NORTHERN ARIZONA UNIVERSITY
College of Engineering, Forestry & Natural Sciences

Active Roof System

Department of Mechanical Engineering; Senior Capstone

Final Project Presentation

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Overview

- Project Description
- Three Roof System Prototypes
- Model Building Design & Construction
- Internal Building Systems
- Simulated Sun
- Testing Procedures & Results
- Conclusions

Introduction to Project

- Large warehouse buildings use a significant amount of power keep the interior cool during the summer.
  - Heat is transferred into these buildings through the roof
    - The larger the surface area the more sun radiation which hits it

Need Statement & Project Goal

- Need Statement
  - The amount of power used to keep the interior of large buildings at a comfortable, cool temperature is too high.
- Project Goal
  - To design and build roof system prototypes that can maintain the interior at constant temperature of a building model while using minimal power.

Objectives and Constraints

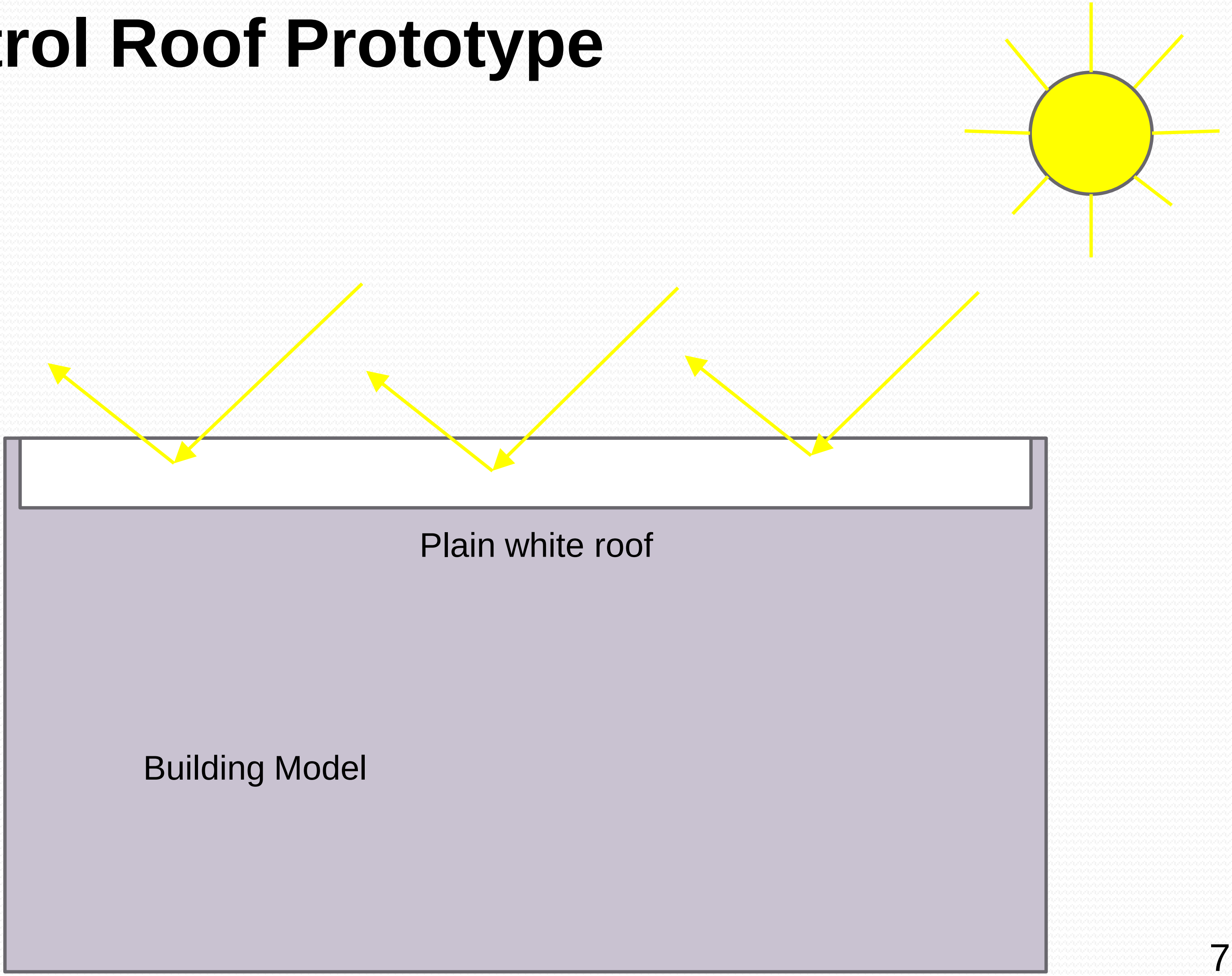
- Constriants
  - Create a scale model of a large warehouse
  - Interior of building must be maintained at 70°F
- Objectives

Objective	Measurement Basis	Units
Maintain Internal Temperature of 70°F	Interior Temperature of Scale Model	°F
Low Power Usage	Amount of Time A/C System is Used Throughout the Day	Seconds

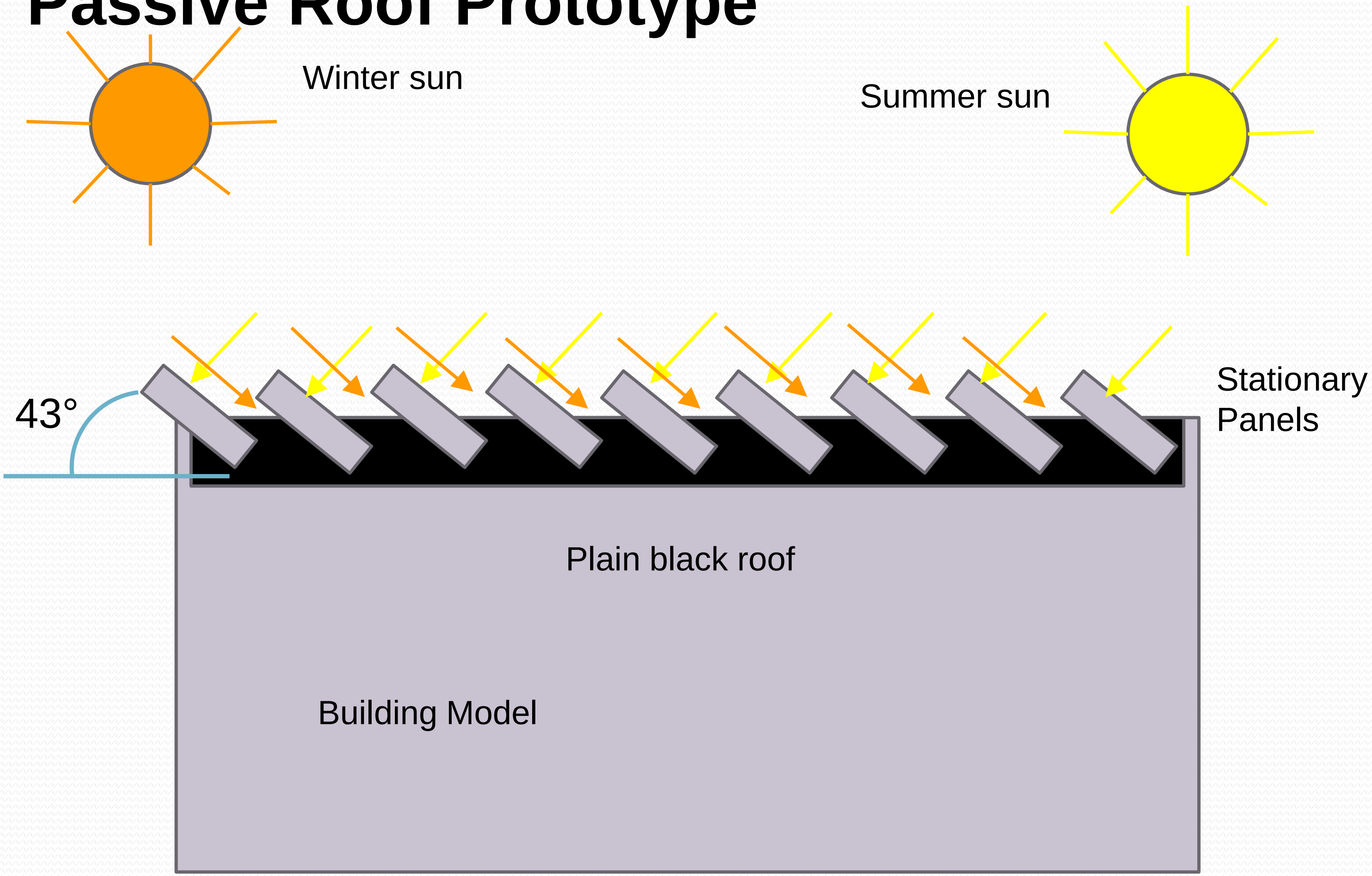
Project Description

- Project will investigate roof designs that will lower this power consumption
  - Control Roof ~ Plain White Roof
  - Passive Roof ~ Stationary Panels
  - Active Roof ~ Solar Tracking Panels

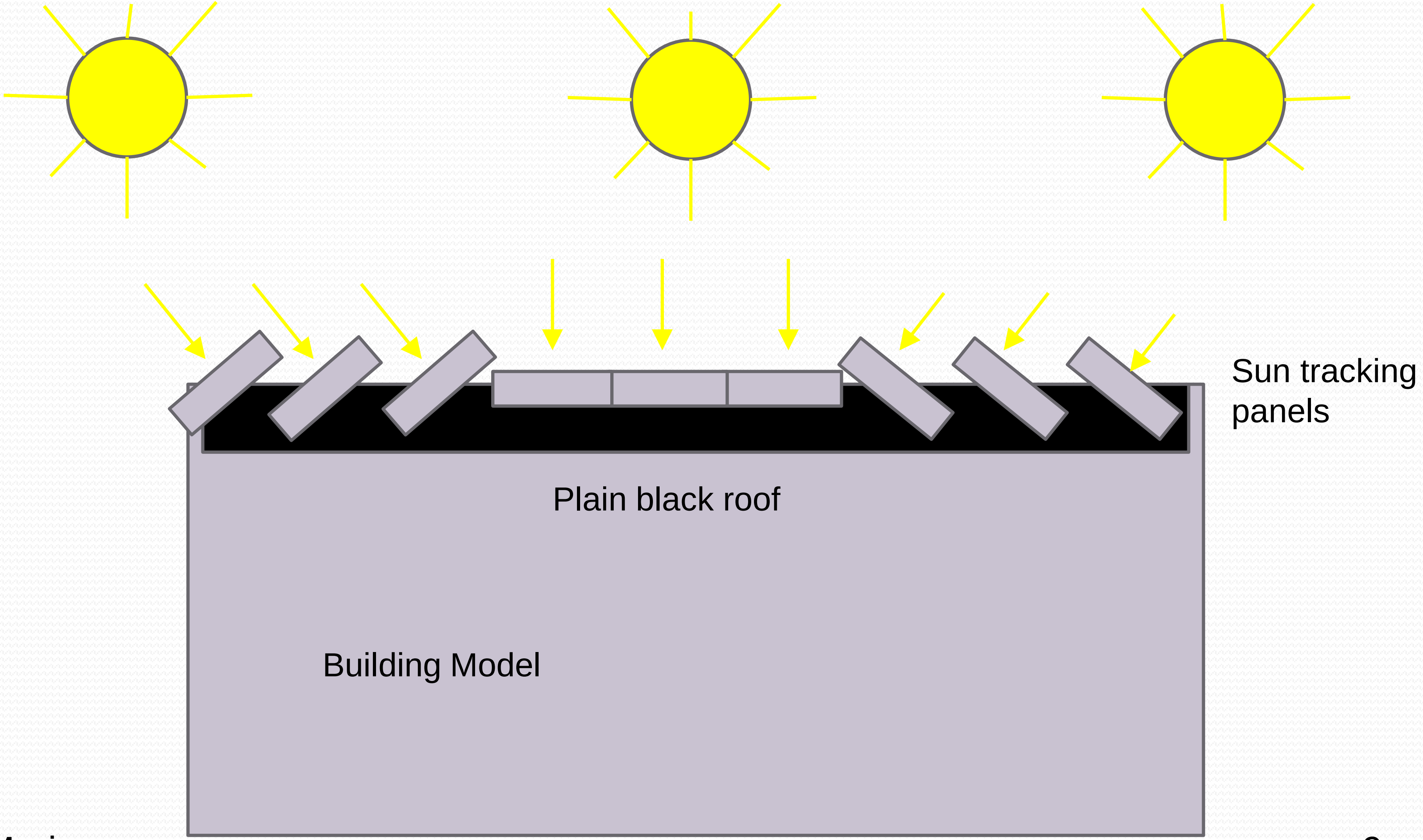
Control Roof Prototype



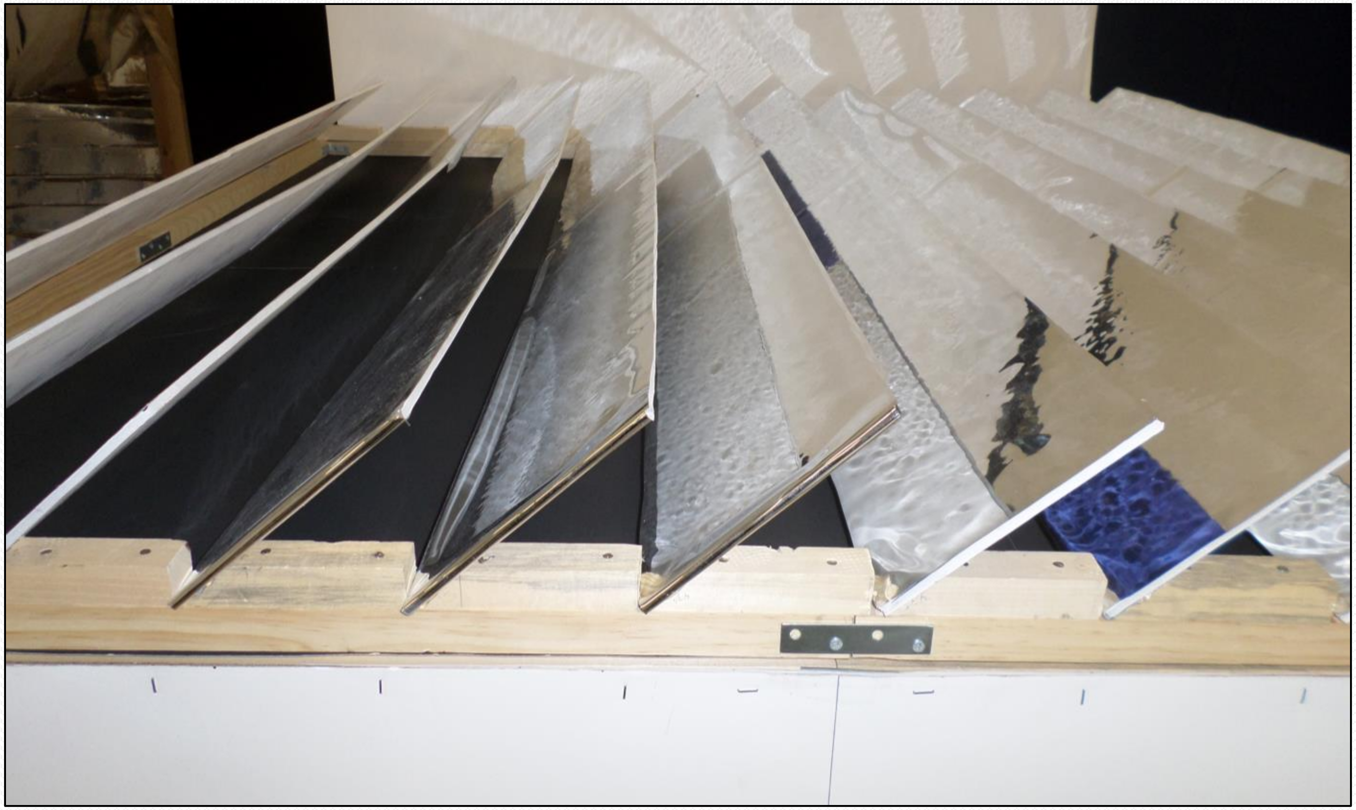
Passive Roof Prototype



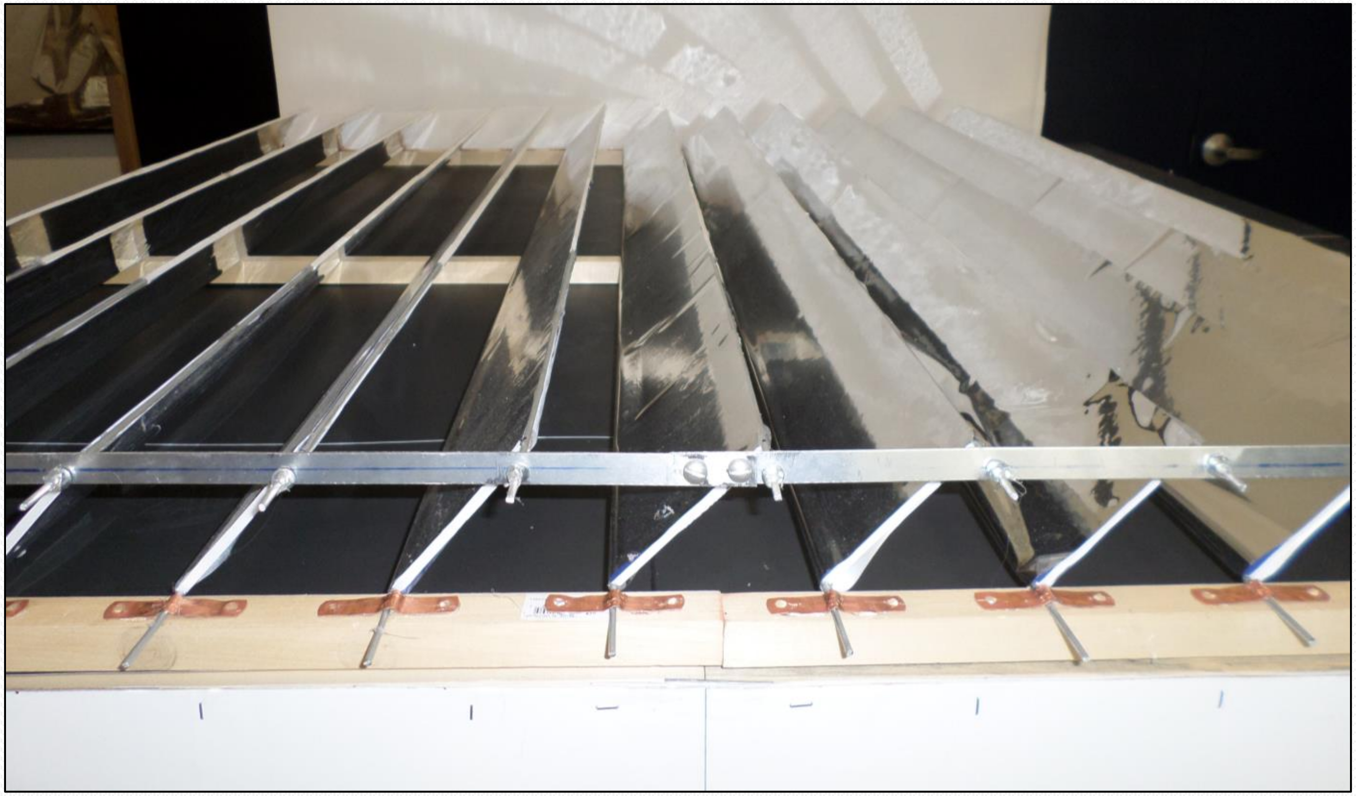
Active Roof Prototype



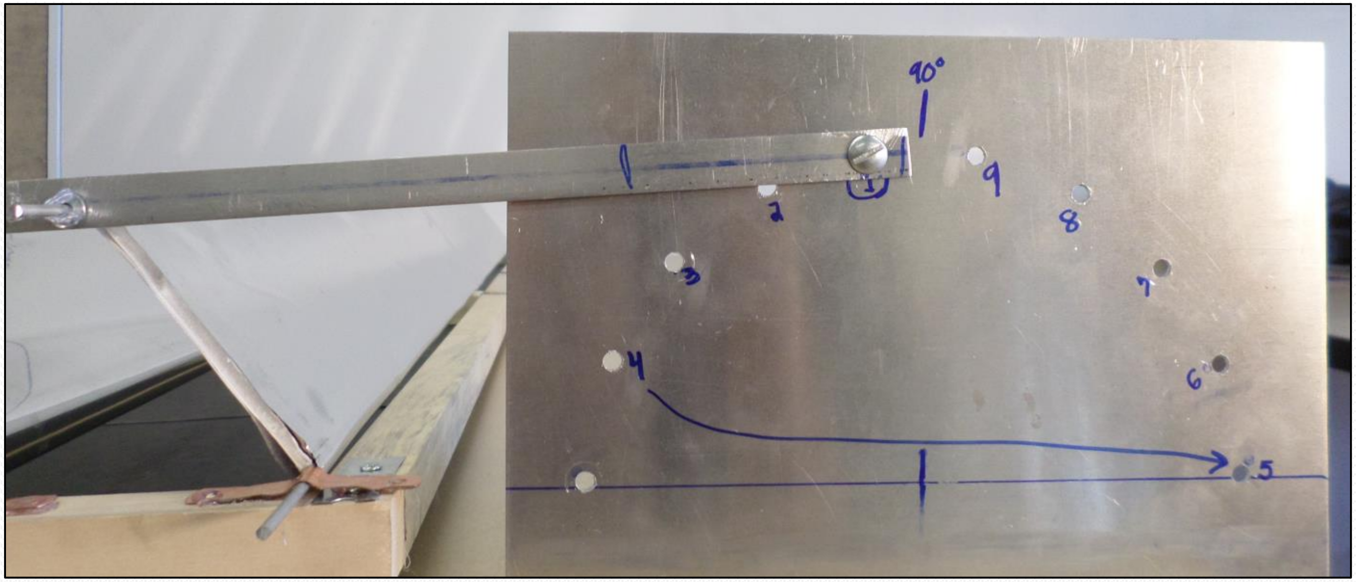
Passive Roof Prototype Constructed



Active Roof Prototype Constructed



Active Roof Prototype Constructed Cont.

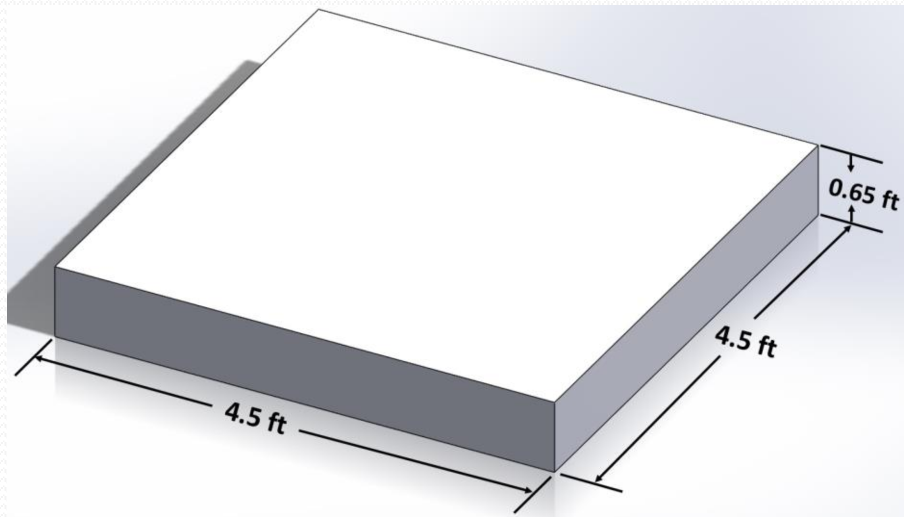


Model Building Design & Construction

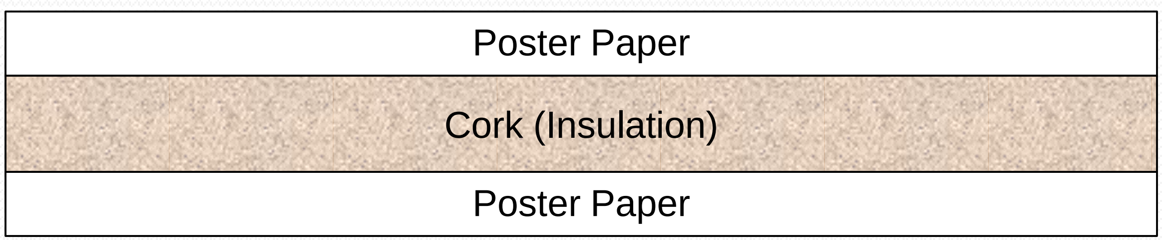
- Model building is scaled after a 30,000ft^2 warehouse
  - Scaling factor dependent on the insulation material for model building
    - Selected 3/32in thick cork
  - Scaling Factor is 1/40

Model Building Design & Construction

- Model building

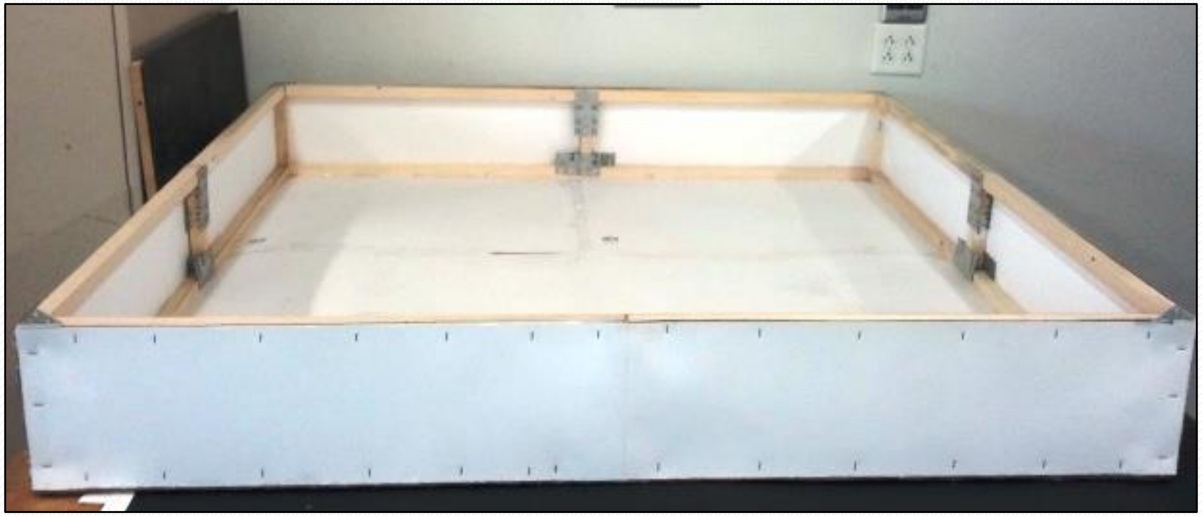


  - Walls are made of



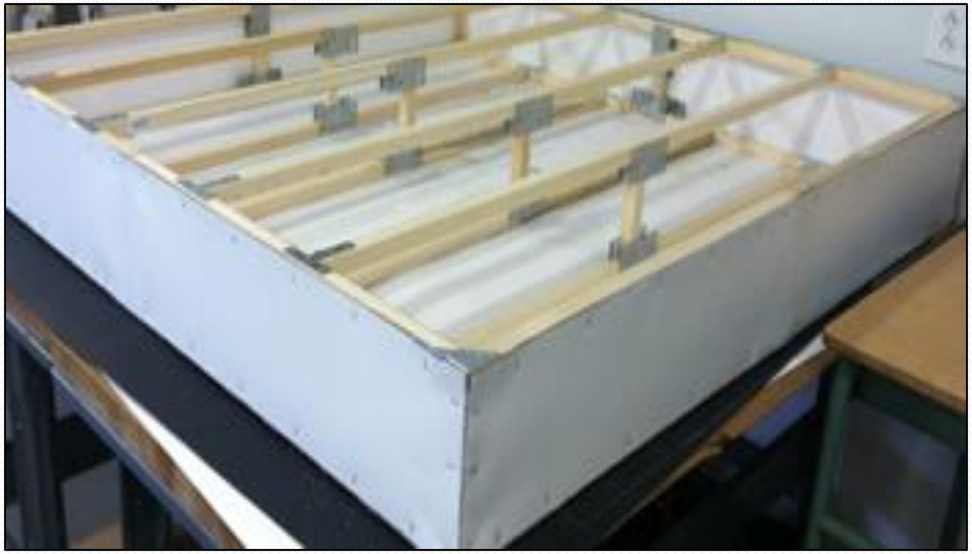
Model Building Design & Construction Cont.

- Beginning framework and walls



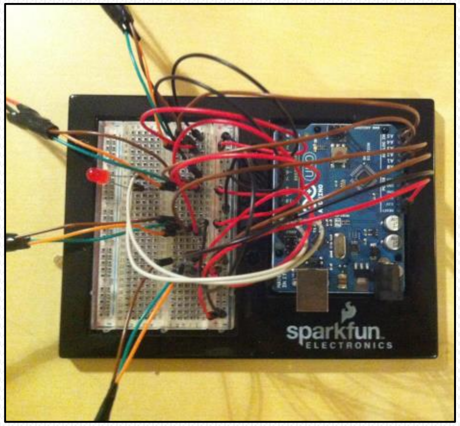
Model Building Design & Construction Cont.

- Added support frames



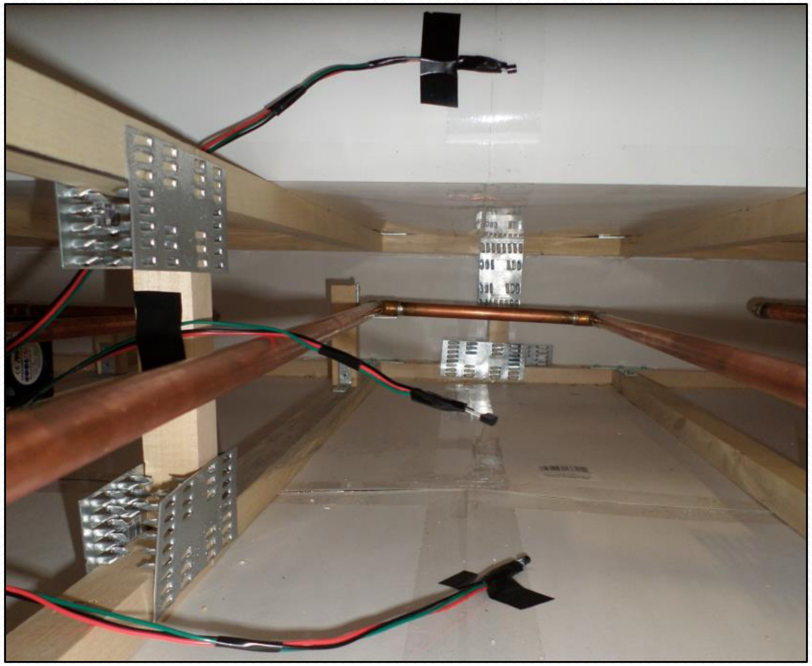
Temperature Monitoring

- UNO Arduino
- 4 Thermistors
- Arduino programmed to
  - Read temperatures
  - Send signals to the A/C system
  - Record the time when the A/C is running



Temperature Monitoring Cont.

- Placement of thermistors inside model building



A/C System

- Activated when internal temperature reaches 75°F
  - Then, turn off when returns to 70°F (avg room temp)
- Serpentine layout with 1/2in Copper piping
- Centralized location for even cooling

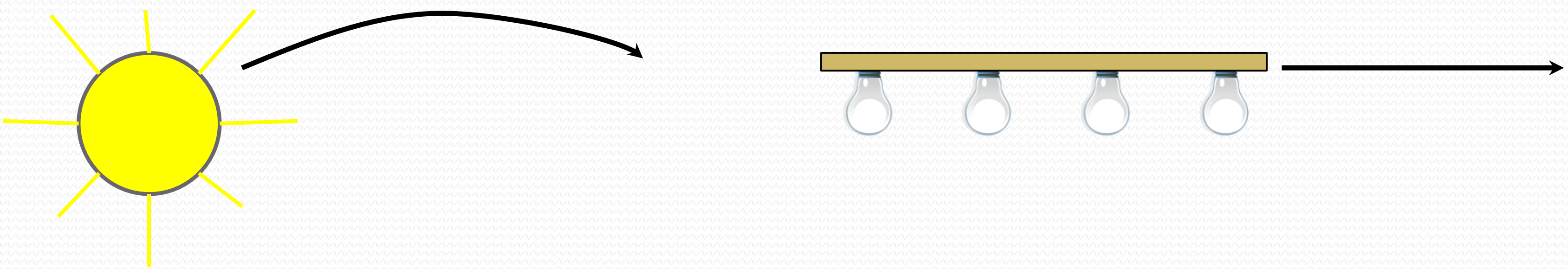
A/C System Cont.

- ~32^{o}F (ice) water pumped through the piping
  - Ice water is contained in cooler
- Radiant cooling with fans
- Connected to arduino to control on/off



Simulated Sun

- Why its needed?

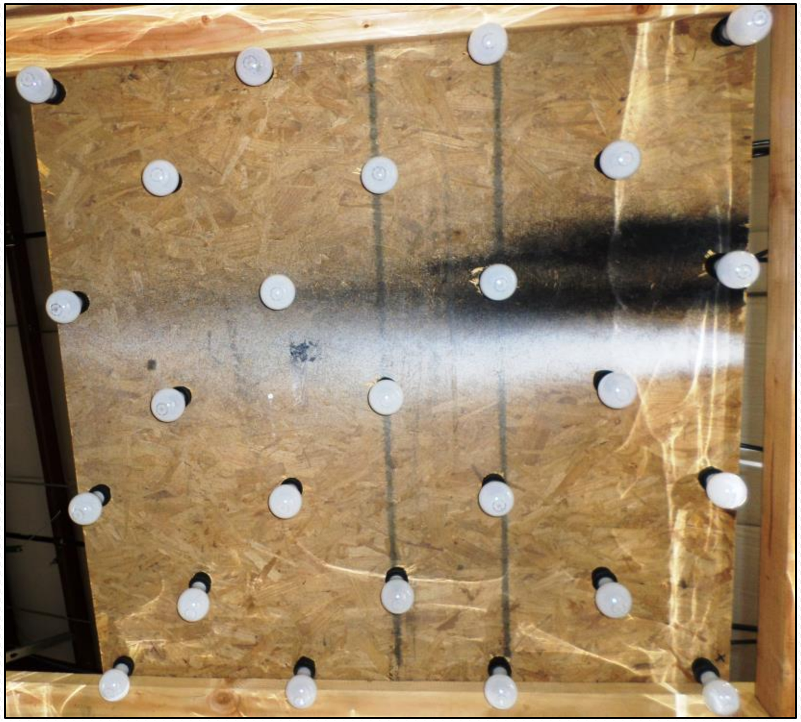


- The ability to test indoors

Simulated Sun Cont.

Lighting System

- 25 - 100W Incandescent light bulbs
- Wired into 4 strands



Simulated Sun Cont.

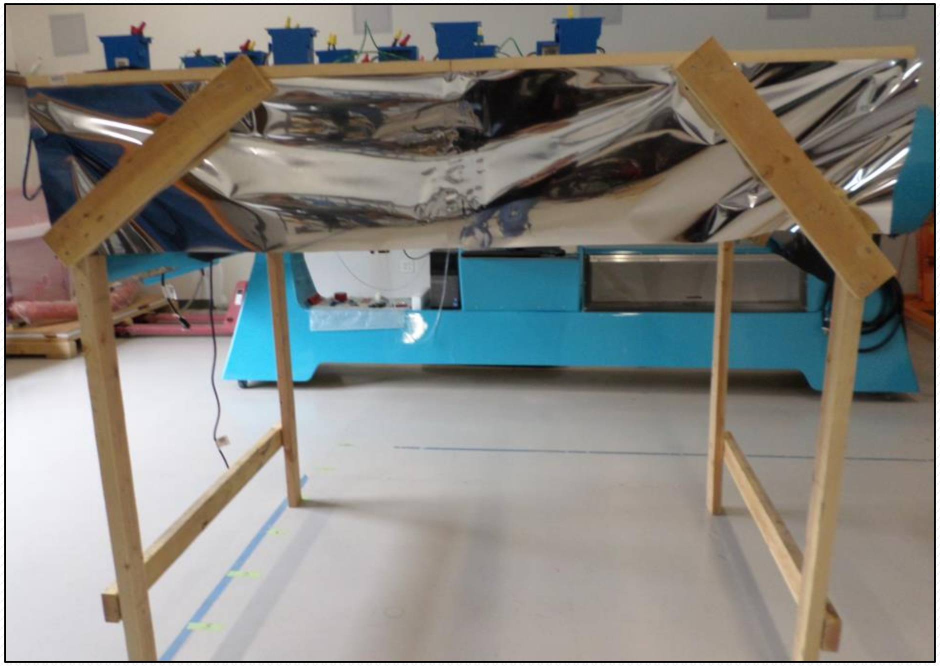
Power Source

- Briggs & Strattion portable generator
  - 5500 Watts
- Ran outside and used extension cords
  - Breaker Boxes placed between cords

Simulated Sun Cont.

Frame

- To suspend lights above building model
- Mylar added around to prevent radiation loss

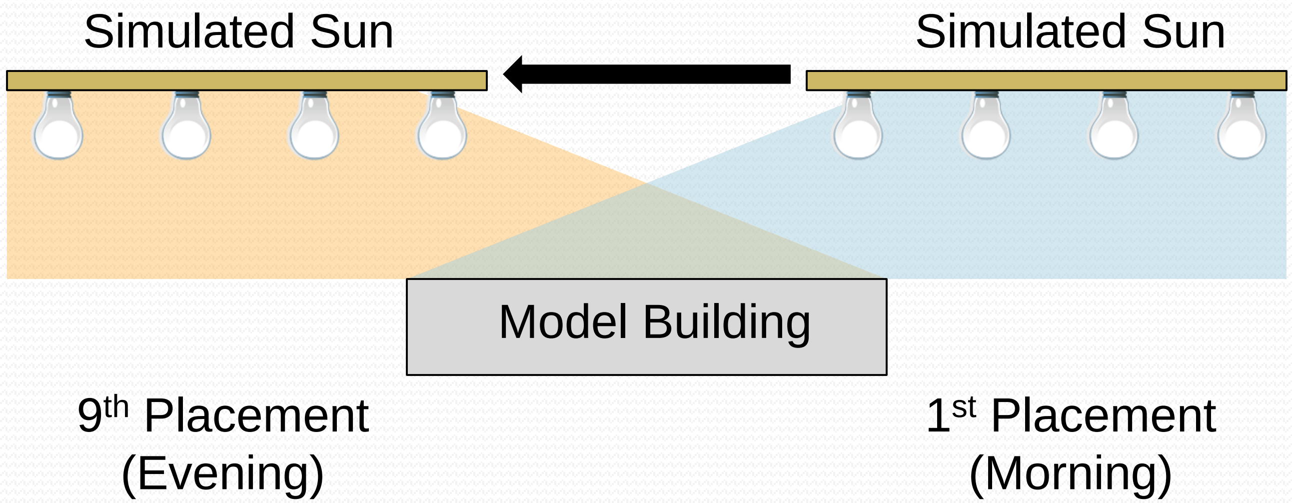


Testing Procedure

- Testing each prototype twice
  - Each test is 1 hour long
  - Using simulated sun in a controlled enviroment
- During testing simulate sun is moved
  - Every 6:40min, equal spaces (Total of 9 moves)
    - Move 5 represents 12pm-2pm
  - Active roof panels are rotated to a new angular position as well

Testing Procedure Cont.

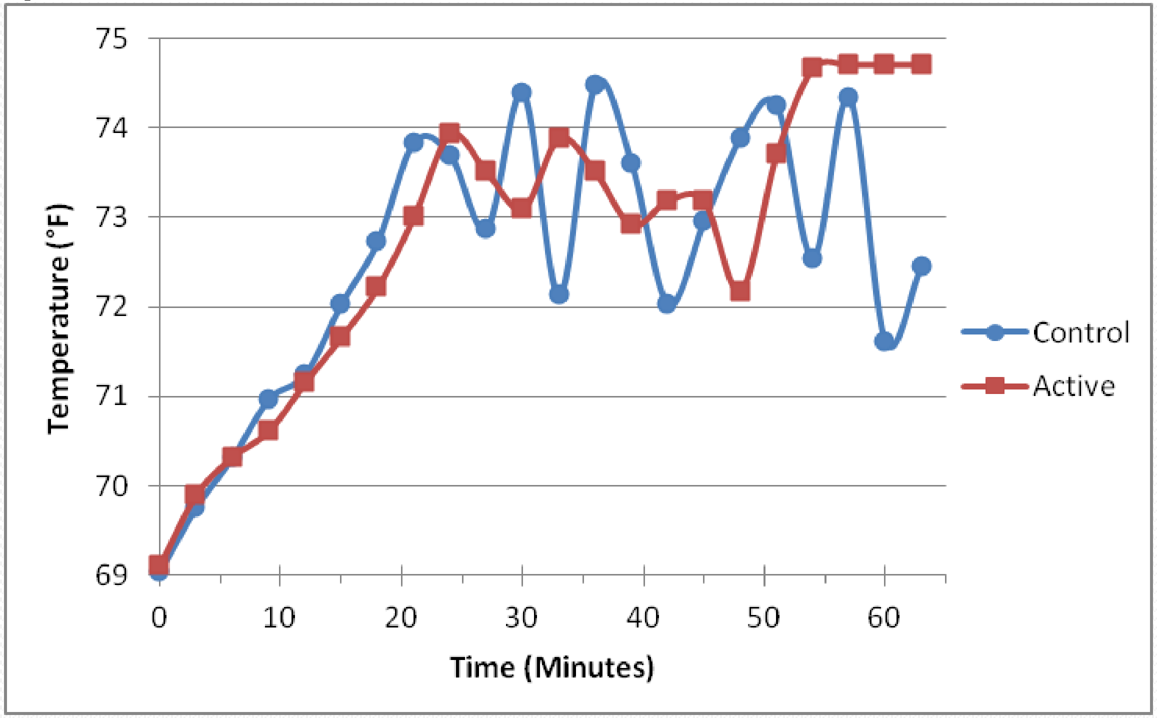
- Movement of simulated sun



Testing Procedure Cont.

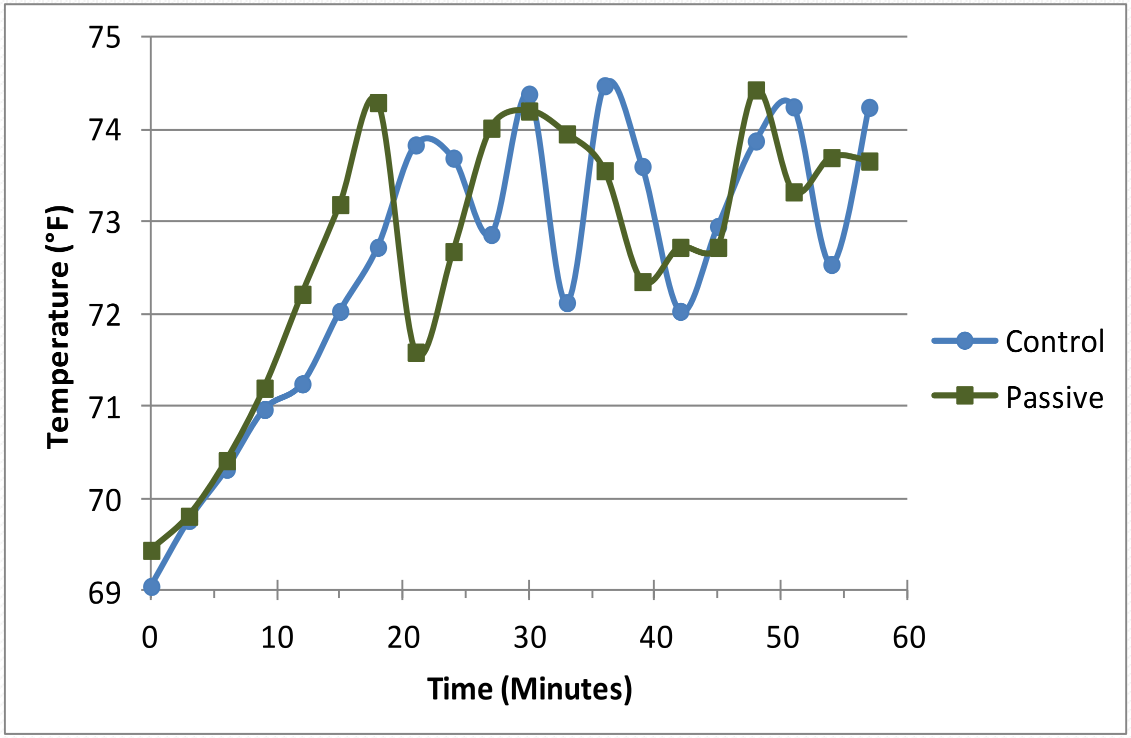
Testing Results

Temperature vs. Time for Control and Active Roofs



Testing Results

Temperature vs. Time for Control and Passive Roofs



Testing Results

- The results of the passive and active roof prototypes are compared to the control roof.

Prototype Roof	% Reduction in Power Usage
Passive	43%
Active	72%

  - The power usage of the active roof prototype also includes the hypothetical power usage of a motor if it were used to autonomously rotate the panels.

Conclusions

- The active roof prototype had the lowest power usage (even with added power of “motor”)
  - The passive roof did significantly reduce the power usage as well
- The active roof was more efficient at reflecting away radiation during the testing positions representing 12pm-2pm.
- The active roof panels also require less materials than the passive roof

Conclusions Cont.

- However, in reality, the cost of construction of the active system may be higher than the passive
  - So in the short run it may be more *cost effective* to install the passive roof.

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