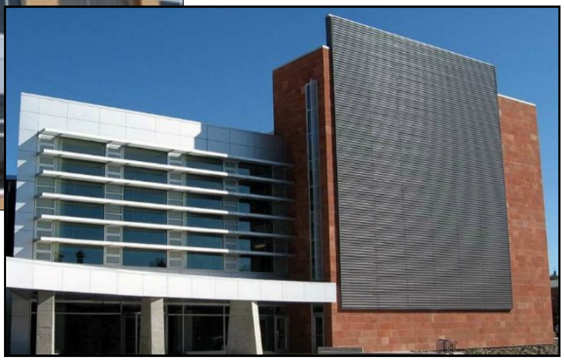
Bemidji State University
Evaluation Committee

Solar Transpired Air Heat Feasibility Study



Rural Renewable Energy Alliance (RREAL)
2330 Dancing Wind Road SW, Suite 2
Pine River, MN 56474
www.rreal.org 218-587-4753 info@rreal.org

November 11th, 2011

Bemidji State University
1500 Birchmont Drive Northeast
Bemidji, MN 56601
(218) 755-2001

Re: Solar Transpired Air Feasibility Study

Dear Bemidji State University,

Thank you for your interest in solar energy. We appreciate the opportunity to investigate the feasibility of transpired solar air heat for buildings on campus and provide you with information regarding the costs and savings associated with installing these durable energy systems at Bemidji State University..

Enclosed, you will find:

- An overview of the investigated technology
- Individual summaries of feasibility for each of the buildings analyzed containing:
    - Summary of suitability
    - Analysis of solar resource
    - Overview of proposed system
    - Existing energy demand and infrastructure
    - Annualized performance estimates
    - Associated financial and carbon savings
    - Estimate of installed investment cost
- Report Summary
- Statement of RREAL's qualifications.

The Renewable Energy Alliance 501c3 is dedicated to making solar energy accessible to the residential and commercial sector. We have been doing so for more than a decade, and we hope we are able to assist you in meeting your clean energy needs for the future.

Sincerely,

Jason Edens, Director

Rural Renewable Energy Alliance (RREAL)
2330 Dancing Wind Road SW, Suite 2
Pine River, MN 56474
www.rreal.org 218-587-4753 info@rreal.org

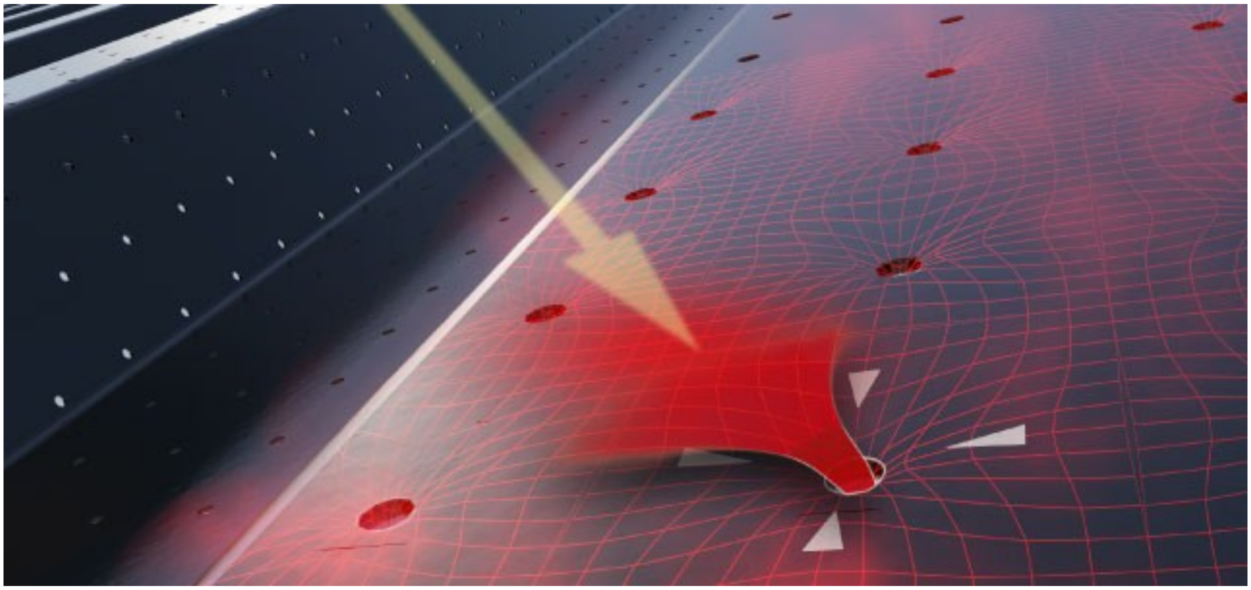
Executive Summary

Transpired air is a solar air heating technology adapted for large-scale installations on commercial buildings. The primary application for transpired air is to pre-heat fresh air as it is drawn inside, reducing the amount of fuel needed to keep a building warm. This can significantly reduce carbon emissions and heating energy costs and could play a role in helping to make the Bemidji State campus more sustainable.

RREAL has conducted an analysis of the non-residential buildings on campus in order to determine their suitability for transpired air technology. This includes an evaluation of year-round solar exposure at each potential installation site, measurement of wall space available for solar collectors, and inspection of HVAC units to determine volume flow rates for the makeup air systems and potential locations to feed solar-heated air into the system. This information was used to design an appropriate transpired air system along with a cost estimate for each building. RETScreen software was used to estimate the annual energy production and cost savings from each of these potential systems. This analysis reveals several buildings which would make very good candidates to receive solar transpired air collectors.

Rural Renewable Energy Alliance (RREAL)
2330 Dancing Wind Road SW, Suite 2
Pine River, MN 56474
www.rreal.org 218-587-4753 info@rreal.org

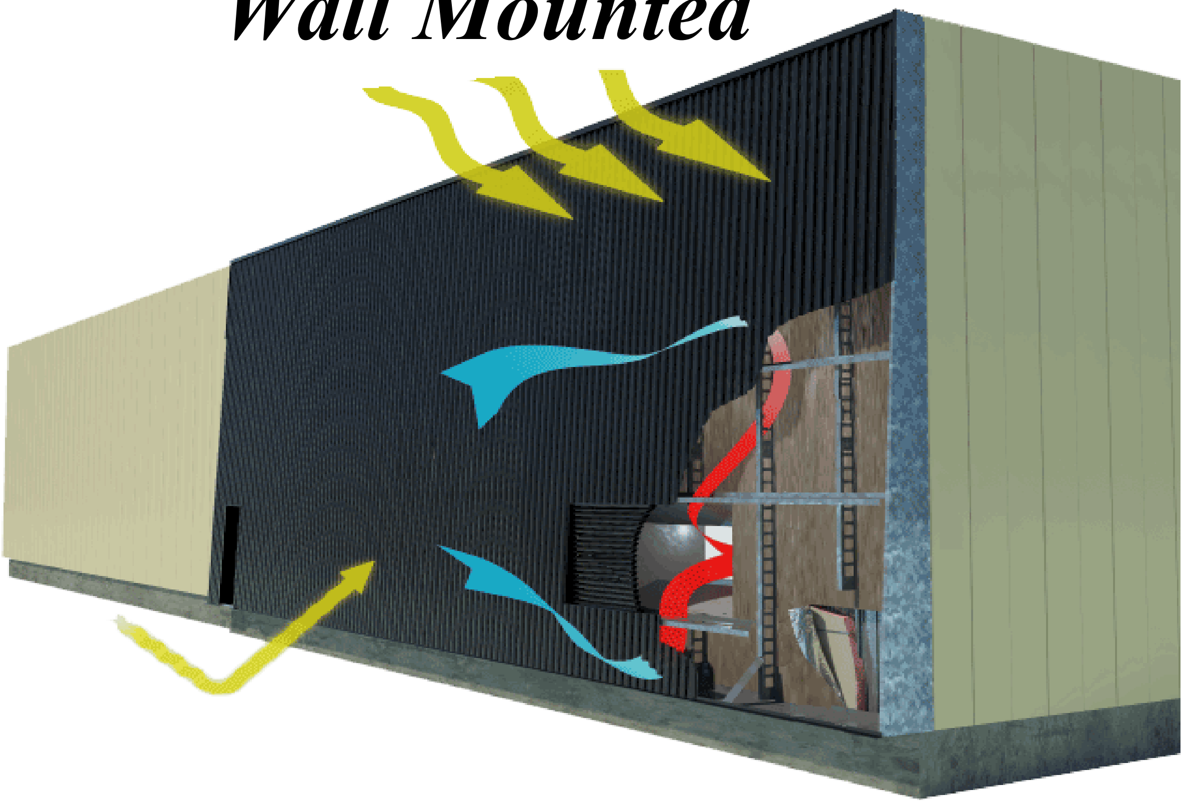
Solar Transpired Air



Transpired air technology consists of an exterior metal wall cladding which collects solar energy in order to pre-heat air coming into a building. The metal cladding is covered with small holes. The sun warms the metal surface, which in turn heats outside air as it is drawn through the holes and into the building. The air, which may now be 20° F warmer than ambient, is then ducted into the makeup air system for the building. This provides a substantial reduction in the energy required to provide fresh air for building occupants.

Rural Renewable Energy Alliance (RREAL)
2330 Dancing Wind Road SW, Suite 2
Pine River, MN 56474
www.rreal.org 218-587-4753 info@rreal.org

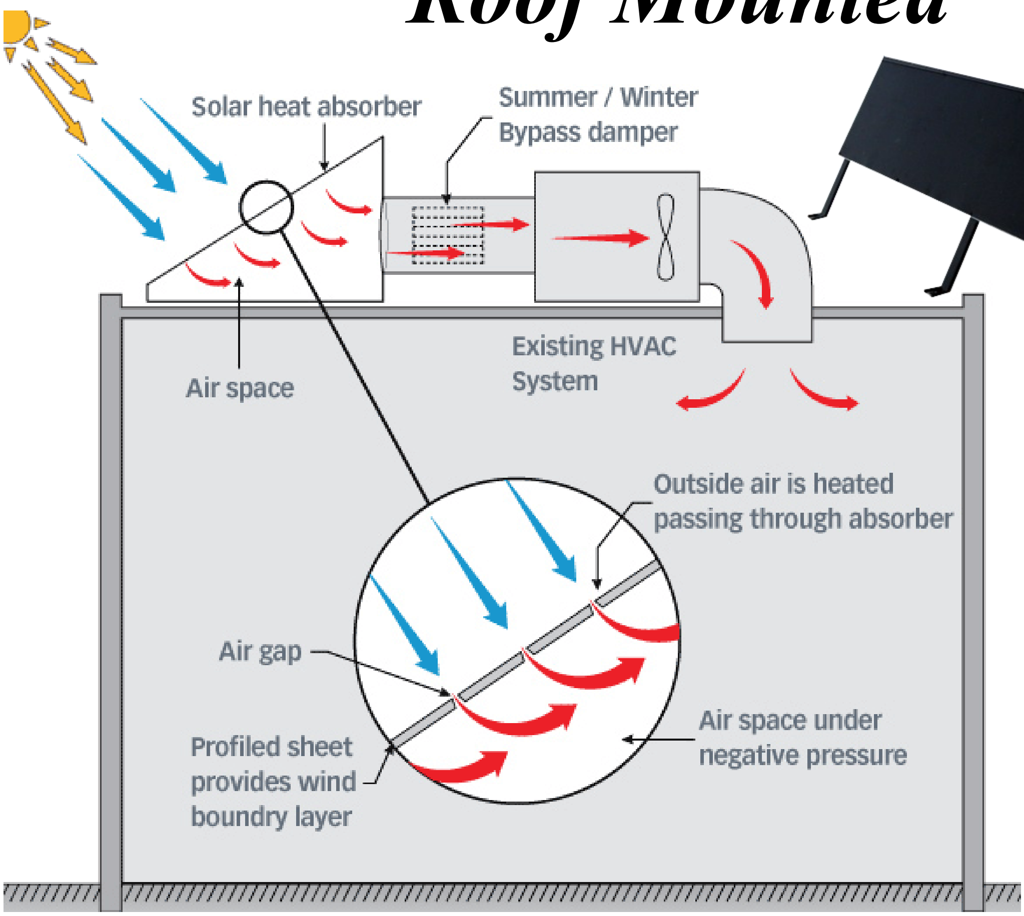
Wall Mounted



The solar cladding is attached to the building with support bars which form a gap with the existing wall. The system may use new ducting or may take advantage of existing air intakes, requiring very little alteration to the existing HVAC system. During the summer when warm air is not needed, bypass louvers allow fresh air to come directly from outside. Transpired air solar heating systems provide a very attractive return on investment due to their simplicity and low installation cost.

The benefits of transpired air for a particular site depends on a number of factors. Installing the cladding on a south-facing wall is ideal, but within 45° of true south there is only a minor loss in performance. Even east and west walls can receive a significant amount of solar energy. The year-round effect of shading should also be considered. If there is a good solar resource on the walls, there also needs to be enough wall space in order to provide the required volume of airflow. Transpired collectors can provide 3-9 cfm per square foot of collector area, and achieve the highest energy efficiency at 7-8 cfm/ft^2. Finally, there must be a reasonable path for ducting from the collectors to the air handling system. Installing the cladding around an existing intake is the simplest option, but ducting on the outside or through a wall can also be done. All of these factors were considered in order to determine the suitability of transpired air solar collectors for each of the buildings on the Bemidji State campus.

Roof Mounted



Transpired air also takes the form of modules which can be mounted on rooftops. A building's roof is often the area with the greatest solar resource. This type of installation is also very unobtrusive and can provide easy access to rooftop air intakes.

In this case however, installation would be difficult and costly due to MNScu's requirements for roofs. These requirements specify a built-up roof with a 40 year lifetime. Roof penetrations must be kept to a minimum and nothing can sit on top of the roof in order to prevent failure of the roof over that time period. Installing rooftop collectors would require supports attached directly to the roof deck and flashed to 1 foot above the roof membrane. The modules would then be installed on rails mounted to the supports so they would not contact the roof surface. This type of structure could more than double the cost of the installation.

Rural Renewable Energy Alliance (RREAL)
2330 Dancing Wind Road SW, Suite 2
Pine River, MN 56474
www.rreal.org 218-587-4753 info@rreal.org

Gillett Recreational Facility

Gillett has excellent solar exposure with ample space for transpired solar collectors on the south and West walls. Fresh air is provided through an air handling unit with an exhaust flow rate of 19,000 cfm. This requires between 2375 and 3167 sq. ft. of collector area. The building has four units which operate in a yearly rotation (each unit is used every four years), so that must be considered in designing the supply from the solar collectors.

Option 1: Install collectors in nine individual sections on the west wall, between the outcropping brick columns and below the windows. This offers a more integrated aesthetic but would cost more and provide about one third less energy than option 1.

Collector area: 2376 sq. ft.
Solar exposure: 94%, azimuth 90°
2009 heating cost: $45,491
Yearly performance estimate
- Delivered energy: 315.5 mmBtu
- Heat recaptured: 109.9 mmBtu
- Carbon savings: 26.3 tons CO_2, 4.8 cars not used
- Cost savings: $4,591

Parts and labor estimate: $56,100 + 100' duct + external ducts between sections + mechanical interface + building penetration

Gillett Recreational Facility

Option 2: Collectors mount across the south wall. This provides the most solar exposure for a wall-mounted installation on this building. The sections on the corners align with the windows on the upper wall to integrate with existing architecture.

Collector area: 2414 sq. ft.
Solar exposure: 94%, azimuth 0°
2009 heating cost: $45,491
Yearly performance estimate
- Delivered energy: 406.8 mmBtu
- Heat recaptured: 108.9 mmBtu
- Carbon savings: 31.8 tons CO_2, 5.8 cars not used
- Cost savings: $5,565
- Equity payback: 11.8 years

Parts and labor estimate: $49,700 + 200’ duct + mechanical interface + building penetration

Jon Glas Fieldhouse

The fieldhouse has a very large unobstructed south wall with marginal solar exposure. Covering just a portion of this wall will provide pre-heated air for the 15,000 cfm air handling unit.

Collector area: 220 ft. wide, 11 ft. tall, 2420 sq. ft.
Solar exposure: 74%, azimuth 0°
2009 heating cost: $53,168
Yearly performance estimate
- Delivered energy: 285.0 mmBtu
- Heat recaptured: 110.4 mmBtu
- Carbon savings: 24.4 tons, 4.5 cars not used
- Cost savings: $4,268
- Equity payback: 14.1 years

Parts and labor estimate: $49,480 + 100’ duct + building penetration

Hobson Lower Union

Transpired air collectors can be installed on the southeast and southwest walls of the mechanical room. Since this is located on a penthouse, the system would have little visual impact if any. The solar cladding will go on the same wall as the intake vents on the southeast wall, so installation will be simple with no building penetrations or ductwork required. This system will serve an air handling unit that provides 100% outside air to the kitchen, which is an ideal application for this technology.

- Collector area: 786 sq. ft.
- Solar exposure: 95%, azimuth -40°
- 2009 heating cost: $35,700
- Yearly performance estimate
  - Delivered energy: 129 mmBtu
  - Heat recaptured: 54.7 mmBtu
  - Carbon savings: 10.7 tons CO_2, 2.0 cars not used
  - Cost savings: $1,983
  - Equity payback: 9.5 years
- Parts and labor estimate: $20,300

Sattgast Hall of Science

This building has good solar exposure and enough area available for transpired air collectors to serve one of the air handling units. The system will be installed on the walls of the original penthouse mechanical room. The intake vent is located in the middle of the proposed solar wall, so no ducting or penetrations are necessary. The cladding will start at the edge of the doorway on the west end and wrap around the wall all the way to the east end of the penthouse.

- Collector area: 1051 sq. ft.
- Solar exposure: 85%, azimuth 10°
- 2009 heating cost: $41,983
- Yearly performance estimate
  - Delivered energy: 160.7 mmBtu
  - Heat recaptured: 70.4 mmBtu
  - Carbon savings: 14.3 tons CO_2, 2.6 cars not used
  - Cost savings: $2,494
  - 11.3 years
- Parts and labor estimate: $31,500

Sattgast Hall of Science

The new addition to Sattgast does not have enough space to install transpired cladding on the walls. No airflow specifications were available for this air handling unit, but judging by its size much more wall area would be needed for the system to function properly.

Bridgeman Hall

This location has good solar exposure and enough space for a solar wall to supply one of the air handling units. The system will use an existing air intake on the eastern wall of the penthouse.

- Collector area: 1000 sq. ft.
- Solar exposure: 90%, azimuth 18°
- 2009 heating cost: $140,162
- Yearly performance estimate
  - Delivered energy: 138.6 mmBtu
  - Heat recaptured: 3.6 mmBtu
  - Carbon savings: 8.8 tons CO_2, 1.6 cars not used
  - Cost savings: $1,542
  - Equity payback: 13.4 years
- Parts and labor estimate: $23,200

Bangsberg Fine Arts Complex

This building has very good solar exposure and sufficient space on the southern wall for enough transpired collectors to supply two air handling units. Installations can be completed on one or both ends of the southern wall.

Option 1: The west section of the southern wall offers enough space to supply one air handling unit. The system would require ducting from the east edge of the collector to the air intake located on the inset part of the building.

Collector area: 1787 sq. ft.
Solar exposure: 94%, azimuth 30°
2009 heating cost: $34,034
Yearly performance estimate
- Delivered energy: 269.4 mmBtu
- Heat recaptured: 120.2 mmBtu
- Carbon savings: 24.0 tons CO_2, 4.4 cars not used
- Cost savings: $4,204
- Equity payback: 8.2 years

Cost estimate: $38,000 + 30’ exterior duct

Bangsberg Fine Arts Complex

Option 2: The eastern section of the south wall also contains enough space to supply one air handling unit. The system would require ducting from the west edge of the collector to the air intake. Obstacles on this end of the south wall increase installation costs and reduce the surface area available. This makes this option less appealing than option 1 as a standalone option, but it is a very suitable site for installing additional transpired air heat collectors to meet a greater portion of energy needs while improving aesthetics of the overall installation.

Collector area: 1787 sq. ft. minus windows
Solar exposure: 94%, azimuth 30°
2009 heating cost: $34,034
Yearly performance estimate

- Delivered energy: 269.4 mmBtu
- Heat recaptured: 120.2 mmBtu
- Carbon savings: 24.0 tons CO_2, 4.4 cars not used
- Cost savings: $4,204
- Equity payback: 8.2 years

Cost estimate: $38,000 + 30’ exterior duct

Deputy Hall

Deputy Hall has an acceptable solar resource. Transpired cladding on the upper portion of the south wall could serve up to two of the air handing units.

Collector area: 1248 sq. ft.
Solar exposure: 82%, azimuth 30°
2009 heating cost: $25,832
Yearly performance estimate
- Delivered energy: 179.5 mmBtu
- Heat recaptured: 85.4 mmBtu
- Carbon savings: 16.3 tons CO_2, 3.0 cars not used
- Cost savings: $2,858
- Equity payback: 10.6 years

Parts and labor estimate: $27,300 + interior ducts + building penetration

Education-Art Building

The top half of this building has a passable solar resource and a solar collector could serve the air handling unit in the basement. The collector would be mounted in the upper middle section of the south wall and would require ducting down to the intake vent at the base of the building.

Collector area: 400 sq. ft.
Solar exposure: 78%, azimuth 30°
2009 heating cost: $26,513
Yearly performance estimate
- Delivered energy: 49.7 mmBtu
- Heat recaptured: 27.2 mmBtu
- Carbon savings: 4.8 tons CO_2, 0.9 cars not used
- Cost savings: $831
- Equity payback: 17.0 years

Parts and labor estimate: $11,900 + 14' exterior duct

Other Buildings Analyzed

Hobson Upper Union

This building has excellent solar exposure on the penthouse but unfortunately does not have enough wall space to serve the large air handling unit.

American Indian Resource Center

This building has an excellent solar resource on the roof but there is no wall space available to install solar collectors.

Walnut Hall

Walnut has a large makeup air requirement for the kitchen and there is not enough space on the south wall or the short penthouse walls for solar collectors to meet this need.

Hagg-Sauer Hall

Though it has a good solar resource, this building has a complex wall shape and no convenient air inlet locations, which would make installation difficult and would compromise the performance of solar air heat collectors.

Summary

Here is a summary chart showing the savings and payback of each building. Potential installation sites are arranged by fastest return on investment. Note that the savings listed represent real money that each installation will empower BSU to avoid paying to fuel companies during just the first 30 years, while the system will continue to function almost indefinitely with very minimal maintenance. These estimates assume fuel prices do not rise any faster than they have for the past 15 years. If fuel prices rise faster, the systems will pay for themselves even more quickly and save BSU more money. These thousands of dollars in avoided fuel costs can instead be utilized for other institutional and educational needs. Every solar system you choose to install ensures more of your energy needs will be met reliably with Minnesota technologies and local resources while freeing BSU from volatility and spikes in fuel prices.

Other benefits: extra layer of insulation (slow (reduced temperature differential between interior and exterior wall surface temperatures) AND recapture conductive heat loss (when it does escape it enters the plenum and is redirected back into the building), block summer heat, protect building exteriors and finishes from weathering)

Rural Renewable Energy Alliance (RREAL)
2330 Dancing Wind Road SW, Suite 2
Pine River, MN 56474
www.rreal.org 218-587-4753 info@rreal.org

Statement of Qualifications for the RREAL Team

Relevant Licensure:

⇒ **MN General Contractor's 20629837**
⇒ **MN State Certified Residential Energy Auditor**
⇒ **NABCEP Certified Solar Thermal Installer ST091110-13**
⇒ **NABCEP PV installer 032407-39**

- 501(c)(3) nonprofit established in 2000, making solar power accessible to everyone.
- Developed the Solar Powered Furnace, the nation's most efficient patent pending solar air heat collector, following the most extensive direct vent solar air heat research project in the US.
- Manufacture and installation of the largest glazed solar air heating system in the country at the Hunt Utilities Group campus in Pine River, MN.
- Solar Rating and Certification Corporation (SRCC) Certified (SRCC OG-100)
- Received Minnesota Cup award in 2009 in the Social Entrepreneurs division.
- Awarded Outstanding Green Venture from the Initiative Foundation in 2009.
- Experience installing more than 200 solar systems across the country on homes, businesses, municipal buildings, and schools of all sizes.

Board of Directors:

Since its inception in 2000, RREAL has benefited from a strong, well-rounded governing board. The Board of Directors currently consists of the following individuals:

1. Steven Benson - Interim Board Chair, Rehabilitation Counselor, Entrepreneur.
2. Danielle Butenhoff - Secretary, Environmental Educator, Dodge Nature Center.
3. Barb Mann - Treasurer, Community Education Director, Pine River-Backus Schools.
4. Ben Butcher - Energy Auditor, Entrepreneur.
5. Wendell King - Inventor/Entrepreneur.
6. Steven Spigarelli - Professor Emeritus, Bemidji State University.
7. Erika Bailey-Johnson - Sustainability Coordinator, Bemidji State University.
8. Sherry Rovig - Architect, Inventor, Entrepreneur.

⇒ **All proceeds from this installation will go directly towards our Solar Assistance and Educational Outreach programs which provide solar heating systems to low-income families struggling with fuel poverty and increase awareness around renewable energy technologies respectively. By installing this system with RREAL you will not only be empowering Bemidji State University as a beacon for sustainability, you will also be empowering the underprivileged youth and families of Minnesota.**

Rural Renewable Energy Alliance (RREAL)
2330 Dancing Wind Road SW, Suite 2
Pine River, MN 56474
www.rreal.org 218-587-4753 info@rreal.org