DEPARTMENT OF MECHANICAL ENGINEERING

TEAM 23

Five Guys

Stephen Carrera, Emanuel Gancayco, Stephen Johnson, Andrew Lai, Michael Yang

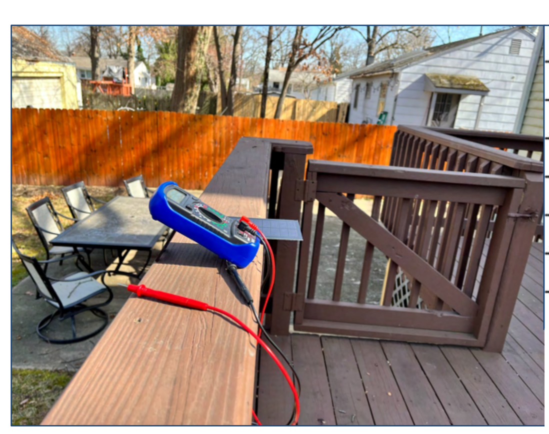
A. JAMES CLARK SCHOOL OF ENGINEERING
UNIVERSITY OF MARYLAND

Problem Definition

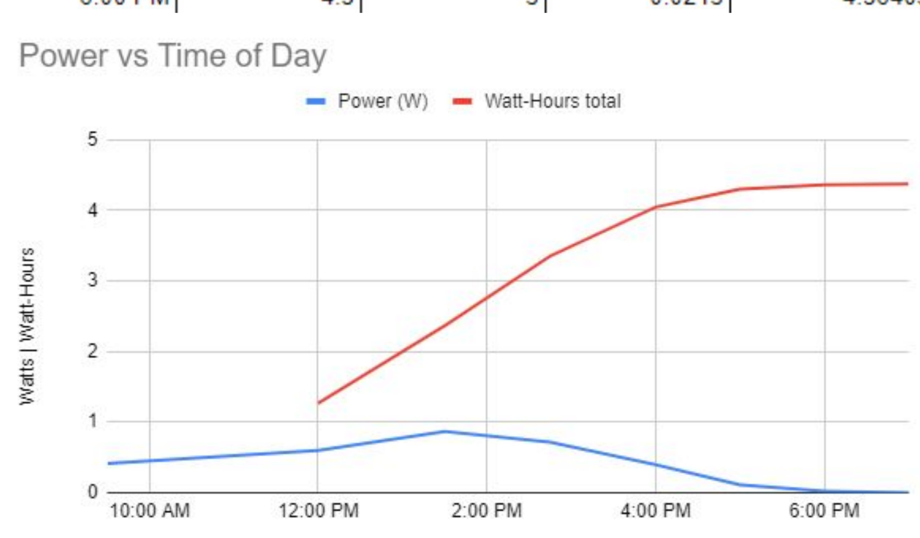
Campers and hikers often bring along various small electronic devices, such as phones, cameras, and flashlights, which have limited battery life. Such hobbyists do not usually have readily available electricity to recharge their devices, and will often resort to giving up much-needed packing space and weight to sets of spare batteries. As batteries are used and depleted, they are either kept in storage or littered in the environment, which can have several repercussions. While lithium batteries, typically the kind used in cameras and GPSs, are safe, if the battery is damaged, various chemicals such as manganese, cobalt, and nickel can pollute nearby bodies of water and be otherwise incredibly toxic to the environment.

Instead of spare batteries, campers and hikers may attempt to utilize rechargeable batteries and generators to provide power to their equipment. However, typical gas powered generators are costly, large, heavy, and resource intensive, and are not as environmentally friendly as most would prefer. Ideally, the solution to the problem would be lightweight (less than a kilogram), compact (fit in a 20 by 10 by 5 centimeter area), and generate at least 25 Watt-Hours per day cycle. This guarantees that the customer can easily add it to their backpack without adding excessive weight and bulk, as well as the device being powerful enough to forgo spare batteries. With there being an estimated 53 million hikers in the United States in 2023, and about 36 million annual campers as of 2021, this problem affects a sizable portion of the population. As such, a reliable and readily available solution could go a long way to improving the average outdoor experience.

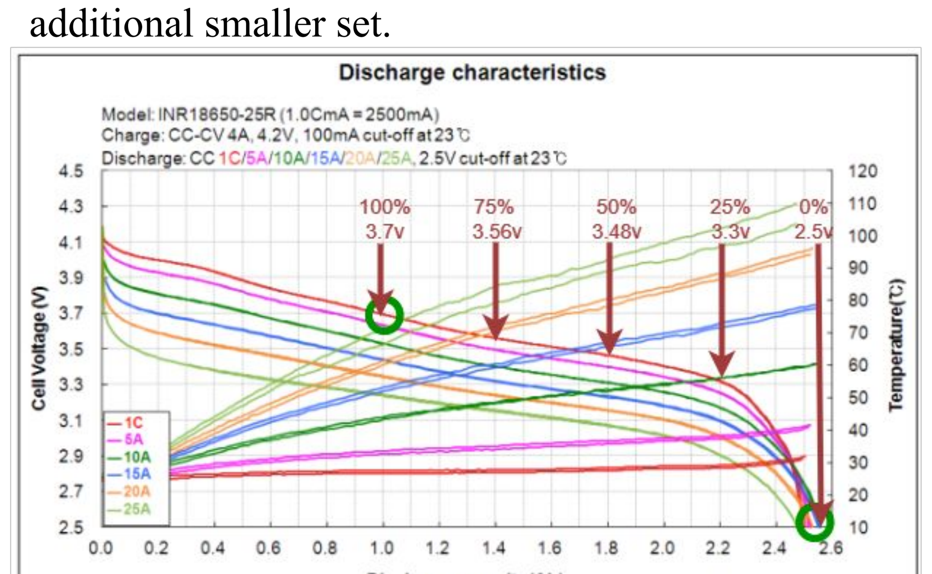
Design Calculations & Analysis



Time	Voltage	Amperage (mA)	Power (W)	Watt-Hours total
9:30 AM	5.5	75	0.4125	
12:00 PM	6	100	0.6	1.26563
1:30 PM	6.5	133	0.8645	2.36400
2:45 PM	6.5	110	0.715	3.35119
4:00 PM	6.6	60	0.396	4.04556
5:00 PM	6.2	17.7	0.10974	4.29843
6:00 PM	4.3	5	0.0215	4.36405

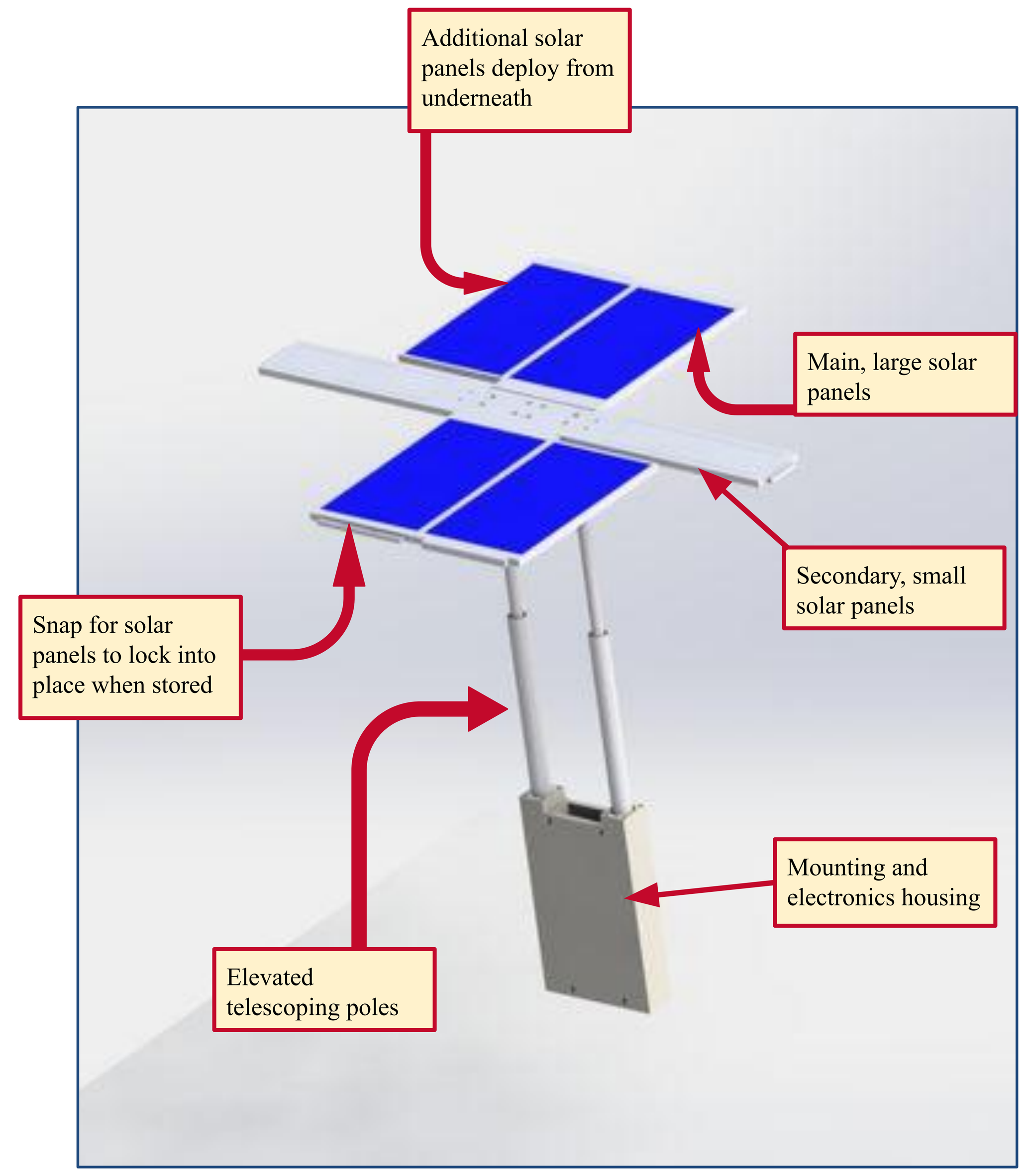


The early stages of our project focused on proof-of-concept. The earliest testing we did revolved around documenting the power output of solar panels throughout the day. From this, we found that a single panel could correspond to between 4 and 5 Watt-Hours during a day of charging, and in order to achieve the desired total 25 Watt-Hours we would need to include 4 of the tested solar panels, as well as an additional smaller set.

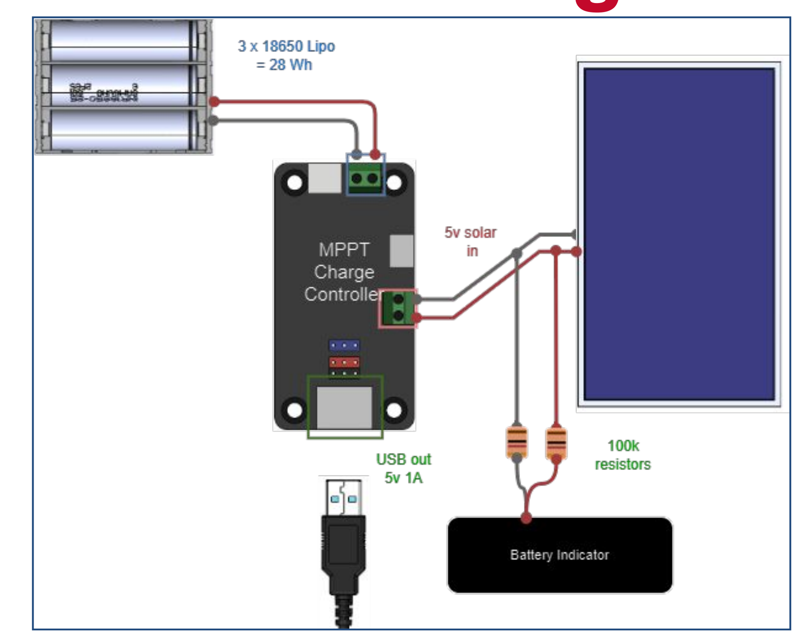


The other main portion of the project was storing generated energy, so that it could be discharged whenever the user desired. In order to do so, the team settled on using 3.7v 2500mAH lithium rechargeable batteries. Following the calculation for Watt-Hours from volts and Amp-Hours, each battery had the potential for approximately 9 Watt-Hours of capacity, and thus the product would require three to reach the capacity goal.

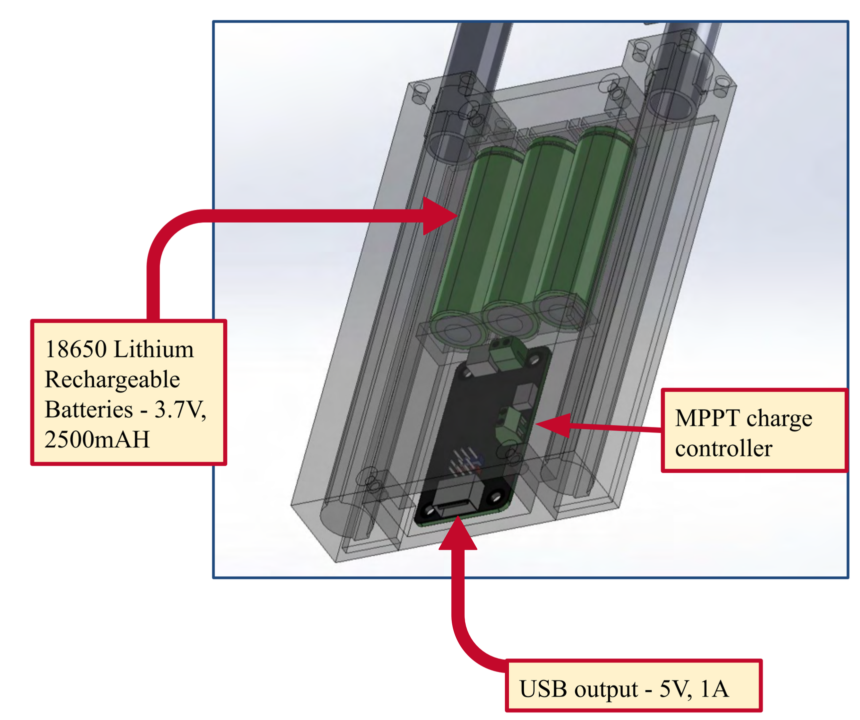
Final Design

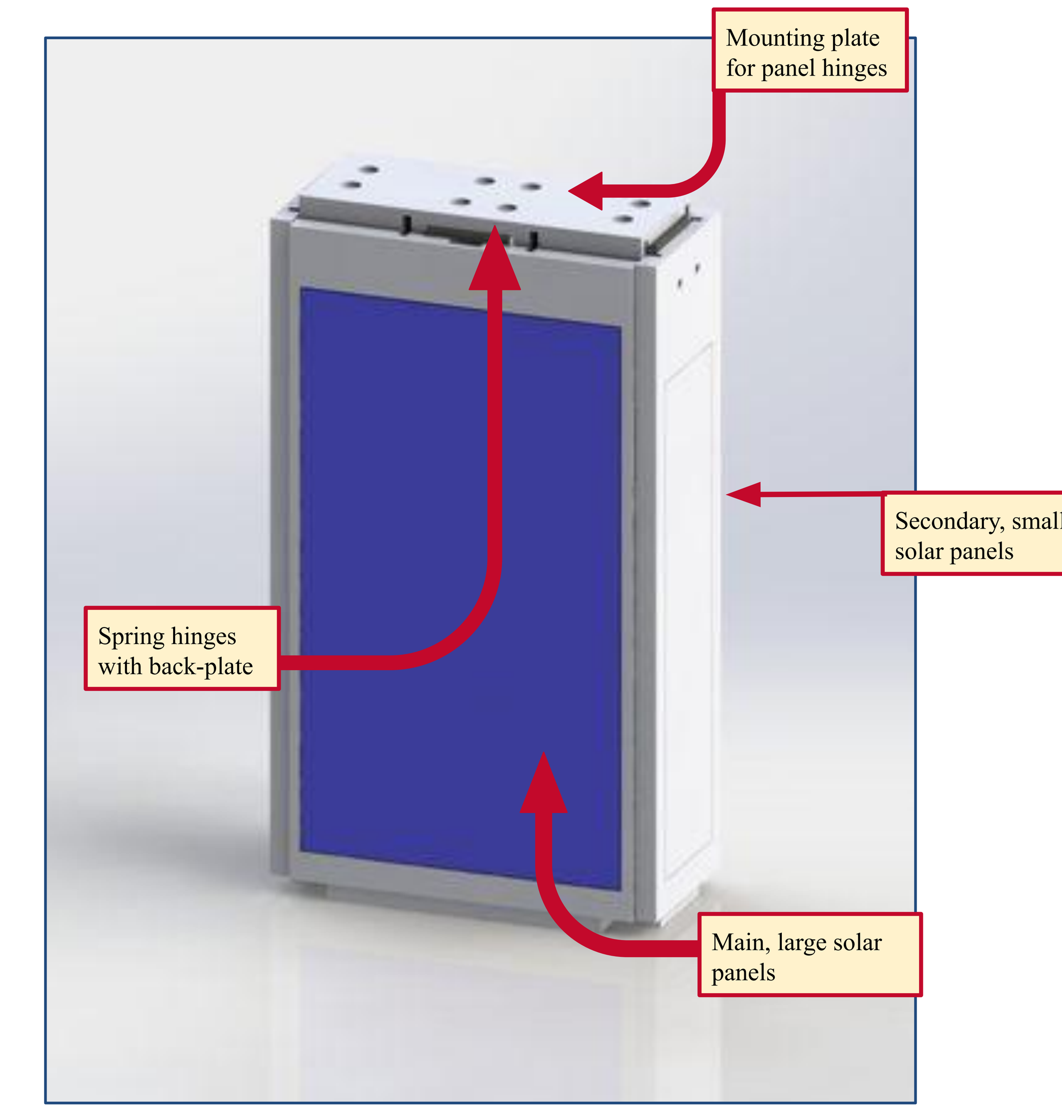


The deployed state of the final design makes use of two telescoping extensions to elevate the solar panels above the user's head, while the main housing carrying the electronics remains mounted on a backpack strap. In order to provide additional power, solar panels are folded out from under their primary counterparts, and can fold back in to be stored.



The electronics housing contains the battery pack, consisting of three 18650 lithium-ion rechargeable batteries, as well as holds the Maximum Power Point Tracker (MPPT) charge controller, which regulates the voltage and current across the batteries. Additionally, it controls the draw from the USB port to 5V at 1A.





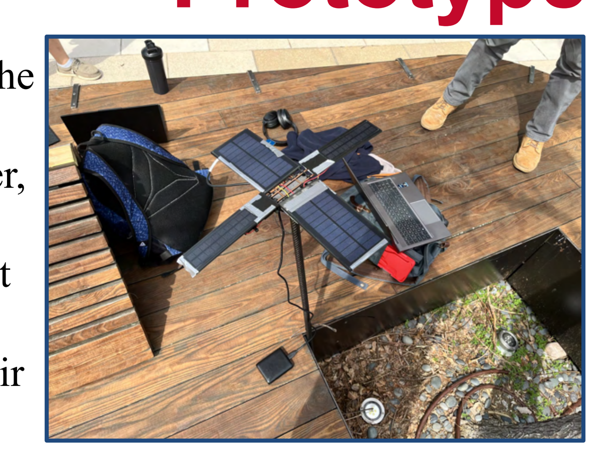
The device folds and collapses to a size of 20cm by 10cm by 5cm - about 8 in. by 4 in. by 2 in. - to be easily stored or carried. With the USB port at the bottom of the device, the user is still able to charge their personal devices while the device is in deployed or stored state.

Another key issue to address is that the power supplied by the solar panels is not consistent. Additionally, since the batteries supply 3.7V, and less depending on their state of charge, while the desired USB output is 5V, a battery management system must be constructed that completes key tasks:

- Regulate the voltage across the batteries in order to charge them consistently and safely
- Convert a variable battery charge to a steady output at 5 volts
- Allow for the reading of the voltage across the battery for use in testing and prototyping

Prototype & Test Results

Our first iteration prototype consisted of the necessary electronics - battery, MPPT controller, and current reader - simply mounted without their housings, plus the main solar panels in their deployed condition.



This test sought to verify the integrity of our electronics by reading the current in an acceptable range. During the test, we placed the device in both shadow and full sunlight. We found that the device with two large and two small solar panels reached a current of 600 mA in direct sunlight, but dropped to around 200 mA while in full shade.