Group 37
EEL4914

Divide and Conquer 1.0
Two-cycle Power

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Senior Design I - Group 37

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Project description

Energy consumption is increasing every day. This is due to the constant upgrades in technology. As we become more advanced, the need for more power arises. Power companies are scrambling to find new methods to meet the power needs of customers. However, with the need for more power, comes the need for better ways of making electricity. In today's market, green energy has increased in both popularity and efficiency. At an individual's home, solar panels are becoming a more prominent option for green energy solutions. This allows each customer to generate their own power, and causes less reliability on conventional methods of power generation.

Another method of green energy is the use of hydro generation. Hydro plants have become the most efficient methods of making green energy. However, they can only be used for short periods of time. With this in mind, our goal is to combine the two forms of green energy generation together. Simply put, we would use solar energy to power a pump that would then push volumes of water across the hydro generators. This is the basic concept behind a two-cycle power system, which is when you use one source to power another source.

Solar power is changing the power industry. As the technology of the panels increases, the efficiency of the panels also increases. Panels are increasing in life and power output. Using one of the new types of panels, we will be able to produce enough power to constantly run a pump and charge a battery system. A battery system is key, because one of the major drawbacks to solar is the inconsistency of when power can be generated. Whenever there is a major storm or the sun sets for night, the power generated by the solar panel will either decrease or have nearly no output at all. Storing the excess power will allow us to maintain power needed for the pump.

Micro hydro generation is a newer form of green energy. This system is mainly used in places where running water, for example a downhill stream, is abundant. Micro hydro is also used in places where solar is less effective. These generators can range from 10 W to 600 W. Naturally, the amount of water that can be accessed will dictate the output of the system. Because of the reliance on a decent flow of water, hydro generation is only a viable option in certain locations and applications. For this project we will be designing a hydro system to have a set output. Power to provide the water flow will be given by the solar system. By powering our own water flow, the system will be able for use in a large area. Combining solar and hydro power together, we will create the two-cycle system that we set out to achieve.

With the use of the two power sources, we will need a method of controlling the two. First controller will be for the battery charging system. Using a microcontroller, we will read the battery life and begin charging at a set threshold. Because batteries lose their max charge, when they are constantly charging, the system will need to adjust the power flow depending on the percentage of the battery. If the battery is at full charge, then the system will send constant power to the water pump. If the battery needs to be charged, the system will send small amounts of solar energy to keep it at the threshold. Successfully keeping the battery at the appropriate level, will ensure the customer that the pump will be able to push water across the hydro generator for the length of the night.

Another controller will be needed for the load of the system. Lets say, the system begins to produce more energy than is needed. When this happens, we need to know what to do with the excess energy. The best idea would be to send the excess power to the existing power grid. In order to perform this task, we will need another microcontroller to read both the power coming into the house and the load demand of the house. If the incoming power is greater than the power needed, we will use a relay to connect the system and begin feeding power to the power company system. Being able to produce power for the whole system will make an individual home a generating source for the power company. Another benefit to connecting to the grid is if the need for power to run the pump is needed. Our system could use this power and still maintain a greater output.

In this project we will be simulating load demands of an average home. This will be an important factor in the design because we are having a microcontroller read the load and turn on the secondary power source to help when needed. Types of devices normally run throughout the day will include things like water heaters, A/C units, lights, and other devices which will determine the total amount of load the system will need to power. Also, we will need to manually adjust the load to match a normal day. Following an average trend, we will be increasing the load for different times of the day and decreasing it during others. This will show that the system is working as intended.

Currently in today's market, customers are choosing to use either solar or micro hydro power. Solar is the more popular type. Because micro hydro is limited to only certain areas of the world. New Zealand is an example, where solar is not able to be used, but micro hydro takes it place. With this system, we will be able to use both forms in conjunction with each other to produce enough energy. This essentially allows every home with this system implemented to become a small generation plant. By creating this type of system, the need for large industrial plants will be lessened. This will also reduce the need for fossil fuels and decrease the amount of pollution placed in the atmosphere. With the demand for more green energy, we feel this system will provide another method for power companies to generate more energy at a lower cost. This makes this system beneficial for both consumers and producers alike.

Requirements Specifications

Requirements For Hardware

1.0	The system shall have the ability to generate 10 watts of power from solar panels.
1.1	The system shall have the ability to pump at least 240 gallons per hour from the micro hydro-generator.
1.2	The system shall have the ability to charge a 7 amp-hour battery.
1.3	The system shall have an LCD display, which shows power generated and consumed.
1.4	The system shall have the ability to control when the solar panel and the hydro-generator are operated.
1.5	The system shall be able to be remotely operated at a range of 25 meters.
1.6	The system shall conform to applicable safety standards.
1.7	The system shall have the ability to switch between generating power from solar panels and the hydro-generator within 5 minutes.
1.8	The system shall have the ability to engage both power generation sources simultaneously at a predetermined load power threshold (6 Watts).
1.9	The system shall be able to be implemented into pre-existing households within 2 hours.
1.10	The sensor's measuring power shall remain accurate within 0.2 Watts.

Table 1. Engineering hardware requirements

Requirements For Software

2.0	The program shall be able to read and manage data from the system sensors continuously.
2.1	The program shall be able to manage data from the power generating sources within 0.2 watts.
2.2	The program shall be able to display data on an LCD screen at 30 frames per second.
2.3	The program shall be able to send updated data to another device wirelessly every 1 minute.
2.4	The program shall be able to adjust where the power is outputting based on energy demands within 1 minute.
2.5	The program shall be able to shut down parts of the system manually upon reaching unsafe levels and thresholds within 1 minute.

Table 2. Engineering software requirements

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Project diagrams and figures

Diagram for the power flow in the system

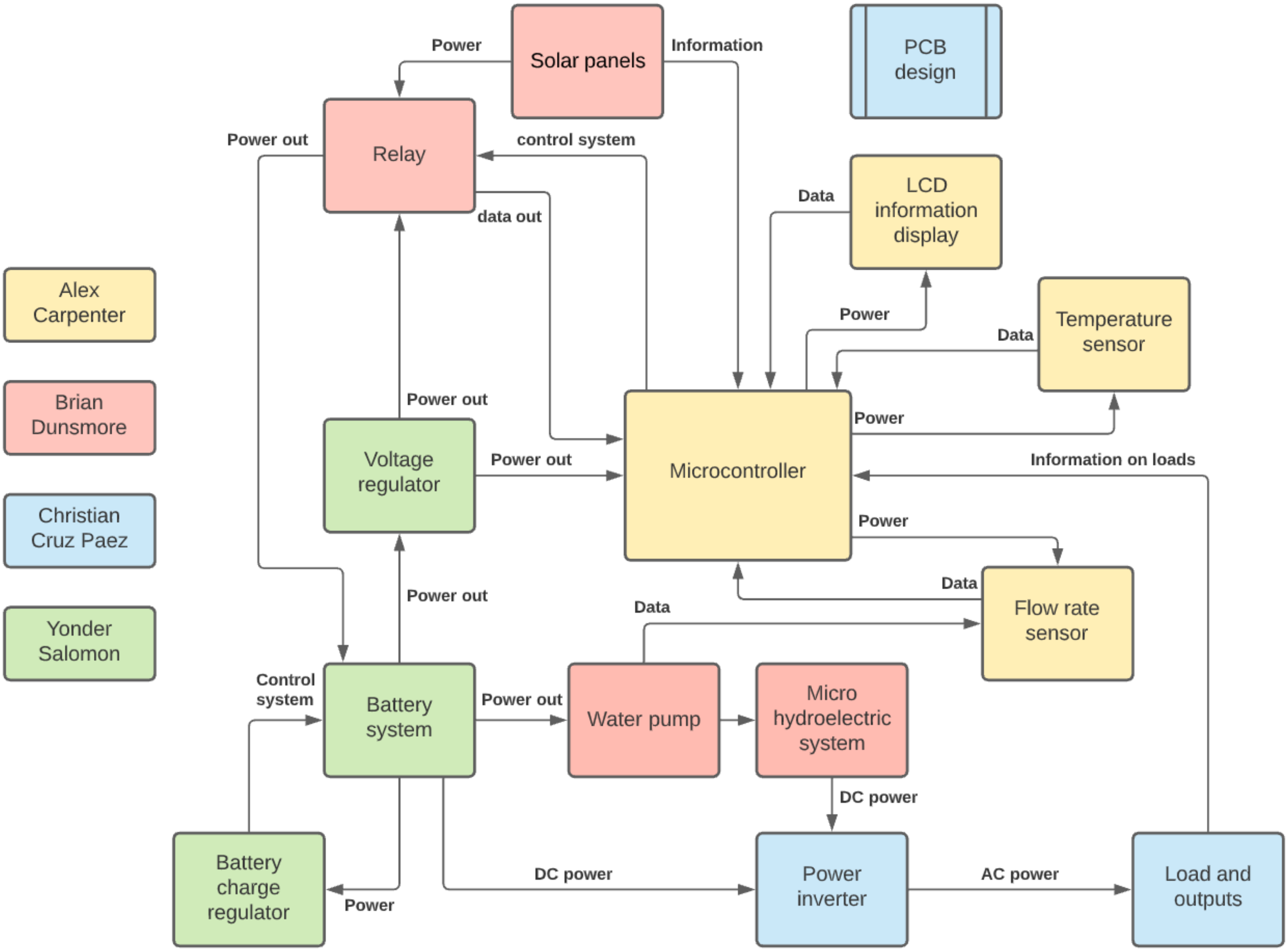


Figure 1. System power flow diagram

Flowchart of software components and data

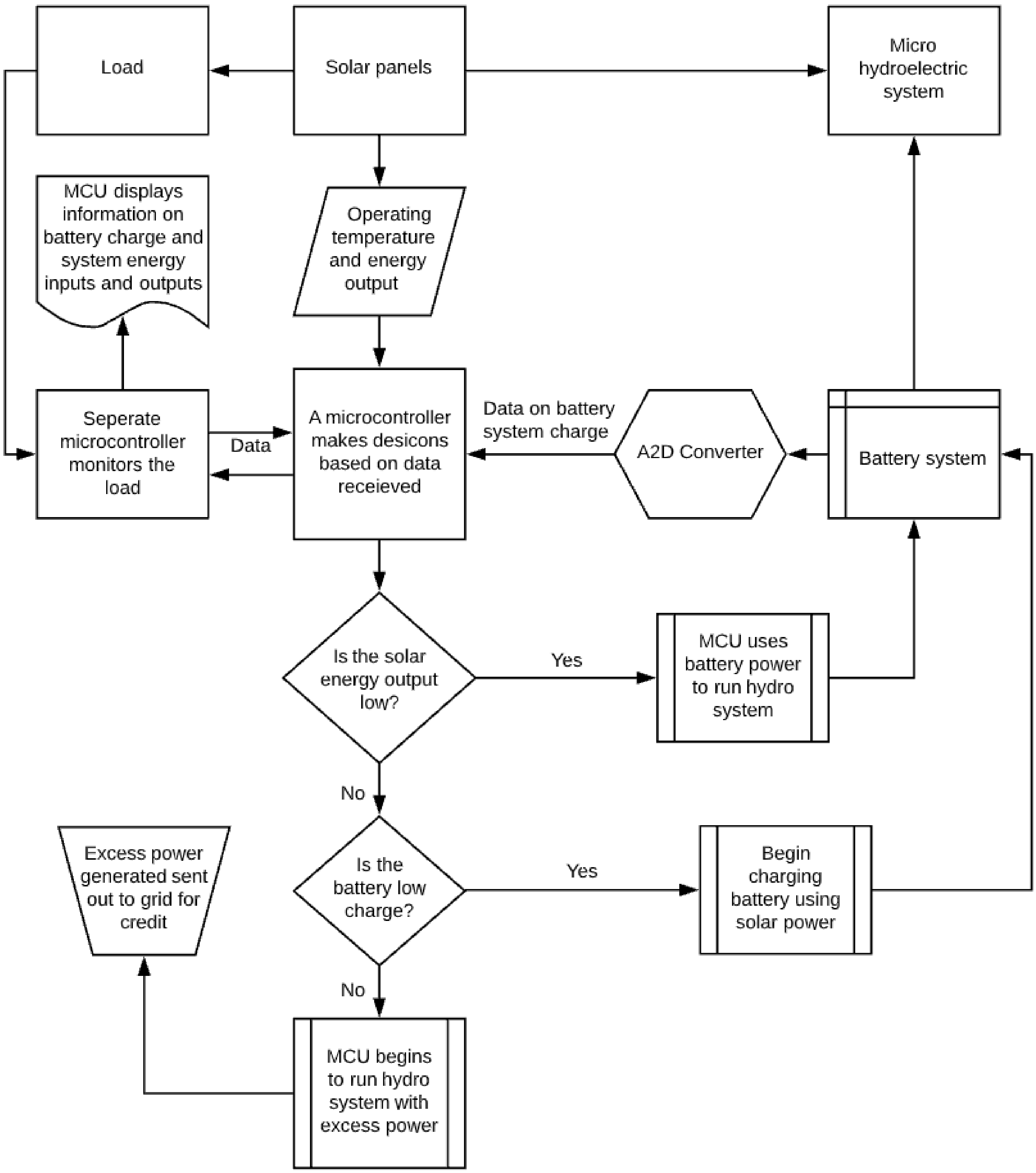


Figure 2. Software component flowchart

Behavioral Graph of the System under Normal Conditions

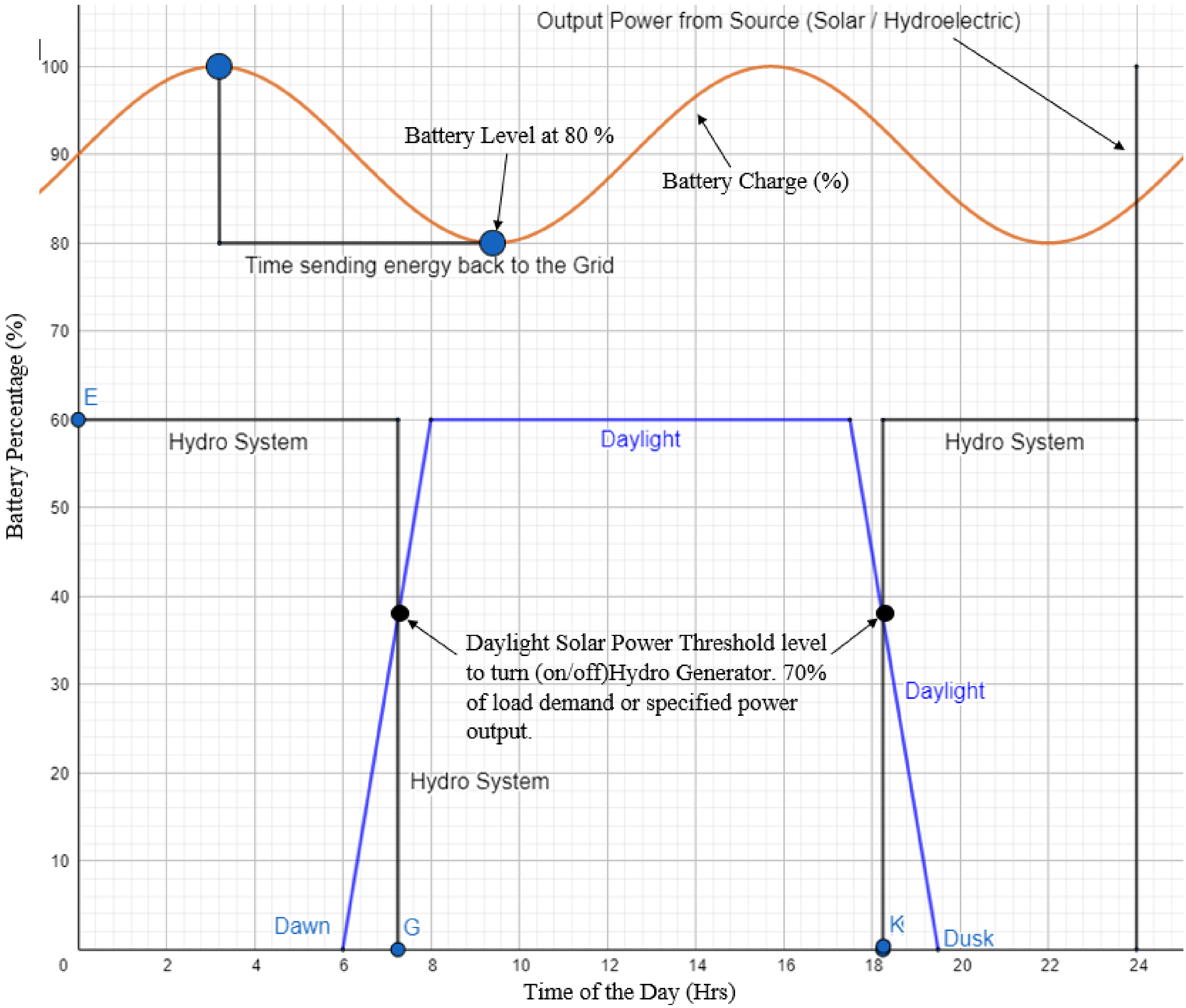


Figure 3. System output under normalized conditions

Behavioral Graph of the System under Normal Conditions Cont.

The above Figure shows the intended behavior of our 2-cycle power system. It is the intent to set up a certain threshold on the battery charging patterns to only charge the battery when it is below a certain point in charge levels. This threshold will be determined based on the type of battery used in order to preserve the battery usable life and contingent on live data regarding the load demands present.

The power input for our system varies upon the time of the day and available resources. As shown on the graph, past a certain time during early morning late afternoon the system shall automatically switch from one primary source to the other in order to cover the load demand and satisfy the battery needs.

While this graph only covers the ideal conditions of operations, i.e.: no unexpected outage from any of the two systems, it is plausible that there will be the need to run the hydro system during a period of expected solar power input. The main processor will take certain variables into consideration in order to determine the needs of the system at that given point. The best metric in place to determine how many sources and to what extent it is to be used is the battery charge level in addition to any manual overrides.

Possible Project Constraints

Considering this project is still early in the development process, constraints have been limited so far. However, an early onset problem arose when considering how to make the water pump system produce more power than it consumes. Possible solutions include the utilization of natural flowing water sources to help in the production of energy, however that would limit the locations in which the system could be implemented. Another constraint arises when considering the efficiency of power transfer between the power generation sources, the system monitoring and distributing the power, and the load sources the power is being distributed to. It is easy due to wiring errors, part incompatibility, ect. for a power system to experience loss, and would require investment on the development of this part of the system to mitigate loss as much as possible.

Budget and Funding

Our budget will be self-funded, and when assessing estimates of component costs for the project, it appears very affordable. Equipment malfunction and breakage should be accounted for due to the nature of this project involving power generation, so all PCB, sensor, and software development parts have an increased quantity requirement. Based on these requirements, the cost estimate for this project can be evaluated using the estimated component costs located below.

ITEM	QUANTITY	PRICE ESTIMATE
Raspberry Pi Pico (RP2040)	3	<=$14
5v-12v small submersible water pump	1	$12
12v-24v DC submersible water pump	1	$50
Custom PCB	3	$30-$100
Universal DC Water Turbine Generator	2	<=$30
20 Watt 12v Solar Panel Kit	1	$42
LCD Display	1	$5-$40
Battery Bank	1	$30-$50
Voltage/Current/Power Sensor	2	$27-$35
Wires/Development Tools	1	$0
LED lights	100	$6
100W Voltage Regulator	1	$15-$35
Relay	1	$9
Waterproof Flow Rate Sensor	1	$10-$19
Temperature Sensor	1	$10-$19
Battery Charge Regulator	1	$20
TOTAL (Estimated Range)	**N/A**	~$280-$481

Table 3. Total funding estimate

Project Milestones

Number	Milestone	Planned Completion Week (SD1 and SD2)
1	Test/solve second power source constraint	8
2	Have both power sources producing required power	9
3	Interface RP2040 with Power Sensors	10
4	Interface power sensors/RP2040 with power sources	11
5	Interface system with load components (provide power to end customer)	12
6	Develop Code that controls operation of power sources	13
7	Design PCB 1.0 and Order	14-16
8	Implement and test PCB 1.0	17
9	Design PCB 2.0 and Order	17-19
10	Implement system with designed PCB	18-19
11	Design and Build Final Model	19-22
12	Final testing and revisions	19-END

Table 4. Major project milestones

House of quality (HoQ)

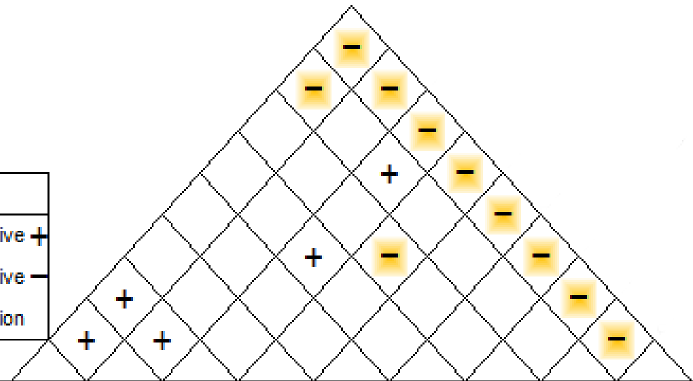
Below we can see figure 4 for the house of quality. This chart shows the relationship between the major categories pertaining to the engineering specifications and the market specifications. In our two-cycle power system, the relationships and impacts of each requirement can be seen in reference to each other through the legend presented in the top left corner.

Due to the nature of our senior design project, there are no viable two-cycle power systems that consist of solar and micro-hydroelectricity, which means we do not have a frame of reference for what competitors' priorities and level of quality is for comparison. Though there are other larger scale systems that exist in other countries, these applications and implementations are not comparable to our implementation due to the scale of both systems being very different.

Diagram for the House of Quality

Relationships	
Strong	●
Moderate	○
Weak	▽

Direction of Improvement		Correlations	
Maximize	▲	Positive	+
Target	◇	Negative	−
Minimize	▼	No Correlation	



Column #	1	2	3	4	5	6	7	8	9
Direction of Improvement	▲	◇	▲	▼	◇	◇	▼	▲	▼
Customer Requirements (Explicit and Implicit) / Engineering Requirements	Output Power	Pump output	Efficiency	Total size	Processor speed	Sensor data accuracy	Installation time	Voltage regulation	Cost
Ease of installation				●			●		▽
Lifespan of system	▽		●		▽	●		●	○
Battery life		●	●					▽	●
Cost	●	▽	●	○		▽	▽	○	●
LCD Display interface					○				▽
Reliability	●		▽		▽			○	○
Safety	▽		▽		○	●		●	▽
Target	25W	240GpH	50%	< 2500 cubic inches	125 mHz	Accurate within 0.2 W	2 Hours	-1 V to +1 V	< $600

Table 5. House of quality