Deliverable G: Prototype II and Client Feedback

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1 Introduction

This document outlines the second prototype and the critical components using detailed descriptions. Feedback for our prototypes, and design were obtained during the third client meeting. A brief section for the client feedback is included in this document. This document also includes sections for the potential user feedback and the third prototype plan. The potential user feedback section explains how our project plans were expanded by a civil engineering student, and what they thought about our project and prototype plan. The third prototype plan section briefly explains our plan for our third prototype will be made.

2 Feedback From Client

As part of the last client meeting, we presented or concept and plan for the upcoming prototypes and asked for feedback or if there was anything he would like us to do differently. In response to this question the client stated he was happy with the direction our prototype and there is currently nothing he would change. We take that to mean he has no negative feedback or concerns, and recommends we continue as we plan.

3 Prototype II

This prototype is comprised of a single component of our final prototype. The prototype is made from 25 ft of partially clear vinal tubing, and an electric water pump, with 8 out of the 25 ft serving as the main solar water heating coil.

4 Critical Components

Our prototype will include the THEC, an air inlet, a thermal battery, a solar water heater, a fan, a water pump, a thermostat analog, and a pipe layout as its main subsystems and components.

The THEC is filled with water and the fan is attached to the larger lower exit hole by using electrical tape and hot glue. The pipe layout is connected to the larger holes and is used as the main airflow pipe for the system. The lower hole will be drilled to the pipe and watertight sealed. We will also use hot glue for this part to make sure that there are no leaks between the pipe and the THEC. The upper hole will be cut in a lid, so there will be no adhesive of permanent fixation used to make sure the THEC can be opened if modification or transportation is needed.

The smaller holes of the THEC will be used for the vinal tubing that will coil around the larger airflow pipe. The vinal tubing will connect to either end of the thermal battery, the upper and lower small holes on the THEC, and the circulation pump. We will use hot glue to seal this.

The pump will circulate water from the coil exit up to the solar water heater. The solar water heater is made from vinal tubing, which is held in place by two or more Styrofoam blocks. There will be no need for adhesives, as the blocks are there to rigidity.

All the outflow from the bottom of the solar water heater travels through the tubing to the thermal battery. The battery is a plastic box, similar to the THEC, but is insulated using Styrofoam insulation glued to all of the edges of the box. The box also has two holes which allow for tubing to be made in order to connect the solar water heater to the THEC.

The system will be powered using a thermostat that runs the pump and fan using a wall adapter with a temperature switch. This is because the pump and fan have higher power requirements than what an Arduino can supply, and the temperature switch is an easy and effective way of controlling the system.

5 Prototype II Results

Unfortunately, in the testing of this prototype there was an unavailability in measurement equipment. No team member in Ottawa had access to a thermometer and no thermometer could be delivered or found before the testing of the prototype was to be completed. As a result, there was no ability to quantitatively measure the rate heat was absorbed by the water for this prototype. Instead we performed different tests to ensure that all components were functional in the final prototype.

Instead, we tested whether the prototype if functioning appropriately enough in its ability to move water to move forward to the next prototype. Firstly, we determined that the pump was capable cycling the water in a closed loop as we desired. This was determined by creating the closed loop as seen in Figure 1 and Figure 2.

Figure 1: Prototype 2 Closed Loop 1

Figure 2: Prototype 2 Closed Loop 2

Air gaps in the pipe were seen to repeatedly circulate the pipe through the pump over and over, indicating that the water in the pipe was circulating.

We then modified the prototype by disconnecting it from a closed loop and coiling it around 5 ft of what is going to be the air pipe. This is approximately the same length of pipe that will be coiled in the final prototype. Using a stopwatch, we timed to the nearest second the time for 1 L of water to circulate in the system. This was determined by the time it takes the pump to intake 1 L of water from a reservoir. Five trials were done with times 55, 50, 50, 60, 48 seconds for an average 52.6 seconds to pump 1 L of water.

What as also realised but not tested in detail was the maximum heigh the pump could push the water. The pump fell short of pumping water from the floor to the maximum height (as seen in Figure 3) by a few inches (estimate) but could easily pump from the ledge to the maximum height. This height from ledge to maximum is near the total height as presented in the CAD model of the final prototype thus indicating there should be no concerns to the pump and solar water heater performing as required.

Figure 3: Prototype 2.1 Small Height

6 Potential User Feedback

As part of the development and refinement process the team contacted a couple of outside sources that may have useful perspectives on the project and prototype.

6.1 Civil Engineering Student

The civil engineering student and employee for an Ottawa property discussed in the previous prototype developed further questions related to our project and was eager to continue to discus feedback and comments. The first concern they raised was regarding the volume of water needed to maintain the system temperature. As this would be proportional to the amount and number of solar water heaters on the roof possible causing unnecessary stress and possible damage. They then followed up with the recommendation to place the solar water heater near the top of the roof for three reasons. Firstly, resale and market value, having the equipment near the edge places it in view of buyers and may make the property less appealing visually. Placing the heater near the top of the roof “hides” the equipment making it more appealing. Second, placing the heater lower down provides more opportunity for trees and other objects to create shadows reducing the efficiency of the system. And thirdly, lower down on the roof there is less support thus, at lower areas the roof may need to be installed with additional reinforcement to support the weight; however, the top of the roof is better supported and is more likely to support the weight of the heater. Their final concern is in regard to the Ottawa winter weather and the impact snow, freezing rain will impact the system.

7 Prototype III Plan

Prototype 2 will be a complete physical model of the heating system comprised of the unmodified pump and the tubing that creates the solar water heater panel and thermal battery. The purpose of the prototype is to analyze and confirm the heat gained from solar energy and heat lost from static water in the thermal battery, related to weather and length of tubing. The prototype will encounter one test measuring the rate of heating using a thermometer to periodically measure the temperature of the water in the system. The prototype will be placed indoors in an area with large availability to sunlight and the pump will be able to run continuously over a full day. The test will ideally be run several times with different levels of sunlight. Each test will conclude after the sun sets each day, or if the temperature of the water in the pipe nears 60 degrees Celsius the maximum temperature rating for the pump. Also, in this time we wish to complete the final prototype which will contain all critical components outlined above. The final prototype will function as a model to simulate extended use of the design and see whether the design is successful.

8 Conclusions

Unfortunately, due to a lack of proper testing equipment we were unable to perform the planed test. However, alternative tests and indications from this prototype and the previous indicate a high likelihood the final prototype to perform to expectations. The tests performed on this prototype indicate the mechanisms behave as desired and any possible issues fall are not projected to cause problems in further prototypes. Given this the team feels comfortable moving forward with the next prototype and taking planed test.