LOW ENERGY GREENHOUSE FOR SOUTHERN ALBERTA

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Project Motivation

Design and build an energy efficient greenhouse to function within Calgary year-round.

Challenges

To complete the assigned goal, we were designated a budget of $500 to construct the prototype. This prototype would have to endure temperature variations between -40C and +30C while maintaining an ideal indoor environment for chickpea growth. The requirements for Chickpeas can be seen in Table 1 below:

Chickpea Requirements	
Temperature	Day: 20-25°C Night: 17°C
Humidity	RH: <86%
Water	Saturated soil up to twice/day
Sunlight	7-9 hours

Table 1: Chickpea requirements

Construction

- Glazing – Two Pane Glass
- Structure – Donated 2”6” and Pulp Board
- Insulation – Repurposed R-20 insulation board
- Solar Collector – Recycled Cans
- Thermal Reservoir – two 23L Water containers
- Fasteners and Sealants

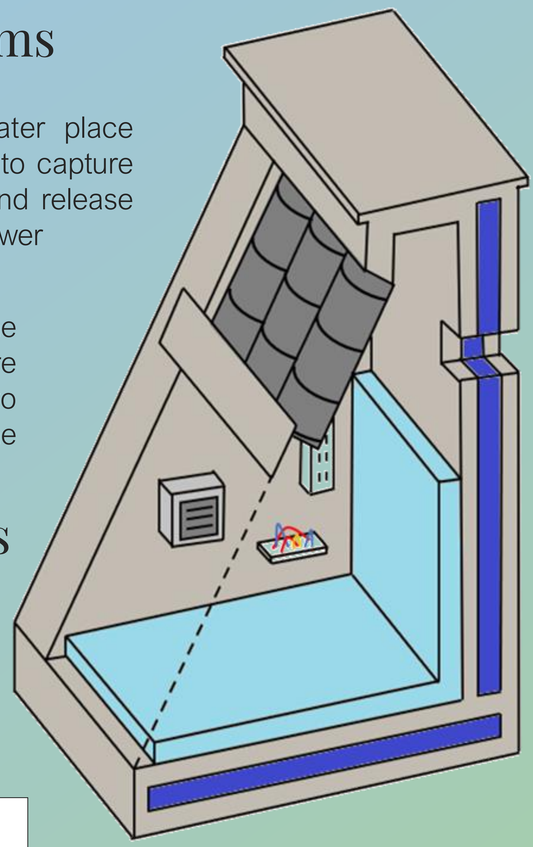
Passive Systems

Thermal Reservoir

Two containers of water place against the back wall to capture excess heat energy and release it when temperature lower

Solar Collector

Built into the top of the greenhouse to capture additional solar hear to be blown back into the greenhouse



Active Systems

- Heating: 500W at temperature range of 15C - 23C
- Cooling: AC, Vents, and Fans
- Wall outlet

Structure

The structure is designed to best capture solar energy in the winter, while blocking it in the summer. To do this, the glazing faces South and is angled to capture low angle incident light in the winter and block high angle incident light in the summer. A diagram of this can be seen in Figure 5 below:

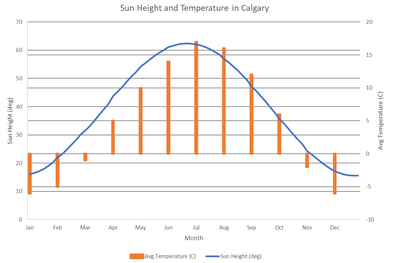


Figure 4: Incident Light and Temperature

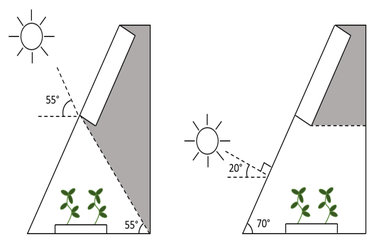


Figure 5: Shape Design

Results

Energy Usage

From simulations and testing, we were able to produce Figures 6, 7, 8, and 9 below which show the results of our prototype:

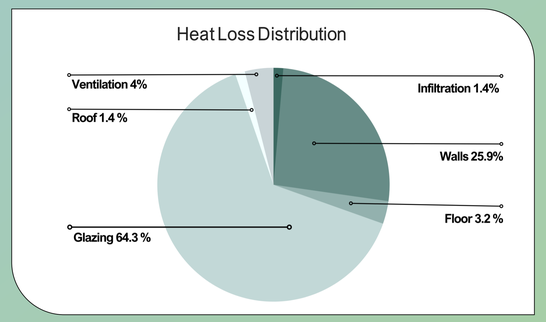


Figure 6: Distribution of Heat Loss

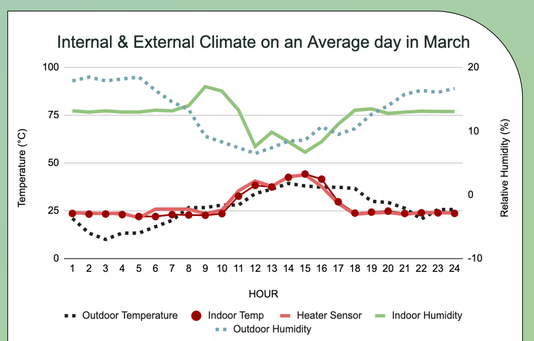


Figure 7: Test 1 Results

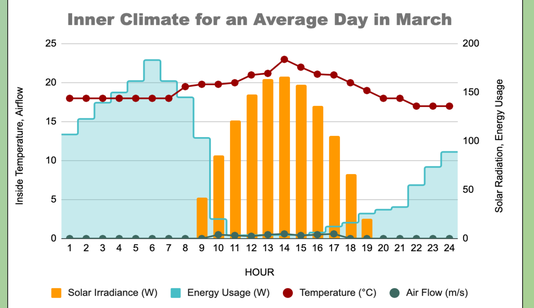


Figure 8: Test 2 Results

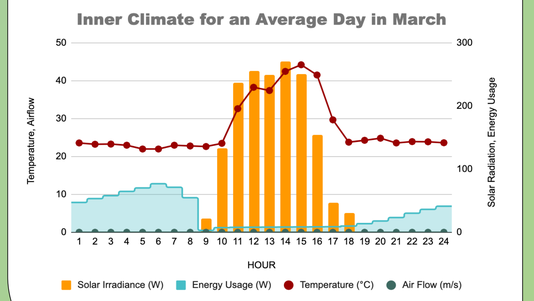


Figure 9: Test 3 Results

Control System

1. Heating: XH-W1209 Controller and 500W Heater
2. All other systems: Arduino controlling lights, vents, fans and sensors.

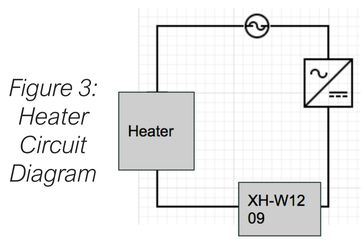


Figure 3: Heater Circuit Diagram

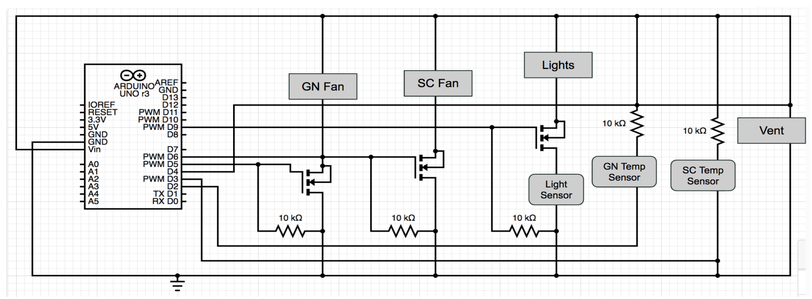


Figure 2: Greenhouse Circuit Diagram

Conclusions

Lessons Learned

It is immensely difficult to design a system which operates efficiently between such a large temperature range. Being optimized to capture solar heat for -40C climates, it became difficult to cool the greenhouse when temperatures were above 0C.

Future adjustments

- Ground source heat pump for heating/cooling
- ETFE skin for glazing
- Different or removable insulation design
- Improved ventilation design
- Improved thermal reservoir system
- Automatic watering system
- Evaporative cooling wet-wall system

Special thanks to our sponsors and the University of Calgary staff and facilities