RENEWABLE ENERGY

A Guide to Renewable Energy at Northland College

NORTHLAND COLLEGE

Acknowledgements

This book would not be possible without the generous help from:

Scott McTavish - Conservation Technologies
Rick Waligora - Facilities Maintenance at Northland College
Dr. Scott Grinnell - Associate Professor of Physics at Northland College
Clare Hintz - Campus Sustainability Coordinator at Northland College
Tom Wojciechowski - Ashland County UW Extension Community Resource Director
David Saetre - Campus Minister at Northland College
Grant Herman - Director, Sigurd Olson Environmental Institute at Northland College
David Danielson - Conservation Technologies

Table of Contents

SECTION 1

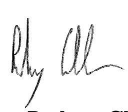
Greetings,

This book has been designed as a reference tool for the renewable energy systems on Northland College campus. It is available in a hard copy as well as digital. It is a working document where new information can be added when new systems are completed. This book is the renewable systems to the best of my knowledge in the spring of 2010.

As it goes with knowledge, there is always more to be learned. This is not a complete guide to the systems on campus. There are many more facets to the systems that is not included in this book.

I have provided a history for each system because each system went through a different process to become the way it is. Many of these processes were radical and groundbreaking at there instatement and should be acknowledged.

This is my Environmental Studies senior capstone in Renewable Energy. There was a great amount of input from other people in the drafting of this document. Without the people listed in the acknowledgments this book would not have been possible. Thank you all for your help,



Rodney Claiborne
2010 Environmental Studies major
with an emphasis in Renewable Energy

History Of Renewable Energy at Northland

Renewable Energy Fund (REF)

Figure 1

The REF was created in 2000 through a joint effort between the Northland College Student Association (NCSA) and the Environmental Leadership Center. The REF was designed to offset coal and nuclear power plants by providing clean alternative energy sources. Up until 2008 the REF was chosen by the NCSA president, but in the 2008 the newly created director of sustainability position took the roll of deciding what the REF funding will be used for. Applicants for the fund submit their proposals to the director of sustainability.

When created the REF charged every student $10 per semester, which went into the fund for paying for projects. It was doubled to $20 a semester in 2002, and doubled again in 2009 to $40 per semester. The guidelines for the REF do not specify that the money has to be used every year, it can be saved for a more expensive project down the road. It can also be used to fund multiple projects in a year. It does not have to be a conventional "green energy" project. The project has been used projects such as a composting system, a hybrid car for the admissions department, Fat Spaniel monitoring project, Geothermal wells on the Craig A. Ponzio Campus Center, and evacuated tube solar hot water on McMillan.

U.S. Green Building Council LEED Certifications

Figure 2

The United States Green Building Council is a non-profit based in Washington D.C. LEED is a non-governmental organization that provides a rating system for the impact a building has on the environment. It takes into account energy savings, water efficiency, CO_2 emissions reduction, improved indoor environmental quality, stewardship of resources, and sensitivity to their impacts. LEED takes into account the building of the structure, where the resources came from, who built the structure, how the building functions after it is built, and how the long the building was built to last.

Northland College was active with LEED when the program was being developed. The MELLC was a pilot project for LEED. Many of its features were incorporated into the LEED 1.0 certification model.

In 2007 Northland committed to a standard of LEED Silver on all new construction or major renovation.

AASHE

Northland College is part of the Association for the Advancement of Sustainability in Higher Education (AASHE). AASHE was founded in 2001 as an association of colleges and universities that are working to create a sustainable future.

Figure 3

AASHE's program called Sustainability Tracking Assessment and Rating System (STARS) allows colleges to track and rate their progress towards sustainability. AASHE also is a great resource and reference tool for colleges. It is a network where ideas can be passed around from school to school.

In 2008 Northland was honored by AASHE when it won the Campus Sustainability Leadership Award.

Wisconsin Focus On Energy

Wisconsin has developed a wonderful program for the instillation and maintenance of renewable energy in its Focus On Energy Program. Funding is available for site surveys and installation. They provide aid in photovoltaics, solar hot water, wind, biomass combustion, and in biogas digestion. There are incentives available through the national and state governments that can be applied for to receive funding.

Figure 4

Northland College has partnered with Focus on Energy for a number of projects on campus. The Craig A. Ponzio Campus Center and the President's House are two projects that the school applied for and received funding on.

Sustainability Initiatives Timeline

1970

- The Northland College Board of Trustees initiated the development of the College's Environmental Studies program.

1971

- Northland hosted its first Environmental Conference. Guest speakers were Senator Gaylord Nelson and renowned outdoors writer and conservationist Sigurd Olson.

1972

- The College enrolled its first class of Environmental Studies students and founded the Sigurd Olson Environmental Institute.

1974

- Northland began a systematic upgrade of all windows and boilers in every building on campus.

1981

- Construction began on a new building for the SOEI, which features sustainable design principles, and also began a community education program on energy conservation.

1989

- Northland College Environmental Council was formed of staff, students, and faculty to determine environmental projects and policies for the College.

1994

- Mino Aki, a student-run garden, was created on campus, fertilized by compost from the cafeteria. The garden continues to grow food used in community potlucks and other events, such as fall orientation trips.

1995

- Students began the Sunshine Community Bike Program, which provides free bikes to anyone who needs to borrow one. The bike shop also repairs bikes, and students can build their own bike in exchange for service hours.
- The cafeteria has offered vegan and vegetarian entrees at all meals since 1995, and now features 100% sustainably harvested seafood, cage-free shell eggs, no trans-fat frying oils, and Fair Trade coffee.

1998

- The McLean Environmental Living and Learning Center, which served as a model in developing the national LEED standards, began housing over a hundred students a year.

1999

- Students finished major construction on the Strawbale Lab, a demonstration off-grid building powered by a small wind turbine and photovoltaic array, and heated through passive solar design and in-floor heat from hot water solar panels.

2000

- Northland adopted a green building policy for all new construction or major renovations, and in 2007, with the signing of the ACUPCC, the college committed to a standard of LEED Silver on all new construction and substantial renovation.
- The NCSA developed and implemented the REF.

2001

- The Craig A. Ponzio Campus Center was constructed, featuring a geothermal heating and cooling system and other green features.

2006

- Northland officially adopted the Natural Step Framework as its definition of sustainability.

2007

- Northland became a member of the leadership circle of signatories of the American Colleges and Universities Presidents' Climate Commitment.
- The solar hot water system is completed on McMillan hall, partially heating the water with the sun and thereby reducing the use of non-renewable energy.
- Students open the Reuse Center, a space to give and receive free clothes, books, and other items instead of throwing them away and buying new.
- NCSA formed a contract with Bay Area Rural Transit (B.A.R.T.) to provide free transportation to students wishing to travel around the bay area without a car.

2008

- Students in a May term course installed a solar panel array at the President's house. Students participating earned certification in solar panel installation.
- Dexter Library, renovated in the summer of 2008, featuring Northland's second geothermal system.
- Northland wins two national sustainability awards: a Campus Sustainability Leadership Award from the Association for the Advancement of Sustainability in Higher Education, and a Sustainability Innovator Award from the National Endowments Institute.
- After positive response from students using the free B.A.R.T. passes, the free service was expanded to include faculty and staff.
- The Mino Aki community garden began producing food for orientation trips, students planted an herb spiral.

2009

- Students enrolled in the May term course Sustainable Living: Photovoltaics, helped install 72 solar panels on the roof Dexter Library. With the addition of the solar panels, the library is expected to receive LEED Gold Level Certification and will be heating and cooling neutral.
- Students voted to double their contribution to the Renewable Energy Fund. The fee is now $40 per semester and one of the highest in the nation.

SECTION 2

MELLC

Figure 1

History

The Wendy and Malcolm McLean Environmental Living and Learning Center (MELLC) was built in 1998. The dormitory was built as a LEED 1.0 pilot project. It never received any certification due to a need for $15,000 to provide documentation for the certification. The building was also a pilot project for the Minnesota Sustainable Building Guidelines (MSBG), which was drafted by the University of Minnesota College of Design.

Students were involved in the building design process. The building was built using passive solar, renewable energies, low water use appliances, two composting toilets, an advanced heat recovery system, as well as recycled materials in the construction process. There are a few light tubes that provide passive lighting to the upper floor.

The MELLC harnesses a variety of renewable systems including solar hot water, photovoltaic, and wind. The overall renewable contractor for the building was Chris LaForge of Great Northern Solar. He worked with the solar hot water and the photovoltaic systems. The wind tower was contracted out to Lake

Michigan Wind & Sun.

The solar hot water systems are mounted above the apartments of the MELLC. All four of the apartments have a separate water heating system. Three of them are heated by the solar hot water system. The array is broken into two strands of five and one of four panels to heat the water. The panels were salvaged from the Minnesota zoo. The installation cost of the system was $12,400.

The photovoltaic system consists of three different pole mounts, one is fixed, one is single axis tracking, and the third is dual axis tracking. They were put together this way to track data and see how tracking affects photovoltaic production in northern latitudes. In June of 2000 the tracking system failed due to a lightning strike on the wind tower. The system has since been repaired and is properly functioning.

The wind tower was originally equipped with a 20 kW Jacobs Model MEP20-1016 turbine. There were many problems associated with this turbine and the inverter. It is not clear if the problem was the combination of the two or the turbine itself. The turbine worked well while it was working, but it broke down frequently. The turbine was replaced with a 10 kW BWC Excel turbine which has worked well since its installation.

A year long monitoring project on the MELLC was conducted by the firm CDH. They placed sensors all over the building and tracked their results. Their findings were compiled in a document titled *Performance Monitoring of a Sustainable Residence Hall at Northland College* published in September of 2000. It is a great resource if looking for more information on the MELLC. Please see the valuable resources (pg 61) section for more information on this document

Solar Hot Water

Figure 2

There are 14 solar hot water panels mounted at a 60 degree angle affixed to the roof of the MELLC providing 215 square feet of collector surface. They are solar panels made by Lenox originally used in a hot water application at the Minnesota Zoo. They are used to preheat water before it goes through the hot water heater. By using the sun's energy to preheat the water less gas is used during the final heating stages.

There are three different systems involved in the solar hot water process. There are two systems with five panels and one with four. The multi-crystalline photovoltaic panel above them runs a DC pump. Each of the three strings has its own DC pump. The pumps are parallel wired to the photovoltaic panel that circulates the fluid throughout the systems.

The fluid is pumped through a quad rod heat exchanger (see Figure 3) where hot fluid runs through pipes in the exchanger and the hot pipes warm the water to preheat it for the final heating in the hot water boilers.

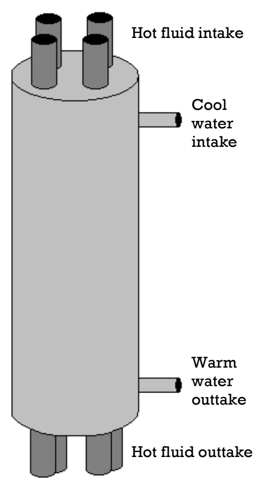


Figure 3 - Quad rod heat exchanger

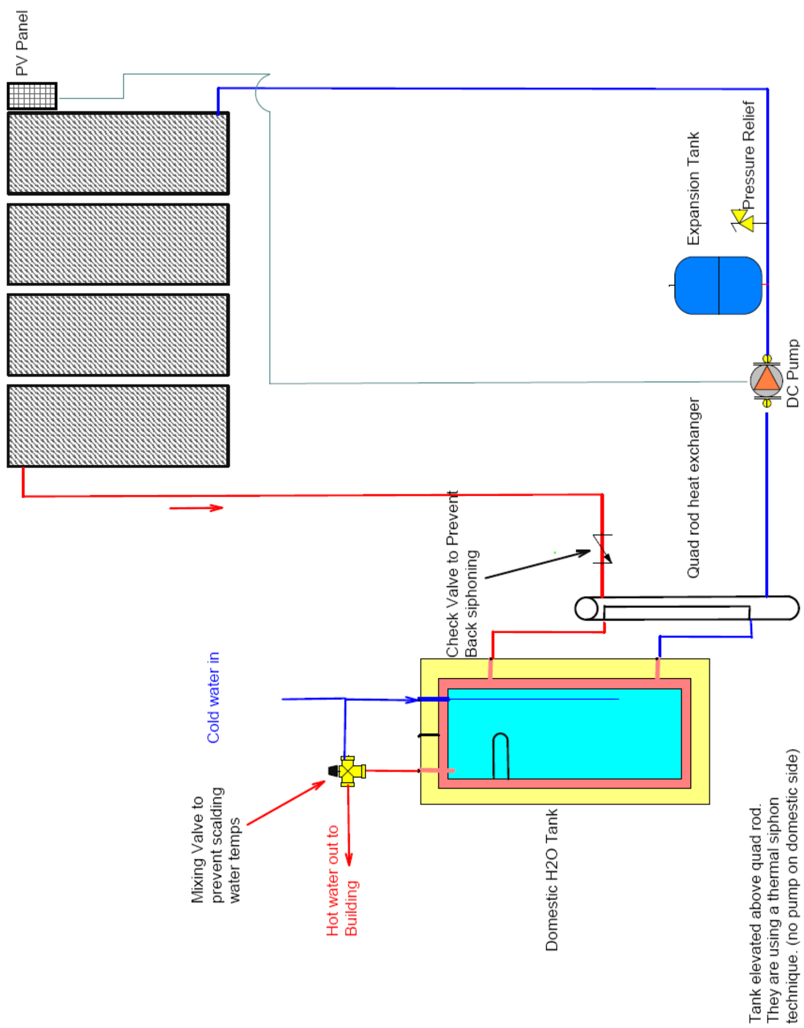


Figure 4 - Schematic of the MELLC Solar Hot Water system

Photovoltaic

There are three separate photovoltaic arrays in the MELLC energy complex. Their combined total provides for 3.2 kW of electricity. Each system is composed of 15 Siemens 75 watt panels on a 3 x 5 rack and hooked up to a Fronius IG 2000 Inverter (page 16). The easternmost array has is dual axis tracking, the center array is single axis tracking, and the westernmost array is fixed. Both tracking systems are Wattsun Trackers.

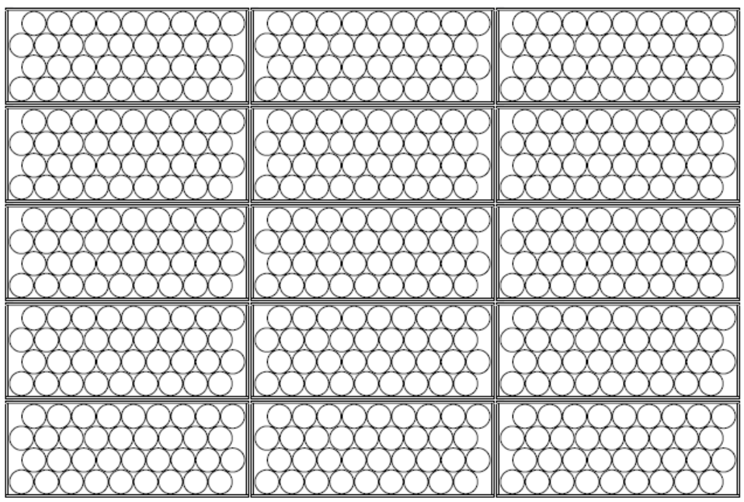


Figure 5 - MELLC PV grid

All three pole mounted racks are aligned in a grid pattern shown in figure 5. The three types of arrays were mounted to test and see how great of an impact tracking systems make on electricity generated.

When all three systems are combined they provide 3.6 kW of power at 110 volts.

Siemens Model SP75 Panels

Solar module

Model:	**SP75**
Rated power:	**75 Watts**
Limited Warranty:	**25 Years**

Certifications and Qualifications

- UL-Listing 1703
- TÜV safety class II
- JPL Specification No. 5101-161
- IEC 61215
- CE mark
- FM Certification

Figure 6 - Panel Specs

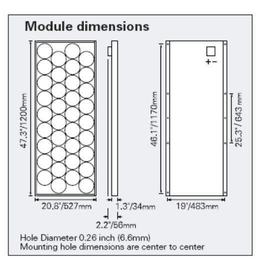


Figure 7 - Panel dimensions

Solar module SP75	
Electrical parameters	12 V/6 V
Maximum power rating P_{max} [Wp] [1]	75
Rated current I_{MPP} [A]	4.4/8.8
Rated voltage V_{MPP} [V]	17.0/8.5
Short circuit current I_{SC} [A]	4.8/9.6
Open circuit voltage V_{OC} [V]	21.7/10.9
Thermal parameters	
NOCT [2] [°C]	45 ±2
Temp. coefficient: short-circuit current	2.06 mA / °C
Temp. coefficient: open-circuit voltage	-.077 V / °C
Qualification test parameters [4]	
Temperature cycling range [°C]	-40 to +85
Humidity freeze, Damp heat [% RH]	85
Maximum system voltage [V]	600 V per UL (1000 V per ISPRA)
Wind Loading PSF [N/m²]	50 [2400]
Maximum distortion [3] [°]	1.2
Hailstone impact Inches [mm]	1.0 [25]
MPH [m/s]	52 [v=23]
Weight Pounds [kg]	16.7 [7.6]

Figure 9 - Panel Statistics

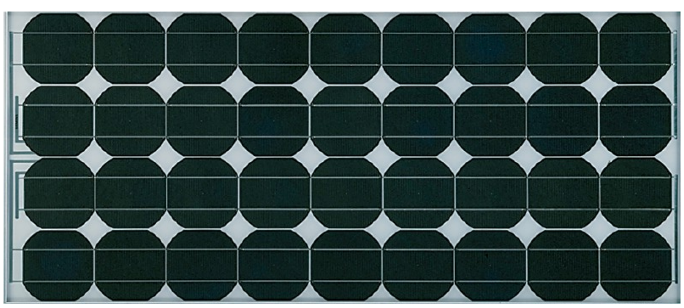


Figure 8

Fronius IG 2000

The Fronius IG is a common inverter on the Northland College Campus. They are used on the majority of the photovoltaic systems on campus. Different systems use different sizes of inverters. The MELLC uses three IG 2000 inverters. One for each array that is set up

Figure 10 - IG 2000

DC Input Data	**IG 2000**	**IG 3000**
Recommended PV power	1500-2500 Wp	2500-3500 Wp
Operating DC voltage range	150 – 450 V	150 – 450 V
MPPT voltage range	150 – 400 V	150 – 400 V
Max. DC input voltage	450 V	450 V
Max. DC input current	13.6 A	18 A
AC Output Data	**IG 2000**	**IG 3000**
Nominal output power	1800 W	2500 W
Maximum output power	2000 W	2700 W
Utility AC voltage range	212 – 264 V (240 V nom)	
Nominal AC current	7.5 A	10.4 A
Maximum AC current	8.35 A	11.25 A
Operating frequency range	59.3 – 60.5 Hz (60 Hz nom)	
Total Harmonic Distortion THD	< 5%	
Power Factor	1	
General Data	**IG 2000**	**IG 3000**
Peak efficiency	94.4%	94.4%
Power Consumption in stand-by	< 0.15 W (night)	
Power Consumption during operation	7 W	
Enclosure	NEMA 3R	
Size (l x w x h)	18.5 x 16.46 x 8.78 inches (470 x 418 x 223 mm)	
Weight	26 lb. (11.5 kg)	
Ambient temperature range	-4 - 122 °F (-20 to +50 °C)	
Cooling	controlled forced ventilaton	
Integrated AC and DC disconnects	optional	
Ground fault protection	Internal GFDI	
DC reverse polarity protection	Internal diode	
Over temperature protection	Output power de-rating	
AC wire sizing	Use minimum AWG 14 194°F (90 °C) copper wire	
Warranty	5 years	
Certifications	UL 1741*, IEEE 929, NEC Art 690, FCC Chapter 15 Part B	

*in process

Figure 11 - Inverter Statistics

Wind

The wind tower is stands just east of the MELLC. It is a 120 foot non-guyed lattice tower. The base of the tower is fenced off to prevent people from climbing on it. To service the turbine a crane must be used to lift the turbine off and lower it to the ground for service. The turbine is a BWC Excel 10 kW turbine. It governs itself by turning itself out of the wind when the airspeed is too fast. When it governs itself the blades make a loud noise as they cut through the wind. There is nothing malfunctioning when this noise is made, the turbine is only turning itself sideways to move the rotor out of the wind.

Figure 12 - BWC Performance

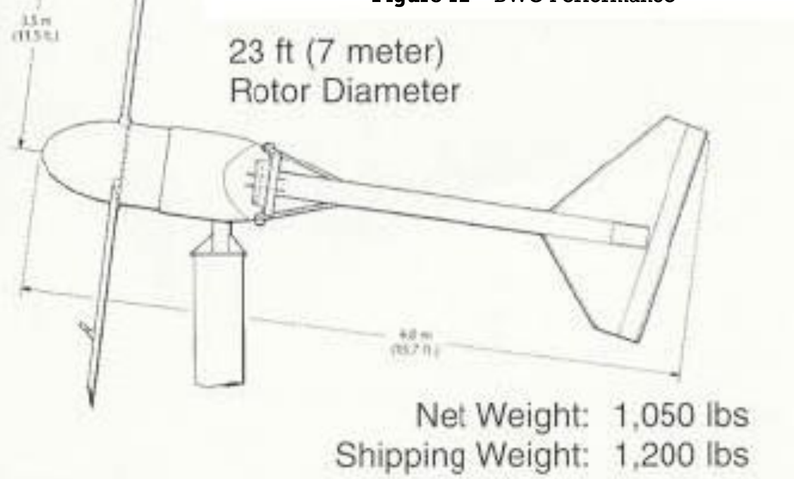


Figure 13 - BWC dimensions

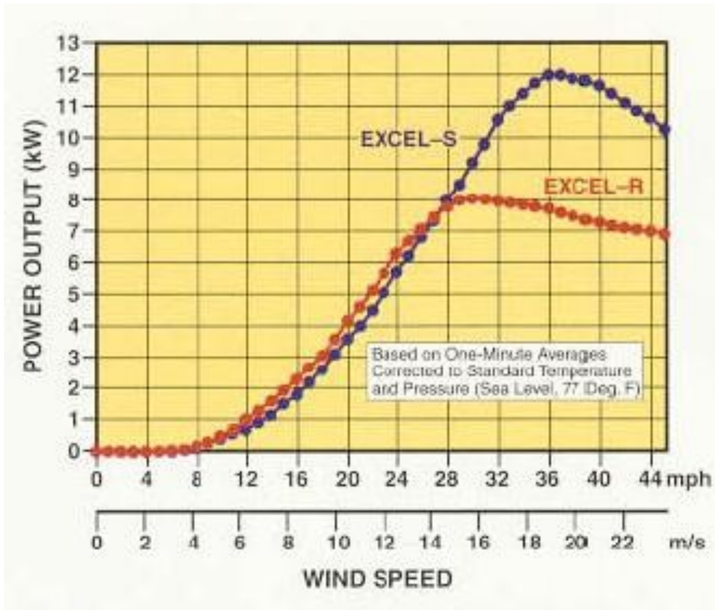


Figure 14 - Kilowatt output at various wind speeds

Predicted Monthly Energy Production

Wind Speeds Taken at Top of Tower

Average Wind Speed	8 mph	9 mph	10 mph	11 mph	12 mph	13 mph	14 mph
Excel–S (AC kWh)	240	370	520	700	900	1,130	1,370
Excel–R (DC kWh)	340	500	680	880	1,090	1,320	1,550

Wind Speeds Taken at 10 meters (per standard wind resource maps)

Average Wind Speed		8 mph	9 mph	10 mph	11 mph	12 mph	13 mph	14 mph
60 ft. Tower	Excel–S	330	480	670	870	1,110	1,350	1,610
	Excel–R	440	620	830	1,050	1,280	1,510	1,740
80 ft. Tower	Excel–S	430	620	840	1,100	1,370	1,670	1,960
	Excel–R	560	780	1,030	1,290	1,550	1,820	2,060
100 ft. Tower	Excel–S	490	700	950	1,220	1,510	1,820	2,130
	Excel–R	630	870	1,140	1,410	1,680	1,950	2,200
120 ft. Tower	Excel–S	550	780	1,050	1,340	1,650	1,970	2,280
	Excel–R	700	960	1,240	1,530	1,800	2,070	2,320

Assumptions: Inland Site, Rayliegh Distribution, Shear Exponent = 0.18, Altitude = 1,000 ft.
Note: Battery charge regulation (batteries full) will reduce actual Excel–R performance.
Your Performance May Vary.

Figure 15 - Predicted Monthly Energy Production

Figure 16

SECTION 3

Dexter Library

Figure 1

History

The Dexter Library was renovated in the summer and fall of 2008. This renovation included a geothermal heat pump for heating and cooling of the building. The renovations are part of an effort to make it a LEED certified building. The photovoltaic panels were installed to cover the electricity used to pump the geothermal system.

Along with these additions the building has lessened the use of lights and provided more natural lighting through sky-lights, more windows, and a light sink. Low flow toilets and water fixtures have also been implemented to make the building less consumptive.

The Dexter Library has been using its geothermal system for a couple winters at the time of publication and has not had to use the boilers to heat. The geothermal pumps have used the earths temperature to keep a relatively moderate climate inside the building.

Photovoltaic

The Dexter Library is the only roof mounted photovoltaic system currently at Northland College. It is also the largest single system. The array consists of seventy-two 200 watt Sanyo Bifacial panels. It is a 14 kilowatt system designed to power the pumps for the geothermal heat pump. It is roof mounted on two racks each consisting of 36 panels in a 18 x 2 grid pattern (see figure 2). The wires from the panels go into a conduit down the south side of the building to a DC shut off box. They then go into the building through conduit to the boiler room where there are two SMA 7000U Sunny Boy Inverters that put the electricity on the grid.

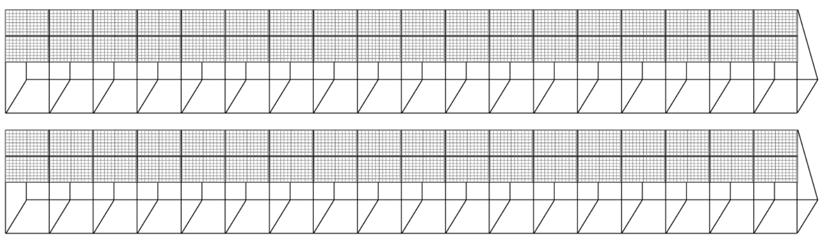


Figure 2

Sanyo 200w Bi-Facial Panels

Sanyo Bi-facial photovoltaic panels collect light from both sides of the panel. They collect energy directly from the top face and collect reflected light off of the buildings roof on the bottom face of the panel. The roof of the Dexter Library is a white PVC lined roof that is a very reflective surface which enables the panels to collect as much energy as possible.

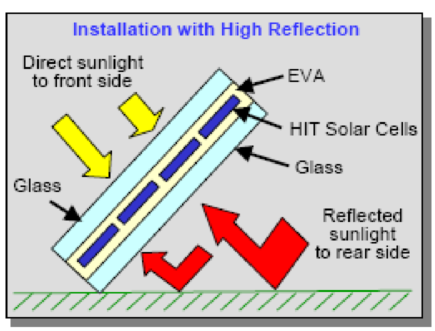


Figure 3 - Bi-facial reflection

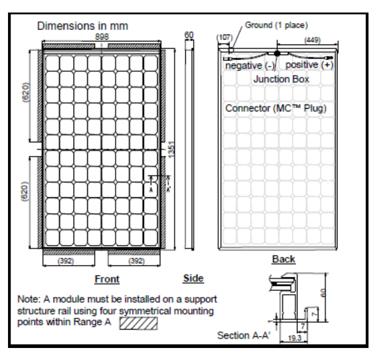


Figure 4 - Panel dimensions

Electrical Specifications		200W
Rated Power (Pmax)[1]	W	200
Maximum Power Voltage (Vpm)	V	56.2
Maximum Power Current (Ipm)	A	3.56
Open Circuit Voltage (Voc)	V	68.8
Short Circuit Current (Isc)	A	3.75
Minimum Power (Pmin)	W	190.0
Max. System Voltage (Vsys)	V	600
Series Fuse Rating	A	15
Temperature Coefficient (Pmax)	%/ºC	-0.29
Temperature Coefficient (Voc)	V/ºC	-0.172
Temperature Coefficient (Isc)	mA/ºC	0.88
Electrical Tolerance	%	+10/-5
Warranted Tolerance	%	+10/-0
Cell Efficiency	%	19.7
Module Efficiency	%	16.5
Power per Square Foot	W	15.3

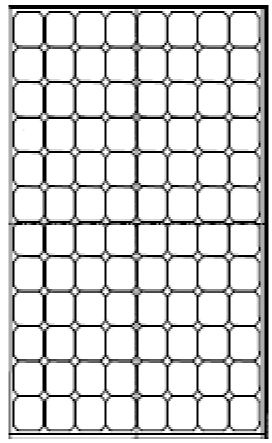


Figure 5

Mechanical Specifications

Internal Bypass Diodes	4 Bypass Diodes
Module Area (ft²)	13.06 ft² (1.21m²)
Weight (kg)	50.7 lbs. (23kg)
Dimensions LxWxH (mm)	53.2x35.35x2.36in (1351x898x60mm)
Cable Lengths (mm)	39.4in each (1000mm)
Cable Size / Connector Type	No.12 AWG / MC™ Connectors
Static Load Wind / Snow	50PSF (2400Pa) / 39PSF (1876Pa)
Pallet Dimensions LxWxH (mm)	54.3x36x70.1in (1379x912x1781mm)
Pallet Quantity & Weight (kg)	20pcs / 1014Lbs (460kg)
Qty per 20'/40'/53' Container	200pcs / 420pcs / 540pcs

Safety Ratings & Limited Warranty

Hail Safety Impact Velocity	1" hailstone (25mm) at 52mph (23m/s)
Fire Safety Classification	Class A
Safety & Rating Certifications	UL 1703, cUL, CEC
Limited Warranties	2-Yrs Workmanship / 20-Yrs Output

[1]STC: Cell Temp. 25ºC, AM1.5, 1000W/m²

Note: Specifications and products above may change without notice. 5/1/07

Figure 6 - Sanyo Bi-facial 200 watt –panel specifications

SMA 7000U Sunny Boy Inverter

Two SMA 7000U Sunny Boy inverters convert the 14 kW system to AC and synchronize the electricity with the grid.

Figure 7

	SB 7000US
Input Data (DC)	
Max. Recommended Array Input Power (DC @ STC)	8750 W
Max. DC Voltage	600 V
Peak Power Tracking Voltage	250 - 480 V
DC Max. Input Current	30 A
DC Voltage Ripple	< 5%
Number of Fused String Inputs	4
PV Start Voltage (adjustable)	300 V
Output Data (AC)	
AC Nominal Power	7000 W
AC Maximum Output Power	7000 W
AC Maximum Output Current (@ 208, 240, 277 V)	34 A, 29 A, 25.3 A
AC Nominal Voltage / Range	183 - 229 V @ 208 V 211 - 264 V @ 240 V 244 - 305 V @ 277 V
AC Frequency / Range	60 Hz / 59.3 Hz - 60.5 Hz
Power Factor	1
Efficiency	
Peak Inverter Efficiency	97.1 %
CEC weighted Efficiency	95.5 % @ 208 V 96.0 % @ 240 V 96.0 % @ 277 V
Mechanical Data	
Dimensions W x H x D in inches	18.4 x 24.1 x 9.5
Weight / Shipping Weight	143 lbs / 154 lbs
Ambient temperature range	- 13 to + 113 °F
Power Consumption: standby / nighttime	< 7 W / 0.25 W
Topology	PWM, true sinewave, current source
Cooling Concept	Convection with regulated fan cooling
Mounting Location Indoor / Outdoor (NEMA 3R)	● / ●
Features	
LCD Display	●
Lid Color: aluminum / red / blue / yellow	● / ❍ / ❍ / ❍
Communication: RS485 / Wireless	❍ / ❍
Warranty: 10-year	●
Compliance: IEEE-929, IEEE-1547, UL 1741, UL 1998, FCC Part 15 A & B	●

Specifications for nominal conditions ● Included ❍ Option – Not available

Figure 8 - Sunny Boy specifications

Geothermal Heat Pump

The geothermal heat pump system on the Dexter Library is composed of thirty wells drilled two-hundred thirty feet deep in the ground.

Figure 9 illustrates what is in each borehole. Two pipes are inserted with a U-joint in the base, connecting them. The pipes are filled with an environmentally friendly water and anti-freeze mixture. This mixture goes 230 feet deep into the earth and absorbs the ambient temperature of the ground and uses it to pre-heat or pre-cool (depending on the preferred function, see figures 11 and 12) the air in the duct system of the building.

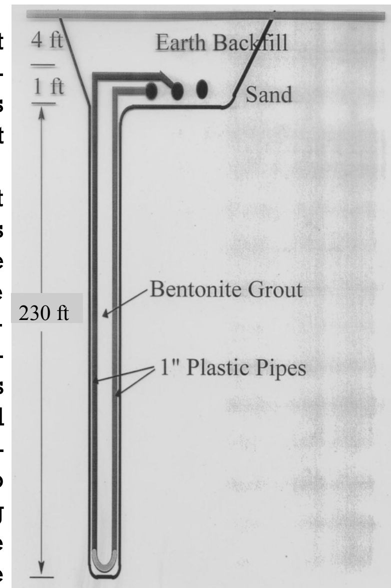


Figure 9 - Borehole diagram

The geothermal heat pump at the Dexter Library is a closed loop system (see figure 10) with thirty vertical wells.

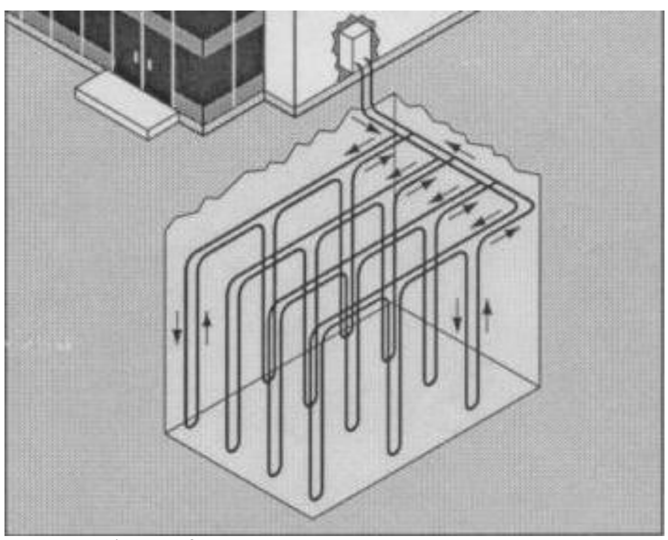


Figure 10 - How a geothermal heat pump works

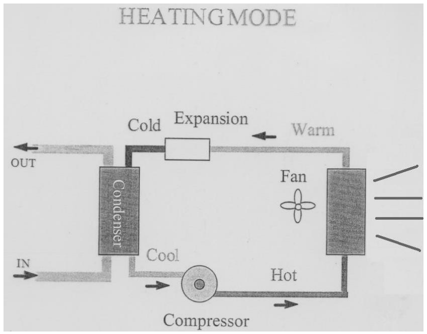


Figure 11 - Heating mode cycle

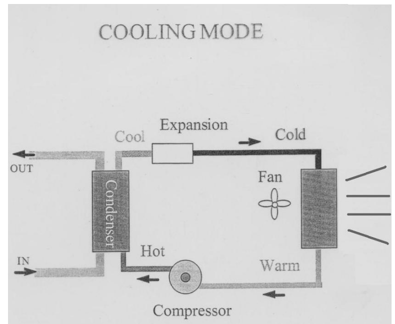


Figure 12 - Cooling mode cycle

Figure 13 - Condenser

The Dexter Library geothermal heat pump system has two condensers (see figure 13) to match the amount of thermal capacity gathered from the wells. These condensers or chillers are made by the Multistack corporation. Each model MS20C4A2H condenser is rated to 25.6 tons, making a combined the total capacity 51.2 tons. The heat recovery chillers produce simultaneous heating and cooling producing 44˚F chilled water in cooling mode and 120˚F hot water in the heating mode. The condenser transfers the heat or cooling gain into the blowers to provide heating/cooling for the building.

SECTION 4

President's House

Figure 1

History

In May of 2008 professor Scott Grinnell taught a class on photovoltaics. In the beginning weeks the class studied the principles of photovoltaic technology, electrical codes, site assessment, wiring, and system sizing. The remainder of the course was spent putting together the system, providing a hands-on application of what they learned. The class surveyed the site and picked out the appropriate location for the array. All of the work was done by Professor Grinnell and his students.

The system received grants from the Wisconsin Focus On Energy as well as from federal assistance. All of this work would not have been able to happen without the generous gift of then president Karen Halbersleben who paid the remainder of the costs for the system.

Photovoltaic

The photovoltaic array connected to the president's house is a grid tied dual axis tracking system with a Wattsun tracker. It is a 2.1 kW system. Figure 2 shows how the system is wired, including DC and AC shut off switches for servicing. Figure 3 (see page 28) is an aerial view of the site. The positive and negative wires were put in conduit and buried while the grounding wire was buried uncovered. The wires go into the house to the inverter and then connect to the grid.

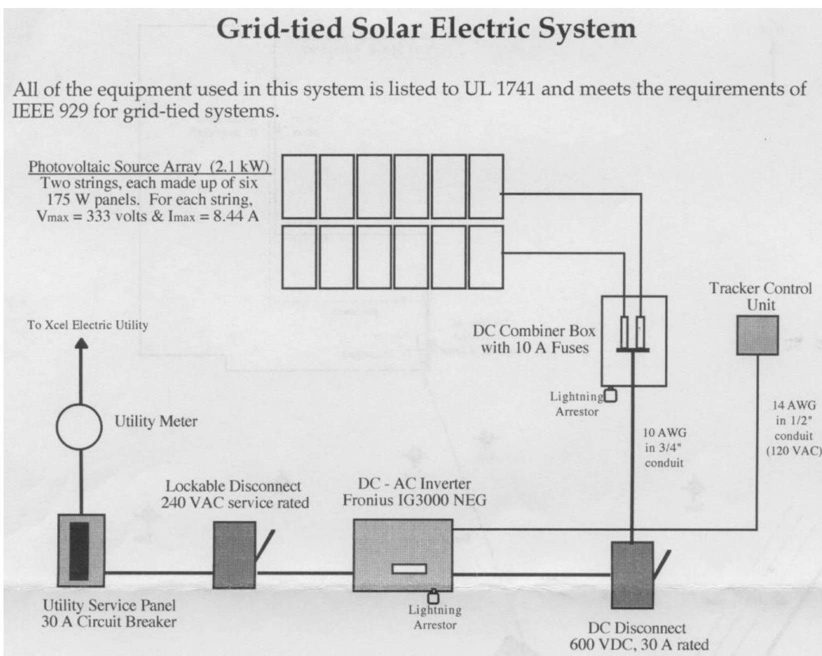


Figure 2 - Wiring schematic

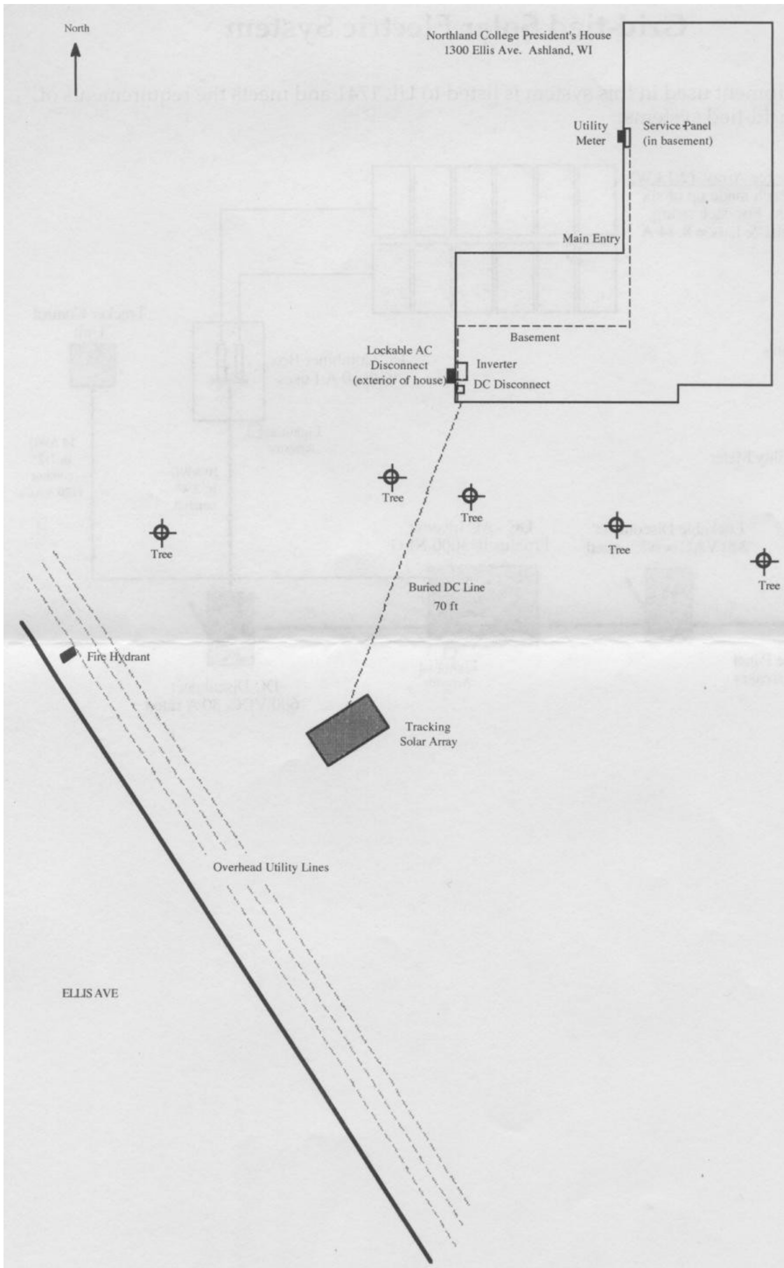


Figure 3 - Site layout

Sharp NT-175U1

The Sharp 175 panels are capable of producing 175 watts apiece. On the President's house they are arranged in two strings of six.

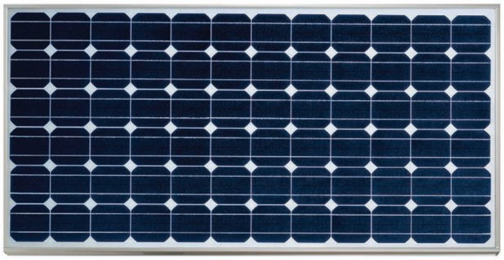


Figure 4

ELECTRICAL CHARACTERISTICS	
Maximum Power (Pmax)*	175 W
Tolerance of Pmax	+10%/-5%
Type of Cell	Monocrystalline silicon
Cell Configuration	72 in series
Open Circuit Voltage (Voc)	44.4 V
Maximum Power Voltage (Vpm)	35.4 V
Short Circuit Current (Isc)	5.40 A
Maximum Power Current (Ipm)	4.95 A
Module Efficiency (%)	13.45%
Maximum System (DC) Voltage	600 V
Series Fuse Rating	10 A
NOCT	47.5°C
Temperature Coefficient (Pmax)	-0.485%/°C
Temperature Coefficient (Voc)	-0.36%/°C
Temperature Coefficient (Isc)	0.053%/°C

*Measured at (STC) Standard Test Conditions: 25°C, 1 kW/m², AM 1.5

MECHANICAL CHARACTERISTICS	
Dimensions (A x B x C below)	32.5" x 62.0" x 1.8"/826 x 1575 x 46 mm
Cable Length (G)	43.3"/1100 mm
Type of Output Terminal	Lead Wire with MC Connector
Weight	35.3 lbs / 16.0 kg
Max Load	50 psf (2400 Pascals)

QUALIFICATIONS	
UL Listed	UL 1703
Fire Rating	Class C

WARRANTY
25-year limited warranty
Contact Sharp for complete warranty information

Figure 5 - Panel specifications

Fronius IG 3000

The Fronius IG 3000 is a larger version of the inverters found on the MELLC. Fronius inverters are prized for their dependability and lower price. The IG 3000 was used on the President's house to accommodate the larger system size.

Figure 6 - IG 3000

DC Input Data	IG 2000	IG 3000
Recommended PV power	1500-2500 Wp	2500-3500 Wp
Operating DC voltage range	150 – 450 V	150 – 450 V
MPPT voltage range	150 – 400 V	150 – 400 V
Max. DC input voltage	450 V	450 V
Max. DC input current	13.6 A	18 A
AC Output Data	**IG 2000**	**IG 3000**
Nominal output power	1800 W	2500 W
Maximum output power	2000 W	2700 W
Utility AC voltage range	212 – 264 V (240 V nom)	
Nominal AC current	7.5 A	10.4 A
Maximum AC current	8.35 A	11.25 A
Operating frequency range	59.3 – 60.5 Hz (60 Hz nom)	
Total Harmonic Distortion THD	< 5%	
Power Factor	1	
General Data	**IG 2000**	**IG 3000**
Peak efficiency	94.4%	94.4%
Power Consumption in stand-by	< 0.15 W (night)	
Power Consumption during operation	7 W	
Enclosure	NEMA 3R	
Size (l x w x h)	18.5 x 16.46 x 8.78 inches (470 x 418 x 223 mm)	
Weight	26 lb. (11.5 kg)	
Ambient temperature range	-4 - 122 °F (-20 to +50 °C)	
Cooling	controlled forced ventilaton	
Integrated AC and DC disconnects	optional	
Ground fault protection	Internal GFDI	
DC reverse polarity protection	Internal diode	
Over temperature protection	Output power de-rating	
AC wire sizing	Use minimum AWG 14 194°F (90 °C) copper wire	
Warranty	5 years	
Certifications	UL 1741*, IEEE 929, NEC Art 690, FCC Chapter 15 Part B	

*in process

Figure 7 - Inverter information

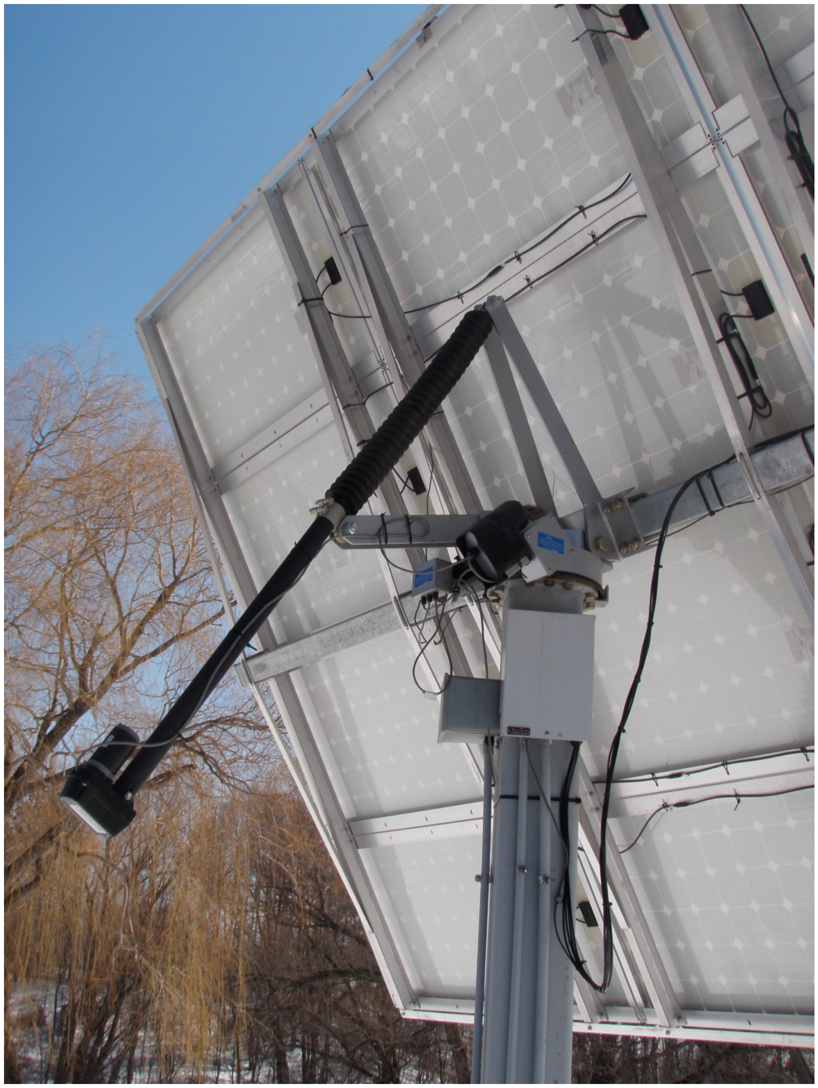


Figure 8 - Wattsun duel axis tracker

SECTION 5

McMillan

Figure 1

History

The evacuated tubes atop McMillan hall are products of the Renewable Energy Fund completed in 2007.

The water is preheated on the roof of the building as it runs through the fifteen Sunda Seido evacuated tubes. The preheating of the water means that less energy is needed to heat the water for the building.

Much research was done when selecting what kind of panels to use for solar hot water on McMillan. The results showed that evacuated tubes are a much more efficient means for heating in a cold northern climate. The vacuum sealed glass tubes contain a thin copper pipe affixed to a heat collecting plate. The vacuum seal provides insulation so the heat is transferred to the glycol mixture.

Since the McMillan array is so large it has a complicated plumbing system, however it is a very effective system that has proven to need little maintenance (see figure 4 on pages 34 & 35 for a more detailed look at the plumbing of the system).

Solar Hot Water

Evacuated tubes are much like flat plate collectors, but they are in a tube shape that allows even heating throughout the tube. The fluid goes through the tube and makes a U-shape running down then back up the inside of the tube, warming up the fluid in the process.

Sunda Seido 5-16AS Evacuated Tubes

Figure 2

Technical data	
Type	**SEIDO5**
Specification	Heat pipe vacuum tube with bent absorber
Configuration	
Absorber area	0.225 m²
Weight	4.7 kg
Installation tilt angel	35° – 90°
Dimension	Ø100mm x 2000mm
Collect heat pipe	Heat pipe copper Ø 8 mm
Absorber material	Copper- Aluminium sunstrip, 0.47 mm thickness
Selective coating	Aluminum nitride Al-N-O selective coating; Absorptance: a > 0.92; Emittance: e < 0.08
Glass tube material	Borosilicate glass Thickness: 2.5 mm Transmittance of glass: 91%
Vacuum	< 10-5 mbar
Min. ambient tem.	-45°C
Stagnation temp.	247°C
Resistance to hail	Ø35mm

Figure 3 - Collector Statistics

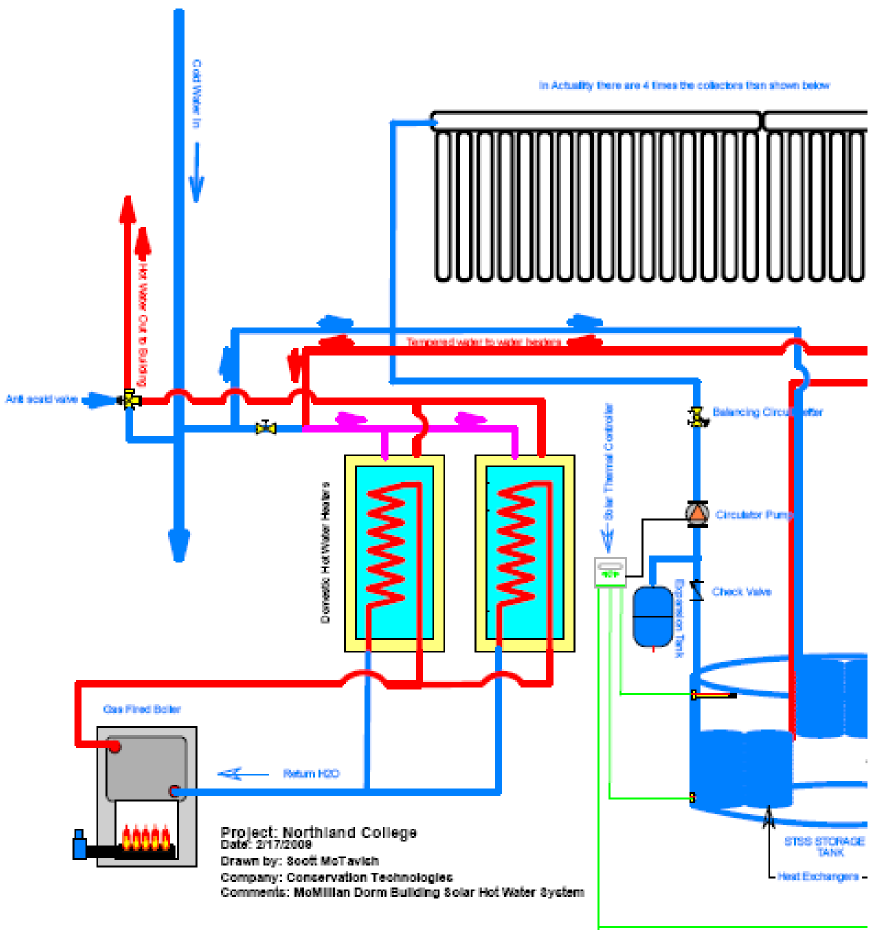


Figure 4 - Detailed diagram of plumbing

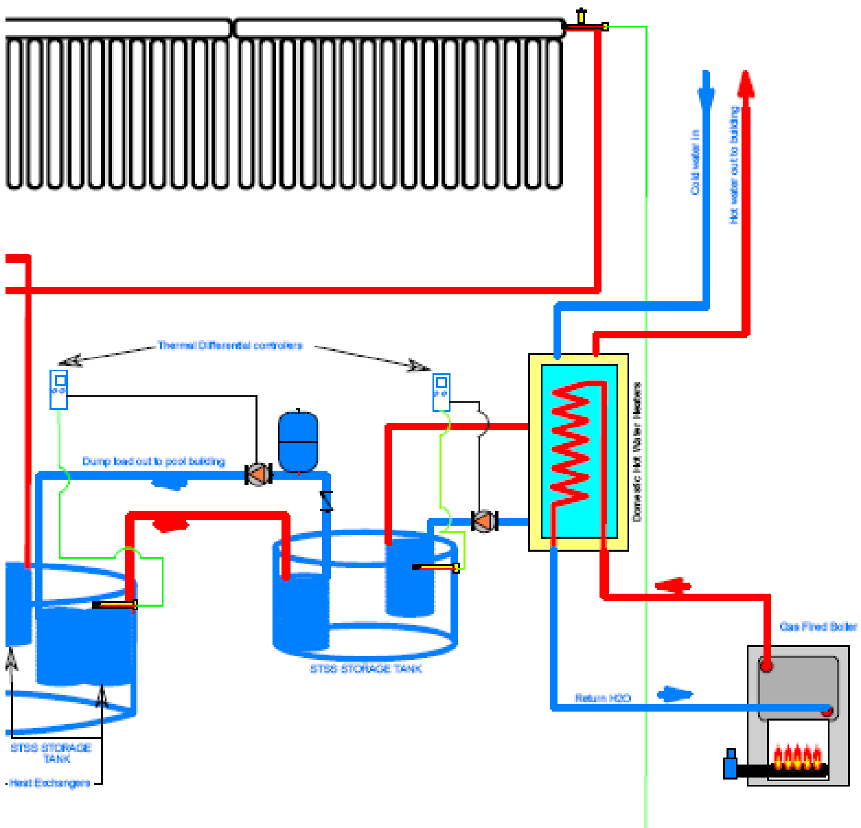


Figure 4 - Detailed diagram of plumbing (continued)

SECTION 6

Strawbale House

Figure 1

History

The Strawbale House was built and designed by Northland Students. A grant was written by Tom Wojciechowski and Clayton Russell to the Wisconsin Environmental Education Board (WEEB) to fund the project. Once the funding was received Grant Herman became the professor for the class. Mark Morgan, a trained builder from the Midwest Renewable Energy Association was contracted to facilitate the strawbale construction. The Strawbale house is completely off the grid. It runs on a battery backed direct current system. Electricity is provided by a 900 watt wind turbine and three 75 watt panels. It is heated by passive solar construction and radiant in-floor heating from a solar hot water system.

The Strawbale House is the only example of off grid technology currently at Northland College. It can be used as a comparison to the grid tied systems in place at the school.

Solar Hot Water

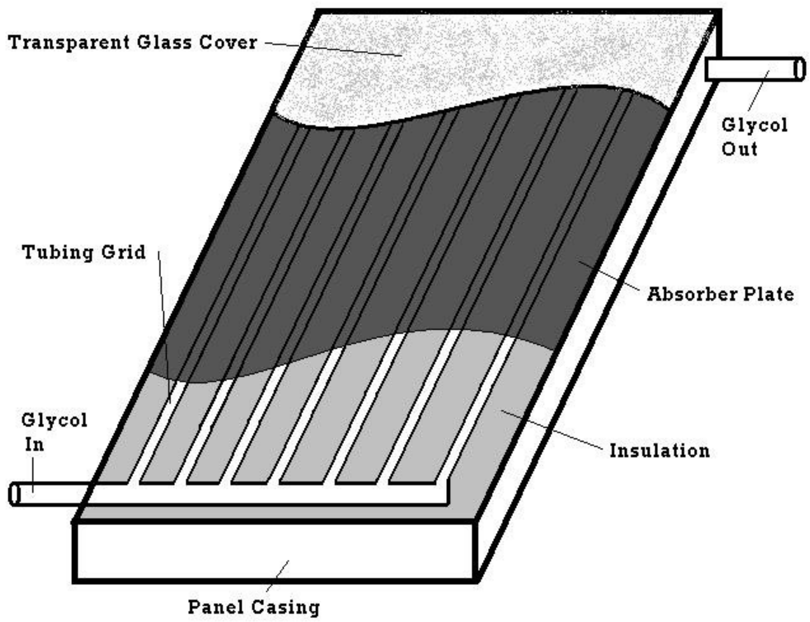


Figure 2 - Cutaway view of a solar hot water panel

The solar hot water panels at the Strawbale House, like the panels on the MELLC are reclaimed Lenox panels from the Minneapolis Zoo. The collector plate is coated with black chrome on bright nickel for a high solar absorptivity of 0.94 and a low thermal emission of 0.10. The four panels at the Strawbale House collect a surface area of 61.6 square feet.

The solar panels were part of the original design, but it took a few years to get them in place. The Strawbale House was built without a finished floor. Two years after the building was completed the floor was put in. A bed of sand was placed with radiant in-floor tubing in it then covered with cement. The panels were mounted on the rack outside and connected to the floor. The panels and tubing were then filled with glycol to begin heating the building.

The superior insulation of strawbale construction allows the building to be heated mainly by passive solar construction. The solar hot water system provides extra heating to ensure warm temperatures during the cold winter months.

Figure 3 - Wiring inside the Strawbale House

Photovoltaic

Three Siemens SP75 panels on a fixed pole mount. The photovoltaic system for the Strawbale house is battery backed DC, so no inverter is needed and the system is not grid tied. These panels are extras from the MELLC project. The wind and photovoltaic technology provide electricity for lighting as well as outlets in the Strawbale House.

Siemens Model SP75 Panels

Solar module

Model:	**SP75**
Rated power:	**75 Watts**
Limited Warranty:	**25 Years**

Certifications and Qualifications

- UL-Listing 1703
- TÜV safety class II
- JPL Specification No. 5101-161
- IEC 61215
- CE mark
- FM Certification

Figure 4 - Panel Specs

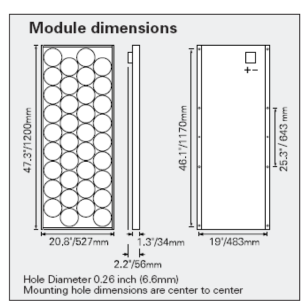


Figure 5 - Panel Dimensions

The fixed pole mount can be adjusted from season to season to take into account the different levels of the sun from season to season. This is not necessary for the angle to the sun to be changed, but it is an option to make the system more efficient.

Figure 7 shows the details of the panels; what they produce, their electric limits, and their physical limits.

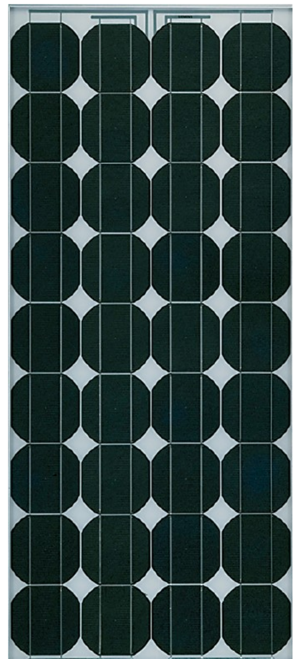


Figure 6

Solar module SP75		
Electrical parameters		12 V/6 V
Maximum power rating P_{max}	[Wp] 1)	75
Rated current I_{MPP}	[A]	4.4/8.8
Rated voltage V_{MPP}	[V]	17.0/8.5
Short circuit current I_{SC}	[A]	4.8/9.6
Open circuit voltage V_{OC}	[V]	21.7/10.9
Thermal parameters		
NOCT 2)	[°C]	45 ±2
Temp. coefficient: short-circuit current		2.06 mA / °C
Temp. coefficient: open-circuit voltage		-.077 V / °C
Qualification test parameters 4)		
Temperature cycling range	[°C]	-40 to +85
Humidity freeze, Damp heat	[%RH]	85
Maximum system voltage	[V]	600 V per UL (1000 V per ISPRA)
Wind Loading	PSF [N/m²]	50 [2400]
Maximum distortion 3)	[°]	1.2
Hailstone impact	Inches [mm]	1.0 [25]
	MPH [m/s]	52 [v=23]
Weight	Pounds [kg]	16.7 [7.6]

Figure 7 - Panel statistics

Wind

The wind tower at the Strawbale house site is a Southwest Windpower Whisper H40 turbine mounted on a J-pole, which means it can be lowered down with a winch to be serviced. This system is also completely DC. The wind tower and turbine were donated for this project, the provided turbine needed to be replace, and the Whisper H40 was chosen as the replacement.

Rotor Diameter:	7 ft. (2.1m)
Weight:	47 lbs (21kg)
Mount:	2.5" schedule 40
Start-up wind speed:	7.5 mph (3.4m/s)
Voltage:	12, 24, 36, 48 VDC
Peak Power:	900 watts at 28mph (12.5m/s)
Turbine Controller:	Whisper Charge Controller
Blades (three):	Polypropylene/Carbon
Kilowatt hours per month:	100 kWh/mo @12mph (5.4m/s)
Warranty:	2 Year Limited Warranty
Survival Wind speed	120 mph (55 m/s)

Figure 8 - Whisper H40 stats

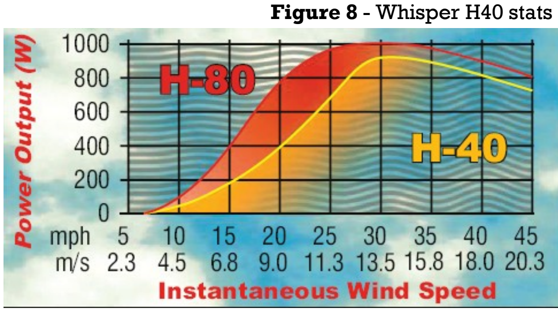


Figure 9 - Instantaneous power output

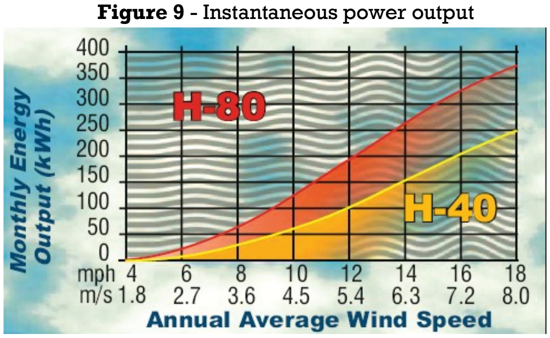


Figure 10 - Average energy output

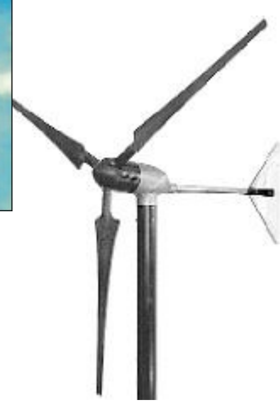


Figure 11 - Whisper H40

Battery Bank

Figure 12 - Strawbale Battery Bank

Four Deka 8L16 batteries wired in parallel make up the battery bank for the Strawbale house. Each battery is six volts. They are sealed in a venting box. The batteries should be periodically checked for acid levels and eventually replaced once they are no longer properly functioning.

SECTION 7

Craig A. Ponzio Campus Center

Figure 1

History

The Craig A. Ponzio Campus Center is a central meeting ground building on campus that houses student life offices and the business office. It also has meeting spaces, the Alvord Theatre, a post office, and the Baldwin Commons/cafeteria. This large building has 69,293 square feet of space to heat and cool.

Northland applied and received a Wisconsin Focus on Energy Grant for a feasibility study for a geothermal heat pump. The REF helped fund the remainder for the study. The study was conducted in March 2003 through the joint efforts of Geothermal Bore Technologies of Maple Plain, MN and Trane Heating and Cooling.

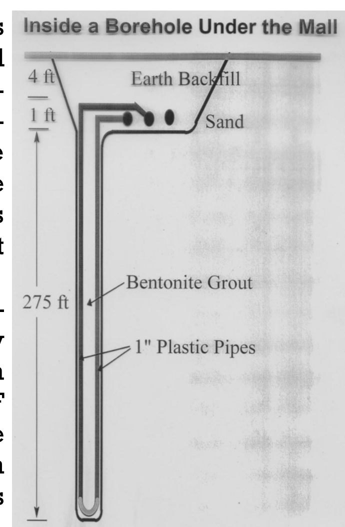


Figure 2 - Borehole diagram

Geothermal Exchange vs. Air Conditioner

Effect	Air Conditioner	Geothermal
Installation cost	$120,000	$340.000
Ponzio fossil fuel use	15% increase	7% increase
Compressor noise	loud compressor near Mead	silent (pump in basement)
Space required	10'x25'x6' box by Ponzio	Dedicated open space in mall
Annual heat/cool bill ('03 $)	$81,000	$60,000
Annual loan payment (15 year)	$0	$21,000
Conservation payback period	None	11 years
Conservation grants available	None	$17,000+
Lifetime conservation savings	None	$1.5 million

Figure 3 - Geothermal heat exchanger vs. conventional air conditioning

In spring of 2004 the installation process of the system began. Dale Zank from Trane Heating and Cooling was the project manager who organized the system installation. Geothermal Bore Technologies supervised the digging of the wells and installation of the pipes.

Figure 4 - Drilling of boreholes

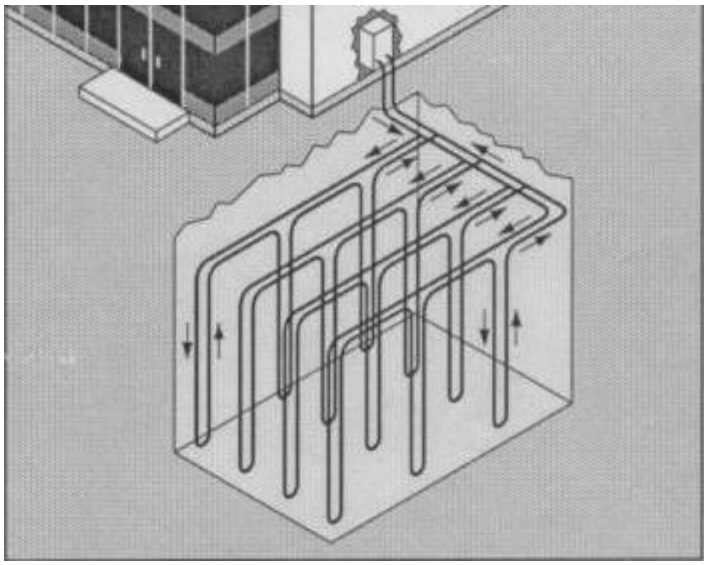


Figure 5 - How a geothermal heat pump works

Geothermal Heat Pump

Three rows of twenty holes, each fifteen feet apart from each other were drilled for a total of sixty wells. Each well is two-hundred seventy-five feet deep. The wells were drilled under the Northland Mall. For a detailed diagram see figure 6.

Figure 2 illustrates what is in each drilled well. Two pipes are inserted with a U-joint in the base, connecting them. The pipes are filled with an environmentally friendly water and anti-freeze mixture. This mixture goes deep into the earth and absorbs the ambient temperature of the ground and uses it to pre-heat or pre-cool (depending on the preferred function. see figures 9 and 10) the air in the duct system of the building.

Figures 6 and 7 are blueprints for the system. They provide a detailed description of the plumbing systems that make up the geothermal heat pump. Figure six is an outside view of the wells and where they attach to the Ponzio. Figure 7 is the inside view of the basement of the Ponzio and how the system attaches to the heating a cooling systems. For more information and a more detailed look at these blueprints contact the Campus Sustainability Coordinator.

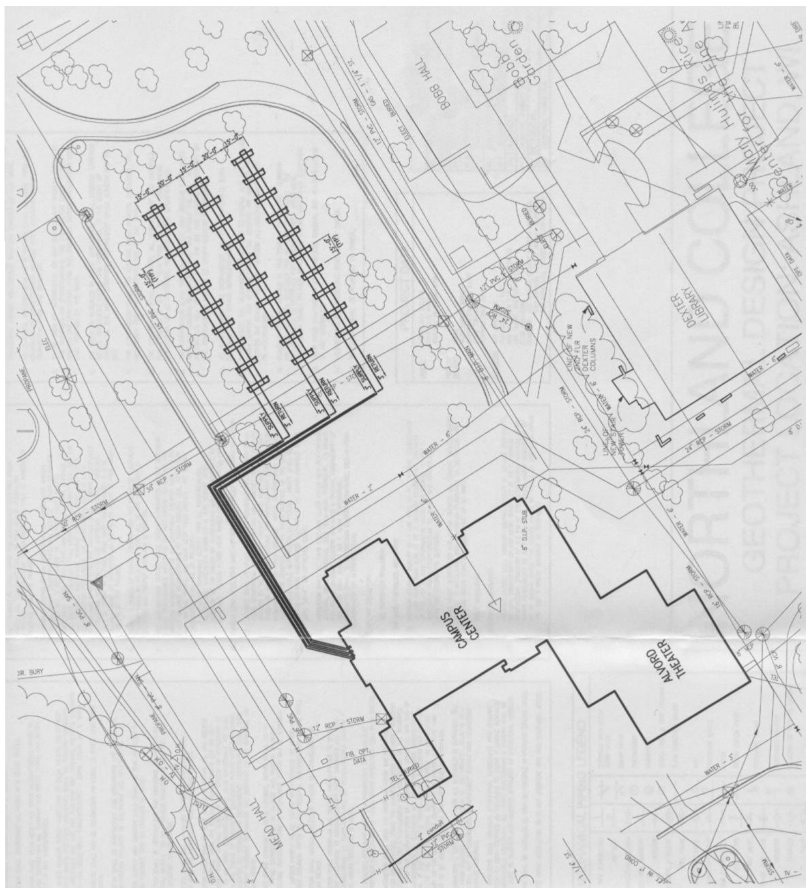


Figure 6 - Location of boreholes

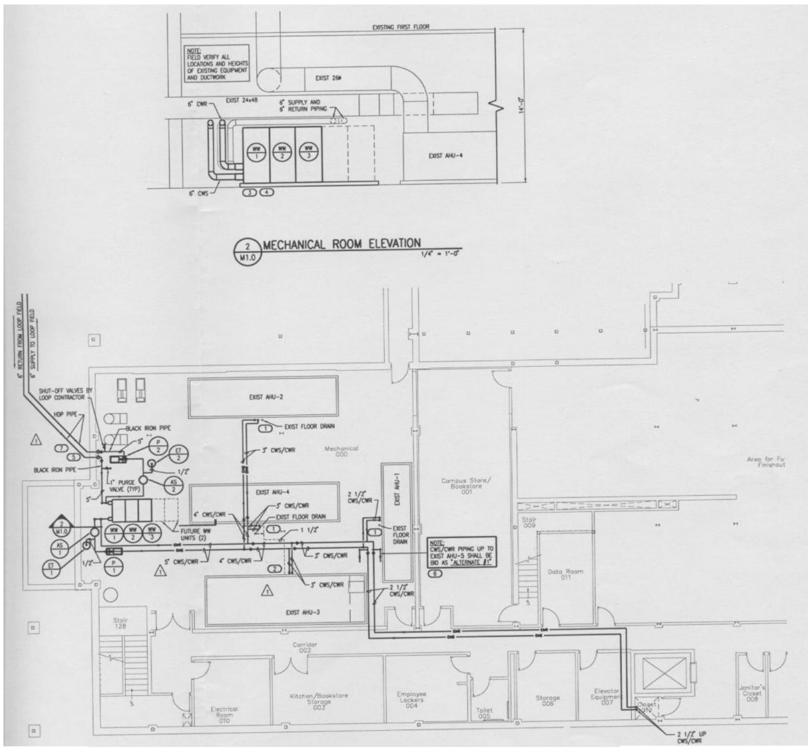


Figure 7 - Blueprint of plumbing in basement of Ponzio

Figure 8 - Condenser

The Ponzio geothermal heat pump system has three condensers (see figure 8) to match the amount of thermal capacity gathered from the wells. These condensers or chillers are made by the Multistack corporation. Each model MS30C2-2R condenser is rated to 30 tons, making a combined the total capacity 90 tons. The condenser transfers the heat or cooling gain into the blowers to provide heating and cooling for the building.

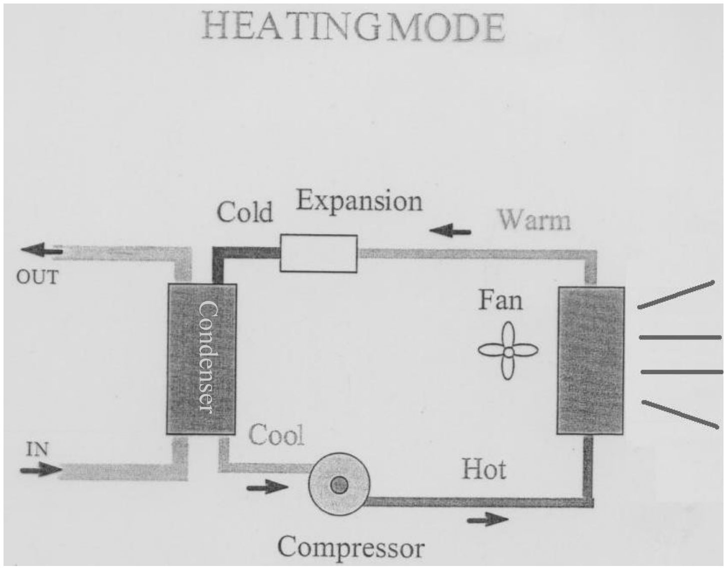


Figure 9 - Heating mode cycle

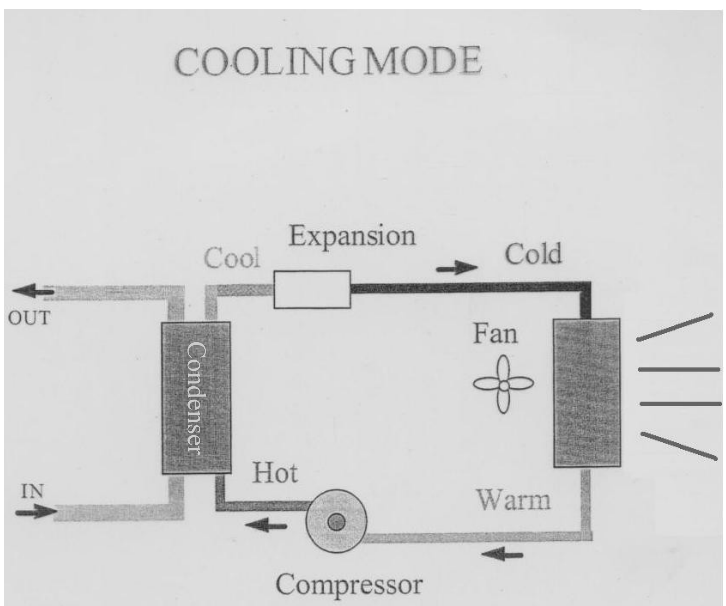


Figure 10 - Cooling mode cycle

SECTION 8

Kendrigan Gymnasium

Figure 1

History

The Kendrigan Gymnasium was equipped with two racks of 12 solar hot water panels that were provided by the first NCSA Renewable Energy Fund. The panels were used to heat the water for the swimming pool. The panels were made by a company out of Green Bay, WI called Solar Mining. Unfortunately the company is no longer in operation. The panels are also no longer functioning. The panels became neglected and the glycol content was not monitored. Too much water got into the system and the it froze. When a solar hot water system freezes the water in the panels expands and breaks the panels rendering them useless.

According the facilities maintenance there are plans to put a new set of solar collectors in the pre-existing rack. They are now dependant on the NCSA's Renewable Energy Fund or a donation from some other source.

Though the panels were ruined in the freezing of the system, the plumbing is still functional.

Solar Hot Water

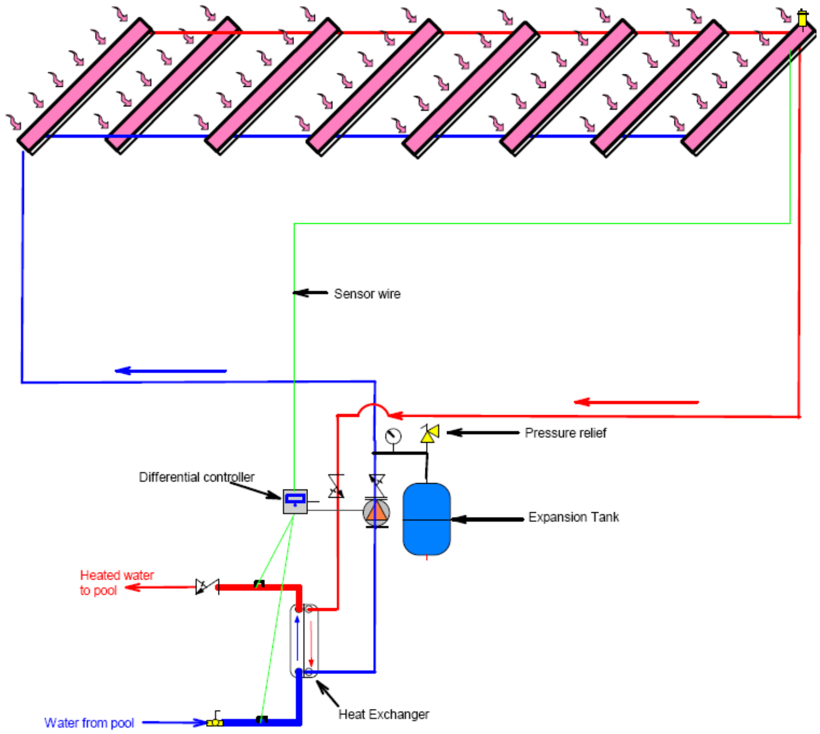


Figure 2 - Plumbing schematic

Figure 2 shows how the system ran and will run once the new panels are set into place.

SECTION 9

Monitoring

Figure 1

Monitoring is an extremely important part of renewable energy. Monitoring allows Northland to know how their systems are functioning. They can be tracked and data can be compiled to be used for a myriad of different things. It can be used in literature for attracting new students, grant writing, and a myriad of other applications.

Data tracking is primarily done by the Energy workstudy position in Environmental Council, but all systems are monitored by many different people. A list on page 55 tells who all is monitoring the systems, and how they are being monitored.

Systems Connected to Fat Spaniel

The Fat Spaniel monitoring database is an online tool that tracks some of the renewable systems on campus. The eventual goal is to have all systems hooked up to this website for monitoring. Currently four systems are live on the website, the MELLC, the Dexter Library, the President's house, and McMillan. The 2008 REF enabled the systems to be hooked up to the database.

To access the database, go to www.fatspaniel.com then click on the button that says "How it Works." Then, click on the box that says Live Sites. This will bring up a list off sites and installers. Search Northland College in the search site tab. This will bring up the currently connected sites.

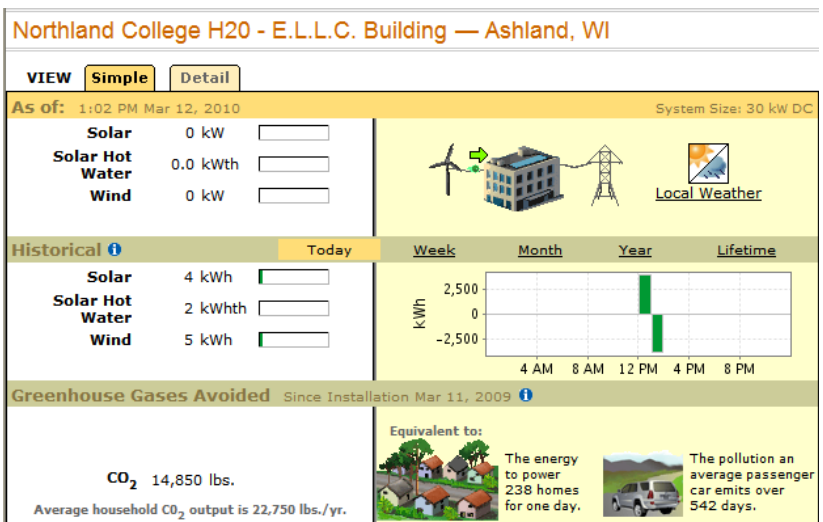


Figure 2 - MELLC Fat Spaniel display

The page for the MELLC is a little bit different from the rest of the sites due to it being a multi-faceted system. There is a simple view and a detailed view. The simple view tell what the system is currently producing. This can be used to monitor to see if the system is working properly.

If something shows up not working properly the detailed view can be clicked upon. AC out and DC in are both monitored.

By checking the AC in and DC out one can tell if the array is malfunctioning or if the inverter is what is the problem. If the DC is properly functioning and the AC is not it is the inverter that has encountered a problem.. If the DC in is not working then the AC should not be working either, so the problem could be the array, or it could be both. If a problem is noticed, alert facilities maintenance.

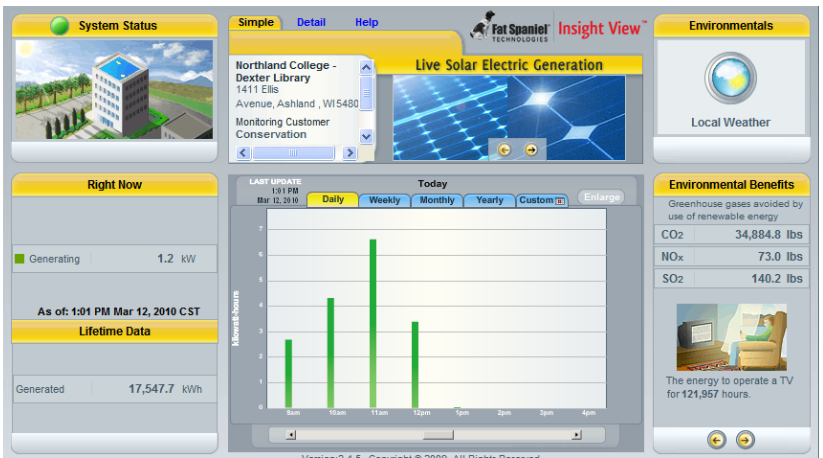


Figure 3 - Dexter Library Fat Spaniel Display

The Dexter Library is in format of the other three currently hooked up systems. This formatting also has simple and detailed layouts. In the detailed format the AC out and DC in can also be tracked and troubleshooted.

The detailed view of the Dexter Library shows two separate arrays. Each row of panels is hooked up to a separate inverter. These inverters then connect to the grid to create the 14 kW system.

The geothermal heat pump is not currently hooked up to the Fat Spaniel database, but there are plans to connect it to the database.

All data for the sites connected to the Fat Spaniel database can be downloaded. This information will be useful to track. The results can be used in marketing for the college as well as in grant applications

Figure 4 - President's House Fat Spaniel Display

At the time of printing the President's house has not been connected to feed live information to the Fat Spaniel database, but it has been added to the database and appears on the web-site.

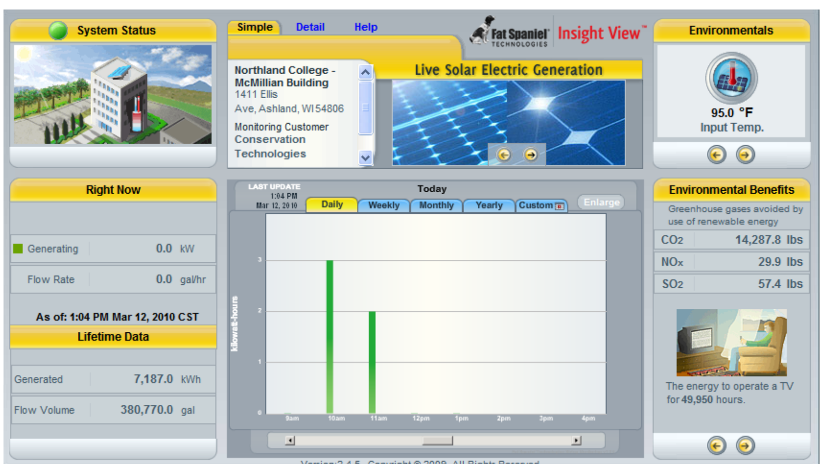


Figure 5 - McMillan Fat Spaniel Display

The data for McMillan is a bit different. Since it is solar hot water it won't have amps or voltage, but the system does measure fluid temperatures. It measures the temperature of the fluid going in and the temperature of it once it leaves the collectors. Figures 6 and 7 show typical input and output temperatures for the fluid during a spring day.

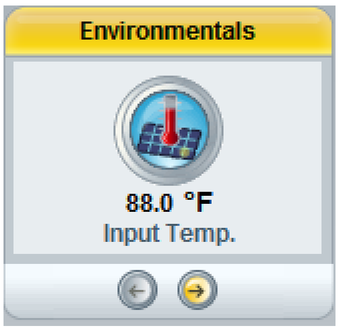


Figure 6 - Input Temperature

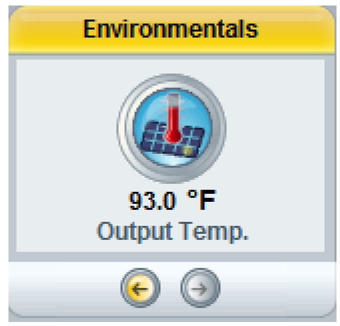


Figure 7 - Output Temperature

It is important to remember when reviewing the data for solar hot water that it is not going to be needed as much in the summer time. There are not students occupying the building so the systems do not need to be used.

Systems Not Connected to Fat Spaniel

The systems not currently connected to the Fat Spaniel database will also need to be monitored. These can be more difficult to assess.

The Craig A. Ponzio Campus Center can be difficult to monitor since geothermal heat pumps are not as easily measured as photovoltaic or wind systems. The best way to make sure the system is properly working is to monitor heating bills and check to see if there are any spikes. It is important to remember that the spikes could be from cold temperatures, but it could also signify something askew with the system.

The Strawbale house is an even more difficult situation. Since the house is not currently used for a regular function it is difficult to tell if the systems are working properly. The building is also completely off the grid so there are no energy bills to review. One of the best things to do would be to go into the building periodically and test to see if the lights are working and also check the charge controller. The battery acid levels will also need to be monitored to make sure they do not burn out.

These systems should hopefully be connected to the Fat Spaniel database so that they can be tracked with more ease and efficiency.

Who is Monitoring the Systems

There are many different people monitoring the systems to keep them properly functioning. **It is important to remember that any noticed malfunction or failure should be brought to the attention of Facilities Maintenance.** These are the people who are currently monitoring the systems on the Northland College Campus:

Facilities Maintenance: Facilities Maintenance is in charge of all of the buildings on campus. They make sure that buildings are properly functioning. Since many of our buildings have renewable systems attached to them, they are under Facilities Maintenance's jurisdiction.

Conservation Technologies: Conservation technologies is the company that is currently contracted to work on and repair the various systems around campus.

Environmental Council: Environmental Council is a group of active environmental stewards on campus. There is an energy coordinator position who works with renewable energy and overall energy consumption on campus. Much of the data collection is done by the energy coordinator.

Campus Safety: As campus safety does their periodic checks around campus they go into boiler and electric rooms. In the past they had noticed an inverter out, which they alerted to Facilities Maintenance who made sure the system was repaired.

SECTION 10

References to Figures

Section 1 - Introduction

Figure 1 - Logo courtesy of NCSA
Figure 2 - Logo courtesy of USGBC
Figure 3 - Logo courtesy of AASHE
Figure 4 - Logo courtesy of Focus on Energy

Section 2 - MELLC

Figure 1 - Photo courtesy of Rodney Claiborne
Figure 2 - Photo courtesy of Rodney Claiborne
Figure 3 - Graphic courtesy of Rodney Claiborne
Figure 4 - Graphic courtesy of Scott McTavish of Conservation Technologies
Figure 5 - Siemens Solar Model SP75 Information Sheet Organized by Rodney Claiborne
Figure 6 - Siemens Solar Model SP75 Information Sheet courtesy of Conservation Technologies
Figure 7 - Siemens Solar Model SP75 Information Sheet courtesy of Conservation Technologies
Figure 8 - Siemens Solar Model SP75 Information Sheet courtesy of Conservation Technologies
Figure 9 - Siemens Solar Model SP75 Information Sheet courtesy of Conservation Technologies
Figure 10 - Image Courtesy of www.ecodirect.com/v/vspfiles/photos/Fronius-IG-2000-2T.jpg
Figure 11 - Fronius IG 2000 Information Sheet courtesy of Conservation Technologies
Figure 12- Bergey Windpower BWC Excel Turbine Information Sheet. www.bergey.com/Products/Exell.Spec.Frt.pdf
Figure 13 - Bergey Windpower BWC Excel Turbine Information Sheet. www.bergey.com/Products/Exell.Spec.Frt.pdf
Figure 14 - Bergey Windpower BWC Excel Turbine Information Sheet. www.bergey.com/Products/Exell.Spec.Frt.pdf

Figure 15 - Bergey Windpower BWC Excel Turbine Information Sheet. www.bergey.com/Products/Exell.Spec.Frt.pdf
Figure 16 - Courtesy of Northland College Communications Department

Section 3 - Dexter Library

Figure 1 - Photo courtesy of Rodney Claiborne
Figure 2 - Graphic courtesy of Rodney Claiborne
Figure 3 - Sanyo Bifacial Photovoltaic Modules Information Sheet courtesy of Conservation Technologies
Figure 4 - Sanyo Bifacial Photovoltaic Modules Information Sheet courtesy of Conservation Technologies
Figure 5 - Sanyo Bifacial Photovoltaic Modules Information Sheet courtesy of Conservation Technologies
Figure 6 - Sanyo Bifacial Photovoltaic Modules Information Sheet courtesy of Conservation Technologies
Figure 7 - SMA SB5000 US Information Sheet courtesy of Conservation Technologies
Figure 8 - SMA SB5000 US Information Sheet courtesy of Conservation Technologies
Figure 9 - Slide courtesy of Clare
Figure 10 - Diagram from Energy Efficiency and Renewable Energy Clearing House from the Department of Energy September 1998. www.eren.doc.gov/erec/factsheets/geo_heatpumps.pdf

Section 4 - President's House

Figure 1 - Photo courtesy of Rodney Claiborne
Figure 2 - Graphic courtesy of Dr. Scott Grinnell
Figure 3 - Graphic courtesy of Dr. Scott Grinnell
Figure 4 - Image courtesy of www.beyondoilsolar.com/Sharp175.pdf
Figure 5 - Table courtesy of www.beyondoilsolar.com/Sharp175.pdf

Section 5 - McMillan

Section 6 - Strawbale House

tion Sheet courtesy of Conservation Technologies

Figure 12 - Photo courtesy of Rodney Claiborne

Section 7 - Craig A. Ponzio Campus Center

Figure 1 - Photo courtesy of Rodney Claiborne
Figure 2 - Slide courtesy of Clare Hintz
Figure 3 - Slide courtesy of Clare Hintz
Figure 4 - Slide courtesy of Clare Hintz
Figure 5 - Diagram from Energy Efficiency and Renewable Energy Clearing House from the Department of Energy September 1998. www.eren.doc.gov/erec/factsheets/geo_heatpumps.pdf
Figure 6 - Blueprint from MEP Associates Sheet M0.1 Geothermal Design For: Northland College. March 26, 2003
Figure 7 - Blueprint from MEP Associates Sheet M1.0 Geothermal Design For: Northland College. March 26, 2003
Figure 8 - Multistack water cooled condensing unit installation guide and users manual. http://www.multistack.com/literature/Installation/MS_30_50DX_Install_manual.pdf
Figure 9 - Slide courtesy of Clare Hintz
Figure 10 - Slide courtesy of Clare Hintz

Section 8 - Kendrigan Gymnasium

Figure 1 - Photo courtesy of Rodney Claiborne
Figure 2 - Kendrigan Plumbing Diagram by Scott McTavish of Conservation Technologies

Section 9 - Monitoring

Figure 1 - Courtesy of Fat Spaniel
Figure 2 - Courtesy of Fat Spaniel
Figure 3 - Courtesy of Fat Spaniel
Figure 4 - Courtesy of Fat Spaniel
Figure 5 - Courtesy of Fat Spaniel
Figure 6 - Courtesy of Fat Spaniel
Figure 7 - Courtesy of Fat Spaniel

Section 11

Valuable Resources

Section 1: Introduction

NCSA - http://ncsanorthland.org/
Phone: (715) 682-1289
Fax: (715) 682-1863
Email: ncsa@northland.edu
United State Green Building Council LEED - http://www.usgbc.org/LEED/
AASHE - http://www.aashe.org/
Wisconsin Focus on Energy - http://www.focusonenergy.com/

Section 2: MELLC

Northland College's Environmental Living and Learning Center - A Process Evaluation of a Green Building. By Ingo Bensch. September 2000 http://www.p2pays.org/ref/40/39349.pdf
Performance Monitoring of a Sustainable Residence Hall at Northland College. By Steven Carlson. September 2000 http://www.ecw.org/ecwresults/198-1.pdf
Fronius International - http://www.fronius.com/
Wattsun - http://www.wattsun.com/
Siemens - http://www.energy.siemens.com/us/en/power generation/renewables/solar-power/
Bergey - http://www.bergey.com/

Section 3: Dexter Library

Multistack Corporation - http://www.multistack.com/
SMA Solar Technology - http://www.sma-america.com/en_US.html
Sanyo - http://us.sanyo.com/Environmental-Solutions

Section 4: President's House

Fronius International - http://www.fronius.com/
Sharp - http://www.sharpusa.com/SolarElectricity.aspx
Wattsun - http://www.wattsun.com/

Section 5: McMillan

Sunda - http://www.sundasolar.com/product_index.html

Section 6: Strawbale House

Siemens - http://www.energy.siemens.com/us/en/power generation/renewables/solar-power/
Southwest Windpower - http://www.windenergy.com/index_wind.htm

Section 7: Craig A. Ponzio Campus Center

Multistack Corporation - http://www.multistack.com/

Section 8: Kendrigan Gymnasium

Solar Mining - http://www.solarminingco.com/

Section 9: Monitoring

Fat Spaniel - http://www.fatspaniel.com/
Facilities Maintenance - (715)-682-1283
Conservation Technologies - http://www.conservtech.com/
Environmental Council - environmentalcouncil@northland.edu
Campus Safety - (715)-682-1499

NORTHLAND
COLLEGE
1411 Ellis Ave.
Ashland WI 54806