Project Plan & Product Specification

Team 7

Personal Hydroelectric Generator

Members:

Joseph Bonfardino	jjb12f@my.fsu.edu
Galen Bowles	gtb12b@my.fsu.edu
Brendan McCarthy	bbm10@my.fsu.edu
Parth Patel	prp12@my.fsu.edu
Shane Radosevich	srr11c@my.fsu.edu
Ilan Sadon	ilanesadon@gmail.com
Brandon Shaw	bs10m@my.fsu.edu
Mathew Vila	mjv11c@my.fsu.edu

Faculty Advisor

Seungyong Hahn, Ph.D.

Sponsor

Michael D. Devine, Ph.D.

Instructors

Nikhil Gupta, Ph.D. & Chiang Shih, Ph.D.

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1 Introduction

There is currently a need for personal hydroelectric generators in the current market. These generators convert organic kinetic energy from the flow of rivers to produce a top necessity, electricity. This entrepreneurial project was proposed by Shane Radosevich who is the current Team Leader of this senior design group. The faculty approved the idea and the entrepreneurial faculty advisor became the sponsor for the development of this idea. The current small-scale hydroelectric generators do not produce enough power necessary for a comfortable camping trip or use in third-world countries. Therefore, the goal is to fill this void and design and build a personal hydroelectric generator that is affordable and produces a sufficient amount of power.

2 Project Definition

2.1 Need Statement

This project is an entrepreneurial-based mission sponsored by FAMU-FSU College of Engineering, specifically through Dr. Michael D. Devine. Currently, there is no effective, simple, and quiet way to get power to remote locations. These remote locations include campsites, mountainsides, and third world countries. In order to supply energy to items such as lights, heaters, or USB chargers, a gas generator is traditionally used. These types of generators are too loud and too heavy to be effectively used in remote locations.

"People in remote locations do not have access to electricity for powering their electrical devices."

2.2 Goal Statement & Objectives

Goal Statement:

"Develop a portable device that transforms organic kinetic energy into usable electricity."

Objectives:

- Produce 1kW of power from accessible water source under defined constraints.
- Minimize the weight of the device to ensure portability.
- Produce a device that is safe to operate and leaves negligible negative ecological consequences.
- Produce a device that is conveniently setup and disassembled.

2.3 Constraints

- Device weight must not exceed 100lbs
- Compact (less than 3 ft^3)
- Single directional flow
- Water proof / (resistant to corrosion)
- Durable
- Operate in the confines of the provided budget
- Meet with all effected safety standards applicable
- Operates below 50 dBa (moderate level of sound)

2.4 Budget

The dean of the FAMU-FSU College of Engineering has provided a grant through the college funds totaling $1,500. More funds may be provided to the team if necessary and can be validated. Staying within the budget is important to our design as an entrepreneurial project because if accomplished, the design will have better market potential. As of right now, no parts or other resources will be given from anyone other than the college. Ring Power Corporation has agreed to provide financial help in the way of discounting all parts purchased through them in hopes to help meet the goal. The team feels that the original budget of $1,500 will be sufficient

2.5 Quality Function Deployment

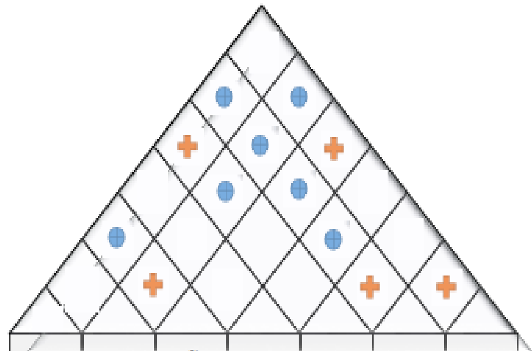
HOQ Legend

\# - 1-5 scale (5 best)

\# - 1-10 scale (10 direct correlation)

- Strong correlation

- Weak correlation



Customer requirements	Importance to Customer	Rate of Power Generation	Cost	Weight of Device	Stream Lined Profile	Power Output Efficiency	Mechanical Complexity	User Friendly	Selling Points	HydroBee	Bourne Energy	Target Values
Functionality	5	10	5	2	9	10	5	4	225	5	5	5
Easy to Operate	3						6	10	64	4	3	4
Light Weight	4	7	7	10	4		3	8	117	5	2	3
Compact	4	6	2	8	6	2	6	8	114	5	2	3
Price	2	4	10	5		6	8	3	144	4	2	4
Durability	3		7	3	1	5	6	2	120	2	4	5
Aesthetically pleasing	1		4		8				48	4	2	4
Maintenance	3		3	5	2		5	8	92	2	4	4
Importance Weighting		110	115	116	102	85	128	150				

Competitor Comparison

	Rate of Power Generation	Cost	Weight of Device	Stream Lined Profile	Power Output Efficiency	Mechanical Complexity	User Friendly
Direction of Improvement	+	-	-	+	+	-	+
HydroBee	40 W	$200	1 lb	Moderate	70%	Moderate	Very
Bourne Energy	500 W	$3,000	30 lbs	Not	70%	Very	Difficult
Target Values	500 W	$2,000	25lbs	Moderate	70%	Moderate	Moderate

Figure 1: House of Quality

The quality function deployment (QFD) is a method that transforms qualitative user requirements into quantitative design parameters. This process was executed by first determining the customer requirements (CR). The CR's were developed from benchmarking the team's conceptual design against known competitors, doing back ground research on the developing field of technology micro power generation, and meeting with the group's financial and academic advisors. From this point the group determined critical aspects of design otherwise known as engineering characteristics (EC). Next the EC's were related to the CR's through a relationship matrix known as the house of quality (HOQ) as seen in Table 1. After defining the relationships between the CR's and EC's it was determined that the most critical aspects of design will be functionality, price, and durability.

2.6 Schedule

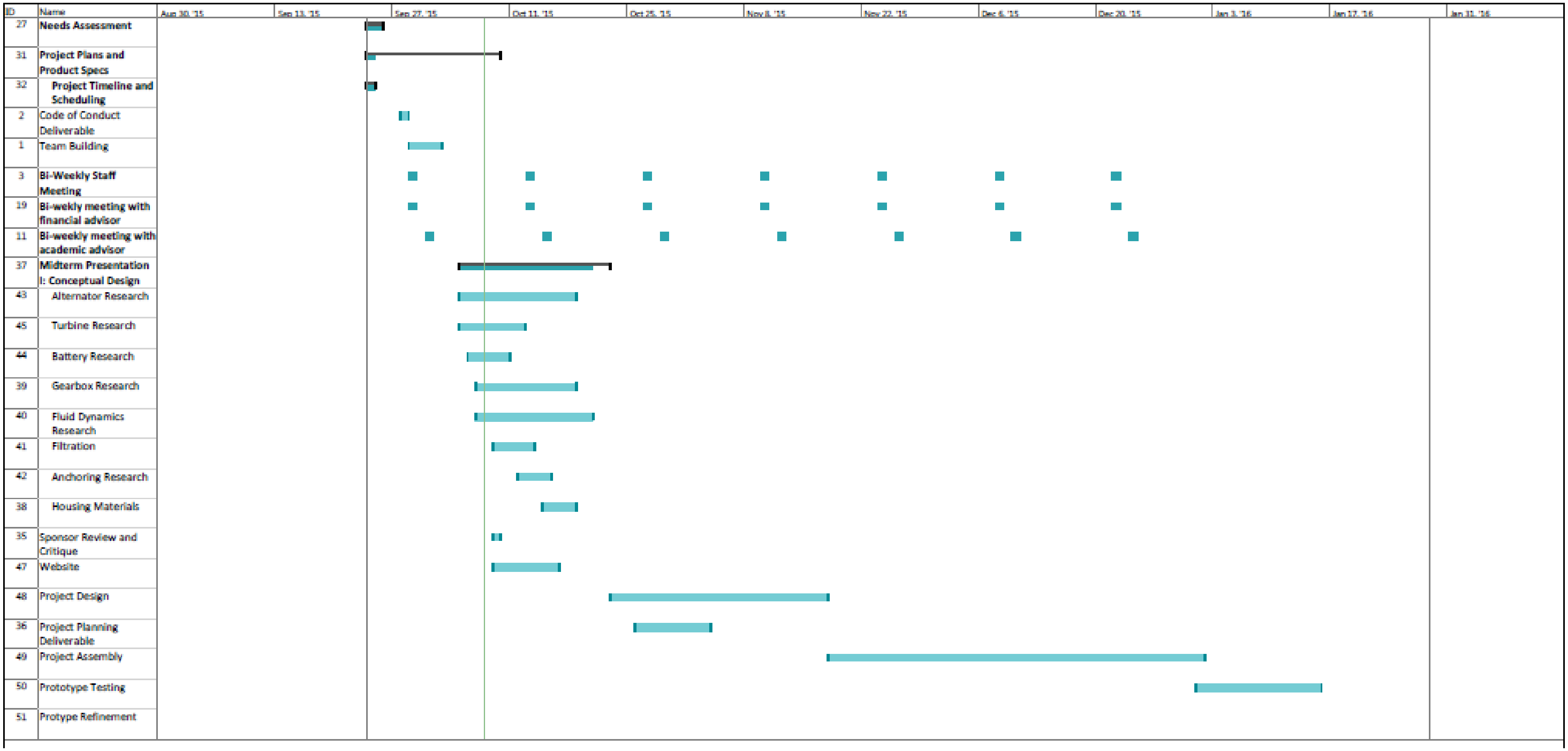


Figure 2: Gantt chart for Team 7’s proposed schedule

3 Production Specifications

3.1 Mechanical Characteristics

Turbine Designs

The water turbine is said to be the heart of a hydroelectric generator. As water flows through the turbine housing it strikes the blades of the turbine creating torque and making the turbine shaft rotate. The team has decided to implement the use of one of two turbine designs: Francis turbine or Turgo turbine. A Francis turbine is a radial flow type turbine and is shown in Figure 3. Turgo turbines are axial flow type turbines and is shown in Figure 4. Both of these turbines are suitable candidates for this project, and the selection of one over the other will most likely depend on the ability to manufacture or purchase them.[2]

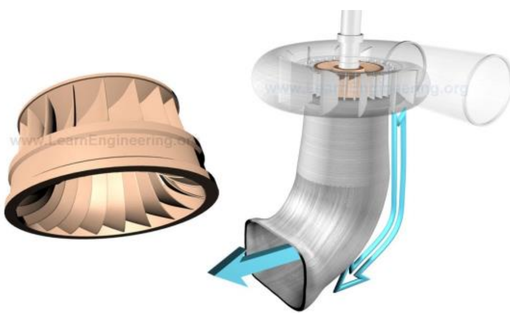


Figure 3. Francis Turbine

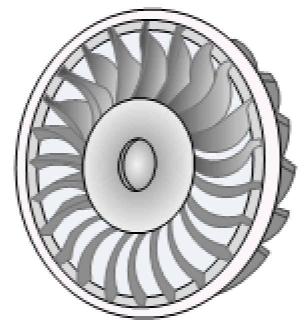


Figure 4. Turgo Turbine

Housing and Mounting Techniques

Different mounting techniques will be tested to show the most efficient form of anchoring for the generator and propeller. This anchoring is to stabilize the whole system from unwanted movement in the stream. An important characteristic that has been decided is to actually anchor the mechanism to the shore of the river so that it will be more secure. A possible way of accomplishing this is by using long, sharp spikes as feet of the securing station. These spikes can be driven into the ground by use of a hammer to prevent any movement. The actual mechanism that will be submerged in the river will be attached to the shore by extending poles that can adjust how far out it should be. The mechanism in the water should also be fully enclosed in a waterproof casing, besides where the water meets the fin so that the electrical components do not fail and the mechanical components are less likely to corrode. Proper flotation devices will be secured to the floating apparatus so that it will be submerged but not dragging on the bottom of the river. A strong, transparent plastic that will withstand the beating of the current and allow the user to inspect the mechanism will be important. A metal frame will be used for the frame of the anchoring system so that the spikes can be driven down into the ground without damage.

Gearbox Design

The gearbox design will take a torsional shaft torque and turn it into a high rpm rotation. With analysis of the toque, a metal gear box system will be selected to avoid wear and catastrophic failure. The desired rotational speed in the alternator within the generator will be around 1000 rpm to achieve sufficient power generation. Once the turbine blade design is complete, torque input into the gear box can be calculated with the turbine radius and acting forces caused by the fluid flow of the stream. The gear type will maintain a linear input and output shaft rotation with the use of spur or helical gears.

3.2 Power Generation

Alternator Selection

Power generation can be produced through a generator or alternator. The decision to use an alternator has been determined. Alternators have the great advantage over direct-current generators, which makes them simpler, lighter, and more rugged than a DC generator. The stronger construction of alternators allows them to turn at higher speed, allowing an automotive alternator to turn at twice engine speed, improving output when the engine is idling. The availability of low-cost solid-state diodes from about 1960 allowed auto manufacturers to substitute alternators for DC generators. The use of Brushless alternators will eliminate the hurdle of having a high RPM to generate the power needed for the project. Brushless alternators outputs a lower amperage but a higher voltage at lower rpm's.[3]

Battery Selection

An Energy storage unit for the hydroelectric generator will be assessed with certain specifications. These include size, weight, capacitance, power output, and output voltage. There are a different types of batteries that can be used to store the energy produced by our generator. Lithium Iron Phosphate battery have a lower energy density compared to Lithium Cobalt oxide's but offers longer lifetimes, have a better power density and are safer. Lithium Cobalt provides a higher capacitance but are thermally unstable. Therefore using a $LiFePO_4$ (Lithium Iron Phosphate) battery will be beneficial. Other advantages include a constant voltage discharge, the cell can deliver full power until discharge. This also eliminates a voltage regulator within the system.

3.3 Flow Characteristics

Filtration Technique

When dealing with flowing streams or rivers, it is highly likely that debris of various sizes or wildlife will be encountered. To address this, a screen needs to be installed in front of the turbine. This screen will need to be fine enough to keep out damaging debris or fish, but open enough so that it does not restrict the water flow into the turbine. It should be resilient enough to withstand impacts from large objects moving at relatively high speeds. It should also be corrosion resistant so that it does not need to be replaced frequently, even if it is used in saltwater conditions. The ideal material for this application would be an aluminum wire mesh with a PVC coating.

Flow Control

The system will incorporate a converging cone leading into the turbine housing. This will produce a faster flowrate of water hitting the turbine blades in a more streamline and consistent manner. The exhaust flow will be diverted with a diverging cone where the flow can exit if the generator is behind the turbine.

4 Conclusion

The assigned Senior Design Project relies on a river stream's kinetic energy, specifically the power of moving water in order to generate useable electrical energy. The finished product is ideally portable and will be used under such applications as lights and heaters in a relatively remote location where a power grid is unavailable or unreliable. Our research into hydroelectric generators and dams have shown an efficiency of about 80%; our competitors such as HydroBee and Bourne Energy provide 10W and 600W of energy respectively.[4,5] Generators produce electricity through the use of Faraday's principle of electromagnetic induction. This allows the generated mechanical power to be transformed into a higher quality and more useful electrical power. The design of our device should include a propeller, generator, gear train, anchor mount, and battery as the main components. A new innovative set of prototype propeller designs will be designed and tested in order to determine which is most efficient and practical. A gear train ratio will be designed to increase the torque or axel rotation speed from the turbine in order to suit the generator specifications. Shape and load calculations must be done in order to determine the mounting/anchoring necessary for the generator. An established HOQ shows the importance of functionality, durability, and price as the most important characteristics of our project.

5 References

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