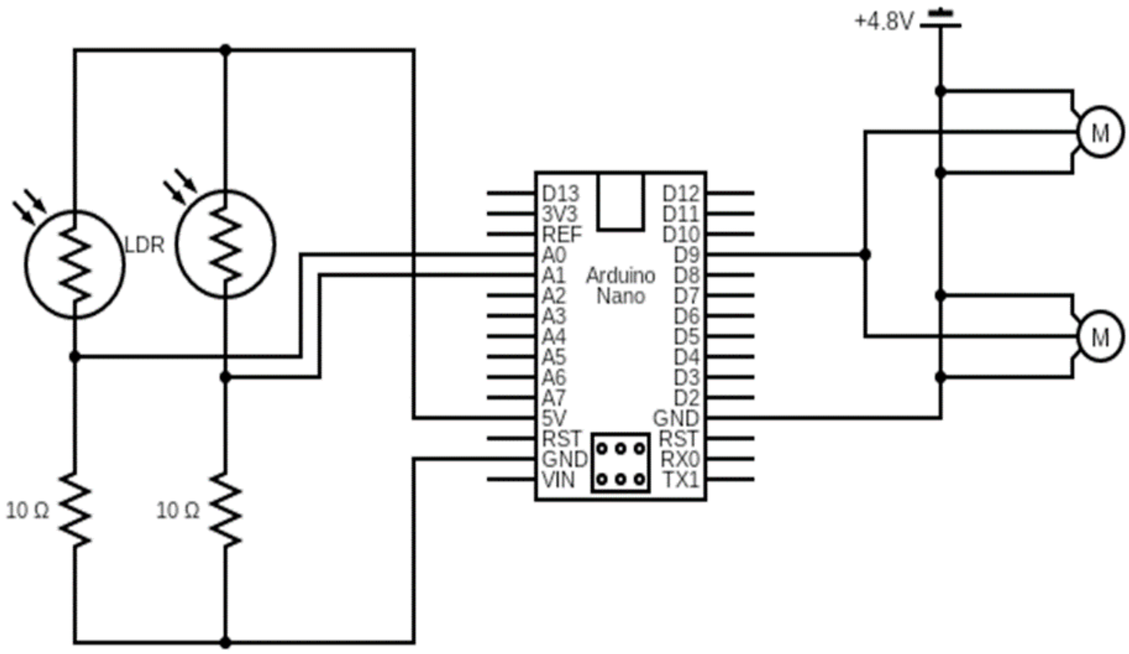
Sub-Systems:

The electrical system can be split into two different subsystems that are used to complete the objective of the project. The first sub-system is responsible for adjusting the solar panel to maximize its energy production. The second sub-system is responsible for taking the energy generated from the solar panel and storing it in a battery. Both systems work together to maximize and store energy.

Solar Panel Rotation Sub-System:

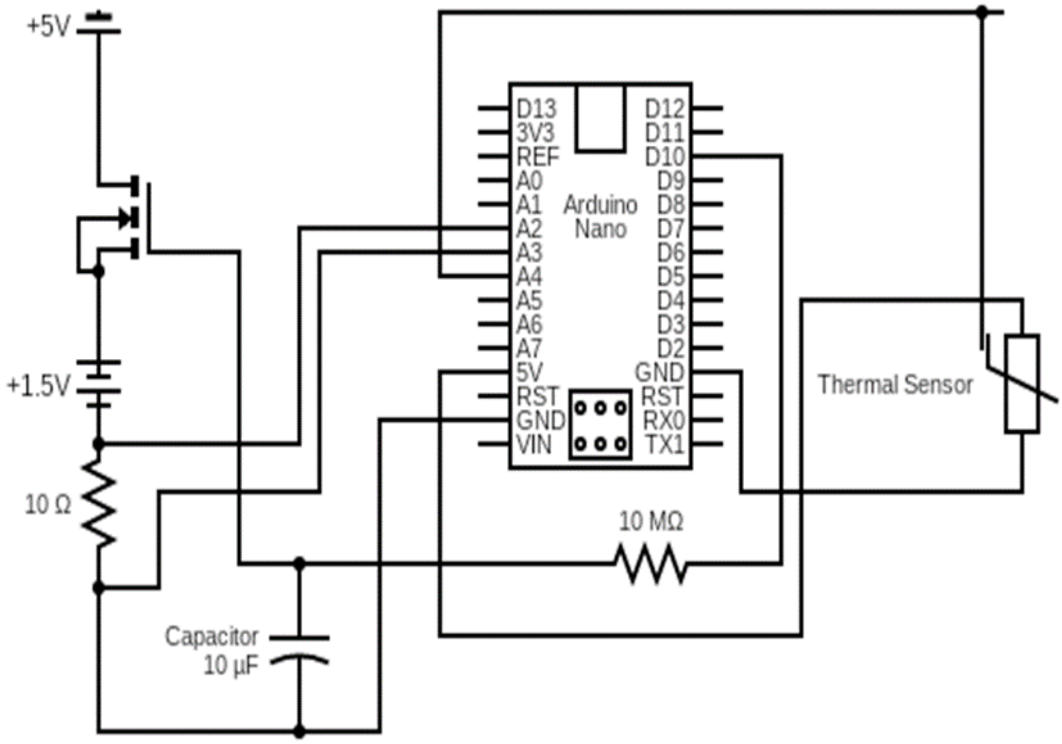


Name	**Amount**	**Description**	**Voltage Required (V)**	**Current Required (mA)**	**Voltage Provided (V)**	**Current Provided (mAh)**
Micro Servo	2	Mini servo motors used to rotate different parts.	4.8 – 5.0	500	0	0
Resister (10 kΩ)	2	Used to reduce the current flow from the LDR and reduce signal noise.	0	0	0	0

LDR	2	Sensors are used to measure the amount of sunlight on the sensor and quantify it into values.	3.3 – 5.0	Minimum of 15 but can be increased to change sensitivity.	0	0
AA Battery	4	Batteries used to power the servo motors.	0	0	1.2	2500
Arduino	1	Microcontroller of the entire system. Reads the values from the LDR and moves the servo motors accordingly.	3.7 from a Li-Po single cell or 5 from a regular battery.	1024	3.3 and 5.	400mA between the 3.3 and 5 volts pins.

The objective of this sub-system is to maximize the amount of energy that the solar panel can produce. The LDRs are placed on both sides of the solar panel platform and are connected to the analog pins of the Arduino. Both signals are measured and turned into numeral values from 0 – 1023. Arduino would compare the two values and move the servo motors to the direction of the LDR with the higher value. The servo motors would be controlled by the tenth digital pin.

Battery Charger Sub-System:



Name	Amount	Description	Voltage Required (V)	Current Required (mA)	Voltage Provided (V)	Current Provided (mAh)
Transistor (NChannel Mosfet)	1	Electronic devices are used to switch on and off a part of the circuit.	Uses 4-5 and can use the digital pin of the Arduino.	20 - 40	0	0
Resister (10 Ω)	1	Used to reduce the current of a circuit.	0	0	0	0
Resister (10 MΩ)	1	Used to reduce noise and current on a circuit.	0	0	0	0

Capacitor (1 μF)	1	Used to reduce the noise of the circuit and delay time.	0	0	0	0
Temperature Sensor	1	Used to measure the amount of heat from sources near it.	Uses 3.3 to 5.	0.5	0	0
NiMH AA Rechargeable Battery	1	Acts as the storage for the power generated from the solar panel.	3.3 to 5.	Maximum current is 2000.	0	0
Arduino	1	Microcontroller of the entire system. Reads the values from the LDR and moves the servo motors accordingly.	3.7 from a Li-Po single cell or 5 from a regular battery.	1024	3.3 and 5.	400mA between the 3.3 and 5 volts pins.

The goal of this sub-system is to monitor and charge the NiMH battery with the use of the solar panel. The sub-system monitors the current of the battery, by using a resistor and placing an analog pin on their entrance and exit. The thermal sensor would be placed next to the battery to measure its temperature. The Mosfet would act as a switch and would be controlled by a PWM output pin on the Arduino. The pulses from the pin would be smoothed out by the resistor and capacitor. The sub-system uses the values from the analog pins and thermal sensors to judge the progress of the battery. If the calculated voltage is high or the battery is hot, the Arduino would stop giving power to the Mosfet, which would disconnect the battery from the rest of the circuit.

Electronic Calculations:

For the design to meet the energy requirements, the system must be able to make more energy than it uses. The system uses two different sources of energy. One is the lithium battery that powers the Arduino, and the other is the 4 AA batteries that power the servo motors. Since the Arduino powers the other electronics, only the lithium and AA batteries need to be accounted for.

If we assume that the battery life of the lithium battery controls how long the system would last, without changing its batteries. The total voltage produced could be found by calculating how many batteries could be charged before the lithium battery runs out of power. The following equations were used to calculate the battery capacity and charging time,

Charging Time = Battery Capacity (mAh) / Charging Current (mA)

Battery Life = Battery Capacity (mAh) / Device Current Consumption (mA)

The charging time of the AA battery is equal to the battery capacity of the AA battery divided by the charging current of the solar panel. The battery life is equal to its battery capacity divided by the current consumption of the Arduino.

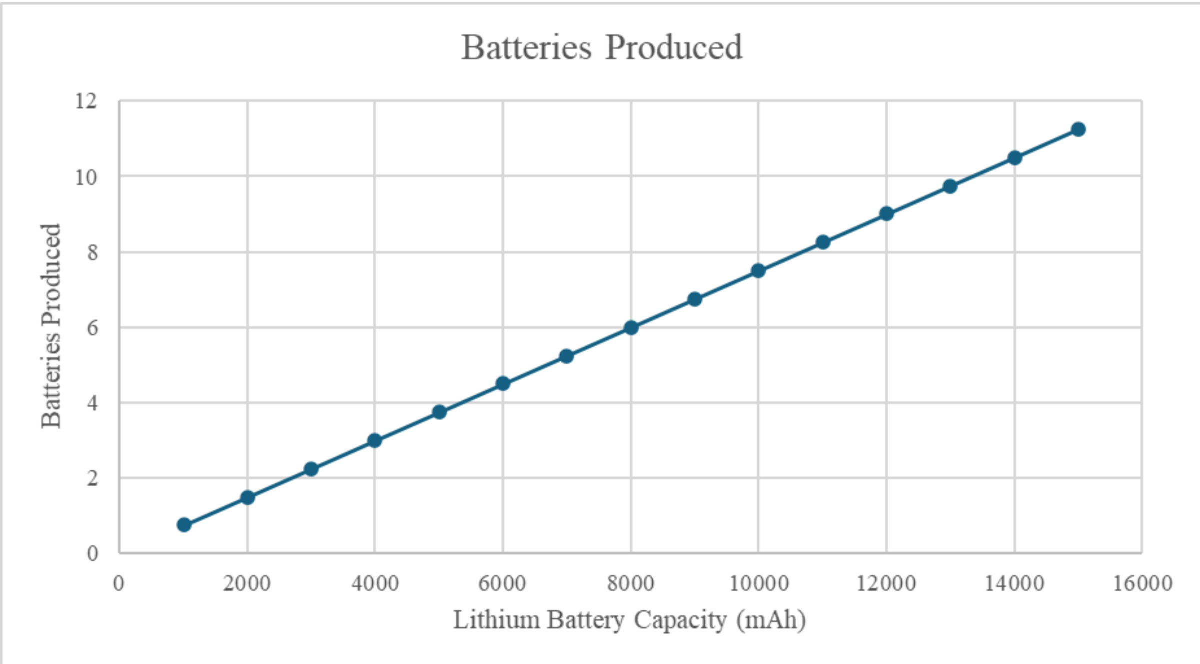


Figure 1. Number of batteries produced based on the lithium battery capacity.

Figure 1 shows the relationship between the capacity of the lithium battery and the number of batteries the system can fully charge. As the battery capacity increases, the number of batteries we could produce increases. This means we can produce more voltage than we are using, but the current per hour doesn't keep that relationship. The voltage of the systems remains the same even if the current capacity of the battery increases, which is why increasing the capacity would eventually allow the system to make more voltage than it uses. The current input would increase as the battery capacity increases.

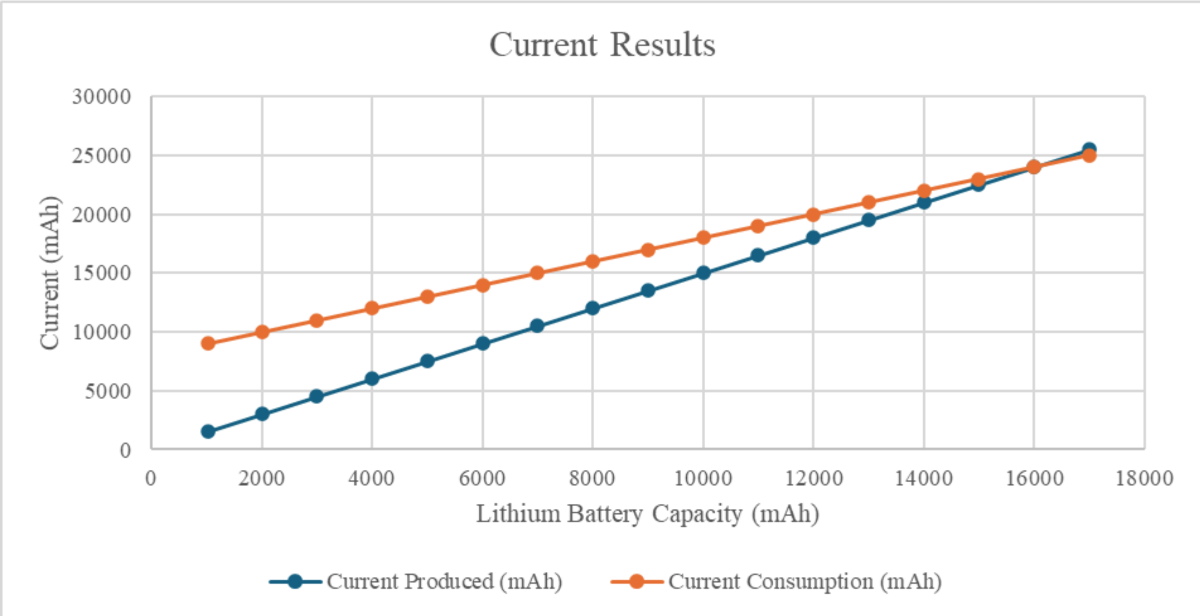


Figure 2. This figure shows the relationship between the battery capacity and the current consumption and production of the system. As the battery capacity increases, the currents increase. The current produced has a higher rate of increase compared to the current consumed.

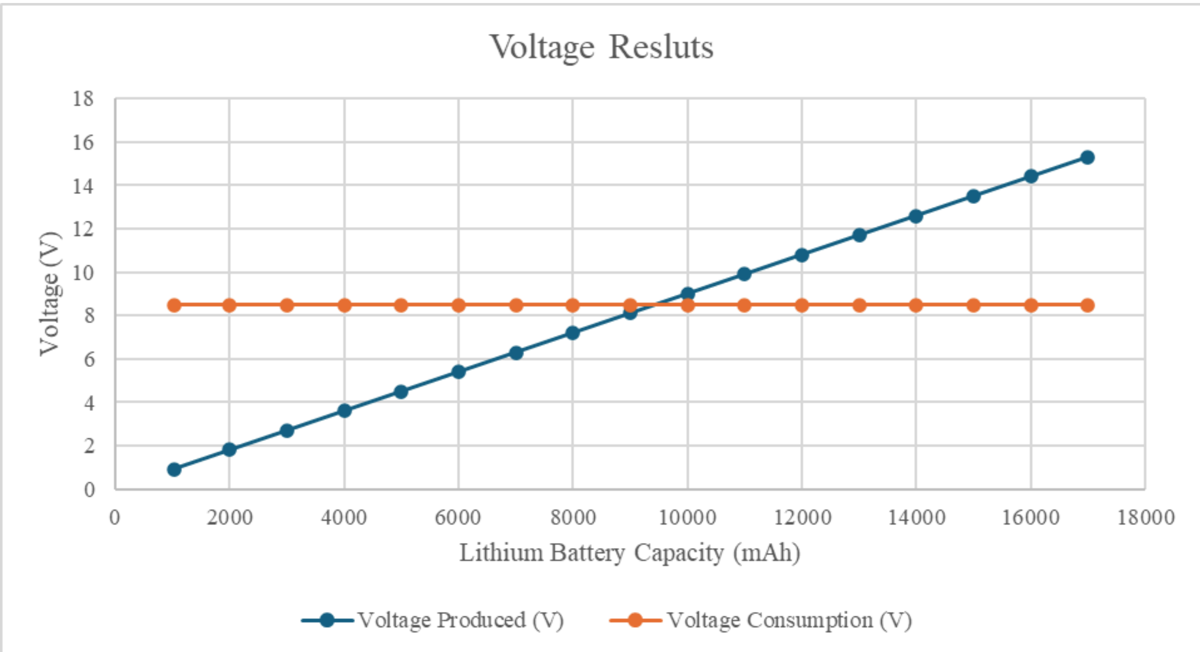


Figure 3. This figure shows the relationship between the battery capacity, and the voltage consumption and production. The voltage consumption remains constant, while the production increases as the battery capacity increases.

Based on figures 2 and 3, if the lithium battery capacity is greater than 16000 mAh, the system would have a positive net voltage and current. As the battery capacity increases, so does the price. To maintain the budget of the project, a 16000 mAh battery will be used since it would produce as much current and more voltage than the system uses.

Values	Input	Output
Voltage (V)	8.5	14.4
Current (mAh)	24000	24000

Shows the input and output of the system based on the 16000 mAh lithium Battery.