Deliverable E: Project Plan and Cost

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1 Introduction

The purpose of this document is to introduce a detailed description of our prototype design plan, as well as a list of the required materials with their cost and quantity, as well as their shopping location. The document also includes a list of the required equipment (software or hardware) for the prototype production, the prototype risks, the associated contingency plan, and information about the prototype test plan.

2 Complete Solution Design

The complete solution includes all components of the final product and includes designs not currently being tested. The complete solution includes an Inlet, the Heat Exchange chamber (THEC), the complete Pipe Layout, the Heating system, and the Blower. [Figure 1].

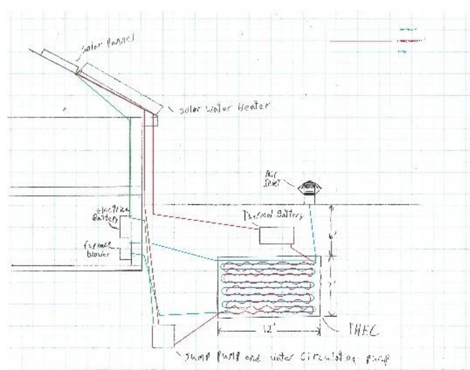

Figure 1: Complete Solution Diagram

A furnace blower draws air through this system and runs off the house's power grid. Air is pulled through the inlet as seen below in Figure 2.

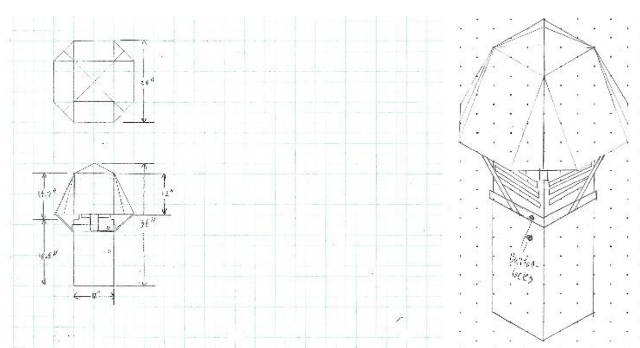

Figure 2: Inlet Design

This air is cooled or heated inside the THEC, which is not changed from the client's original patent. Inside of THEC, the pipe layout has been changed into ten columns of ten rows of pipes connected vertically as seen in Figure 3.

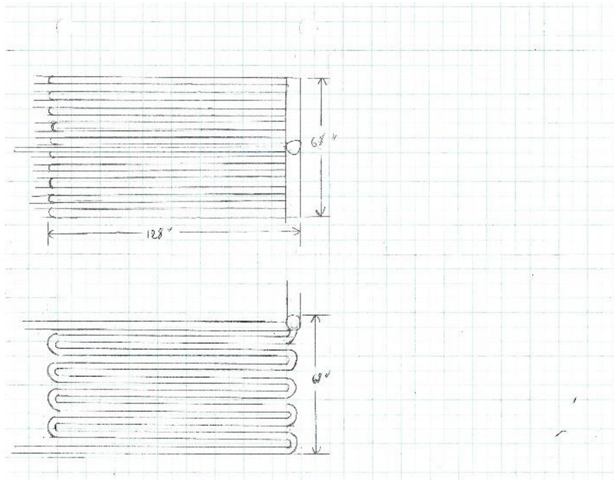

Figure 3: Pipe Layout of Complete Design

In winter, when the ground temperature is insufficient to completely heat a house additional heat is collected using a solar water heater and stored in a thermal battery, the water is then circulated using a water pump located at the bottom of the THEC [Figure 4]. The whole system is powered by an array of solar panels and thermoelectric plates connected to batteries [Figure 1].

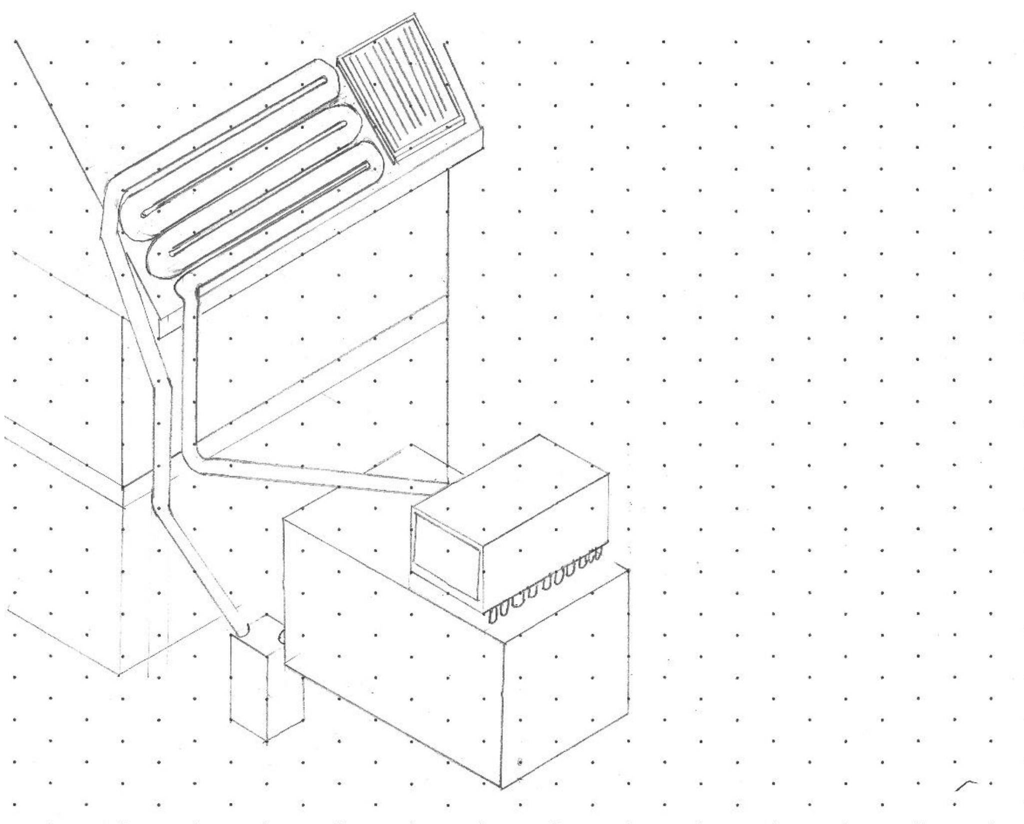

Figure 4: Heating System Isometric View

The general processes this system will follow are outlined in the following block diagrams [Figure 5].

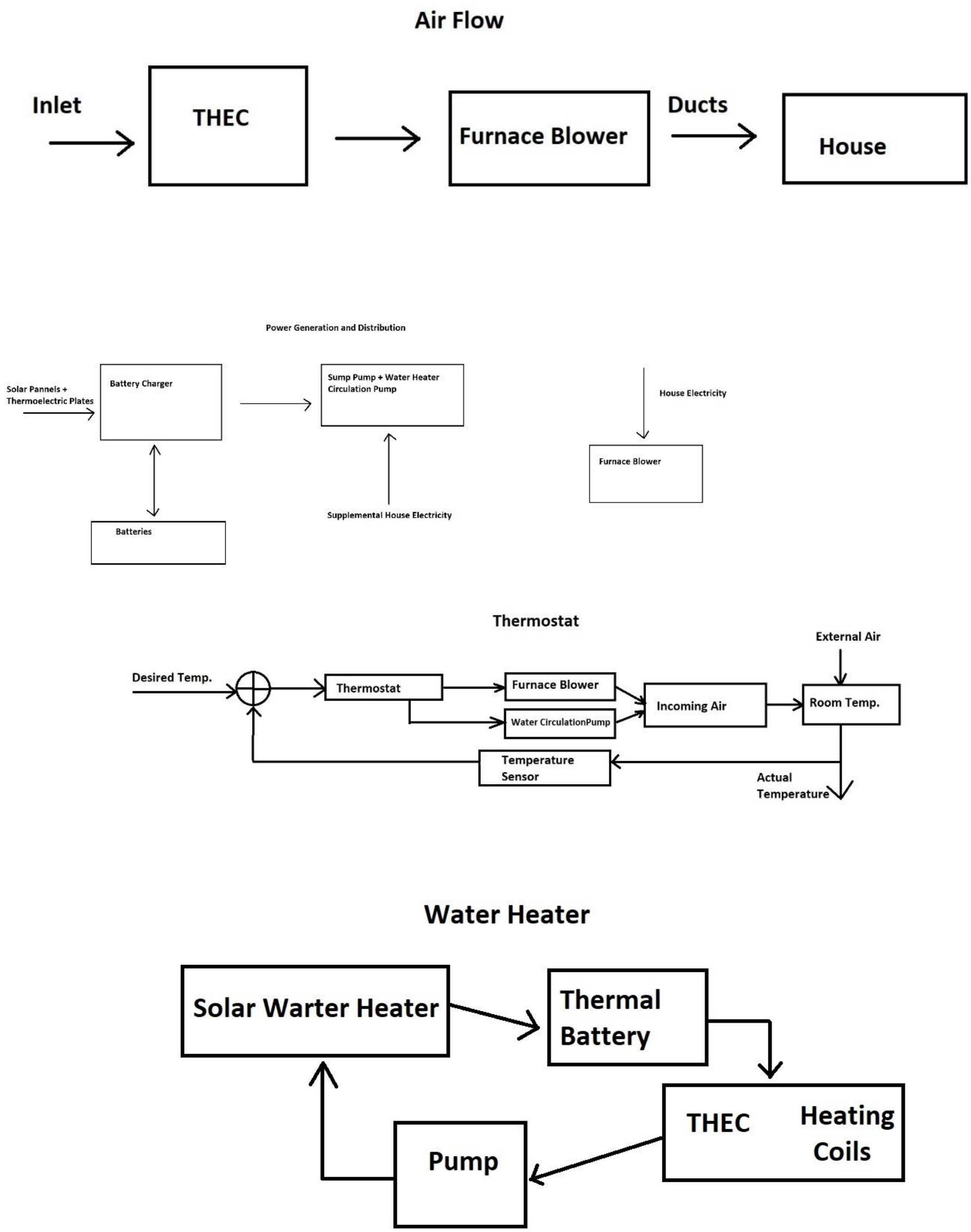

Figure 5: Block Diagrams

3 Project Prototype Design

The main part element this group wishes to test is the efficacy of the proposed heating system. The focus of this group is not on the power generation of the solar panels and thermoelectric plates, but rather on whether the required temperature output can be achieved. Thus, the only components involved in the project moving forward are a simplified pipe layout, THEC, thermal battery, solar water heater, fan, water pump, and a thermostat analog. To begin, the design includes a THEC filled with water with the fan attached at the larger lower exit hole using hot glue and electrical tape [Figure 6].

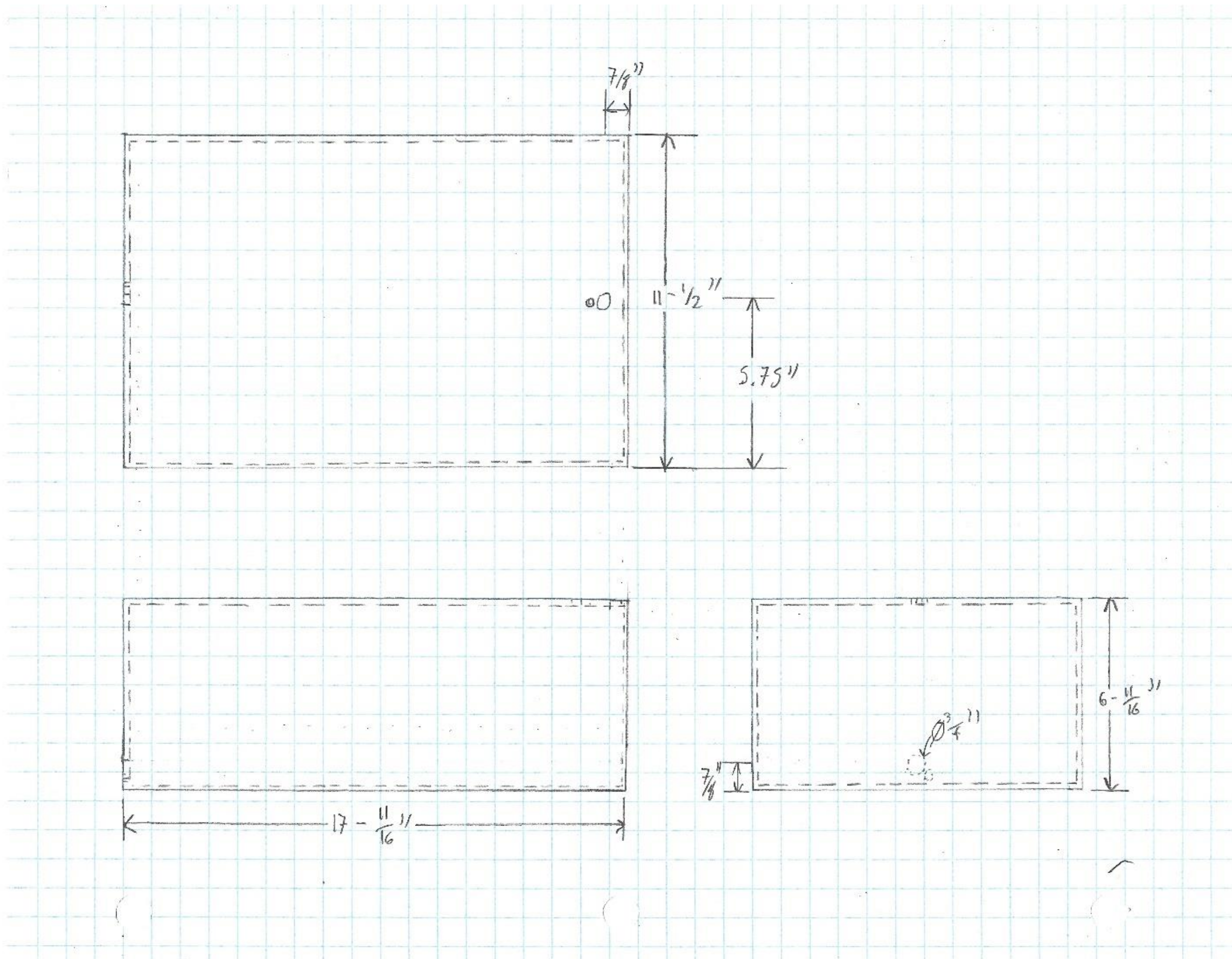

Figure 6: Prototype THEC

The simplified pipe layout [Figure 7] connects the larger holes and is the main airflow pipe of our system. The lower hole will be drilled to the diameter of the pipe and watertight seal using hot glue to ensure there are no leaks between the pipe and THEC. As the upper hole will be cut in a lid no adhesive of permanent fixation will be used to ensure THEC can be opened for modification and transportation.

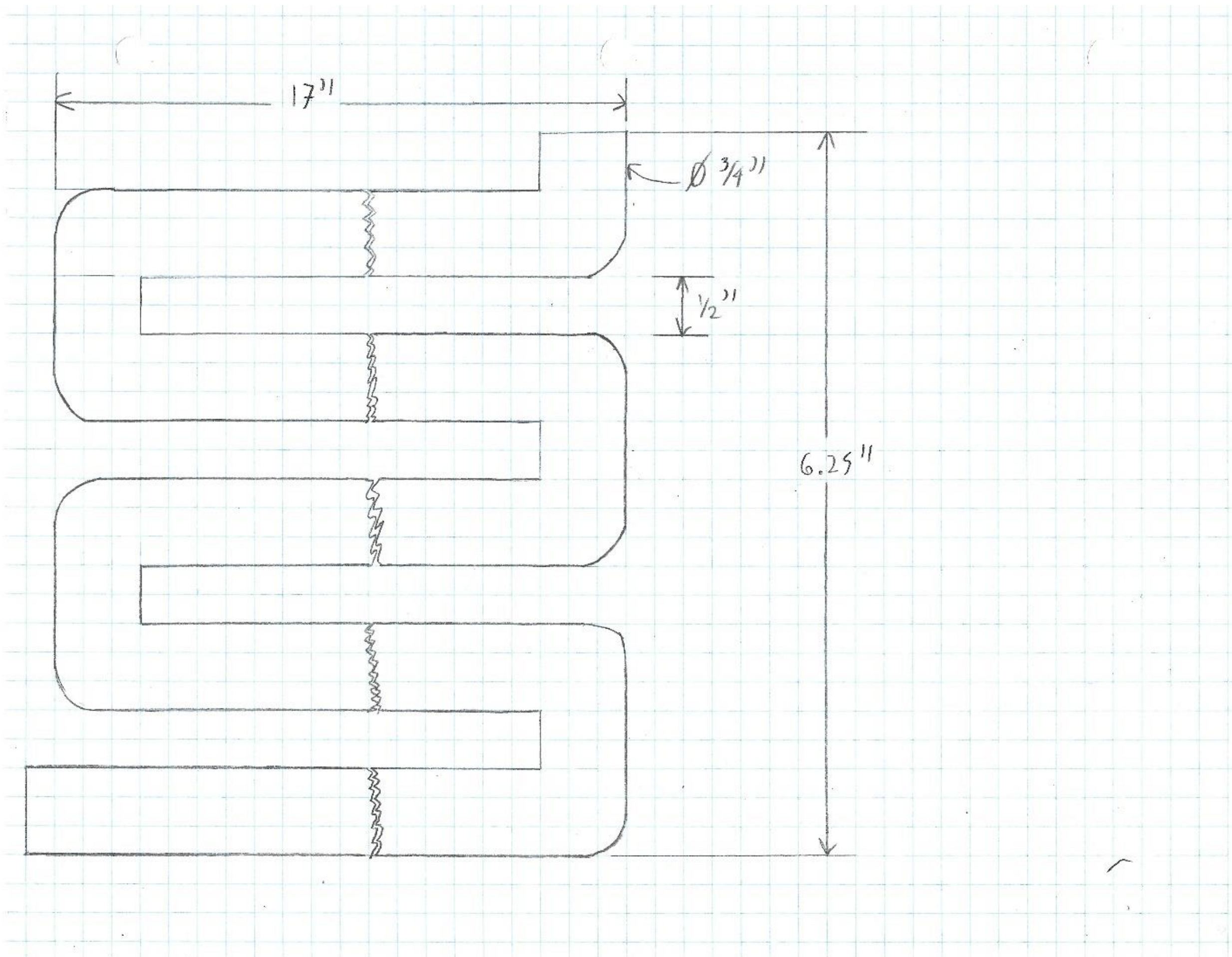

Figure 7: Simplified Pipe Layout

The smaller holes in THEC are intended for the vinal tubing that coils around the larger airflow pipe [Figure 8]. This vinyl tubing is connected on either end to the thermal battery and the circulation pump, the upper and lower small holes on THEC respectively, and is once again sealed using hot glue.

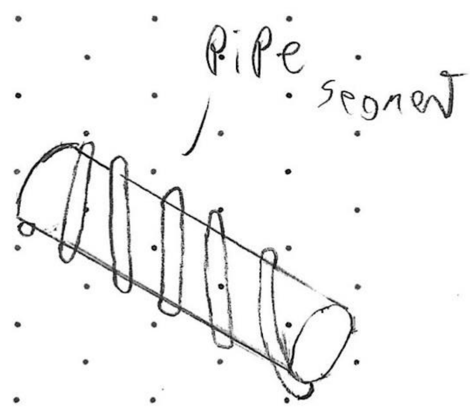

Figure 8: Pipe coil

The pump circulates water from the coil exit up to the solar water heater that is made from more vinal tubing held in place by 2 or more Styrofoam blocks [Figure 9]. Creating an arrangement as seen in Figure 10. As the blocks are there to rigidity, there is no need for adhesive or fasteners.

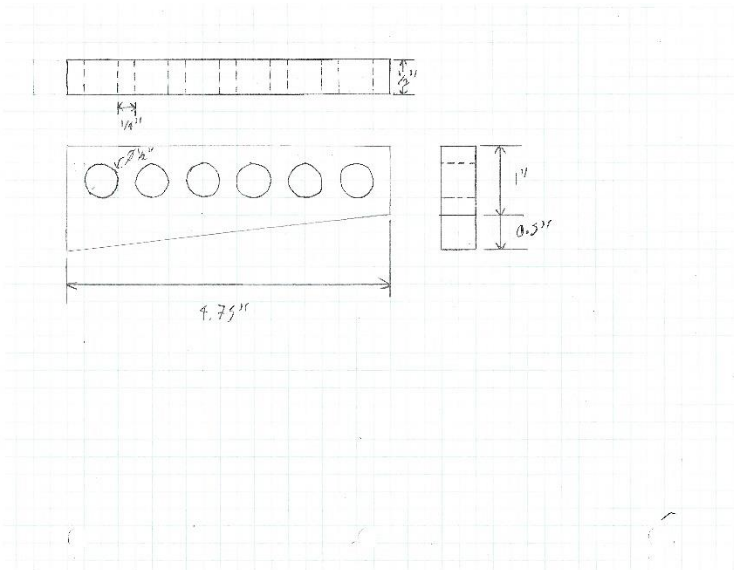

Figure 9: Styrofoam Blocks

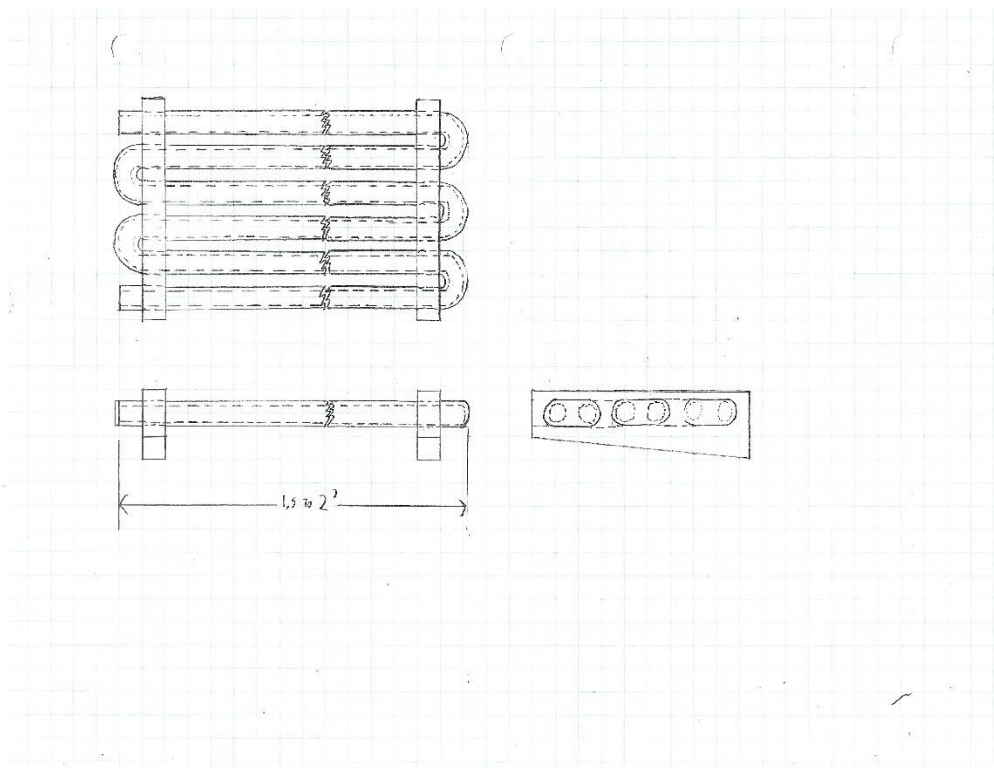

Figure 10: Solar Water Heater

The outflow from the bottom of the solar water heater is transported by tubing to the thermal battery [Figure 11]. The battery is a plastic box like THEC but with Styrofoam insulation glued to all edges of the box. There are two holes in the box where tubing can be inserted to connect the solar water heater and the THEC.

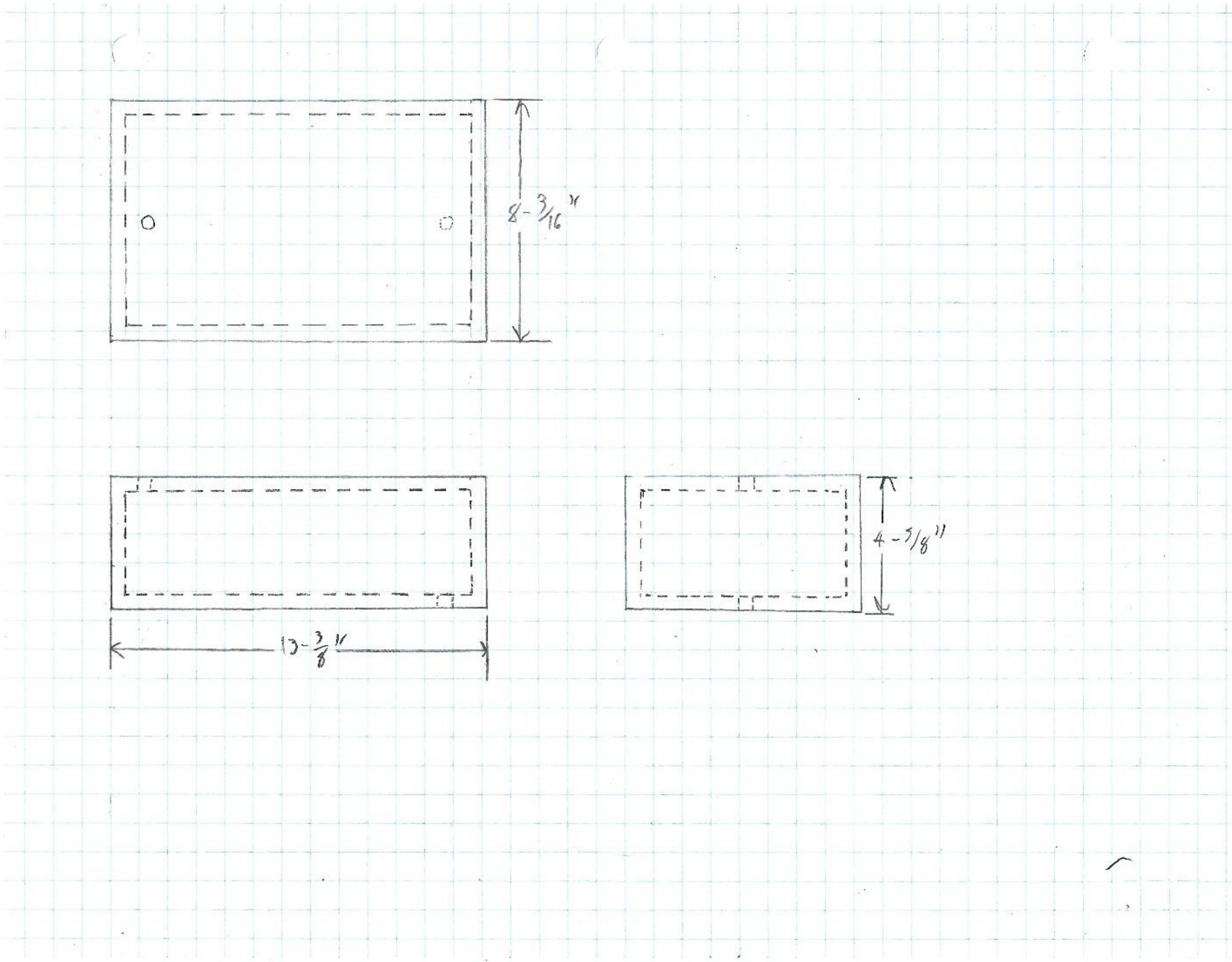

Figure 11: Thermal Battery

To power this system and simulate using a thermostat the group intends to run both the pump and the fan in parallel off a wall adapter with a temperature switch [Figure 12]. This is because both the pump and the fan have higher power requirements than what can be supplied by an Arduino with the temperature switch being an easy and effective way of controlling the system.

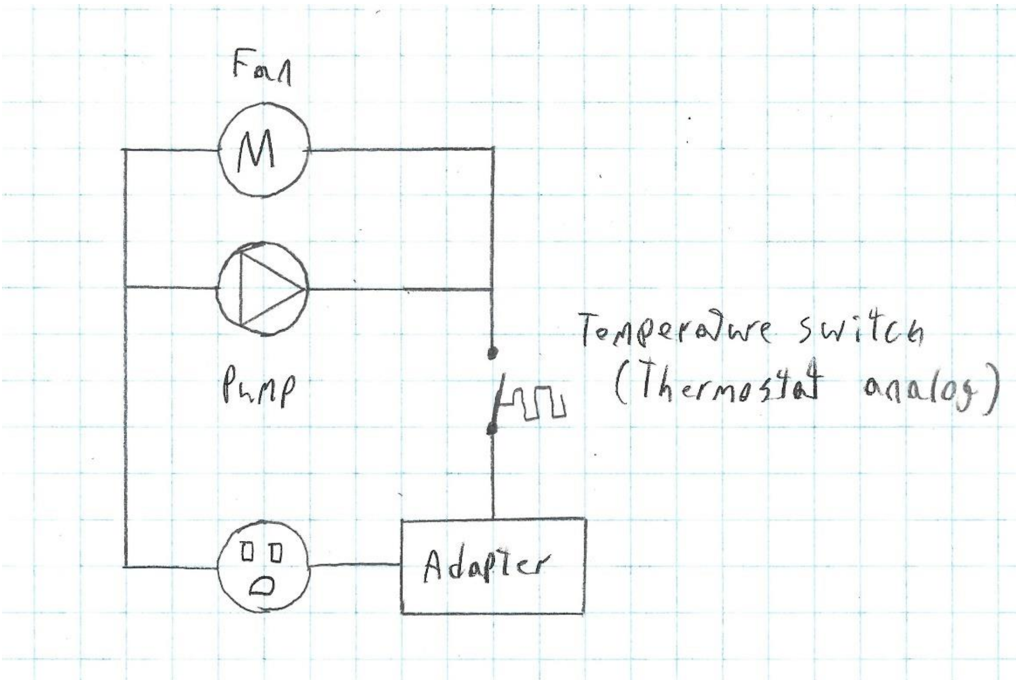

Figure 12: Power circuit

4 Materials and cost

To build the prototype, a list of materials that this prototype will require to build is listed in Table 1. All materials and uses have been outlined previously in section 3. In addition to these materials, there is a list of equipment needed to build the prototype.

Table 1: Bill of Materials

Item #	Item	Unit price	Quantity	Total Price	Purpose
1	Temperature switch	$ 9.59	1	$ 9.59	To trigger the pump and fan, thermostat analog
2	Small Plastic container	$ 3.99	1	$ 3.99	For thermal battery
3	Computer fan	$ 13.00	1	$ 13.00	To act as a small furnace blower
4	Fish tank pump	$ 12.00	1	$ 12.00	For circulating the water
5	Styrofoam sheet	$ 8.99	1	$ 8.99	Insulation for the thermal battery
6	large plastic container	$ 9.99	1	$ 9.99	THEC box
7	vinyl tubing	$ 6.22	2	$ 12.44	Heating tubes
8	90 deg elbow	$ 1.18	9	$ 10.62	To connect the air pipe into pipe layout
9	¾-inch PVC Piping	$ 13.40	1	$ 13.40	Air pipe
10	wiring	$ 1.99	1	$ 1.99	extra wire to run the temperature switch
11	Hot Glue	$ 1.25	1	$ 1.25	To seal and attach most components
			Total:	$ 97.26	

4.1 Equipment

The list of equipment includes drills, drill bits, hot glue guns, wire cutters and strippers, razor blades, measuring implements such as meter sticks and squares, a soldering iron and solder, and tools such as OnShape. This list outlines all expected items to manufacture the final prototype and model components.

5 Anticipated Risks

In addition to analyzing what is required to build the prototype, possible risks were also assessed. This group broke the risks into three categories Prototype Development, Possible Injuries, Success Related. Prototype Development risks are any risk that may prevent a functional prototype from being developed. Success Related risks are related to component or prototype failure that cause significant setbacks and impede success. Finally, Possible Injuries are prototype and prototype development related injuries. These risks with an associated likelihood and our plan to mitigate their likelihood are outlined in Table 2.

Table 2: Risks and Mitigation

Risk	Likelihood	Mitigation
	Prototype development	
No one is available to develop the prototype (sickness or availability related)	Unlikely	Develop a routine development schedule for working on prototypes and testing.
No availability of required materials	Unlikely	Purchase the materials in advance. If materials are expected to not arrive have secondary sources prepared.
	Possible Injuries	
Hot water burns	Unlikely	Do not handle water after significant time to heat water has been reached
Electric shocks	Very unlikely	Make sure the electric devices are connected to the power outlet correctly, never use a wet hand to touch any parts of the electric system.
Fan cuts fingers	Unlikely	Never touch the fan while the fan is connected to the power
Manufacturing related injuries	Mildly Likely	Before starting work on any tools or equipment all users need to be familiar with the safety precautions and procedures
	Success Related	
Insufficient weather for testing the prototype.	Possible	Check the weather, and develop a testing schedule around the weather
Fan or pump failure	Mildly Likely	Order new components when necessary and run passive tests while waiting for new parts to arrive.
Water leaks cause damage to other components	Likely	Attempt to plug and seal components best possible, if a leak occurs all components that could be damaged are in safe areas

6 Conclusion

In summary, we conclude the design concepts with lots of detailed design drawings. In this document, we outlined the prototype by a spreadsheet, the potential risk of the project, and prototype production with contingency plans, and the document covered a list of equipment and materials, including the cost of each material, that is required for the prototype production.

7 Price References

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