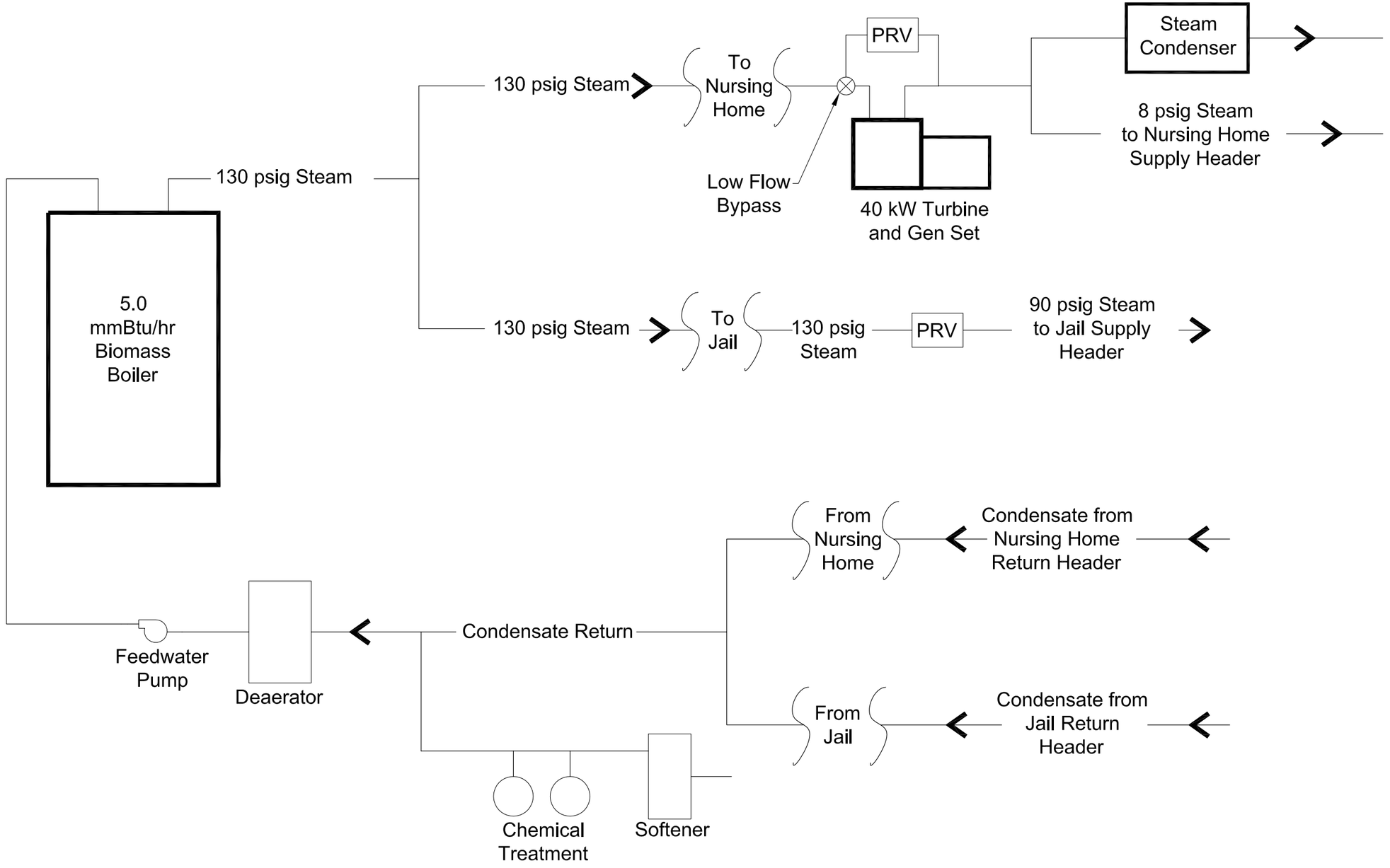
WERC

Wood Education and Resource Center
United States Forest Service
United States Department of Agriculture

REVISIONS

Date	Description	Approved

Appendix A.5



Designed DEM 9-23-11
Drawn DEM 9-23-11
Checked DAW 9-27-11
Approved
Date
Title
Job Class

Sullivan County Complex
Claremont, NH

Option 3 System Schematic

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United States Forest Service
United States Department of Agriculture

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Appendix A.6

Appendix B

Capital Cost Estimates

- Option 1 – Steam only
- Option 2 – CHP: Biomass Plant and Nursing Home
- Option 3 – CHP: Nursing Home Only

Option 1 - Steam Only Capital Cost Estimate

Biomass Boiler Manufacturer Contract

Line Item			Cost
5.0 mmBtu/hr biomass steam boiler rated at 150 psig (5,000 lb/hr steam), installed		$	527,000
Biomass boiler room piping and specialties, installed		$	73,000
Fuel bunker receiving, storage, material transfer, installed		$	137,000
Boiler platform, stairs, and ladders installed		$	19,000
Multicyclone, installed		$	35,000
Sub-total		$	791,000
Boiler Manufacturer Bid Bond and Insurance	*2%*	$	15,820
Total Boiler Manufacturer Contract		**$**	**806,820**

General Contract

Line Item			Cost
Biomass Boiler Building and Chip Storage Pit [1]		$	319,000
Site work		$	23,500
1,150 ft. of buried steam supply and condensate return piping, installed [2]		$	298,000
Electrical		$	69,000
Mechanical		$	99,500
Sub-Total		$	809,000
Contractor profit overhead and insurance	*16%*	$	129,440
Sub-Total		$	938,440
Contingency	*15%*	*$*	*121,350*
Total General Contract Building and Site		**$**	**1,059,790**

Total Project Cost

Line Item			Cost
Project Sub-Total (Boiler and General Contracts)		$	1,866,610
Professional Services [3]	*12%*	*$*	*223,993.20*
Total Project Cost[4,5,6]		**$**	**2,090,603**

Notes:
1 - The building is assumed to be a simple pre-engineered building.
2 - Exact pipe routes and connections should be evaluated in additional detail as the project moves forward.
3 - Professional Services includes engineering, permitting, legal, and project management
4 - Assumes that biomass boiler and general contract are bid seperately
5 - General contract costs are approximate. A detailed geotechnical investigation is required to identify final site and building costs.
6 - Estimate is based on competitive bidding.

Option 2 - CHP: Biomass Plant and Nursing Home Capital Cost Estimate

Biomass Boiler Manufacturer Contract

Line Item			Cost
5.0 mmBtu/hr biomass steam boiler rated at 450 psig (5,000 lb/hr steam), installed		$	652,000
Biomass boiler room piping and specialties, installed		$	73,000
Fuel bunker receiving, storage, material transfer, installed		$	137,000
Boiler platform, stairs, and ladders installed		$	19,000
Multicyclone, installed		$	35,000
Sub-total		$	916,000
Boiler Manufacturer Bid Bond and Insurance	*2%*	$	18,320
Total Boiler Manufacturer Contract		**$**	**934,320**

General Contract

Line Item			Cost
Biomass Boiler Building and Chip Storage Pit [1]		$	319,000
Site work		$	23,500
1,150 ft. of buried steam supply and condensate return piping, installed[2]		$	298,000
Electrical		$	89,000
Mechanical		$	129,500
40 kW backpressure steam turbine, installed		$	101,000
50 kW backpressure steam turbine, installed		$	104,000
Steam Condensing Unit, installed		$	22,000
Sub-Total		$	1,086,000
Contractor profit overhead and insurance	*16%*	*$*	*173,760*
Sub-Total		$	1,259,760
Contingency	*15%*	$	188,964
Total General Contract Building and Site		**$**	**1,448,724**

Total Project Cost

Line Item			Cost
Project Sub-Total (Boiler and General Contracts)		$	2,383,044
Professional Services [3]	*12%*	*$*	*285,965*
Total Project Cost[4,5,6]		**$**	**2,669,009**

Notes:
1 - The building is assumed to be a simple pre-engineered building.
2 - Exact pipe routes and connections should be evaluated in additional detail as the project moves forward.
3 - Professional Services includes engineering, permitting, legal, and project management
4 - Assumes that biomass boiler and general contract are bid seperately
5 - General contract costs are approximate. A detailed geotechnical investigation is required to identify final site and building costs.
6 - Estimate is based on competitive bidding.

Option 3 - CHP: Nursing Home Only Capital Cost Estimate

Biomass Boiler Manufacturer Contract

Line Item			Cost
5.0 mmBtu/hr biomass boiler rated at 150 psig (5,000 lb/hr steam), installed		$	527,000
Biomass boiler room piping and specialties, installed		$	73,000
Fuel bunker receiving, storage, material transfer, installed		$	137,000
Boiler platform, stairs, and ladders installed		$	19,000
Multicyclone, installed		$	35,000
Sub-total		$	791,000
Boiler Manufacturer Bid Bond and Insurance	*2%*	$	15,820
Total Boiler Manufacturer Contract		**$**	**806,820**

General Contract

Line Item			Cost
Biomass Boiler Building and Chip Storage Pit [1]		$	319,000
Site work		$	23,500
1,150 ft. of buried steam supply and condensate return piping, installed[2]		$	298,000
Electrical		$	79,000
Mechanical		$	109,500
40 kW backpressure steam turbine, installed		$	101,000
Steam Condensing Unit, installed		$	22,000
Sub-Total		$	952,000
Contractor profit overhead and insurance	*16%*	$	*152,320*
Sub-Total		*$*	*1,104,320*
Contingency	*15%*	$	*165,648*
Total General Contract Building and Site		**$**	**1,269,968**

Total Project Cost

Line Item			Cost
Project Sub-Total (Boiler and General Contracts)		$	2,076,788
Professional Services [3]	*12%*	$	*249,215*
Total Project Cost[4,5,6]		**$**	**2,326,003**

Notes:
1 - The building is assumed to be a simple pre-engineered building.
2 - Exact pipe routes and connections should be evaluated in additional detail as the project moves forward.
3 - Professional Services includes engineering, permitting, legal, and project management
4 - Assumes that biomass boiler and general contract are bid seperately
5 - General contract costs are approximate. A detailed geotechnical study is required to identify final site and building costs.
6 - Estimate is based on competitive bidding.

Appendix C

Detailed Financial Analysis

- 20 yr. 4.5% Financing-Option 1
- Sensitivity Analysis-Option 1
- 20 yr. 4.5% Financing -Option 2
- Sensitivity Analysis-Option 2
- 20 yr. 4.5% Financing -Option 3
- Sensitivity Analysis-Option 3

Appendix C — Option 1 -Steam Only 20 yr., 4.5% Financing Analysis

Input Variables	Value	Units
Project Costs Financed	2,090,603	$
Financing Term	20	# years
Financing Rate (apr)	4.5%	Percent
Current Fuel Oil Usage	124,940	gal
Year 1 Fuel Oil Average Price	3.25	$/gal
Wood Chip Usage	1,468	tons/yr
Year 1 Wood Chip Purchase Price	42	$/ton
Annual Fuel Oil Usage w/ Wood System	31,235	gal/yr
Fuel Oil Inflation Rate (apr)	3.3%	Percent
Wood Chip Inflation Rate (apr)	2.7%	Percent
General Inflation Rate (apr)	2.7%	Percent
Added Annual O&M Costs for Biomass Plant	$ 24,264	$/yr

Year	Fuel Oil Cost, Current System	Wood Chip Cost	Fuel Oil Cost, w/ Wood System	Net Operating Savings	Annual Financing Payment	Net Cash Flow	Present Value of Net Cash Flow
1	$ 406,056	$ (61,640)	$ (101,514)	$ 218,639	$ (160,718)	$ 57,921	$ 57,921
2	$ 419,456	$ (63,304)	$ (104,864)	$ 226,369	$ (160,718)	$ 65,652	$ 63,925
3	$ 433,298	$ (65,013)	$ (108,325)	$ 234,369	$ (160,718)	$ 73,651	$ 69,829
4	$ 447,597	$ (66,768)	$ (111,899)	$ 242,647	$ (160,718)	$ 81,929	$ 75,635
5	$ 462,368	$ (68,571)	$ (115,592)	$ 251,212	$ (160,718)	$ 90,495	$ 81,346
6	$ 477,626	$ (70,423)	$ (119,406)	$ 260,076	$ (160,718)	$ 99,358	$ 86,965
7	$ 493,387	$ (72,324)	$ (123,347)	$ 269,247	$ (160,718)	$ 108,530	$ 92,496
8	$ 509,669	$ (74,277)	$ (127,417)	$ 278,737	$ (160,718)	$ 118,020	$ 97,939
9	$ 526,488	$ (76,282)	$ (131,622)	$ 288,556	$ (160,718)	$ 127,839	$ 103,299
10	$ 543,862	$ (78,342)	$ (135,966)	$ 298,717	$ (160,718)	$ 137,999	$ 108,577
11	$ 561,810	$ (80,457)	$ (140,452)	$ 309,229	$ (160,718)	$ 148,512	$ 113,777
12	$ 580,350	$ (82,629)	$ (145,087)	$ 320,107	$ (160,718)	$ 159,389	$ 118,900
13	$ 599,501	$ (84,860)	$ (149,875)	$ 331,361	$ (160,718)	$ 170,644	$ 123,949
14	$ 619,285	$ (87,152)	$ (154,821)	$ 343,006	$ (160,718)	$ 182,288	$ 128,926
15	$ 639,721	$ (89,505)	$ (159,930)	$ 355,054	$ (160,718)	$ 194,336	$ 133,833
16	$ 660,832	$ (91,921)	$ (165,208)	$ 367,519	$ (160,718)	$ 206,801	$ 138,674
17	$ 682,639	$ (94,403)	$ (170,660)	$ 380,416	$ (160,718)	$ 219,698	$ 143,449
18	$ 705,166	$ (96,952)	$ (176,292)	$ 393,759	$ (160,718)	$ 233,041	$ 148,160
19	$ 728,437	$ (99,570)	$ (182,109)	$ 407,563	$ (160,718)	$ 246,846	$ 152,811
20	$ 752,475	$ (102,258)	$ (188,119)	$ 421,846	$ (160,718)	$ 261,128	$ 157,403
21	$ 777,307	$ (105,019)	$ (194,327)	$ 436,622		$ 436,622	$ 256,268
22	$ 802,958	$ (107,855)	$ (200,740)	$ 451,908		$ 451,908	$ 258,267
23	$ 829,456	$ (110,767)	$ (207,364)	$ 467,723		$ 467,723	$ 260,278
24	$ 856,828	$ (113,757)	$ (214,207)	$ 484,084		$ 484,084	$ 262,300
25	$ 885,103	$ (116,829)	$ (221,276)	$ 501,010		$ 501,010	$ 264,335
					Net Present Value		**$ 3,499,261**

Appendix C

Option 1 -Steam Only

First Year Net Operating Savings Sensitvity Analysis*

Price of Fuel Oil per Gallon

Price of Wood Chips - per Ton	$2.50	$2.75	$3.00	$3.25	$3.50	$3.75	$4.00	$4.25
$10	$171,897	$203,132	$234,367	$265,602	$296,838	$328,073	$359,308	$390,543
$15	$164,559	$195,794	$227,029	$258,264	$289,499	$320,735	$351,970	$383,205
$20	$157,221	$188,456	$219,691	$250,926	$282,161	$313,397	$344,632	$375,867
$25	$149,883	$181,118	$212,353	$243,588	$274,823	$306,058	$337,294	$368,529
$30	$142,545	$173,780	$205,015	$236,250	$267,485	$298,720	$329,956	$361,191
$35	$135,207	$166,442	$197,677	$228,912	$260,147	$291,382	$322,617	$353,853
$40	$127,869	$159,104	$190,339	$221,574	$252,809	$284,044	$315,279	$346,515
$45	$120,531	$151,766	$183,001	$214,236	$245,471	$276,706	$307,941	$339,176
$50	$113,193	$144,428	$175,663	$206,898	$238,133	$269,368	$300,603	$331,838
$55	$105,855	$137,090	$168,325	$199,560	$230,795	$262,030	$293,265	$324,500
$60	$98,517	$129,752	$160,987	$192,222	$223,457	$254,692	$285,927	$317,162
$65	$91,179	$122,414	$153,649	$184,884	$216,119	$247,354	$278,589	$309,824
$70	$83,841	$115,076	$146,311	$177,546	$208,781	$240,016	$271,251	$302,486

**Note: Excludes financing costs.*

Appendix C

Option 2 - CHP: Biomass Plant and Nursing Home
20 yr. 4.5% Financing Analysis

Input Variables	Value	Units
Project Costs Financed	2,669,009	$
Financing Term	20	# years
Financing Rate (apr)	4.5%	Percent
Annual Fuel Oil Input	124,940	gal
Year 1 Fuel Oil Average Price	3.25	$/gal
Wood Chip Usage	1,916	tons/yr
Year 1 Wood Chip Purchase Price	42	$/ton
Annual Fuel Oil Usage w/ Wood System	12,494	gal/yr
Electricity generated	297,096	kWh/yr
Electricity value	0.133	$/kWh
Fuel OIl Inflation Rate (apr)	3.3%	Percent
Wood Chip Inflation Rate (apr)	2.7%	Percent
General Inflation Rate (apr)	2.7%	Percent
Electric Inflation Rate (apr)	3.3%	Percent
Added Annual O&M Costs for Biomass Plant	$ 28,264	$/yr

Year	Fossil Fuel Cost, Current System	Value of Generated Electricity	Wood Chip Cost	Fuel Oil Cost, w/ Wood System	Net Operating Savings	Annual Financing Payment	Net Cash Flow	Present Value of Net Cash Flow
1	$ 406,056	$ 39,514	$ (80,459)	$ (40,606)	$ 296,241	$ (205,183)	$ 91,058	$ 91,058
2	$ 419,456	$ 40,818	$ (82,632)	$ (41,946)	$ 306,670	$ (205,183)	$ 101,487	$ 98,818
3	$ 433,298	$ 42,165	$ (84,863)	$ (43,330)	$ 317,460	$ (205,183)	$ 112,277	$ 106,450
4	$ 447,597	$ 43,556	$ (87,154)	$ (44,760)	$ 328,624	$ (205,183)	$ 123,441	$ 113,958
5	$ 462,368	$ 44,993	$ (89,507)	$ (46,237)	$ 340,175	$ (205,183)	$ 134,992	$ 121,345
6	$ 477,626	$ 46,478	$ (91,924)	$ (47,763)	$ 352,127	$ (205,183)	$ 146,944	$ 128,616
7	$ 493,387	$ 48,012	$ (94,406)	$ (49,339)	$ 364,492	$ (205,183)	$ 159,309	$ 135,773
8	$ 509,669	$ 49,596	$ (96,955)	$ (50,967)	$ 377,286	$ (205,183)	$ 172,103	$ 142,821
9	$ 526,488	$ 51,233	$ (99,573)	$ (52,649)	$ 390,522	$ (205,183)	$ 185,339	$ 149,762
10	$ 543,862	$ 52,924	$ (102,261)	$ (54,386)	$ 404,217	$ (205,183)	$ 199,034	$ 156,599
11	$ 561,810	$ 54,670	$ (105,022)	$ (56,181)	$ 418,385	$ (205,183)	$ 213,202	$ 163,337
12	$ 580,350	$ 56,474	$ (107,858)	$ (58,035)	$ 433,043	$ (205,183)	$ 227,860	$ 169,977
13	$ 599,501	$ 58,338	$ (110,770)	$ (59,950)	$ 448,208	$ (205,183)	$ 243,025	$ 176,524
14	$ 619,285	$ 60,263	$ (113,761)	$ (61,928)	$ 463,897	$ (205,183)	$ 258,714	$ 182,979
15	$ 639,721	$ 62,252	$ (116,832)	$ (63,972)	$ 480,128	$ (205,183)	$ 274,945	$ 189,347
16	$ 660,832	$ 64,306	$ (119,987)	$ (66,083)	$ 496,920	$ (205,183)	$ 291,736	$ 195,628
17	$ 682,639	$ 66,428	$ (123,226)	$ (68,264)	$ 514,291	$ (205,183)	$ 309,108	$ 201,828
18	$ 705,166	$ 68,620	$ (126,553)	$ (70,517)	$ 532,261	$ (205,183)	$ 327,078	$ 207,947
19	$ 728,437	$ 70,885	$ (129,970)	$ (72,844)	$ 550,852	$ (205,183)	$ 345,669	$ 213,988
20	$ 752,475	$ 73,224	$ (133,479)	$ (75,248)	$ 570,084	$ (205,183)	$ 364,901	$ 219,955
21	$ 777,307	$ 75,641	$ (137,083)	$ (77,731)	$ 589,979		$ 589,979	$ 346,279
22	$ 802,958	$ 78,137	$ (140,785)	$ (80,296)	$ 610,560		$ 610,560	$ 348,937
23	$ 829,456	$ 80,715	$ (144,586)	$ (82,946)	$ 631,850		$ 631,850	$ 351,611
24	$ 856,828	$ 83,379	$ (148,490)	$ (85,683)	$ 653,873		$ 653,873	$ 354,301
25	$ 885,103	$ 86,130	$ (152,499)	$ (88,510)	$ 676,655		$ 676,655	$ 357,006
							Net Present Value	**$ 4,924,844**

Option 2 - CHP: Biomass Plant and Nursing Home
First Year Net Operating Savings Sensitvity Analysis*

Price of Fuel Oil per Gallon

Price of Wood Chips - per Ton	$2.50	$2.75	$3.00	$3.25	$3.50	$3.75	$4.00	$4.25
$10	$273,209	$301,321	$329,432	$357,544	$385,655	$413,767	$441,878	$469,990
$15	$263,630	$291,742	$319,854	$347,965	$376,077	$404,188	$432,300	$460,412
$20	$254,052	$282,164	$310,275	$338,387	$366,498	$394,610	$422,722	$450,833
$25	$244,474	$272,585	$300,697	$328,808	$356,920	$385,031	$413,143	$441,255
$30	$234,895	$263,007	$291,118	$319,230	$347,341	$375,453	$403,565	$431,676
$35	$225,317	$253,428	$281,540	$309,651	$337,763	$365,874	$393,986	$422,098
$40	$215,738	$243,850	$271,961	$300,073	$328,184	$356,296	$384,408	$412,519
$45	$206,160	$234,271	$262,383	$290,494	$318,606	$346,718	$374,829	$402,941
$50	$196,581	$224,693	$252,804	$280,916	$309,027	$337,139	$365,251	$393,362
$55	$187,003	$215,114	$243,226	$271,337	$299,449	$327,561	$355,672	$383,784
$60	$177,424	$205,536	$233,647	$261,759	$289,870	$317,982	$346,094	$374,205
$65	$167,846	$195,957	$224,069	$252,180	$280,292	$308,404	$336,515	$364,627
$70	$158,267	$186,379	$214,490	$242,602	$270,714	$298,825	$326,937	$355,048

**Note: Excludes financing costs.*

Appendix C

Option 3 - CHP: Nursing Home Only
20 yr. 4.5% Financing Analysis

Input Variables	Value	Units
Project Costs Financed	2,326,003	$
Financing Term	20	# years
Financing Rate (apr)	4.5%	Percent
Annual Fuel Oil Input	124,940	gal
Year 1 Fuel Oil Average Price	3.25	$/gal
Wood Chip Usage	1,828	tons/yr
Year 1 Wood Chip Purchase Price	42	$/ton
Annual Fuel Oil Usage w/ Wood System	12,494	gal/yr
Electricity generated	137,294	kWh/yr
Electricity value	0.133	$/kWh
Fuel OIl Inflation Rate (apr)	3.3%	Percent
Wood Chip Inflation Rate (apr)	2.7%	Percent
General Inflation Rate (apr)	2.7%	Percent
Electric Inflation Rate (apr)	3.3%	Percent
Added Annual O&M Costs for Biomass Plant	$ 26,264	$/yr

Year	Fossil Fuel Cost, Current System	Value of Generated Electricity	Wood Chip Cost	Fuel Oil Cost, w/ Wood System	Net Operating Savings	Annual Financing Payment	Net Cash Flow	Present Value of Net Cash Flow
1	$ 406,056	$ 18,260	$ (76,774)	$ (40,606)	$ 280,674	$ (178,814)	$ 101,859	$ 101,859
2	$ 419,456	$ 18,863	$ (78,846)	$ (41,946)	$ 290,554	$ (178,814)	$ 111,740	$ 108,801
3	$ 433,298	$ 19,485	$ (80,975)	$ (43,330)	$ 300,777	$ (178,814)	$ 121,963	$ 115,633
4	$ 447,597	$ 20,128	$ (83,162)	$ (44,760)	$ 311,355	$ (178,814)	$ 132,541	$ 122,359
5	$ 462,368	$ 20,792	$ (85,407)	$ (46,237)	$ 322,299	$ (178,814)	$ 143,485	$ 128,980
6	$ 477,626	$ 21,479	$ (87,713)	$ (47,763)	$ 333,623	$ (178,814)	$ 154,809	$ 135,500
7	$ 493,387	$ 22,187	$ (90,081)	$ (49,339)	$ 345,339	$ (178,814)	$ 166,525	$ 141,923
8	$ 509,669	$ 22,920	$ (92,513)	$ (50,967)	$ 357,460	$ (178,814)	$ 178,646	$ 148,251
9	$ 526,488	$ 23,676	$ (95,011)	$ (52,649)	$ 370,001	$ (178,814)	$ 191,187	$ 154,487
10	$ 543,862	$ 24,457	$ (97,577)	$ (54,386)	$ 382,977	$ (178,814)	$ 204,162	$ 160,635
11	$ 561,810	$ 25,264	$ (100,211)	$ (56,181)	$ 396,401	$ (178,814)	$ 217,586	$ 166,696
12	$ 580,350	$ 26,098	$ (102,917)	$ (58,035)	$ 410,289	$ (178,814)	$ 231,475	$ 172,674
13	$ 599,501	$ 26,959	$ (105,696)	$ (59,950)	$ 424,657	$ (178,814)	$ 245,843	$ 178,571
14	$ 619,285	$ 27,849	$ (108,549)	$ (61,928)	$ 439,522	$ (178,814)	$ 260,708	$ 184,389
15	$ 639,721	$ 28,768	$ (111,480)	$ (63,972)	$ 454,900	$ (178,814)	$ 276,086	$ 190,132
16	$ 660,832	$ 29,717	$ (114,490)	$ (66,083)	$ 470,810	$ (178,814)	$ 291,995	$ 195,802
17	$ 682,639	$ 30,698	$ (117,581)	$ (68,264)	$ 487,268	$ (178,814)	$ 308,454	$ 201,401
18	$ 705,166	$ 31,711	$ (120,756)	$ (70,517)	$ 504,295	$ (178,814)	$ 325,481	$ 206,931
19	$ 728,437	$ 32,757	$ (124,017)	$ (72,844)	$ 521,909	$ (178,814)	$ 343,095	$ 212,395
20	$ 752,475	$ 33,838	$ (127,365)	$ (75,248)	$ 540,131	$ (178,814)	$ 361,317	$ 217,795
21	$ 777,307	$ 34,955	$ (130,804)	$ (77,731)	$ 558,981		$ 558,981	$ 328,085
22	$ 802,958	$ 36,109	$ (134,336)	$ (80,296)	$ 578,480		$ 578,480	$ 330,604
23	$ 829,456	$ 37,300	$ (137,963)	$ (82,946)	$ 598,652		$ 598,652	$ 333,137
24	$ 856,828	$ 38,531	$ (141,688)	$ (85,683)	$ 619,518		$ 619,518	$ 335,686
25	$ 885,103	$ 39,803	$ (145,513)	$ (88,510)	$ 641,103		$ 641,103	$ 338,249
							Net Present Value	**$ 4,910,974**

Option 3 - CHP: Nursing Home Only
First Year Net Operating Savings Sensitvity Analysis*

Price of Wood Chips - per Ton	Price of Fuel Oil per Gallon							
	$2.50	**$2.75**	**$3.00**	**$3.25**	**$3.50**	**$3.75**	**$4.00**	**$4.25**
$10	$254,833	$282,944	$311,056	$339,168	$367,279	$395,391	$423,502	$451,614
$15	$245,693	$273,805	$301,916	$330,028	$358,140	$386,251	$414,363	$442,474
$20	$236,553	$264,665	$292,777	$320,888	$349,000	$377,111	$405,223	$433,335
$25	$227,414	$255,525	$283,637	$311,749	$339,860	$367,972	$396,083	$424,195
$30	$218,274	$246,386	$274,497	$302,609	$330,720	$358,832	$386,944	$415,055
$35	$209,134	$237,246	$265,358	$293,469	$321,581	$349,692	$377,804	$405,915
$40	$199,995	$228,106	$256,218	$284,329	$312,441	$340,553	$368,664	$396,776
$45	$190,855	$218,967	$247,078	$275,190	$303,301	$331,413	$359,524	$387,636
$50	$181,715	$209,827	$237,938	$266,050	$294,162	$322,273	$350,385	$378,496
$55	$172,576	$200,687	$228,799	$256,910	$285,022	$313,133	$341,245	$369,357
$60	$163,436	$191,547	$219,659	$247,771	$275,882	$303,994	$332,105	$360,217
$65	$154,296	$182,408	$210,519	$238,631	$266,742	$294,854	$322,966	$351,077
$70	$145,156	$173,268	$201,380	$229,491	$257,603	$285,714	$313,826	$341,937

**Note: Excludes financing costs.*