Minnesota Department of Natural Resources

Cook County Schools & YMCA

Biomass Energy System

Preliminary Feasibility Report

Wilson Engineering Services, PC

FINAL

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1.0 EXECUTIVE SUMMARY

Cook County Schools and the Cook County Community YMCA share a campus in Grand Marais, MN. The YMCA facility opened in January 2014 and includes a swimming pool and spa. The campus is heated by propane hot water boilers and has used an annual average of 106,288 gallons of propane for the first two years since the YMCA opened. Cook County Schools has paid an average propane price of $1.32 per gallon over the previous four years. A heating system utilizing woody biomass has the potential to reduce fuel costs and greenhouse gas emissions for this facility, while utilizing a renewable, local fuel source.

Modern biomass combustion systems can efficiently and cleanly utilize a variety of fuels with a wide range of moisture content. Wood chips are the fuel type evaluated for this facility based on the size of the facility and regional fuel availability. The system evaluated in this study would require an estimated 1,033 tons of wood chips, annually. Table ES1 compares the cost of delivered heat for wood chips and propane.

Table ES1 – Fuel Pricing and Cost per mmBtu

Fuel, units	Unit Cost ($/unit)	Heating Value (mmBtu/unit)	Assumed Efficiency	Output Cost ($/mmBtu)
Propane (4-year average), gallon	$1.32	0.091502	85%	$16.99
Green wood chips[1], ton	$60	10.0	70%	$8.57

Note 1: Green wood chips are approximately 40-45% moisture content wet basis.

The biomass boiler system evaluated for this facility consists of a wood chip hot water boiler, rated 2.0 mmBtu/hr. A 2,000 gallon thermal storage tank would be installed with the boiler system to provide additional heating capacity and improve system efficiency. The biomass boiler would be installed in a new boiler building located behind the school near the existing boiler room, and connected to the existing hydronic system. The biomass boiler would offset approximately 90% of the facility's annual propane use from the existing boiler system.

Estimated capital costs for the proposed system, including construction and installation, are listed in Table ES2.

Table ES2 – Capital Cost Estimate Summary

Option	Estimated Capital Cost
2.0 mmBtu/hr Wood Chip Boiler System	$1,236,700

A proposed system fuel use profile is provided in Table ES3 showing the estimated annual fuel use compared to the existing propane system.

Table ES3 – Proposed System Fuel Use Profile

Current Annual Fuel Use	Biomass Demand Coverage	Annual Fuel Use with Proposed Biomass System	
Propane (gal)		Estimated Wood Chip Use (tons)	Estimated Propane Use with Biomass System (gal)
102,758	90%	1,033	10,276

Table ES4 provides a comparison of fuel costs and operating costs for the options.

Table ES4 – Fuel and Operating Cost Comparison

Current Annual Fuel Costs	Estimated Annual Costs with Proposed Biomass System			Estimated First Year Operational Savings	Thermal Production Incentive	Estimated Net Cash Flow
Propane Cost	Biomass Cost	Propane Cost	O&M Increase			
$135,773	$61,995	$13,577	$12,090	$48,111	$36,164	$84,275

A summary of the estimated capital costs and payback is provided in Table ES5. This table also evaluates the biomass system with an assumed 25% grant. No specific grant funding opportunity has been identified. Detailed financial analyses were generated and are included in Appendix C.

Table ES5 – Cost and Payback Analysis

System / Grant Funding	Estimated Capital Cost	Assumed Grant Funding	Investment Amount	Simple Payback Period[1]	Net Present Value (25 years)
2.0 mmBtu/hr Biomass / 0% Grant	$1,236,700	$0	$1,236,700	18.2	$567,024
2.0 mmBtu/hr Biomass / 25% Grant	$1,236,700	$309,175	$927,525	11.8	$876,199

Note 1: Simple payback is calculated taking into account the assumption that thermal production incentive payments end after 10 years.

A modern biomass boiler system would allow Cook County Schools to reduce fossil fuel use while utilizing a local and renewable source of energy. This project would provide a first year net operating savings of $48,111 before taking into account payments from the thermal production incentive, and would have a capital cost of $1,236,700.

Financial performance of the evaluated system is heavily dependent on the cost of fossil fuels and wood fuels, as shown by the sensitivity analyses in Appendix C. If the cost of propane rises, then the savings will increase substantially.

Payments from the Minnesota Biomass Thermal Production Incentive are a major driver of savings. The annual incentive payment would be approximately $48,111. It is important to note that these payments only occur for 10 years following startup of the project. With the incentive payments, the 25-year net present value of this project is $567,024.

Additional benefits provided through the use of local biomass at the facility include:

- Net reduction of greenhouse gas emissions by 460 metric tonnes annually,
- Keeping ~$62,000/yr spent on energy within the region,
- Diversification of fuels used by Cook County Schools,
- Reduction in operating budget volatility due to wide fluctuations in fossil energy pricing,
- Creating markets for low-value woody biomass to enhance opportunities for forest management activities to reduce pests and disease, prevent fires, and manage for ecological diversity, soil health, and water quality.

Should Cook County Schools be interested in pursuing a biomass option, WES recommends that county staff in both administration and operations visit modern biomass boiler installations to develop a detailed understanding of the equipment and its capabilities. The MN SWET is available to assist in arranging tours of existing facilities. As Cook County Schools continues to pursue renewable biomass energy options, WES recommends that the next level of evaluation includes detailed consideration of the following items:

- Work with the MN SWET to identify alternative funding sources (low interest loans, grants, and incentives)
- Perform site investigations (utility, geotechnical) for the new boiler room and fuel storage building and further develop the biomass plant layout and capital cost based on investigation results.

2.0 INTRODUCTION

2.1 MN SWET PROGRAM

The Minnesota Statewide Wood Energy Team (MN SWET) is working to implement commercially available wood energy systems by strategically identifying businesses, government buildings and other institutions that are:

- Currently using propane or fuel oil for heating and do not have direct access to natural gas
- Located in an area of the state with sufficient wood resources and in need of forest market expansion and/or wildfire risk management
- Capable of meeting the space and operational requirements needed for contemporary wood heating systems, and
- Financially committed to thermal wood energy options.

Wilson Engineering Services, PC (WES) was contracted by the Minnesota Department of Natural Resources (MN DNR), on behalf of the MN SWET, to provide Intermediate Woody Biomass Thermal Energy feasibility assessments. The feasibility assessments provide a preliminary engineering and financial analysis for potential projects that are recommended by MN SWET after preliminary screening. The purpose of the feasibility assessments is to facilitate sound decision making by the facilities regarding the installation of wood energy systems. The feasibility assessments address key design parameter choices, such as fuel type (chips, pellets, and cord wood), layout, thermal storage needs, heat distribution, and estimated capital and operating costs.

2.2 COOK COUNTY SCHOOL DISTRICT OPPORTUNITY

The Cook County Schools are located in Grand Marais, MN. The schools' campus encompasses an elementary, middle and high school. A community YMCA facility shares the same grounds with the schools and is also tied into its heating system. The campus is currently heated with propane. Because of the abundance of wood resources in the area, Cook County is investigating whether it is feasible to install a wood energy system to supply heat. A wood heating system utilizing wood chips has the potential to reduce fuel costs and greenhouse gas emissions for this facility, while utilizing a renewable, local fuel source.

3.0 FACILITY OVERVIEW

WES personnel conducted a site visit on June 22, 2016 in order to evaluate the existing systems and become familiar with the physical plant layout. The schools' campus consists of Sawtooth Elementary School, Cook County Middle and High School, and the Cook County Community YMCA. The construction of the YMCA, dedicated in January 2014, consisted of renovation of existing space coupled with the addition of space to house a swimming pool. The total gross area of the buildings on campus is approximately 168,600 ft^2, 36,296 ft^2 of which is attributed to the YMCA. The original building was built in 1951, and was expanded in 1970, 1997, and 2014.

The campus is heated by four Aerco Benchmark 2.0 boilers, firing propane and located in a central boiler room in the back of the school. Each boiler has an input capacity of 2.0 mmBtu/hr. Output capacity and boiler efficiency depend on the system's return water temperature. With winter loop supply temperatures in the range of 165-170°F, the output capacity of each boiler is estimated to be 1.7 mmBtu/hr with an efficiency of 85%.

Figure 1 – Central Boiler Room

A hydronic distribution system provides space heat to the schools and the YMCA facility. The two main pumps for distribution are controlled by variable frequency drives (VFD) based on differential pressure. The supply hot water splits into three zones: the elementary school, middle and high school, and the YMCA. Air handler units as well as hydronic baseboard heaters utilize the hot water for space heat. Current practice is to shut the boilers down from the end of May through September, as space heating is generally not needed.

The YMCA also has two Lochinvar propane boilers for heating of the swimming pool and spa, located in the pool mechanical room. The swimming pool is maintained at a temperature of 86°F while the spa is maintained at 104°F. The swimming pool boiler and spa boiler have an input capacity of 750,000 Btu/hr and 500,000 Btu/hr, respectively.

In order to separate out the cost of heating the YMCA from the schools, heat sent to the YMCA is metered and recorded monthly. Metering is performed by an Onicon metering system, measuring water flow and supply and return temperatures.

All propane use for the campus is supplied by a single, 18,000 gallon propane tank. Propane supplied to the YMCA pool and spa water heaters is metered and recorded monthly in order to separate the cost from the schools' propane costs. In addition to the boilers discussed above, there are several domestic hot water heaters throughout the campus, which are propane fired. Propane is also used in the schools' kitchen for its ovens and a cooktop.

4.0 BUILDING HEAT DEMAND

Cook County Schools staff provided WES with propane delivery and costs for the previous four years. Table 1 summarizes the propane deliveries and costs by year. Propane is delivered to a single tank shared by Cook County Schools and Cook County YMCA. Propane and heat, in the form of hot water, are metered to the YMCA, with the balance allocated as use by the school. The average unit cost of propane for the previous four years was $1.32 per gallon. This average unit cost is used in the economic analysis of this study. The significant increase in propane delivery beginning in 2014 is due to the addition of the YMCA, which began operation in January 2014.

Table 1 – Annual Propane Fuel Deliveries

Year	Propane Deliveries (gallons)	Propane Cost ($)	Propane Unit Cost ($/gal)
2012	65,088	$77,131	$1.19
2013	66,672	$86,378	$1.30
2014	124,361	$174,396	$1.40
2015	88,215	$123,698	$1.40
Average	***86,084***	***$115,401***	***$1.32***

Note 1: Cook County YMCA began operation in January, 2014.

The shared propane tank serves the school propane boilers, YMCA pool and spa boilers, multiple domestic hot water heaters, and school kitchen equipment. Propane use by end user for 2014 and 2015 was estimated based on metering and delivery data and is presented in Table 2. Propane use by the YMCA boilers and that attributed to the metered hydronic heat to the YMCA AHU's was calculated from the metering data. Propane use for domestic hot water for the combined facilities was estimated based on an assumed occupancy schedule and hot water use per day per occupant. Propane use by kitchen equipment at the schools was determined to be negligible. The remaining propane is attributed to boiler use for heating the schools. The calculated YMCA metered heat, pool boiler propane use, and estimated school heating propane use is used in developing the estimated annual heating demand for the facility. The propane use for the domestic hot water heaters and kitchen equipment do not represent heating demand and therefore are not included in the annual heating demand.

Table 2 – Estimated Propane Use by End User

Year	YMCA - metered heat, propane equivalent[1] (gallons)	YMCA Pool Boilers - metered propane[2] (gallons)	Estimated DHW Use for Combined Facilties[3] (gallons)	Estimated Cook County School Propane[4] (gallons)	Total Propane Delivered (gallons)
2014	33,922	25,226	3,530	61,683	124,361
2015	19,322	25,226	3,530	40,137	88,215
Average	***26,622***	***25,226***	***3,530***	***50,910***	***106,288***

Note 1: Propane is calculated from the metered Btu's of heat using propane HHV and assumed boiler efficiency.
Note 2: Propane use is based on metered propane from calendar year 2014. The meter was offline for the majority of 2015 and the data is, therefore, unavailable.
Note 3: Estimated DHW use is based on an estimated 2 gal/day of hot water for 325 occupants for the schools and 4 gal/day for 200 occupants for the YMCA.
Note 4: The balance of propane delivered to the facilities is attributed to the Cook County Schools.

Meter readings for the YMCA are recorded monthly for both heat in the form of hot water and the propane to the pool and spa boilers. This provides a picture of how heat is used throughout the year at the YMCA. A chart of the monthly heating demand (delivered heat in the form of hot water) of the YMCA is presented in Figure 2. Monthly heating demand for the facility follows outside air temperature, which is typical. The figure shows some summer time heating demand in 2014, however, current operation is to shut down the boilers during the months of June to September.

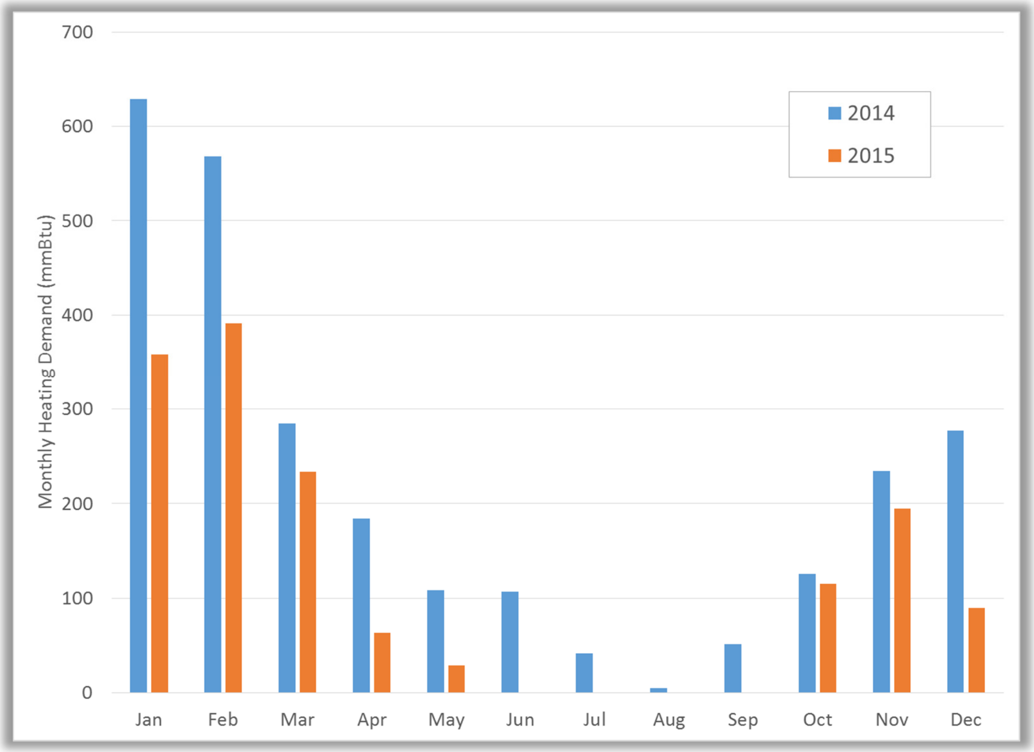


Figure 2 – Monthly YMCA Heating Demand (hot water metering)

Note 1: Monthly heating demand values have been adjusted to the standard number of days per month by multiplying the average daily demand by the number of days per month.

A chart of the monthly heating demand (propane use) of the YMCA pool and spa boilers is presented in Figure 3. Heating demand for the pools is due to evaporation loss from the pool and spa surfaces and is consistent throughout the year. The pool and spa averaged 164 mmBtu of heating demand per month in 2014. This equates to a continuous base heating load of 224,000 Btu/hr, throughout the year. 2015 heating demand data was unavailable.

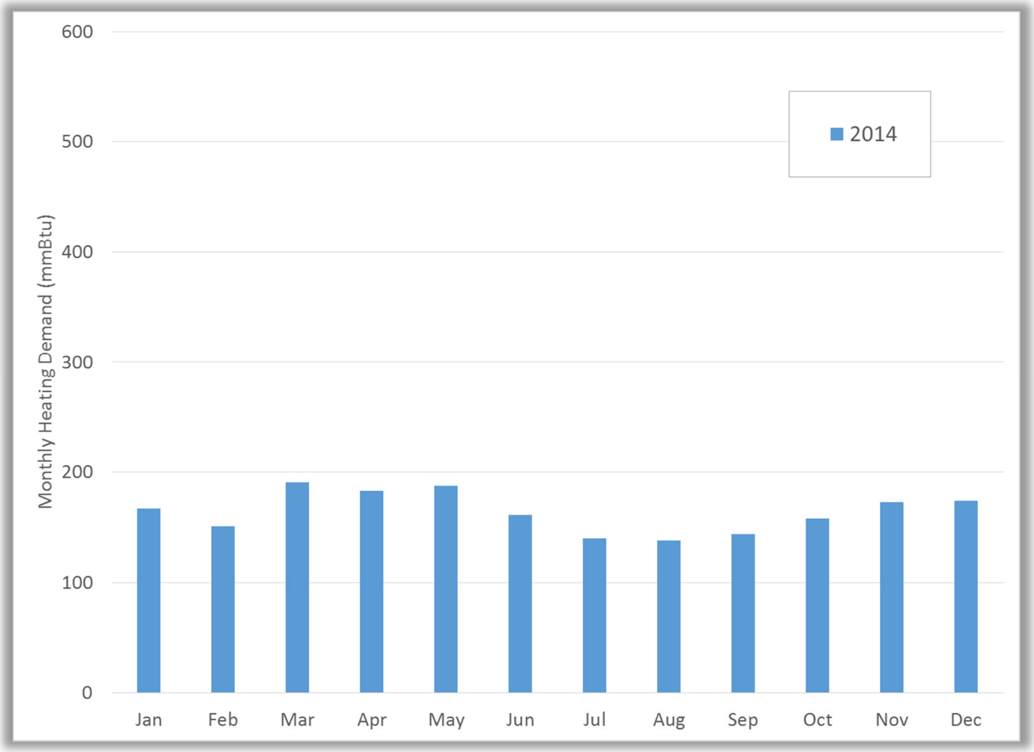


Figure 3 – Monthly Pool & Spa Heating Demand (propane metering)

Note 1: Monthly heating demand values have been adjusted to the standard number of days per month by multiplying the average daily demand by the number of days per month.
Note 2: Values are converted from propane input to heating demand using assumed boiler efficiencies and propane HHV.

A summary of annual heating demand for Cook County Schools and YMCA for years 2014 and 2015 is presented in Table 3. Heating demand for the YMCA is based on metering of heat and propane to the YMCA facility. Heating demand for the schools is based on the estimated propane use presented in Table 2. Estimated propane use for domestic hot water is not included in the total annual heating demand. The 2014-2015 average annual heating demand of 7,992 mmBtu is used as a basis for the economic analysis of this study.

Table 3 – Annual Heating Demand Summary

Year	YMCA Annual Heating Demand (mmBtu)	YMCA Pool & Spa Annual Heating Demand (mmBtu)	Cook County School Annual Heating Demand (mmBtu)	Total Annual Heating Demand (mmBtu)
2014	2,638	1,962	4,798	9,398
2015	1,503	1,962	3,122	6,587
Average	***2,071***	***1,962***	***3,960***	***7,992***

Note 1: YMCA pool and spa heating demand is based on 2014 data. 2015 data was unavailable.

In order to determine proper sizing of a biomass heating system, heating demand models of hourly output were developed using existing fuel and heat information as well as local weather data. Surface weather data was obtained from Grand Marais Airport for 2014 and 2015. Daily mean temperatures were used to calculate the heating degree days (HDD) for each day of the year. Heating degree days are a daily measurement of the outside air temperature relative to a theoretical base temperature in which a building has no heating demand. This study uses a HDD base temperature of 55°F. Models of the daily average hourly heating demand were developed using the YMCA and school heating demands and heating degree days as well as the base heating demand provided by the YMCA pool and spa. The daily average hourly heating demand for 2014 and 2015 is presented in Figure 4.

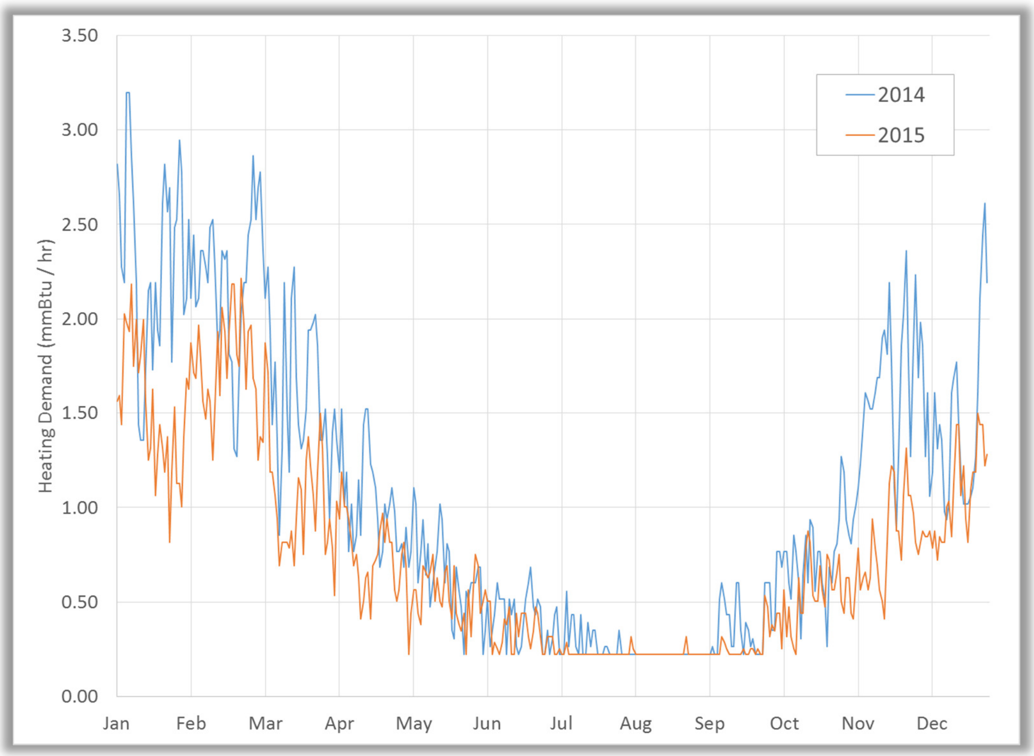


Figure 4 – Daily Average Hourly Demand for 2014 & 2015

Note: Values shown are daily average hourly demand. During the course of a 24-hour period, it is anticipated that the hourly demand would fluctuate both above and below the values shown.

The average hourly demand models presented in Figure 4 were sorted in descending order, as opposed to chronologically, to develop load duration curve models for 2014 and 2015. The load duration curve models are presented in Figure 5. It is important to note how these demand models can be used appropriately. The models present the daily average hourly demand. Over the course of a 24 hour period, the loads will vary above and below the average. Thus, the load curve models are useful for sizing a biomass boiler to ensure efficient operation and demand coverage, but do not indicate actual peak or minimum heating demands.

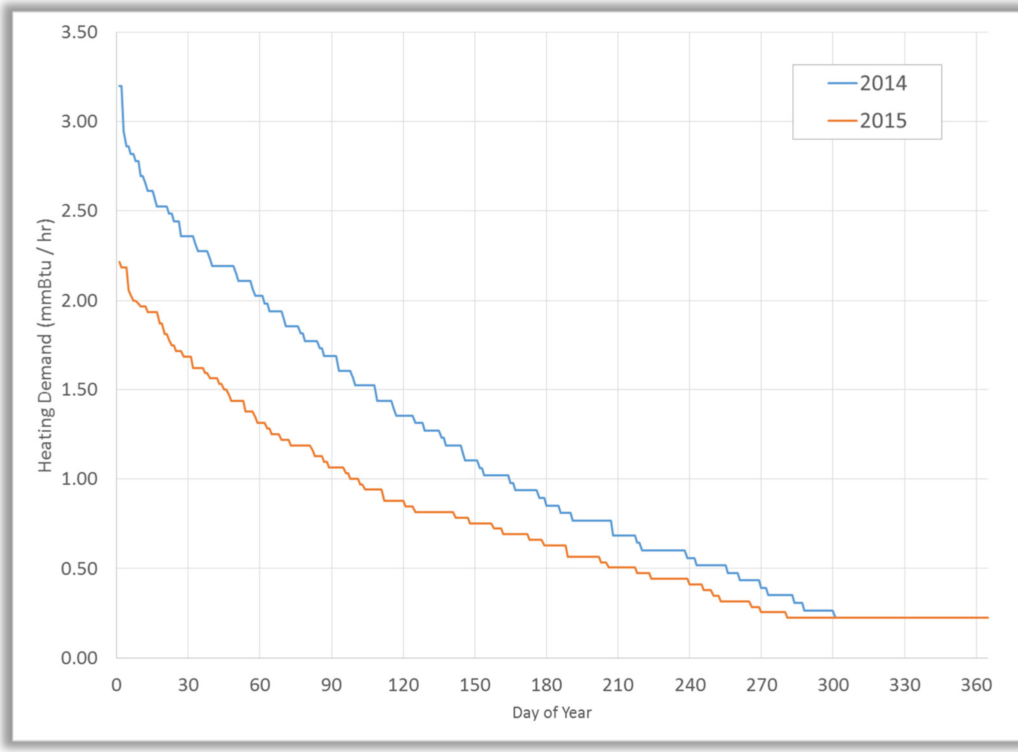


Figure 5 – Load Duration Curves for 2014 & 2015

Note: Values shown are daily average hourly demand. During the course of a 24-hour period, it is anticipated that the hourly demand would fluctuate both above and below the values shown.

5.0 BIOMASS AVAILABILITY AND FUEL COST COMPARISONS

Modern biomass combustion systems can efficiently and cleanly utilize a variety of fuels with a wide range of moisture content. Due to the variations in the potential fuels available in various locations, there are differing systems for each fuel type. Wood pellet systems are commonly limited to firing on pelletized fuel or dry wood chips with allowable moisture content (wet basis) typically in the range of 5–30%. Systems capable of utilizing green wood chips are typically designed for fuel with a moisture content of 20–50%. Some manufacturers offer equipment able to utilize pellets or green chips, although the control parameters and system options may need to be adjusted when targeting one of these fuels in order to maintain efficiency. Cordwood systems are typically designed to use cordwood with a moisture content of approximately 20% wet basis, which is what can be achieved by air drying. Some cordwood systems are able to also use wood pellets following a manual adjustment of the grates.

Due to the heating demands of the Cook County Schools campus, green wood chips were selected as the most appropriate fuel type. The biomass system evaluated in this study would require an estimated 1,033 tons of wood chips, annually.

Table 4 compares the cost of delivered heat for propane and wood chips.

Table 4 – Fuel Pricing and Cost per mmBtu

Fuel, units	Unit Cost ($/unit)	Heating Value (mmBtu/unit)	Assumed Efficiency	Output Cost ($/mmBtu)
Propane (4-year average)[1], gallon	$1.32	0.091502	85%	$16.99
Green wood chips[2], ton	$60	10.0	70%	$8.57

Note 1: The four year average propane unit cost is based on years 2012-2015.
Note 2: Green wood chips are approximately 40-45% moisture content wet basis. Cost is based on Hedstrom Lumber Company's delivered price for green mill chips.

5.1 Wood Chips

Sources of wood chips could be local loggers, regional wood products manufacturers, MN DNR, or the US Forest Service. The primary outlets for low value residuals are Resolute Forest Products in Thunder Bay, Ontario, and wood chip CHP (combined heat and power) plants in Virginia and Hibbing. WES spoke with Hedstrom Lumber Company, a local lumber mill in Grand Marais. Hedstrom is currently selling residual mill chips for $60 per ton. Hedstrom also indicated that they sell green saw dust during shoulder and summer months for a delivered cost of $20 to $30 per ton.

WES also spoke with several local loggers and learned that there are a significant number of logging operations which are doing in-woods chipping between Duluth and Ely. The in-woods chipping is done in conjunction with harvesting of saw timber or pulpwood. The general unofficial chip spec in the woods is a 2" whole tree chip, and these are for the most part delivered to the Laurentian Energy Authority (LEA) power plants in Virginia and Hibbing, or the LEA wood yard in Mountain Iron, for a delivered cost of $30 to $40 per ton. These may be feasible suppliers, however, Grand Marais is further in distance from these operations.

Wood chip moisture content and quality are important considerations when selecting a biomass boiler and fuel handling system. Some boilers require moisture contents of 30% (wet basis) or less and chip size of 1-1/2" or less, while others can tolerate wetter/larger chips. In addition to moisture content, ash content is another quality measure. Bark, leaves, and twigs all have a higher ash content than debarked roundwood. Paper and OSB mills use debarked roundwood chips as their primary feedstocks, and therefore these materials will command a higher price.

Unacceptable feedstocks for wood chip boilers would include contaminated C&D waste, treated lumber, painted lumber, non-wood fuels such as coal or tires, or garbage of any kind. These fuels have the potential to generate significantly elevated emissions, and may damage the combustion unit or boiler.

The wood chip boiler evaluated in this study would be able to accept whole tree, green chips. Dried or partially dried chips would also be acceptable, though they would typically be more expensive. The system also would have the ability to screen out over sized chips.

6.0 EVALUATED BIOMASS SYSTEM

6.1 WOOD CHIP BOILER SYSTEM

A biomass combustor and hot water boiler, rated 2.0 mmBtu/hr, would be installed to burn wood chips and provide heating hot water to the schools and YMCA. The biomass system would be sited in a new building located behind the school, near the existing boiler room.

The biomass boiler would directly heat a 2,000 gallon thermal storage tank, typically maintained at 200°F. A VFD controlled pump would inject hot water from the thermal storage tank into the supply header as needed to maintain the set point temperature. One or more of the existing propane boilers will fire when the biomass boiler fails to maintain the set point temperature. The addition of the thermal storage tank to the system and the storing of water at temperatures above the set point temperature provides an additional 650,000 Btu of capacity to the system, allowing for coverage of temporary peaks above the boiler capacity. Thermal storage also provides a heat sink during periods of low demand, which limits boiler cycling and improves system efficiency. The existing propane boilers will remain in place to maintain system redundancy.

A new 1,760 ft^2 building would be constructed to house the new biomass system and an on-grade wood fuel storage. The fuel storage area would be sized to hold 40 tons of wood chips, which would provide approximately 6 days of fuel storage at maximum boiler output. This would allow for the facility to accept full deliveries of wood chips in walking floor tractor trailers, with additional storage capacity to continue operation of the boiler. Wood chips would be unloaded directly onto the on-grade fuel storage area by the walking floor tractor-trailer. A traveling auger would automatically extract chips from the floor of the fuel storage to a conveyor system, where they would be screened to remove oversized chips, before being fed into the metering bin. Wood chips would then be fed into the combustion unit to maintain the required boiler output. The fuel storage area would be enclosed and heated, to prevent any potential problems associated with frozen chips.

A site plan, conceptual boiler plant layout, and schematics for the biomass system are presented in Appendix A.

Advanced wood chip boilers are sized and operated to ensure that the majority of runtime is within the boilers' most efficient operating range of 25% to 100% of their rated heating output capacity. Wood chip boilers are able to turn down further than 25%, but often during periods of low heating demand, the actual load is intermittent. Wood chip boilers do not have an immediate response time to a drop-off in demand because of the mass of chips that remains burning on the combustor grates. Boiler cycling can cause poor quality combustion of the wood fuel and lead to lower boiler efficiencies. However, in this case, the YMCA swimming pool and spa present a consistent and continuous demand for heat, allowing for a wood chip boiler to continue operate efficiently below a 25% turn down. Modeling of the coverage for this report allows the boiler to run down as low as 10% of the rated capacity while still covering the load.

Load coverage for the boiler is evaluated using data from the 2014 and 2015. Figure 6 shows the expected load coverage of a 2.0 mmBtu/hr boiler to be approximately 94% based on the 2014 LDC model. Figure 7 shows the expected load coverage to be >99% based on the 2015 LDC model. This study assumes a 90% load coverage for the biomass heating system for purposes of estimating existing fuel offset.

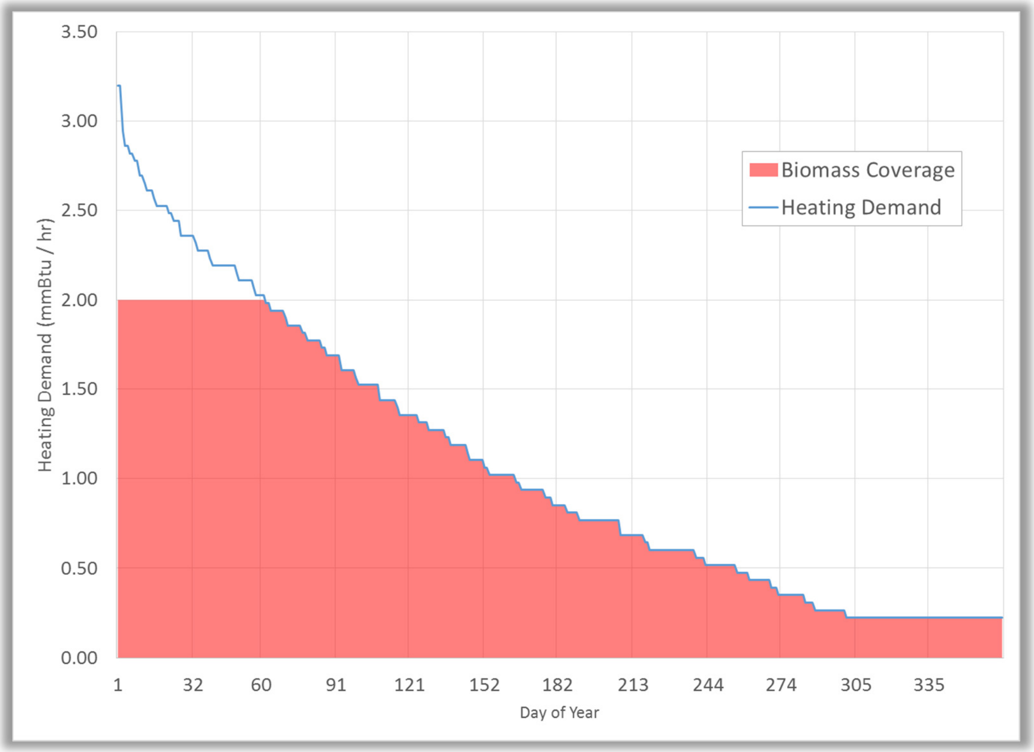


Figure 6 – 2014 LDC and Coverage of 2.0 mmBtu/hr Wood Chip Boiler

Note: Values shown are daily average demands. During the course of a 24-hr period, it is anticipated that the hourly demand would fluctuate both above and below the values shown.

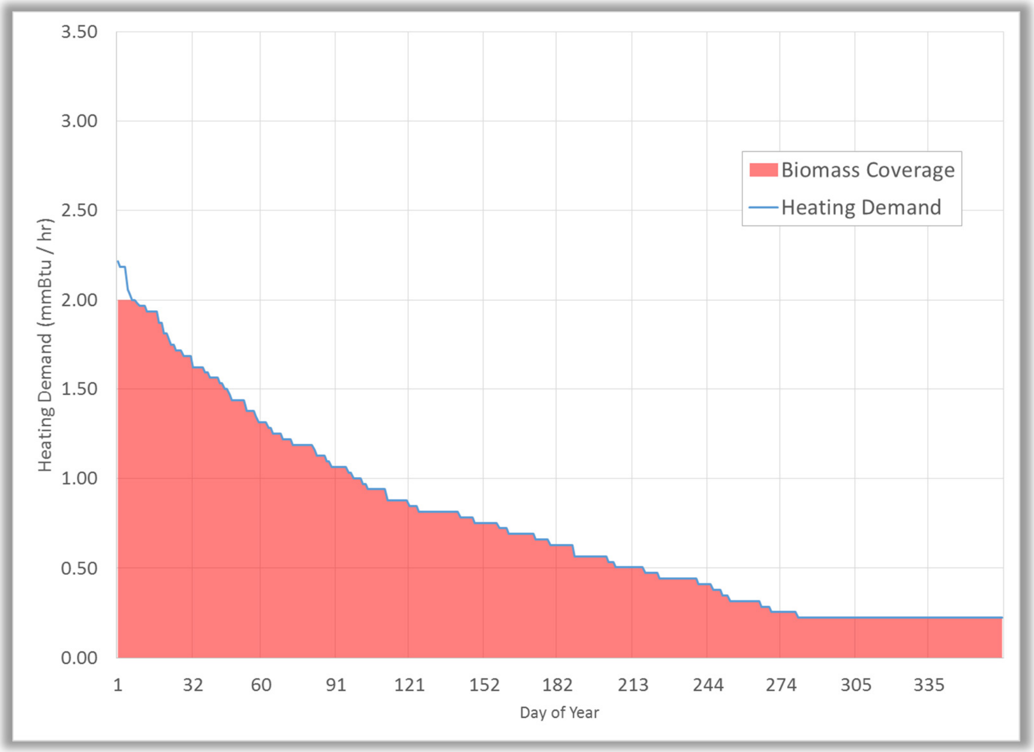


Figure 7 – 2015 LDC and Coverage of Wood Chip Boiler

Note: Values shown are daily average demands. During the course of a 24-hr period, it is anticipated that the hourly demand would fluctuate both above and below the values shown.

6.2 Pool Loop Interconnection

The pool and spa are currently heated by separate boilers on separate heating loops. Each boiler system uses a mixing valve to maintain the proper loop set point temperature. The swimming pool is maintained at 86°F and the spa at 104°F.

With the installation of a biomass heating system, the pool and spa heating loops would be interconnected with the YMCA heating loop. This would allow the biomass boiler system to pick up the pool and spa heating loads as well as the space heating loads of the YMCA, and allow the biomass boiler to operate year-round.

Heat exchangers would be installed on both the swimming pool and spa heating loops. Zone valves will control the flow of heating supply water to each heat exchanger to maintain the set point temperatures in the pool and spa loops. A bypass valve would be installed to bypass the heat exchanger and allow the pool and spa heating systems to operate with their existing boilers.

With the close proximity of YMCA heating supply pipes to the pool mechanical room, interconnection with to YMCA heating loop provides a relatively inexpensive connection cost for the pool and spa heating loops. This would also keep all heat, in the form of hot water, sent to the YMCA on the existing Onicon Btu meter. The interconnection of the pool and spa loops would add additional load to the YMCA loop. During periods of high demand, should the combined heating load of the YMCA and pools exceed the YMCA loop capacity, the existing pool and spa boilers will fire to provide supplemental heat.

7.0 GRANTS AND INCENTIVES

7.1 BIOMASS THERMAL PRODUCTION INCENTIVE

Minnesota Statutes 2015, section 41A.18, and Minnesota Session Laws 2016, chapter 189, article 2, section 21 provide for a "biomass thermal production incentive" which pays eligible facilities $5 for each mmBtu of heat supplied to a building or process using biomass fuel. In order to be eligible, a facility must install a biomass boiler or other similar device after July 1, 2015, and this system must deliver no less than 250 mmBtu to the facility during one single calendar quarter. For a period of 10 years after qualification, the facility owner can receive $5 per mmBtu of thermal output for calendar quarters in which thermal production exceeds 250 mmBtu.

Based on assumptions in Table 5, 250 mmBtu of thermal output is approximately equivalent to 36 tons of wood chips (assuming 70% seasonal boiler efficiency). Based on existing heating demands, Cook County Schools would qualify for this incentive for all four quarters of the year. During qualifying quarters, this incentive would effectively reduce the price of wood chips by $35/ton, to a price of $5/ton.

Specific sustainable harvesting and sourcing requirements have to be met. For facilities within 50 miles of the state border (this includes the Cook County Schools), the material must be sourced from within Minnesota, or within a 100 mile radius including areas outside Minnesota.

8.0 BIOMASS SYSTEM ANALYSIS

Table 5 lists the values and assumptions used in the analysis.

Table 5 – Values and Assumptions

Assumption	Value	Unit	Source
Propane HHV	0.091502	mmBtu/gal	Cook County Schools
4-Year Average Propane Cost	$1.32	$/gal	Cook County Schools
Propane Boiler Efficiency	85%	percent	WES Assumption
Wood Chip HHV (40% moisture wet basis)	10	mmBtu/ton	WES Assumption
Wood Chip Cost	$40	$/ton	WES Assumption
Wood Chip Boiler Efficiency	70%	Percent	WES Assumption
Wood Chip Density	0.01	tons/ft^3	WES Assumption
Wood Chip Ash Content	3%	Percent	WES Assumption
HDD Base Temp	55	˚F	WES Assumption
Heating demand coverage by biomass	80%	Percent	WES Assumption
Electric Cost	$0.10	$/kWh	WES Assumption
Labor Cost (at Biomass Plant)	$30	$/hr	WES Assumption
CO_2 emitted during combustion of Propane	62.87	kg/mmBtu	EPA
CH_4 emitted during combustion of Propane	0.003	kg/mmBtu	EPA
N_2O emitted during combustion of Propane	0.0006	kg/mmBtu	EPA
CO_2 emitted due to use of Electricity (includes line losses)	3.32	kg/kWh	EPA
CH_4 emitted due to use of Electricity (includes line losses)	0.0000644	kg/kWh	EPA
N_2O emitted due to use of Electricity (includes line losses)	0.0000566	kg/kWh	EPA
CH_4 100-year Global Warming Potential	25	* CO_2	IPCC
N_2O 100-year Global Warming Potential	298	* CO_2	IPCC

8.1 CAPITAL COST ESTIMATES AND OPERATING COST SAVINGS

The estimated capital cost is presented in Table 6.

Table 6 – Capital Cost Estimate Summary

Option	Estimated Capital Cost
2.0 mmBtu/hr Wood Chip Boiler System	$1,236,700

Costs for the systems include the combustion unit and boiler, new boiler building, thermal storage, automatic fuel and handling, piping and interconnection, and installation. A detailed breakdown of capital costs is provided in Appendix B.

A breakdown of estimated operating and maintenance costs is presented in Table 7.

Table 7 – Estimated Operating and Maintenance Costs

Electric Use Cost	Ash Removal Cost	Maintenance / Wear Parts Cost	Staff Time Cost	Total O&M Cost
$2,220	$2,170	$5,000	$2,700	$12,090

A fuel use profile is presented in Table 8 showing the estimated annual fuel use for a wood chip boiler system compared to the existing system.

Table 8 – Proposed System Fuel Use Profile

Current Annual Fuel Use	Biomass Demand Coverage	Annual Fuel Use with Proposed Biomass System	
Propane (gal)		Estimated Wood Chip Use (tons)	Estimated Propane Use with Biomass System (gal)
102,758	90%	1,033	10,276

A comparison of fuel and operating costs for the proposed biomass system and the existing operation system is presented in Table 9.

Table 9 – Fuel and Operating Cost Comparison

Current Annual Fuel Costs	Estimated Annual Costs with Proposed Biomass System			Estimated First Year Operational Savings	Thermal Production Incentive	Estimated Net Cash Flow
Propane Cost	Biomass Cost	Propane Cost	O&M Increase			
$135,773	$61,995	$13,577	$12,090	$48,111	$36,164	$84,275

A summary of the estimated capital costs and payback is presented in Table 10. This table also evaluates the biomass system with an assumed 25% grant. No specific grant funding opportunity has been identified.

Table 10 – Cost and Payback Analysis

System / Grant Funding	Estimated Capital Cost	Assumed Grant Funding	Investment Amount	Simple Payback Period[1]	Net Present Value (25 years)
2.0 mmBtu/hr Biomass / 0% Grant	$1,236,700	$0	$1,236,700	18.2	$567,024
2.0 mmBtu/hr Biomass / 25% Grant	$1,236,700	$309,175	$927,525	11.8	$876,199

Note 1: Simple payback is calculated taking into account the assumption that thermal production incentive payments end after 10 years.

Detailed financial analyses are presented in Appendix C.

9.0 EMISSIONS, PERMITTING, AND LICENSING

9.1 PARTICULATE MATTER EMISSIONS

All fuel combustion equipment emits some level of particulate matter from the combustion process. For all fossil fuels and renewable fuels, properly tuned systems are critical to ensure optimal conversion efficiencies and minimal emissions. Modern biomass boilers utilize oxygen sensors and variable speed drives to optimize the combustion process with the proper air/fuel mixture. This results in high combustion efficiencies and low emissions, and this section compares particulate matter emission rates for various fuels and equipment.

Note that in this section, the term lb/mmBtu refers to pounds of a certain pollutant emitted in the flue gas per million Btu of fuel (HHV) input. Based on the assumed efficiencies in Table 5, the proposed wood chip boiler would have a maximum fuel input rate of 2.86 mmBtu/hr.

Minnesota Administrative Rules section 7011.0550 Table II sets the maximum particulate emissions from a boiler at 0.4 lb/mmBtu. This emission requirement can be met by modern wood boilers. Visually, the flue gas of a modern wood boiler would exhibit no opacity.

The EPA publishes emissions factors for a wide range of fuel burning devices in its publication AP-42. Table 11 presents these emissions factors along with the expected emissions factors for wood boilers based on stack test data obtained by WES.

Table 11 – Emissions Factors for PM

Fuel and Source	PM Emissions	Unit
Wood Chip Boiler[1]	0.08 – 0.15	lb/mmBtu
Propane Boiler[2]	0.008	lb/mmBtu

Note 1: Value is representative of independent lab testing of boilers comparable to proposed system
Note 2: Value is based on the EPA's AP-42 for propane combustion.

9.2 Gaseous Emissions

Besides PM, other pollutants from fuel combustion include VOC, NO_X (NO and NO_2), SO_X, and CO. Ozone (O_3) is a byproduct of NO_X and VOC emissions. Emissions factors for the gaseous pollutants mentioned are presented in Table 12.

Table 12 – Emissions Factors for Gaseous Pollutants

Fuel and Source	Emission Factors (lbs/mmBtu)			
	VOC	NO_x	SO_x	CO
Wood Chip Boiler[1]	0.004	0.180	0.002	0.150
Propane Boiler[2]	0.005	0.142	0.0002	0.082

Note 1: Wood chip values are obtained from stack test results.
Note 2: Propane factors are taken from AP-42, S content of 0.2 g/100ft^3

Based on this table, a wood boiler would be comparable to a propane boiler in terms of VOC and NO_X. The elevated level of SO_X is due to naturally occurring sulfur in the wood, and can vary regionally.

9.3 Greenhouse Gas Emissions Benefits

By displacing the existing fossil fuel used for heating (propane), the installation of a biomass boiler system would result in a reduction of Cook County Schools' annual net CO_2 equivalent greenhouse gas emissions by 460 metric tonnes, as shown in Table 13. Although combustion of wood releases CO_2, the use of wood fuel provides net carbon benefit as long as the fuel is sourced in a sustainable manner. CO_2 equivalent values presented in this report include CO_2, as well as CH_4 and N_2O adjusted for their 100-year global warming potential relative to CO_2. These values are listed in Table 5.

Table 13 – Greenhouse Gas Emission (CO_2 equivalent) Reductions

Current System	With Proposed Biomass System			
Propane CO_2 Equivalent Emissions (tonnes)	Biomass CO_2 Equivalent Emissions (tonnes)	Biomass Boiler Electric CO_2 Equivalent Emission[1] (tonnes)	Propane CO_2 Equivalent Emissions (tonnes)	Reduction in CO_2 Equivalent Emissions (tonnes)
594	0	74	59	460

Note 1: Biomass boilers use more electricity than comparable propane boilers due to fuel handling equipment, larger blowers, etc.

9.4 Air Permitting

Boilers in Minnesota can be subject to both state and federal emissions and permitting requirements. Using EPA AP-42 factors for wood and propane boilers, the PTE (potential to emit) of the Cook County

Schools would not exceed the state or federal emissions thresholds for air pollutants with the proposed wood chip system. The PTE of a facility also includes non-combustion emissions sources such as VOCs and dust. WES estimates that there are no significant emissions sources at this facility that would affect the permitting status other than the boilers. Additionally, Cook County Schools would not be subject to any NSPS (New Source Performance Standards). Based on these calculations and assumptions, the addition of a wood chip heating system as described would not trigger any state or federal permitting requirements.

9.5 USE OF WOOD RESIDUALS AS FUEL

Wood pellets are a manufactured product and would not be considered by the Minnesota Pollution Control Agency (MPCA) to be a solid waste.

The MPCA has issued a Standing Beneficial Use Determination (SBUD) codified in Minn. R. 7035.2860, subpart 4(a), that allows for the use of "unadulterated wood, wood chips, bark, and sawdust" as a fuel, as long as the material is stored and managed appropriately. Unadulterated wood means wood that is not contaminated with paints, stains, glues, preservatives, or other chemicals. This SBUD allows facilities to use clean wood chips regardless of the source as a fuel without any further action from MPCA's solid waste program.

9.6 ASH

Whole tree wood chips generally contain about 3% ash by weight. Modern chip boilers have automated or semi-automated ash handling systems which deposit ash in a portable metal container such as a 55-gallon drum. An example of this is shown in Figure 8.

Figure 8 – Automated Ash Collection from Chip Boiler

The proposed biomass system described in this report has the potential to generate 31 tons of ash per year.

Wood ash is a valuable soil amendment which has properties similar to agricultural lime. Studies have shown that land application of wood ash can improve forest health[1]. Wood ash is classified and regulated as a solid waste in Minnesota. However, the MPCA has a process whereby it will make a case-specific beneficial use determination (CSBUD) to decide whether a specific management option for the

[1] https://www.forestry.umn.edu/sites/forestry.umn.edu/files/Staffpaper153.PDF

solid waste is a beneficial use. Because wood ash is known to have valuable properties when used as a soil amendment, the MPCA has made determinations for several other facilities with biomass boilers that ashes can be spread on land, and therefore it is likely that permission will be granted in future cases. Prior to implementation of a biomass project, a proposal should be submitted to the MPCA in order to gain permission for this use of the wood ash.

Beneficial use of the ash is anticipated to be significantly cheaper than landfilling, and could be used beneficially at a lower cost to the facility. However, for purposes of this study, ash is assumed to be removed from site. The Carlton County Extension Office can assist with finding beneficial use sites, and applying for a CSBUD. Additional information on ash use from UMN Extension is provided in Appendix D.

9.7 BOILER OPERATOR REQUIREMENTS

Minnesota Administrative Rules section 5225.1110 requires all boilers be operated, maintained, and attended by a licensed operating engineer, unless specifically exempted. Minnesota Statutes section 326B.988 exempts hot water heating boilers that do not exceed a combined heat input capacity of 750,000 Btu per hour.

Minnesota Statutes section 326B.978 sets the classifications and qualifications for operating engineers. Engineers are divided into four classes based on individual boiler size allowed to be operated: chief, first class, second class, and special engineers. The maximum boiler size allowed to be operated by license class is presented in Table 14. Licenses classes are also divided into Grade A, B, C licenses. Grade C licenses allow for the operation of low pressure boilers (steam less than 15 psig, or hot water less than 160 psig or 250°F). Grade B licenses allow for the operation of low or high pressure boilers. Grade A licenses allow for the operation of low or high pressure boilers with engines, turbines or other appurtenances.

Table 14 – Maximum Boiler Size by License Class

Class	Maximum Boiler Size
Chief Engineer	Unlimited
First Class Engineer	500 HP (16.7 mmBtu/hr)
Second Class Engineer	100 HP (3.35 mmBtu/hr)
Special Engineer	50 HP (1.67 mmBtu/hr)

Attendance requirements for low pressure boilers are set by the chief boiler inspector. A boiler attendance policy issued on July 29, 2014 requires a licensed operating engineer check the boiler(s) at least once each day during normal workdays. For weekends and holidays, boiler attendance policy requires a licensed operating engineer check the boiler(s) if: outside air temperature is forecasted to reach 10°F or below, a situation occurs that impacts the safety of the boiler or equipment, or the building will be occupied by employees or the public. No boiler should be left unattended for more than two consecutive days. A check of the boiler includes visual examination of all associated equipment and a logbook entry of the conditions observed.

The existing aggregate input rate for the boilers is approximately 9.25 mmBtu/hr and already exceeds the limit for boiler operator exemption. The input capacity of the proposed biomass would be approximately 2.86 mmBtu/hr and would fall under the same boiler license requirement as the existing heating boilers. Therefore, no change in license class would be required during the heating season, according to the class designations in Table 14. During summer operation where only the pool and spa boilers are running, attendance requirements still require a licensed boiler engineer, however, only a special class engineer would be required. With the operation of the proposed biomass boiler, a second class engineer would be required year-round.

10.0 CONCLUSIONS AND RECOMMENDATIONS

A modern biomass boiler system would allow Cook County Schools to reduce fossil fuel use while utilizing a local and renewable source of energy. This project would provide a first year net operating savings of $48,111 before taking into account payments from the thermal production incentive, and would have a capital cost of $1,236,700.

Financial performance of the evaluated system is heavily dependent on the cost of fossil fuels and wood fuels, as shown by the sensitivity analyses in Appendix C. If the cost of propane rises, then the savings will increase substantially.

Payments from the Minnesota Biomass Thermal Production Incentive are a major driver of savings. The annual incentive payment would be approximately $48,111. It is important to note that these payments only occur for 10 years following startup of the project. With the incentive payments, the 25-year net present value of this project is $567,024.

Additional benefits provided through the use of local biomass at the facility include:

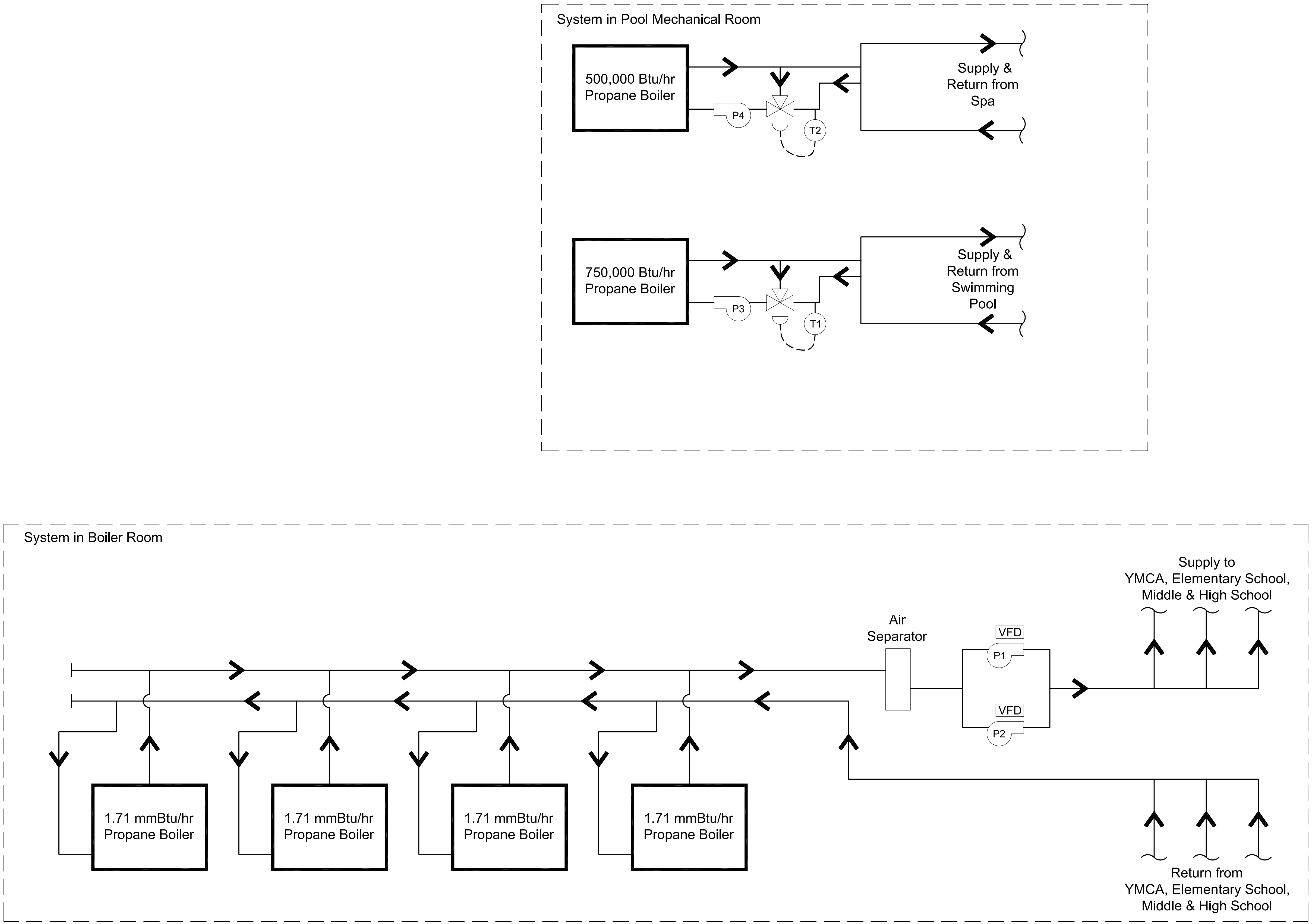
- Net reduction of greenhouse gas emissions by 460 metric tonnes annually,
- Keeping ~$62,000/yr spent on energy within the region,
- Diversification of fuels used by Cook County Schools,
- Reduction in operating budget volatility due to wide fluctuations in fossil energy pricing,
- Creating markets for low-value woody biomass to enhance opportunities for forest management activities to reduce pests and disease, prevent fires, and manage for ecological diversity, soil health, and water quality.

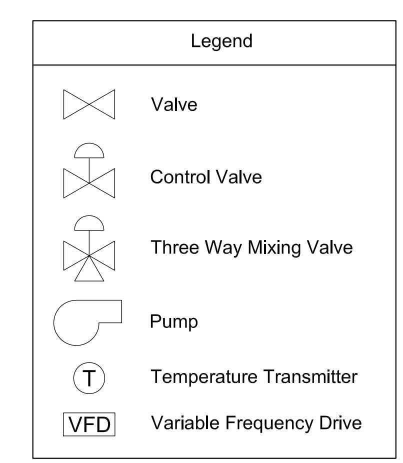
Should Cook County Schools be interested in pursuing a biomass option, WES recommends that county staff in both administration and operations visit modern biomass boiler installations to develop a detailed understanding of the equipment and its capabilities. The MN SWET is available to assist in arranging tours of existing facilities. As Cook County Schools continues to pursue renewable biomass energy options, WES recommends that the next level of evaluation includes detailed consideration of the following items:

- Work with the MN SWET to identify alternative funding sources (low interest loans, grants, and incentives)
- Perform site investigations (utility, geotechnical) for the new boiler room and fuel storage building and further develop the biomass plant layout and capital cost based on investigation results.

Appendix A – Drawings

- A.1 Existing Boiler System Schematic
- A.2 Biomass Boiler System Schematic
- A.3 Biomass System Layout
- A.4 Biomass Building Elevations
- A.5 Biomass Building Section
- A.6 Biomass System Site Plan
- A.7 Biomass Fuel Delivery Diagram





Notes:
1. This drawing is a conceptual layout for the purposes of showing biomass system options.
2. Final design and layout will change based on equipment selected, designer, and site conditions.

Existing Boiler System

Designed	SFK	9/23/16
Drawn	SFK	9/23/16
Checked		

Approved
Date
Title
Job Class

Cook County Schools & YMCA
Grand Marais, MN

Existing Boiler System Schematic

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REVISIONS
Date
Description
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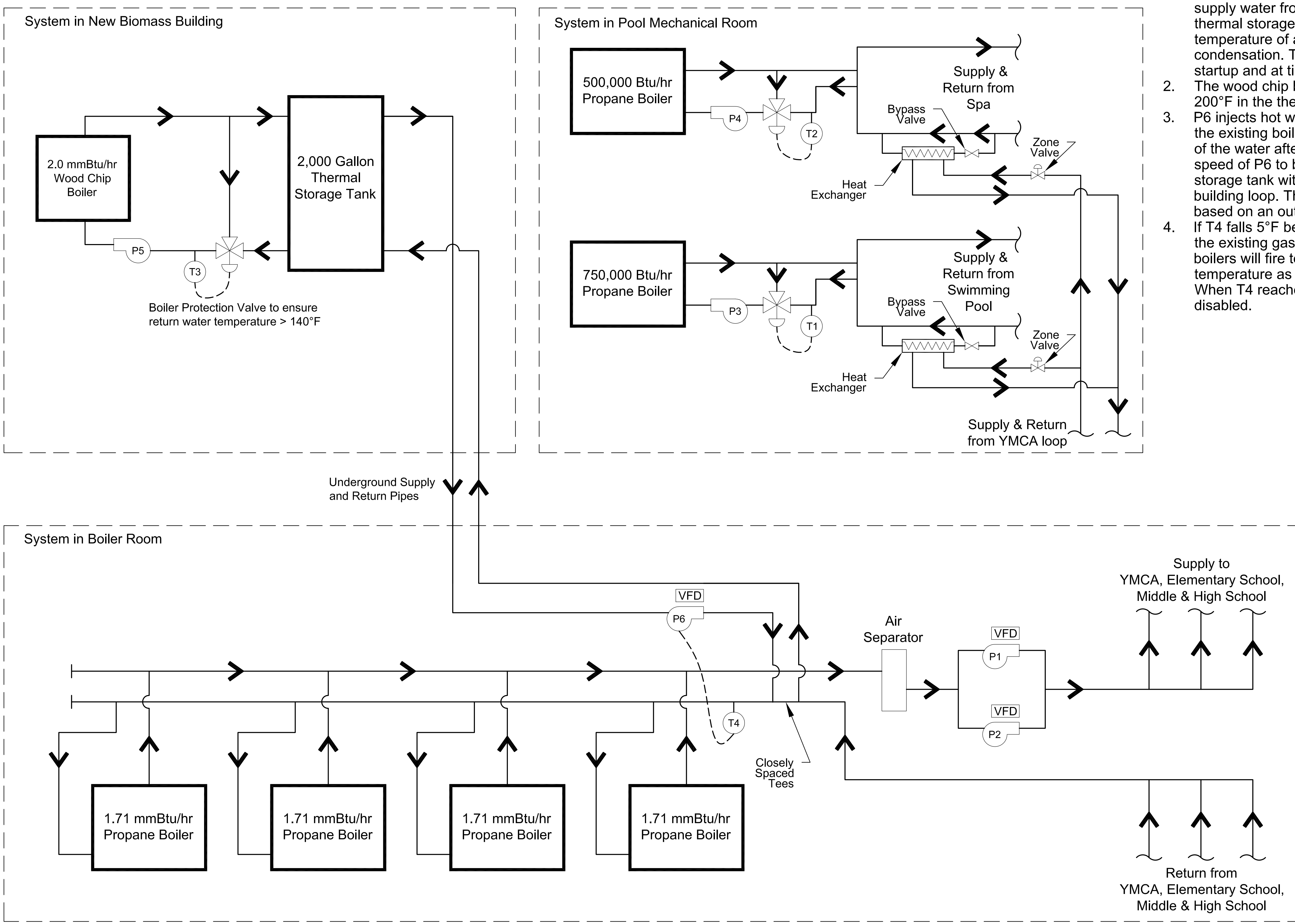
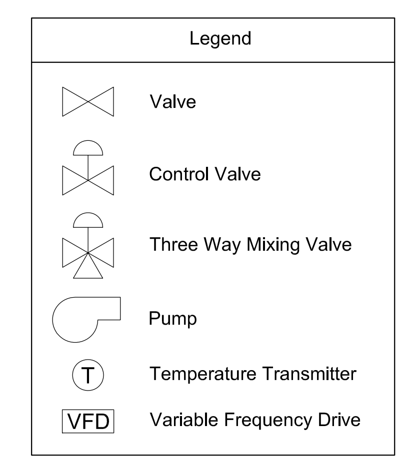
A.1



Sequence of Operations:

1. T3 controls a three way mixing valve which allows supply water from the wood chip boiler to bypass the thermal storage, in order to maintain a return water temperature of at least 140°F to prevent flue gas condensation. This is mainly a concern during boiler startup and at times of heavy load.
2. The wood chip boiler will be controlled to maintain 200°F in the thermal storage tank.
3. P6 injects hot water into the building supply loop in the existing boiler plant. T4 controls the temperature of the water after the injection point by controlling the speed of P6 to blend hot water from the thermal storage tank with cooler return water from the building loop. The temperature set point for T4 is based on an outside reset schedule.
4. If T4 falls 5°F below the set point for 5 minutes, then the existing gas boilers will be enabled. The gas boilers will fire to maintain the building loop temperature as they are currently configured to do. When T4 reaches set point, the gas boilers will be disabled.



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Biomass Boiler System

Designed SFK 9/23/16
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Job Class

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Biomass Boiler System Schematic

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A.2

Notes:

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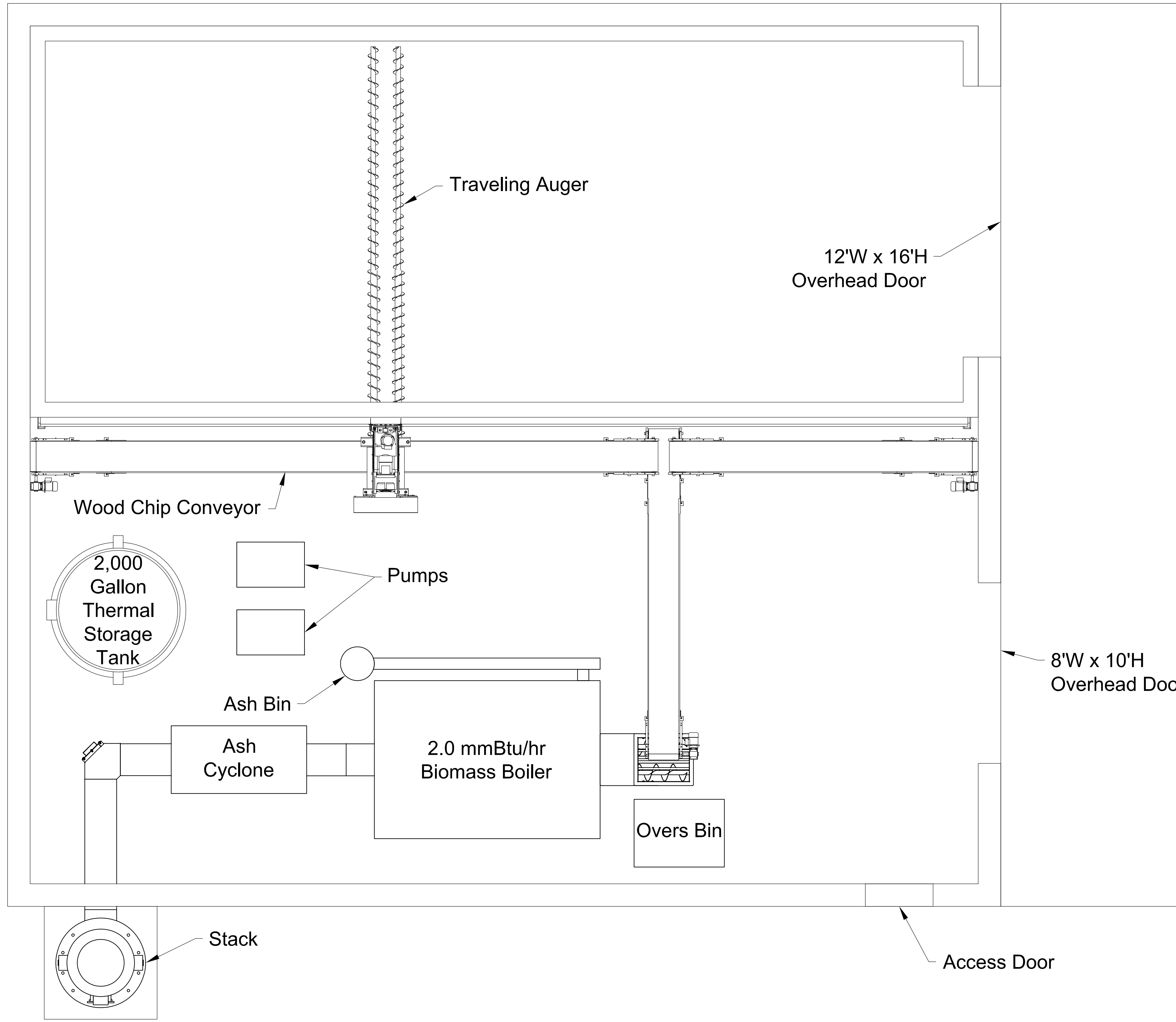

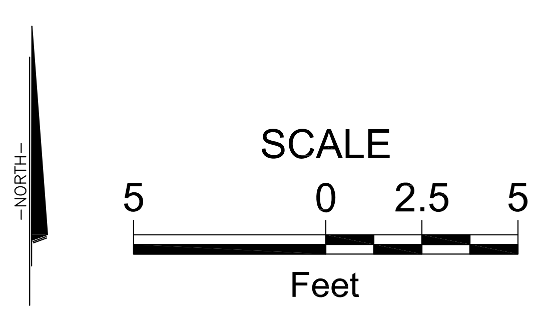

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Biomass System Layout

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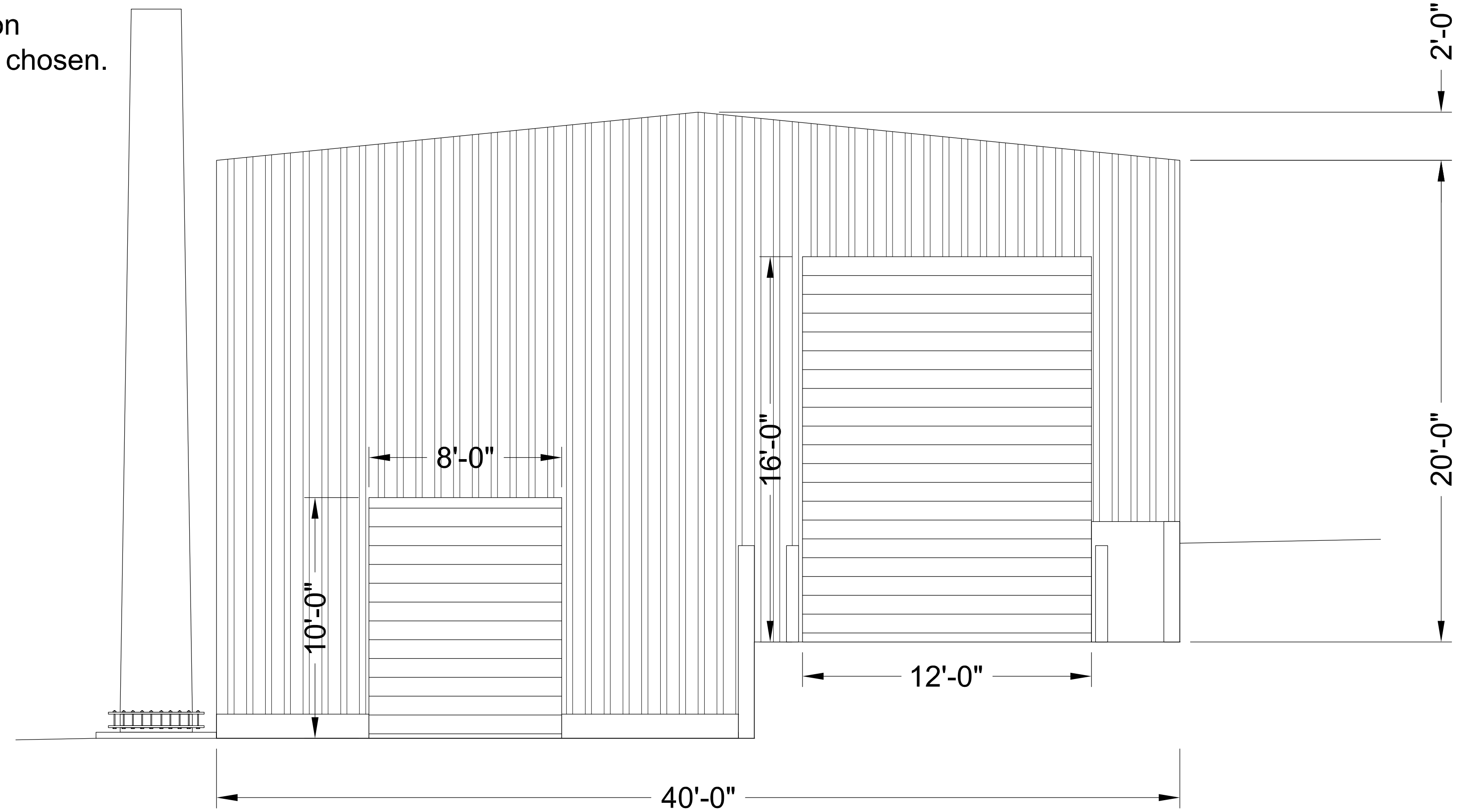
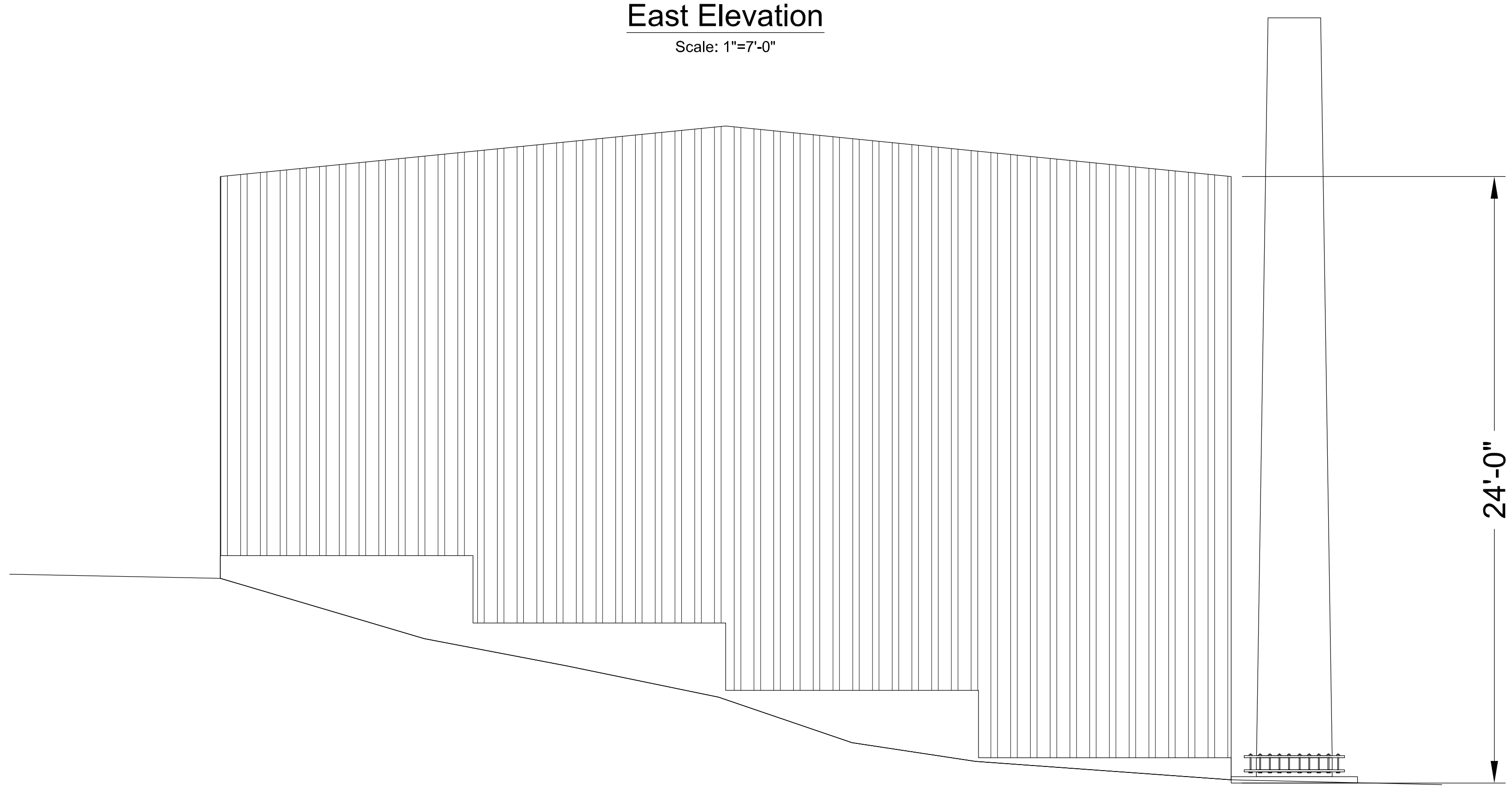
Notes:

- This drawing is for general layout purposes.All dimensions, locations, and orientation may change depending on equipment, vendors,and contractors chosen.



East Elevation
Scale: 1"=7'-0"



West Elevation
Scale: 1"=7'-0"

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Biomass Building Elevations

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Notes:

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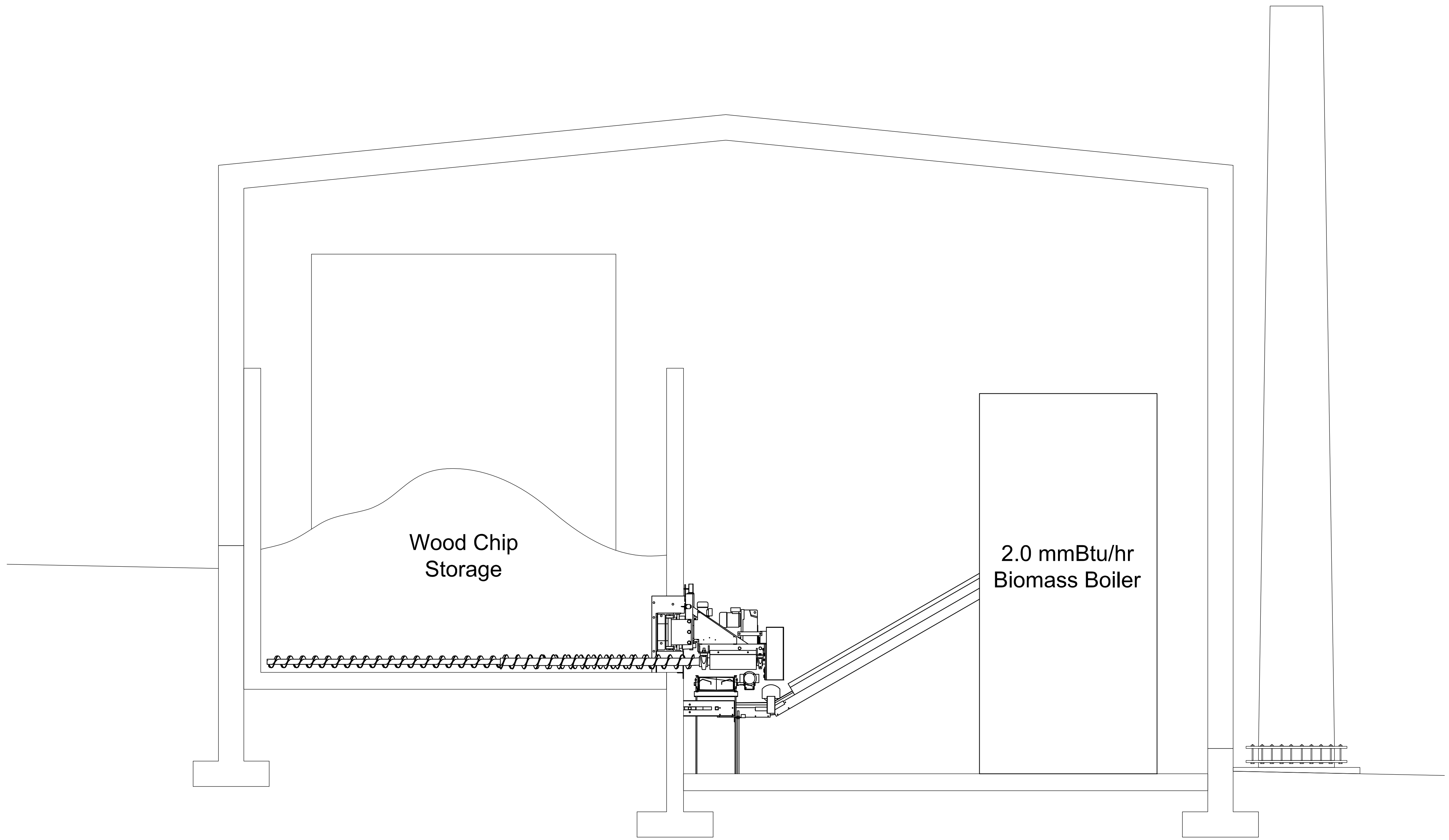

SCALE

5 0 2.5 5

Feet

Designed	SFK 9/23/16
Drawn	dHb 9/23/16
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Approved	Date
Title	Job Class

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Grand Marais, MN

Biomass Building Section

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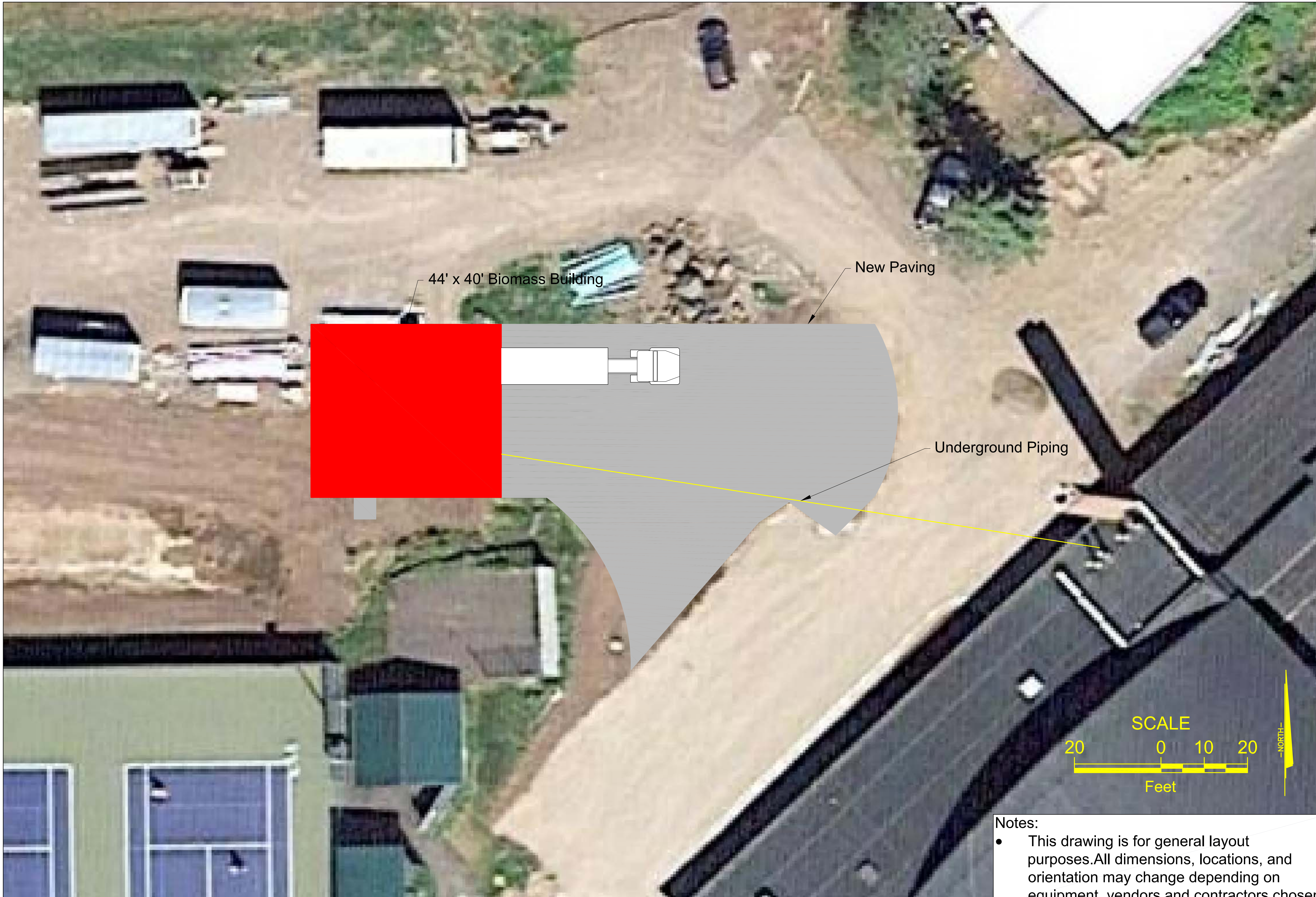

Notes:

- This drawing is for general layout purposes.All dimensions, locations, and orientation may change depending on equipment, vendors,and contractors chosen.

Cook County Schools & YMCA

Grand Marais, MN

Biomass System Site Plan

Designed	SFK	9/23/16
Drawn	dHb	9/23/16
Checked		

Approved ___ Date ___

Title ___ Job Class ___

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Date	Description	Approved

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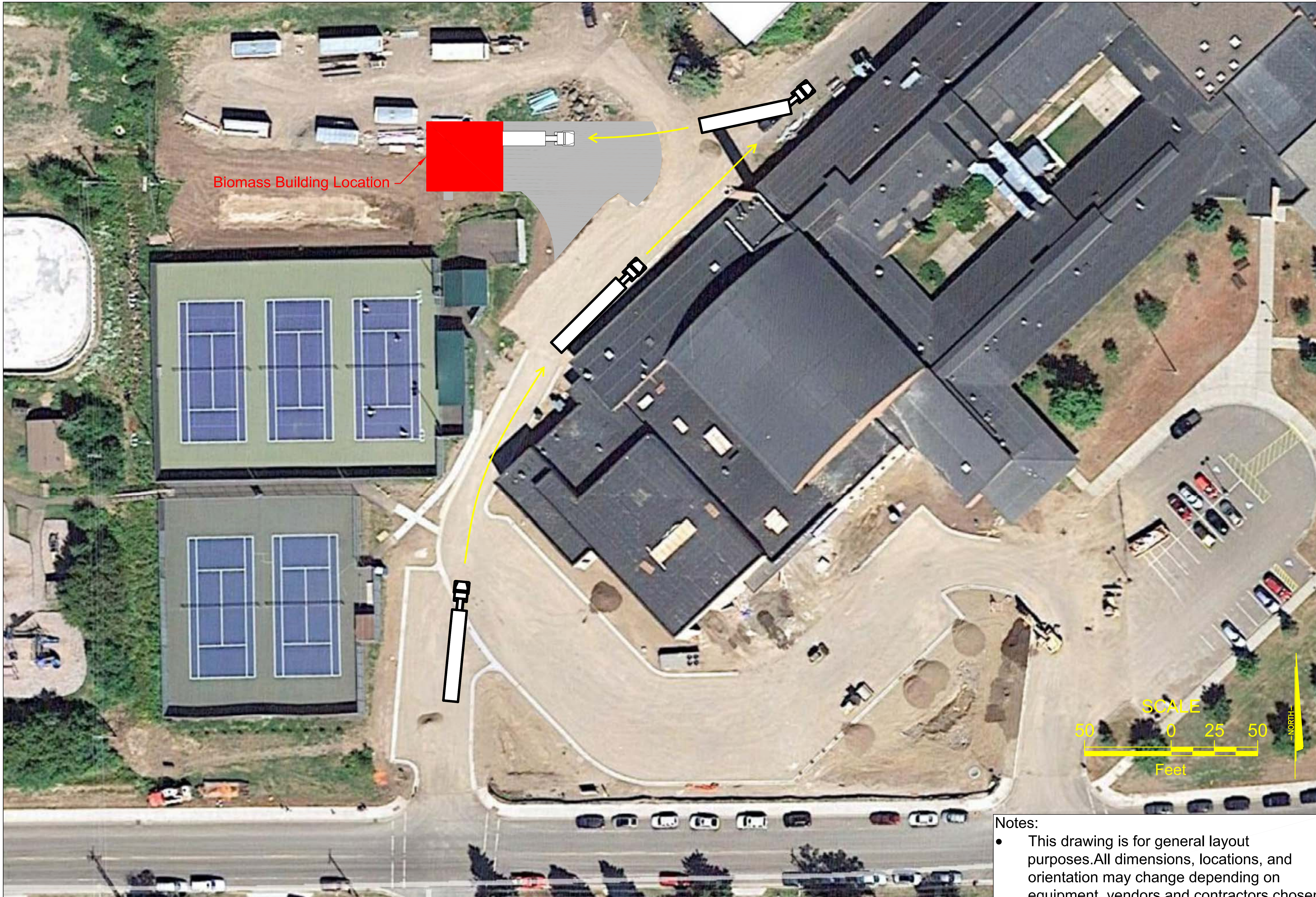

Notes:

- This drawing is for general layout purposes.All dimensions, locations, and orientation may change depending on equipment, vendors,and contractors chosen.

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Drawn dHb 9/23/16
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Job Class

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Biomass Fuel Delivery Diagram

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Date	Description	Approved

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Appendix B – Capital Cost Estimates

- B.1 Wood Chip System Capital Cost Estimate

Wood Chip System Capital Cost Estimate

Biomass Boiler Manufacturer Contract[1]

Line Item	Cost
2.00 mmBtu/hr biomass combustion unit, hot water boiler, fuel handling equipment, cyclone, as	$ 295,000
2,000 gallon thermal storage tank	$ 25,000
Installation and startup	$ 65,000
Total Boiler Manufacturer Contract	**$ 385,000**

General Contract

Line Item	Cost
Site work, grading, utilities, new asphalt paving	$ 75,000
Pre-engineered metal building (1,760 ft^2), foundation, and utilities ($175/$ft^2$)	$ 308,000
Hot water piping (140 ft trench at $200/ft) and connection to existing boiler room	$ 38,000
Interconnection to pool heating loop (from existing heating loop)	$ 20,000
Mechanical	$ 60,000
Electrical	$ 20,000
Sub-Total	$ 521,000
Contractor profit, overhead, and insurance 16%	*$ 83,360*
Total General Contract Building and Site[2]	**$ 604,360**

Total Project Cost

Line Item	Cost
Project Sub-Total (Boiler and General Contract)	$ 989,360
Professional Services[3] 10%	*$ 98,936*
Contingency 15%	*$ 148,404*
Total Project Cost	**$ 1,236,700**

Notes:
1 - Assumes that biomass boiler and general contract are bid seperately.
2 - Costs are approximate. Estimate is based on competitive bidding.
3 - Professional Services includes engineering, permitting, legal, and project management.

Appendix C – Financial and Fuel Cost Analyses

- C.1 Biomass System Financial Analysis
- C.2 Biomass System Financial Analysis with 25% Grant
- C.3 Biomass System Fuel Cost Sensitivity Analysis

Appendix C

Wood Chip System
25-year Cash Flow Analysis

Input Variables	Value	Units
Total Project Costs	$1,236,700	$
Grant Amount	$0	$
Project Costs Financed	$1,236,700	$
Current Annual Propane Use	102,758	gal
4-Yr Average Propane Price	$1.32	$/gal
Wood Chip Use	1,033	tons/yr
Year 1 Wood Chip Price	$60	$/ton
Annual Propane Use w/ Wood System	10,276	gal
Fossil Fuel Escalation Rate (apr)	1.5%	Percent
Wood Fuel Escalation Rate (apr)	0.5%	Percent
Real Discount Rate (apr)	1.0%	Percent
Inflation Rate (apr)	2.7%	Percent
Added Annual O&M Costs for Biomass Plant	$12,090	$/year

Year	Total Fuel Cost w/ Current System	Biomass Fuel Cost	Propane Cost w/ Biomass System	Added O&M Cost	Net Operating Savings	Thermal Production Incentive	Net Cash Flow	Present Value of Net Cash Flow
0	$ -	$ -	$ -	$ -	$ -	$ -	$ (1,236,700)	$ (1,236,700)
1	$ 135,773	$ (61,995)	$ (13,577)	$ (12,090)	$ 48,111	$ 36,164	$ 84,275	$ 83,440
2	$ 137,810	$ (62,305)	$ (13,781)	$ (12,090)	$ 49,634	$ 35,213	$ 84,847	$ 83,175
3	$ 139,877	$ (62,616)	$ (13,988)	$ (12,090)	$ 51,183	$ 34,287	$ 85,470	$ 82,956
4	$ 141,975	$ (62,929)	$ (14,198)	$ (12,090)	$ 52,758	$ 33,386	$ 86,144	$ 82,783
5	$ 144,105	$ (63,244)	$ (14,410)	$ (12,090)	$ 54,360	$ 32,508	$ 86,868	$ 82,652
6	$ 146,266	$ (63,560)	$ (14,627)	$ (12,090)	$ 55,989	$ 31,653	$ 87,643	$ 82,563
7	$ 148,460	$ (63,878)	$ (14,846)	$ (12,090)	$ 57,646	$ 30,821	$ 88,467	$ 82,515
8	$ 150,687	$ (64,197)	$ (15,069)	$ (12,090)	$ 59,331	$ 30,011	$ 89,342	$ 82,506
9	$ 152,947	$ (64,518)	$ (15,295)	$ (12,090)	$ 61,044	$ 29,222	$ 90,266	$ 82,534
10	$ 155,242	$ (64,841)	$ (15,524)	$ (12,090)	$ 62,786	$ 28,454	$ 91,240	$ 82,599
11	$ 157,570	$ (65,165)	$ (15,757)	$ (12,090)	$ 64,558		$ 64,558	$ 57,865
12	$ 159,934	$ (65,491)	$ (15,993)	$ (12,090)	$ 66,359		$ 66,359	$ 58,891
13	$ 162,333	$ (65,819)	$ (16,233)	$ (12,090)	$ 68,191		$ 68,191	$ 59,917
14	$ 164,768	$ (66,148)	$ (16,477)	$ (12,090)	$ 70,053		$ 70,053	$ 60,944
15	$ 167,239	$ (66,478)	$ (16,724)	$ (12,090)	$ 71,947		$ 71,947	$ 61,972
16	$ 169,748	$ (66,811)	$ (16,975)	$ (12,090)	$ 73,872		$ 73,872	$ 63,000
17	$ 172,294	$ (67,145)	$ (17,229)	$ (12,090)	$ 75,830		$ 75,830	$ 64,029
18	$ 174,879	$ (67,481)	$ (17,488)	$ (12,090)	$ 77,820		$ 77,820	$ 65,059
19	$ 177,502	$ (67,818)	$ (17,750)	$ (12,090)	$ 79,844		$ 79,844	$ 66,090
20	$ 180,164	$ (68,157)	$ (18,016)	$ (12,090)	$ 81,901		$ 81,901	$ 67,121
21	$ 182,867	$ (68,498)	$ (18,287)	$ (12,090)	$ 83,992		$ 83,992	$ 68,154
22	$ 185,610	$ (68,840)	$ (18,561)	$ (12,090)	$ 86,119		$ 86,119	$ 69,187
23	$ 188,394	$ (69,185)	$ (18,839)	$ (12,090)	$ 88,280		$ 88,280	$ 70,222
24	$ 191,220	$ (69,530)	$ (19,122)	$ (12,090)	$ 90,477		$ 90,477	$ 71,257
25	$ 194,088	$ (69,878)	$ (19,409)	$ (12,090)	$ 92,711		$ 92,711	$ 72,293
							25-year Net Present Value	**$ 567,024**

Note: All values are in real dollars, and thus, escalation rates and discount rates are over and above inflation. The inflation rate is used to adjust the value of the thermal production incentive.

Wood Chip System
25-year Cash Flow Analysis with 25% Grant Funding

Input Variables	Value	Units
Total Project Costs	$1,236,700	$
Grant Amount	$309,175	$
Project Costs Financed	$927,525	$
Current Annual Propane Use	102,758	gal
4-Yr Average Propane Price	$1.32	$/gal
Wood Chip Use	1,033	tons/yr
Year 1 Wood Chip Price	$60	$/ton
Annual Propane Use w/ Wood System	10,276	gal
Fossil Fuel Escalation Rate (apr)	1.5%	Percent
Wood Fuel Escalation Rate (apr)	0.5%	Percent
Real Discount Rate (apr)	1.0%	Percent
Inflation Rate (apr)	2.7%	Percent
Added Annual O&M Costs for Biomass Plant	$12,090	$/year

Year	Total Fuel Cost w/ Current System	Biomass Fuel Cost	Propane Cost w/ Biomass System	Added O&M Cost	Net Operating Savings	Thermal Production Incentive	Net Cash Flow	Present Value of Net Cash Flow
0	$ -	$ -	$ -	$ -	$ -	$ -	$ (927,525)	$ (927,525)
1	$ 135,773	$ (61,995)	$ (13,577)	$ (12,090)	$ 48,111	$ 36,164	$ 84,275	$ 83,440
2	$ 137,810	$ (62,305)	$ (13,781)	$ (12,090)	$ 49,634	$ 35,213	$ 84,847	$ 83,175
3	$ 139,877	$ (62,616)	$ (13,988)	$ (12,090)	$ 51,183	$ 34,287	$ 85,470	$ 82,956
4	$ 141,975	$ (62,929)	$ (14,198)	$ (12,090)	$ 52,758	$ 33,386	$ 86,144	$ 82,783
5	$ 144,105	$ (63,244)	$ (14,410)	$ (12,090)	$ 54,360	$ 32,508	$ 86,868	$ 82,652
6	$ 146,266	$ (63,560)	$ (14,627)	$ (12,090)	$ 55,989	$ 31,653	$ 87,643	$ 82,563
7	$ 148,460	$ (63,878)	$ (14,846)	$ (12,090)	$ 57,646	$ 30,821	$ 88,467	$ 82,515
8	$ 150,687	$ (64,197)	$ (15,069)	$ (12,090)	$ 59,331	$ 30,011	$ 89,342	$ 82,506
9	$ 152,947	$ (64,518)	$ (15,295)	$ (12,090)	$ 61,044	$ 29,222	$ 90,266	$ 82,534
10	$ 155,242	$ (64,841)	$ (15,524)	$ (12,090)	$ 62,786	$ 28,454	$ 91,240	$ 82,599
11	$ 157,570	$ (65,165)	$ (15,757)	$ (12,090)	$ 64,558		$ 64,558	$ 57,865
12	$ 159,934	$ (65,491)	$ (15,993)	$ (12,090)	$ 66,359		$ 66,359	$ 58,891
13	$ 162,333	$ (65,819)	$ (16,233)	$ (12,090)	$ 68,191		$ 68,191	$ 59,917
14	$ 164,768	$ (66,148)	$ (16,477)	$ (12,090)	$ 70,053		$ 70,053	$ 60,944
15	$ 167,239	$ (66,478)	$ (16,724)	$ (12,090)	$ 71,947		$ 71,947	$ 61,972
16	$ 169,748	$ (66,811)	$ (16,975)	$ (12,090)	$ 73,872		$ 73,872	$ 63,000
17	$ 172,294	$ (67,145)	$ (17,229)	$ (12,090)	$ 75,830		$ 75,830	$ 64,029
18	$ 174,879	$ (67,481)	$ (17,488)	$ (12,090)	$ 77,820		$ 77,820	$ 65,059
19	$ 177,502	$ (67,818)	$ (17,750)	$ (12,090)	$ 79,844		$ 79,844	$ 66,090
20	$ 180,164	$ (68,157)	$ (18,016)	$ (12,090)	$ 81,901		$ 81,901	$ 67,121
21	$ 182,867	$ (68,498)	$ (18,287)	$ (12,090)	$ 83,992		$ 83,992	$ 68,154
22	$ 185,610	$ (68,840)	$ (18,561)	$ (12,090)	$ 86,119		$ 86,119	$ 69,187
23	$ 188,394	$ (69,185)	$ (18,839)	$ (12,090)	$ 88,280		$ 88,280	$ 70,222
24	$ 191,220	$ (69,530)	$ (19,122)	$ (12,090)	$ 90,477		$ 90,477	$ 71,257
25	$ 194,088	$ (69,878)	$ (19,409)	$ (12,090)	$ 92,711		$ 92,711	$ 72,293
						25-year Net Present Value		**$ 876,199**

Note: All values are in real dollars, and thus, escalation rates and discount rates are over and above inflation. The inflation rate is used to adjust the value of the thermal production incentive.

Wood Chip System
Fuel Cost Sensitivity Analysis

Table Shows Sensitivity of Annual Operating Savings to Changes in Propane and Wood Fuel Prices*

Price of Wood Chips ($/ton)	Propane Price ($/gal)						
	$0.75	**$1.00**	**$1.25**	**$1.32**	**$1.75**	**$2.00**	**$2.25**
$40	$15,942	$39,062	$62,183	$68,776	$108,424	$131,545	$154,665
$42	$13,875	$36,996	$60,116	$66,709	$106,358	$129,478	$152,599
$44	$11,809	$34,929	$58,050	$64,643	$104,291	$127,412	$150,532
$46	$9,742	$32,863	$55,983	$62,576	$102,225	$125,345	$148,466
$48	$7,676	$30,796	$53,917	$60,510	$100,158	$123,279	$146,399
$50	$5,609	$28,730	$51,850	$58,444	$98,092	$121,212	$144,333
$52	$3,543	$26,663	$49,784	$56,377	$96,025	$119,146	$142,266
$54	$1,476	$24,597	$47,717	$54,311	$93,959	$117,079	$140,200
$56	($590)	$22,530	$45,651	$52,244	$91,892	$115,013	$138,133
$58	($2,657)	$20,464	$43,584	$50,178	$89,826	$112,946	$136,067
$60	($4,723)	$18,397	$41,518	$48,111	$87,759	$110,880	$134,000
$62	($6,790)	$16,331	$39,451	$46,045	$85,693	$108,813	$131,934
$64	($8,856)	$14,264	$37,385	$43,978	$83,626	$106,747	$129,867
$66	($10,923)	$12,198	$35,319	$41,912	$81,560	$104,680	$127,801

**Notes: All other costs fixed. Excludes financing costs. Excludes thermal production incentive.*

Appendix D –
UMN Extension By-Products Program Brochure

Why Recycle?

- Provide a beneficial use for products that were previously discarded in landfills
- Reduce landfill costs to government and industry and improve environmental quality by removing large volumes of by-products from concentrated landfill disposal
- Improve farm profitability by reducing fertilizer and lime costs
- Contribute to environmental quality and soil conservation by improving the economics of perennial forage crops as an alternative to row crops on more sensitive sites

Before any by-products are delivered to a field, the following requirements must be met:

1. Farmer must sign and follow Best Management Practices (BMP's)
2. Develop a farm plan, which includes crop rotation
3. Mapping and soil sampling of fields
4. Lease agreement signed if field is rented
5. Notification to township officers prior to hauling to site

If interested in receiving any of these by-products, contact the University of Minnesota Extension Service: Carlton County, P.O. Box 307, Carlton, MN (218) 384-3511 or 1-800-862-3760, ext. 223.

University of Minnesota Extension Service

Carlton County

By-products Program

By-products Program

Wood Ash
Bio-Solids
Lime

By-product Program Resources

Troy Salzer
Extension Educator, Agriculture

Dr. Carl Rosen
Soil Scientist – Fertility

Dr. Tom Halbach
Water quality & Waste Mgmt

Russ Mathison
Forage Specialist

Bob Olen
Extension Educator, Horticulture

Dr. George Rehm
U of M Soil Scientist

Paul Peterson
Forage Specialist

MPCA
University Testing Labs
Forestry Specialists
Animal Science Specialists
University Dept on GIS/ Global Positioning

Wood Ash

Recycling wood ash saves valuable landfill space and provides farmers with an excellent liming source, as well as many of the nutrients needed to increase soil fertility. Wood ash increases soil pH and adds elements to the soil, which includes potassium, phosphorus, boron, and sulfur. Wood ash is delivered at no cost, but the farmer is responsible for spreading and incorporation.

There are eight local companies supplying wood ash. Listed below are the companies and the approximate amount of wood ash delivered annually.

	Tons	Acres
Minnesota Power	10,000	800
Georgia-Pacific, Duluth	400	50
Ainsworth, Bemidji	10,400	1,340
Trus Joist	1,300	220
Jardon Home Brands	125	15
Sappi Cloquet LLC	20,000	2,800
Potlatch, Bemidji	400	40
DNR Fisheries	30	10
TOTALS	42,280	5,285

Bio-Solids

Bio-solids are rich in organic matter and will provide nitrogen, along with small amounts of phosphorus, potassium, and lime. Additional commercial fertilizer may be needed to meet soil test recommendations. Each site for bio-solids must be approved by the Minnesota Pollution Control Agency.

However, not all fields qualify for bio-solids application due to soil pH, water table level, or slope. Records are kept to ensure that Best Management Practices are followed. Crops that would respond to the nitrogen in bio-solids are corn, grasses, legumes, and small grains.

Bio-solids are provided by the Western Lake Superior Sanitary District in Duluth, and are hauled, spread, and incorporated at no charge to the farmer.

Lime

We currently have three sources for by-product ag lime. The largest source is from Sappi Fine Paper of North America who delivers and spreads their lime at no cost to the farmers. This lime is made available as they produce it. The product is only produced during scheduled and unscheduled maintenance of the reclaiming kiln. The Effective Neutralizing Power (ENP) of this lime is 1300.

Cutler-Magner in Superior, WI has been the first source of by-product ag lime. The ENP of this lime is 1840. Loads are delivered with a semi-end dump with loads averaging 23 tons per load. The lime is free and the price farmers pay is based on distance from the plant.

Another source of by-product lime in Northeast Minnesota is from Specialty Minerals, Inc. in Cloquet. The ENP of this lime is 1600. This lime is a wet product that's good for certain applications. The lime and trucking are free to the farmer.

Benefits to participating in the By-products Program:

- Proven track record with over a decade of beneficial reuse of by-products
- University research used for application recommendations
- Education programs and field days for both industries and producers to share current research data and cropping improvement technologies
- Unbiased 3rd party involvement
- Provide educational programming to local decision makers/residents describing the research on the re-use benefits of these products.
- Assisting producers in developing environmentally sound crop management systems including the use of industrial by-products as soil amendments.
- Develop packets for individual fields including information about land ownership, soil types, soil analysis, and determine application rates based on crop type and soil analysis.
- Develop, research and secure funding for new potential uses for by-products.