Stockbridge-Munsee
Health and Wellness Center
&
Mohican Family Center
Renewable Energy Feasibility Study

Final Report for Department of Energy Grant #DE-E0005631

Executive Summary

The Stockbridge-Munsee tribe is a small band of Mohican Indians, numbering approximately 1,300 members, and they do not have the expertise on staff to do the renewable energy analysis for the tribal buildings. The Tribe contracted with the group Sustainable emerging Group, LLC out of Madison Wisconsin in order to do the feasibility study for the addition of alternative energy to two of its tribal buildings, the Health and Wellness Center and the Mohican Family Center.

The results of the study of the Health and Wellness Center (HWC) indicate that a variety of renewable energy options and energy conservation measures (ECMs) exist for the facility. Options were considered that could offset 30 to 100 percent of the HWC's energy use. This study identifies that a geothermal system is the most cost effective renewable energy option available to decrease the HWC's energy consumption by 30 to 100 percent. Currently the HWC performs in the lowest 8 percent of buildings in its building category, as scored in the EPA portfolio manager benchmarking tool. Multiple ECM opportunities have been identified with paybacks of less than five years to yield an estimated 25-percent decrease in annual energy consumption. The ECMs within this payback period are estimated to save $26,800 per year with an implementation cost of just $4,650 (0.2 year payback).

The results of the Renewable Energy and Energy Efficiency Feasibility Study of the Mohican Family Center (MFC) indicate that a variety of renewable energy options and energy conservation measures (ECMs) exist for the facility. This study identifies that a geothermal system is the most cost effective renewable energy option available to decrease the MFC's energy consumption by 30 to 100 percent. Currently the MFC performs better than 80 percent of buildings in its building category, as scored in the EPA portfolio manager benchmarking tool. Multiple ECM opportunities have been identified with short term paybacks to yield an estimated 13-percent decrease in energy consumption. The ECMs within this payback period are estimated to save $3,100 per year with an implementation cost of under $20,000.

The energy conservation measures should be implemented before any renewable energy technologies because they can reduce the required size and enhance the economic feasibility of a renewable energy system. Therefore, in order to offset 30 to 100 percent of the building's energy loads, the renewable energy systems would have to offset 244,400 to 814,500 kBTU per year. The geothermal system is the recommended option to offset the MFC's energy use by 30 to 100 percent due to its cost effectiveness. However, a geothermal system can be complemented by a solar electric and/or solar thermal system nicely if they fit in with the MFC's energy goals. A biomass system is a mutually exclusive option to the geothermal system, and carries the lower cost effectiveness. A biomass system also carries several other operational considerations with it – such as fuel storage, odors, and additional maintenance – and is not a recommended option.

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Project Overview

The Stockbridge-Munsee Community, Band of Mohican Indians is a federally recognized Indian Tribe occupying the reservation established for it by the Treaty of 1856. The Tribal government operates pursuant to a Constitution promulgated under the Indian Reorganization Act of 1934. The governing body is the Tribal Council, elected by Tribal members. The Tribal Council is composed of the President, Vice-President, Treasurer and four council representatives. The Tribal Council has jurisdiction over all Tribal trust and purchased lands. The total population living within reservation boundaries is 1,744. About 61% of the residents are Native American and the remaining are non-native (2010 U.S. Census). According the Tribe's Enrollment Office, approximately 610 of reservation residents are enrolled Stockbridge-Munsee; the remaining are Native Americans of other Tribes and non-natives. The Stockbridge-Munsee Community, as of this time, does not have a Tribal energy resource development organization or Tribal consortium for energy development. The Tribal council is committed to the development of a sustainable future for the reservation as indicated by over fifty years of sustainable forestry practices. The Tribal Environmental Department has considered alternative energies and has applied for and received two different funding awards to investigate energy conservation and alternative energy sources. The Environmental Protection Agency (EPA)-funded Indian General Assistance Program Grant (GAP) and the Department of Energy Community Development Block Grant have components of both energy conservation and alternative energy development. On February 24, 2011 the Tribal Council held a working meeting with an energy consultant who had done preliminary viewings of various Tribal buildings and sites. From this, the consultant concurred with the Tribal environmental manager that the most favorable existing Tribal building site for alternative energy development is the Tribal clinic. For this project, the Tribe wishes to investigate the feasibility of integrating alternative energies into the existing clinic. This will accomplish many Tribal sustainability goals; first to reduce dependency on fossil fuels; secondly to reduce the carbon footprint of the building; and finally, to use this as an example of the potential of "alternative energies". However, the greater view is to live in a modern world while adapting modern technologies to capture the age-old cultural value of taking care of the earth for the next seven generations.

Objectives

During the project, the Tribe will investigate the feasibility of utilizing renewable energy resources on site in order to provide electric power as well as heating and cooling energy for the Stockbridge-Munsee Health and Wellness Center (SMHWC) Tribal Clinic, through the following objectives:

Objective 1: The Stockbridge-Munsee Community will determine the feasibility of installing Photovoltaic power to meet from 30% to 100% of electrical energy power needed to operate the Tribal Clinic.

Objective 2: The Stockbridge-Munsee Community will explore the feasibility of installing either a closed or open loop Geothermal Heat pump system to meet from 30% to 100% of energy power needed to heat and cool the Tribal Clinic.

Objective 3: The Stockbridge-Munsee Community will explore the feasibility of installing Solar Thermal and space heating systems to meet from 30% to 100% of energy power needed to heat the Tribal Clinic in the winter months.

Objective 4: The Stockbridge-Munsee Community will explore the feasibility of using Biomass (renewable wood fiber resources) to meet from 30% to 100% of energy power needed to heat the Tribal Clinic in the winter months.

Description of Activities.

The Tribe contracted with an independent engineering firm to do the work for the grant, following the activities list below and fulfilling the objectives listed in the previous chapter. I will list those activities below and then include the contractors report in the body of this report.

Activity 1: Obtain Consultant

The tribe did its best to draft a request for proposal, (RFP) to secure a consultant or qualified personnel to do the feasibility study as outlined in the objectives above. We received five proposals, and the lowest bid proposal was from Sustainable Engineering Group of Madison. I checked with three of the references that they gave in the RFP, and all of them gave very good reports on the work done for them by the group. Two of these were Native American tribes.

Activity 2: Renewable resource assessment (Solar, Geothermal, Biomass)

The contractor hired, working with the tribe and other sources did the site specific analysis of energy potential for the three alternatives energy technologies required. The amounts of each energies were expressed in Kwh or Therms from each site examined.

Activity 3: Tribal energy load assessment

Using data provided by the tribe, the consultant did the analysis of current & future needs for existing structures. These were done for existing and projected future needs, in a 25 year time period.

Activity 4: Transmission and inter-connection considerations

The contractor did the examination of the kind & efficiency of energy transmission from specific sites to the structure. This analysis is in the report from the contractor which follows.

Activity 5: Technology analysis

The contractor did the analysis to determine if alternative energy in question could be integrated into the existing structure without complete change-out of systems. This is outlined in their report following the list of activities.

Activity 6: Economic analysis

The economic analysis has been determine for the alternative energies in question. The ones that could be integrated into existing system in a cost efficient manner and the cost of the systems and installation have been determine, as has the Return on Investment (ROI) on investment.

Activity 7: Environmental assessment

It has been determined by the tribal environmental department that the projected infrastructure of the systems as proposed, the National Environmental Policy Act (NEPA) compliance would be a Categorical Exclusion, due to the fact that very little earth moving would be needed. Trenching for the geo-thermal wells and/or coils would be onsite of previously disturbed ground already cleared by Historic Preservation act section 106 and other actions.

Activity 8: Benefit assessment

The economic feasibility of each technology, solar, biomass and geothermal has been made, based on the assumptions of power generation given, and geothermal was found to be the best "alternative" energy for each of the buildings.

Activity 9: Preliminary system design(s)

As mentioned above, based upon the ROI estimates, geothermal systems were selected to pursue further. Preliminary designs were proposed for that system, including the location(s), the size
and tie-ins to the existing structure.

Activity 10: Training and other Tribal professional development planning

The tribe was unable to send staff from either the Health and Wellness Center or the Mohican Family Center to receive training, however the manager of the environmental staff did attend two DOE tribal program reporting and a DOE alternative energy training in Minnesota.

Activity 11: Long-term operating and maintenance planning

Within the feasibility investigations the planned upkeep and operations of each system was address. It was also found that more efficient of the present system would great enhance the efficiency of the building, especially the Health and Wellness Center.

Activity 12: Business planning for implementing a sustainable renewable energy development project

The current council has been formulating long term goals within an Integrated Resource Management Plan. That plan has been delayed due to suspended funding from the Bureau of Indian Affairs, although there has also been a tribal strategic planning process that will also address energy planning. I have not been a part of that plan, and as it is not finished, I cannot comment on the progress. Thus the goal of a business plan coupled with the long term sustainable vision of the Tribe has been delayed.

Sustainable Engineering Group LLC

RENEWABLE ENERGY AND ENERGY EFFICIENCY FEASIBILITY STUDY

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HEALTH AND WELLNESS CENTER
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EXECUTIVE SUMMARY

The results of the Renewable Energy and Energy Efficiency Feasibility Study of Stockbridge Munsee Community's Health and Wellness Center (HWC) indicate that a variety of renewable energy options and energy conservation measures (ECMs) exist for the facility. A requirement of the Request for Proposal for this study was to assess renewable energy options that could offset 30 to 100 percent of the HWC's energy use. This study identifies that a geothermal system is the most cost effective renewable energy option available to decrease the HWC's energy consumption by 30 to 100 percent.

Currently the HWC performs in the lowest 8 percent of buildings in its building category, as scored in the EPA portfolio manager benchmarking tool. Multiple ECM opportunities have been identified with paybacks of less than five years to yield an estimated 25-percent decrease in annual energy consumption. The ECMs within this payback period are estimated to save $26,800 per year with an implementation cost of just $4,650 (0.2 year payback).

	Propane (gallons/yr)	Energy from Propane (kBTU/yr)	Electricity (kWh/yr)	Energy from Electricity (kBTU/yr)	Total Energy (kBTU/yr)
Current Energy Usage	22,000	2,000,000	679,000	2,350,000	4,350,000
Energy Savings from ECMs	7,800	700,000	103,000	350,000	1,050,000
Projected Base Energy Usage	**14,200**	**1,300,000**	**576,000**	**2,000,000**	**3,300,000** **30 % = 990,000 kBTU/yr**

These immediate-payback measures should be implemented before any renewable energy technologies because they can reduce the required size and enhance the economic feasibility of a renewable energy system. Therefore, in order to offset 30 to 100 percent of the building's energy loads, the renewable energy systems would have to offset 990,000 to 3,300,000 kBTU per year.

	Upfront Cost	Energy Offset (kBTU/yr)	Portion of Building's Use	Payback	25-yr ROI
Geothermal	**$ 240,000**	**1,000,000**	**30 %**	**10 yrs**	**17 %**
Solar Electric	$ 900,000	1,100,000	33 %	25 yrs	0.0 %
Solar Thermal	$ 12,000	10,000	0.3 %	25 yrs	0.0 %
Biomass (Wood Pellet)	$ 205,000	1,000,000	30 %	14 yrs	8.1 %

The geothermal system is the recommended option to offset the HWC's energy use by 30 to 100 percent due to its cost effectiveness. However, a geothermal system can be complemented by a solar electric and/or solar thermal system nicely if they fit in with the HWC's energy goals. A biomass system is a mutually exclusive option to the geothermal system, and carries the lower cost effectiveness. A biomass system also carries several other operation considerations with it – such as fuel storage, odors, and additional maintenance – and is not a recommended option.

INTRODUCTION

This report summarizes the potential opportunities for enhancing energy efficiency and implementing renewable energy technologies at the Stockbridge Munsee Community Health and Wellness Center in Bowler, Wisconsin. Michael Barnett and Andy DeRocher from Sustainable Engineering Group (SEG) visited the Health and Wellness Center (HWC), generator building, and garage on January 22nd and 23rd, 2013 to conduct on-site observations and to review documentation of the existing buildings and their systems.

The weather conditions on the site visit were:

- Jan 22, 2013: High 0 ^{o}F, Low -15 ^{o}F, Wind 0 – 10 mph, Clear skies
- Jan 23, 2013: High 11 ^{o}F, Low -9 ^{o}F, Wind 0 – 10 mph, Cloudy skies

The building systems studied for energy efficiency are:

- HVAC Equipment and Controls
- Lighting and Daylighting
- Domestic Hot Water
- Electrical Plug Loads
- Domestic Hot Water
- Building Envelope

The renewable energy technologies that have been examined are:

- Geothermal
- Solar Electric (also called Photovoltaic, or PV)
- Solar Thermal
- Biomass

The building systems and major components were surveyed to determine how they were initially designed and installed, whether their operation meets the original design intent, and whether there is potential to improve their operation in regards to energy and maintenance costs. Factors such as the general condition and functionality, age and anticipated lifespan, and capability to integrate with new renewable energy or energy efficiency upgrades were analyzed. The results of the analysis are presented in the following sections, organized by system.

BUILDING OVERVIEW

The 30,170 square foot HWC was constructed in 1999, while the generator building and garage were constructed in 2000. The HWC currently operates Monday through Friday from 8:00am to 4:30pm, excluding the 14.5 holidays that the facility is closed. The facility is staffed with approximately 70 full time employees. The HWC provides a wide range of full medical services to the community. The building directory below includes all the services offered in the facility. A building floor plan can be found in Appendix A.

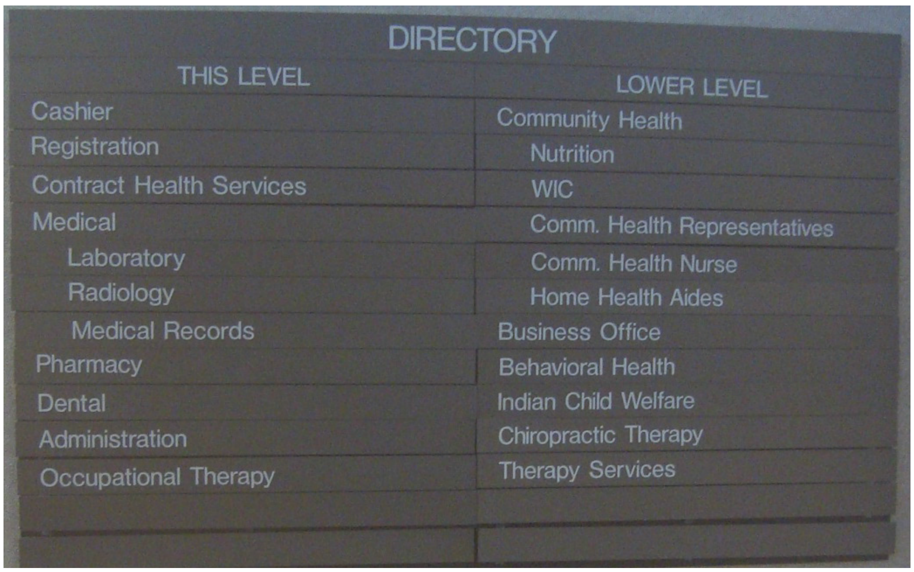


Figure 1. The Health and Wellness Center building directory.

The buildings are tied into the tribal community water system as well as the waste water treatment plant.

The HWC heating and cooling system consists of a water-source heat pump system. There are 34 distributed heat pumps located above the ceiling that provide zone heating and cooling needs. The condenser water used by these heat pumps is cooled by an evaporative cooler during the cooling season and heated by two propane fired boilers during the heating season. There is a building automation system (BAS) located in the mechanical room that controls the heat pump loop and associated heat pumps. This BAS is original to the building construction.

Ventilation air to the HWC is provided by a 100-percent outside air handler equipped with two propane-fired duct heaters and direct expansion (DX) cooling. Ventilation air is ducted to the return side of each heat pump. There are two main building exhaust fans that run whenever the air handler is running.

The HWC's domestic hot water is provided by two propane-fired tank water heaters.

In addition to the main HWC, there are two support buildings that were evaluated as part of this study.

The generator building houses a 600 kW diesel generator and fuel tank used to provide 100 percent of the HWC's power during a power outage. The building is a 576 square foot wood-framed structure with fiberglass insulation and metal siding. The building is heated by a small propane fired unit heater.

Figure 2. The 576 square foot generator building.

The garage is 1,920 square feet and includes five garage stalls to house tribal vehicles used by the HWC staff. The garage is a slab on grade, wood-framed structure with steel siding and fiberglass insulation. The facility is heated with two propane fired unit heaters.

Figure 3. The 1,920 square foot garage.

Propane for all the buildings is provided by a 30,000 gallon tank located behind the garage. Each building has its own propane meter and is billed individually to better account for each building's fuel consumption.

Figure 4. The 30,000 gallon propane tank.

Since the HWC opening in 1999, no significant changes have occurred. The original building mechanical systems remain in use. At this time, there is a remodel planned for the registration area. No other remodels or HVAC upgrades are currently planned for the facility.

The building manager and facilities team have been active with ongoing energy efficiency upgrades. The energy efficiency upgrades to date include the following:

- Lighting occupancy sensors installed in 13 restrooms, 4 janitor's closets, 3 storage rooms and the garage;
- Delamping of over-lit areas including storage closets, mechanical rooms and garage; and
- Scheduling of HVAC equipment.

ENERGY LOAD ASSESMENT

CURRENT UTILITY CONSUMPTION

UTILITY RATE OVERVIEW

SEG evaluated the HWC, generator building and garage electric and propane consumption for the past three years. Propane is supplied from an on-site storage tank that is filled by the Mohican L.P. Gas Company. Each building has a stand-alone propane meter that is used for monthly billing purposes. Electricity is provided by the Gresham Municipal Light and Power. The three buildings share one electric meter for billing purposes.

The current utility pricing is as follows:

Utility	Charge Description	Rate	Comments
Electric	**Virtual Rate**	**$0.10 /kW-hr**	Electric Cost/Consumption
	Customer Charge	$35 /Month	
	Energy Charge	$0.0789 /kW-hr	
	Demand Charge	$5.75 /kW	
	Dist. Demand	$1.50 /kW	
	Power Cost Adj. Clause	$0.025 /kW-hr	Variable cost based on utility.
Propane	**Virtual Rate**	**$1.90 /gal**	Average Cost Based 2012 bills. Equivalent to $2.08/therm.

Table 1. Utility cost summary.

The virtual electric rate of $0.10 per kW-hr is a slightly below average rate for Wisconsin. Propane costs are more volatile than the electric rates and will vary based on the commodity pricing on a monthly basis. On an energy basis, propane is significantly more expensive than natural gas. Currently, natural gas prices are in the range of $0.70 per therm whereas propane is around $2.00 per therm. In the case of the HWC campus, there is no natural gas infrastructure so fuel switching is not an option. However, it is important to consider the high cost of propane consumption when evaluating energy efficiency improvements and renewable technology payback analysis.

BENCHMARKING

Portfolio Manager is an online benchmarking tool provided by the U.S. Environmental Protection Agency. Portfolio Manager provides a powerful environment for tracking energy performance and benchmarking buildings' energy usage. A facility's historical energy consumption is normalized for several significant factors such as the building's size, function, geographical location, etc. The facility is then given an Energy Performance Rating, which ranks the facility's energy performance in comparison to that of similar facilities across the United States on a scale of 1 (worst performance) to 100 (best performance). The Energy Performance Rating is essentially a percentile of the building's energy usage. For example, an Energy Performance Rating of 50 indicates that about half of similar facilities in the United States are less energy intensive than the rated facility, and half are more energy intensive. A facility that scores 75 or higher is eligible to receive the ENERGY STAR label. The rating is based on energy consumption and does not take into account the relative cost of the fuel source.

As part of the HWC energy study, SEG entered the facility information into Portfolio Manager using the gross floor area provided by the staff (30,170 ft^2) and the facility's historical energy usage data. The facility's Energy Performance Rating was 8. This means that 92 percent of buildings in its building category outperform the HWC in energy consumption. Note that this number is also based on the following assumptions which can impact the Rating:

- Type of Building = Medical Office Building
- Floor Area = 30,170 ft^2
- Number of Workers = 70
- Weekly Operating Hours = 42.5
- Portion of gross floor area that is cooled = 100 percent
- Portion of gross floor area that is heated = 100 percent.

The buildings energy metrics are summarized in the table below.

Metric	Result
Energy Star Score	8 out of 100
Energy Cost per sq-ft	\$3.56 /ft^2
Energy Use Intensity (site)	142 kBtu/ft^2
Energy Use Intensity (source)	322 kBtu/ft^2
Total Annual Energy Cost	\$107,000 /year

Figure 5. A summary of HWC's building energy metrics.

In order to improve the facility's energy performance, reduce operating costs, and increase the current Energy Performance Rating to a score of 50, the building's site energy consumption would need to be reduced to about 88 kBtu/ft^2 and the respective source energy intensity to 200 kBtu/ft2. This would be an energy reduction of 38 percent.

FY 2012 CONSUMPTION

SEG compiled the utility information for FY 2012 (July, 2011 through June, 2012) for electricity and propane.

As indicated in Figure 6, the HWC uses 97 percent of the propane used at the three buildings. The three buildings share one electricity meter, so building-by-building electrical consumption data is not available, but it would be reasonable to assume that electrical use is similarly weighted towards the HWC.

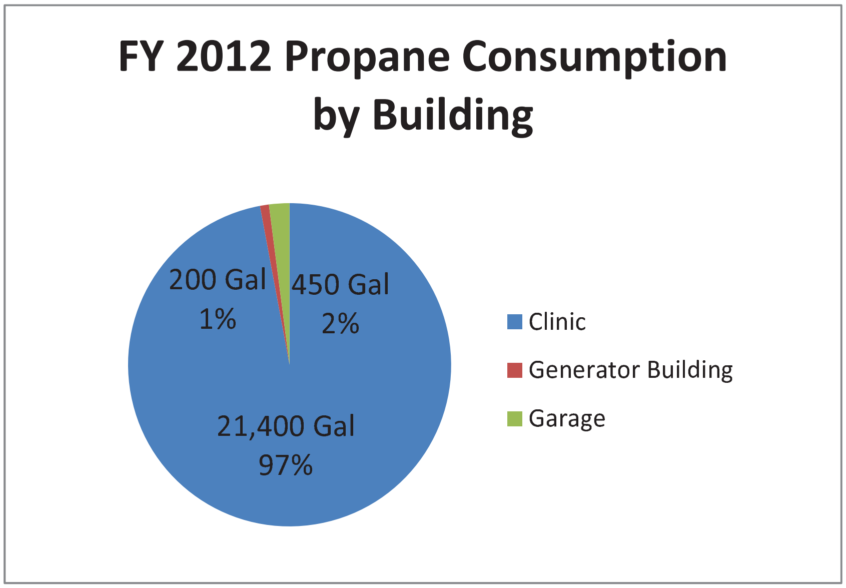


Figure 6. Propone consumption in gallons and percent for each of the three buildings.

As illustrated in Figure 7, the HWC propane usage has a strong seasonal component as it is used to maintain the heat pump loop temperature in the winter and provide heating for the ventilation air in the duct furnaces connected to the air handler, AHU-1. The small baseline propane load is due to the fact that the domestic water heaters are propane fired.

The electric usage is relatively flat throughout the year. This reflects the year-round nature of a water-source heat pump system, where the heat pump compressor uses electricity for heating and cooling.

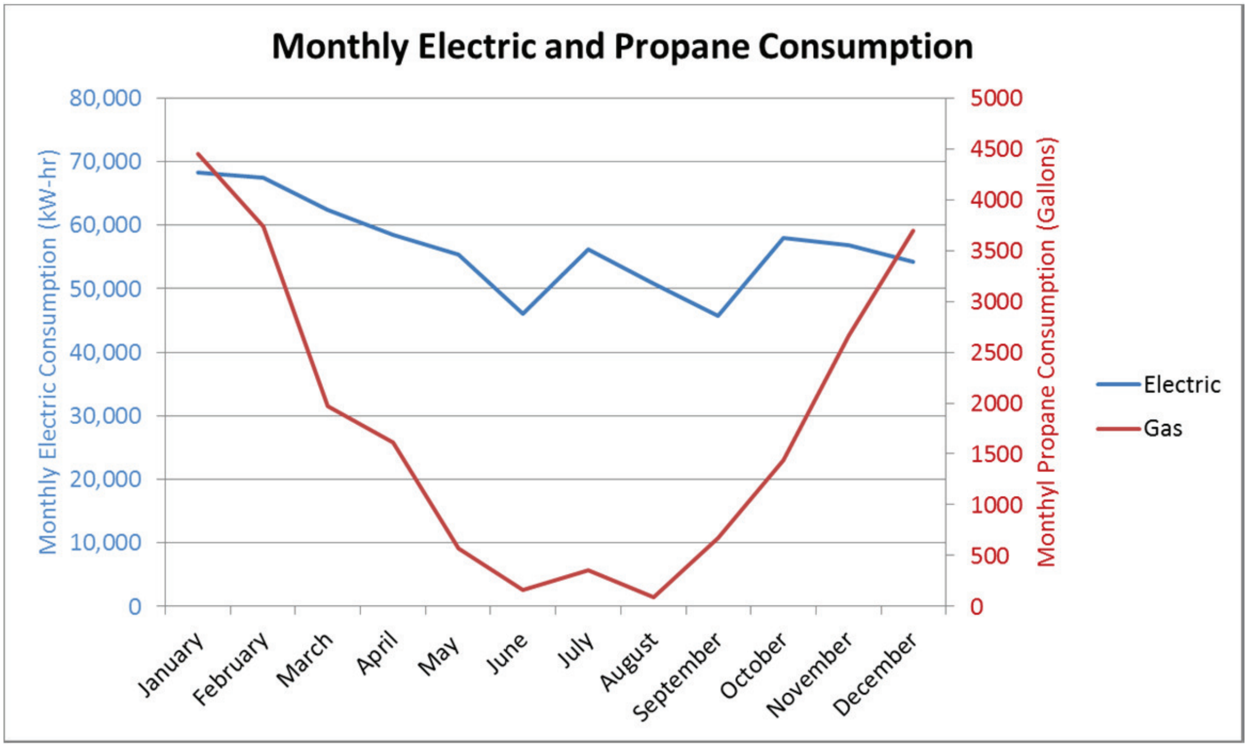


Figure 7. Monthly campus electric consumption and HWC propane consumption for FY 2012.

The electric consumption for 2010, 2011 and 2012 was compared and found to be relatively constant. The consumption varied less than 8 percent over the 3 year period.

Figure 8 below breaks down the electric and propane consumption at the HWC. 62 percent of the utility costs are for electric and 38 percent is for propane.

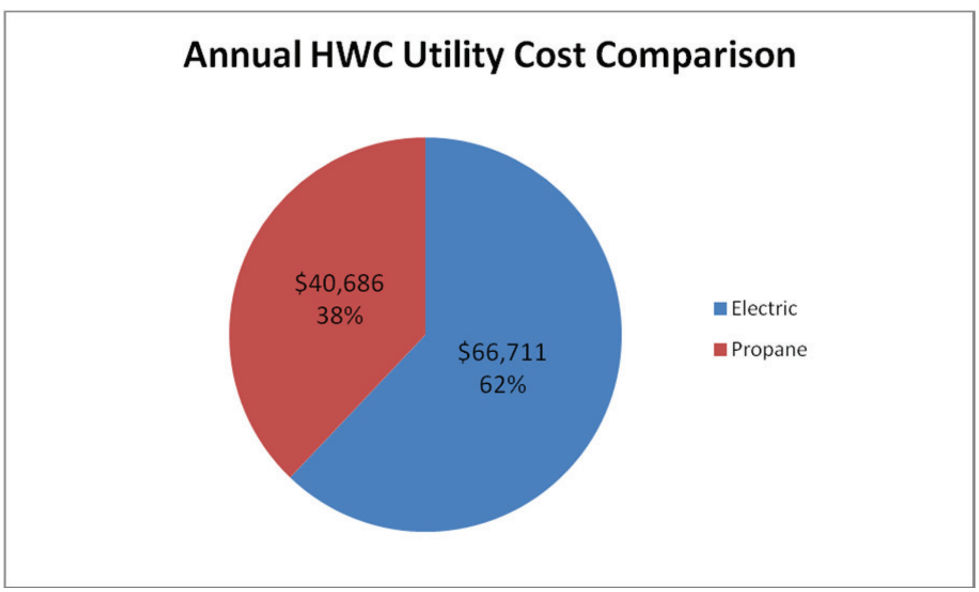


Figure 8. The HWC's electric and propane utility costs for 2012.

25-YEAR PROJECTED ENERGY LOAD ASSESMENT

The 25-year projected energy loads were estimated for the three buildings. All the buildings were grouped together, as the generator building and garage loads are negligible relative to the HWC. The projected consumption rates are based on the 2010-2012 campus consumption data as well as the following assumptions:

- Low-cost energy efficiency recommendations with payback less than 5 years documented in this report are implemented;
- HVAC system will continue to utilize a water source heat pump system;
- Facility will continue to use propane for heating purposes;
- No significant facility modifications are made, such as additions; and
- Equipment is replaced with new, code-compliant equipment.

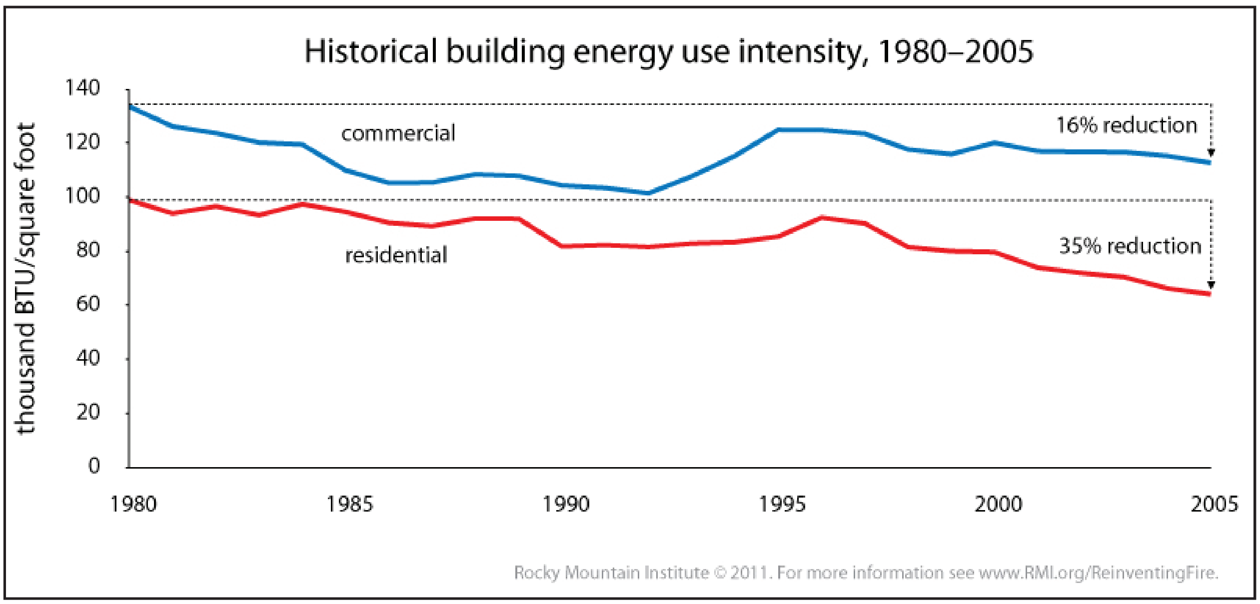


Figure 9. Historical building energy use intensity from 1980 to 2005. This graph shows that energy use intensity has declined by 16 percent for commercial buildings over the last 25 years. This rate has been applied to the HWC's projected energy consumption discussed in this section.

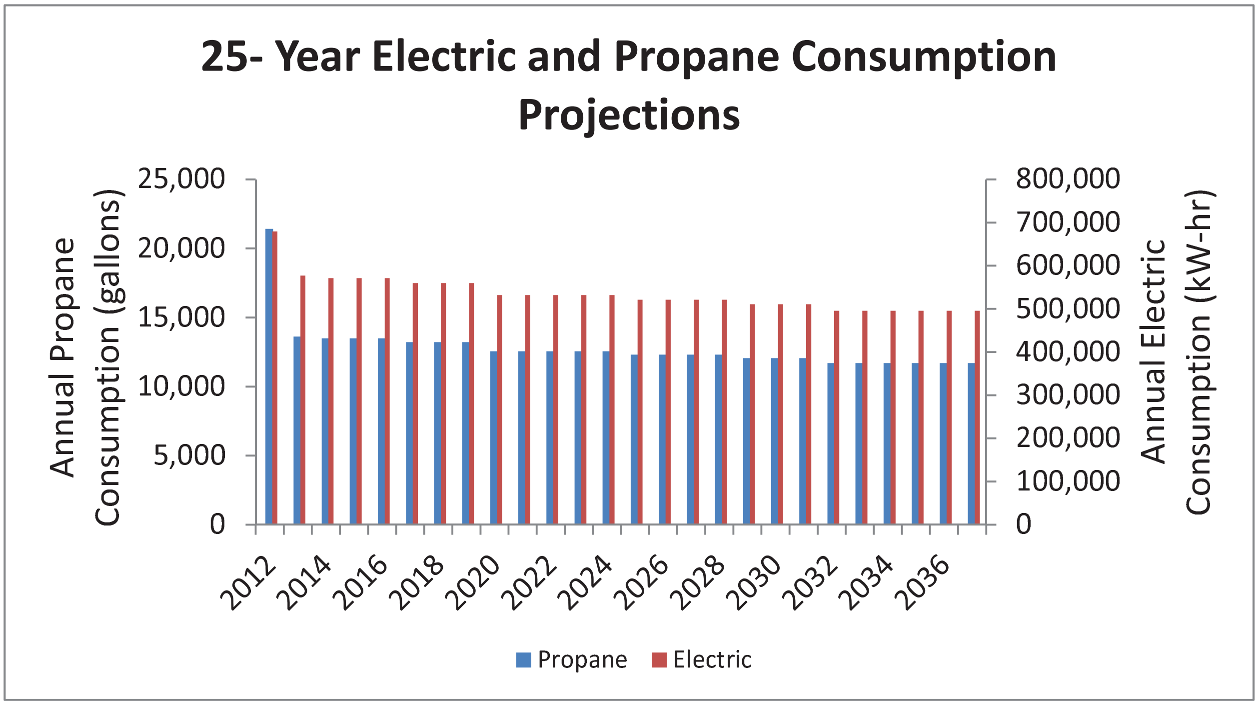


Figure 10. 25 Year Utility Projection. The first year drop is from implementing energy conservation measures outlined in this report.

ENERGY EFFICIENCY

SEG completed an ASHRAE level 1 energy audit of the HWC, generator building, and garage. A level 1 audit consisted of the following elements:

- Preliminary Energy Use Analysis
- Walk-through survey of building evaluating building envelope, HVAC systems, domestic hot water and lighting
- Identification of low-cost/no-cost recommendations
- Identify capital improvements.

Estimates of the potential savings were determined using a combination of engineering judgment and engineering calculations. A level 1 audit is intended to provide client with a rough estimate of potential savings, but does not include exhaustive calculations or in-depth payback analysis.

ENERGY CONSERVATION MEASURE SUMMARY

Energy conservation measures (ECMs) have been identified during the walk-through audit that are estimated to save a total of 135,800 kW-hrs of electricity and 10,700 gallons of propane per year. If the most cost effective ECMs (a payback of less than 5 years) are selected, it is estimated that 102,500 kW-hrs of electricity and 7,800 gallons of propane would be saved. This is would result in saving approximately 25% of the building's energy costs ($26,800 per year in today's costs). These ECMs with a payback of less than 5 years are estimated to cost just $4,650 to implement, yielding a simple payback that is nearly immediate (0.2 years). The ECMs are discussed in further depth later in the report.

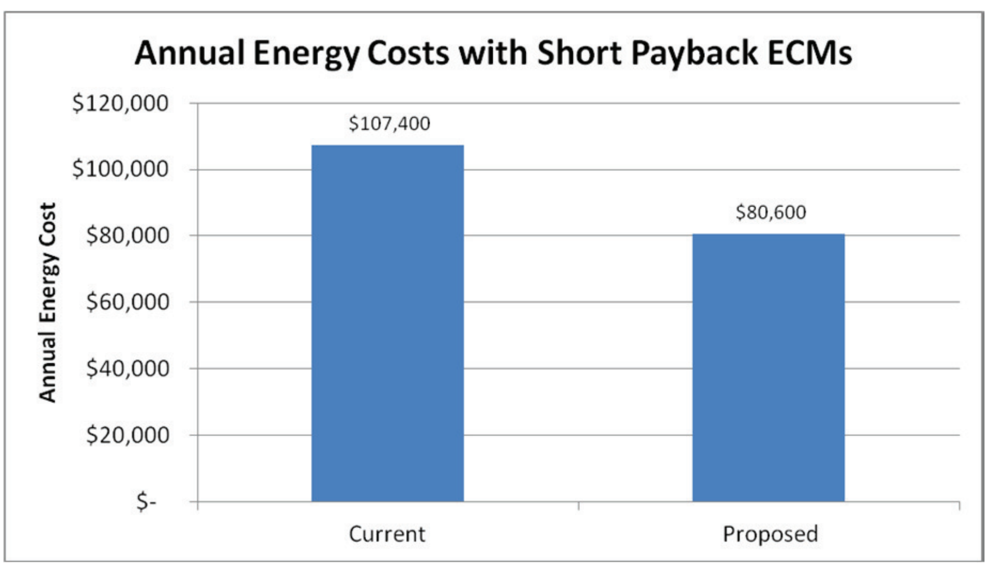


Figure 11. Estimated utility costs after implementing recommended measures that carry a payback of less than 5 years.

ECM #	System	Recommended Improvement	Estimated Electric Savings (kW-hr/yr)	Estimated Propane Savings (gal/yr)	Estimated Cost Savings ($/yr)	Cost to Implement ($)	Payback Period (yrs)
1	HWC HVAC	Ventilation schedule should match occupancy schedule	27,165	6,581	$ 17,793	$ 50	< 1
2	HWC HVAC	Add VFD and control valves to heat pumps	24,453	-	$ 2,445	$ 34,000	14
3	HWC HVAC	Add energy recovery	3,011	2,658	$ 5,351	$ 75,000	14
4	HWC HVAC	Heat pump loop temperature too high	2,000	500	$ 1,150	$ 50	< 1
5	HWC HVAC	Scheduling and setpoint adjustments on heat pumps	30,253	-	$ 2,360	$ 50	< 1
6	HWC HVAC	Humidifier scheduling and control	24,945	-	$ 2,495	$ 50	< 1
7	HWC HVAC	Reduce mechanical room unit heater setpoint		105	$ 200	$ 25	< 1
8	HWC HVAC	Add occupancy sensors in frequently vacant spaces	2,800	-	$ 280	$ 2,000	7
9	HWC HVAC	Modify EF-3 setpoint	400	-	$ 40	$ 25	< 1
10	HWC HVAC	Furnace tune up on AHU duct furnaces	-	536	$ 1,019	$ 500	< 1
11	HWC HVAC	EF-3 damper not closing	-	20	$ 38	$ 25	< 1
12	HWC HVAC	Add flexible connectors and lined ductwork	-	-	-	$ 50,000	-
13	HWC HVAC	Clean AHU-1 cooling coil	-	-	-	$ 150	-
14	HWC Lighting	Connect atrium uplighting to photocell	945	-	$ 95	$ 750	8
15	HWC Lighting	Add lighting occupancy sensors to various spaces	5,000	-	$ 500	$ 2,000	4
16	HWC Lighting	Add daylight sensor to waiting rooms	2,000	-	$ 200	$ 1,500	8
17	HWC Plug Loads	Add timeclock to physical therapy hot water bath	3,500	-	$ 350	$ 200	< 1
18	HWC Plug Loads	Add vending misers to vending machines	8,280	-61	$ 518	$ 1,500	3
19	HWC Envelope	Replace faulty window sills	-	66	$ 125	$ 10,000	80
20	HWC Envelope	Replace doors with better insulated doors	-	105	$ 200	$ 7,500	38
21	Generator Bldg	Seal penetration on generator building	-	16	$ 30	$ 250	8
22	Generator Bldg	Fix leaky generator dampers	-	105	$ 200	$ 1,000	5
23	Garage	More tightly control garage heat trace	1,000	-	$ 100	$ 150	2
24	Garage	Reduce setpoint from 60° to 45°	-	105	$ 200	$ 25	< 1

Table 2. Summary of all ECMs described in this report.

HVAC EQUIPMENT AND CONTROLS

The current equipment is all original to the building construction in 2000. The heating and cooling system used at the HWC is a water-source heat pump system. This type of system has heat pumps distributed throughout the building that provide heating and cooling for the individual zones. The heat pumps use water from the heat pump loop to reject heat or collect heat. The heat pump loop is cooled using an evaporative cooler and heated using conventional non-condensing boilers.

Figure 12 is a schematic of the HVAC system used at the HWC. This is a fairly cost effective system from a first cost perspective and operating costs. This system utilizes primarily electricity for heating in a very efficient way, which reduces the consumption of the costly propane fuel.

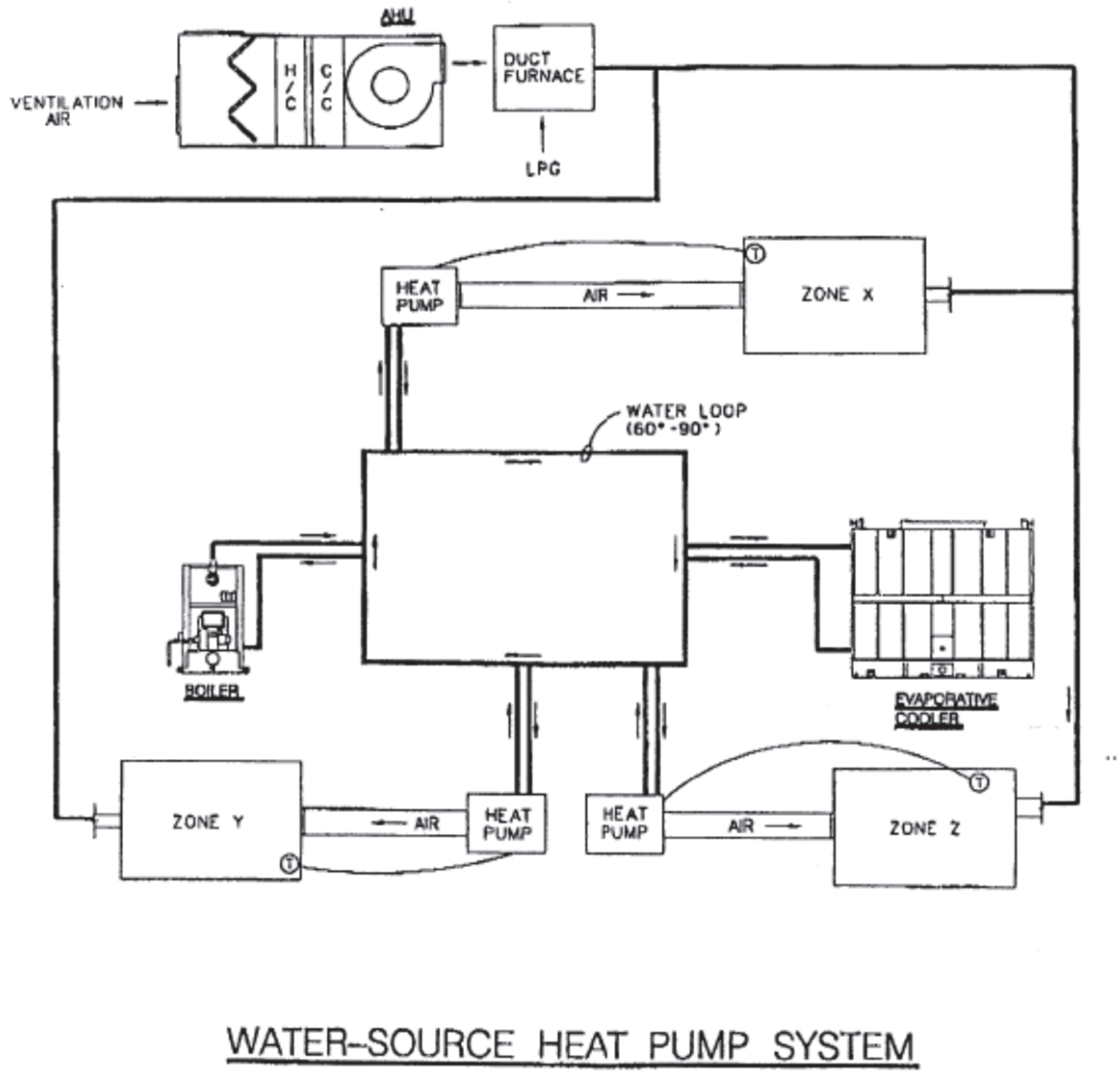


Figure 12. Water-source heat pump system schematic.

Ventilation System

Ventilation for the building is provided by a 100 percent outside air handling unit, AHU-1. This unit is located in the main mechanical room and is original to the building. The unit delivers 6,400 cfm of outside air directly to the return side of the heat pumps. The outside air is heated by two propane-fired duct furnaces. Cooling is provided by a DX coil. The DX condensing unit is located outside the building adjacent to the evaporative cooler.

The unit also has two duct-mounted electric steam humidifiers.

Figure 13. AHU-1 ventilation unit.

Exhaust air for the building is provided by two exhaust fans located on the roof. Exhaust fan EF-1 serves the west side of the building, or everything west of the main atrium. There are exhaust grilles located throughout the spaces that are ducted to a main riser and connected to EF-1. Exhaust fan EF-2 serves the spaces east of the atrium and is ducted in a similar fashion, where many exhaust grilles are tied into the main exhaust riser to the roof.

The AHU schedule is currently set to run from 4:00am to 11:00pm for 7 days per week. It is not clear if the exhaust fan schedule is interlocked with the AHU schedule, or if they are separately scheduled. To maintain proper building pressure, the exhaust fans and AHU should share the same schedule.

Zone Cooling and Heating System

Spaces are heated and cooled with water-source heat pumps that are located above ceiling. These units are tied into the zone thermostats. The units consist of a fan, air filter, compressor, reversing valve and coil. There are 34 heat pumps that serve the building.

Heat Pump Loop Heating and Cooling

The heat pump loop is heated by a pair of Bryan 650 MBH non-condensing boilers.

Figure 14. The heat pump loop boilers.

Controls

The building has the original Building Automation System from 2000. This system is named "SuperVision" and is no longer supported by the original manufacturer. The system is graphically based and appears to be functional.

Miscellaneous Equipment

There are a few pieces of miscellaneous equipment that are not connected to the heat pump loop. This includes a split system for a small server room, two propane-fired unit heaters and one electric cabinet unit heater.

POTENTIAL INITIATIVES

ECM #1: Revise AHU-1 Operating Schedules

Currently, AHU-1, EF-1 and EF-2 are set to run 7 days per week from 4:00am to 11:00pm. Based on conversations with the building manager, the loose schedule was being used because when the building first opened there were issues with high levels of VOCs from the newly installed finishes and other construction related odors. However, these odors should no longer be an issue and a normal occupied schedule can be used to control the ventilation air delivered by AHU-1.

SEG proposes that the AHU-1, EF-1 and EF-2 schedule is set to Monday through Friday from 7:00am to 5:00pm. There are significant savings associated with this measure mainly due to the reduced propane consumption needed to bring 100 percent outside air up to 65°F in the heating season.

Estimated Electric Savings (kW-hr/yr)	Estimated Propane Savings (gal/yr)	Estimated Cost Savings ($/yr)	Cost to Implement ($)	Payback Period (yrs)
27,165	6,581	$17,793	$50	< 1

Table 3. ECM #1 savings.

ECM #2: Install Control Valves at Heat Pumps and Add VFDs on Loop Pumps

Currently, the heat pump loop water flows through the 34 heat pumps regardless if the compressor is running or not. The pumps are circulating a constant volume of 100 gpm of fluid.

In new construction, it is common to install 2-position control valves at each heat pump that will open when the compressor is running and close when the compressor is off. A differential pressure transmitter is located two-thirds down the piping distribution, and a variable frequency drive (VFD) on the pump ramps up and down to maintain a constant differential pressure setpoint.

This ECM typically reduces the pump power consumption by over 50 percent because the pumps only need to pump fluid for the units that are running, which is typically a small portion of the heat pumps.

This measure is expensive because control valves need to be installed at all the heat pumps, differential pressure transmitter installed in piping and two VFDs installed on the pumps. The pumps and motors would also likely be resized and replaced.

Estimated Electric Savings (kW-hr/yr)	Estimated Propane Savings (gal/yr)	Estimated Cost Savings ($/yr)	Cost to Implement ($)	Payback Period (yrs)
24,453	-	$2,445	$34,000	14

Table 4. ECM #2 savings.

ECM #3: Replace AHU-1, EF-1 and EF-2 with Energy Recovery Unit

Currently, the ventilation air is provided by AHU-1 and exhausted by EF-1 and EF-2. AHU-1 uses a significant amount of propane to heat the outside air in the winter months. Then the exhaust fans suck this heated air out of the building. A more efficient ventilation system recovers the heat from the exhaust air before the air leaves the building in the winter. In the summer, the energy recovery system also reduces the amount of cooling needed on the outside air by precooling and dehumidifying the outside air with the cooler and dryer exhaust air.

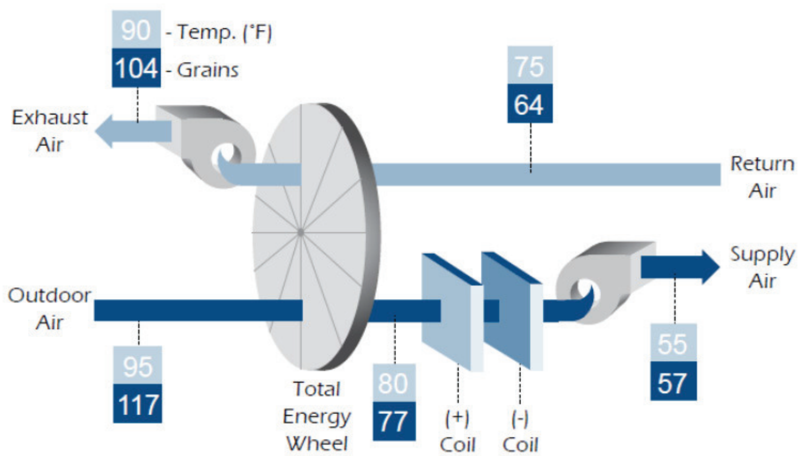


Figure 15. Energy recovery schematic.

This measure would involve re-ducting EF-1 and EF-2 exhaust ducts back to the main mechanical room. There is a high expense associated with redoing the ductwork. Additionally, there is limited space above ceiling so some existing conduit and fire sprinkler piping would be required to be relocated. EF-1 and EF-2 would then be removed and the roof curbs sealed.

The total outside air quantity should also be evaluated to determine if it can be reduced based on the actual space usage.

Estimated Electric Savings (kW-hr/yr)	Estimated Propane Savings (gal/yr)	Estimated Cost Savings ($/yr)	Cost to Implement ($)	Payback Period (yrs)
3,011	2,658	$5,351	$75,000	14

Table 5. ECM #3 savings.

ECM #4: Reduce the Winter Setpoint for the Heat Pump Loop

Currently, the boilers maintain the heat pump loop at 85°F in the winter months. This is a typical temperature in the cooling season, but typical heat pump loops are maintained around 65°F during the heating season. The loop is allowed to float between these temperatures when the loop does not need heating or cooling. SEG recommends that these loop temperatures are used at the HWC.

Maintaining 85°F loop temperature in the winter results in additional propane usage and also reduces the efficiency of the heat pumps that are in the cooling mode, whereas the heat pumps in heating are less affected by a lower loop supply temperature.

Estimated Electric Savings (kW-hr/yr)	Estimated Propane Savings (gal/yr)	Estimated Cost Savings ($/yr)	Cost to Implement ($)	Payback Period (yrs)
2,000	500	$1,150	$50	< 1

Table 6. ECM #4 savings.

ECM #5: Modify Heat Pump Schedules and Unoccupied Setpoints

Currently, the heat pumps share the same schedule as the AHU. The occupied period is scheduled 7 days per week from 4:00am to 11:00pm. The typical unoccupied space temperature setpoints at the HWC are currently 70°F for heating and 90°F for cooling.

SEG recommends that the schedule is changed to Monday through Friday from 7:00am to 5:00pm with an optimal start routine that will start the heat pumps before 7:00am as necessary to get the space temperature to setpoint by 7:00am. SEG also recommends that the unoccupied space temperature setpoints be kept at 65°F for heating and 80°F for cooling.

Estimated Electric Savings (kW-hr/yr)	Estimated Propane Savings (gal/yr)	Estimated Cost Savings ($/yr)	Cost to Implement ($)	Payback Period (yrs)
30,253	-	$2,360	$50	< 1

Table 7. ECM #5 savings.

ECM #6: Modify Humidifier Scheduling and Control

Currently, the humidifier associated with AHU-1 runs whenever the AHU is running. If ECM #1 is implemented, the humidifiers will also reduce the amount of runtime. This ECM accounts for the savings associated with the reduced runtime of the humidifiers.

Additionally, SEG recommends that the humidifiers are controlled based on space humidity levels. Currently, the humidifiers run to maintain a discharge air humidity level which may not accurately reflect the actual space conditions.

Estimated Electric Savings (kW-hr/yr)	Estimated Propane Savings (gal/yr)	Estimated Cost Savings ($/yr)	Cost to Implement ($)	Payback Period (yrs)
24,945	-	$2,495	$50	< 1

Table 8. ECM #6 savings.

ECM #7: Reduce Mechanical Room Unit Heater Setpoint

There is a propane-fired unit heater in the mechanical room that is used to maintain the space temperature. The heating thermostat was set to 70°F. Exhaust fan EF-3 used for cooling this space was set to 50°F. This created a condition where both the exhaust fan and the heater were running, leading to simultaneous heating and cooling in this space.

SEG recommends that the unit heater is set to 55°F and EF-3's cooling setpoint is 80°F. Table 9 calculates the savings for the unit heater only. The savings for EF-3 is calculated in ECM #9.

Estimated Electric Savings (kW-hr/yr)	Estimated Propane Savings (gal/yr)	Estimated Cost Savings ($/yr)	Cost to Implement ($)	Payback Period (yrs)
-	105	$200	$25	< 1

Table 9. ECM #7 savings.

ECM #8: Add Occupancy Sensors for Heat Pump Fan Control

Currently, the heat pump fans run continuously when the building is in the occupied mode of operation. However, there are some spaces served by heat pumps that are not frequently occupied.

SEG recommends that occupancy sensors are added to spaces that are infrequently occupied. The occupancy sensor would allow the heat pump fan to go off if the space temperature was within setpoint and the room was vacant. Because heat pumps may serve multiple rooms, it would be required that all rooms served by one heat pump be vacant.

Estimated Electric Savings (kW-hr/yr)	Estimated Propane Savings (gal/yr)	Estimated Cost Savings ($/yr)	Cost to Implement ($)	Payback Period (yrs)
2,800	-	$280	$2,000	7

Table 10. ECM #8 savings.

ECM #9: Modify EF-3 Setpoint

This measure was discussed in relation to ECM #7. The savings associated with the fan savings has been calculated here.

Estimated Electric Savings (kW-hr/yr)	Estimated Propane Savings (gal/yr)	Estimated Cost Savings ($/yr)	Cost to Implement ($)	Payback Period (yrs)
400	-	$40	$25	< 1

Table 11. ECM #9 savings.

ECM #10: Perform Tune-Up on Boilers and Duct Furnaces

SEG recommends that a tune-up and combustion analysis is performed on the boilers, duct furnaces and unit heaters. During the site visit, the duct furnaces appeared to have a less than optimal flame pattern and combustion efficiency could likely be improved through a tune-up.

Figure 16. AHU-1 duct furnace flame pattern.

Estimated Electric Savings (kW-hr/yr)	Estimated Propane Savings (gal/yr)	Estimated Cost Savings ($/yr)	Cost to Implement ($)	Payback Period (yrs)
-	536	$1,019	$500	< 1

Table 12. ECM #10 savings.

ECM #11: Repair EF-3 Damper

SEG observed that the damper on EF-3 was not closing when the exhaust fan was off. This was resulting in heat escaping from the mechanical room. SEG recommends that the damper is repaired.

Estimated Electric Savings (kW-hr/yr)	Estimated Propane Savings (gal/yr)	Estimated Cost Savings ($/yr)	Cost to Implement ($)	Payback Period (yrs)
-	20	$38	$25	< 1

Table 13. ECM #11 savings.

ECM #12: Modify Heat Pump Ductwork to Reduce Noise Issues

The building manager noted that there are numerous complaints regarding noise coming from the heat pumps above the ceiling. SEG reviewed the installation and observed that the design did not adequately address noise produced by the heat pumps.

To remedy this issue, it is recommended that the first ten feet of the supply and return ducts are lined. Additionally, the supply and return ducts should be connected to the heat pumps using flexible connectors to reduce the vibration transmission between the heat pump and the ducts and diffusers.

Figure 17. Connection of return duct to heat pump without a flexible connection between the heat pump and duct causing noise issues.

Estimated Electric Savings (kW-hr/yr)	Estimated Propane Savings (gal/yr)	Estimated Cost Savings ($/yr)	Cost to Implement ($)	Payback Period (yrs)
-	-	-	$50,000	-

Table 14. ECM #12 savings.

ECM #13: Clean AHU-1 Cooling Coil

SEG observed that the cooling coil on AHU-1 was due for a cleaning.

Estimated Electric Savings (kW-hr/yr)	Estimated Propane Savings (gal/yr)	Estimated Cost Savings ($/yr)	Cost to Implement ($)	Payback Period (yrs)
-	-	-	$150	-

Table 15. ECM #13 savings.

ADDITIONAL COMMENTS

Equipment Life

Overall, the equipment appeared to be in good condition and well maintained. The table below summarizes service life estimates for the equipment in the building based on ASHRAE research studies. This table is intended to give the owner some idea of when replacing equipment will be required. The actual life of the equipment can vary substantially based on the service use, maintenance and other factors.

Equipment	Service Life Estimates
Heat Pumps	20 years
Cooling Tower	20 years
Boilers	25+ years
Duct Furnaces / Unit Heaters	13 years
Air Handlers / DX Condensing Unit	20 years
Pumps	20 years

Table 16. Equipment service life estimates.

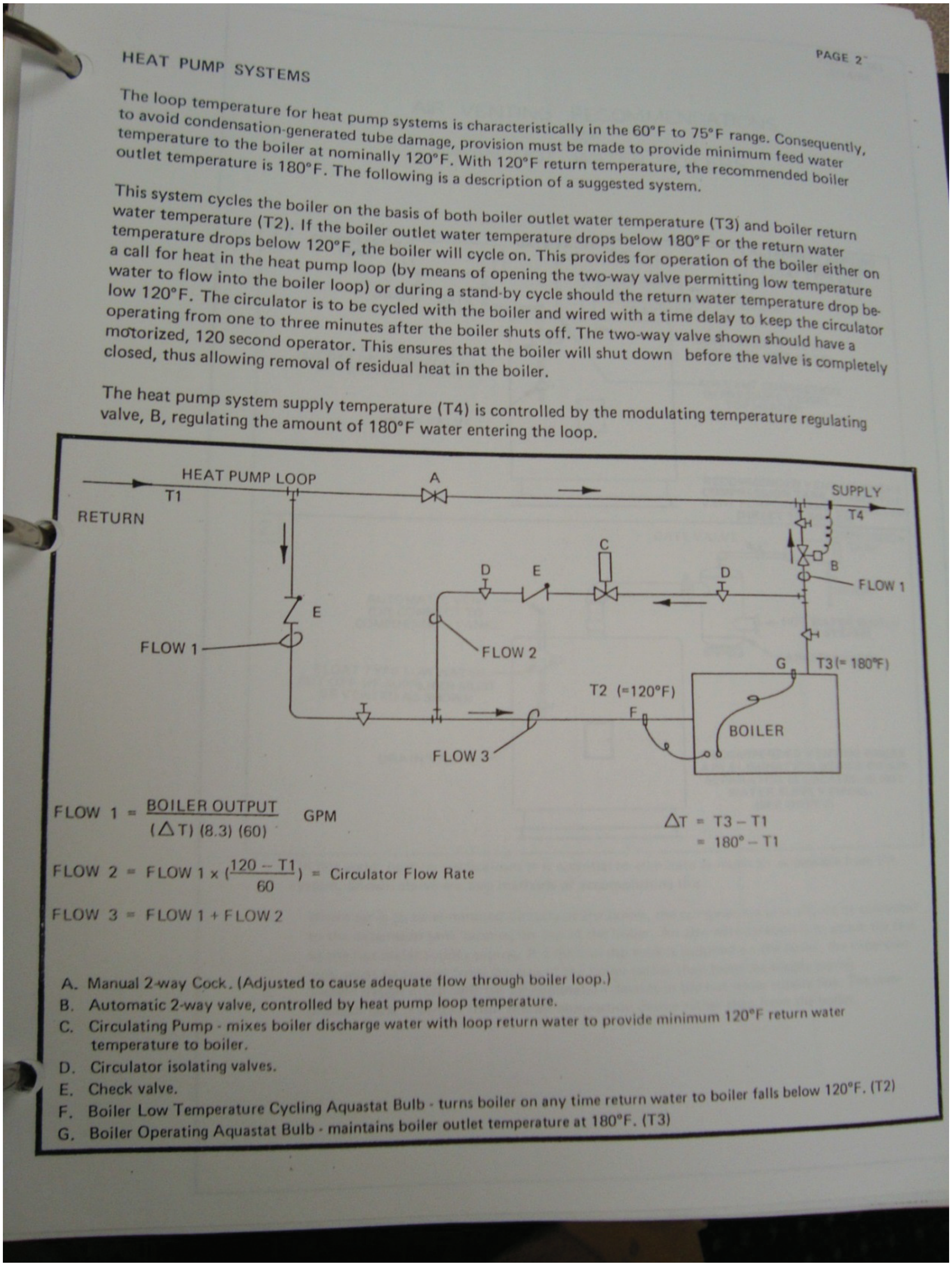
If any extensive energy efficiency measures are going to be performed, such as the installation of energy recovery ventilation or variable speed pumps, it would make economic sense to coincide these upgrades when equipment is due for replacement.

Boiler System Design

The boilers appeared to be installed contrary to the manufacturer's instructions. Specifically, the return water to the boilers was only 80°F. The boiler manufacturer requires the return temperature to be maintained above 120°F. Low return water temperatures will result in flue gases condensing and can lead to boiler flue and tube corrosion.

SEG suggests that when boiler replacement is required, a condensing boiler is used in lieu of the existing boilers because they can operate with low return water temperatures and do so at very high efficiency rates.

The figure below is the boiler manufacturer system design guide for a heat pump system, which is different from the HWC design.



HEAT PUMP SYSTEMS

PAGE 2

The loop temperature for heat pump systems is characteristically in the 60°F to 75°F range. Consequently, to avoid condensation-generated tube damage, provision must be made to provide minimum feed water temperature to the boiler at nominally 120°F. With 120°F return temperature, the recommended boiler outlet temperature is 180°F. The following is a description of a suggested system.

This system cycles the boiler on the basis of both boiler outlet water temperature (T3) and boiler return water temperature (T2). If the boiler outlet water temperature drops below 180°F or the return water temperature drops below 120°F, the boiler will cycle on. This provides for operation of the boiler either on a call for heat in the heat pump loop (by means of opening the two-way valve permitting low temperature water to flow into the boiler loop) or during a stand-by cycle should the return water temperature drop below 120°F. The circulator is to be cycled with the boiler and wired with a time delay to keep the circulator operating from one to three minutes after the boiler shuts off. The two-way valve shown should have a motorized, 120 second operator. This ensures that the boiler will shut down before the valve is completely closed, thus allowing removal of residual heat in the boiler.

The heat pump system supply temperature (T4) is controlled by the modulating temperature regulating valve, B, regulating the amount of 180°F water entering the loop.

$$\text{FLOW 1} = \frac{\text{BOILER OUTPUT}}{(\Delta T)(8.3)(60)} \text{ GPM}$$

$$\Delta T = T3 - T1 = 180° - T1$$

$$\text{FLOW 2} = \text{FLOW 1} \times \left(\frac{120 - T1}{60}\right) = \text{Circulator Flow Rate}$$

$$\text{FLOW 3} = \text{FLOW 1} + \text{FLOW 2}$$

A. Manual 2-way Cock. (Adjusted to cause adequate flow through boiler loop.)
B. Automatic 2-way valve, controlled by heat pump loop temperature.
C. Circulating Pump - mixes boiler discharge water with loop return water to provide minimum 120°F return water temperature to boiler.
D. Circulator isolating valves.
E. Check valve.
F. Boiler Low Temperature Cycling Aquastat Bulb - turns boiler on any time return water to boiler falls below 120°F. (T2)
G. Boiler Operating Aquastat Bulb - maintains boiler outlet temperature at 180°F. (T3)

Figure 18. Boiler manufacturer design schematic requiring return temperatures greater than 120°F.

LIGHTING AND DAYLIGHTING

EXISTING CONDITIONS

Overall, the lighting used in the Health and Wellness Center is energy efficient and well designed. The interior lighting consists mainly of T8 fluorescent fixtures, compact fluorescent cans and compact fluorescent wall sconces.

Occupancy sensors have been installed in some of the storage, janitor closets, and bathrooms after the original construction.

POTENTIAL INITIATIVES

ECM #14: Install Daylight Sensors on Atrium Uplighting

Currently, there are approximately 14 uplights in the Atrium area that are used for architectural accenting. These lights were observed to be on during the day when there was lots of daylight coming in the atrium windows and any architectural effect was minimized. SEG recommends that these lights are tied into a daylight sensor and turned off when there is adequate ambient lighting in the space. Alternatively, these lights could be tied into a timer so that these lights are disabled during the daylight hours.

Figure 19: Atrium uplighting.

Estimated Electric Savings (kW-hr/yr)	Estimated Propane Savings (gal/yr)	Estimated Cost Savings ($/yr)	Cost to Implement ($)	Payback Period (yrs)
945	-	$95	$750	8

Table 17. ECM #14 savings.

ECM #15: Install Additional Occupancy Sensors

SEG recommends that additional occupancy sensors are added to spaces that have intermittent use, such as the exam rooms, break rooms, offices and other similar spaces.

Figure 20. Dental office exam rooms unoccupied with lights on.

Estimated Electric Savings (kW-hr/yr)	Estimated Propane Savings (gal/yr)	Estimated Cost Savings ($/yr)	Cost to Implement ($)	Payback Period (yrs)
5,000	-	$500	$2000	4

Table 18. ECM #15 savings.

ECM #16: Install Daylight Sensors in Waiting Rooms

SEG recommends that daylight sensors are installed in the waiting rooms that have southern exposure, such as the dental waiting area. When the ambient lighting is high enough, the lights would go off.

Estimated Electric Savings (kW-hr/yr)	Estimated Propane Savings (gal/yr)	Estimated Cost Savings ($/yr)	Cost to Implement ($)	Payback Period (yrs)
2,000	-	$200	$1,500	8

Table 19. ECM #16 savings.

DOMESTIC HOT WATER

The portions of the plumbing system surveyed include the water heating equipment and restroom fixtures.

EXISTING CONDITIONS

There are two water heaters serving the building. Table 20 summarizes the existing domestic water heaters and their characteristics.

Equipment	Location	Type	Storage Capacity	Heat Capacity	Serves	Installed Date	Remaining Lifespan (yrs)
HWH #1	Rm 158 Mech Rm	LP	74 gal	MBH	Building	Unknown	Unknown
HWH #2	Rm 158 Mech Rm	LP	74 gal	MBH	Building	Unknown	Unknown

Table 20. List of existing domestic water heaters.

At least one lavatory fixture (Rm 126, lower level conference room) was observed without an aerator to control the output flow rate. An aerator saves water and when using hot water, it thereby saves energy.

POTENTIAL INITIATIVES

Potential sustainability initiatives for the plumbing system include:

1. Install an aquastat and/or timer on domestic hot water recirculation pump. For a 180-watt pump, this is equal to 1,000 kW-hr per year savings.
2. Replace the water heaters with high efficiency propane-fired condensing models with efficiencies of at least 95 percent. Alternatively, in tandem with geothermal, ground-source heat pump water heaters could be considered.
3. Ensure that all lavatory and kitchen sink fixtures have aerators installed that regulate the water flow.
4. Replace water closets with dual-flush, low-flow fixtures with a maximum of 1.3 gallons per flush.

ELECTRICAL PLUG LOADS

POTENTIAL INITIATIVES

ECM #17: Add Time Clock to Physical Therapy Water Bath

In the physical therapy space, there is a small hot water bath. The unit runs 24 hours per day for 7 days per week. SEG recommends that the unit is connected to a time clock and turned off when not needed.

Figure 21. Physical therapy hot water bath.

Estimated Electric Savings (kW-hr/yr)	Estimated Propane Savings (gal/yr)	Estimated Cost Savings ($/yr)	Cost to Implement ($)	Payback Period (yrs)
3,500	-	$350	$200	< 1

Table 21. ECM #17 savings.

ECM #18: Add Vending Misers to Vending Machines

There are two vending machines located in the HWC Building. If these units are maintained by a third party, SEG recommends that the HWC requests that Vending Misers are installed by the equipment vendor. If the HWC owns these machines, it can work with the servicing contractor to install the Vending Misers.

Vending Misers are occupancy sensors that are tied into the machine controls. When the building is not occupied, the machine lights go off and if the unit is refrigerated, the temperature is allowed to float upwards slightly to reduce the cooling load.

Figure 22. Picture of a sample vending miser occupancy sensor mounted to the top of a vending machine.

Estimated Electric Savings (kW-hr/yr)	Estimated Propane Savings (gal/yr)	Estimated Cost Savings ($/yr)	Cost to Implement ($)	Payback Period (yrs)
8,280	-61	$518	$1,500	3

Table 22. ECM #18 savings.

ADDITIONAL COMMENTS

Dehumidifiers were needed during summer months in Rms 102 (Chiropractor Services), 121 (Physical Therapy Services), 124 (Business Offices), 125 (Mechanical Room), 126 (Conference Room), and 145 (Exercise/Mail Room). Improved drainage or storm water management practices could reduce the need for dehumidification in these spaces. It is suspected that runoff from the parking lot and the building may be increasing the moisture content of the soil outside of this below-grade portion of the building.

Additional improvements may include purchasing ENERGY STAR® qualified receptacle equipment, such as computer workstations, dehumidifiers, televisions, microwaves, refrigerators, coffeemakers, etc.

BUILDING ENVELOPE

The building envelope consists of the entire exterior enclosure of the building. It has three main functions: to provide structural support for the building, to control the flow of matter, energy, and people in and out of the building, and to provide a medium for expressing aesthetic and design sensibilities. For this analysis, the current condition of the building envelope and its ability to control the flow of heat, air, and moisture was assessed.

EXISTING CONDITIONS

Walls

The HWC walls are mostly face brick on 2" foam insulation on concrete block, according to the original drawing set.

The walls in the generator building and garage have vertical metal siding over wood framing and appear to be insulated with 3.5" fiberglass batt insulation.

Windows and Doors

The HWC windows have an aluminum frame system and appear to be double-glazed with solar-reflective glazing. In several places, large amounts of condensation were evident. Likewise, the aluminum exterior doors had a lot of condensation and frost on them. Condensation is a sign of poorly insulated areas and excessive levels of it can result in water getting into wall assemblies and causing mold. The overhead door in the receiving area does not seal well and daylight is visible along the sides.

The generator building and garage do not have windows, and no problems were observed with the doors. However, the walls of the generator building have motorized dampers for combustion air for the diesel generator. These dampers do not close well enough to create an air seal, and are a significant source of energy loss in this building.

Roof

The HWC contains mostly flat roof area with a pitched roof area over the main atrium. The flat roof is an EPDM membrane over rigid insulation (tapered for roof drains, average of 4" thickness). The membrane is about one year old at the time of this report. The pitched roof is standing seam metal over an insulated roof panel.

The generator building and garage have pitched shingle roofs. Fiberglass batt insulation is between the wood framing.

ECM #19: Replace Faulty Window Frames

SEG observed multiple window frames with frost and condensation. There were many of the same frames throughout the building that did not indicate any issues with frost or condensation, which indicates that some frames may have failed. Specifically, the thermal break between the interior frame and exterior frame has been compromised.

While there is not a significant energy savings associated with this measure, continued condensation will lead to the water damage of the drywall and wall cavity may lead to mold issues.

Reducing the building humidity setpoint may also help with reducing the amount of condensation occurring on the frame.

Figure 23. Condensation on the window sill from cold window frames.

Estimated Electric Savings (kW-hr/yr)	Estimated Propane Savings (gal/yr)	Estimated Cost Savings ($/yr)	Cost to Implement ($)	Payback Period (yrs)
-	66	$125	$10,000	80

Table 23. ECM #19 savings.

ECM #20: Replace Poorly Insulated Doors

SEG observed that many of the exterior doors were very poorly insulated and had frost covering the majority of the door interior. SEG recommends that these doors are replaced with better insulated doors.

Figure 24. Thermal image of a frosted door indicating an interior surface temperature of 30°F.

Estimated Electric Savings (kW-hr/yr)	Estimated Propane Savings (gal/yr)	Estimated Cost Savings ($/yr)	Cost to Implement ($)	Payback Period (yrs)
-	105	$200	$7,500	38

Table 24. ECM #20 savings.

GENERATOR BUILDING & GARAGE

POTENTIAL INITIATIVES

ECM #21: Seal Penetrations on Generator Building

SEG observed a large crack in the CMU blocking on the south side of the building. SEG recommends that this penetration and any other penetrations are sealed to prevent the infiltration of cold air into the building.

Figure 25. Cracks in the CMU blocking leading to high air infiltration.

Estimated Electric Savings (kW-hr/yr)	Estimated Propane Savings (gal/yr)	Estimated Cost Savings ($/yr)	Cost to Implement ($)	Payback Period (yrs)
-	16	$30	$250	8

Table 25: ECM #21 Savings

ECM #22: Repair or Replace Leaky Dampers at the Generator Building

SEG observed that the generator air intake dampers were not sealing. It is recommended that the dampers and linkages are repaired to reduce the amount of cold air infiltrating the building.

Figure 26. Leaky generator building intake dampers.

Estimated Electric Savings (kW-hr/yr)	Estimated Propane Savings (gal/yr)	Estimated Cost Savings ($/yr)	Cost to Implement ($)	Payback Period (yrs)
-	105	$200	$1,000	5

Table 26. ECM #22 savings.

ECM #23: Add Controls to Garage Heat Trace

SEG observed that the heat trace on the garage was heating when there was no need to provide heat. The heat trace only serves to prevent ice dams and does not need to run when there is no snow or ice on the overhang of the roof. It is recommended that the heat trace is turned on only when needed (manually), is installed with a snow/ice sensor, or put on a timer. The need for heat trace also indicates that there is inadequate insulation or ventilation in the roof.

Figure 27. Heat trace heating but there is no risk of ice damming.

Estimated Electric Savings (kW-hr/yr)	Estimated Propane Savings (gal/yr)	Estimated Cost Savings ($/yr)	Cost to Implement ($)	Payback Period (yrs)
1,000	-	$100	$150	2

Table 27. ECM #23 savings.

ECM #24: Reduce Garage Heating Setpoint

SEG observed that the heating setpoint on the garage thermostat was 60°F. It is recommended that the setpoint be reduced to 45°F. There is no plumbing or fire sprinkler piping that needs to be maintained in this space and it is used primarily for storage.

Estimated Electric Savings (kW-hr/yr)	Estimated Propane Savings (gal/yr)	Estimated Cost Savings ($/yr)	Cost to Implement ($)	Payback Period (yrs)
1,000	-	$100	$150	2

Table 28. ECM #24 savings.

RENEWABLE ENERGY TECHNOLOGIES

The HWC campus was assessed for four separate renewable energy systems:

- Geothermal
- Solar Electric (also called Photovoltaic, or PV)
- Solar Thermal
- Biomass

The Stockbridge Munsee Community has requested that the investigated renewable energy systems can be shown to offset a total of 30 to 100 percent of the building's energy loads. For the purposes of this report, it was discussed that this would be expressed in terms of *site* energy usage (as opposed to *source* energy usage). It is assumed to include the total electrical and propane energy for all three buildings (the HWC, generator building, and garage) combined.

Since electricity and propane are expressed in different units of energy (kWh of electricity and gallons of propane), it is useful to combine them into one unit and to normalize it for building area. The standard unit used for this and the unit used in this report to describe total energy will be kBTUs. One kBTU is equal to 1,000 BTUs, 0.29 kWh of electricity, or 0.011 gallons of propane.

The table below shows the total site energy usage for the HWC campus to be 4,350,000 kBTU per year. The energy efficiency portion of this feasibility study highlighted several opportunities to reduce energy usage with minimal cost. It was identified that approximately 1,050,000 kBTU per year (composed of 103,000 kWh and 7,800 gallons of propane) can be saved with a total implementation cost of less than $5,000 and a payback period of 0.2 years. These immediate-payback measures should be implemented before any renewable energy technologies because they can reduce the required size and enhance the economic feasibility of the renewable energy systems. Therefore, the total site energy load that the calculations are based on is assumed to be 3,300,000 kBTU per year. In order to offset 30 to 100 percent of the building's energy loads, the renewable energy systems examined here would have to offset 990,000 to 3,300,000 kBTU per year.

Diesel fuel is consumed on site for the backup generator. It is an insignificant amount of the total energy use of the building (less than 1 percent), and some renewable energy systems, such as the solar electric system, would not typically operate during a power outage situation and would not decrease generator energy usage. The diesel fuel is therefore not accounted for in the total HWC campus energy usage.

	Propane (gallons/yr)	Energy from Propane (kBTU/yr)	Electricity (kWh/yr)	Energy from Electricity (kBTU/yr)	Total Energy (kBTU/yr)
Current Energy Usage	22,000	2,000,000	679,000	2,350,000	4,350,000
Energy Savings from ECMs	7,800	700,000	103,000	350,000	1,050,000
Projected Base Energy Usage	**14,200**	**1,300,000**	**576,000**	**2,000,000**	**3,300,000** **30 % = 990,000 kBTU/yr**

Table 29. The minimum amount of energy to be offset by a combination of renewable energy systems in this report is 990,000 kBTU/yr.

The geothermal system is the recommended option to offset the HWC's energy use by 30 to 100 percent due to its cost effectiveness. It is estimated to accomplish the goal of reducing the facility's total energy use by 30 percent. This option has the most favorable economics with a payback period of 10 years and a 25-year return on investment (ROI) of 17 percent per year. Compared to a solar electric system, which would offset a similar amount of energy, the upfront cost to implement a geothermal system would be relatively low.

A solar electric system is also capable of offsetting at least 30 percent of the HWC's energy use. However it carries a less favorable economic picture (25-year payback and 0 percent 25-year ROI). A solar thermal system for domestic hot water has similar economics to a solar electric system, but is capable of offsetting a much lower portion of the building's total energy use. If the Stockbridge Munsee Community is interested in offsetting the HWC's total energy use as much as possible with renewable energy and a 25-year payback is acceptable, a solar electric and solar thermal system can complement a geothermal system or a biomass system.

A biomass system is a mutually exclusive option to the geothermal system because both systems aim to provide the building's winter space heating loads. Since the biomass system carries the lower cost effectiveness and several other operation considerations with it, such as fuel storage, possible odors and emissions, additional maintenance, and whether the feedstock could be produced by the Community, a geothermal system is recommended over the biomass system.

	Upfront Cost	Energy Offset (kBTU/yr)	Portion of Building's Use	Payback	25-yr ROI
Geothermal	**$ 240,000**	**1,000,000**	**30 %**	**10 yrs**	**17 %**
Solar Electric	$ 900,000	1,100,000	33 %	25 yrs	0.0 %
Solar Thermal	$ 12,000	10,000	0.3 %	25 yrs	0.0 %
Biomass (Wood Pellet)	$ 205,000	1,000,000	30 %	14 yrs	8.1 %

Table 30. An overview of the economics and performance of the four renewable energy technologies examined in this study.

GEOTHERMAL

TECHNOLOGY OVERVIEW

Geothermal systems are high efficiency HVAC systems that work by using the ground as a thermal battery and therefore generally work very well in climates that experience both a heating season and a cooling season, like in Wisconsin. In the summer a geothermal system cools a building by rejecting heat to the ground, and in the winter the system reverses the cycle to heat the building from the ground. Buildings that have relatively balanced heating and cooling loads simply shift the thermal energy back and forth between the ground and the building.

The ground-source heat pumps would be very similar to the building's existing water-source heat pumps. Instead of using a boiler and cooling tower, a geothermal system would use the ground to maintain the temperature of the source loop. Heating and cooling energy from the ground is transferred to electric heat pumps in the building using a glycol fluid in a closed-loop system.

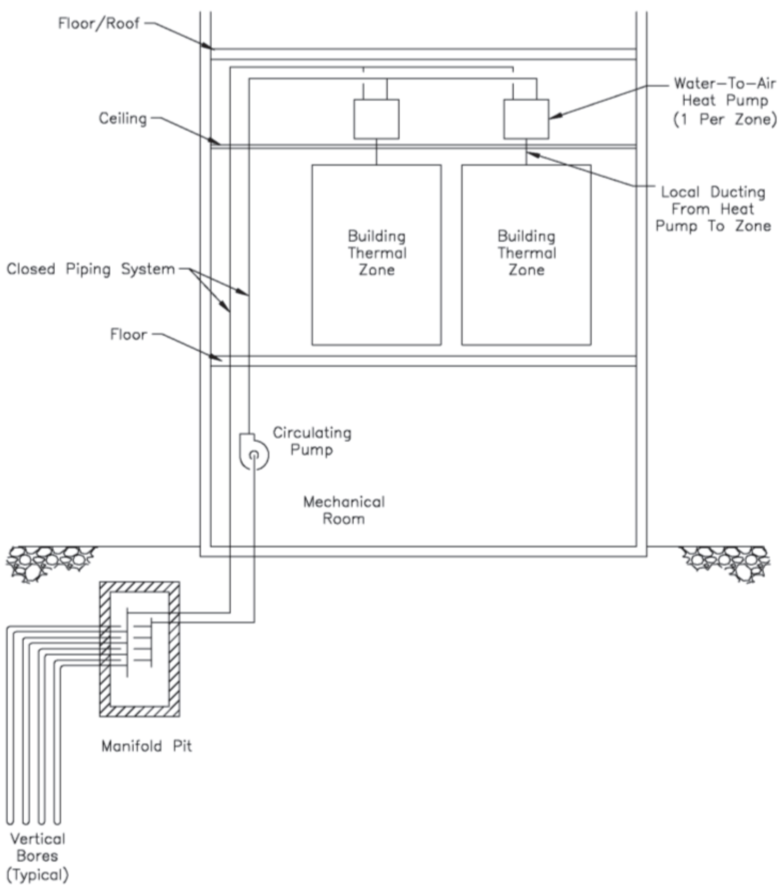


Figure 28. Geothermal heating and cooling system schematic.

The glycol fluid is circulated between the heat pumps and a system of piping that would be installed in the ground. The preferred system is a vertical-bore system, which consists of several bores approximately 6 inches in diameter by approximately 300 to 400 feet deep. Each bore would contain two pipes (one supply, one return) approximately 1 inch in diameter with a U-bend on the bottom. The bore is then filled with a grouting material that surrounds the piping, improves thermal conductivity, and seals the bore to protect groundwater. Trenches are dug to install the piping that connects the bores together, and the piping is routed underground to the mechanical room of the building.

PROJECT RECOMMENDATIONS/COMMENTS

Determining the size of a geothermal system starts with the building's heating and cooling loads. This type of building typically has a cooling load of approximately 450 ft^2 per ton and a heating load of approximately 30 BTU per ft^2, including ventilation loads. This results in a maximum cooling load of 67 tons (800,000 BTUs, or 800 MBH) and a maximum heating load of 900 MBH. A review of the mechanical drawings confirms that these estimates are approximately in line with the heating and cooling equipment originally designed for the 30,170 ft^2 building.

Soil, bedrock and water table characteristics determine the rate of heat exchange for the geothermal system. Favorable geological conditions can lead to a smaller geothermal field, needing fewer total bores to heat/cool the building, and vice versa. Using Wisconsin Department of Natural Resources (WDNR) well log data in the area, these geological characteristics can be estimated. About ten existing wells between 205 and 405 feet deep within one mile of the HWC were examined. Every well showed relatively consistently that there was a combination of sand, clay, gravel, and boulders for approximately the top 10 to 75 feet. Below that, every well showed granite for the remainder of its depth. Granite is a hard bedrock, and may take about 50 percent longer to drill than some bedrocks (such as limestone or sandstone). But granite has good thermal conductivity, good thermal diffusivity, and the water table appears to be relatively high in the area (depth of around 25 to 50 feet). All of these traits mean that the geothermal bores should have very good heat exchange characteristics. Although the WDNR well logs are very useful for estimation purposes, a test bore should be conducted at the outset of a geothermal project to gather a more accurate assessment of the site conditions.

Preliminary analysis using GSHP Calc modeling software indicates that a geothermal field would require approximately 40 bores 300 feet deep. The bores should be spaced out about 20 feet apart. A field that was, for example, 4 rows of 10 bores then would be approximately 60 feet wide by 180 feet long.

Although the existing mechanical system utilizes heat pumps, a geothermal system would require a complete change out of the heat pumps to units that are specific for geothermal systems. The rest of the system would require an investigation as well. Controls would need to be upgraded, and piping and pumps may need to be changed for new flow rates and pressure drops. Even if the existing piping were to remain, the piping would require insulation for system efficiency as well as to avoid condensation due to the cooler operating temperatures of geothermal systems. Other minor components such as valves may also be worth changing.

The existing heat pumps are original to the building, so they are about 14 years old at the time of this report. On average, it can be expected heat pumps to last for approximately 20 to 25 years[1] with proper maintenance like they have had at the HWC. It is recommended to keep up the maintenance and repairs on the heat pumps so that they would not need replacement until the HWC is ready to move forward with a geothermal project. Then, the heat pumps could all be switched over at one time to minimize costs.

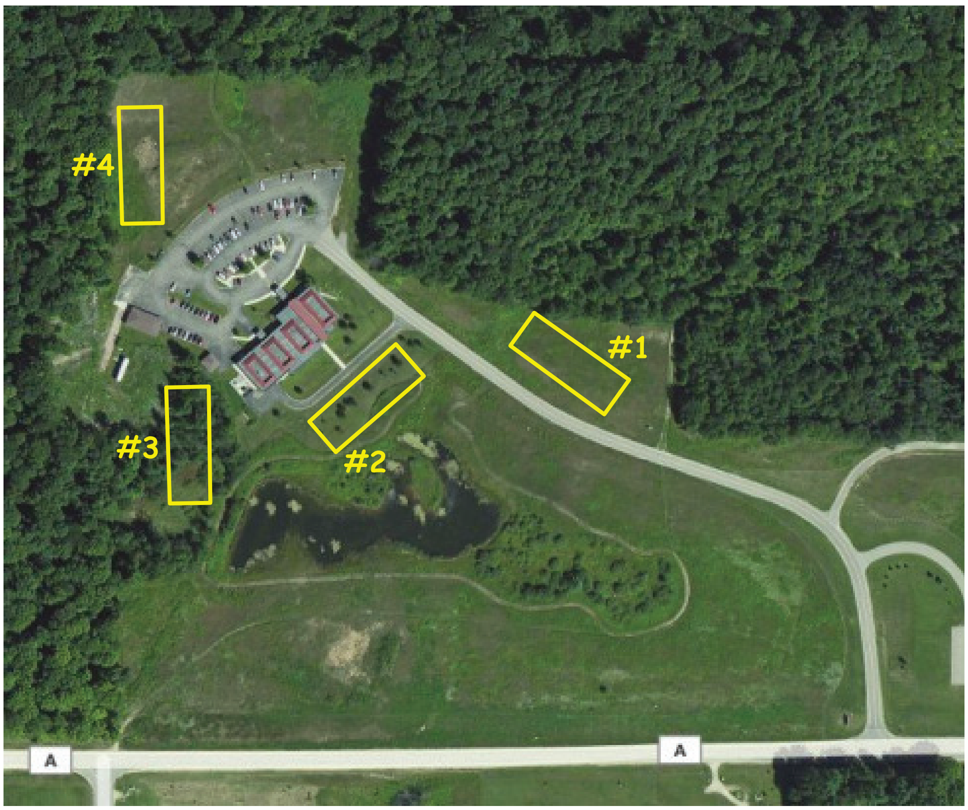


Figure 29. There are several possible areas for a geothermal borefield near the building.

The HWC is considering a future assisted living facility on the campus as well, and some economies of scale may be achieved if a geothermal system is installed for that building at the same time and the same contractors are used for the borefield installation and mechanical work.

[1] 2011 ASHRAE Handbook—HVAC Applications, Chapter 37 Owning and Operating Costs, Table 4 "Comparison of Service Life Estimates."

There are several advantages and tradeoffs for each of the sites shown in Figure 29.

Site #1 –

- Advantages: Clear of trees & landscaping, further away from building leads to less drilling/construction noise, further away from pond is easier to control runoff during drilling
- Tradeoffs: A little further away from the mechanical room than #2 and #3 would lead to a slightly longer pipe run, some directional boring would be required under the roadway

Site #2 –

- Advantages: Closest to mechanical room resulting in the shortest pipe run
- Tradeoffs: Would likely have to remove & replant some trees and landscaping, may be some noise during drilling that would affect operations, may be difficult to control runoff into pond

Site #3 –

- Advantages: Close to mechanical room, should be easier to control runoff into pond than #2
- Tradeoffs: Would have to clear some trees, may be some noise during drilling that would affect operations

Site #4 –

- Advantages: Advantages: Clear of trees & landscaping, further away from building leads to less drilling noise, further away from pond is easier to control runoff, would have least visibility impact during construction
- Tradeoffs: Furthest away from the mechanical room results in the longest pipe run, piping may have some effect on parking lot or existing underground utilities, location of borefield may have some effect on possible future assisted living facility (or may affect a borefield for that facility), construction traffic would be through parking lot which may lead to greater impact on patients and employees and may damage the parking lot

The recommended site for a geothermal system for the HWC is Site #1. The tradeoffs that come with this site are relatively minor compared to the other sites. SEG sees a major benefit in leaving Site #4 open for a future assisted living facility and staying away from the pond, which would have to be protected from runoff during drilling operations.

A CAD drawing of a preliminary borefield design for Site #1 is included in Appendix B and has been provided to the Stockbridge Munsee Community as part of this report.

ECONOMICS ESTIMATES

Since the HWC already utilizes heat pumps that will need to be replaced in about five to ten years, it can be assumed that this portion of a geothermal project carries no extra cost. Heat pumps in a geothermal system have to be selected for the operating temperatures of a geothermal borefield, but this functionality does not cost significantly more than the type of heat pumps the HWC currently has in a water-source heat pump system. So if a project is implemented around the time that the HWC would need to replace their heat pumps, this cost difference is negligible.

The costs associated with a geothermal project would include:

- Borefield: $195,000
  The cost of a geothermal borefield has currently been running approximately $16 per linear foot of bore depth in Wisconsin. This cost includes all drilling and piping back to the building taking into consideration the HWC's granite bedrock conditions and the proximity of the borefield to the building. At 40 bores 300 feet deep each, this is 12,000 linear feet of accumulated bore depth, which would be estimated at $195,000.

- Heat Pumps: $0
  The cost of heat pumps is approximately $2 per cfm. It is assumed that this project would be implemented at the time that the building's existing water-source heat pumps would be replaced, and there is a negligible cost difference between water-source heat pumps and ground-source heat pumps. The heat pumps need to be replaced in any case, so there is no additional cost to the heat pumps associated with a geothermal system.

- Heat Pumps (Ventilation): $15,000
  This type of heat pump also costs approximately $2 per cfm. The building's ventilation is currently heated by two propane duct furnaces and cooled by a DX system, so a ventilation heat pump would need to be added to the system at a cost of approximately $15,000. The project would save the cost of having to replace the duct furnaces and DX unit, but this cost savings would approximately equal any ductwork needed to adapt the existing ventilation air duct to the ventilation heat pump.

- Pipe insulation: $30,000
  The majority of the building's water-source heat pump piping is uninsulated due to the operating temperatures of that type of system. Ground-source heat pump systems can run at lower temperatures, particularly in the winter, which can lead to condensation if the pipes are left uninsulated. It is estimated that the existing piping can be insulated for approximately $30,000.

- Accessories: $60,000
  Additional controls, valves, pumps, expansion tanks, and other accessories will be needed to convert the water-source heat pumps system to a ground-source heat pumps system. It is estimated that this can be completed for approximately $60,000.

- Savings: $60,000
  There would also be costs saved in the form of not having to replace the cooling tower and boilers. This is estimated at approximately $60,000.

- Total = $240,000
  A project cost of $240,000 corresponds very closely with a rule of thumb seen in Wisconsin geothermal projects of $8 per ft^2 for a retrofit building.

- Potential Incentives = $30,000
  The Focus on Energy program currently incentivizes retrofit geothermal systems in Wisconsin through their New Construction/Major Retrofit program. The incentive is $1 per ft^2. The Focus on Energy program is continuously updating and changing their specific incentive programs, so this will have to be re-examined at the time of the project.

The table below outlines the estimated system cost, energy saved, incentives available, payback period, and environmental impact in terms of CO_2 offset. The payback analysis includes a rate of escalation of 7 percent on propane rates, which is equal to the long-term historical rate for commercial use in the U.S., and 3 percent on electrical rates, which is equal to the long-term historical rate for commercial use in Wisconsin.[2]

The majority of the building's propane use would be eliminated by changing to a geothermal system. The boilers and duct furnaces would be replaced. The only propane-fueled equipment that would remain are the domestic water heaters and a couple of unit heaters throughout the building.

Changing to a geothermal system would result in greater electricity use for the building. There would be essentially no change in electrical use from changing the water-source heat pumps out for ground-source heat pumps, because they would run at approximately the same overall efficiency to heat and cool the building. There would be some savings by going from DX to a ground-source heat pump for cooling the ventilation air, as well as from eliminating the cooling tower fan, switching the two distribution pumps to variable volume, and eliminating the cooling tower and boilers, thereby reducing the required pumping energy. However, the ventilation air is currently heated by propane and switching this to a heat pump will result in an increase in electricity use.

[2] U.S. Energy Information Administration, www.eia.gov.

The table below assumes that the ECMs described earlier in the report are followed. For example, it was assumed that the existing ventilation air handling unit's schedule was adjusted to reduce energy use. The estimated percentage of the building's total energy savings from a geothermal system is based on the projected usage after ECMs (3,300,000 kBTU/yr).

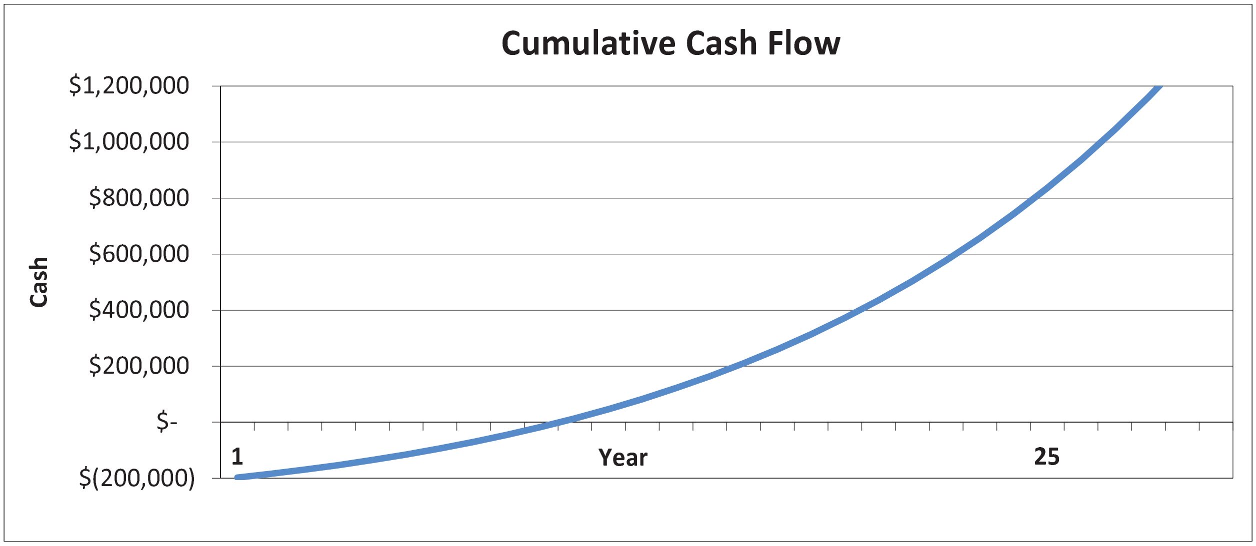


Figure 30. Cumulative cash flow for a geothermal project showing positive cash flow (payback) at 10 years.

Production	
Geothermal system's size	40 bores, 300 ft deep
Estimated propane offset	14,500 gallons/yr
Estimated electricity increase	100,000 kWh/yr
Estimated total site energy offset	1,000,000 kBTU/yr
Percentage of total building's energy	30 %
Cost and Economics	
Installed cost	$ 240,000
Incentives	$ 30,000
Final cost after possible incentives	$ 210,000
ROI, 25-yr average	17 %
Simple payback period	10 yrs
Environmental Impact	
CO_2 emission reduction	34 ton/yr

Table 31. Estimated production, cost and economics, and environmental impact of a 40 bore geothermal system.

SOLAR ELECTRIC (PV)

TECHNOLOGY OVERVIEW

PV systems use the sun to produce electricity. When sunlight hits PV modules, electricity is generated in the form of direct current (DC). Modules are wired to one or more inverters, which are electronic devices that transform the DC into alternating current (AC). This is the same type of electricity used in buildings, and the inverter matches the characteristics of the power that the electric utility provides.

When a PV system generates more electricity than the building is consuming, a typical system allows the power to go backwards through the building's meter and out to the grid. In this scenario, the meter keeps track of the excess energy being generated and the customer receives a credit for it. Otherwise, when the building demands more energy than the system is generating, the extra necessary power is drawn from the grid to supplement the PV production.

Being grid-tied in this manner is a significant advantage of PV systems compared to other solar energy systems, such as solar thermal systems. PV systems are able to use the grid like a battery and every kilowatt-hour is either used in the building or credited to the owner. In contrast, solar thermal systems generate thermal energy, which remains on-site (usually in a storage tank) until it is used and excess energy generation is generally wasted. Solar thermal systems are discussed in greater detail in their own section of this report.

Figure 31. A photo of a typical PV system on a roof type that is similar to the architectural panels on the HWC.

Grid-tied PV systems are as reliable as the electrical grid itself. For some buildings the grid is extremely reliable and is hardly ever down, while for others it means frequent outages. If the grid is down for any reason, a grid-tied PV system would immediately and automatically shut itself down. Even though the building would have electricity from its generator, the PV system would shut down due to a safety feature of the inverter. As soon as the grid comes back up, the system would automatically restart and perform as normal.

The most commonly installed PV systems do not use batteries for storage. A battery-free system is generally preferred because it requires simpler and fewer components than those with batteries, which lowers system cost. Batteries also require a large amount of maintenance, have special storage considerations, and need to be replaced at a significant cost every five to ten years. Battery backup systems are a better application when either grid power is not available or a generator does not already provide backup power.

PROJECT RECOMMENDATIONS/COMMENTS

PV systems can be located on the roof or on the ground. Since the building is located off the road and no one is around at nights or on weekends, it has been discussed that a roof location is preferred in this case to lower the risk of accidental damage or vandalism. However, a ground location would be necessary in order to achieve a system size that offsets at least 30 percent of the building's electrical demand, even after all of the efficiency measures covered in this report are accounted for.

Roof System

There is sufficient roof space for an approximately 25-kilowatt (kW) PV system. The roof is a typical flat roof with an EPDM membrane system, but it has some architectural steel roof panels tilted up to add aesthetic interest to the building, shown in Figures 33 - 35 below. The roof panels are constructed on a structurally engineered steel rack designed to withstand the wind and snow loads. It is very likely that these roof panels could support arrays of PV modules because the arrays would not significantly increase the wind loading or snow loading on the roof above the loads that the architectural panels already experience. A qualified structural engineer should be consulted during the planning and design phases of a PV project to confirm this. This would be a normal step in any solar project that may alter the structural loads on a building.

There are three areas (#1, 2, and 3 in Figure 32) of the roof with these architectural panels, each containing a southeast-facing section that has 8 ft by 18 ft of usable roof space and a southwest-facing section that has 8 ft by 45 ft of usable roof space. These three areas are pitched at an angle of 6/12, or 27 degrees. There is also a pitched, standing seam metal roof area (#4 in Figure 32) over the atrium that contains a usable roof area of 12 ft by 85 ft facing southwest. It is pitched at 3/12, or 15 degrees.

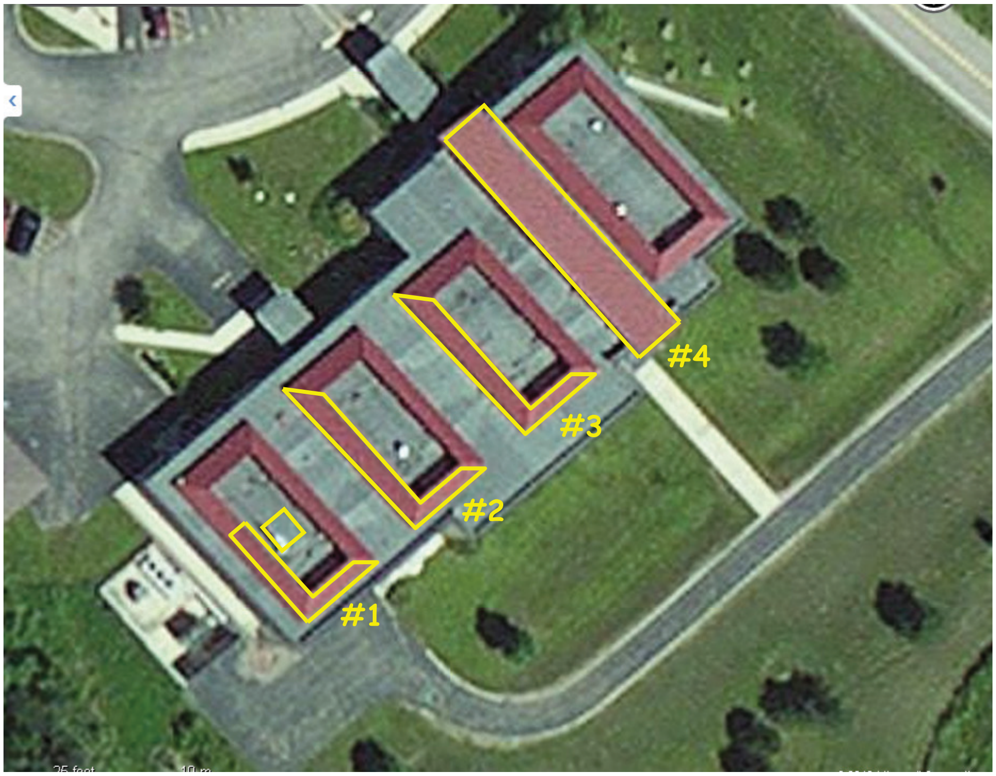


Figure 32. This aerial photograph shows the plan view of the roof. The yellow-outlined southeast- and southwest-facing roof areas are available for the PV system discussed in this report. The square in the southwest roof area is the location of the pipe chase that goes down to the ground-level mechanical room/electrical room area. The roof area not outlined in yellow on the northeast end of the building receives some shade by the atrium roof (roof area #4), and is not recommended for a solar energy system.

Ideally, a PV system would face due south and be pitched at approximately 35 degrees for the best year-round production in Wisconsin. A system's production takes a less than 10 percent deduction by facing southeast or southwest at a slightly shallower angle. It is possible for modules to be tilted off the southeast or southwest facing roofs in a way that they would face more southerly, but the extra racking would introduce costs that may not be worthwhile for the extra production. Tilting the modules would also result in greater wind loads and lower aesthetic appeal. All discussion in this report will assume that the arrays of modules are mounted parallel to their respective roof slope, facing southeast and southwest.

There is a chase that goes from the roof (near the southwest end of the building) down to the ground-level mechanical room (Room 158). This mechanical room is very near the main electrical room (Room 159) where the main panels and several subpanels are located. See Appendix A for a floor plan with room numbers.

Figure 33. A photo looking at southwest-facing roof area #1 (camera looking north-northwest). This roof area experiences 2 percent average annual shading from some trees to the southwest. A pipe chase is located from the roof to the mechanical room where the vent pipes are sticking up over the architectural panels.

Figure 34. A photo looking at the other roof areas on the building (camera looking north-northeast).

Figure 35. A photo showing the structure supporting the architectural panels. The architectural panels are attached to a C-channel that spans across square tubing pedestals that penetrate the roof and are welded to the steel I-joists. The observed areas of this structure appeared to be in good shape. The paint was intact and no rust was seen. A structural engineer should be consulted to determine the structural adequacy for use with solar electric or solar thermal collectors.

Ground System

Ground mounted PV systems often have the benefit of having more space available when compared to roof mounted systems. The size of a ground mounted PV system is usually limited either by an owner's budget or by the amount of electricity used at the building. An additional advantage to ground mounted systems includes being able to orient the array due south and at an optimum angle for production (about 35 degrees).

For the purposes of this report, a 220-kW ground mounted array will be considered (further background on this size selection will be discussed in the following section). Assuming relatively flat ground, each kilowatt of PV capacity occupies approximately 200 ft^2 of ground space. This includes the area behind a row of modules that is necessary to avoid shading the row behind it. Therefore, a 220-kW system would require an area of 44,000 ft^2, which is approximately one acre.

Ground mounted systems are sometimes located in a very visible location and used for demonstration and education purposes. Other building owners prefer to locate systems in a way that is more discreet. The HWC has areas available nearby that fit both of these descriptions. There is an area to the north of the facility that would be hidden by the building itself from the view of the highway. A second area worth considering is just southeast of the building, which would be very visible from the highway.

Both sites are feasible from the perspective of proximity to the building's electrical service entrance, but the southeast site has more space and would result in less trenching for the underground wire run. Furthermore, the more hidden area north of the HWC is a possible candidate site for a future assisted living facility. These factors may make the site southeast of the HWC more flexible.

One consideration with both of these sites is they are the same sites examined for a possible geothermal system. The PV and geothermal projects discussed in this report would require similar amounts of land as each other and it would be possible for them to share the same site. Careful planning and design would be required to coordinate the locations and scheduling of the PV arrays, geothermal bores, electrical conduit and wiring, and geothermal piping. A geothermal system will be discussed in its own section later in the report.

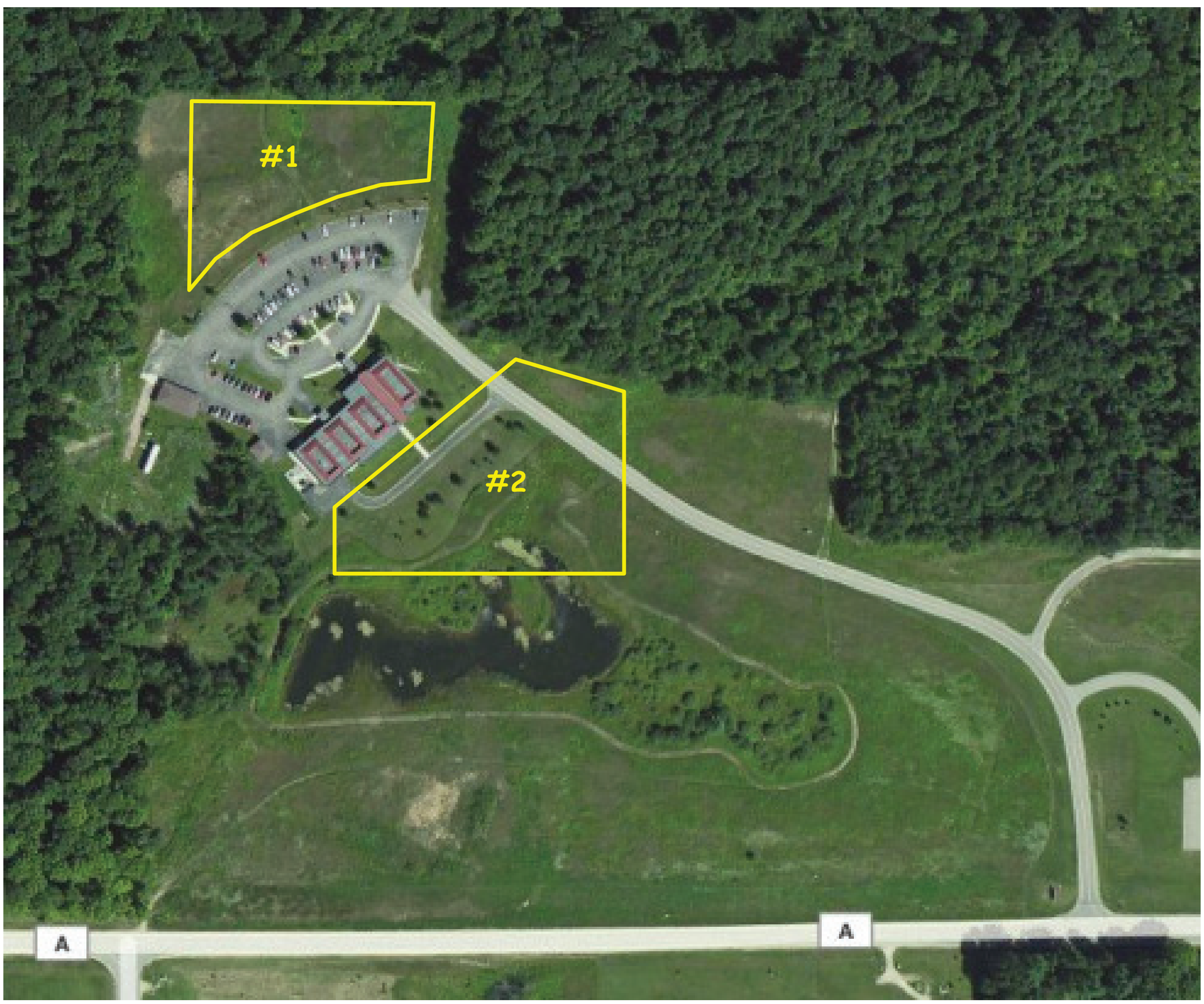


Figure 36. The two areas discussed for ground mounted PV systems in this report.

Combined Roof and Ground System

PV system size and production estimates for the roof and ground located systems are broken out below in Table 32.

Roof Site						
Roof Area	Available Roof Dimensions	Direction (Azimuth)	Tilt (Deg)	Capacity (kW-DC)	Shading	Production (kWh/yr)
#1	8' x 35'*	SW (230°)	6/12 (27°)	2.9	2 %	3,150
#1	8' x 18'	SE (140°)	6/12 (27°)	1.4	0 %	1,650
#2	8' x 45'	SW (230°)	6/12 (27°)	3.8	0 %	4,250
#2	8' x 18'	SE (140°)	6/12 (27°)	1.4	0 %	1,650
#3	8' x 45'	SW (230°)	6/12 (27°)	3.8	0 %	4,250
#3	8' x 18'	SE (140°)	6/12 (27°)	1.4	0 %	1,650
#4	12' x 85'	SW (230°)	3/12 (15°)	10.8	0 %	11,700
Total on Roof				**25 kW**		**28,300 kWh/yr = 97,000 kBTU/yr**
* The southwest facing section of roof area #1 is 8' x 45', like the other southwest facing areas. However, 10' is reserved for a solar thermal system, leaving 8' x 35' for the PV system on this roof section. See Table 34 for information on the solar thermal system.						
Ground Site						
Ground Site	Required Area (ft^2)	Direction (Azimuth)	Tilt (Deg)	Capacity (kW-DC)	Shading	Production (kWh/yr)
#1 or #2	44,000	S (180°)	35°	220	0 %	266,900
Total on Ground				**220 kW**		**266,900 kWh/yr = 1,000,000 kBTU/yr**
Total Combined System						
Total System				**245 kW**		**295,200 kWh/yr = 1,097,000 kBTU/yr**

Table 32. PV system size and production estimates are broken out by roof area. The roof areas are labeled in Figure 32.

Assumptions in Table 32:

- The southwest facing roof area #1 would be partially utilized by a solar thermal system for domestic water heating. However, it could be used entirely for a PV system instead, if desirable.
- The PV module used for the purposes of estimating capacity and production is an average 240-watt module with a dimension of 40” x 66”. There are several similar products that essentially meet this description and are high quality, competitively priced, widely available, and U.S.-manufactured.
- System production was estimated using PVWatts v.1, which is available at: http://www.nrel.gov/rredc/. Production used a de-rate factor of 0.77 to account for DC-to-AC losses, wire losses, and snow cover.

The economic value of the solar-produced electricity depends on the size of the PV system. Policies for interconnecting PV systems to the grid vary from one electric utility to the next, but most Wisconsin utilities, including Gresham Municipal Light and Power, have a net-metering cap of 20 kW. This means that a system 20 kW or smaller would receive full retail rate for all electrical generation, even if the generation exceeded the usage of the facility.

Systems larger than 20 kW do not qualify for net-metering, but it is possible to maintain the full retail value of all generation to the facility as long as generation never exceeds the consumption over the utility’s “true-up” period. The true-up period is typically one month. As long as the generation remains below the building’s total consumption during every monthly period, the PV generation is fully counted toward the building’s consumption and would offset the electric bill by the full retail value of the electricity. For the HWC’s monthly electrical consumption, they could fully utilize a PV system larger than 20 kW.

To determine the largest size PV system that could be installed at the HWC without exceeding the building’s monthly energy usage, the predicted monthly PV production was plotted against the building’s historical minimum monthly usage in Figure 37 below. The consumption graph looked at the years 2010 through 2012, and used the minimum value in each month throughout the three years to account for a typical low energy-use year. Consumption was also reduced to factor in the energy conservation measures suggested in the report that had payback period of less than five years. A PV system would peak in production in May through July, which are also the lower energy consumption months for the HWC. A 240-kW PV system (assuming 215 kW on the ground and 25 kW on the roof) remains just below the minimum estimated production of the HWC.

The penalty for exceeding the building’s consumption with PV generation is insignificant if it happens only rarely, but it can add up if it happens frequently. Any excess electrical production that gets sent to the grid at the end of the true-up period would receive a negotiated electrical rate. This negotiated rate is usually significantly less than the retail rate, and sometimes as low as the utility’s avoided cost of the energy, which is about $0.03 per kWh. A system that frequently receives this negotiated rate for excess generation will have less desirable economics than a system that generates less than the building uses.

Since a 240-kW PV system avoids this penalty and is large enough to offset the goal of 30 percent of the total building energy usage, the analyses in this report will be limited to this system size.

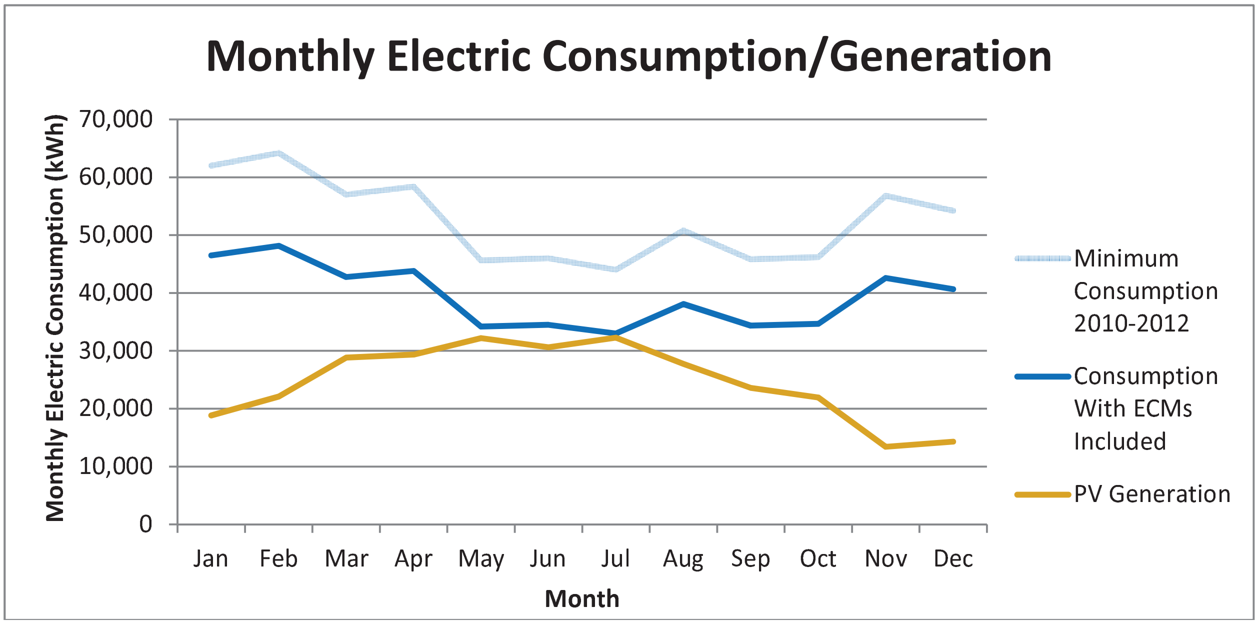


Figure 37. The estimated monthly electrical generation of a 240-kW PV system remains less than the estimated monthly electrical consumption before and after 5-year payback ECMs are included.

ECONOMICS ESTIMATES

Large-scale PV systems currently cost $4,000 to $5,000 per kilowatt installed on average, which would be a total of $960,000 to $1,200,000 for a 240-kW system.

The primary source of incentives available for non-profit/government facilities in Wisconsin is the Focus on Energy program. Current as of 2013, funding for PV systems is made available through a competitive Request for Proposals (RFP) process, where an application is filed and reviewed. Projects under $1,000,000 in total implementation cost and with a payback less than 25 years are eligible, and the most cost effective projects are approved for a grant of up to $100,000. Due to the competitiveness of this grant, not all eligible projects are awarded grant money.

There is also a federal tax credit incentive for solar energy systems that is in place through 2016 that would cover up to 30 percent of the total installed project costs. It is not believed the HWC would be eligible for federal tax credits due to a lack of federal income tax liability, and there are currently no programs in place to take advantage of the credit for non-profit/government facilities. If the HWC does have federal income tax liability, it would be recommended to consult a qualified tax professional to determine the HWC's specific eligibility for this incentive.

Assuming the project receives Focus on Energy assistance, the payback would be 25 years. Without the Focus on Energy grant, the payback would slightly increase to 26 years. A cash flow graph and other calculated parameters are included below. The analysis includes a rate of escalation of 3 percent on electric rates, which is equal to the long-term historical rate for commercial use in Wisconsin.[3]

It was examined whether demand charges could be reduced due to the generation of a PV system, but the HWC experiences a pretty level demand year round due to the heat pump heating and cooling system. Therefore, it could not be assumed that it would be sunny – and therefore the PV system would be operating – while the building was under peak load.

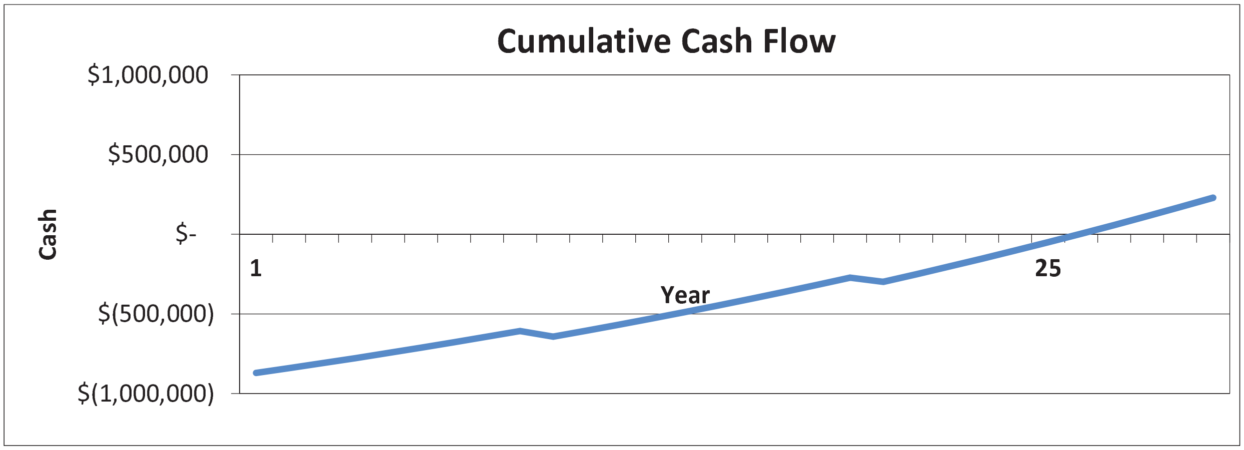


Figure 38. Cumulative cash flow for a 240-kW PV project showing positive cash flow (payback) at 25 years. The dips in the curve every ten years are due to typical costs incurred for the replacement of the inverters.

Production	
PV system's rated module capacity	240 kW (DC)
Estimated system output	295,200 kWh/yr
Estimated system output (site energy)	1,097,000 kBTU/yr
Percentage of total building's energy	33 %
Cost and Economics	
Installed cost	$ 1,000,000
Incentives	$ 100,000
Final cost after possible incentives	$ 900,000
ROI, 25-yr average	0.0 %
Simple payback period	25 yrs
Environmental Impact	
CO_2 emission reduction	192 tons/yr

Table 33. Estimated production, cost and economics, and environmental impact of a 240-kW PV system.

[3] U.S. Energy Information Administration, www.eia.gov.

SOLAR THERMAL

TECHNOLOGY OVERVIEW

Solar thermal systems collect heat from the sun to be used for domestic water heating, pool heating, and occasionally for winter space heating. This building does not have a swimming pool and is not a good application for winter space heating due to the roof orientation and the building's heating load characteristics, which are small compared to the cooling loads. However, there is a small domestic hot water load that would be well served by a solar thermal system.

In Wisconsin's climate, the solar thermal system must utilize a reliable strategy to prevent the heat transfer fluid from freezing. One common system type way to do this is by using 50 percent glycol in a type of system that is usually called a pressurized-glycol system. There is a second freeze-protected system called a drainback system, which drains the collectors of the fluid whenever the system is off due to insufficient temperatures (i.e., cloudiness, nighttime, etc). This type of system can use water as the fluid, but these often use glycol for an additional layer of insurance.

In both types of systems, the type of glycol is normally propylene glycol because it is non-toxic and products are available that are specially formulated for service in solar thermal systems. A pump turns on to circulate the fluid through the system whenever the collectors are hot enough. The fluid is heated as it flows through the collectors and transfers this heat to a storage tank with heat exchanger in the mechanical room. This storage tank would be piped inline before the building's propane water heater.

Figure 39. A photo of a typical solar thermal system used for domestic water heating.

PROJECT RECOMMENDATIONS/COMMENTS

Like a PV system, it has been discussed that a roof location is preferred for a solar thermal system to lower the risk of accidental damage or vandalism. A solar thermal system for domestic water heating is relatively small in size, so there would be no benefit of installing a system on the ground for additional space allowances. It is not anticipated there will be any structural issues on the roof, but a qualified structural engineer should be consulted at the time of the project to confirm this. This would be a normal step in any solar project that may alter the structural loads on a building.

It is recommended to locate the solar thermal system on the southwest facing section of roof area #1, as shown in Figure 40 below. One benefit of this location is that it is closer to the pipe chase that leads to the mechanical room. Compared to PV systems, solar thermal systems are more sensitive to proximity to the mechanical room compared to PV systems because it is expensive to run insulated copper or stainless steel piping over long distances, and because longer distances result in some heat loss from the pipes. A second reason this southwest facing section of roof area #1 is preferable is that there is a minor amount of shading, and solar thermal systems are generally a little bit more forgiving to shading than PV systems.

There is a chase that goes from the roof (near the southwest end) down to the ground-level mechanical room (Room 158). The water heaters are immediately below the opening of this chase, and there is room for a storage tank near the water heaters. See Appendix A for a floor plan with room numbers.

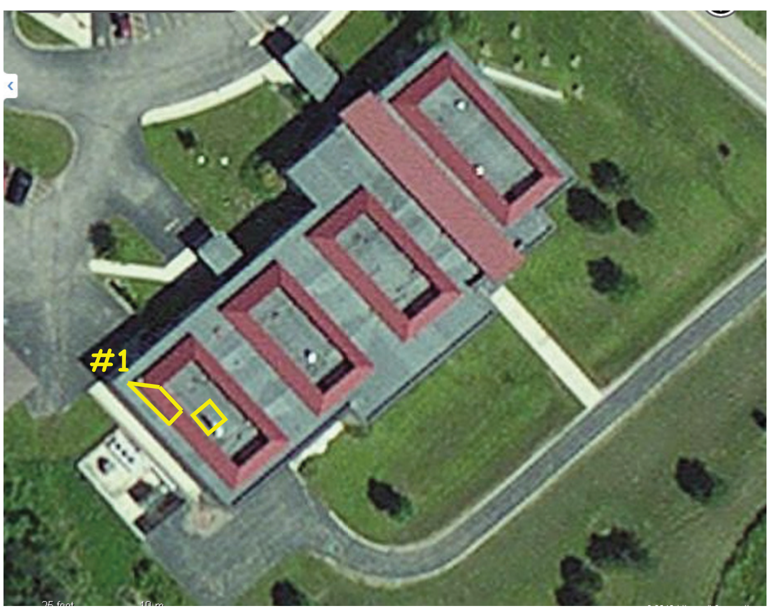


Figure 40. This aerial photograph shows the plan view of the roof. The yellow-outlined southwest-facing roof area is available for the solar thermal system discussed in this report. The outlined square near the roof area is the location of the pipe chase that goes down to the ground-level mechanical room/electrical room area. Much of the remaining roof space is preferable for a PV system.

Figure 41. The propane water heaters in the mechanical room.

The size of a solar thermal system is based on the domestic hot water load. The hot water load from this building's thirteen restrooms and two break rooms would be compared to an office building, which is about 1.0 gallons per occupant per day[4]. However, there are several reasons that the actual hot water use may be slightly higher than this:

- Since this is a healthcare facility, there is likely more hand-washing than a typical office building.
- There is an exercise room and there are showers in the locker rooms. A review of the exercise room log shows that it is used about six to ten times per month.
- There is a kitchen which is used for three or four classes per month, which might add some occasional dishwashing loads.

There are approximately 70 employees in the building, plus patients. It is estimated that the total daily hot water load for the building is around 100 gallons per day, for five days per week. A system that would be a good fit for this load would be two 4' x 8' collectors (64 square feet) paired with an 80-gallon storage tank.

Like a PV system, a solar thermal system's production takes approximately a 5 to 10 percent deduction by facing southwest at a slightly shallower angle. It is possible for collectors to be tilted off the roof in a way that they face more southerly, but the extra racking would introduce costs that may not worthwhile for the extra production. Tilting the collectors would also result in greater wind loads and lower aesthetic appeal. All discussion in this report will assume that the collectors are mounted parallel to the roof slope, facing southwest.

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[4] 2011 ASHRAE Handbook—HVAC Applications, Chapter 50 Service Water Heating, Table 7 "Hot-Water Demands and Use for Various Types of Buildings."

Roof Area	Available Roof Dimensions	Direction (Azimuth)	Tilt (deg)	Size	Shading	Propane Offset
#1	8' x 10'*	SW (230°)	6/12 (27°)	(2) 4' x 8' panels	2 %	110 gallons/yr = 10,000 kBTU/yr
* This roof area is 8' x 45', like the other southwest facing areas. 35' is reserved for a solar electric system, leaving 8' x 10' for the solar thermal system on this roof section. See Table 32 for information on the solar electric system.						

Table 34. Estimated energy savings (in gallons of propane) by a solar thermal system.

Assumptions in Table 34:

- The solar thermal collector used for the purposes of estimating production is an average flat panel collector with a nominal dimension of 4' x 8'. There are a wide variety of products and systems that could be used to achieve essentially the same thing, such as systems utilizing evacuated tube collectors or other sizes of flat panel collectors.
- System production was estimated using RETScreen v.4, which is available at: http://www.retscreen.net/. Production estimate assumes 80-percent thermal efficiency of the propane water heaters. The assumed hot water load is 100 gallons of hot water per day.
- The southwest facing roof area #1 experiences shading after 2:30 pm during the months of November, December, and January (equivalent to 2 percent average annual shading) from a wooded area to the southwest and west of the building.

ECONOMICS ESTIMATES

Solar thermal systems currently cost about $175 to $200 per square foot of collector installed on average, which would be a total of $11,000 to $13,000 for a 64 square foot system.

The primary source of incentives available for non-profit/government facilities in Wisconsin is the Focus on Energy program. However, a solar thermal project at the HWC would not qualify for Focus on Energy funding because the water heating is currently fueled by propane. Propane dealers are not mandated to participate in the Focus on Energy program, so the funding is not spent on projects that offset propane. (This is true even when the HWC's electric provider, Gresham Municipal Light and Power, is a member utility of Focus on Energy. If the water heating were fueled by electricity, then the HWC would be Focus on Energy-eligible for a solar thermal project.)

There is also a federal tax credit incentive for solar energy systems that is in place through 2016 that would cover up to 30 percent of the total installed project costs. It is not believed the HWC would be eligible for federal tax credits due to a lack of federal income tax liability, and there are currently no programs in place to take advantage of the credit for non-profit/government facilities. If the HWC does have federal income tax liability, it would be recommended to consult a qualified tax professional to determine the HWC's specific eligibility for this incentive.

Assuming a project cost of $12,000 and no incentives available, the payback would be 25 years. A cash flow graph and other calculated parameters are included below. The analysis includes a rate of escalation of 7 percent on propane rates, which is equal to the long-term historical rate for commercial use in the U.S.[5]

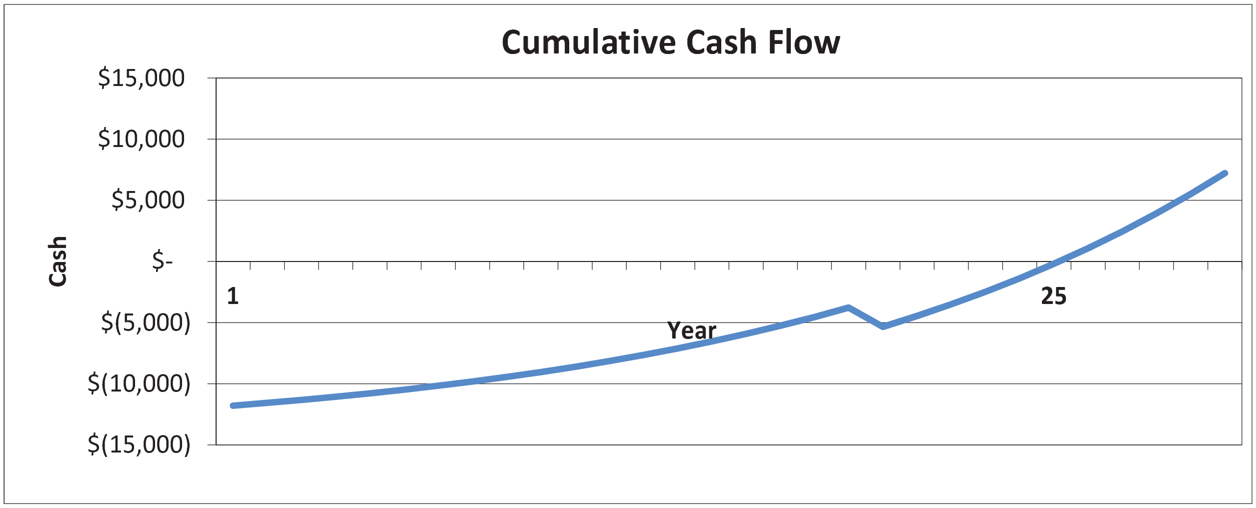


Figure 42. Cumulative cash flow for a 64 square foot solar thermal project showing positive cash flow (payback) at 25 years. The bump in the curve at twenty years is due to typical costs incurred for the replacement of the fluid, pump, and tank.

Production	
Solar thermal system's size	64 ft^2 / 80 gallons
Estimated propane offset	110 gallons/yr
Estimated propane offset (site energy)	10,000 kBTU/yr
Percentage of total building's energy	0.3 %
Cost and Economics	
Installed cost	$ 12,000
Incentives	$ 0
Final cost after possible incentives	$ 12,000
ROI, 25-yr average	0.0 %
Simple payback period	25 yrs
Environmental Impact	
CO_2 emission reduction	1 ton/yr

Table 35. Estimated production, cost and economics, and environmental impact of a 64 square foot solar thermal system.

[5] U.S. Energy Information Administration, www.eia.gov.

BIOMASS

TECHNOLOGY OVERVIEW

Biomass energy can come in many forms, including grass crops like switchgrass, manure, trees, and urban wood waste from tree and brush trimmings. This report will focus on wood-sourced biomass from trees because there are local wood resources potentially available through the Stockbridge Munsee Community Forestry Department. Wood-sourced biomass energy is considered renewable because trees can be produced and harvested sustainably, and the net zero carbon cycle occurs in a relatively short time period (i.e., the carbon dioxide that is released during combustion is equal to the amount of carbon dioxide absorbed in the tree's life).

Wood-sourced biomass can be chopped, pelletized, or chipped for use in wood boilers. Traditional wood boilers generate significant smoke, odors, and particulate pollution, which would be undesirable in a healthcare environment. An important distinction can be made in wood gasification boilers, which take advantage of modern combustion techniques that are both more energy efficient and less polluting than traditional wood boiler design. Most modern commercial wood boilers can be considered gasification boilers.

Figure 43. Wood pellets (left) and wood chips (right).

In the gasification process, wood feedstock heats in an oxygen-starved environment until volatile wood gases are released. The wood gas is relatively low-energy (about 150 BTU/ft^3) when compared to natural gas or propane gas (about 900 to 1,000 BTU/ft^3). The gases are mixed with air for combustion in a boiler appliance to generate heat. This heat is in addition to the normal heat generated from burning the solid wood material.

After surveying a variety of biomass feedstock options, SEG chose to evaluate two types of feedstock: wood pellets and wood chips. For this study, both feedstocks are paired with a typical gasification wood boiler that can accommodate either type.

Both wood pellets and wood chips are viable candidates with important differences. Typically, either product would be purchased from a commercial dealer. Although pellet feedstock is more expensive than chip feedstock, wood chip boiler systems carry higher maintenance costs and are typically up to three times more expensive in upfront cost than pellet systems of the same heating capacity. There are several reasons for this price difference. First, wood chips are less dense than pellets and therefore supply less energy per unit volume. In order to provide the same amount of energy, a greater volume of wood chips than wood pellets are required. The volume difference translates into a larger storage footprint, usually involving a building dedicated to storing the chips. Second, wood chips are somewhat more difficult to process as combustion fuel as compared to pellets due to their irregular sizing. As a result, wood chip boilers require more robust equipment and a different 'burn box' than a comparable pellet system. The much higher price of the wood chip systems tends to steer customers toward pellet systems.

The Stockbridge Munsee Community has a significant local timber resource that might be utilized for biomass. The Community could produce either wood chips or wood pellets for themselves if they were willing to make the investment in a chipping or densification facility. While those facilities would be expensive, such an operation would reduce long term feedstock costs. According to a local supplier, the Community would need to supply enough feedstock for about 100 average buildings in order to make the investment in a chipping or pellet densification facility attractive. Due to the required investment to produce wood chips or pellets, it is assumed that the HWC would have to buy commercially available wood products for the purpose of this feasibility study.

If the Community intends to produce their own wood products, a more detailed study of wood feedstock production would be required. This study would analyze:

- Type of forest resource the Community would be willing to use – This would examine residues and full logs. An example of typical residues is shown in Figure 44.

Figure 44. Example of forest residues.

- How the Community would gather the materials – Residues are usually left behind in the forest during logging operations, but gathering them up could be expensive.
- The kind of feedstock the Community would produce -- There are some raw material size requirements dictated by the type of feedstock and processing equipment used to produce that feedstock. For example, wood chips cannot be produced with material smaller than the

minimum chip size, usually at least 1 inch wide and 1.5 inches long. Two examples of wood chip production are shown in Figure 45.

Figure 45. Potential wood chip production options. Horizontal chipper (left) and portable chipper (right).

- Quantity of feedstock the Community would produce -- For a small volume, such as would be required at the HWC, there are opportunities to partner with an existing wood product producer. For a large volume, a full production facility could be built.
- Economic assistance – The Community could be eligible for a Woody Biomass harvesting credit from the State of Wisconsin. This could be worth 10 percent of harvesting equipment cost with a cap at $900,000.[6] It is not believed the HWC would be eligible for tax credits due to a lack of state income tax liability, and there are currently no programs in place to take advantage of the credit for non-profit/government facilities. If the HWC does have state income tax liability, it would be recommended to consult a qualified tax professional to determine the HWC's specific eligibility for this incentive.

PROJECT RECOMMENDATIONS/COMMENTS

After considering the existing two-boiler configuration, it is recommended to replace only one of the existing propane boilers with a wood pellet boiler. This wood boiler would operate as the primary boiler to offset as much of the building's heating loads as possible. It would be sized to offset a portion (for example 50 to 75 percent) of the design heat load of the building to ensure it operates at a high efficiency for as much of the heating season as possible. The propane boiler would remain in place as a backup system and to allow for extra heating at times of peak heating load.

The following schematic illustrates how the mechanical system might look with the recommended wood boiler system. It includes the design changes discussed elsewhere in this study, such as implementing

[6] Wisconsin Department of Agriculture, Trade and Consumer Protection, http://datcp.wi.gov/Business/Tax_Credits/Woody_Biomass_Harvesting_and_Processing_Investment_Credit/index.aspx, Obtained May 7, 2013

VFDs on the circulating pumps. The following changes should also be examined for suitability with the existing HVAC system:

- The existing piping configuration of the propane boiler may need to be changed to operate with the wood boiler. The propane boiler return temperatures should operate at a minimum temperature of 120°F and the wood boiler can operate up to 212°F, while the heat pump loop should be allowed to vary around 60°F during the heating season.
- Replace existing duct heaters with hot water coils. The existing duct heaters currently operate with propane, which is expensive. They could be replaced with hot water coils that connect directly to the boiler hot water loop. This would enable the ventilation heating to be provided from wood heat. Coils have have to be installed in the ductwork and piping would have to be added to make these connections.
- A heat exchanger may be required to serve the zone heat pumps. A heat exchanger adds some inefficiencies and some additional costs, but it may be a necessity to keep the boiler fluid separate from the building fluid (if glycol is needed for the ventilation coils) and a heat exchanger may be used to assist with controlling the temperatures from the boiler loop out to the building.

This design is merely a suggestion; a thorough follow-up should be done to ensure all system components are properly utilized.

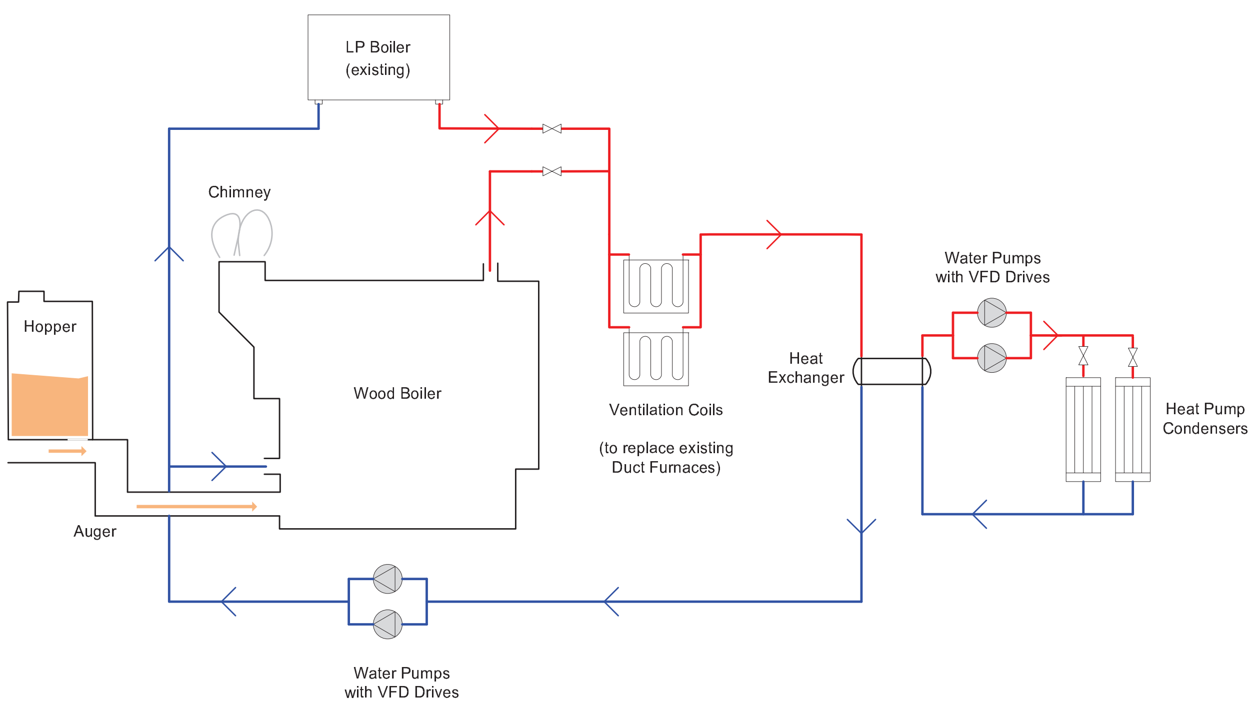


Figure 46. Wood boiler system schematic.

With the installation of a pellet or wood chip system, a location is required to place a hopper to store the feedstock. The hopper should be capable of holding enough supply to last at least 10 days of operation. A good candidate would be in a space adjacent to the current mechanical systems paddock, as shown in the photo below. The feedstock could be delivered in bulk and loaded directly into the hopper.

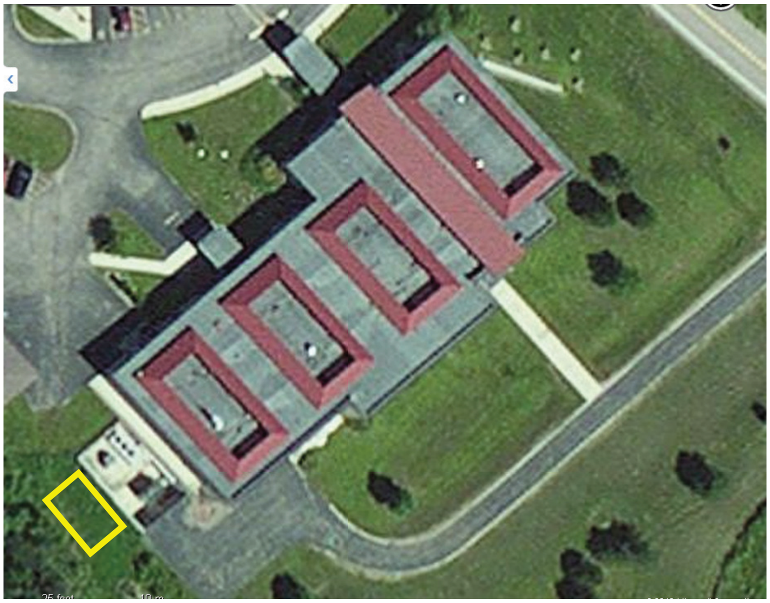


Figure 47. Possible biomass hopper location is outlined in yellow. This location is near the cooling tower, just outside of the mechanical room.

Although many manufacturers claim that emissions from wood boilers are equivalent to natural gas or propane combustion, the possibility of odors and poor air quality is a legitimate concern, especially at a healthcare facility, that should be ruled out before proceeding with a project. If the Community is interested in exploring this option further, they could visit an already installed system to verify its performance and environmental impacts. Several nearby options are available:

- Ashland Memorial Medical Center, Ashland, WI (biomass heating system)
- Gundersen Health System, LaCrosse, WI (biomass heating system)
- Wolf Ridge Environmental Learning Center, Finland, MN (biomass heating district)

ECONOMIC ESTIMATES

A local supplier provided preliminary price estimates that include the cost to implement a new wood boiler system (both wood pellet and wood chip), including feedstock, a feedstock storage bin, auger, and other required system components. The installed cost figures listed in the table below include the cost to make the recommended system changes described previously. The value used for wood pellets in this analysis is $1.12 per therm, while the value for wood chips used is $0.43 per therm (100,000 BTUs).

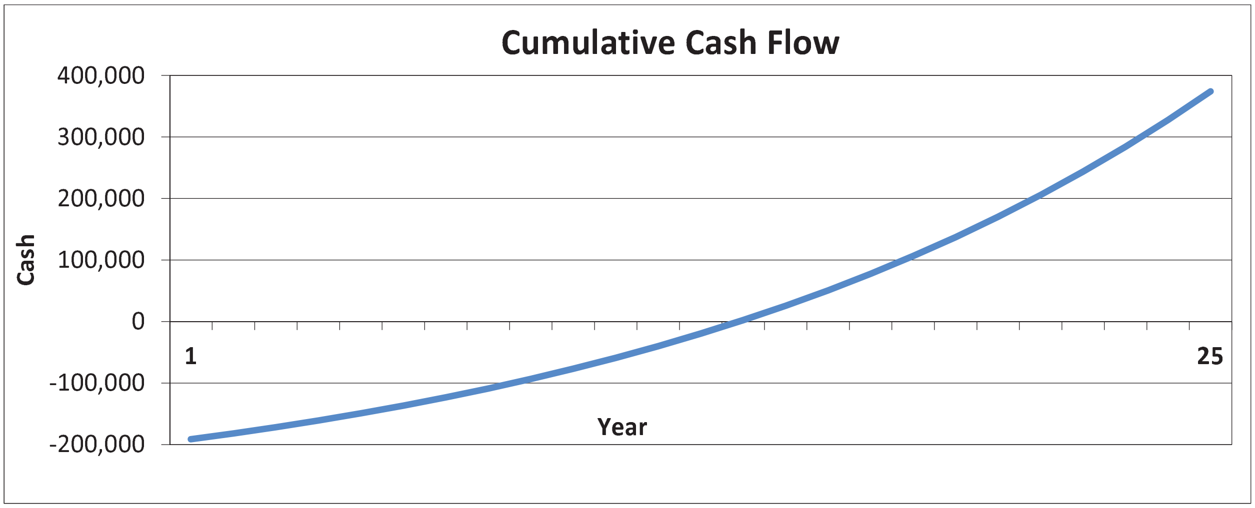


Figure 48. Cumulative cash flow for a wood pellet project showing positive cash flow (payback) at 14 years

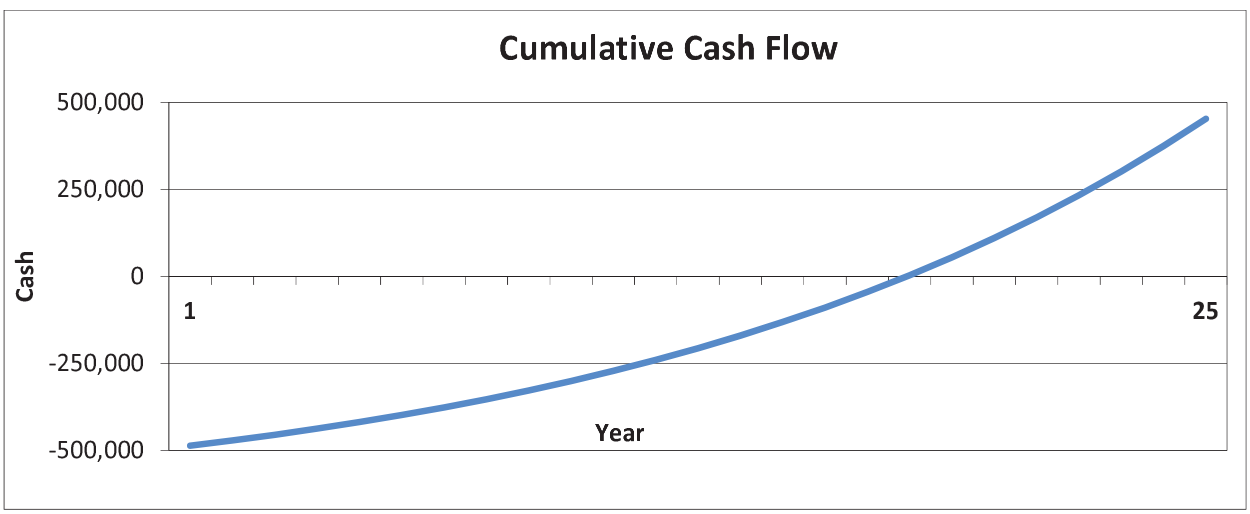


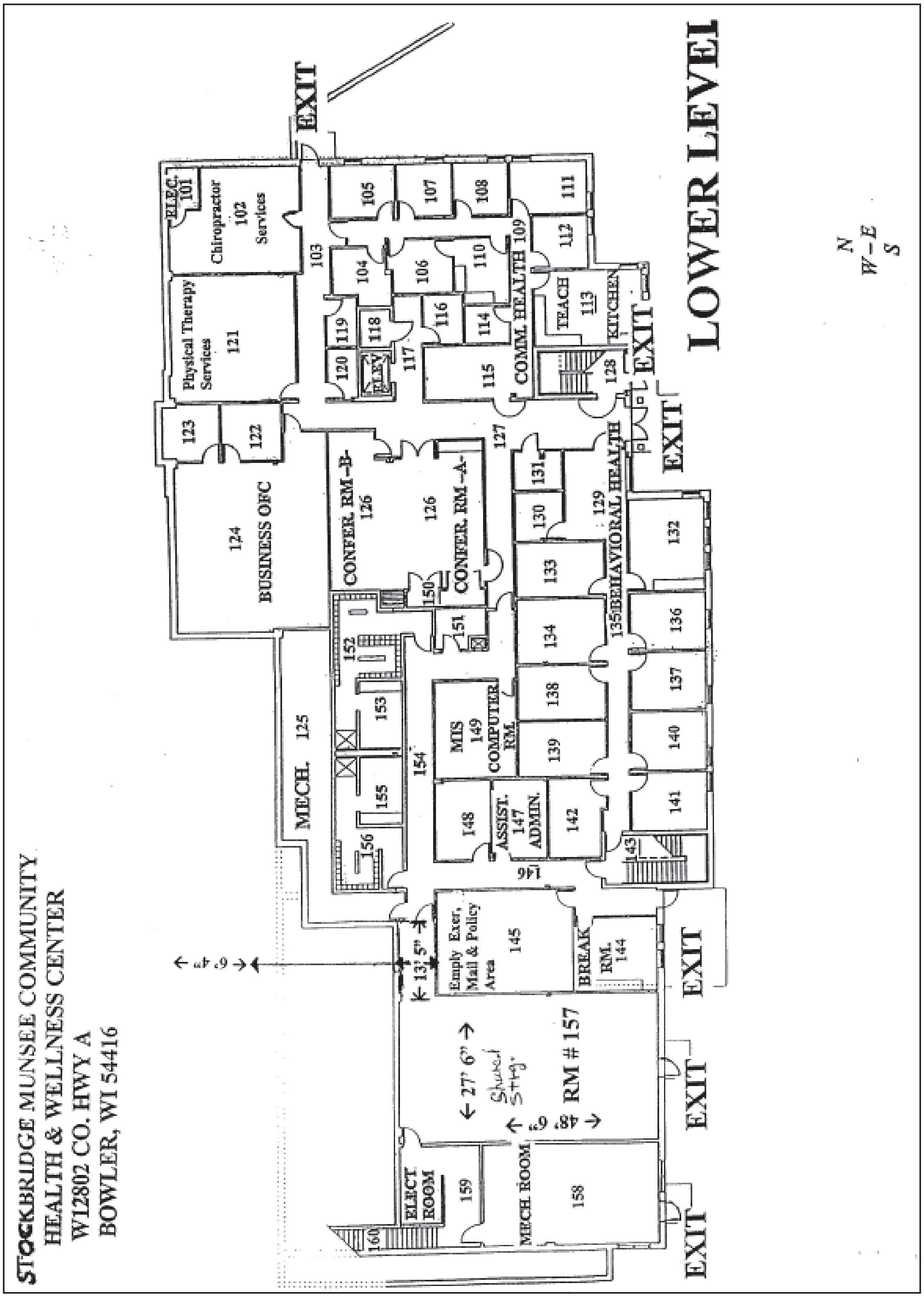
Figure 49. Cumulative cash flow for a wood chip project showing positive cash flow (payback) at 18 years

Production		
Biomass system type	Wood Pellet	Wood Chip
System size	625 MBH	625 MBH
Estimated propane offset	10,800 gallons/yr	10,800 gallons/yr
Estimated total site energy offset	990,000 kBTU/yr	990,000 kBTU/yr
Percentage of total building's energy	30 %	30 %
Cost and Economics		
Installed cost	$ 205,000	$ 510,000
Incentives	$ 0	$ 0
Final cost after possible incentives	$ 205,000	$ 510,000
ROI, 25-yr average	8.1 %	4.5 %
Simple payback period	14 yrs	18 yrs
Environmental Impact		
CO_2 emission reduction	67 ton/yr	67 ton/yr

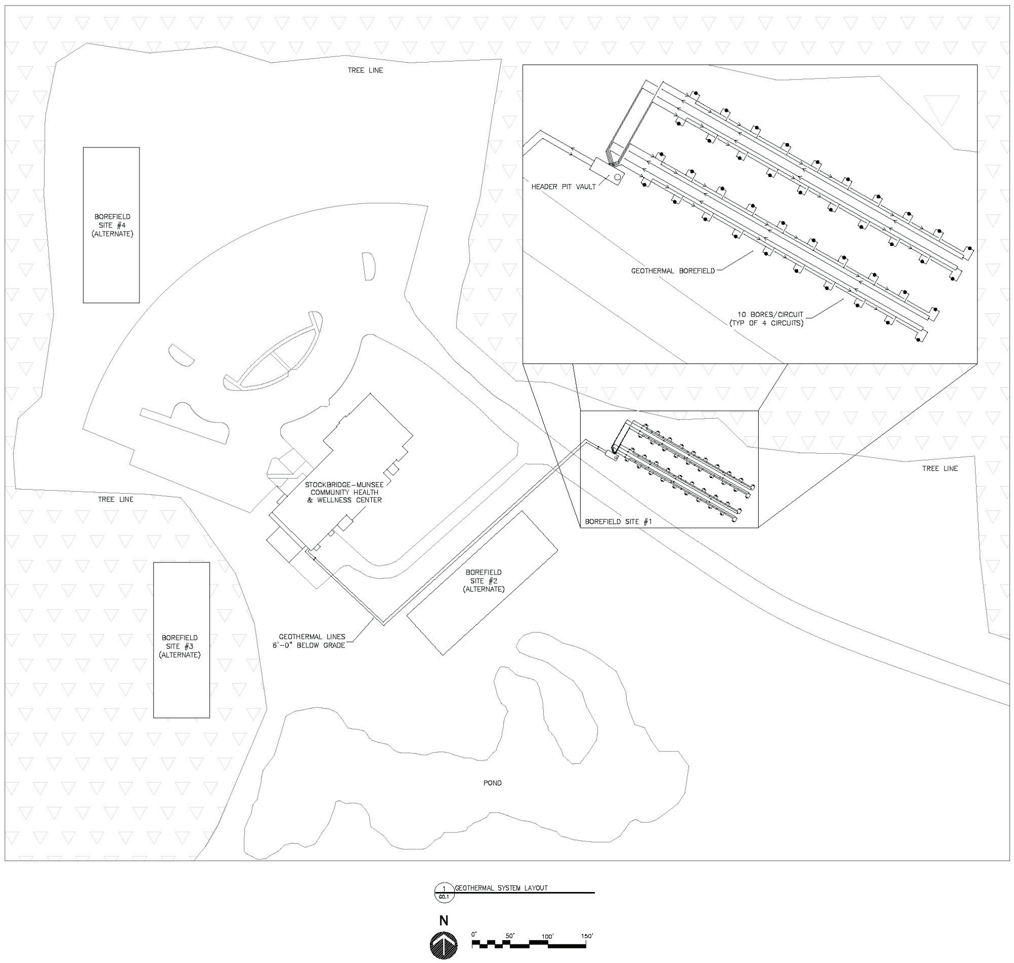
Table 36. Estimated production, cost and economics, and environmental impact of two types of wood boiler systems.

A biomass system with wood feedstock is a viable option for the HWC. Depending on the choice of feedstock, the payback for such a system could be within 15 to 20 years. The Community could potentially supply their own feedstock but a detailed study would be required before making such a commitment.

APPENDIX A: BUILDING FLOOR PLAN



APPENDIX B: GEOTHERMAL BOREFIELD PLAN

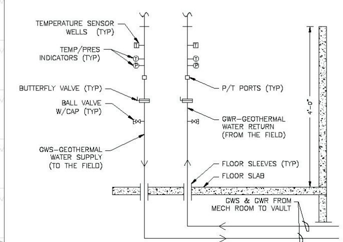


GENERAL NOTES:

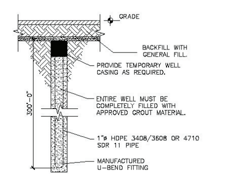
THIS IS A PRELIMINARY DRAWING NOT INTENDED FOR BIDDING OR CONSTRUCTION. THE INTENDED USE OF THIS DRAWING IS TO PROVIDE A REPRESENTATION OF A TYPICAL GEOTHERMAL BOREFIELD FOR THE STOCKBRIDGE-MUNSEE COMMUNITY FOR FEASIBILITY STUDY PURPOSES. FURTHER ANALYSIS IS REQUIRED TO DETERMINE THE FINAL FEASIBILITY, DESIGN, AND CONSTRUCTION DETAILS OF A GEOTHERMAL SYSTEM.

GEOTHERMAL FIELD INFORMATION	
NUMBER OF GEOTHERMAL BORES	40
BORE DEPTH	300'
NUMBER OF CIRCUITS	4
NUMBER OF BORES PER CIRCUIT	10
TYPICAL BORE SPACING	20'
GEOTHERMAL BORE SIZE	6"ø
BORE PIPE SIZE	1"ø
PIPE TYPE, BORE PIPING	SDR 11 PE4710
PIPE TYPE, LATERAL CIRCUIT PIPING	SDR 11 PE3454/PE4710
FLUID WITHIN PIPING	25% PROP GLYCOL
BUILDING ENTERING WATER TEMPERATURE	87°F MAX./32°F MIN.
PEAK HEATING LOAD	900 MBH
PEAK COOLING LOAD	800 MBH
GROUT THERMAL CONDUCTIVITY	1.00 BTU/H-FT-F
ESTIMATED GROUND THERMAL CONDUCTIVITY	1.65 BTU/H-FT-F
ESTIMATED UNDISTURBED GROUND TEMPERATURE	50 °F
ESTIMATED GROUND THERMAL DIFFUSIVITY	1.17 SF/DAY

2 G0.1 GEOTHERMAL FIELD INFORMATION
NO SCALE



3 G0.1 GEOTHERMAL PIPE CONNECTION AT BUILDING
NO SCALE



4 G0.1 GEOTHERMAL BORE DETAIL
NO SCALE

PRELIMINARY DRAWING
NOT FOR CONSTRUCTION

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Stockbridge-Munsee Community Health & Wellness Center
Bowler, Wisconsin

PROJECT #
DATE 09/23/13
REVISION | DATE
DRAWING # G0.1

RENEWABLE ENERGY AND ENERGY EFFICIENCY FEASIBILITY STUDY

STOCKBRIDGE MUNSEE COMMUNITY
MOHICAN FAMILY CENTER
N8605 OAK ST.
BOWLER, WI

MARCH 14, 2014

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EXECUTIVE SUMMARY

The results of the Renewable Energy and Energy Efficiency Feasibility Study of Stockbridge Munsee Community's Mohican Family Center (MFC) indicate that a variety of renewable energy options and energy conservation measures (ECMs) exist for the facility. A requirement of the Request for Proposal for this study was to assess renewable energy options that could offset 30 to 100 percent of the MFC's energy use. This study identifies that a geothermal system is the most cost effective renewable energy option available to decrease the MFC's energy consumption by 30 to 100 percent.

Currently the MFC performs better than 80 percent of buildings in its building category, as scored in the EPA portfolio manager benchmarking tool. Multiple ECM opportunities have been identified with short-term paybacks to yield an estimated 13-percent decrease in energy consumption. The ECMs within this payback period are estimated to save $3,100 per year with an implementation cost of under $20,000.

	Propane (gallons/yr)	Energy from Propane (kBTU/yr)	Electricity (kWh/yr)	Energy from Electricity (kBTU/yr)	Total Energy (kBTU/yr)
Current Energy Usage	6,800	623,200	94,700	323,100	946,300
Energy Savings from ECMs	1,100	100,800	9,100	31,000	131,800
Projected Base Energy Usage	**5,700**	**522,400**	**85,600**	**292,100**	**814,500** **30 % = 244,400 kBTU/yr**

The energy conservation measures should be implemented before any renewable energy technologies because they can reduce the required size and enhance the economic feasibility of a renewable energy system. Therefore, in order to offset 30 to 100 percent of the building's energy loads, the renewable energy systems would have to offset 244,400 to 814,500 kBTU per year.

	Upfront Cost	Energy Offset (kBTU/yr)	Portion of Building's Use	Payback	25-yr ROI
Geothermal (Vertical Loop)	**$ 320,500**	**395,900**	**49 %**	**20 yrs**	**3.5 %**
Solar Electric	$ 178,500	164,800	20 %	28 yrs	-1.1 %
Solar Thermal (DHW Only)	$ 8,500	8,600	1 %	23 yrs	1.5 %
Biomass (Wood Pellet)	$ 290,500	412,400	51 %	28 yrs	-1.2 %

The geothermal system is the recommended option to offset the MFC's energy use by 30 to 100 percent due to its cost effectiveness. However, a geothermal system can be complemented by a solar electric and/or solar thermal system nicely if they fit in with the MFC's energy goals. A biomass system is a mutually exclusive option to the geothermal system, and carries the lower cost effectiveness. A biomass system also carries several other operational considerations with it – such as fuel storage, odors, and additional maintenance – and is not a recommended option.

INTRODUCTION

This report summarizes the potential opportunities for enhancing energy efficiency and implementing renewable energy technologies at the Stockbridge Munsee Community Mohican Family Center in Bowler, Wisconsin. Michael Barnett and Andy DeRocher from Sustainable Engineering Group (SEG) visited the Mohican Family Center (MFC) on January 17th, 2014 to conduct on-site observations and to review documentation of the building and its systems.

The weather conditions on the site visit were:

- Jan 17, 2014: High 21 ^{o}F, Low 2 ^{o}F, Wind 5 – 10 mph, Clear skies in AM / Mostly cloudy in PM

The building systems studied for energy efficiency are:

- HVAC Equipment and Controls
- Lighting
- Electrical Plug Loads
- Domestic Hot Water
- Building Envelope

The renewable energy technologies that have been examined are:

- Geothermal
- Solar Electric (also called Photovoltaic, or PV)
- Solar Thermal
- Biomass

The building systems and major components were surveyed to determine how they were initially designed and installed, whether their operation meets the original design intent, and whether there is potential to improve their operation in regards to energy and maintenance costs. Factors such as the general condition and functionality, age and anticipated lifespan, and capability to integrate with new renewable energy or energy efficiency upgrades were analyzed. The results of the analysis are presented in the following sections, organized by system.

BUILDING OVERVIEW

The MFC was constructed in approximately 1993. The MFC currently operates Monday through Friday from 6:00am to 9:00pm with partial hours on Saturday. The facility is staffed with approximately 5 employees and can be used by as many as 25 to 50 occupants of all ages, but many of them kids.

The MFC building is a 15,100 ft² steel structure. The overall footprint is 128 feet by 118 feet with a west wing and an east wing. The west wing is about 74 feet by 118 feet and includes the gym, locker rooms, storage/mechanical room, and a weight room mezzanine above the locker rooms and storage/mechanical room. The east wing is about 54 feet by 118 feet and includes an exercise/Pilates room, game room, daycare area, class room, kitchen, and administrative offices. Construction drawings for the building were not available. A building floor plan and thermal zoning plan can be found in the Appendix.

The two-story west wing has a shallow pitched (approximately 2/12, or 9°) gable roof, while the one-story east wing has a shallow pitched (approximately 1.5/12, or 7°) shed roof. The roof is a metal roof product with a trapezoidal rib. The building's siding is vertical metal siding.

Future improvements that are in the preliminary stages of planning for the building include site work to the baseball field and added building envelope insulation in the building.

Figure 1. The exterior of the building viewed from the northwest (left).
Figure 2. The lobby (right).

Figure 3.Gym (left).
Figure 4. Weight room (right).

Figure 5. Exercise/Pilates room (left).
Figure 6. Game room (right).

Figure 7. Kitchen (left).
Figure 8. Administrative area (right).

ENERGY LOAD ASSESMENT

CURRENT UTILITY CONSUMPTION

UTILITY RATE OVERVIEW

SEG evaluated the MFC electric and propane consumption for a period of two years to determine utility rates: November 2011 – October 2013. Propane is supplied from an on-site storage tank that is filled by the Mohican L.P. Gas Company. Electricity is provided by Central Wisconsin Electric Cooperative (CWEC).

The current utility pricing is as follows:

Utility	Charge Description	Rate	Comments
Electric	**Virtual Rate**	**$0.11 /kWh**	Total Electric Cost/Usage (includes all charges) for most recent 12 months.
Propane	**Virtual Rate**	**$1.90 /gal**	Total Propane Cost/Usage for most recent 12 months. Equivalent to $2.07/therm.

Table 1. Utility cost summary.

The virtual electric rate of $0.11 per kW-hr is a slightly below average rate for Wisconsin. Propane costs are more volatile than the electric rates and will vary based on the commodity pricing on a monthly basis. On an energy basis, propane is significantly more expensive than natural gas. Currently, natural gas prices are in the range of $0.70 per therm whereas propane is around $2.00 per therm. In the case of the MFC, there is no natural gas infrastructure so fuel switching is not an option. However, it is important to consider the high cost of propane consumption when evaluating energy efficiency improvements and renewable technology payback analysis.

BENCHMARKING

Portfolio Manager is an online benchmarking tool provided by the U.S. Environmental Protection Agency. Portfolio Manager provides a powerful environment for tracking energy performance and benchmarking buildings' energy usage. A facility's historical energy consumption is normalized for several significant factors such as the building's size, function, geographical location, etc. The facility is then given an Energy Performance Rating, which ranks the facility's energy performance in comparison to that of similar facilities across the United States on a scale of 1 (worst performance) to 100 (best performance). The Energy Performance Rating is essentially a percentile of the building's energy usage. For example, an Energy Performance Rating of 50 indicates that about half of similar facilities in the United States are less energy intensive than the rated facility, and half are more energy intensive. A facility that scores 75 or higher is eligible to receive the ENERGY STAR label. The rating is based on energy consumption and does not take into account the relative cost of the fuel source.

As part of the MFC energy study, SEG entered the facility information into Portfolio Manager using the gross floor area provided by the staff (15,100 ft^2) and the facility's most recent 12 months of energy usage data. The facility's Energy Performance Rating was 80. This means that 20 percent of buildings in its building category outperform the MFC in energy consumption. Note that this number is also based on the following assumptions which can impact the rating:

- Type of Building = K-12 School*
- High School = No
- Gross Floor Area = 15,100 ft^2
- Gymnasium Floor Area = 6,983 ft^2
- Number of Workers = 5
- Student Seating Capacity = 60
- Months in Use = 12
- Weekend Operation = Yes
- Number of Computers = 8
- Cooking Facilities = Yes
- Number of Walk-in Refrigeration/Freezer Units = 0
- Percent That Can Be Heated = 100%
- Percent That Can Be Cooled = 50% (All except gym)

* Since community center or similar is not an available building category, a K-12 school was deemed the most similar building type.

The building's energy metrics are summarized in the table below.

Metric	Result
Energy Star Score	80 out of 100
Energy Cost	$1.61 /$ft^2$
Energy Use Intensity (Site)	62 kBtu/ft^2
Energy Use Intensity (Source)	111 kBtu/ft^2
Total Annual Energy Cost	$24,300 /year

Table 2. A summary of MFC's building energy metrics.

HISTORIC CONSUMPTION

Average monthly propane usage for the past six years (July 2007 – June 2013) and electric usage for the past two years (November 2011 – October 2013) is illustrated below in Figure 9. The MFC propane usage has a strong seasonal component as it is used for heating the space and the ventilation air in the winter. The propane tank is filled infrequently during the summer, so the data set has less resolution during the warmer months of the year. However, it is expected that there is a small baseline propane load during the summer since the domestic water heaters and kitchen range are propane fired.

The electric usage also varies seasonally. It is higher in the summer due to the higher cooling loads, which are satisfied by DX cooling. Electric consumption increases slightly in the middle of winter due to increased fan energy by the furnaces and lighting.

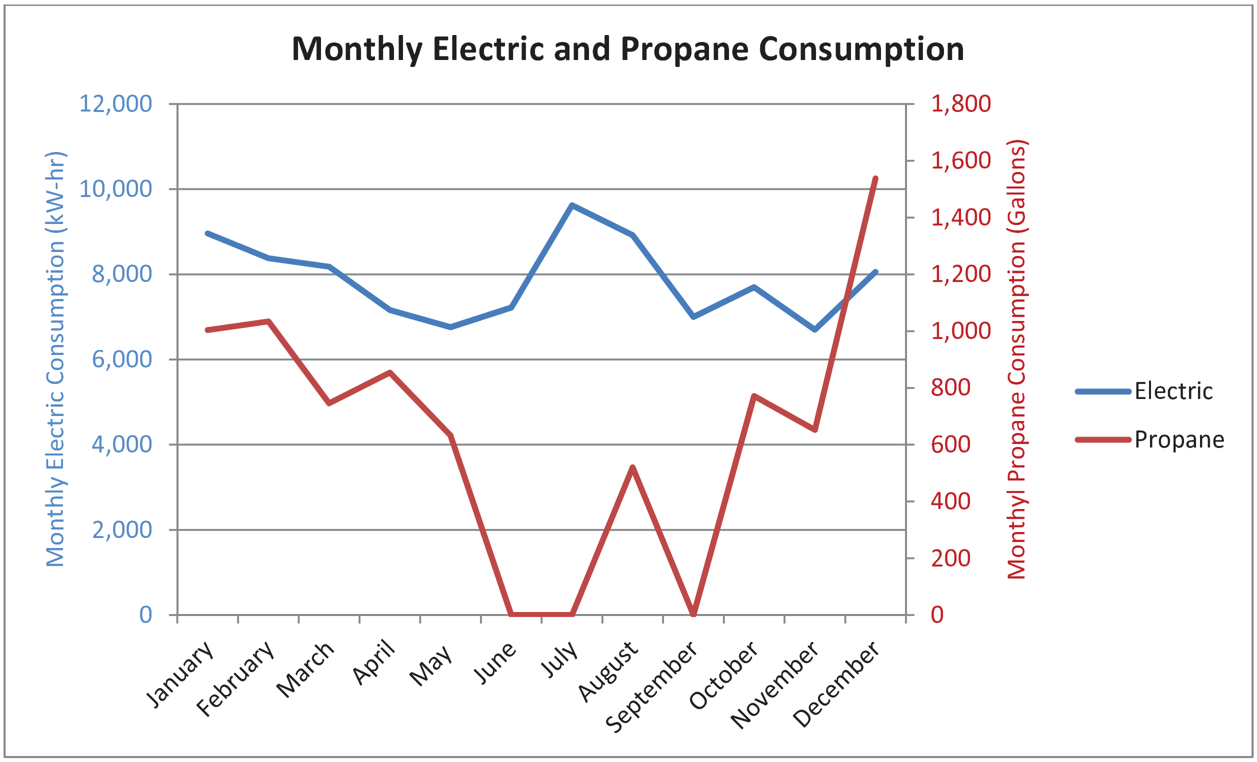

Figure 9. Average monthly electric and propane consumption.

Figure 10 below breaks down the average electric and propane costs at the MFC for the period of November 2011 – October 2013. 45 percent of the utility costs are for electric and 55 percent is for propane.

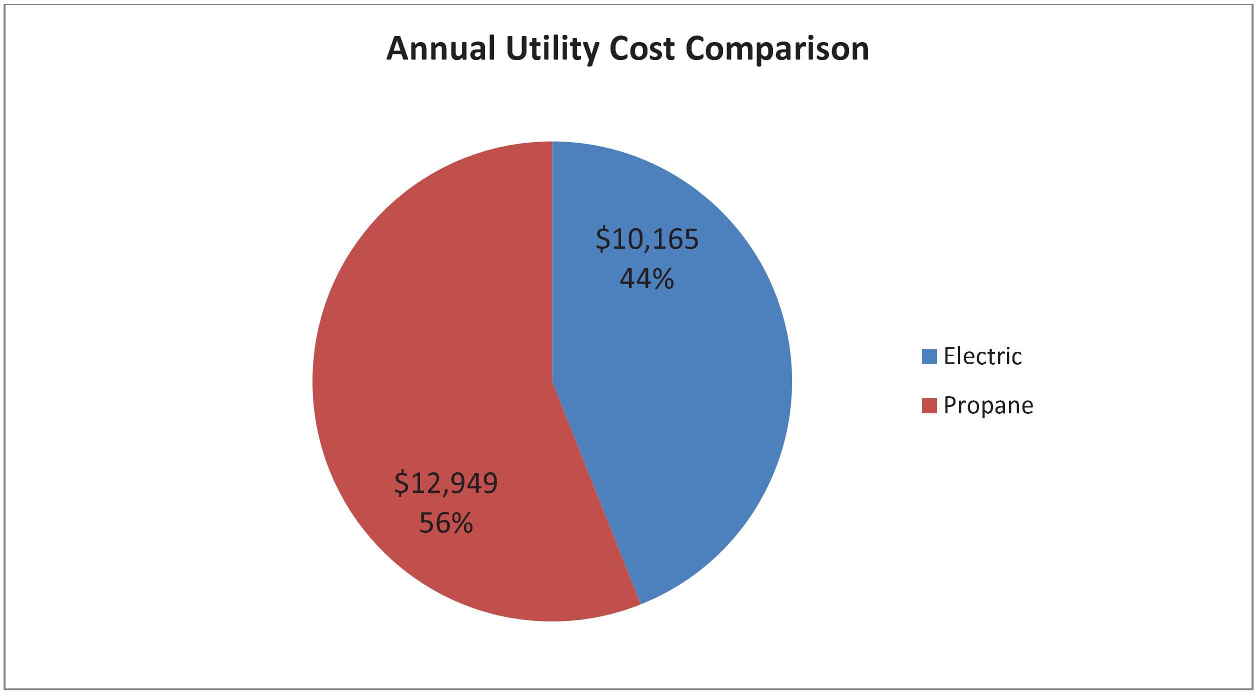

Figure 10. The MFC's electric and propane utility costs for November 2011 – October 2013.

25-YEAR PROJECTED ENERGY LOAD ASSESMENT

The 25-year projected energy load was estimated for the MFC. The projected consumption rates are based on the November 2011 – October 2013 data as well as the following assumptions:

- Low-cost energy efficiency recommendations documented in this report are implemented;
- HVAC system will continue to utilize a distributed furnace system;
- Facility will continue to use propane for heating purposes;
- No significant facility modifications are made, such as additions; and
- Equipment is replaced with new equipment, ductwork is improved (i.e., sagging runs of flexible ductwork are replaced with rigid ductwork and better supported, etc.), and airflow rates are balanced.

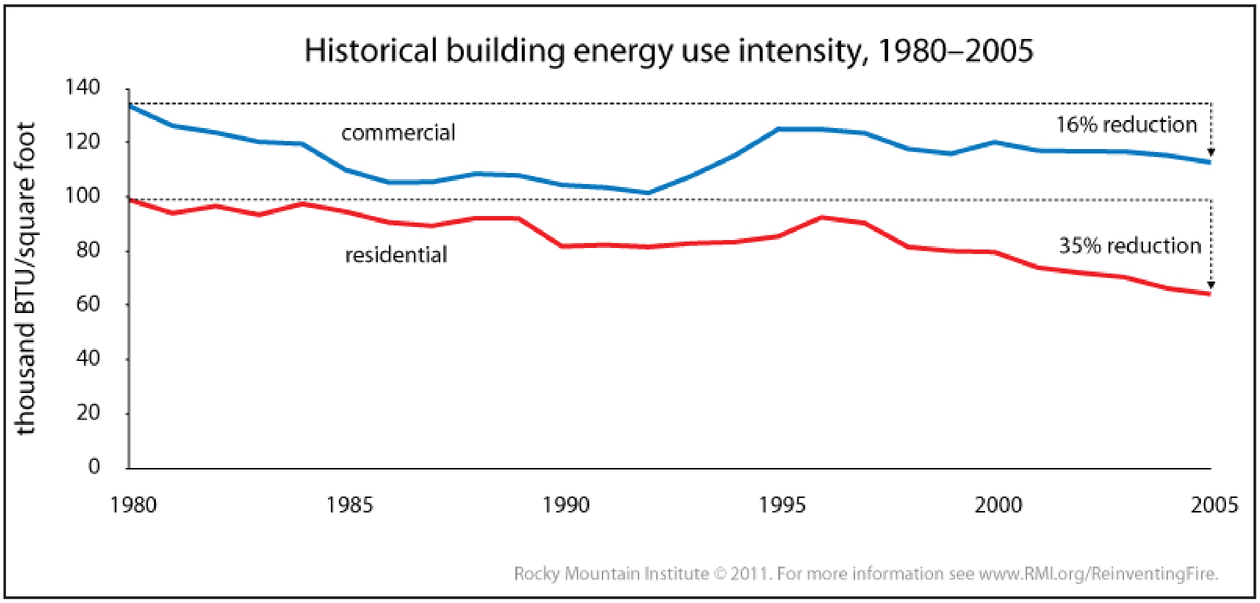

Figure 11. Historical building energy use intensity from 1980 to 2005. This graph shows that energy use intensity has declined by 16 percent for commercial buildings over the last 25 years. This rate has been applied to the MFC's projected energy consumption discussed in this section.

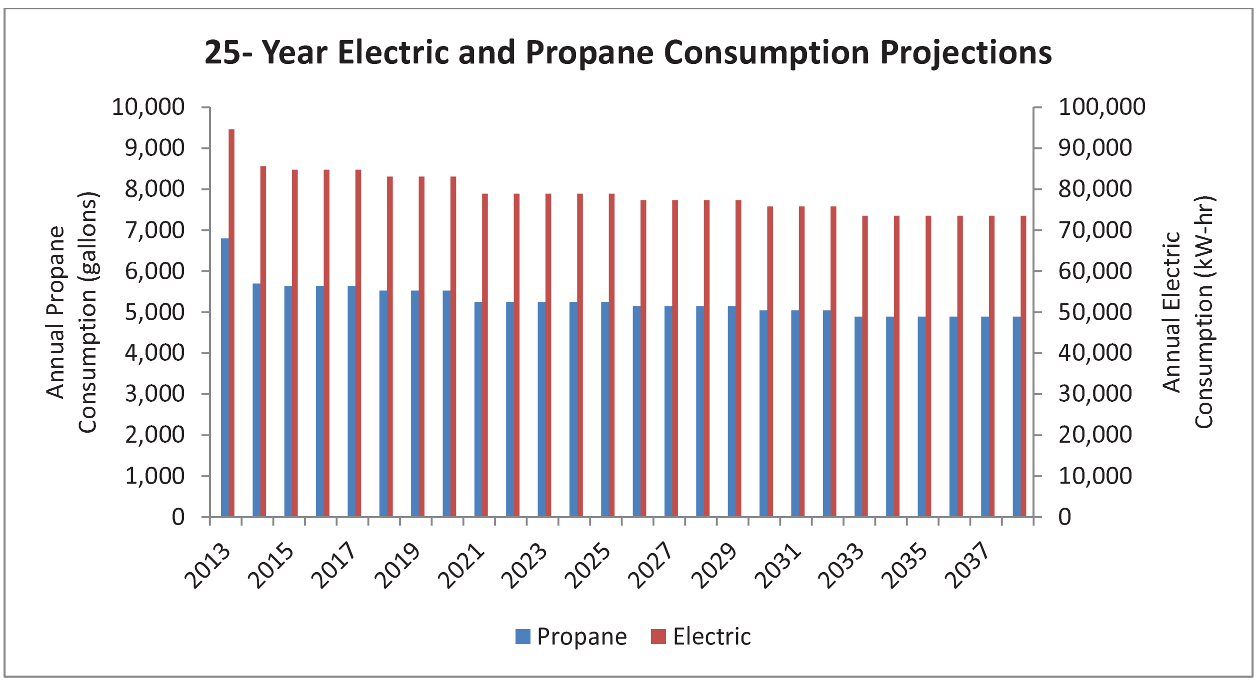

Figure 12. 25 Year Utility Projection. The first year drop is from implementing energy conservation measures outlined in this report.

ENERGY EFFICIENCY

SEG completed an ASHRAE level 1 energy audit of the MFC. A level 1 audit consisted of the following elements:

- Preliminary Energy Use Analysis
- Walk-through survey of building evaluating building envelope, HVAC systems, domestic hot water and lighting
- Identification of low-cost/no-cost recommendations
- Identify capital improvements.

Estimates of the potential savings were determined using a combination of engineering judgment and engineering calculations. A level 1 audit is intended to provide client with a rough estimate of potential savings, but does not include exhaustive calculations or in-depth payback analysis.

EQUIPMENT AND CONTROLS

EXISTING CONDITIONS

Heating and Cooling System

The MFC heating and cooling system consists of eight distributed forced air furnaces. The furnaces are approximately 15 years old and are essentially residential quality units. They were reported to replace the original rooftop unit system which contributed to roof leaks. Two furnaces are located in a mechanical room near the locker rooms and serve the exercise/Pilates room and the weight room. Two furnaces are located above the drop ceiling over the weight room and serve the gym. The remaining four furnaces are located above the drop ceiling over the lobby and corridor areas and serve the following zones: 1) Administrative area & lobby, 2) Game room and lobby, 3) Class room, and 4) Daycare room. The locker rooms are heated by radiant ceiling panels. A building floor plan with approximate heating/cooling zoning diagram can be found in Appendix B.

Each furnace is propane fired and direct vented for heating and each furnace has a DX cooling coil and outdoor condensing unit, except the two furnaces serving the gym which do not have cooling capability.


Figure 13. A radiant ceiling panel in the locker room (left).
Figure 14. A typical air-cooled condensing unit for DX cooling (right).

Figure 15. The furnace serving the exercise/Pilates room.

The ductwork is relatively noisy in some areas, and the overall installation could be improved. There are many long lengths of flexible ductwork that are not well supported and experience sharp bends, which increases noise and reduces airflow. Very little of the rigid ductwork is insulated.

The gym is equipped with an exhaust fan and several ventilation air dampers for cooling. It was unclear how this system is controlled or how often it is used by the building occupants.

Figure 16. Typical flexible ductwork installed between the main supply trunk and the diffusers is not well supported and contains sharp bends.

Figure 17. The gym exhaust fan is located behind the sheet metal cover seen in the upper-right of this image, and one of the four intake louvers is located behind the insulated cover seen in the upper left of this image.

Ventilation System

Ventilation air is ducted from outside air louvers around the building into the return side of each furnace. When the furnace fan runs, the negative pressure on the return side pulls in ventilation air. It appears that each ventilation duct has a motorized damper that is intended to open when the furnace fan runs. Since the furnace fans cycle on and off with calls for heating or cooling, ventilation air is not provided continuously.

Building exhaust is provided by exhaust fans located in the locker rooms and bathrooms. Some exhaust fan ductwork observed was very long lengths of flexible ductwork that was sagging and appeared to be small diameter, thereby limiting airflow.

The kitchen includes a range vent hood without makeup air. The exhaust fan for this vent hood was not observed and the airflow is unknown.

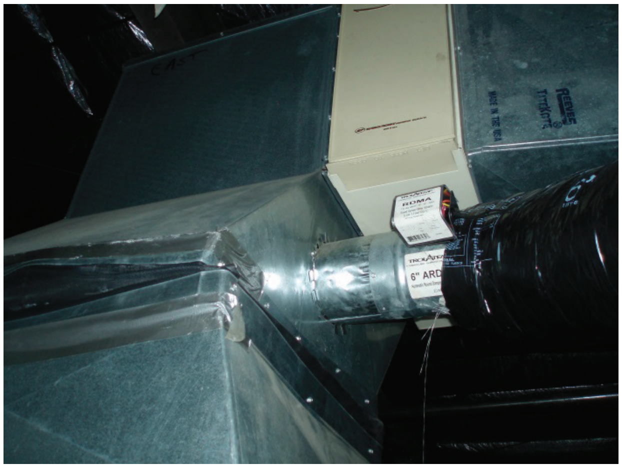

Figure 18. This 6" round duct with motorized damper is a typical ventilation air inlet on the furnaces (left).
Figure 19. The kitchen range vent hood (right).

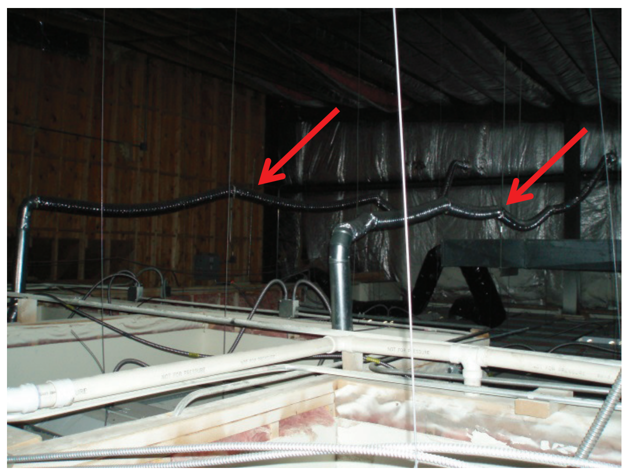

Figure 20. The exhaust grille for a bathroom fan can be seen in the top of this image (left).
Figure 21. The exhaust ductwork for the bathroom fans is long lengths of small diameter, high-resistance flexible duct (right).

Controls

Each furnace is controlled by a stand-alone thermostat located in the spaces they serve. The thermostats are relatively simple in function. Most of them differ from each other. The weight room and pilates have non-programmable thermostats that cannot be setback. All the other space thermostats have programmable thermostats. Setbacks were observed in some spaces but were not consistent throughout the entire building. The cold ambient temperatures may have required some setbacks be removed to maintain proper temperatures in the spaces.

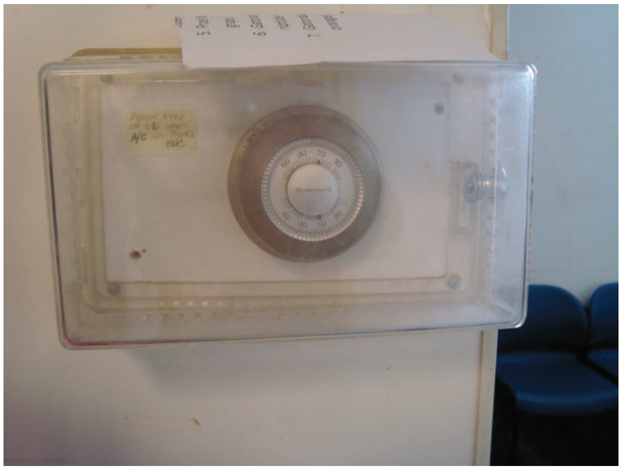

Figure 22. The thermostat for the weight room (left).
Figure 23. The thermostat for the lobby and game room (right).

Equipment Life

Overall, the furnaces appeared to be near the end of their expected lifespans. One unit serving the gym was not firing its burner and the unit serving exercise/Pilates room showed a lot of rust from condensate. Several units showed other signs of corrosion on the draft inducer motors and controls. SEG advises that all the furnace units are inspected, including confirmation that the heat exchangers are not compromised.

Figure 24. The weight room furnace shows a fair amount of rust and other moisture damage.

The eight units were reported to be about 15 years old, while the estimated average lifespan is 18 years based on ASHRAE research studies published in the 2011 ASHRAE Handbook – HVAC Applications (Chapter 37 Owning and Operating Costs, Table 4 "Comparison of Service Life Estimates"). This average lifespan is intended to give the owner some idea of when replacing equipment will be required. The actual life of the equipment can vary substantially higher or lower than average based on the service use, maintenance and other factors.

At some point in the near future, the furnace units will require replacement. If similar residential-quality units are desired, it would be recommended to select high efficiency, condensing units with ECM fan motors. It is suggested that the new units get controlled by a programmable thermostat system that ties into an interface at the building operator's computer. The units should be capable of running ventilation air continuously during occupied times and setting back the space temperature setpoint and turning off ventilation during unoccupied times. At the time of replacing the furnaces, the ductwork should be examined for the following opportunities:

- Better placement of grilles and diffusers: In some spaces return grilles were located right next to a supply diffuser, and also generated a lot of air movement noise.
- Flexible ductwork improvements: Flexible ductwork should be shortened to lengths less than five feet and should be better supported to eliminate sagging and make their bends as gradually as possible.
- Rigid ductwork improvements: Rigid ductwork should have its joints sealed and should be insulated for better efficiency and quieter operation. High efficiency takeoffs can be added for better airflow and reduced fan energy.
- Energy recovery ventilation: An ERV would require new ductwork to be added above the ceiling.
- Airflow balancing: After new furnaces, an ERV, and any ductwork changes are installed, a certified Testing, Adjusting, and Balancing (TAB) contractor should be hired to do a full system air balance to ensure the airflows are providing the correct amount of heating, cooling, and ventilation air to each space.

An alternate option to replacing the furnaces with new units is to install a geothermal system. This option will be discussed in greater length in its own section later in the report. Distributed geothermal heat pumps would replace the furnaces throughout the building. Similar ductwork optimizations discussed above would be recommended, and piping distribution would need to be added above the ceiling. The existing mechanical room would contain space for some geothermal equipment (pumps, controls, valves, and gauges).

If any extensive energy efficiency improvements to the system are going to be performed, such as the installation of energy recovery ventilation and/or the installation of a geothermal system, it would make economic sense to coincide these upgrades when the furnaces are due for replacement.

IDENTIFIED ISSUES

Numerous issues were identified with the mechanical system. This section is intended to highlight those issues. These issues are not included in the "Potential Initiative" section because they are not energy efficiency measures. However, when fixed, they will improve the overall building comfort and reliability.

Issue #1: Weight Room Furnace Condensate Drain Disconnected

On the weight room furnace, the condensate hose had become disconnected from the drain, leading to water leaking into the unit base and corroding of the unit. The hose clamp should be reinstalled on the unit to prevent leakage and additional corrosion. The low voltage transformer also showed signs of rust. In general, this unit is past its useful life.

Figure 25: Condensate hose was disconnected from the PVC drain.

Issue #2: Gas Fired Domestic Water Heater Back Drafting into Space

The propane fired domestic water heater is a natural vent type unit. However, the building pressure is slightly negative (0.03" H_20) which results in the unit back drafting into the space as observed by the combustion odor in the mechanical room. The building exhaust cfm is greater than the outside air being supplied which leads to the back drafting of the unit. SEG recommends that a power exhaust unit is utilized, or the building pressure control is improved through proper balancing and scheduling of exhaust and ventilation air.

Issue #3: Gym Furnace Unit Air Filter Not Installed

There is no air filter installed on the weight room unit. This will lead to the fouling of the furnace and A/C coil, as well as dust accumulating in the supply ductwork. A filter should be installed in this unit.

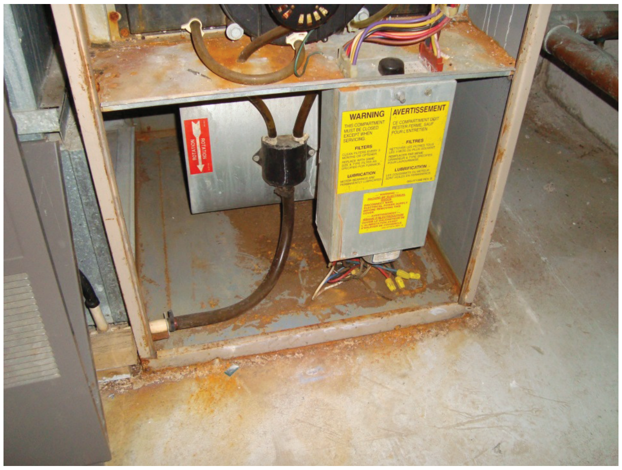

Figure 26: Gym furnace unit with missing filter. Filter is typically installed at the connection between return duct and the fan section.

Issue #4: Shower Exhaust Fan is Not Functional

The exhaust fan serving the shower area is not functional. This unit should be evaluated by service tech. SEG did not access the women's bathroom, but these units should be verified as well.

Figure 27: Faulty men's shower exhaust fan.

Issue #5: Gym East Furnace is Not Functional

The gas furnace serving the east side of the gym is not functional. The unit is trying to ignite, but is not firing. A tech should evaluate this unit to determine issue. After this unit is functional, temperature control issues in gym should be eliminated as current occupants reported cold gym temperatures when the outside air is below 15°F.

Issue #6: Weight Room Duct Work Supported by Ceiling Grid

The ductwork installed above the weight room is supported by the ceiling grid structure. The ceiling grid is not a weight bearing surface. Ductwork should be supported by the building structure.

Figure 28: Weight Room ductwork is supported by the ceiling grid.

Issue #7: West Gym Furnace Thermostat Installed in Poor Location

The west gym unit thermostat is installed in the area framed around the column. This area is very cold and is causing the furnace to run all the time in cold weather regardless of the room temperature. The thermostat should be relocated or insulated in a way that the thermostat will sense room temperature and not the temperature in the column cavity.

Figure 29: West gym thermostat location leading to poor temperature control and excessive furnace run time (after east unit is repaired).

Issue #8: West Gym Furnace Burner Cover Removed

The burner cover on the west furnace was removed and never reinstalled. The open flame is a fire hazard and the cover should be reinstalled.

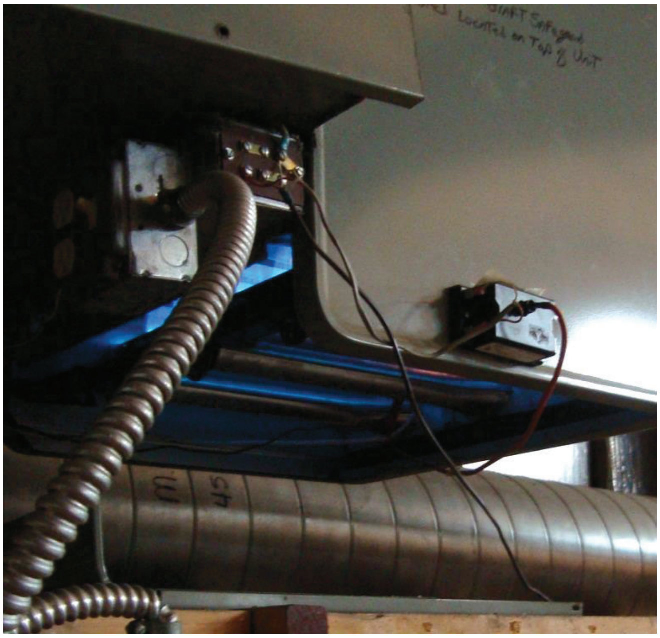

Figure 30: West gym unit burner cover removed and is sitting directly below unit.

Issue #9: Lobby Thermostat LCD Is Failing

The thermostat in the lobby area is failing and should be replaced. The LCD display cannot be read and it is not clear if the thermostat has been programmed with a night setback schedule.

Figure 31: Lobby thermostat LCD screen is failing.

ENERGY CONSERVATION MEASURE SUMMARY

Energy conservation measures (ECMs) have been identified during the walk-through audit that are estimated to save a total of 9,100 kW-hrs of electricity and 1,100 gallons of propane per year. If the ECMs identified in this report are selected, this would result in saving approximately 13 percent of the building's energy costs ($3,100 per year in today's costs). These ECMs are estimated to cost under $20,000 to implement, yielding a simple payback that is within 6 years. The ECMs are discussed in further depth later in the report.

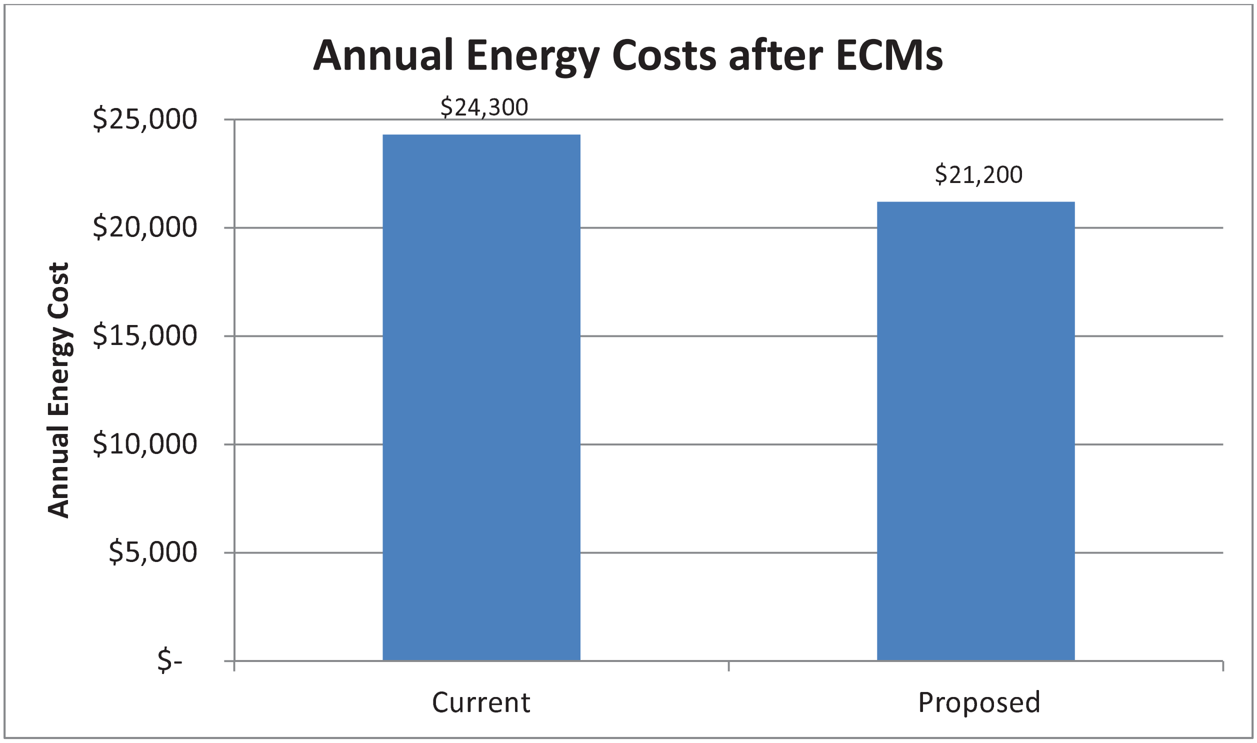

Figure 32. Estimated utility costs after implementing recommended measures identified in this report.

ECM #	System	Recommended Improvement	Estimated Electric Savings (kWh/yr)	Estimated Propane Savings (gal/yr)	Estimated Cost Savings ($/yr)	Cost to Implement ($)	Payback Period (yrs)
1	HVAC	Upgrade thermostats and utilize night setback	484	341	$ 710	$ 800	1.1
2	HVAC	Add timer controls to bathroom exhaust fans	1,273	-	$ 140	$ 300	2.1
3	Lighting	Install lighting occupancy sensors in intermittently occupied spaces	3,784	-	$ 416	$ 1,000	2.4
4	Plumbing	Install a timer control on domestic hot water recirculation pump	479	58	$ 164	$ 300	1.8
5	Plumbing	Upgrade DWH to high efficiency unit	-	24	$ 46	$ 1,000	22
6	Plug Load	Install vending miser on vending machines	2,070	-16	$ 197	$ 180	0.9
7	Envelope	Air seal building envelope	968	682	$ 1,420	$ 15,104	11
	Total		**9,058**	**1,088**	**$ 3,093**	**$ 18,684**	**6.0**

Table 3. Summary of all ECMs described in this report.

POTENTIAL INITIATIVES

ECM #1: Standardize Thermostats and Utilize Night Setback

There are a total of 8 thermostats in the building that control residential furnaces in the building. 6 of the 8 have setback capabilities. However, there is no consistency between thermostat models which makes it more difficult for the staff to program the thermostats and utilize the night and weekend setback features of the units. Additionally, most of the programmable units cannot utilize different schedules on Saturday and Sunday.

SEG proposes that the existing thermostats are replaced with user-friendly 7-day thermostats. Night setback should be programmed for the hours that are outside the building hours. Typical setbacks are 62°F for heating and 80°F for cooling.

Estimated Electric Savings (kW-hr/yr)	Estimated Propane Savings (gal/yr)	Estimated Cost Savings ($/yr)	Cost to Implement ($)	Payback Period (yrs)
484	341	$710	$800	1.1

Table 4. ECM #1 savings.

ECM #2: Add Time Clock to Locker Room Exhaust Fans

The gym locker rooms each have a bathroom and shower exhaust fan that run 24/7. These fans are not required to run when the building is unoccupied. SEG recommends that a time clock is added to control these exhaust fans. The fans would be turned off when the building is unoccupied.

In addition to saving electricity from the fan energy savings, the building infiltration will also be reduced because the building pressure will not be negative, which will reduce the amount of unconditioned outside air being brought into the building.

Estimated Electric Savings (kW-hr/yr)	Estimated Propane Savings (gal/yr)	Estimated Cost Savings ($/yr)	Cost to Implement ($)	Payback Period (yrs)
1,273	-	$140	$300	2.1

Table 5. ECM #2 savings.

LIGHTING

EXISTING CONDITIONS

Overall, the lighting used in the MFC is energy efficient. The interior lighting consists mainly of T8 fluorescent fixtures with wall switches. The gym utilizes high output T5 fluorescent fixtures with wall switches. Exterior lighting appeared to be high intensity discharge (HID), and is on a photocell. Although building occupants appeared to do a good job at turning off lights when they left a room, there are some opportunities to reduce lighting energy with occupancy sensors.

Figure 33. Typical 2' x 4' 4-lamp T8 fluorescent lighting throughout the interior (left).
Figure 34. Typical HID exterior parking lot lights (right). Some baseball field lights can be seen in the background.

Light levels were measured in a sample of spaces. Overall the lighting levels were generally suitable for the space types.

Space	Measured Light Level (foot-candle)	Recommended Light Level (foot-candle)
Gym	40	30-50
Weight Room	20	20-40
Pilates Room	35	20-40
Kitchen	38	50-100
Director's Office	55	30-50
Lobby	21	20-50
Game Room	32	20-40
Craft Room	55	100-200
Fitness Room	13	20-40
Day Care	33	20-40

Table 6. Measured light levels throughout the MFC.

ECM #3: Install Occupancy Sensors in Intermittently Occupied Spaces

All interior lighting is currently controlled through the use of wall switches. However, the lights are left on in spaces when there are no occupants. SEG recommends that occupancy sensors are installed in intermittently occupied spaces that will turn the lights off when the room is not occupied.

In most cases, the existing wall switch can be replaced with an occupancy sensor type switch. In cases where the wall switch is not located suitably for an occupancy sensor, an occupancy sensor can be installed in the ceiling tile and tied into the existing circuit. In spaces where fluorescent lights would be turned on/off more than 5 times/day, programmed start type ballasts are recommended to avoid lamp life reduction.

The following spaces would be well suited to occupancy sensors:

- Locker rooms
- Bathrooms
- Pilates room
- Weight room
- Craft room
- Fitness room
- Private offices
- Kitchen
- Storage room

Estimated Electric Savings (kW-hr/yr)	Estimated Propane Savings (gal/yr)	Estimated Cost Savings ($/yr)	Cost to Implement ($)	Payback Period (yrs)
3,784	-	$416	$1,000	2.4

Table 7. ECM #3 savings.

DOMESTIC HOT WATER

The portions of the plumbing system surveyed include the water heating equipment and fixtures in the bathrooms and kitchen.

EXISTING CONDITIONS

The MFC's domestic hot water is provided a propane-fired, atmospheric-vented tank water heater. It has a capacity of 100 gallons and a burner rated at 75,100 BTU/hr. It was installed in approximately 2007. The setpoint is approximately 120°F. An odor of gas was noticeable near the flue. There is a domestic hot water recirculation pump, which did not appear to be functioning.

Figure 35. The domestic water heater.

ECM #4: Install Time Clock Domestic How Water Recirculation Pump

The purpose of the domestic hot water recirculation pump is to maintain hot water near the point of use, without needing to run the hot water faucet for an extended period of time. A recirculation pump consumes energy in the form of pumping energy as well as increased water heating energy, but it can save water and is a convenience feature available in most commercial buildings.

The domestic hot water recirculation pump is currently not functioning. The pump is likely original to the building and requires replacement.

When the new pump is installed a combination aquastat and timer should be installed so that the pump turns off when the aquastat senses hot water in the return line or when the building is not occupied.

Estimated Electric Savings (kW-hr/yr)	Estimated Propane Savings (gal/yr)	Estimated Cost Savings ($/yr)	Cost to Implement ($)	Payback Period (yrs)
479	58	$164	$300	1.8

Table 8. ECM #4 savings.

Figure 36: Domestic hot water pump with integral time clock.

ECM #5: Install High Efficiency Water Heater

The existing natural vent propane fired water heater has an efficiency of approximately 80%.

When the water heater reaches the end of its useful life, SEG recommends that it is replaced with a high efficiency propane-fired condensing models with efficiencies of at least 95 percent. Alternatively, in tandem with geothermal, ground-source heat pump water heaters could be considered.

Another advantage of the high efficiency units is that they are power vented directly to the outside that will eliminate any chances of combustion gases back drafting into the mechanical room.

The implementation cost used in the table below is the additional cost above the replacement cost of a standard water heater.

Estimated Electric Savings (kW-hr/yr)	Estimated Propane Savings (gal/yr)	Estimated Cost Savings ($/yr)	Cost to Implement ($)	Payback Period (yrs)
-	24	$46	$1,000	22

Table 9. ECM #5 savings.

Figure 37: Example of high efficiency water heater.

ELECTRICAL PLUG LOADS

POTENTIAL INITIATIVES

ECM #6: Add Vending Misers to Vending Machines

There is one vending machine located in the MFC Building. If this unit is maintained by a third party, SEG recommends that the MFC requests that Vending Misers are installed by the equipment vendor. If the MFC owns these machines, it can work with the servicing contractor to install the Vending Miser.

Vending Misers are occupancy sensors that are tied into the machine controls. When there is no foot traffic near the machine, such as during unoccupied periods, the machine lights go off and the temperature is allowed to float upwards slightly to reduce the cooling load.

Estimated Electric Savings (kW-hr/yr)	Estimated Propane Savings (gal/yr)	Estimated Cost Savings ($/yr)	Cost to Implement ($)	Payback Period (yrs)
2,070	-16	$197	$180	0.9

Table 10. ECM #6 savings.

Figure 38: Example of vending machine occupancy sensor "Vending Miser."

BUILDING ENVELOPE

The building envelope consists of the entire exterior enclosure of the building. It has three main functions: to provide structural support for the building, to control the flow of matter, energy, and people in and out of the building, and to provide a medium for expressing aesthetic and design sensibilities. For this analysis, the current condition of the building envelope and its ability to control the flow of heat, air, and moisture was assessed.

EXISTING CONDITIONS

Roof and Walls

The MFC roof is insulated with 5.5-inch foil-faced fiberglass insulation (approximately R-19). This foil-faced insulation continues down the walls except where the walls are wood-framed in the east wing (the day care area, class room, game room, exercise/Pilates room, and admin area). These wood framed walls are typically 9-foot high, 2-inch by 6-inch wood stud walls insulated with 5.5-inch fiberglass batt insulation (approximately R-19). The intersection between these two types of 5.5-inch fiberglass insulation is not sealed and significant air movement can be felt at this seam. Penetrations in the insulation (such as around ducted louvers) were also not well sealed and daylight was visible in some cases.

Figure 39. Foil-faced fiberglass roof insulation in the gym (left).
Figure 40. A hole in the foil-faced fiberglass roof insulation above the lobby (right).

Figure 41. The foil-faced fiberglass insulation continues on the wall below the roof until it intersects the wood framed wall where the drop ceiling begins (left).
Figure 42. At this intersection atop the wood-framed wall, the blankets of foil-faced fiberglass hang loose (right). They are not sealed or fastened in any way to the wall assembly and insulation system below. Significant air movement is present at this seam around the entire perimeter of the east wing.

Windows and Doors

The MFC windows have an aluminum frame system and appear to be double-glazed with solar-reflective glazing. The main doors were also aluminum frame with double glazing, while emergency doors were generally unglazed steel doors. The frames and glass edges were generally free of condensation on this visit (outside air temperature = 10 to 20°F, inside air relative humidity = 15%), but signs of condensation or perhaps water leakage were seen at some thresholds. These are indications that there is air leakage around doors.

Figure 43. Rust is visible on this door in the day care area, which is a sign of condensation or water infiltration.

ECM #6: Perform Air Sealing of Building Envelope

SEG observed ice damming issues throughout the building. Ice damming is an indication that heat is escaping the building and melting snow on the roof. The water then refreezes as it runs down the roofline. Upon further inspection, SEG observed building wide issues with the air barrier. Specifically, there were numerous locations where no continuous air barrier was installed. The most significant location was in the east wing of the building, where the framed wall terminates and the blanket insulation begins. Figure 42, above, shows one location in the day care room above the drop ceiling with this condition.

Figure 44. Ice damming near the east side entrance adjacent to car canopy

While fiberglass insulation is installed throughout the building, there is no means from preventing the wind-washing effect of the insulation because an air barrier is not located to the exterior of the batt insulation. Specifically, the blanket and batt insulation is exposed to the air pervious building cladding, such as the roof panels and the metal siding. In modern day construction, building wraps such as Tyvek or continuous foam board is typically used to prevent this wind washing effect and provide a weather barrier for the building envelope. Short of reconstructing the building envelope, there is no cost effective solution to this problem.

SEG recommends that MFC work with an experienced air sealing contractor that can assist with improving the building performance. The following approach is recommended:

- Perform a blower door evaluation to establish baseline value for whole building air leakage
- Fasten and seal the seam between the plenum walls and framed walls
- Increase insulation thickness in roof and plenum walls, if cost effective
- Air seal around ducted louvers
- Patch holes in fiberglass insulation vapor barrier
- Perform a second blower door evaluation to determine level of improvement and identify additional areas for improvement

Estimated Electric Savings (kW-hr/yr)	Estimated Propane Savings (gal/yr)	Estimated Cost Savings ($/yr)	Cost to Implement ($)	Payback Period (yrs)
968	682	$1,420	$15,104	11

Table 11. ECM #6 savings.

RENEWABLE ENERGY TECHNOLOGIES

The MFC campus was assessed for four separate renewable energy systems:

- Geothermal
- Solar Electric (also called Photovoltaic, or PV)
- Solar Thermal
- Biomass

The Stockbridge Munsee Community has requested that the investigated renewable energy systems can be shown to offset a total of 30 to 100 percent of the building's energy loads. For the purposes of this report, it was discussed that this would be expressed in terms of *site* energy usage (as opposed to *source* energy usage). It is assumed to include the total electrical and propane energy for the MFC.

Since electricity and propane are expressed in different units of energy (kWh of electricity and gallons of propane), it is useful to combine them into one unit and to normalize it for building area. The standard unit used for this and the unit used in this report to describe total energy will be kBTUs. One kBTU is equal to 1,000 BTUs, 0.29 kWh of electricity, or 0.011 gallons of propane.

The table below shows the total site energy usage for the MFC to be 946,300 kBTU per year. The energy efficiency portion of this feasibility study highlighted several opportunities to reduce energy usage with minimal cost. It was identified that approximately 131,800 kBTU per year (composed of 9,100 kWh and 1,100 gallons of propane) can be saved with a total implementation cost of less than $20,000 and a payback period of 6 years. These short-term payback measures should be implemented before any renewable energy technologies because they can reduce the required size and enhance the economic feasibility of the renewable energy systems. Therefore, the total site energy load that the calculations are based on is assumed to be 814,500 kBTU per year. In order to offset 30 to 100 percent of the building's energy loads, the renewable energy systems examined here would have to offset 244,400 to 814,500 kBTU per year.

	Propane (gallons/yr)	Energy from Propane (kBTU/yr)	Electricity (kWh/yr)	Energy from Electricity (kBTU/yr)	Total Energy (kBTU/yr)
Current Energy Usage	6,800	623,200	94,700	323,100	946,300
Energy Savings from ECMs	1,100	100,800	9,100	31,000	131,800
Projected Base Energy Usage	**5,700**	**522,400**	**85,600**	**292,100**	**814,500** **30 % = 244,400 kBTU/yr**

Table 12. The minimum amount of energy to be offset by a combination of renewable energy systems in this report is 244,400 kBTU/yr.

The geothermal system is the recommended option to offset the MFC's energy use by 30 to 100 percent due to its cost effectiveness. It is estimated to accomplish the goal of reducing the facility's total energy use by at least 30 percent. This option has the most favorable economics with a payback period of 20 years and a 25-year return on investment (ROI) of 3.5 percent per year.

A biomass system could be compared to the geothermal system because they are mutually exclusive options since both systems aim to be the primary heat source for the building's winter space heating loads. However, a biomass system would have a significantly longer payback, one that is longer than its probable lifetime of 25 years, which results in a 25-year ROI of -1.3 percent per year. Since the biomass system carries the lower cost effectiveness and several other operation considerations with it, such as fuel storage, possible odors and emissions, additional maintenance, and whether the feedstock could be produced by the Community, a geothermal system is recommended over the biomass system.

If the Stockbridge Munsee Community is interested in offsetting the MFC's total energy use as much as possible with renewable energy and a 25- to 30-year payback is acceptable, a solar electric and solar thermal system can complement a geothermal system or a biomass system.

	Upfront Cost	Energy Offset (kBTU/yr)	Portion of Building's Use	Payback	25-yr ROI
Geothermal (Vertical Loop)	**$ 320,500**	**395,900**	**49 %**	**20 yrs**	**3.5 %**
Solar Electric	$ 178,500	164,800	20 %	28 yrs	-1.1 %
Solar Thermal (DHW Only)	$ 8,500	8,600	1 %	23 yrs	1.5 %
Biomass (Wood Pellet)	$ 290,500	412,400	51 %	28 yrs	-1.2 %

Table 13. An overview of the economics and performance of the four renewable energy technologies examined in this study.

GEOTHERMAL

TECHNOLOGY OVERVIEW

Geothermal systems are high efficiency HVAC systems that work by using the ground as a thermal battery and therefore generally work very well in climates that experience both a heating season and a cooling season, like in Wisconsin. In the summer a geothermal system cools a building by rejecting heat to the ground, and in the winter the system reverses the cycle to heat the building from the ground. Buildings that have relatively balanced heating and cooling loads simply shift the thermal energy back and forth between the ground and the building.

A closed piping system carries a glycol fluid and connects a geothermal field to heat pumps installed throughout the building. The heat pumps are specially selected for use in geothermal systems. In this case, the heat pumps would replace the existing furnaces, the piping distribution would need to be added, ductwork would need to be changed, and the geothermal field would need to be installed. Geothermal fields can be categorized as either horizontal loop or vertical loop geothermal fields.

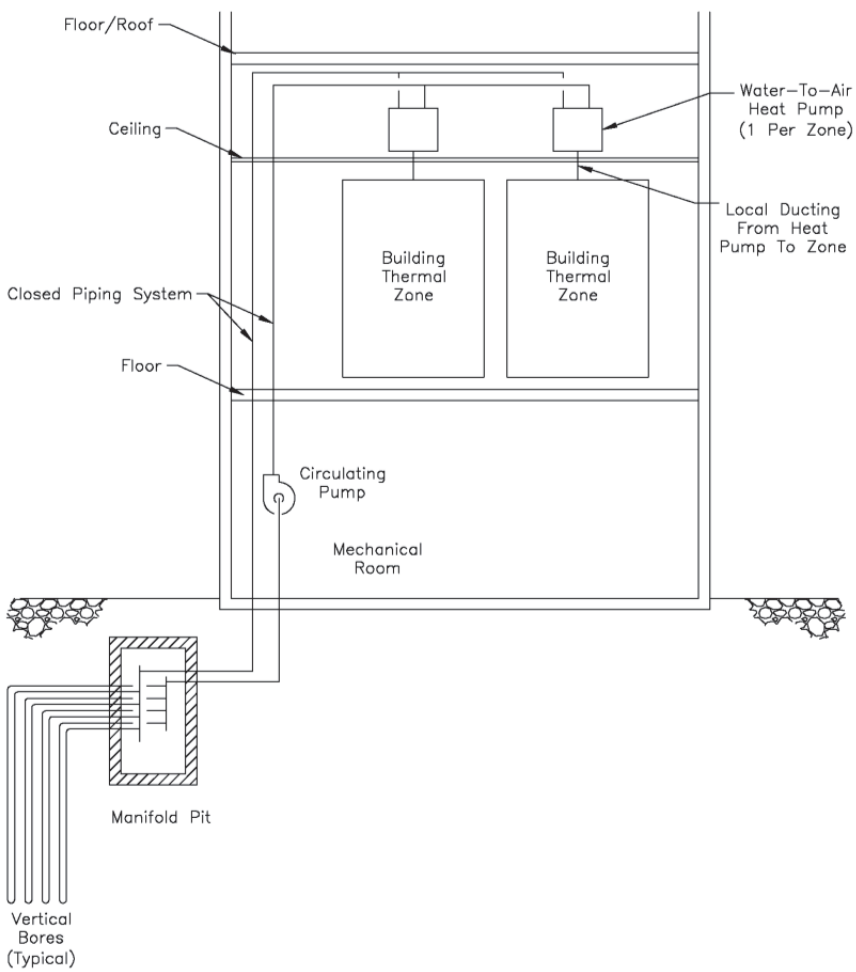

Figure 45. Geothermal heating and cooling system schematic. Vertical loop field bores are shown here, but a horizontal loop field would be similar schematically.

A horizontal loop geothermal field consists of loops of piping that are usually installed about 6 to 8 feet below the surface. Two common piping configurations that achieve the required surface area for heat exchange are parallel runs of piping (sometimes called racetrack systems) or spiraled coils of pipe (sometimes called slinky systems). Bedding sand is used to surround and protect the piping, and the excavated soil is then backfilled, compacted, and landscaped.

A vertical loop geothermal field consists of several bores that are drilled into the ground that are generally 6 inches in diameter and 300 to 400 feet deep. Each bore would contain two pipes (one supply, one return) approximately 1 inch in diameter with a U-bend on the bottom. The bore is then filled with a grouting material that surrounds the piping, improves thermal conductivity, and seals the bore to protect groundwater. Trenches are dug to install the piping that connects the bores together, and the piping is routed underground to the mechanical room of the building.

Figure 46. A typical racetrack horizontal loop geothermal field (left). This field served a 10,000 ft² fire station in Madison, WI.
Figure 47. A typical slinky horizontal loop geothermal field (right). Photo credit: G.O. Loop, Randolph, WI.

Figure 48. A typical vertical loop geothermal bore drilling operation (left) at a 54,000 ft² elementary school in Mosinee, WI.
Figure 49. A typical vertical loop geothermal field circuit trench (right). Each vertical loop bore is located where each pair of pipes branches off and elbows down into the soil (indicated by arrow). This geothermal field serves a 113,000 ft² elementary school in Shawano, WI.

There are several tradeoffs between horizontal and vertical loop geothermal fields:

- Upfront cost – Even though the cost of vertical loop geothermal fields has fallen in recent years due to increasing competition between geothermal drillers, a horizontal loop geothermal field is typically less expensive upfront to install due to lower cost of installation equipment required.

- Operating cost – Horizontal loop geothermal fields experience higher operating costs that should be considered carefully against their lower upfront installation cost. One contributing factor is greater pumping energy is required due to the greater overall length of piping.

  More importantly, however, is that the temperature of the soil surrounding the horizontal loop geothermal field usually drops to a lower temperature range after the system has extracted heat out of the ground all winter. Conversely, vertical loop geothermal fields take advantage of more stable temperatures at greater depths, which results in a higher heat pump efficiency (usually expressed as Coefficient of Performance, or COP). Similarly by the end of the summer, soil temperatures stay cooler in a vertical loop geothermal system, again increasing operating efficiency (usually expressed as Energy Efficiency Ratio, or EER). This efficiency difference is approximately 10 percent, but the difference can be much higher in cases where a horizontal loop system relies on electric resistance or propane heating for backup heating.

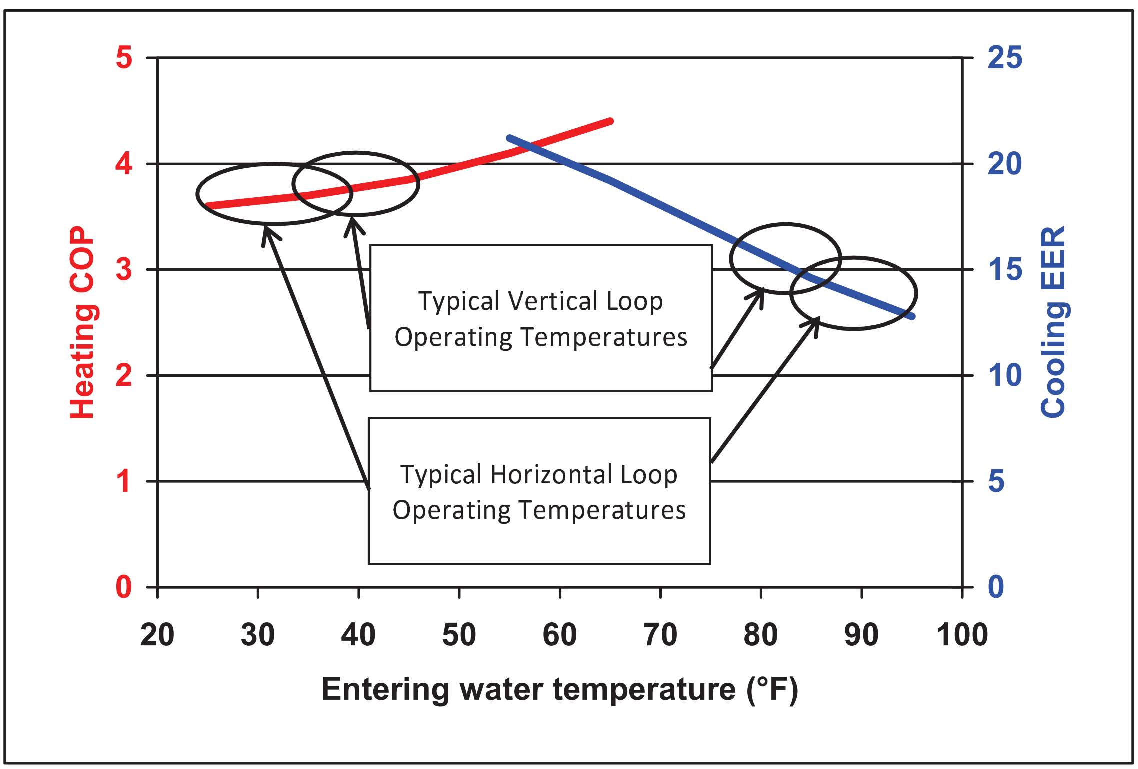

Figure 50. Efficiency of a typical 4-ton heat pump unit as a function of entering water temperature. For both COP and EER, a higher number means it is more efficient. Vertical loop system heat pumps have higher heating and cooling efficiencies than horizontal loop system heat pumps.

- Heat Pump Capacity – Because a horizontal loop geothermal system operates at a lower heating and cooling efficiency than a vertical loop geothermal system, heat pumps in a horizontal loop system need to be sized larger to maintain the necessary capacity to heat/cool the building during peak loads. This results in heat pumps that are approximately 25 percent larger and more expensive in a horizontal loop system than a vertical loop system.

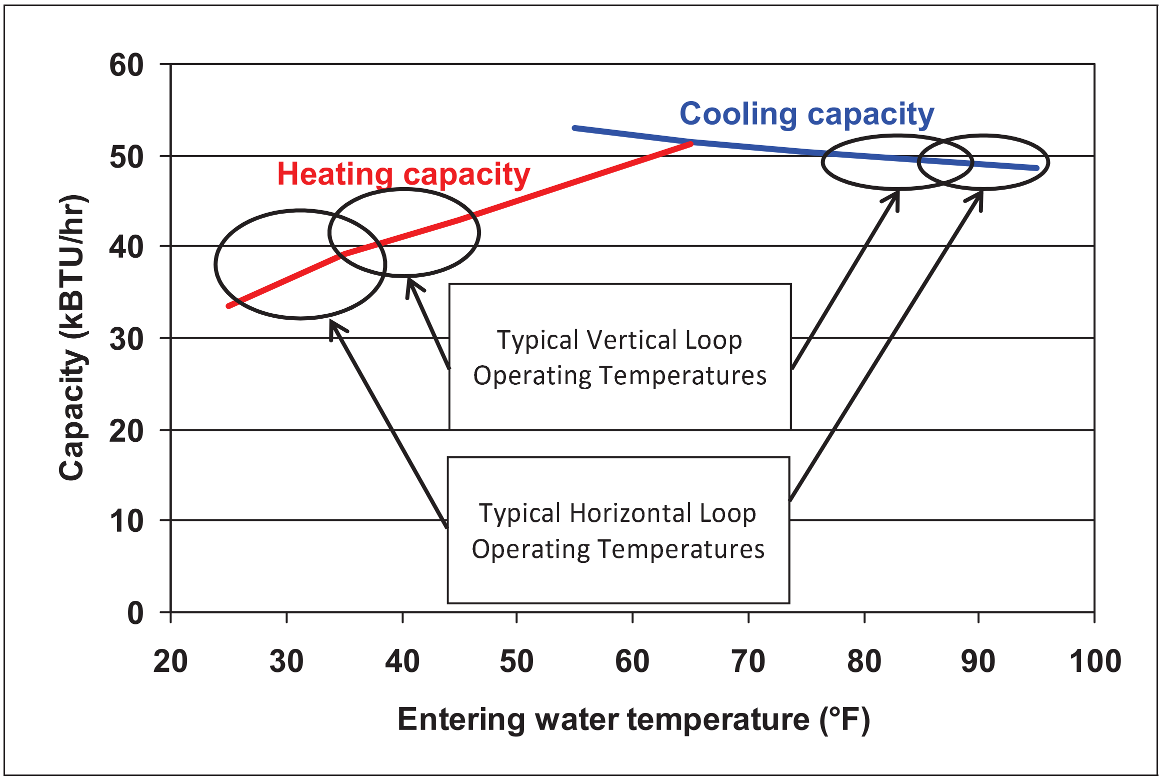

Figure 51. Capacity of a typical 4-ton heat pump unit depending on entering water temperature. Vertical loop system heat pumps have higher heating and cooling capacities than horizontal loop system heat pumps.

- Land Use Efficiency – Due to the way piping is laid out in a horizontal loop geothermal field, this type of system requires approximately 15 to 20 times more land space than a vertical loop geothermal field of the same capacity. If available land area is not a limitation, then this is not necessarily a factor in determining whether a horizontal or vertical loop field should be chosen.

- Reliability – Since a vertical loop geothermal system is located in soil and bedrock depths that are relatively unaffected by air temperatures, there is greater certainty in designing a system. Horizontal loop geothermal systems have to be sized based on factors that are dynamic in nature, such as soil temperature, frost depth, water table depth, and moisture content. Each of these factors varies on a seasonal or even weekly basis, affecting the performance of a horizontal loop geothermal field. This results in additional capacity and backup heating (electric resistance or propane) requirements in a horizontal loop geothermal system to perform reliably.

PROJECT RECOMMENDATIONS/COMMENTS

Determining the size of a geothermal field starts with the building's heating and cooling loads. This type of building typically has a cooling load of approximately 450 ft^2 per ton and a heating load of approximately 30 BTU per ft^2, including ventilation loads. This results in a maximum cooling load of 34 tons (408,000 BTUs, or 408 MBH) and a maximum heating load of 500 MBH for the 15,100 ft^2 building. These are approximate loads for the purposes of this feasibility study. A complete thermal load calculation including ventilation loads should be completed before designing a geothermal system. Vertical and horizontal loop geothermal field sizes will be explained in their respective sections below.

Geothermal Field and Piping Location

Athletic fields often make good locations for a vertical or horizontal loop geothermal field. This site has a baseball field that has some future work planned. Installing a geothermal field requires a lot of large earthwork equipment that can tear up a site. Large trenches are typically dug for the piping and re-grading and re-sodding are often required at the end of a project. It is therefore recommended that a geothermal field is coordinated with and included in the master plan for the baseball field.

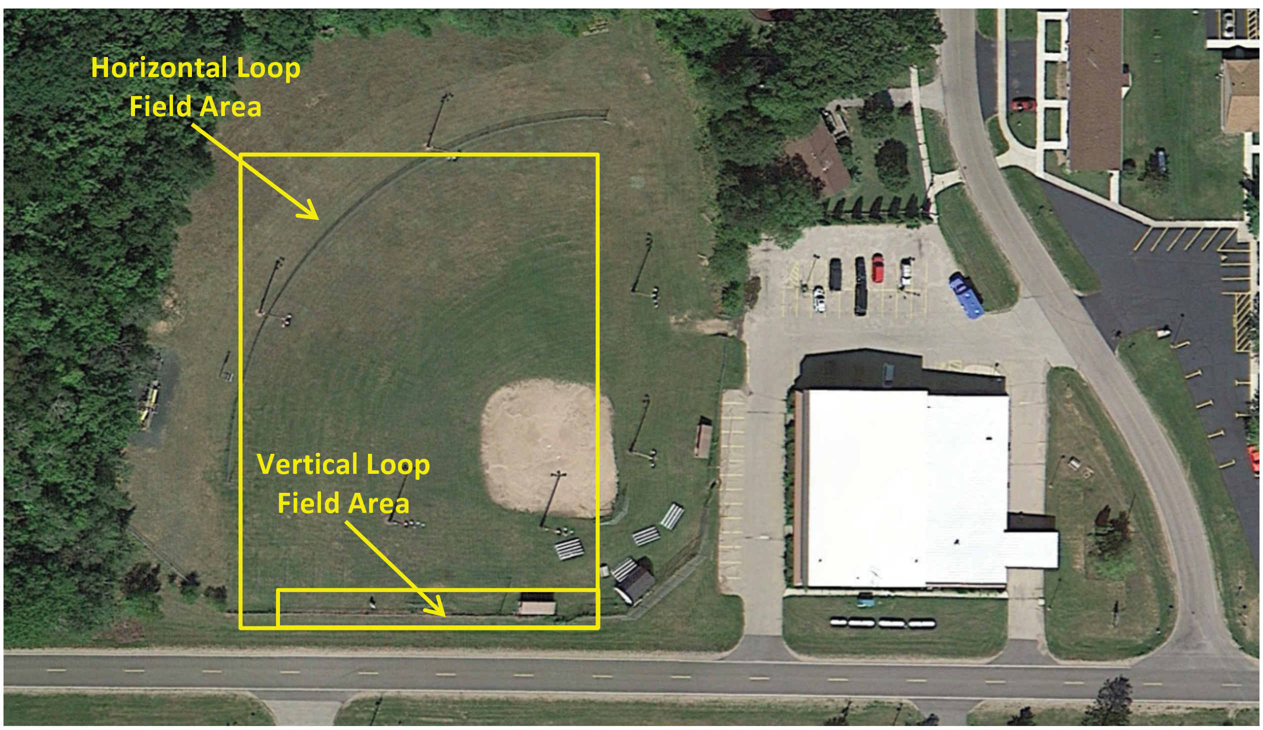

Figure 52. The recommended geothermal field location is underneath part of the nearby baseball field on site. A horizontal loop field would require approximately 15 to 20 times the area of a vertical loop field.

Piping would be routed from the geothermal field to the building's mechanical room which is along the middle of the southern edge of the building. The building's generator and several propane tanks are located to the south of the building, so geothermal piping should be coordinated with other existing underground utilities (electricity, propane, water, etc.). If water lines cross the geothermal lines, they should be separated by a minimum of 2 feet to avoid freezing the water line.

Vertical Loop Geothermal Field

Soil, bedrock, and water table characteristics determine the rate of heat exchange for a vertical loop geothermal field. Favorable geological conditions can lead to a smaller geothermal field, needing fewer total bores to heat/cool the building, and vice versa. Using Wisconsin Department of Natural Resources (WDNR) well log data in the area, these geological characteristics can be estimated. Seven existing wells between 185 and 428 feet deep within one quarter mile of the MFC were examined. Every well showed relatively consistently that there was a combination of sand, clay, and gravel for approximately the top 25 to 50 feet. Below that, every well showed granite for the remainder of its depth.

Granite is a hard bedrock, and may take about 50 percent longer to drill than some bedrocks (such as limestone or sandstone). But granite has good thermal conductivity, good thermal diffusivity, and the water table appears to be relatively high in the area judging by the well logs (depth of around 10 to 25 feet). All of these traits mean that the geothermal bores should have very good heat exchange characteristics. Although the WDNR well logs are very useful for estimation purposes, a test bore should be conducted at the outset of a geothermal project to gather a more accurate assessment of the site conditions. The test bore can be reused as part of the eventual borefield.

SEG has been involved with geothermal design and commissioning services on projects with vertical loop geothermal fields with similar granite bedrock conditions in the region. Examples include Mosinee Elementary School (48 bores) and Shawano Elementary School (150 bores).

Preliminary analysis using GSHP Calc modeling software indicates that a geothermal field at the MFC would require approximately 22 bores 300 feet deep. The bores should be spaced out about 20 feet apart. A field that was, for example, 2 rows of 11 bores then would be approximately 20 feet wide by 200 feet long.

Horizontal Loop Geothermal Field

Soil type, moisture content, water table depth, and ground water movement determine the rate of heat exchange for a horizontal loop geothermal field. Moisture content, water table depth, and ground water movement can change on a weekly, seasonal, or annual basis in the soil layers near the surface, so a horizontal loop geothermal field must be sized in a way that carefully considers these changing factors. The Stockbridge Munsee Community has land use and wetland specialists on staff that have the skills and resources to log this data for use in a future project.

Using design methods in 2011 ASHRAE Handbook – HVAC Applications, a horizontal loop geothermal field would be approximately 225 feet by 250 feet and would contain approximately 40,000 linear feet of tubing 8 feet below grade. This corresponds well with other horizontal loop geothermal fields SEG has been involved with for similar types of buildings.

Heat Pumps

The existing mechanical system utilizes furnaces, so a geothermal system would require a complete change out of the units. Heat pumps that are specific for geothermal systems would be installed in the place of the furnaces. Controls would need to be upgraded, ductwork would need to be overhauled (see the recommendations earlier in the report), and a piping distribution including pumps, valves, and gauges would need to be added to the building. There is a considerable amount of room to work above the drop ceiling throughout the building to accomplish this.

The existing furnaces were installed in approximately 1998, so they are about 15 years old at the time of this report. On average, furnaces can be expected to last for an average of 18 years[1] with proper maintenance and operating conditions. With good maintenance and upkeep on the furnaces, they may not need replacement until the MFC is ready to move forward with a geothermal project.

System Recommendation

The recommended geothermal field type for the MFC is vertical loop due to more favorable life cycle economics as discussed further in the next section. A CAD drawing of a preliminary vertical loop geothermal field design for the site is included in Appendix C and has been provided to the Stockbridge Munsee Community as part of this report.

ECONOMICS ESTIMATES

The estimated costs and savings of vertical and horizontal loop geothermal systems are broken out below. Although a horizontal loop field costs less in upfront costs to install than a vertical loop field, the end difference is only about 5 percent because the remaining costs (heat pumps, ductwork, etc.) in the project are similar between the two project types.

Estimated Cost Comparison of Vertical and Horizontal Loop Geothermal Systems

System type	Vertical Loop	Horizontal Loop
Geothermal Field	$ 105,000	$ 80,000
Heat Pumps	$ 70,000	$ 80,000
Savings	($ 20,000)	($ 20,000)
Ductwork, Piping, Controls, Balancing	$ 170,000	$ 170,000
Total	$ 325,000	$ 310,000
Potential Incentives	($ 4,500)	($ 4,500)
Final Cost After Incentives	**$ 320,500**	**$ 305,500**

[1] 2011 ASHRAE Handbook—HVAC Applications, Chapter 37 Owning and Operating Costs, Table 4 "Comparison of Service Life Estimates."

Geothermal Field

The estimated cost of a vertical loop geothermal field has currently been running approximately $16 per linear foot of bore depth in Wisconsin. This cost includes all drilling and piping back to the building taking into consideration the MFC's granite bedrock conditions and the proximity of the borefield to the building. At 22 bores 300 feet deep each, this is 6,600 linear feet of accumulated bore depth, which would be estimated at $105,000.

Horizontal loop geothermal fields tend to cost less than vertical loop geothermal fields basically because it is a time, energy, and material intensive process to drill the bores in a vertical loop field. According to the MFC's electric utility CWEC, who offers horizontal loop geothermal system installation services for residential applications, local excavators are currently charging about $1,500 to excavate and backfill an area that is about 25 feet by 100 feet for typical residential projects. Considering the field for the MFC would be approximately 225 feet by 250 feet, would require a higher level of compaction for use as an athletic field, and would have more site earthwork (erosion control, etc.) than a typical residential system, it is estimated that the excavation costs would be about $45,000. This is in line with construction estimation reference tools, such as RSMeans Mechanical Cost Data 2010. If the water table is high at the time of installation and dewatering is necessary, the cost could be higher. Approximately 40,000 linear feet of heat exchange piping would be required, plus about 1,000 feet of main piping. This would cost approximately $35,000 for a total geothermal field cost of $80,000.

Heat Pumps

The estimated cost of heat pumps includes eight units for heating and cooling only (no ventilation) and one heat pump with energy recovery for ventilation. It is assumed the heat pumps would be distributed similarly to the existing furnaces with the current zones.

The ventilation unit is assumed to handle approximately 3,000 cfm using ASHRAE Standard 62.1 to estimate the maximum required ventilation rate for the different types of uses in the building (gym, office, class room, game room, etc). An engineering analysis would be required to determine the exact code ventilation requirements.

Heat pumps for a vertical loop geothermal system are estimated to cost $70,000 based on similar projects SEG has past experience with. The estimated heat pump cost for a horizontal loop system is $80,000 due to the larger capacity required for more extreme entering water temperatures and the addition of electric duct heaters for backup heating.

Savings

Since it is recommended that a system is installed around the same time the existing furnaces would be at the end of their lifetime, there would be costs saved in the form of not having to replace the furnaces as scheduled. This is estimated at approximately $20,000.

Ductwork, Piping, Controls, Balancing, Etc

It is assumed that the existing ductwork would be significantly overhauled. The ductwork sizes may need to be changed depending on the requirements of the new heat pumps. Even if the existing ductwork is the correct size, many improvements could be made to reduce fan energy and increase the overall system efficiency, sound, and comfort. These types of improvements include better placement of grilles and diffusers, flexible ductwork improvements (shortening flexible ductwork and improving supports), and rigid ductwork improvements (duct sealing, insulation, and high efficiency takeoffs).

This estimated cost also includes a new piping distribution system, including insulated piping from the mechanical room to each of the heat pumps, new condensate piping from each heat pump to a local drain, pumps, valves, gauges, and other piping accessories.

Controls would need to be upgraded. The estimated cost assumes that a basic building automation system that is viewable on the building operator's computer screen is included.

The estimated cost for this scope of work is the same whether a vertical or horizontal loop system is selected. It is estimated at $170,000, but could vary significantly depending on the quality of equipment and experience level of the contractor selected.

Total Costs

A project cost of $325,000 corresponds very closely with a rule of thumb seen in Wisconsin geothermal projects of $22 per ft^2 for a new building. This project would compare well with a new building because it is essentially an entirely new system (geothermal field, heat pumps, ductwork, piping, and controls), and the accessibility and large amount of room to work with above the ceiling will assist with making the installation easier than a typical retrofit would be.

Potential Incentives

The Focus on Energy program currently incentivizes qualifying retrofit geothermal systems in Wisconsin through their Business Program. In order to qualify, the building must be served by a utility that is a member of the Focus on Energy program. Using Focus on Energy's list of participating utilities, CWEC is not listed as a member utility. However, the CWEC representative contacted for this study reported that they try to match Focus on Energy's programs and incentives. Focus on Energy's program awards an incentive of approximately $0.30 per square foot through their custom project program for similar projects as this one, and the CWEC representative confirmed that they would attempt to match an incentive of approximately $4,500 for the 15,100 ft^2 facility. Focus on Energy and utilities are continuously updating and changing their specific incentive programs, so the Stockbridge Munsee Community would have to contact CWEC for further details on the specific eligibility requirements of this incentive at the time of the project.

Life Cycle Cost Analysis

The table below outlines the estimated system cost, energy saved, incentives available, payback period, and environmental impact in terms of CO_2 offset for both vertical and horizontal loop geothermal systems. The payback analysis includes a rate of escalation of 7 percent on propane rates, which is equal to the long-term historical rate for commercial use in the U.S., and 3 percent on electrical rates, which is equal to the long-term historical rate for commercial use in Wisconsin.[2]

Higher operating costs were accounted for the horizontal loop geothermal field due to a 10 percent lower efficiency (lower heating COP and cooling EER) and 5 percent increased supplementary heating (electric resistance or propane).

The majority of the building's propane use would be eliminated by changing to a geothermal system. The furnaces would be replaced. The only propane-fueled equipment that would remain is the domestic water heater and kitchen stove.

The table below assumes that the ECMs described earlier in the report are followed. For example, it was assumed that the air sealing of the building was completed to reduce energy use. The estimated percentage of the building's total energy savings from a geothermal system is based on the projected usage after ECMs (814,500 kBTU/yr).

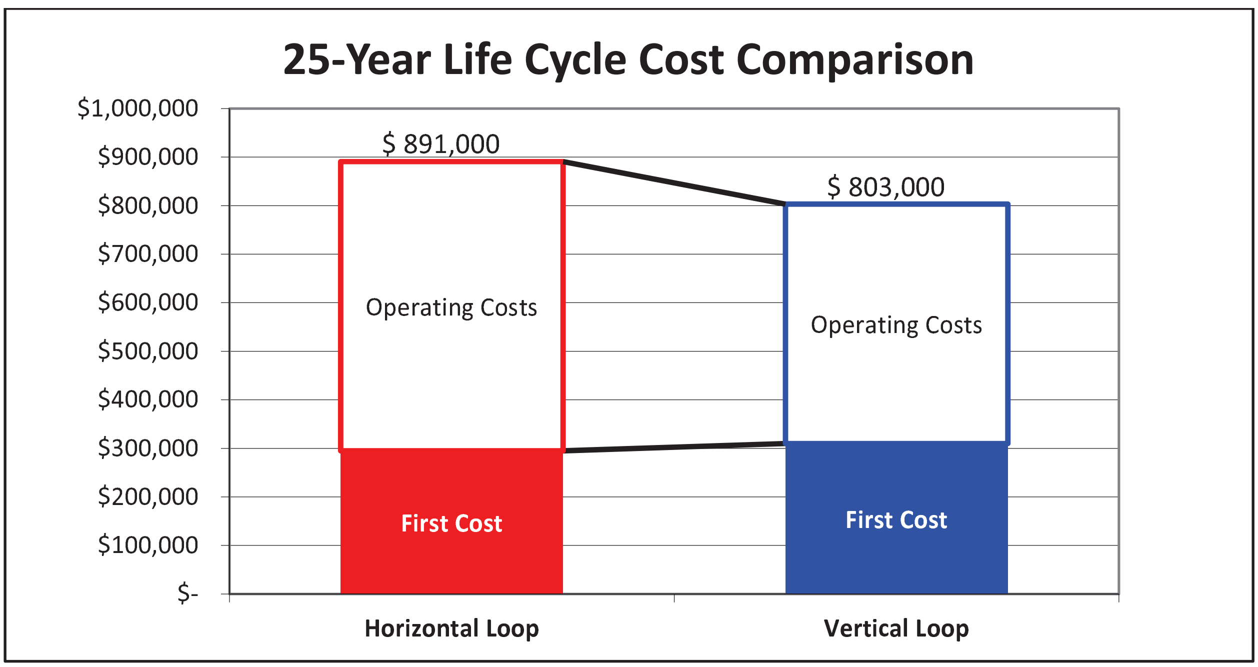

Figure 53. Over the course of 25 years, the vertical loop geothermal system carries a total cost of approximately $90,000 less than a horizontal loop system. Although the vertical loop system is slightly more expensive to install, it carries lower operating costs.

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[2] U.S. Energy Information Administration, www.eia.gov.

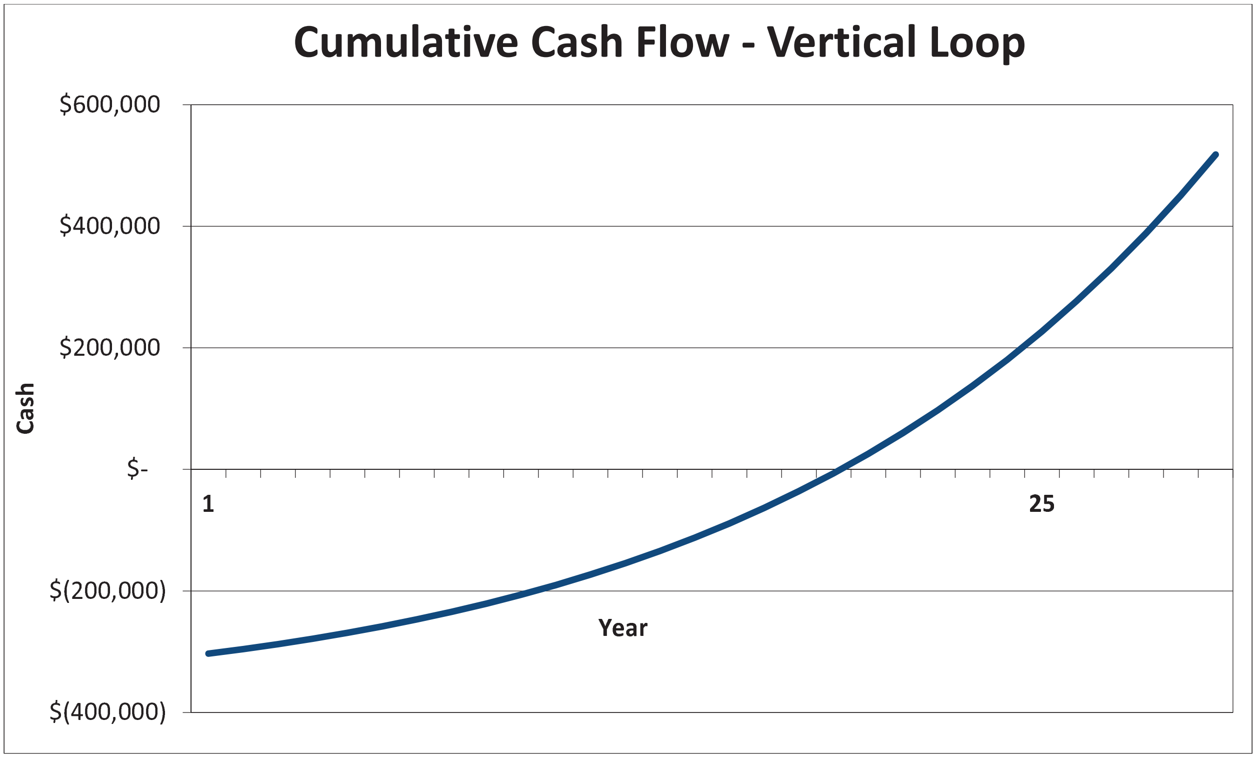


Figure 54. Cumulative cash flow for a vertical loop geothermal system showing positive cash flow (payback) at 20 years.

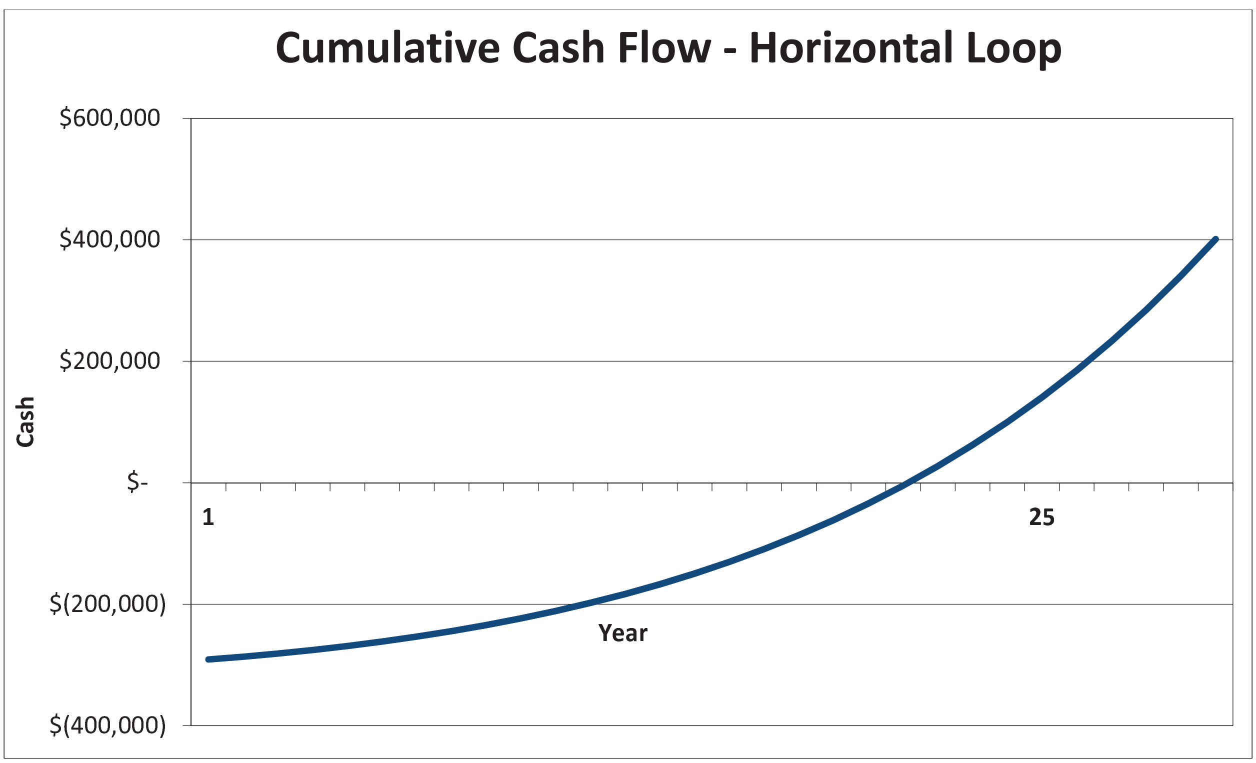


Figure 55. Cumulative cash flow for a horizontal loop geothermal system showing positive cash flow (payback) at 22 years.

Production		
System type	Vertical loop	Horizontal loop
Geothermal field size	22 bores, 300 ft deep	40,000 lf
Estimated propane offset	5,600 gallons/yr	5,600 gallons/yr
Estimated electricity increase	34,400 kWh/yr	60,000 kWh/yr
Estimated total site energy offset	395,900 kBTU/yr	308,500 kBTU/yr
Percentage savings of total building's energy	49 %	38 %
Cost and Economics		
Installed cost	$ 325,000	$ 310,000
Incentives	$ 4,500	$ 4,500
Final cost after possible incentives	$ 320,500	$ 305,500
ROI, 25-yr average	3.5 %	2.2 %
Simple payback period	20 yrs	22 yrs
Environmental Impact		
CO_2 emission reduction (increase)	7 ton/yr	(13 ton/yr)*
* The horizontal loop geothermal field results in an increase in CO_2 emissions. Although it offsets about the same amount of propane as the vertical loop field, the increase in electrical use is significantly higher and therefore the CO_2 emissions are higher as well.		

Table 14. Estimated production, cost and economics, and environmental impact of vertical and horizontal loop geothermal systems.

SOLAR ELECTRIC (PV)

TECHNOLOGY OVERVIEW

PV systems use the sun to produce electricity. When sunlight hits PV modules, electricity is generated in the form of direct current (DC). Modules are wired to one or more inverters, which are electronic devices that transform the DC into alternating current (AC). This is the same type of electricity used in buildings, and the inverter matches the characteristics of the power that the electric utility provides.

When a PV system generates more electricity than the building is consuming, a typical system allows the power to go backwards through the building's meter and out to the grid. In this scenario, the meter keeps track of the excess energy being generated and the customer receives a credit for it. Otherwise, when the building demands more energy than the system is generating, the extra necessary power is drawn from the grid to supplement the PV production.

Being grid-tied in this manner is a significant advantage of PV systems compared to other solar energy systems, such as solar thermal systems. PV systems are able to use the grid like a battery and every kilowatt-hour is either used in the building or credited to the owner. In contrast, solar thermal systems generate thermal energy, which remains on-site (usually in a storage tank) until it is used and excess energy generation is generally wasted. Solar thermal systems are discussed in greater detail in their own section of this report.

Figure 56. A photo of a typical PV system on a roof type that is similar to the metal roof on the MFC.

Grid-tied PV systems are as reliable as the electrical grid itself. For some buildings the grid is extremely reliable and is hardly ever down, while for others it means frequent outages. If the grid is down for any reason, a grid-tied PV system would immediately and automatically shut itself down. Even though the building would have electricity from its generator, the PV system would shut down due to a safety feature of the inverter. As soon as the grid comes back up, the system would automatically restart and perform as normal.

The most commonly installed PV systems do not use batteries for storage. A battery-free system is generally preferred because it requires simpler and fewer components than those with batteries, which lowers system cost. Batteries also require a large amount of maintenance, have special storage considerations, and need to be replaced at a significant cost every five to ten years. Battery backup systems are a better application when either grid power is not available or a generator does not already provide backup power.

PROJECT RECOMMENDATIONS/COMMENTS

PV systems can be located on the roof or on the ground. Roof mounted systems are often preferable because they are out of the way and do not consume land space. There is a considerable amount of land space near the baseball field, but this is not a recommended area for a PV system due to the risk for damage. The recommended PV system is a roof mounted system, and there is enough roof space to achieve a system size that would offset at least 30 percent of the building's energy demand after all of the efficiency measures covered in this report are accounted for (a 65 kW system would offset 78,400 kWh, or 33 percent of the building's energy demand). However, due to utility interconnection policies and the electrical loads of the building, a system no larger than 40 kW is recommended for economic feasibility reasons.

The roof is a shallow pitched metal roof product with a trapezoidal rib. The two-story west wing is an east-west gable roof pitched at approximately 2/12 (9°), while the one-story east wing is an east-facing shed roof pitched at approximately 1.5/12 (7°). The west wing contains about 74 feet by 118 feet of total roof space and the east wing about 54 feet by 118 feet of total roof space. All roof surfaces pitch to the east or west, so arrays of PV panels would need to be tilted up off the roof to face southward.

Access to the underside of the roof was too limited to identify the specific structural elements due to the roof insulation system. The metal roof panels appear to be structural and span across purlins that are spaced approximately 4 to 6 feet on center. There may be additional purlins that are concealed behind the insulation, but the main purlins that were visible are approximately 6 inches deep judging by the thickness of the insulation, and they span across beams that are approximately 24 feet spaced on center. All structural elements should be verified prior to proceeding with a PV project. A structural analysis should consider the effects of sliding snow and ice since this building experiences significant snow and ice buildup. The snow and ice can shed off in very large sheets and could affect tilt-up rack hardware for PV arrays. A qualified structural engineer should be consulted during the planning and design phases of a PV project.


Figure 57. A view of the building's roof slopes from the south (left).
Figure 58. An example of a large sheet of ice beginning to shed off the roof (right). Sliding snow and ice should be considered as part of the structural analysis for a PV system.

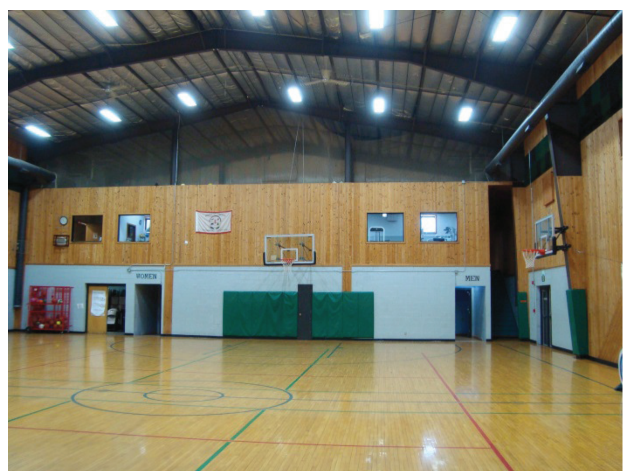



Figure 59. A view of the underside of the metal roof product (left).
Figure 60. A view of the roof structure (right). The main beams and purlins can be seen in this photo.

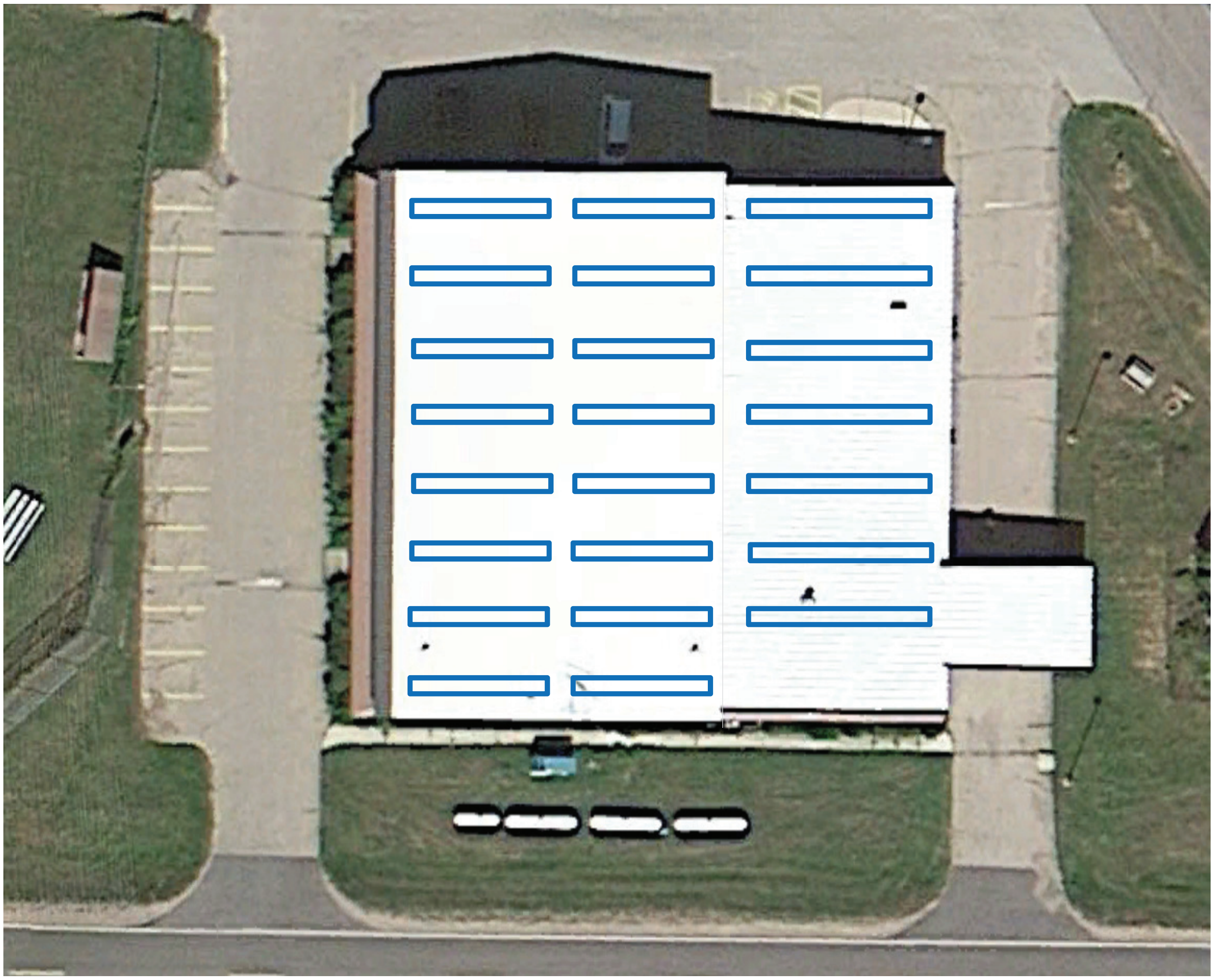


Figure 61. This aerial photograph shows the plan view of the roof. The blue-outlined rectangles are a schematic representation of the PV arrays used as a basis for this report. The total system capacity shown would amount to 65 kW to offset at least 30 percent of the building's energy use. A 40 kW system is being recommended and would use less roof space than shown. An area on the southeast corner of the roof is reserved for a solar thermal system discussed in a later section of this report.

Ideally, a PV system would face due south and be pitched at approximately 35 degrees for the best year-round production in Wisconsin. In this case, it was assumed that the panel tilt would be reduced to 30 degrees, which shortens the required inter-row spacing between the arrays and thereby allows a greater number of PV modules on the roof. This maximizes the total system capacity and system generation. A PV module's production takes a less than 1 percent deduction by being tilted at 30 degrees instead of 35 degrees, but the overall system generation increases by 15 percent due to the extra panels that could fit on the roof. The lower angle also reduces wind loading on the system and makes the system less visible.

The main electrical meter and service entrance are located on the south exterior wall near the middle of the building. The electrical panels are in the mechanical room, which can be seen on the floor plan in Appendix A.

PV system size and production are broken out below in Table 15.

Estimated System Production to Offset 30% of Building's Energy						
	Available Roof Dimensions	Direction (Azimuth)	Tilt (Deg)	Capacity (kW-DC)	Shading	Production (kWh/yr)
West Wing	74' x 118'	S (180°)	30°	38.4	0 %	46,300
East Wing	54' x 118'*	S (180°)	30°	26.6	0 %	32,100
Total				**65 kW**		**78,400 kWh/yr = 267,500 kBTU/yr**

* The roof on the east wing of the building is 54' x 118' and could hold a total of about 30 kW of PV. However, a portion is reserved for a solar thermal system, leaving room for approximately 26.6 kW of PV on the east wing roof section. See Table 17 for information on the solar thermal system.

Estimated System Production of Recommended System (Offset 20% of Building's Energy)						
	Required Area (ft^2)	Direction (Azimuth)	Tilt (Deg)	Capacity (kW-DC)	Shading	Production (kWh/yr)
West Wing	74' x 118'	S (180°)	30°	24.0	0 %	29,000
East Wing	54' x 118'*	S (180°)	30°	16.0	0 %	19,300
Total				**40 kW**		**48,300 kWh/yr = 164,800 kBTU/yr**

Table 15. PV system size and production estimates.

Assumptions in Table 15:

- The southernmost portion of the roof on the east wing is reserved for a solar thermal system for domestic water heating. However, it could be used entirely for a PV system instead, if desirable.
- The PV module used for the purposes of estimating capacity and production is an average 240-watt module with a dimension of 40" x 66". There are several similar products that essentially meet this description and are high quality, competitively priced, widely available, and U.S.-manufactured.
- System production was estimated using PVWatts v.1, which is available at: http://www.nrel.gov/rredc/. Production estimates were derived using climate data from Green Bay, Wisconsin with a de-rate factor of 0.77 to account for DC-to-AC losses, wire losses, and snow cover.

The economic value of the solar-produced electricity depends on the size of the PV system and how much energy is used on site or sent back to the grid. Policies for interconnecting PV systems to the grid vary from one electric utility to the next. CWEC reports that for small systems (less than 20 kW), excess power sent out to the grid is credited at a rate of $0.0705 per kWh.

Systems larger than 20 kW may receive a negotiated rate for excess generation. Many utilities consider this on a case by case basis, but the negotiated rate is sometimes as low as their avoided cost of producing the electricity at the power plant and is usually significantly less than the retail rate. A typical avoided cost rate is about $0.03 per kWh.

However, it is possible to maintain the full retail value ($0.11 per kWh) of all generation to the facility as long as generation never exceeds the consumption over the utility's "true-up" period. The true-up period is typically one month. As long as the generation remains below the building's total consumption during every monthly period, the PV generation is fully counted toward the building's consumption and would offset the electric bill by the full retail value of the electricity.

To determine the largest size PV system that could be installed at the MFC without exceeding the building's monthly energy usage, the predicted monthly PV production was plotted against the building's historical minimum monthly usage in Figure 62 below. The consumption graph looked at the data from November, 2011 through October, 2013, and used the minimum value in each month throughout the two years to account for a typical low energy-use year. Consumption was also reduced to factor in the energy conservation measures suggested in the report. A PV system would peak in production in May through July due to longer, sunnier days than the rest of the year, while electrical loads are volatile during this time period due to fluctuating cooling loads. A 40-kW PV system remains just below the minimum estimated consumption of the MFC.

The penalty for exceeding the building's consumption with PV generation is insignificant if it happens only rarely, but it can add up if it happens frequently. Any excess electrical production that gets sent to the grid at the end of the true-up period would receive the negotiated electrical rate of approximately $0.03 per kWh. A system that frequently receives this negotiated rate for excess generation will have less desirable economics than a system that generates less than the building uses. Since a 40-kW PV system avoids this penalty, the remaining analyses in this report will be limited to this system size.

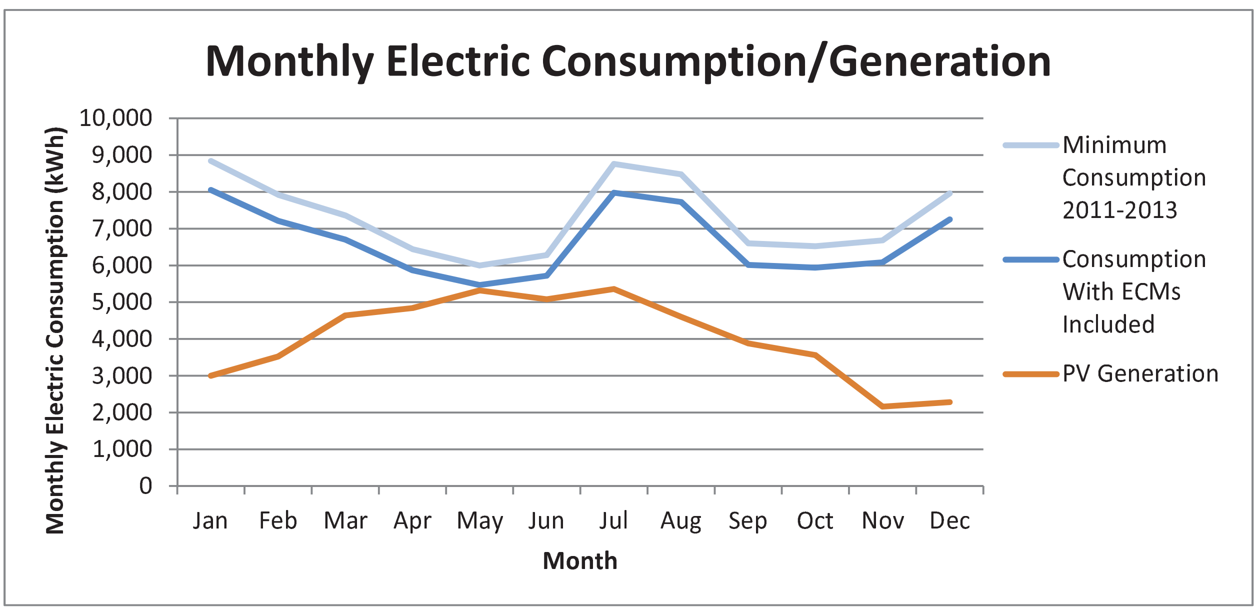


Figure 62. The estimated monthly electrical generation of a 40-kW PV system remains less than the estimated monthly electrical consumption before and after ECMs are included.

ECONOMICS ESTIMATES

Large-scale PV systems currently cost $4,000 to $5,000 per kilowatt installed on average, which would be a total of $160,000 to $200,000 for a 40-kW system.

The primary source of incentives available for non-profit/government facilities in Wisconsin is the Focus on Energy program. In order to qualify, the building must be served by a utility that is a member of the Focus on Energy program. Using Focus on Energy's list of participating utilities, CWEC is not listed as a member utility. CWEC's website states that no incentives for renewable energy systems are available at this time, but the CWEC representative contacted for this study reported that they try to match Focus on Energy's programs and incentives and they offer an incentive for solar electric systems that amounts to 30 percent of the system cost with a cap of $1,500. Focus on Energy and utilities are continuously updating and changing their specific incentive programs, so the Stockbridge Munsee Community would have to contact CWEC for further details on the specific eligibility requirements of this incentive at the time of the project.

There is also a federal tax credit incentive for solar energy systems that is in place through 2016 that would cover up to 30 percent of the total installed project costs. It is not believed the MFC would be eligible for federal tax credits due to a lack of federal income tax liability, and there are currently no programs in place to take advantage of the credit for non-profit/government facilities. If the MFC does have federal income tax liability, it would be recommended to consult a qualified tax professional to determine the MFC's specific eligibility for this incentive.

Assuming the project receives no assistance with economic incentives, the payback would be 28 years. A cash flow graph and other calculated parameters are included below. The analysis includes a rate of escalation of 3 percent on electric rates, which is equal to the long-term historical rate for commercial use in Wisconsin.[3]

It was examined whether demand charges could be reduced due to the generation of a PV system, but the MFC experiences a large portion of its electrical consumption during the winter months. This is likely due to greater lighting loads when the days are shorter and cloudier, and due to greater fan energy from the furnaces. Therefore, it could not be assumed that it would necessarily be sunny – and therefore the PV system would be operating – while the building was under peak load.

[3] U.S. Energy Information Administration, www.eia.gov.

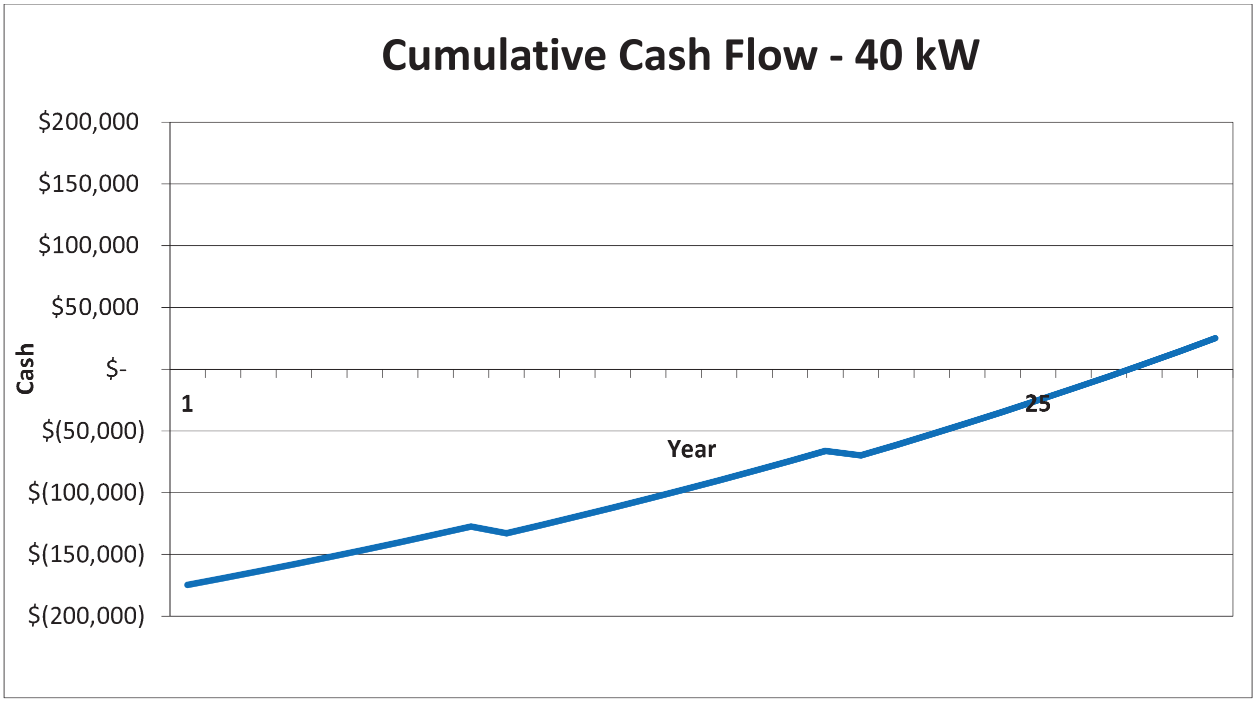


Figure 63. Cumulative cash flow for a 40-kW PV project showing positive cash flow (payback) at 28 years. The dips in the curve every ten years are due to typical costs incurred for the replacement of the inverters.

Production	
PV system's rated module capacity	40 kW (DC)
Estimated system output	48,300 kWh/yr
Estimated system output (site energy)	164,800 kBTU/yr
Percentage of total building's energy	20 %
Cost and Economics	
Installed cost	$ 180,000
Incentives	$ 1,500
Final cost after possible incentives	$ 178,500
ROI, 25-yr average	-1.1 %
Simple payback period	28 yrs
Environmental Impact	
CO_2 emission reduction	39 tons/yr

Table 16. Estimated production, cost and economics, and environmental impact of a 40-kW PV system.

SOLAR THERMAL

TECHNOLOGY OVERVIEW

Solar thermal systems collect heat from the sun to be used for domestic water heating, pool heating, and occasionally for winter space heating. This building does not have a swimming pool but there is a small domestic hot water load that would be well served by a solar thermal system. A winter space heating system could be an option if some significant challenges are overcome as discussed later on in this section on solar thermal systems. Winter space heating systems are sometimes called combination systems because they typically serve domestic hot water loads in addition to the space heating loads.

In Wisconsin's climate, the solar thermal system must utilize a reliable strategy to prevent the heat transfer fluid from freezing. One common system type way to do this is by using 50 percent glycol in a type of system that is usually called a pressurized-glycol system. There is a second freeze-protected system called a drainback system, which drains the collectors of the fluid whenever the system is off due to insufficient temperatures (i.e., cloudiness, nighttime, etc). This type of system can use water as the fluid, but these often use glycol for an additional layer of insurance.

Figure 64. A photo of a typical solar thermal system used for domestic water heating and/or winter space heating.

In both types of systems, the type of glycol is normally propylene glycol because it is non-toxic and products are available that are specially formulated for service in solar thermal systems. A pump turns on to circulate the fluid through the system whenever the collectors are hot enough. The fluid is heated as it flows through the collectors and transfers this heat to a storage tank with heat exchanger in the mechanical room. In a domestic water heating system, this storage tank would be piped inline before the building's propane water heater. In a winter space heating system, this storage tank would ideally still be located near the propane water heater, but the location may be somewhat more flexible in this case due to the furnaces being distributed throughout the building.

PROJECT RECOMMENDATIONS/COMMENTS

Two types of solar thermal systems will be discussed in this section – one that serves just the domestic water heating loads of the building, and one that serves both domestic hot water and winter space heating loads of the building (i.e., a combination system).

Domestic Water Heating System

Like a PV system, a roof location is typically preferred for a solar thermal system to lower the risk of accidental damage and to preserve usable land space. A solar thermal system for domestic water heating is relatively small in size, so there would be no benefit of installing a system on the ground for additional space allowances.

The size of a solar thermal system is based on the domestic hot water load. The hot water load from this building's restrooms, locker rooms, and kitchen would be most closely compared to a school, which is about 0.6 to 1.8 gallons per occupant per day[4]. Since there is an average of approximately 40 occupants per day (including staff and users), it is estimated that the total daily hot water load for the building is around 50 gallons per day, for five days per week. This is just an estimate, and a water meter with data logger could be installed for a temporary period of time to determine the actual hot water consumption.

A system that would be a good fit for this load would be one 4 ft x 10 ft collector (40 square feet) paired with a 50-gallon storage tank. A good location for the collector would be on the southernmost roof area of the east wing of the building, and it is recommended to mount the collector in a landscape orientation (i.e., such that it is 4 ft high and 10 ft long) for better wind loading characteristics and aesthetics. Either a drainback or pressurized-glycol system would be suitable in a domestic water heating application, but pressurized-glycol systems offer better freeze protection, are better suited for landscape-oriented collectors, and have less pumping energy consumption in such a small system.

[4] 2011 ASHRAE Handbook—HVAC Applications, Chapter 50 Service Water Heating, Table 7 "Hot-Water Demands and Use for Various Types of Buildings."

Even with a PV system as discussed in the previous location, there would be sufficient space for this system on the roof. The roof is a shallow pitched metal roof product with a trapezoidal rib. The one-story east wing is an east-facing shed roof pitched at approximately 1.5/12 (7°). Since the roof surface on the east wing pitches to the east, the solar thermal collector would need to be tilted up off the roof to face southward at approximately a 45° angle. It may be desirable, however, to tilt it at a 30° angle to match the tilt of PV panels aesthetically, as well as to reduce shading on PV panels behind the solar thermal collector.

One benefit of the location on the southernmost roof area on the east wing is that it is closer to the mechanical room. Compared to PV systems, solar thermal systems are more sensitive to proximity to the mechanical room because it is expensive to run insulated copper or stainless steel piping over long distances, and longer distances result in greater pumping energy and some heat loss from the pipes.

Figure 65. A view of the building's roof slopes from the south (left).
Figure 66. An example of a large sheet of ice beginning to shed off the roof (right). Sliding snow and ice should be considered as part of the structural analysis for a solar thermal system.

Figure 67. A view of the underside of the metal roof product (left).
Figure 68. A view of the roof structure (right). The main beams and purlins can be seen in this photo.

Access to the underside of the roof was too limited to identify the specific structural elements due to the roof insulation system. The metal roof panels appear to be structural and span across purlins that are spaced approximately 4 to 6 feet on center. There may be additional purlins that are concealed behind the insulation, but the main purlins that were visible are approximately 6 inches deep judging by the thickness of the insulation, and they span across beams that are approximately 24 feet spaced on center. All structural elements should be verified prior to proceeding with a solar thermal project. A structural analysis should consider the effects of sliding snow and ice since this building experiences significant snow and ice buildup. The snow and ice can shed off in very large sheets and could affect tilt-up rack hardware for the solar thermal collector. A qualified structural engineer should be consulted during the planning and design phases of a solar thermal project.

The propane water heater is located in the mechanical room, which is located near the south exterior wall in the middle of the building. The mechanical room location can be seen on the floor plan in Appendix A. There is room for a 50-gallon storage tank within about 10 feet from the water heater, in between the two furnaces in the mechanical room.

Figure 69. The domestic water heater (left).
Figure 70. The recommended location for the solar thermal storage tank is in between these two furnaces (right). Currently this space is used for general storage of folding tables and other supplies. The water heater is approximately 10 feet away and is located just to the right of the photo edge.

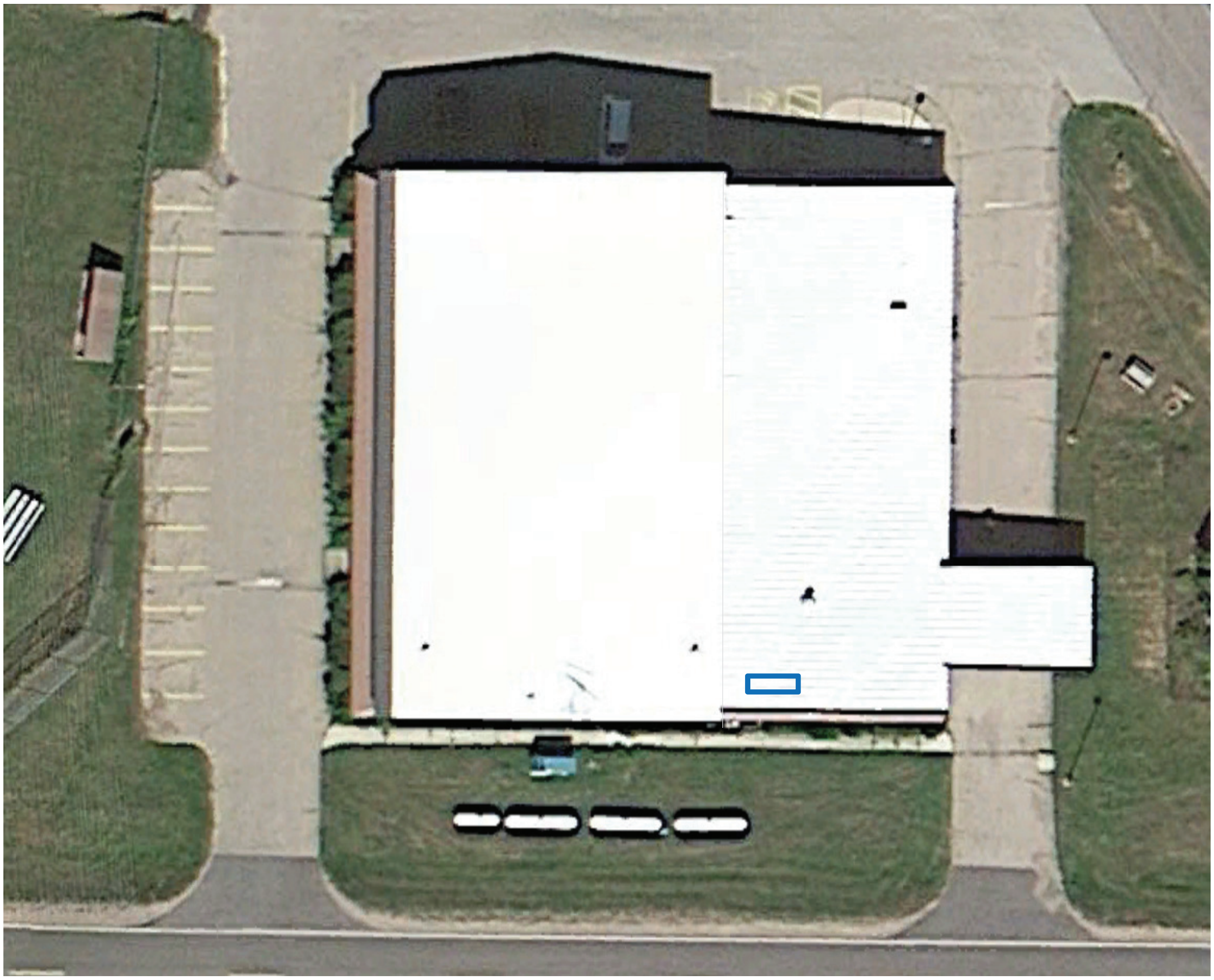


Figure 71. This aerial photograph shows the plan view of the roof. The blue-outlined rectangle is a schematic representation of the solar thermal collector used as a basis for this report. The remaining roof is reserved for a solar PV system discussed in an earlier section of this report.

System	Available Roof Dimensions	Direction (Azimuth)	Tilt (deg)	Size	Shading	Propane Offset
Domestic Water Heating	4' x 10'*	S (180°)	30°	(1) 4' x 10' collector	0 %	95 gallons/yr = 8,600 kBTU/yr
* The building's roof area would accommodate a larger system, but the majority of the roof area is reserved for a solar electric system. See Table 15 for information on the solar electric system.						

Table 17. Estimated energy savings (in gallons of propane) by a solar thermal system used for domestic water heating.

Assumptions in Table 17:

- The solar thermal collector used for the purposes of estimating production is an average flat panel collector with a nominal dimension of 4' x 10'. There are a wide variety of products and systems that could be used to achieve the same production, such as systems utilizing evacuated tube collectors or other sizes of flat panel collectors.
- System production was estimated using RETScreen v.4, which is available at: http://www.retscreen.net/. Production estimate assumes 80-percent thermal efficiency of the propane water heaters. The assumed hot water load is 50 gallons of hot water per day.

Combination System

Combination solar thermal systems provide heat for domestic water heating and winter space heating loads. A system could be designed to handle just winter space heating loads, but it is usually more cost effective to supplement both loads.

A roof location is typically preferred for PV and solar thermal systems, but combination solar thermal system collectors should be tilted up at a fairly steep angle (45 to 90 degrees from horizontal) in order to take advantage of the lower winter sun. Mounting steeply tilted solar collectors on a shallow pitched roof results in large wind loads and an unsightly system. It is instead suggested to mount solar collectors for a combination solar thermal system on the mansard roof that wraps around the building about halfway up the exterior walls. This is pitched at approximately 4 over 1, or 75 degrees. This would be a very good angle to mount solar collectors for a combination solar thermal system.

Since winter space heating is such a large load on a building (currently about 6,700 gallons of propane per year, or about 5,600 gallons of propane per year after ECMs), a combination solar thermal system can be a fairly large system. The size of a solar thermal system is based on the winter space heating load. A typical solar collector can deliver approximately 750 BTUs per square foot of collector on a sunny winter day in Wisconsin. Using the projected energy use of 5,600 gallons of propane per year, a system with 3,200 square feet of collectors would offset the building's winter space heating load on a typical sunny winter day. There is only about 800 square feet of roof area on the mansard roof, so a system would be limited to this size.

A system that would be a good fit for this available roof area would be thirty two 4 ft x 6 ft collectors (about 25 square feet each, 800 square foot total) paired with a 1,000-gallon storage tank. This storage volume could be comprised of one single 1,000-gallon tank, or several smaller tanks that are piped together that add up to 1,000 gallons. This storage system would be a central point to distribute heat to the domestic water heater and each of the distributed furnaces (which would need hot water coils added to them), heat pumps (in the case of a geothermal system), or fan coil units (in the case of a biomass boiler system). A hot water piping distribution system including insulated copper or steel piping throughout the building, control valves, circulating pumps with variable frequency drives (VFDs), and all necessary accessories (expansion tank, makeup water, thermometers, pressure gauges, etc) would be necessary to connect the solar thermal storage tank to the terminal units.

The biggest challenge with a solar thermal combination system would be coming up with enough space for the new storage tank(s). There is a storage area between the gym and mechanical room that is actively utilized for storing supplies for the MFC's programs. Perhaps the storage area could be reduced and the mechanical room could be enlarged for the new solar storage tank(s).

ECONOMICS ESTIMATES

Solar thermal systems currently cost about $175 to $200 per square foot of collector installed on average. There are economies of scale, so a small system may even cost a little more than range. It is estimated that a 50 square foot domestic water heating system would cost about $10,000, while an 800 square foot combination system would cost about $160,000.

The primary source of incentives available for non-profit/government facilities in Wisconsin is the Focus on Energy program. In order to qualify, the building must be served by a utility that is a member of the Focus on Energy program. Using Focus on Energy's list of participating utilities, CWEC is not listed as a member utility. CWEC's website states that no incentives for renewable energy systems are available at this time, but the CWEC representative contacted for this study reported that they try to match Focus on Energy's programs and incentives and they offer an incentive for solar thermal systems that amounts to 30 percent of the system cost with a cap of $1,500. Focus on Energy and utilities are continuously updating and changing their specific incentive programs, so the Stockbridge Munsee Community would have to contact CWEC for further details on the specific eligibility requirements of this incentive at the time of the project.

There is also a federal tax credit incentive for solar energy systems that is in place through 2016 that would cover up to 30 percent of the total installed project costs. It is not believed the MFC would be eligible for federal tax credits due to a lack of federal income tax liability, and there are currently no programs in place to take advantage of the credit for non-profit/government facilities. If the MFC does have federal income tax liability, it would be recommended to consult a qualified tax professional to determine the MFC's specific eligibility for this incentive.

Assuming a domestic hot water project cost of $10,000 and no incentives available, the payback would be 25 years. For a combination system cost of $160,000 and no incentives, the payback would be 29 years. Cash flow graphs and other calculated parameters are included below. The analysis includes a rate of escalation of 7 percent on propane rates, which is equal to the long-term historical rate for commercial use in the U.S.[5]

[5] U.S. Energy Information Administration, www.eia.gov.

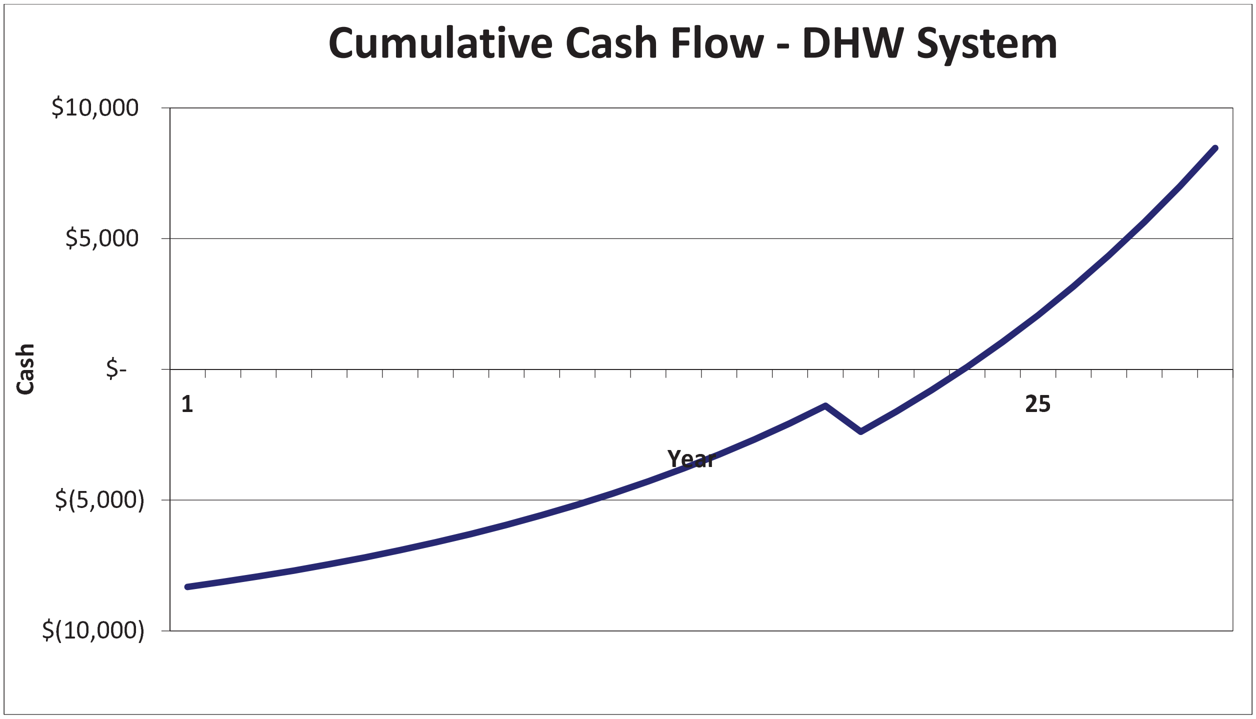


Figure 72. Cumulative cash flow for a 40 square foot solar thermal project for domestic water heating showing positive cash flow (payback) at 23 years. The bump in the curve at twenty years is due to typical costs incurred for the replacement of the fluid, pump, and tank.

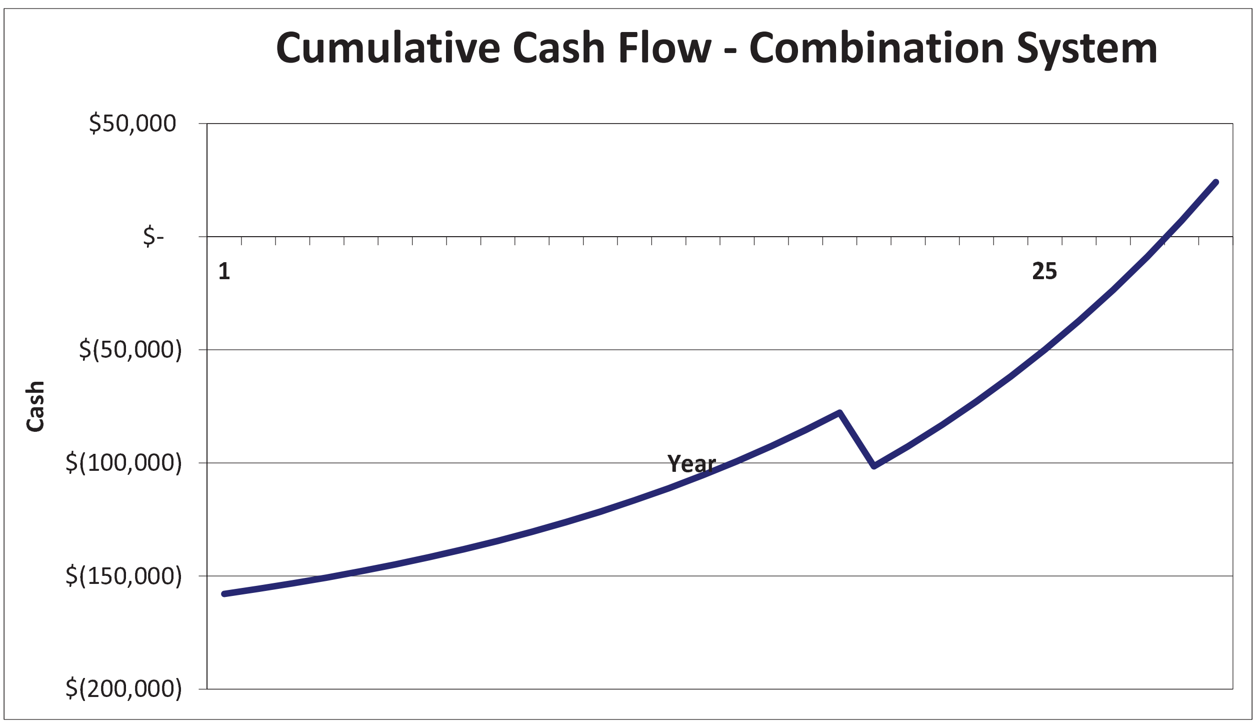


Figure 73. Cumulative cash flow for an 800 square foot solar thermal project for combined domestic water heating and winter space heating showing positive cash flow (payback) at 29 years. The bump in the curve at twenty years is due to typical costs incurred for the replacement of the fluid, pump, and tank.

Production		
System type	Domestic Hot Water	Combination
Solar thermal system's size	40 ft^2 / 50 gal	800 ft^2 / 1,000 gal
Estimated propane offset	95 gallons/yr	1,100 gallons/yr
Estimated propane offset (site energy)	8,600 kBTU/yr	100,800 kBTU/yr
Percentage of total building's energy	1 %	12 %
Cost and Economics		
Installed cost	$ 10,000	$ 160,000
Incentives	$ 1,500	$ 1,500
Final cost after possible incentives	$ 8,500	$ 158,500
ROI, 25-yr average	1.5 %	-2.4 %
Simple payback period	23 yrs	29 yrs
Environmental Impact		
CO_2 emission reduction	1 ton/yr	7 tons/yr

Table 18. Estimated production, cost and economics, and environmental impact of two solar thermal system types.

BIOMASS

TECHNOLOGY OVERVIEW

Biomass energy can come in many forms, including grass crops like switchgrass, manure, trees, and urban wood waste from tree and brush trimmings. This report will focus on wood-sourced biomass from trees because there are local wood resources potentially available through the Stockbridge Munsee Community Forestry Department. Wood-sourced biomass energy is considered renewable because trees can be produced and harvested sustainably, and the net zero carbon cycle occurs in a relatively short time period (i.e., the carbon dioxide that is released during combustion is equal to the amount of carbon dioxide absorbed in the tree's life).

Wood-sourced biomass can be chopped, pelletized, or chipped for use in wood boilers. Traditional wood boilers generate significant smoke, odors, and particulate pollution, which would be undesirable in a public facility. An important distinction can be made in wood gasification boilers, which take advantage of modern combustion techniques that are both more energy efficient and less polluting than traditional wood boiler design. Most modern commercial wood boilers can be considered gasification boilers.

Figure 74. Wood pellets (left) and wood chips (right).

In the gasification process, wood feedstock heats in an oxygen-starved environment until volatile wood gases are released. The wood gas is relatively low-energy (about 150 BTU/ft^3) when compared to natural gas or propane gas (about 900 to 1,000 BTU/ft^3). The gases are mixed with air for combustion in a boiler appliance to generate heat. This heat is in addition to the normal heat generated from burning the solid wood material.

After surveying a variety of biomass feedstock options, SEG chose to evaluate two types of feedstock: wood pellets and wood chips. For this study, both feedstocks are paired with a typical gasification wood boiler that can accommodate either type.

Both wood pellets and wood chips are viable candidates with important differences. Typically, either product would be purchased from a commercial dealer. Although pellet feedstock is more expensive than chip feedstock, wood chip boiler systems carry higher maintenance costs and are typically up to three times more expensive in upfront cost than pellet systems of the same heating capacity. There are several reasons for this price difference. First, wood chips are less dense than pellets and therefore supply less energy per unit volume. In order to provide the same amount of energy, a greater volume of wood chips than wood pellets are required. The volume difference translates into a larger storage footprint, usually involving a building dedicated to storing the chips. Second, wood chips are somewhat more difficult to process as combustion fuel as compared to pellets due to their irregular sizing. As a result, wood chip boilers require more robust equipment and a different 'burn box' than a comparable pellet system. The much higher price of the wood chip systems tends to steer customers toward pellet systems.

The Stockbridge Munsee Community has a significant local timber resource that might be utilized for biomass. The Community could produce either wood chips or wood pellets for themselves if they were willing to make the investment in a chipping or densification facility. While those facilities would be expensive, such an operation would reduce long term feedstock costs. According to a local supplier, the Community would need to supply enough feedstock for about 100 average buildings in order to make the investment in a chipping or pellet densification facility attractive. Due to the required investment to produce wood chips or pellets, it is assumed that the MFC would have to buy commercially available wood products for the purpose of this feasibility study.

If the Community intends to produce their own wood products, a more detailed study of wood feedstock production would be required. This study would analyze:

- Type of forest resource the Community would be willing to use – This would examine residues and full logs. An example of typical residues is shown in Figure 75.

Figure 75. Example of forest residues.

- How the Community would gather the materials – Residues are usually left behind in the forest during logging operations, but gathering them up could be expensive.
- The kind of feedstock the Community would produce -- There are some raw material size requirements dictated by the type of feedstock and processing equipment used to produce that feedstock. For example, wood chips cannot be produced with material smaller than the minimum chip size, usually at least 1 inch wide and 1.5 inches long. Two examples of wood chip production are shown in Figure 76.

Figure 76. Potential wood chip production options. Horizontal chipper (left) and portable chipper (right).

- Quantity of feedstock the Community would produce -- For a small volume, such as would be required at the MFC, there are opportunities to partner with an existing wood product producer. For a large volume, a full production facility could be built.

PROJECT RECOMMENDATIONS/COMMENTS

After considering the existing distributed furnace system, the recommended way to implement a biomass boiler system is install a hot water piping distribution system off of the biomass boiler. This new hot water piping system would feed several distributed fan coil units, which would replace the existing furnaces.

The following schematic illustrates how the mechanical system might look with the recommended wood boiler system. It includes the design changes discussed elsewhere in this study, such as air sealing the building. This design is merely a suggestion; a thorough design and commissioning should be done to ensure all system components are properly utilized. A biomass boiler system would include the following additions and changes to the existing mechanical system:

- Install the central boiler system – One new biomass boiler and one new propane boiler would need to be added to the building. The weight room and Pilates furnaces located in the mechanical room would be removed, but this likely would not be enough space for the new equipment. There is a storage area between the gym and mechanical room that is actively utilized for storing supplies for the MFC's programs. Perhaps the storage area could be reduced and the mechanical room could be enlarged for the new biomass and propane boiler equipment. The biomass boiler would be the primary source of heat and would be sized to offset a portion (for example 50 to 75 percent) of the design heat load of the building to ensure it operates at a high efficiency for as much of the heating season as possible. A propane boiler would be installed for redundancy and to allow for extra heating at times of peak heating loads.

- Install a hot water piping distribution system – This would include insulated copper or steel piping throughout the building, control valves, circulating pumps with variable frequency drives (VFDs), and all necessary accessories (expansion tank, makeup water, thermometers, pressure gauges, etc) to connect the boilers to the terminal units.
- Replace existing furnaces with fan coil units. The existing furnaces duct heaters have propane burners for heating and a DX coil for cooling. They would be replaced with a fan coil unit which would have a hot water coil for heating and a DX coil for cooling. All propane and vent piping to and from the existing furnaces could be removed. The hot water coils would connect directly to the boiler hot water loop, and the cooling coils would be provided cooling from outdoor air-cooled condensing units like the existing furnaces currently are. Since ventilation air is routed to the return side of the furnaces, this configuration could remain in the new fan coil units.

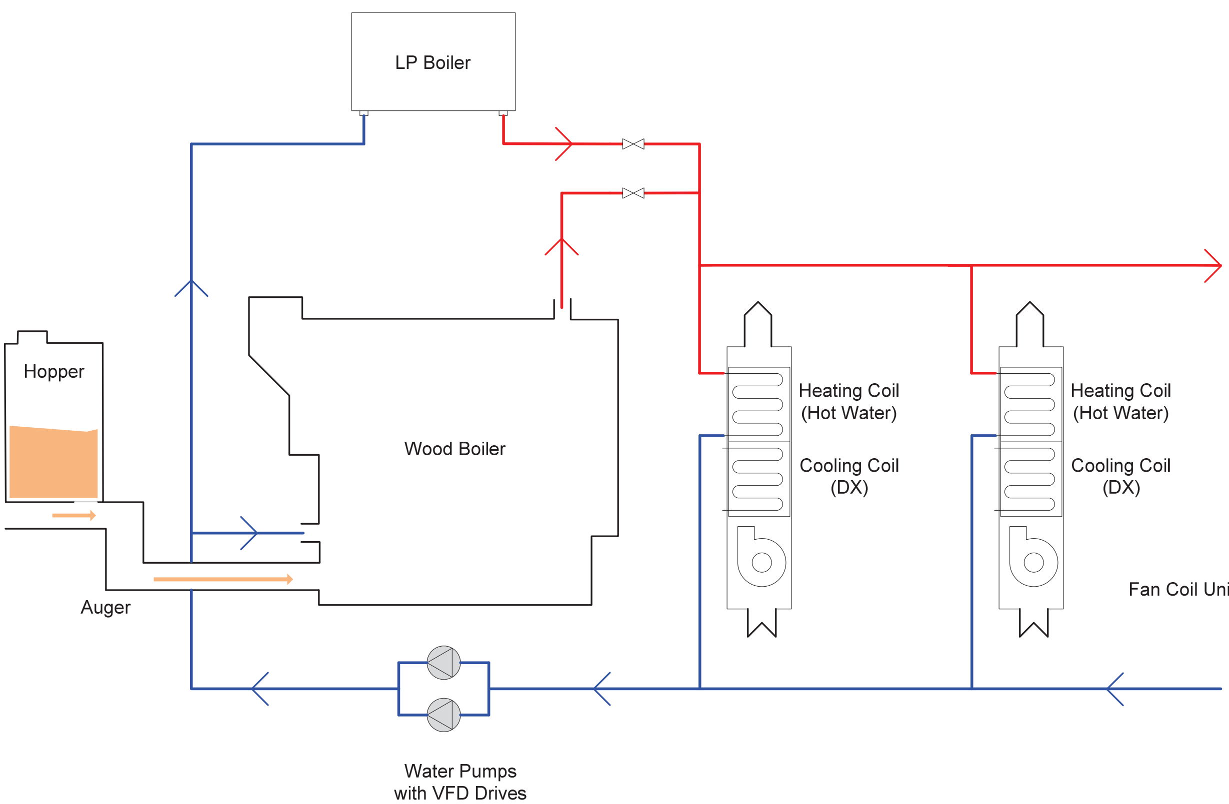


Figure 77. Wood boiler system schematic.

With the installation of a pellet or wood chip system, a location is required to place a hopper to store the feedstock. The hopper should be capable of holding enough supply to last at least 10 days of operation. A good candidate would be in a space near the current mechanical room, as shown in the photo below. The feedstock could be delivered in bulk and loaded directly into the hopper.

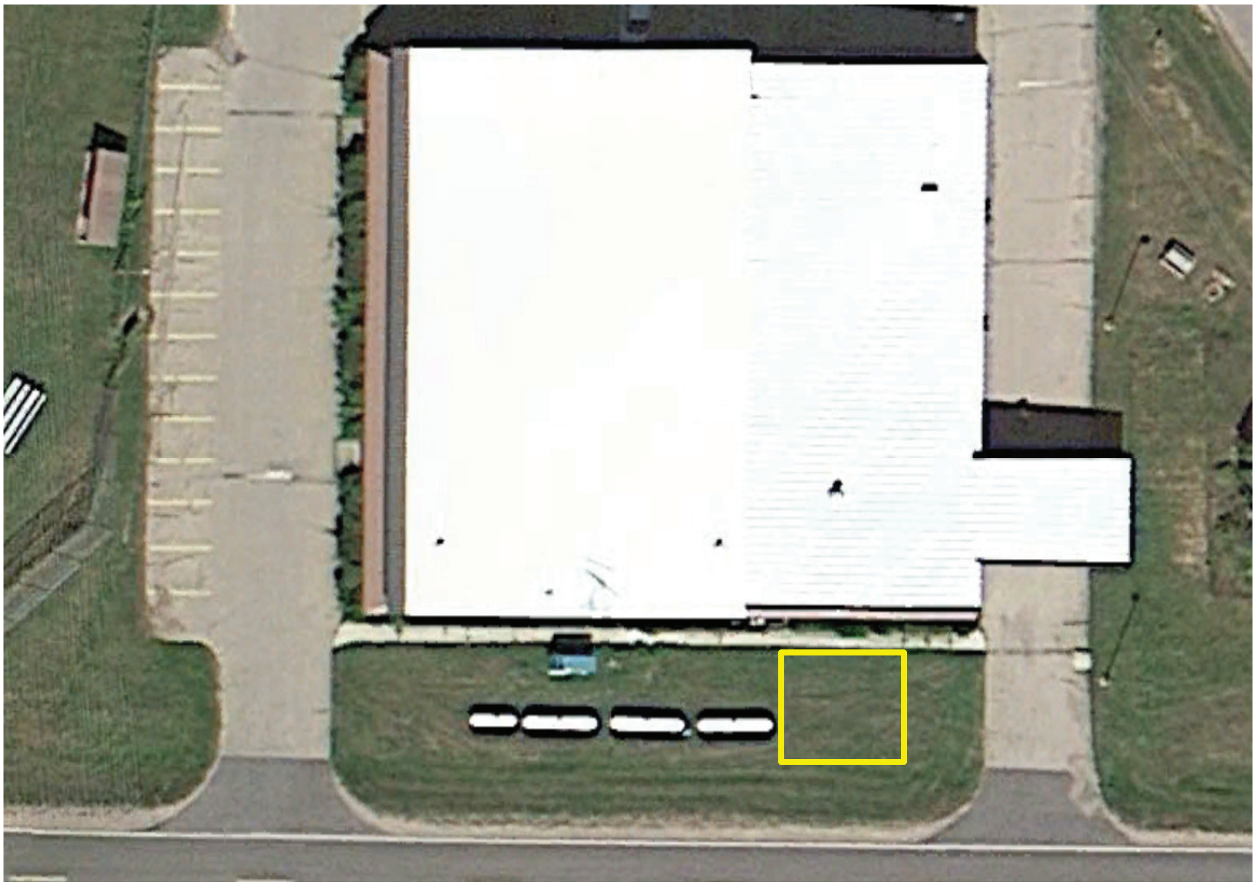


Figure 78. Possible biomass hopper location is outlined in yellow. The mechanical room location is along the south edge of the building, near the middle. The mechanical room location can be seen in the floor plan in Appendix A.

Although many manufacturers claim that emissions from wood boilers are equivalent to natural gas or propane combustion, the possibility of odors and poor air quality is a legitimate concern, especially at a public facility, that should be ruled out before proceeding with a project. If the Community is interested in exploring this option further, they could visit an already installed system to verify its performance and environmental impacts. Several nearby options are available:

- Ashland Memorial Medical Center, Ashland, WI (biomass heating system)
- Gundersen Health System, LaCrosse, WI (biomass heating system)
- Wolf Ridge Environmental Learning Center, Finland, MN (biomass heating district)

ECONOMIC ESTIMATES

A local supplier provided preliminary price estimate information that included the cost to implement a new wood boiler system (both wood pellet and wood chip), including feedstock, a feedstock storage bin, auger, and other required system components. The installed cost figures listed in the table below include the cost to make the recommended system changes described previously. The value used for wood pellets in this analysis is $1.12 per therm, while the value for wood chips used is $0.43 per therm (1 therm = 100,000 BTUs).

The Focus on Energy program currently incentivizes qualifying biomass systems in Wisconsin through their Business Program. In order to qualify, the building must be served by a utility that is a member of the Focus on Energy program. Using Focus on Energy's list of participating utilities, CWEC is not listed as a member utility. However, the CWEC representative contacted for this study reported that they try to match Focus on Energy's programs and incentives. Focus on Energy's program awards an incentive of approximately $0.30 per square foot through their custom project program for similar projects as this one, which would amount to an incentive of approximately $4,500 for the 15,100 ft² facility. Focus on Energy and utilities are continuously updating and changing their specific incentive programs, so the Stockbridge Munsee Community would have to contact CWEC for further details on the specific eligibility requirements of this incentive at the time of the project.

Additionally, there is a Woody Biomass Harvesting and Processing Tax Credit from the State of Wisconsin. This could be worth 10 percent of harvesting equipment cost with a cap at $900,000.[6] It is not believed the MFC would be eligible for tax credits due to a lack of state income tax liability, and there are currently no programs in place to take advantage of the credit for non-profit/government facilities. If the MFC does have state income tax liability, it would be recommended to consult a qualified tax professional to determine the MFC's specific eligibility for this incentive.

As seen in the following cash flow graphs, a biomass system with wood feedstock is a viable option for the MFC from a technological standpoint, but there are other more economical renewable energy options outlined in this report.

[6] Wisconsin Department of Agriculture, Trade and Consumer Protection, http://datcp.wi.gov/Business/Tax_Credits/Woody_Biomass_Harvesting_and_Processing_Investment_Credit/index.aspx, Obtained May 7, 2013

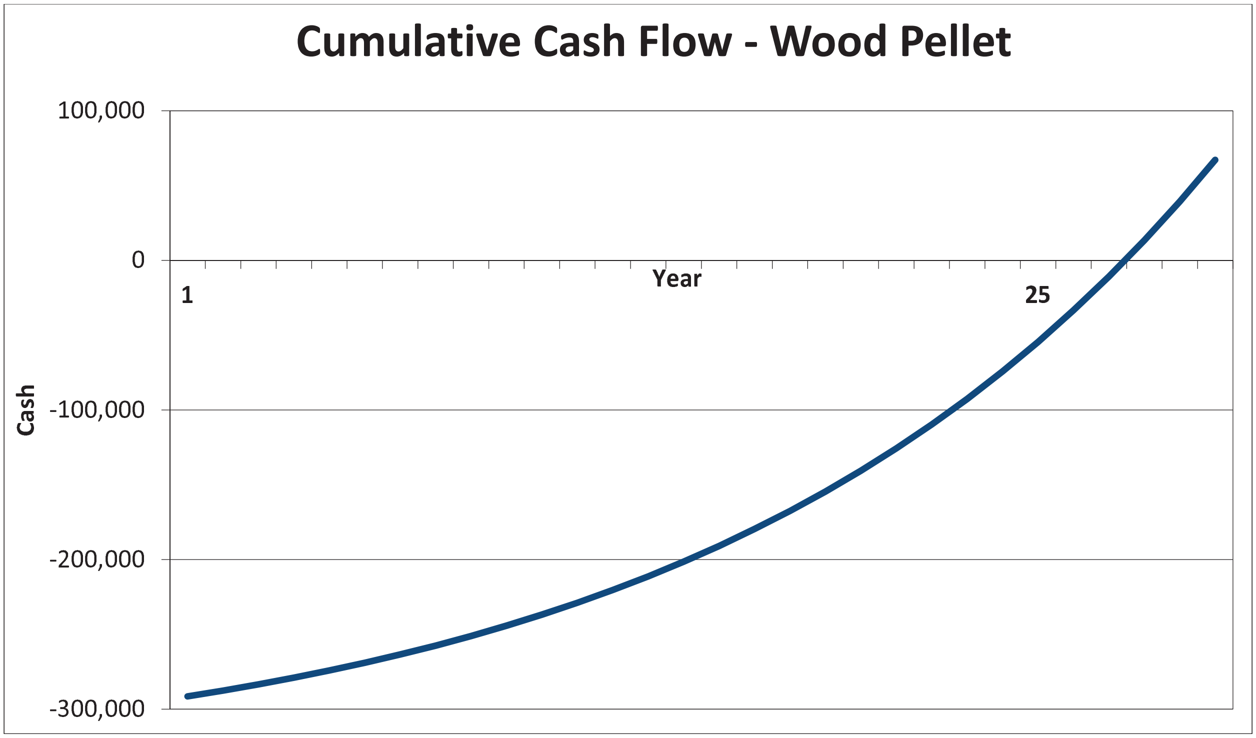


Figure 79. Cumulative cash flow for a wood pellet project showing positive cash flow (payback) at 28 years.

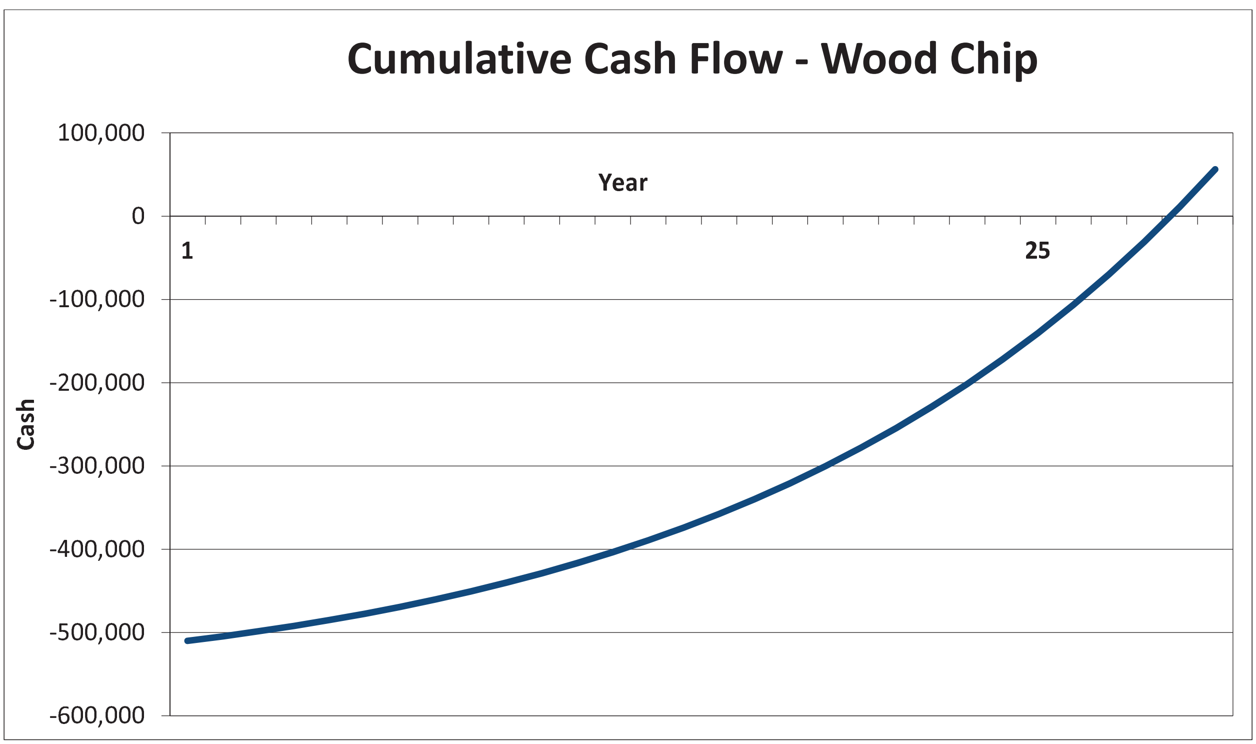


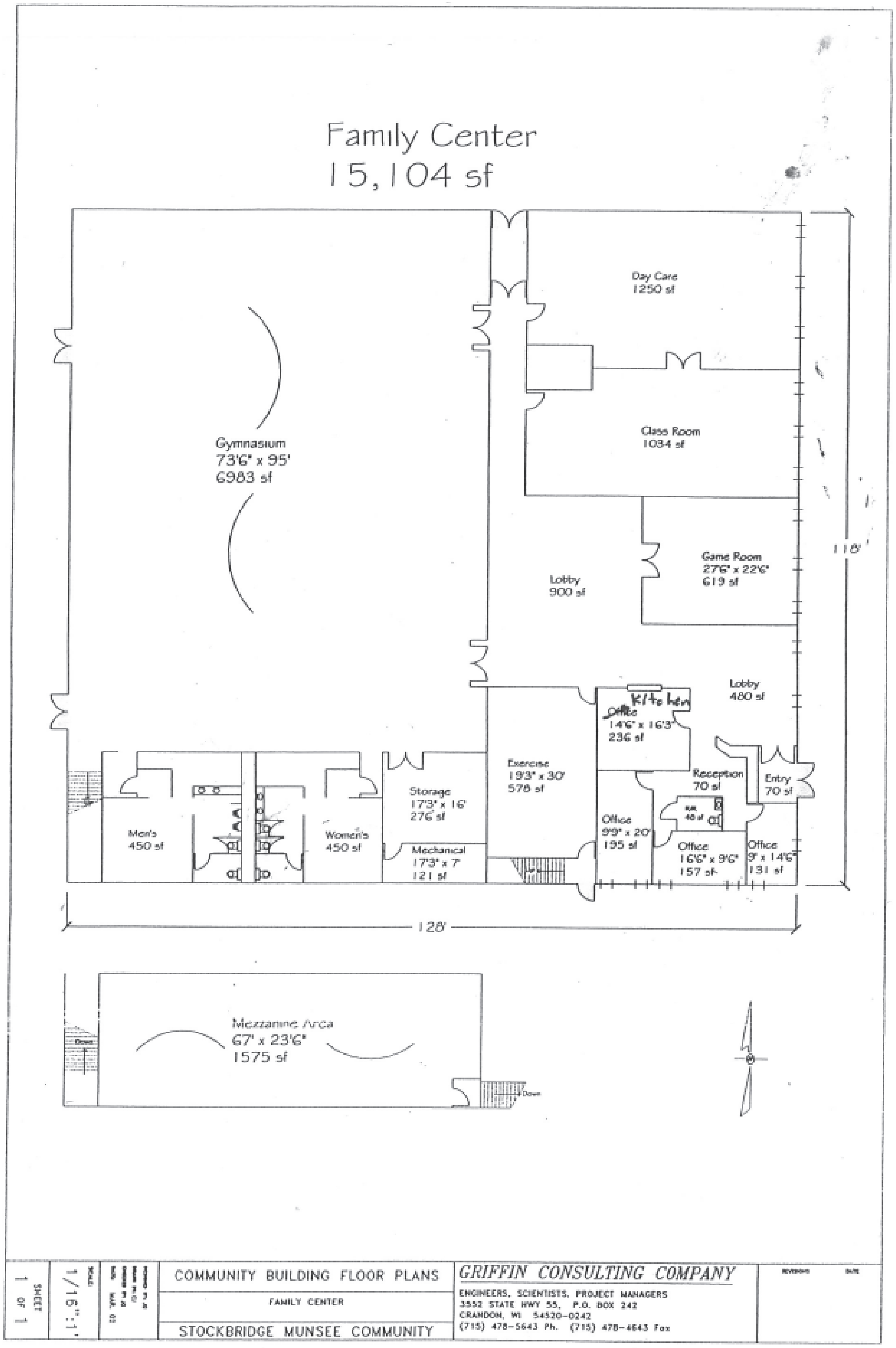
Figure 80. Cumulative cash flow for a wood chip project showing positive cash flow (payback) at 29 years.

Production		
Biomass system type	Wood Pellet	Wood Chip
System size	450 MBH	450 MBH
Estimated propane offset	4,500 gallons/yr	4,500 gallons/yr
Estimated total site energy offset	412,400 kBTU/yr	412,400 kBTU/yr
Percentage of total building's energy	51 %	51 %
Cost and Economics		
Installed cost	$ 295,000	$ 515,000
Incentives	$ 4,500	$ 4,500
Final cost after possible incentives	$ 290,500	$ 510,500
ROI, 25-yr average	- 1.2%	- 1.9%
Simple payback period	28 yrs	29 yrs
Environmental Impact		
CO_2 emission reduction	28 ton/yr	28 ton/yr

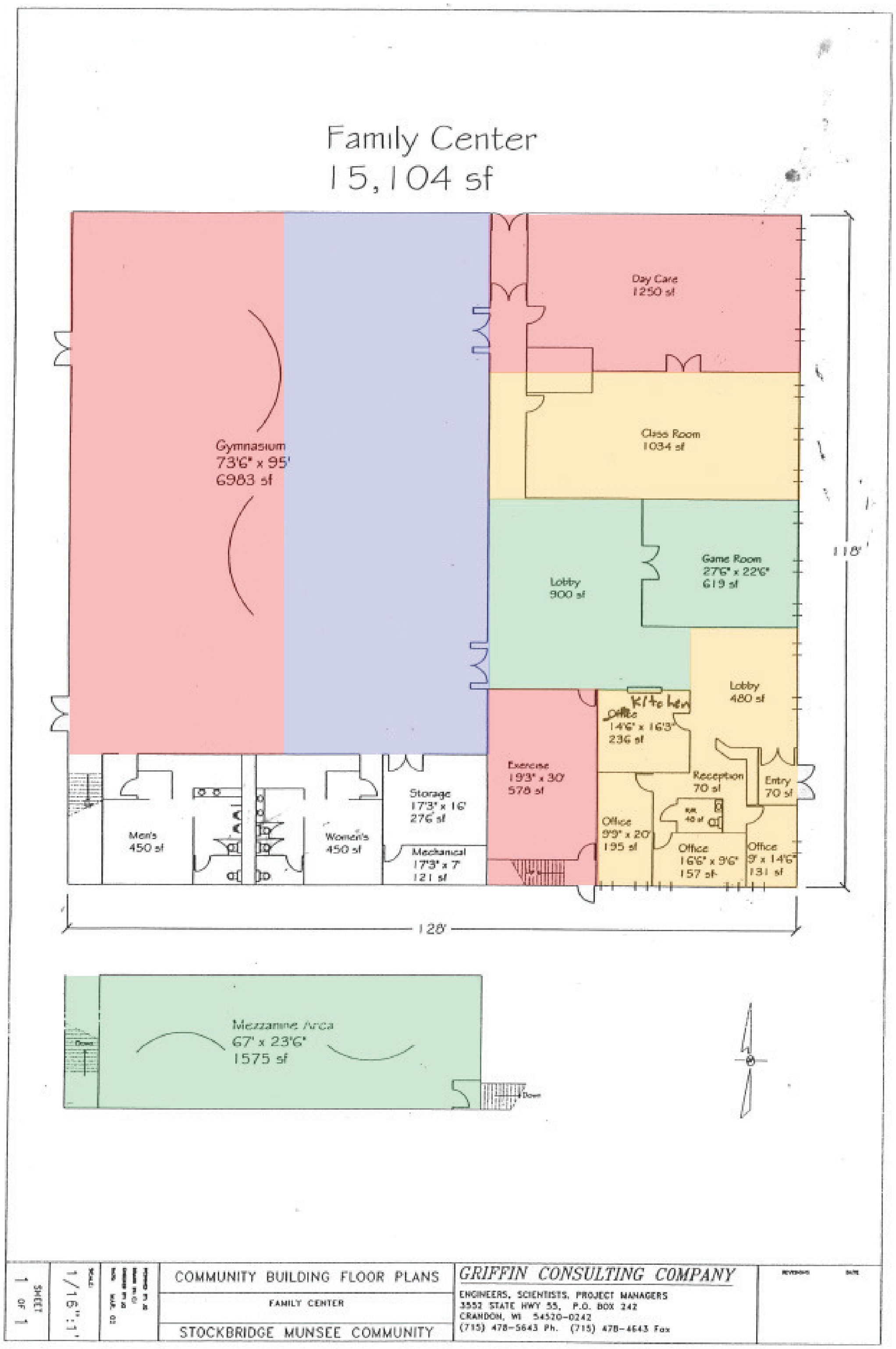
Table 19. Estimated production, cost and economics, and environmental impact of two types of wood boiler systems.

No matter the choice of feedstock, the payback period was calculated at 28 to 29 years, which may be much longer than the expected lifetime of the equipment. The long payback of such a system is due to the significant upfront cost of not just the biomass boiler system, but also reworking the existing mechanical systems to install a backup propane boiler, a piping distribution system with pumps and accessories, a new ductwork system with fan coil units, controls, and system balancing. The Community could potentially supply their own feedstock, which would save some fuel costs, but a detailed study would be required before making such a commitment and the upfront equipment costs for a new biomass system would remain.

APPENDIX A: BUILDING FLOOR PLAN



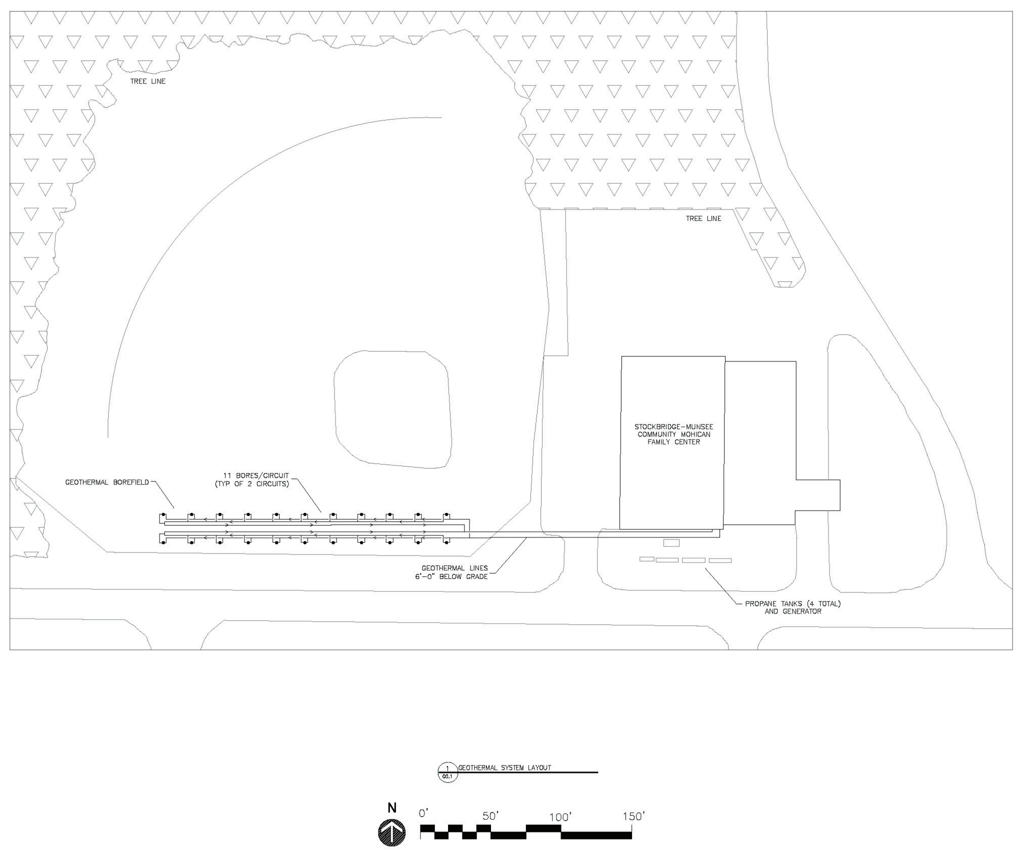
APPENDIX B: BUILDING FLOOR PLAN WITH HEATING ZONE MAP



APPENDIX C: GEOTHERMAL FIELD PLAN – VERTICAL LOOP

GENERAL NOTES:

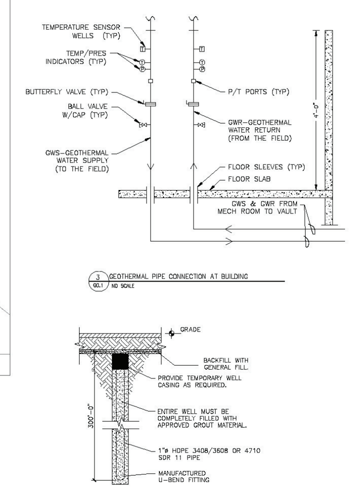
THIS IS A PRELIMINARY DRAWING NOT INTENDED FOR BIDDING OR CONSTRUCTION. THE INTENDED USE OF THIS DRAWING IS TO PROVIDE A REPRESENTATION OF A TYPICAL GEOTHERMAL BOREFIELD FOR THE STOCKBRIDGE–MUNSEE COMMUNITY FOR FEASIBILITY STUDY PURPOSES. FURTHER ANALYSIS IS REQUIRED TO DETERMINE THE FINAL FEASIBILITY, DESIGN, AND CONSTRUCTION DETAILS OF A GEOTHERMAL SYSTEM.



1 GEOTHERMAL SYSTEM LAYOUT (G0.1)

GEOTHERMAL FIELD INFORMATION	
NUMBER OF GEOTHERMAL BORES	22
BORE DEPTH	300'
NUMBER OF CIRCUITS	2
NUMBER OF BORES PER CIRCUIT	11
TYPICAL BORE SPACING	20'
GEOTHERMAL BORE SIZE	6"ø
BORE PIPE SIZE	1"ø
PIPE TYPE, BORE PIPING	SDR 11 PE4710
PIPE TYPE, LATERAL CIRCUIT PIPING	SDR 11 PE3454/PE4710
FLUID WITHIN PIPING	25% PROP GLYCOL
BUILDING ENTERING WATER TEMPERATURE	87°F MAX./32°F MIN.
PEAK HEATING LOAD	500 MBH
PEAK COOLING LOAD	408 MBH
GROUT THERMAL CONDUCTIVITY	1.00 BTU/H-FT-F
ESTIMATED GROUND THERMAL CONDUCTIVITY	1.65 BTU/H-FT-F
ESTIMATED UNDISTURBED GROUND TEMPERATURE	50 °F
ESTIMATED GROUND THERMAL DIFFUSIVITY	1.17 SF/DAY

2 GEOTHERMAL FIELD INFORMATION (G0.1) NO SCALE



3 GEOTHERMAL PIPE CONNECTION AT BUILDING (G0.1) NO SCALE

4 GEOTHERMAL BORE DETAIL (G0.1) NO SCALE

PRELIMINARY DRAWING
NOT FOR CONSTRUCTION

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Stockbridge-Munsee Community Mohican Family Center
Bowler, Wisconsin

PROJECT #
DATE 03/14/14
REVISION | DATE
DRAWING # G0.1

Conclusions and Recommendations

The first step in implementation of the feasibility studies contained here-in are to follow the recommended energy conservation measures (ECMS) in the two tribal buildings analyzed. If these ECMs were followed, as reported in the contractor's reports, a substantial amount of energy would be saved, especially in the tribal Health and Wellness Center. (see report on values) The personal in the environmental office cannot do the implementation of the ECMs, only strongly urge the tribe to go forward with them. This will be done in two ways, the first being to work with the managers of the buildings studied and have them ask for the funding from the tribal council for the energy conservation measures in the annual budget request. The second way is to ask the tribal council directly to supply a special line item budget for those upgrades in the new budget as they prepare it for the next fiscal year.

Lessons Learned

Sometimes it has proven difficult to stir the interest of the tribe and the council to go forward with a concerted effort to work towards energy sovereignty in the daily operations facing the tribal government and businesses. Small steps have been made however, and community awareness has been growing. The first steps to this were On December 20, 2011, when the Stockbridge-Munsee Community Tribal Council adopted a long term energy sustainability statement titled: Energy Sovereignty Statement. It reads as follows:

> The Stockbridge-Munsee Community, since time immortal has deeply cared for the natural resources from mother earth that fulfills our nutritional, economic and spiritual needs. More recently, this is evidenced by Tribal Council, Tribal Committees and Tribal departments that manage its natural resources for today and tomorrow. Such natural resources include the Tribe's land base, the Tribe's timber resources, the Tribe's water resources, and the Tribe's wildlife.
>
> The Tribe's energy resources are also a precious commodity and if not thoughtfully consumed can cause damage to the Tribe's environment and the world's environment. As such, the Tribe supports efforts internally, locally, nationally and internationally to be more energy efficient and the Tribe supports renewable energy resources.
>
> For its part, the Tribe will continually evaluate current energy needs and will continually strive to reach energy sovereignty by reducing its carbon footprint on mother earth by reducing energy needs and by utilizing renewable energy resources whenever feasible.

There is a very bright side to the slow awakening of the tribe to the issue of energy saving, or even perhaps energy independence. That is the fact that the new elderly drop-in center, kitchen and cafeteria which is being designed now, as this report is being written, will incorporate geo-thermal for its heat and cooling systems. These heat pumps and closed system loops will be build into the newly expanded elderly center and greatly reduce the future operational cost of the facility.

Further recommendations from this department, which have already have champions on the tribal council are the to pass new tribal building codes which mandate any new home or tribal building constructed on the reservation to be built to much higher energy standards than the code call for. These so called "green building codes" will be pursued very soon on the reservation and hopefully become part of the tribal code within a year or two.