Green Builders

A

SUSTAINABLE GREENHOUSE

FOR AN AIRPORT COMMUNITY RESERVE

GNG 1103
ENGINEERING DESIGN

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Abstract

A greenhouse is designed and built to address the problem of the client and the needs of the users. Basing from the client's specifications, the Green builders managed to make a greenhouse that could be as sustainable to the users. The team incorporated their ideas into one sustainable greenhouse with five key systems: Insulation, Ventilation, Security, Water Collection, and Electrical power. Wood framing with polyethylene sheets covered with bubble wraps was used as insulation. Holes between the roof and walls were considered as ventilation, and a hanging fan was added to help the air circulation inside the greenhouse. For security, a simple lock is attached to the doors. Gutters were attached on the roof to gather the rainwaters, and the gutters were linked to a pipe that's connected to a storage tank that's inside the greenhouse. A solar panel is put on the roof to collect sunlight and produce electricity for the hydroponics system inside. Limitations such as time and cost were kept in mind. Given the cost limit of $250 dollars, choosing of materials were done wisely. And the whole construction was done in a total of 21-28 hours.

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Needs Identification

The client is looking for a greenhouse with a budget of $250 to feed around 50 people on a small reserve in Quebec. They are looking to grow hearty foods year round, even during the harsh winters. With no running water or access to electricity, the client is looking for an alternative method of retrieving water to provide for the crops. They are wanting a durable material, they have not specified a single material and are open to the team's ideas.

Problem Statement

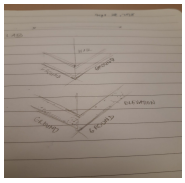
With its harsh winters and remote location, the Airport Community reserve finds it very difficult to grow and keep fresh crops year round. They are looking for a low cost, sustainable greenhouse to implement into their community and provide a reliable source to maintain their crops. The greenhouse must be lightweight and easy to carry and assemble since it must be delivered to the community.

Design Criteria

Requirements	Criteria	Justification	Success Criteria
Form	1. Should let in lots of sunlight.	1. The greenhouse will be used in the winter where the days are short, so the plants need the most light they can get.	1. Glass walls facing the direction with most sunlight.
Function	1. Insulation 2. Ventilation 3. Water Collection and Filtration 4. Pests control 5. Solar power	1. Maintain warmer temperature during winter. 2. Maintain proper ventilation for plants. 3. Provide clean drinking water. 4. Minimize rats and mosquitoes. 5. Have access to electricity.	1. Insulating materials 2. Windows and heaters controlled by a thermostat 3. Water treatment system. 4. Screen, sealed walls 5. Solar panels

Structure	1. Maximum size : 15' x 10' of the full size greenhouse.	1. The structure cannot be too big as it will be difficult to deliver.	1. Follow the size specifications and make the greenhouse easy to take apart for delivery.
User-Centered	1. Should be big enough to grow food to feed around 50 people 2. Can be locked	1. This is how many people live in the reserve. 2. People might break in and steal stuff.	1. Make the greenhouse the maximum size possible 2. Lock on the door, use a clear plastic instead of glass as it is more difficult to break
Materials	1. Low cost 2. Durable 3. Insulation	1. 250 $ max 2. Could withstand different weathers/ seasons. 3. During winter, it could reach up to -30 C.	1. Affordable materials; make use of recycled materials 2. Protect the materials using a waterproof coating. 3. Insulating materials.
Representations	1. 2D sketch of the structure, along with a list of materials. 2. 3D model made on Solidworks	Required by the project manager.	Include these requirements in the final portfolio.

Conceptual Design

Insulation	Ventilation	Water Collection & Filtration	Pests Control	Security	Electrical Power
Bubble wrap over glass Soft material insulation on glass double as protection Styrofoam on walls DIY cellulose insulation (recycled material) treated with chemicals to make rodent proof Double layered walls	Small opening near the ceiling with screen Fans hanging from the ceiling for circulation Windows that open and close, controlled by a thermostat	Guttering system and storage that's connected inside. Rain barrel condensed water collection from the roof Water heating system for snow in the winter Homemade water filtration system using sand, carbon, plastic bottles, etc. Rain barrels of clear plastic placed in sunlight to use solar water disinfection method to filter the water.	Barrier above the floor and up walls. Maybe metal? Copper mesh Screen for openings Elevation, or maybe baseboards that couldn't let rats pass through  Sealant around walls and in cracks	Code Lock on door Glass or plastic walls that are difficult to break Security Alarm Simple combinati on lock - to save money	Wind turbine Solar panels and batteries for backup Portable Generator Inverter for AC power if needed

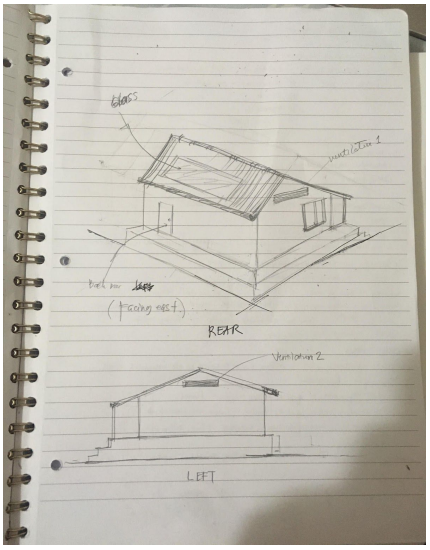
Benchmarking

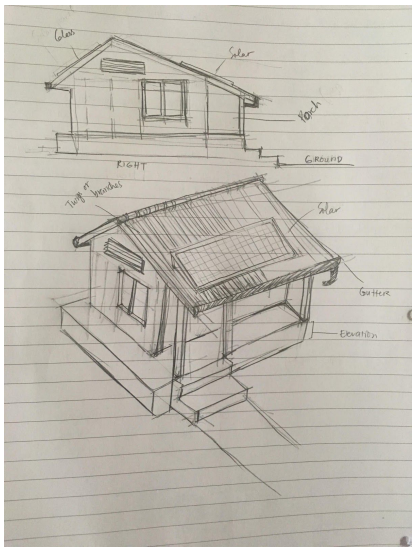
Selection matrix

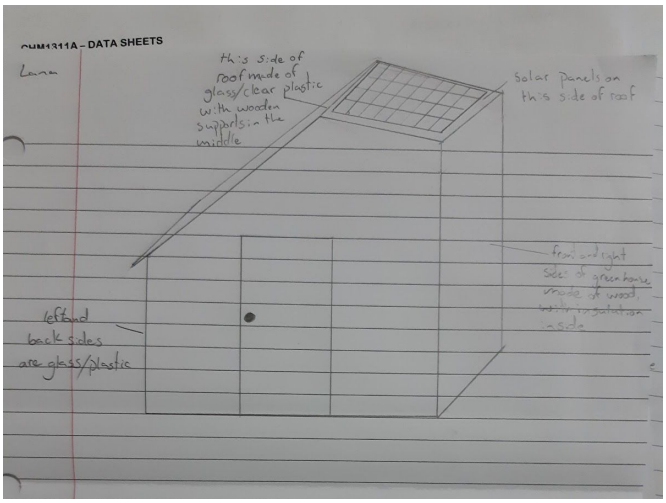
3- green
2- yellow
1- red

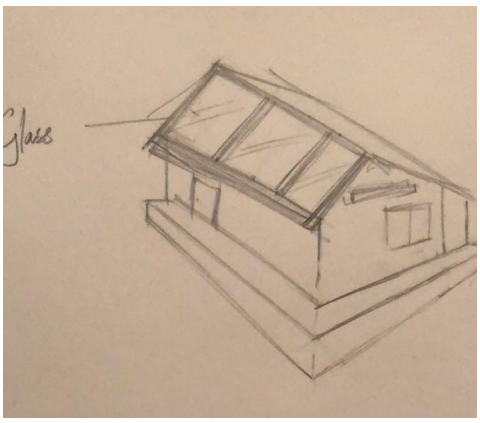
	Option 1 - High Tech	Option 2	Option 3 - Low budget
Insulation	Styrofoam on Walls	Bubble wrap over Glass	Recycled insulation (chemical treated)
Ventilation	Windows that open and close & Thermostat	Fans Attached to Ceiling	Small Opening Near Ceiling with Screen
Water Collection & Filtration	Gutter and Storage System	Clear Plastic Rain Barrels	Homemade water Filtration system
Pests Control	Copper mesh around Base and up walls	Elevation	Sealant around walls and Cracks
Security	Security Alarm	Code Lock Door	Simple Combination Lock
Electrical Power	Portable Generator	Solar Panels	Wind Turbine
Total	12	16	12

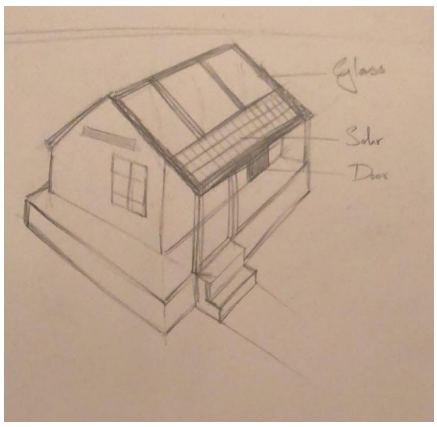
Design Plans







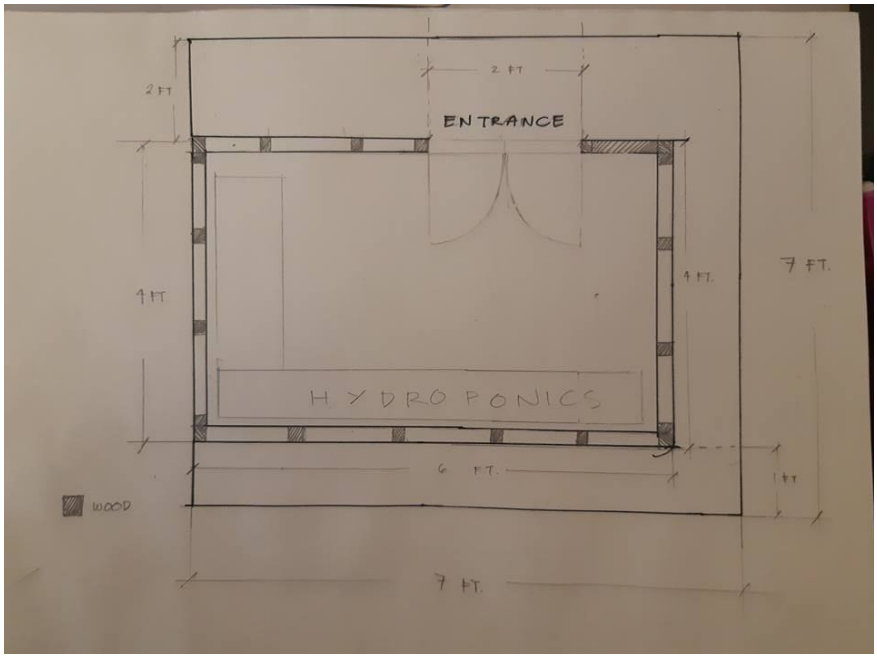




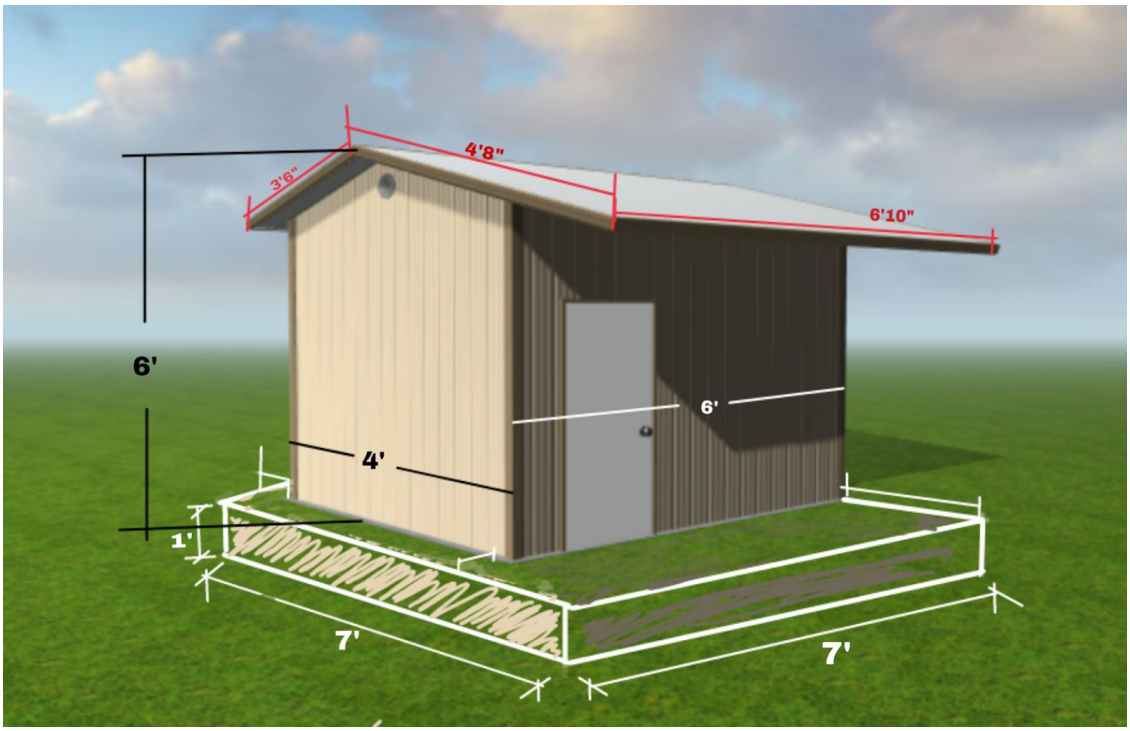
Prototype I

Prototype I was a very basic model of the design. Constructed of cardboard and tape a small scale model of the original design was created to help further visualize the greenhouse. This original design was presented to the client in order for them to voice any concerns.

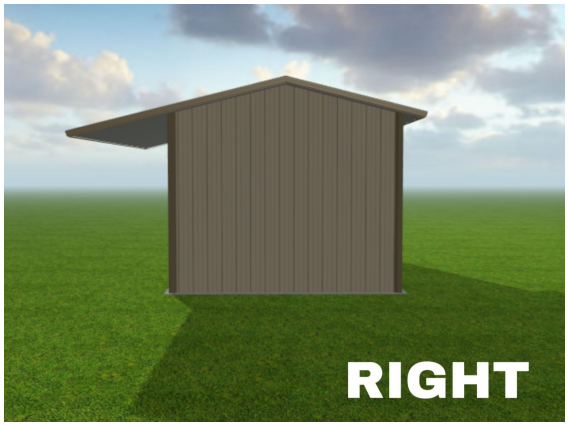
Prototype II

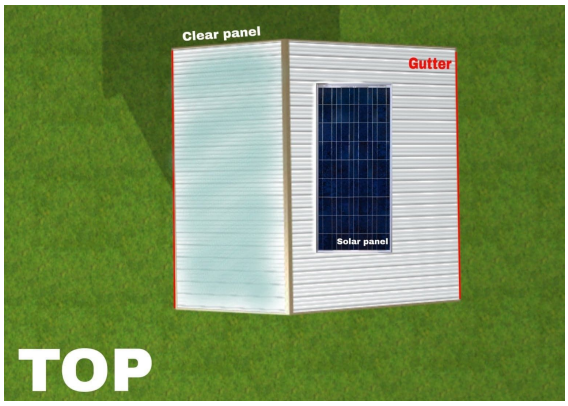


Floor plan



Perspective

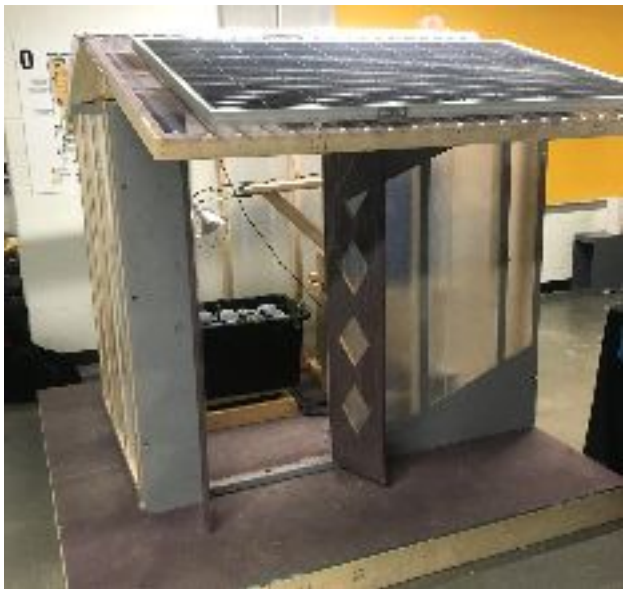




Presumed Walls

Prototype II is a more detailed model of our revised design. After meeting with the client a few adjustments were put in place to enhance the original design. This prototype was made on an online graphic software allowing a more detailed 3D model of the structure.

Prototype III



Prototype III was the final model of our design. It was constructed of primarily wood, with the use of corrugated plastic on the roof. This prototype accurately represents the greenhouse that would be built in real life, and includes much more detail than any of the previous prototypes. Some details of this prototype include copper mesh surrounding the interior to act as pest prevention, bubble wrap on the interior as added insulation and a functioning solar panel on the roof.

Key Design Elements

Oversized base - extra space to place plants in the summer, water won't flood the greenhouse in the spring when the snow melts. Allows for walking space around the perimeter of the structure.

Over extended roof - easier access to door during the winter (due to snow), larger surface area on the roof to place the solar panel

One side OSB, rest plastic - the OSB wall provides extra insulation and stability to the house, while the rest of the walls are plastic to maximize sunlight.

Double door - the door needs to open out, and a regular door would not open because of the over extended roof.

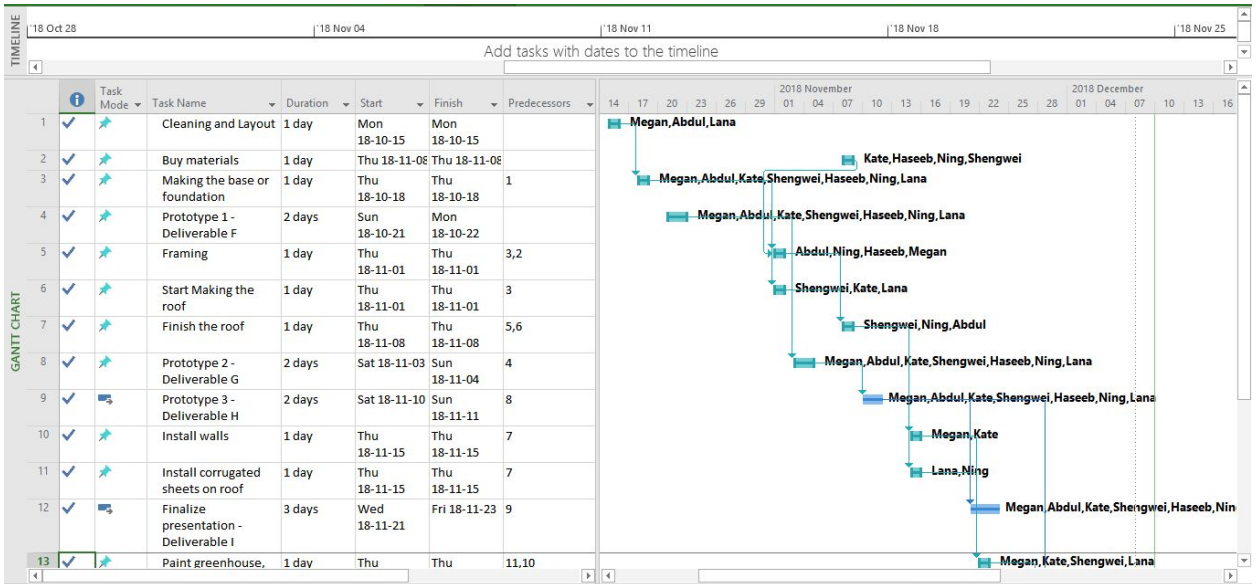
Bubble wrap insulation - the plastic sheets are too thin to block the cold from

outside, using OSB instead would prevent light from entering. Conventional insulation is not cost efficient and defeats the purpose of using clear plastic sheets on the walls and roof. Bubble wrap is budget friendly, allows light in, and easily obtainable.

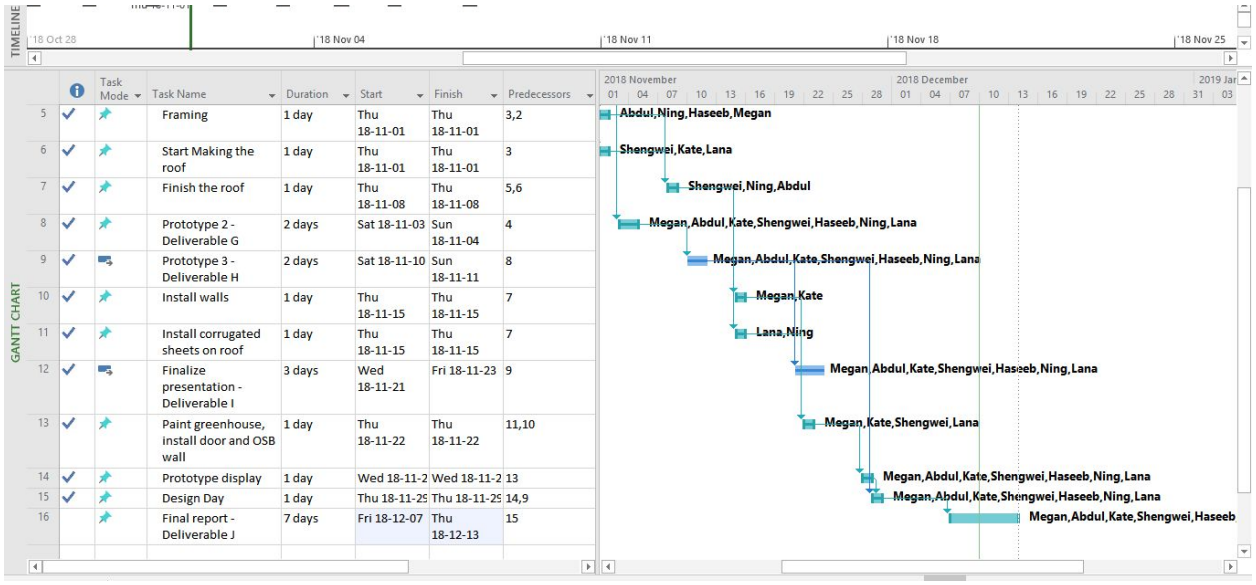
Diamond holes of the door - for aesthetic purposes, and to let extra light in.

Copper mesh around base - pest control. Other methods, such as using a sealant in cracks and openings is impractical in case we have to take apart the house to relocate. Pests can also chew their way inside through the sealant.

Project Plan



	Task Mode	Task Name	Duration	Start	Finish	Predecessors
1		Cleaning and Layout	1 day	Mon 18-10-15	Mon 18-10-15	
2		Buy materials	1 day	Thu 18-11-08	Thu 18-11-08	
3		Making the base or foundation	1 day	Thu 18-10-18	Thu 18-10-18	1
4		Prototype 1 - Deliverable F	2 days	Sun 18-10-21	Mon 18-10-22	
5		Framing	1 day	Thu 18-11-01	Thu 18-11-01	3,2
6		Start Making the roof	1 day	Thu 18-11-01	Thu 18-11-01	3
7		Finish the roof	1 day	Thu 18-11-08	Thu 18-11-08	5,6
8		Prototype 2 - Deliverable G	2 days	Sat 18-11-03	Sun 18-11-04	4
9		Prototype 3 - Deliverable H	2 days	Sat 18-11-10	Sun 18-11-11	8
10		Install walls	1 day	Thu 18-11-15	Thu 18-11-15	7
11		Install corrugated sheets on roof	1 day	Thu 18-11-15	Thu 18-11-15	7
12		Finalize presentation - Deliverable I	3 days	Wed 18-11-21	Fri 18-11-23	9
13		Paint greenhouse,	1 day	Thu	Thu	11,10



Materials and Cost Estimates

BASE & FLOORING							
No.	Quantity	Unit	Description	Measurements	Unit Price $	Total Price $	Hardware
1	2	pcs	OSB	4'x8'	10.98	21.96	RONA
2	9	pcs	2x6	2"x6"x8'	5.60	50.4	
TOTAL						72.36	

WALLS							
No.	Quantity	Unit	Description	Measurements	Unit Price $	Total Price $	Hardware
1	8	pcs	Wood studs	2"x3"x8'	2.37	18.96	RONA
2	2	pcs	Plywood (OSB)	4'x8'	10.98	21.96	RONA
3	1	rolls	Polyethylene	40" x 100'	10.00	10.00	ULINE

			(Polypropylene)sheets				
TOTAL						50.92	

ROOF							
No.	Quantity	Unit	Description	Measurements	Unit Price $	Total Price $	Hardware
1	3	pcs	Corrugated plastic (clear & colored)	26"x 12'	17.23	51.69	Lowes
2	2	pcs	Gutter	10'	provided	provided	provided
3	1		Ridge cap		16.79	16.79	RONA
TOTAL						68.48	

OPENINGS							
No.	Quantity	Unit	Description	Measurements	Unit Price $	Total Price $	Hardware
1	1	pcs	OSB for Door	4'x8'	10.98	10.98	RONA
TOTAL						10.98	

OTHERS						
No.	Quantity	Unit	Description	Unit Price $	Total Price $	Hardware
1	1	pcs	Solar Panel	provided	provided	
2			Tools	provided	provided	
3	1	pcs	Fans	20.00	20.00	Amazon

4	1	roll	Copper mesh	20.00	20.00	Amazon
5	1	roll	Bubble wrap	20.00	20.00	Amazon
6	2		Paint	provided	provided	
TOTAL					**40.00**	

Total Cost Estimate: $242.74

Conclusion

For the majority of the team, this project was their first experience in construction and woodwork. Every step in the process of building the greenhouse involved new knowledge being gained by the whole team. The first and most important lesson learned is the importance of planning in the design process. Planning what tasks had to be completed each lab session was necessary to ensure that the limited lab time available was used effectively. In addition, planning exactly what the greenhouse looked like prior to the start of construction allowed us to learn which designs were feasible, which design features were not ideal, and the reasoning behind it. This allowed us to provide a clear representation of our ideas to our client. Planning also played an important role in team management and task division among team members. Another lesson learned was proper client interaction. Communicating with the client to learn as much as possible about their needs in order to create a solution that meets all of the requirements is crucial. Other lessons learned in the construction process were the proper use of various tools and the proper techniques.

Recommendations & Future Developments

If given additional budget and time, the team is planning on improvements like:

- Glass walls- to increase the stability of the greenhouse.
- Properly cured cemented base- for a more effective pest control.
- Bigger fan- for better air circulation.
- Plastic tube around fan - focus the hot air on where the plants are.

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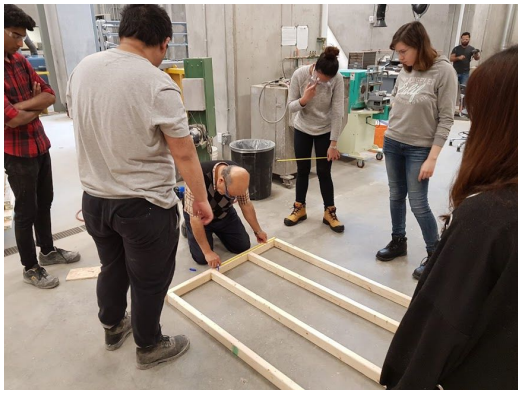
Roof shapes
https://www.roofcostestimator.com/top-15-roof-types-and-their-pros-cons/https://www.roofcostestimator.com/top-15-roof-types-and-their-pros-cons/

Copper Wire
http://ratcontrolreviews.com/copper-wire-mesh

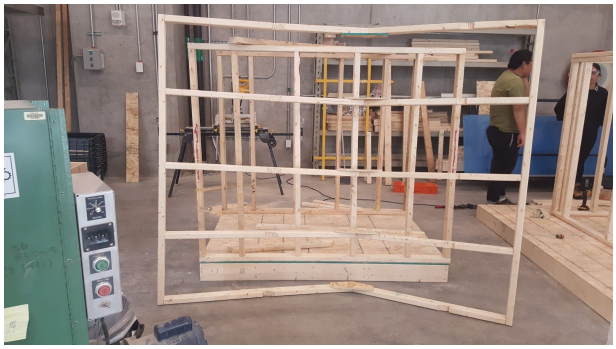
Appendix

Day 1: Base Framing

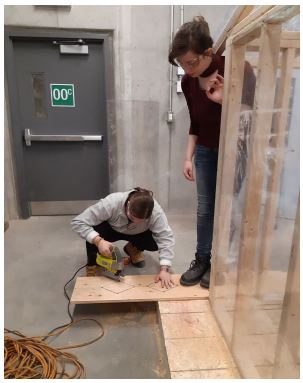


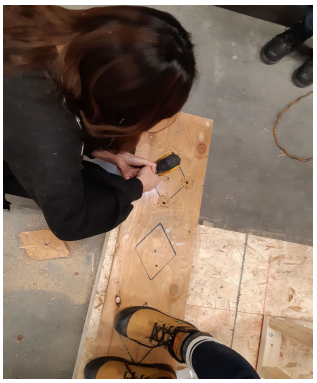
Day 2: Wall framing

Day 3: Roof Framing



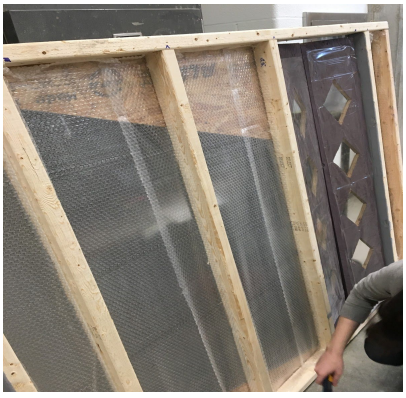
Day 4: Application of Wall Sidings and the making of Doors

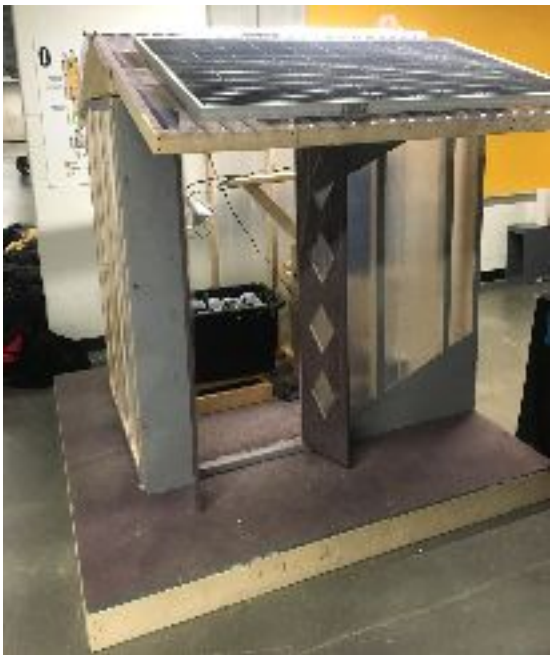




Day 5: Application of Roof Panels and Doors

Day 6: Painting, Application of Bubble wraps, and Disassembling the whole prototype



Day 7: Assembling the whole prototype for 'Design Day,' Application of Copper wire, Gutters, drain, Solar panels, and setting the Hydroponics system inside.

Design Day