Solar Team Shed 1 Final Report

GNG1103-B

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1. Introduction

The residents of the Algonquin Barriere Lake do not have adequate shelter. As a result, we were assigned to build a cheap, but reliable house that is able to shelter the habitants of the land properly. However, since the generator is at maximum capacity, it is our job to build a self sufficient shed with the budget and materials we are given. Using the resources given, we will ensure that the residents have proper electricity to power the home as well as a proper warmth in an affordable, safe and efficient manner.

1.1. Needs Identification

- Self sufficient
- Needs to be cheap
- Able to be used all year round
- Be raised to prevent flooding
- Needs to be modular
- Must be easily transported
- Easily sourced materials
- Recyclable materials

1.2 Design Criteria

The initial design criteria consisted of the following three solutions: Water Heating, Air Heating and, Insulated Water Storage Tanks. All of these solutions use the power of the sun and nothing else.

1.3. Our design

The design we chose for all systems were found to be the best in all areas to provide the people of barrier lake with a truly self sustainable home. The PEX / Aluminum water heater is our developed design. After extensive research we concluded that pairing the PEX piping with a sheet metal casing will enable better heat absorption. Apart from molding the sheet metal casing, the overall construction of this water heater will be fairly simple and straightforward. Our plan for heating the house is with a pop can air heater. We decided that we would encase columns of aluminum cans in a wooden frame covered by a polycarbonate sheet and black spray paint. To optimize our design we decided it would be best to allow the panel to change angles depending on where the sunlight should be directed. To help with this design we included expandable air ducts to allow for the air to be directed in and out of the system. Although hot air rises, we decided to add a fan inside the shed so that we can push and hot air that is not able to

rise. For the solar setup we needed to find a spot on the roof that will give the solar panel the maximum amount light capture. Ideally, it would be the most beneficial is it were faced towards the south. Install a mount that has an adjustable angle. In the summer, the ideal angle for a solar panel is 25 degrees towards the sun whereas in the winter it is 55 degrees. Next, attaching all the wiring and circuiting to the charge controller which are connected to the batteries then to the inverter. Then, attach the panel onto the mount. We plan on storing the inverter and battery in an electrical box which would be accessible to the residents of this house. We were told that the inverter has outlets attached as well so we transmit power throughout the house via extension cords. Will need about 86.7 amp hours of energy per day to give about 4 hours of energy.

2.0 - Design Thinking Process:

Throughout this course, the engineering design process was a method that was the main focus throughout the entire course. It is essentially a decision making process in which the basic sciences, mathematics, and engineering sciences are applied to convert resources optimally to meet a stated objective. Among the fundamental elements of the design process are the establishment of objectives and criteria, synthesis, analysis, construction, testing and evaluation. It's main components consist of these five steps: empathize, define, ideate, prototype. These steps primarily act as an approach to solving design problems by understanding user needs and developing the design tools required to solve those problems.

2.1 - Empathize:

This initial stage is mainly based off the customer needs. What is a customer needs identification? Customer needs identification is the process of determining what and how a user interacts with a product. User needs are non-technical, and they reflect the users' perception of the product, not the actual design specifications. Although they are frequently closely related goals of customer needs identification Focuses the product development process on the actual needs of the customer.

In this shed scenario, a client came in and expressed her needs for a cheap, self sufficient, mobile house that would be able to shelter her indigenous group. Her needs and specifications are listed below:

- 350-400 people
- around 10-12 per 2 bedroom house
- insufficient materials that the house is made of, bad water, falling apart
- lots of contaminated water from the river from the mines nearby where they are
- materials need to be reusable and environmentally friendly
- solar and wind power
- (solar panels can warp due to the climate up there)
- on a reserve so not a lot of protection from elements (trees and stuff)
- in the summer, they build cabins so they move around to hunt and build cabins in bushes
- no water in these areas to sewage need to kept in mind (mercury filled)- people often boil water
- needs to be as cheap as possible
- under 3rd party management so an accounting company is responsible for all their money (around $500, 000)
- the generator is at max capacity so no more houses can be made (can only be repaired)
- people living in these houses are from 3-4 generations
- they peel down trees and build shacks (has no power/electricity)
- they make wood heat stoves
- but not practical for a small home
- generators make a lot of carbon monoxide
- about 3 hours north of Ottawa
- 75% are unemployed
- small medi center, school etc.
- no plumber/carpenters/handy dudes
- a self supported building that is cheap and protective deep in the forest
- 59 acres
- self sufficient
- all year round
- have the potential to flood (the ones that are closer to the lake but not super likely)
- funding : $100 each for automation, water and solar (we already get solar panel and battery ($500 and $300, respectively). Endless for construction
- in the end, we want to connect a few of the made sheds so that more people can fit into them
- each solar panel produces 250 watts/hour
- if there are 3 together when attached, only one converter and one battery is needed, otherwise if its separated then one for each
- fridge, heat, (there is propane for eating), small appliances, lights, few outlets
- some sensors (more for automation), manual system needed as back up

- small pump needed to pump water to higher elevation
- a system that heats the air by using solar energy without a heater (like at night when theres no sun)
- area needs to be cleared
- needs to be a portable shed
- on deep sand

Since all there was to empathize from were the client meetings, using other forms of data collection were not possible in this case. In a real world scenario, it would be most beneficial to collect raw data in ways such as actually travelling to the reserved area of land and really seeing the struggles that they are facing with their current housing situation.As the solar team, the tasks that needed to be taken on were mainly problems regarding anything to do with solar energy (heating, electricity, etc.)

2.2 - Define:

A problem statement is needed to be made that outlines the problem that will be addressed by the designing process base on the customer needs.

“The task assigned was to build a cheap, but reliable house that is able to shelter the habitants of the land properly. However, since the generator is at maximum capacity, it is our job to build a self sufficient shelter within the budget and materials provided.

Using the needs of the client, three main problem categories were generated: the air heater, the water heater and the actual installation and attachment of the solar panel. This was extremely beneficial as there were six team members and three problems, meaning that two members could tackle a task at a time. This was proven to be very helpful and a good use of time. Several ideas were generated when the tasks were split up and this led to incredibly innovative designs in the end. The first roughly half of the course was spent mainly brainstorming and generating ideas.

2.3 - Ideate:

The ideation process consists of many different ways to represent an idea. There is a concept generation which consists of: a divergent phase is when all ideas are accounted for without judgement, no rules to formulate ideas, needs to be at least 3 conceptual ideas. Freehand sketching can also be done in sketching styles such as: isometric, oblique and orthographic. Engineering analysis process should also be practiced throughout this phase.

Since each problem was assigned to two members, several ideas were able to be created and below are the ones that were created:

Water Heating

Design Solution 1: Solar Thermal Copper Coil Water Heater

The copper coil water heater is a viable option for heating water. The construction of this water heater is very simple and straightforward.

Advantages:

- Minimal to no maintenance required
- Scalable (can be easily implemented into several housings in the Algonquin Barriere Lake)
- Corrosion Resistant copper
- Recyclable
- Antibacterial
- Unaffected by UV rays

Disadvantages:

- Takes up additional space on the roof
- Glass cover can break during shed transportation
- Copper piping has become expensive
- Cold climates may cause copper pipes to burst
- Water can have metallic taste

Design Solution 2: Solar Thermal PEX (Cross Linked Polyethylene) Water Heater

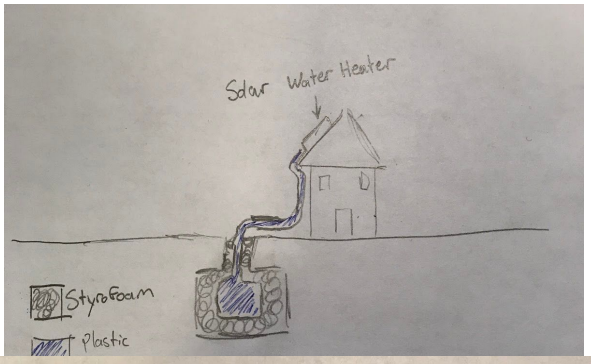
This solution is identical to the first however we are replacing the copper coil with a polyethylene piping.

Advantages:

- Cheaper than copper
- Resistant to Chlorine
- Faster installation (fewer connections)
- More efficient (retains heat)
- Resistant to freezing
- Safe for drinking

Disadvantages:

- Not ideal for outside use
- Cannot be recycled



Insulated Water Storage Tanks

Design Solution 1: Underground, styrofoam insulated tank

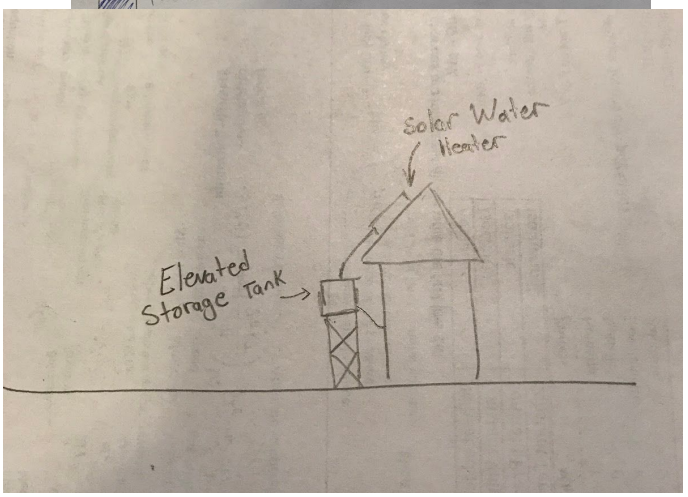
This solution utilizes heat from the ground coupled with styrofoam insulation to store warm water and keep it warm.

Advantages:

- Styrofoam insulation is affordable
- Geothermal heat is a clean source of energy

Disadvantages:

- A pump is required to return the stored water to the house
- Need to dig below the frost line (4 feet+)
- Underground storage tank will interfere with the transportability of the house.



Design Solution 2: Elevated storage tank using both styrofoam and air as insulation.

This tank will consist of a styrofoam coating outside its walls coupled with an air pocket. The air pocket will isolate the outer temperature from the temperature inside the tank.

Advantages:

- Carries water under the force of gravity (no pump required)
- Affordable

Disadvantages:

- Elevated tank interferes with transportability
- Not as efficient as geothermal heat

Heating Air

Design solution 1: Pop can air heater

The aluminium cans are cheap and easy to obtain. The construction of this air heater is simple and straightforward.

Advantages

- Cheap material and easy to obtain
- Recyclable
- Easy to transport

Disadvantages:

- Not a very efficient method to heat air
- Will require some sort of fan or air pressure system
- Only works with direct sunlight
- For optimal efficiency, will take up space on the roof

Design Solution 2: Wood/Pellet Heating

With the use of wood and convection, a complex furnace can be designed.

Advantages:

- Efficient design for heating air
- Abundant supply of wood in the Barriere Lake
- Versatile (Can heat water)

Disadvantages:

- Very Expensive
- Emit air pollutants
- Dangerous if not installed professionally or inside the shed
- Must be constantly maintained

Design Solution 3: Propane Heating

Propane is one of the main sources of heat and is widely used in the community and is easily portable

Advantages:

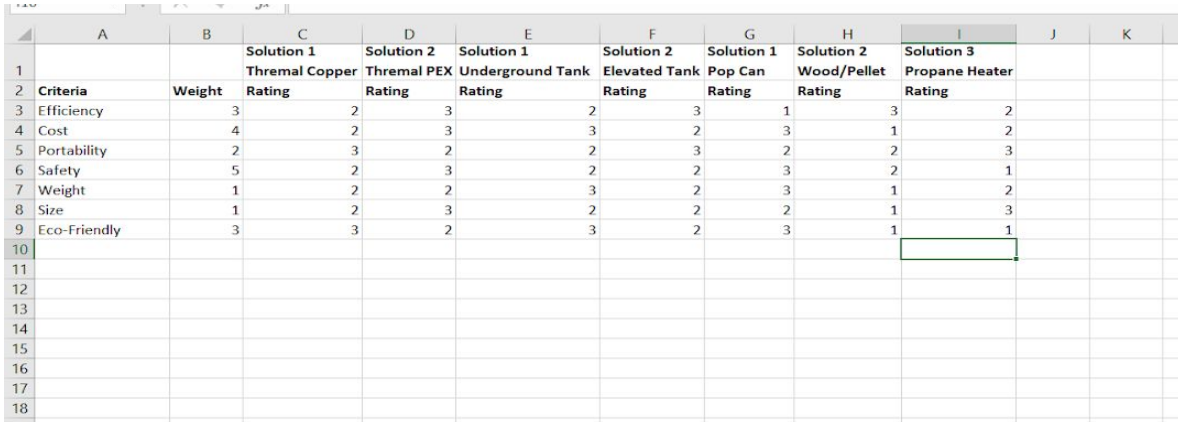
- Very portable
- Very cheap both gas and heating unit
- Can be used without electricity
- Can also buy a unit that heats water too

Disadvantages:

- Can be dangerous if not attended and watched
- Can take up lots of room depending on the unit picked
- Expensive unitis if used for heating air and water
- May need electricity depending on unit choice

Very unsafe due to vapours if not vented correctly

Another major component in this phase is benchmarking. This helps with figuring out what “competition” is doing already and helps with innovation.



	A	B	C	D	E	F	G	H	I	J	K
1			Solution 1 Thremal Copper	Solution 2 Thremal PEX	Solution 1 Underground Tank	Solution 2 Elevated Tank	Solution 1 Pop Can	Solution 2 Wood/Pellet	Solution 3 Propane Heater		
2	Criteria	Weight	Rating	Rating	Rating	Rating	Rating	Rating	Rating		
3	Efficiency	3	2	3	2	3	1	3	2		
4	Cost	4	2	3	3	2	3	1	2		
5	Portability	2	3	2	2	3	2	2	3		
6	Safety	5	2	3	2	2	3	2	1		
7	Weight	1	2	2	3	2	3	1	2		
8	Size	1	2	3	2	2	2	1	3		
9	Eco-Friendly	3	3	2	3	2	3	1	1		
10											
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Lastly, a gantt chart was created in order to help incline the productivity of the group as there were actual milestones and deadlines that needed to be met and could easily be physically seen.

Shed Project- Solar Team	**01/08/18**	**03/29/18**		**59d**
– Deliverable A	**01/08/18**	**01/26/18**		**15d**
Sub-task 1 - Create a Team Contract	01/08/18	01/15/18	Reethi Paul	6d
Sub-task 2- Sign the Team Contract	01/15/18	01/22/18	Everyone	6d
Sub-task 3- Complete ITP metrics	01/22/18	01/26/18	Everyone	5d
– Deliverable B	**01/28/18**	**02/02/18**		**6d**
Sub-task 1- Identify Problems	01/28/18	02/02/18	Everyone	6d
Sub-task 2- Create a Problem Statement	02/02/18	02/02/18	Everyone	1d
– Deliverable C	**02/04/18**	**02/09/18**		**6d**
Sub-task 1- Categorize Our Problems Into a Few General Ones	02/04/18	02/09/18	Everyone	6d
– Sub-task 2-Find Design Ideas for Each Problem			Everyone	
Sub-Sub Task 1- Air Heating			Jeffrey and Kyle	
Sub-Sub Task 2- Water Heating			Sari and Lucas	
Sub-Sub Task 3- Solar Panel Installation			Reethi and Alex	
Sub-task 3- Bench Marking	02/04/18	02/09/18	Sari	6d
– Deliverable D	**02/11/18**	**02/16/18**		6d
Sub-task 1-Narrow Down the Design Ideas For Each	02/11/18	02/16/18	Everyone	6d
Sub-task 2- Client Meeting	02/15/18	02/15/18	Kyle and Alex	1d
– Deliverable E	**01/08/18**	**03/02/18**		40d
Sub Task 1- Cost Estimates	02/18/18	03/02/18	Sari	11d
– Sub-task 2- Start Building	01/08/18	02/22/18		34d
Sub-Sub Task 1- Air Heating Frames	02/19/18	02/22/18	Sari, Reethi, Lucas	4d
Sub-Sub Task 2- Water Heating Frames	01/08/18	01/08/18	Sari, Reethi, Lucas	1d
– Deliverable F	**02/18/18**	**03/02/18**		11d
– Sub-task 1- Prototype 1	02/18/18	03/02/18		11d
Sub-Sub Task 1-Water Heater	02/18/18	03/02/18	Sari	11d
Sub-Sub Task 2- Air Heater	02/18/18	03/02/18	Jeffrey	11d
Sub-task 2- Order Needed Parts			Justine	
– Deliverable G	**03/04/18**	**03/09/18**		6d
Sub-task 1 - Prototype 2	03/04/18	03/09/18		6d
Sub-task 2- Team Leader Meeting	03/05/18	03/05/18	Reethi Paul	1d
Sub-task 3- Insallation Using Ordered Parts	03/05/18	03/05/18	Everyone	1d
– Deliverable H	**12/18/17**	**03/23/18**		70d
Sub-task 1 - Prototype 3	03/18/18	03/23/18	Everyone	6d
Sub-task 2-Installation to The House	12/18/17	03/23/18	Everyone	70d
– Design Day	**03/29/18**	**03/29/18**		1d
Presentations	03/29/18	03/29/18	Everyone	1d

2.4 - Prototype:

The main objective of this step is to be more aware of costs, fidelity, ideration time and functional design.

Listed below are the cost estimations that were made.:

Materials	Cost (CAD) tax included
2X4 Wooden frame	$0 (Recycled material from structure lab)
Plywood	$0 (Recycled material from structure lab)
Insulation (40 sq. ft. - used for air heater as well)	$21.7
PEX piping (½ inch - 20 feet)	$10.15
Spray Foam Insulation	$10.14
Aluminum Sheet Metal	$0 (Recycled material from structure lab)
Plexiglass	$0 (Recycled material from structure lab)
Total	$41.99

Materials	Cost (CAD) tax included
Wooden frame	$0 (Recycled material from structure lab)
Plexiglass	$0 (Recycled material from structure lab)
Aluminum Foil	$0 (Recycled material from structure lab)
Electric Fan	$0 (Recycled material from structure lab)
Hinges	$2.98
Expandable Air Ducts	$10.48
Total	$13.46

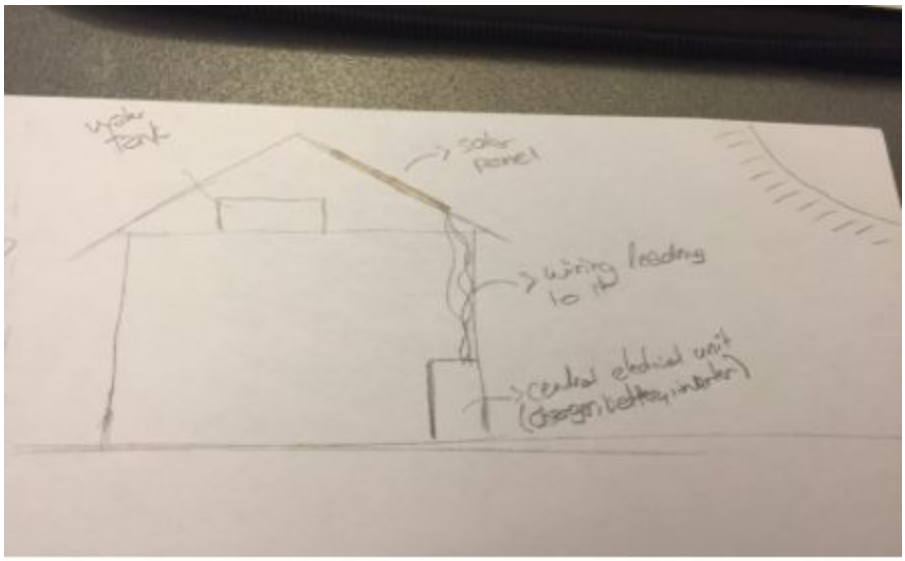
Materials	Cost (CAD) tax included
Battery- Eaton 140Ah 12V agm	$0 (Originally around $250 but is given to us)
Sunforce 11240 1000 Watt Pure Sine Wave Inverter	$0(Originally around $300 but is given to us)
260W Solar Panel	$0(Originally aroudf $250 but is given to us
MOHOO Intelligent Home 20A 12V/24V LCD Display Solar Charge Controller with USB Port	$0(Originally around $15 but is given to us)
Total	$0

As for the modelling portion of the prototype, a physical model version and sketches were chosen as this would be the most appropriate choice for a shed project. This is was was modelled:

Water Heater:

Air Heater:

Solar Panel:



2.5 - Testing:

This final step is crucial in that a physical model for testing can reduce the cost and time. This type of physical model can simplify the design concept. **Simulations** can also be used to complement physical prototypes being tested.

However, due to time shortage and bad luck with the weather, actual testing was not able to be completed prior to design day. Ideally, the systems should work. However, since the testing phase was essentially skipped, the answer is actually unknown as to whether it works properly or not. This was what was finally presented on the due date:


SOLAR CHARGE CONTROLLER

3 - Conclusion

As a team, a mutual agreement that was going through the design thinking process to provide solutions for real life problems was a very rewarding learning process.

initially, there was some struggle with the distribution and management of tasks, however, after producing a Gantt chart there was an immediate, noticeable and drastic incline in the level of productivity. Managing conflict during the design process by compromising and accommodating to needs.

Considering the several compromises in the design due to restrictions in budget, time and space, we managed to produce very sustainable systems. If there were to have a bigger budget it would primarily be focused on scaling down the size of our systems without compromising their efficiency. Smaller panels will result in better compatibility which enables the product to be used worldwide in all types of housing situations. Having additional time and resources will also enable it to produce better testing and analysis of the prototypes.

This team in particular faced several challenges. Some being time, shed size and limited feedback just to name a few. Many mistakes were made as well, however, most of it was due to the lack of communication.

In the future, if there were another project of such scale, it will focus more on communication mainly.