SolAir Heating Innovations

Semester: Fall 2025


Calvin Schenkenberger


Joseph Meza


Brendan Frazier


Tyler Hedgecock


Jacob Apodaca

Northern Arizona University
Mechanical Engineering

Renewable Energy Lab,
Northern Arizona University,
Flagstaff, AZ 86011

Abstract

Our team aims to design a renewable heating system that utilizes renewable energy sources, mainly solar energy. The purpose of this project is to supply sufficient heating to the Renewable Energy (RE) building during the cold winter months, utilizing solar energy to protect the building's battery storage and as an alternative to non-renewable energy sources such as fossil fuels. To achieve this, our team refurbished two recycled solar air collectors and mounted them on the eastern side of the building's roof. The solar panels have two primary energy inputs: the existing photovoltaic solar panels and electric batteries. The system is connected through custom-built ductwork and a control network that distributes heated air throughout the building. Two vents are located in the building's larger room while one is located in the smaller room. From engineering analyses, including modeling, simulations, and hand calculations, results show that the solar air collectors can provide a sufficient amount of heating during the winter, covering about one half of the building's heating demand. From results, the design demonstrates it can account for safety, efficiency, and performance. Although the building requires supplemental heating in the winter, our project demonstrates the scalability of solar air heaters and shows that we have met our goal to lower carbon emissions, reduce costs, and extend the life of existing clean energy.

Requirements

Customer Requirements

- The system must reduce the heating load by 30% during the winter.
- The system must function during the winter months and when sunlight is not obstructed by obstacles (i.e., clouds, trees, buildings, etc.).
- The system must utilize renewable energy (i.e., sunlight) as its primary source and exclude non-renewable sources, such as oil, unless in an emergency.
- Installing the system must not require making any significant modifications to the building.
- The system must be safe and comply with codes established by ASHRAE, plumbing, electrical, and solar thermal standards [1].
- The system must have minimal maintenance (<4 hours) by staff or building owners.
- The payback period must be under 10 years.
- The system must have a visual indicator of its operating status.
- The system must have a monitoring system for temperature and performance.
- The system cannot overheat or cause interior overheating.

Engineering Requirements

- Energy Stored (kWh): The system must collect a sufficient amount of solar energy to both store and utilize during times when the sun is out.
- Efficient Insulation (R value): Confirm or improve building insulation for heat storage
- Flow rate (CFM): In accordance with ASHRAE standards, the fans must supply a sufficient amount of air in CFM.
- Life Expectancy (years): Material selection and system design will provide a 10-year minimum lifetime.
- Cost ($): This project has a budget of $2500
- Mounting System (kg): Mounting system maximum weight should be less than 25kg

Methods

Process

- Refurbish old solar air heaters
- Build mounting system
- Attach solar air heaters to roof
- Build electrical system with the use of conduit
- Run ducting through attic and have the input and output vents in building


Figure 1: Duct Work Throughout Ceiling


Figure 2: Solar Air Heaters

Experiments were performed to optimize solar air heaters output. For example, testing for air leaks allowed the team to increase output temperatures and output volumetric flow rate by minimizing losses through ducting.

A combination of flexible and rigid ducting was used to direct the heated air to the building. Figure 1 shows flexible ducting leading to main room.

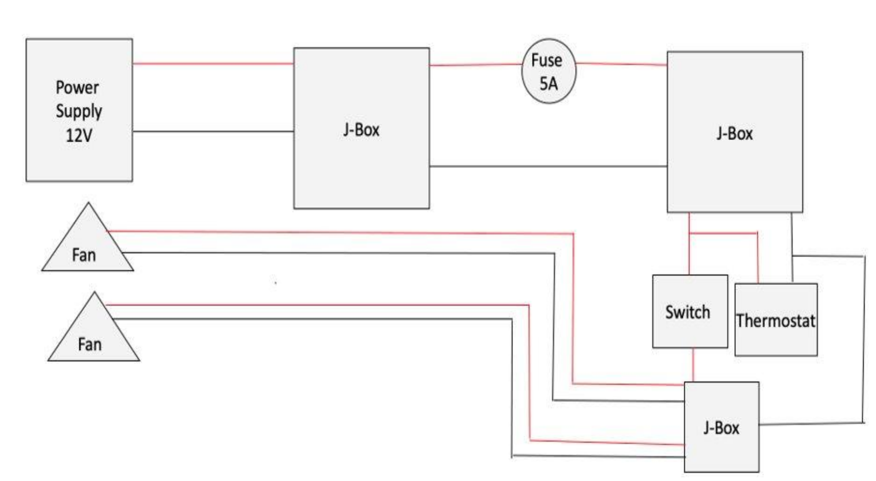

Figure 3: Circuit Diagram


Figure 4: Inlet Duct


Figure 5: Thermostat and Master Switch

Testing and Results

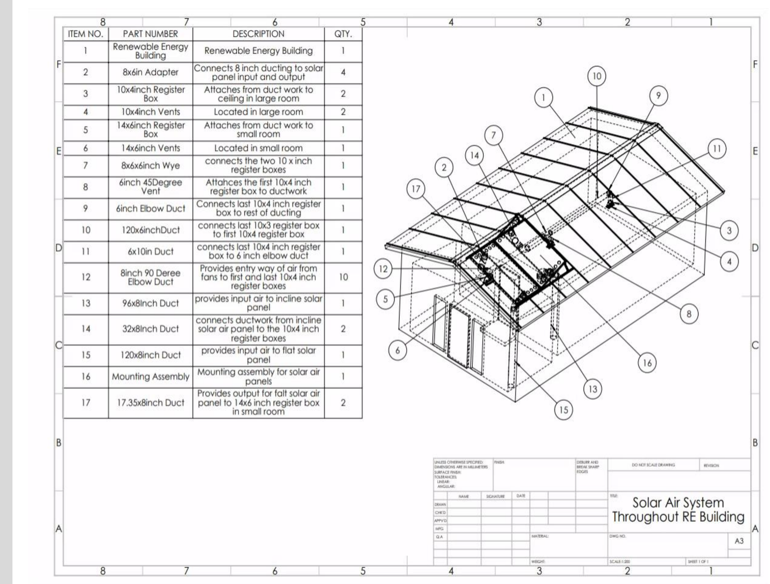
Figure 6: Engineering Drawing of Project

- Final CAD design for the solar air heating system throughout the Renewable Energy Building.
- Solar air panels are mounted on east side of the roof to absorb maximum solar energy.
- Fans are attached to solar air panels to distribute heated air throughout building.

- Daily energy supply for winter months based on annual irradiation
- Average Irradiance: 1000 W/m^2
- Average daily heat supply: 12.5kWh
- Compared with irradiation during testing to prove validity of model

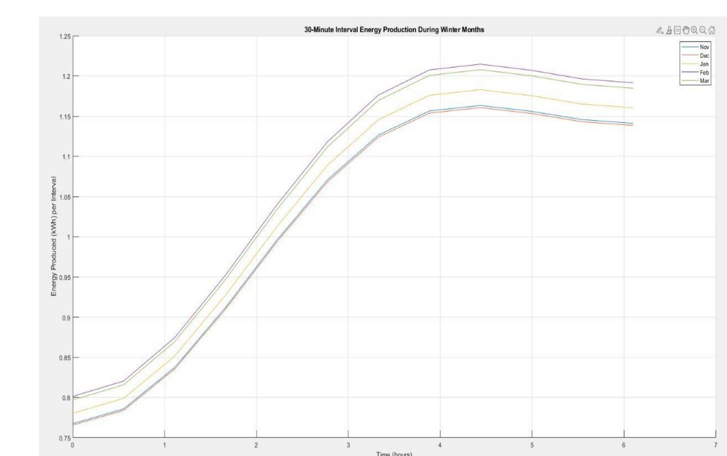
Figure 7: MATLAB Simulation of Energy Input

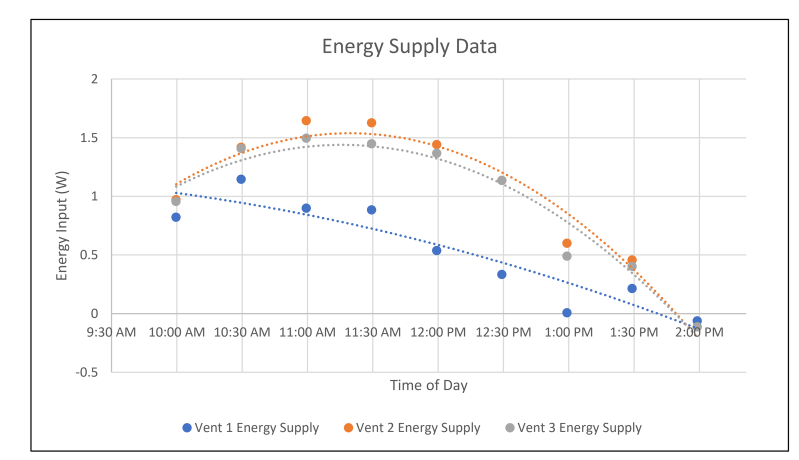

Figure 8: Energy Input Data

- Solar Irradiation: 522 W/m^2
- Vent 1 Energy Supply: 1.6kWh
- Vent 2 Energy Supply: 3.1kWh
- Vent 3 Energy Supply: 2.9kWh

Conclusion

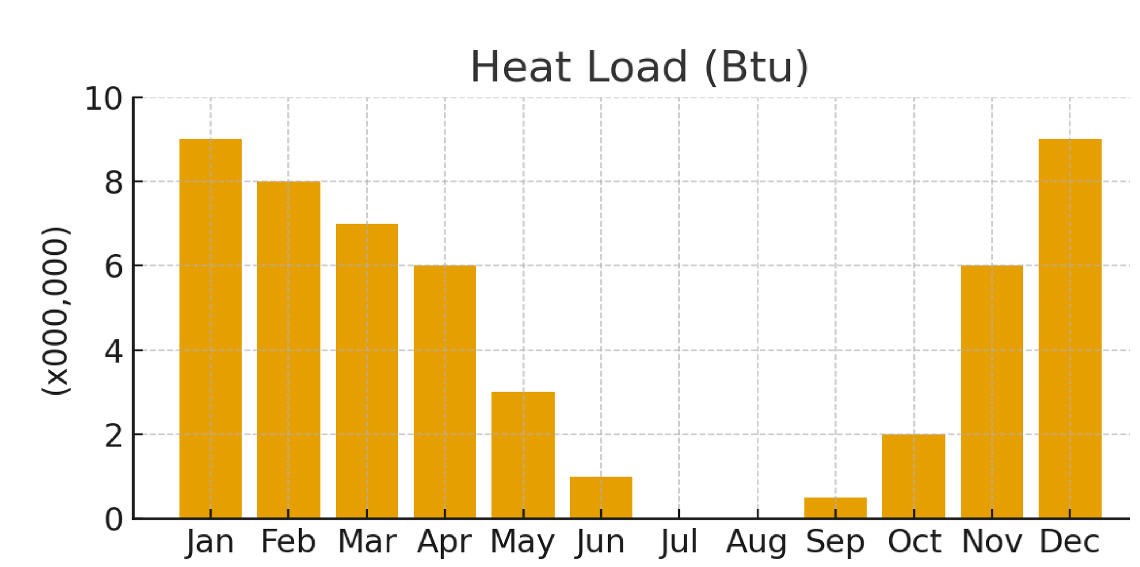

Figure 9: Heat Load Simulation Results

The SolAir Heating Innovations team met the goal of using solar energy as the primary energy input for our system. Through calculations and simulations, we have proven that the solar air system can meet one of the main customer requirements, that the heat load must be reduced by 30%. The team decided to utilize two solar panels because it was shown to reduce the heat load by 53.25%. Our team decided to mount both solar panels on the southeast side of the roof from AR simulations.

References

[1] Standards and guidelines, https://www.ashrae.org/technical-resources/standards-and-guidelines

[2] T. L. Bergman, *Fundamentals of Heat and Mass Transfer, 8th Edition*. New York: John Wiley & Sons, Incorporated, 2016.

[3] US, "Time Series Viewer," *Weather.gov*, 2025. https://www.weather.gov/wrh/timeseries?site=QFLA3

[4] Windfinder.com, "Wind and weather statistic Flagstaff Pulliam Airport," Windfinder.com, https://www.windfinder.com/windstatistics/flagstaff

Acknowledgements

- Prof. Carson Pete – NAU Faculty Support
- NAU Mechanical Engineering Department - Sponsor
- Home Depot – Sponsor and Supplier