**Memo**

To: Professor Pisano, Professor Kotiuga, Professor Osama, Professor Hirsch

From: Hal Levin, Moises Bensadon, Stanley Nguyen

Team: 21 - Efficient hybrid solar panels for hot water.

Date: 3/17/23

Subject: Second Prototype Test Report

**Equipment**

* 1. Electric Components
* 30W Solar Panel
* 12V Battery
* Alligator Clip connectors
* Solar Panel Power Controller
* Water Pump
* Arduino Uno
* 10k and 100k ohm resistors
* Thermistor
* Arduino software on a computer
* Arduino Compatible Micro SD Card Reader
* Multimeter
  1. Water and Other Physical Components
* Plastic water Tank
* Water
* Tank Lid
* Plastic Tubing
* Copper Tubing/Connectors
* Copper backplate
* Wood backplate
* Wood panel support frame
* Screws
* Water heater

**Set-Up**

The set-up of our test was consistent with the set-up section from our test plan which can be seen below.

The plastic tank is filled with water. There is a pump inside the tank that is connected to one end of plastic tubing, which exits the tank through a hole in the lid. The plastic tubing then connects to copper pipes. These pipes are arranged in a zig-zag pattern horizontally (shorter zig zag). It consists of vertical 8” copper pipes of diameter ½” which connect to a copper street elbow and then a normal copper elbow connecter to the next vertical pipe. All of the connections are soldered using a blowtorch to seal the connections. This zig-zag piping is flush against a copper back plate that is against the back of the solar panel. On the other side of the pipes, there is an insulative backing made of wood holding the flat zig zag securely against the copper sheet metal, which minimizes the environment's impact on the temperature of the solar panel. The solar panel with the tubing and backing on it is supported by a wood frame. This wood frame holds the panel horizontally (facing the sky) and the water tank fits underneath the frame. The frame rests on a corner of the wood, allowing for future modifications that may include using stepper motors to adjust the angle of the solar panel wood structure to aim the solar panel towards the sun throughout the day. When the pump turns on, water is pumped through the pipes on the back of the panel, then it goes through the end of the piping into another hole in the lid of the water tank.

An Arduino is connected to a thermistor, a voltage divider, a micro sd card module, and to a relay to supply power to the water pump. The Arduino reads the temperature of the surface of the solar panel using the thermistor. When it measures above a chosen temperature at the time of testing, the Arduino sends power to the pump, which allows it to pump water underneath the panel, cooling it. Once the temperature is then sensed by the thermistor/Arduino to be below this chosen temperature, the Arduino stops supplying power to the pump, stopping the flow of ice water. The Arduino is also connected to a voltage divider which is connected to the 12V battery that the solar panel supplies power to. This allows us to monitor the voltage of the battery over time, to see how much power the solar panel is supplying. For this prototype, we will demonstrate the effects of heat on the solar panel’s efficiency by flowing hot water under the panel instead of cold water which our product’s ultimate goal is.

**Testing**

Our second prototype demonstrated our new cooling system as well as our data logging. This new copper cooling system is much more efficient than our previous plastic tubing. We wrote data to an sd card that we used to upload to our site. For this testing, we demonstrated how heating the water rather than cooling it helped prove our point of the efficiency decreasing with temperature increase. From this prototype test, we show our capability of gathering quantitative efficiency and savings data to output to our user. In this test, we showed the pump being able to turn on when a specific temperature is reached, and measured temperature, voltage and current output to our micro sd card. This data was also displayed during our prototype test on our user output site that displays this data vs time on graphs. Based on this data collected over time, we can determine the optimal operating temperature of the solar panel for maximum power output. This temperature will be what we use in our final design for when to turn on the pump to cool the panel.