**Memo**

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

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

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Subject: Second Prototype Test Plan

1. **Required Materials**
   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

**2.0 Set-Up**

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.

**3.0 Pre-Testing Procedure**

1. Connect the 12V battery to the solar panel power controller using alligator clips
2. Connect the power controller to the solar panel
3. Ensure the solar panel is receiving enough light to supply power to the battery by checking the indicator light on the controller
4. Connect Arduino to computer
5. Read the output of temperature from the thermistor from the Arduino and the voltage of the battery from the voltage divider from the Arduino
6. Fill the water tank with water
7. Read the temperature of the solar panel using the thermistor
8. Based on the room temperature and water temperature, choose a minimum temperature detected that the pump should turn on at to effectively simulate being in a climate that gets hotter
9. Edit Arduino code using this chosen temperature
10. Measure current, when this is combined with the temperature and voltage output written to the micro sd card, this file can then be displayed on our site, showing change in efficiency vs temperature

**4.0 Testing Procedure and Measurable Criteria**

Our second prototype demonstrates 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 now write data to an sd card that we can use to upload to our site. For this testing we demonstrate how heating the water rather than cooling can help 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 will show the pump being able to turn on when a specific temperature is reached, and can measure temperature, voltage and current output to our micro sd card.