**Memo**

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

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Subject: First 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
  1. Water and Other Physical Components
* Plastic water Tank
* Water
* Ice
* Tank Lid
* Plastic Piping
* Cardboard
* Zip-Ties
* Wood
* Screws

**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 was chosen so we could focus on the ECE components for the first prototype, yet in the near future, we will use a harder material to work with such as copper for the tubing that would transfer heat much better. This tubing is then adhered to the back of a photovoltaic cell, coiled in a flat spiral against the back. There is an insulative backing holding the flat spiral securely against the panel, which minimizes the environment's impact on the temperature of the solar panel. The solar panel with the piping 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 tube 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, and to the power supply of 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 ice 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.

**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 ice water
7. Read the temperature of the water 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

**4.0 Testing Procedure and Measurable Criteria**

The main purpose of our first prototype is proof of concept of cooling the panel using water tubing. For the testing, the pump can be shown to turn on when the temperature of the thermistor increases to a certain temperature. The pump will then be shown to turn off once the water flowing under the solar panel has cooled the thermistor back under the temperature threshold that it turned on at. For this prototype, we do not have any rigid data collection or modeling yet of the water’s cooling effects nor of the effects of the cooling on how much power the solar panel provides the battery. For the majority of this modeling, we will first build a more robust prototype that uses metal piping with much better heat transfer, so we can get more accurate data collection. For this first prototype that uses plastic tubing, we just monitor the temperature output and collect data on time vs temperature while cooling. We can also monitor the voltage of the battery vs time.