Needs Assessment

Team 7

<u>Personal Hydroelectric Generator</u>

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Abstract

This Senior Design Project focuses on the conversion of a river stream's kinetic energy to useable electrical energy that's portable for applications such as lights and heaters in a location where a power grid is unavailable. Research into hydroelectric generators have shown higher than 80% efficiency and other companies like HydroBee and Bourne Energy have proven to provide 10W and 600W of energy respectively. Generators use Faraday's principle of electromagnetic induction which allows mechanical power to transform into a higher quality electrical power. The design of the machine will include a propeller, generator, gear train, anchor mount, and battery to complete the problem. A set of prototype propeller designs will be created to find the most efficient shape and a gear train ratio will be designed to generate the torque or axel rotation speed needed for the generator specifications. Shape and load calculations will determine the mounting/anchoring of the generator. A HOQ developed shows the importance of functionality, durability, and price as the most important characteristics of this project.

1 Introduction

In this modern day there is a high demand for electricity even in the most remote areas. Whether the need is for outdoor enthusiasts going camping or a secluded community in a third-world country, people want lights and heat. To supply this demand, the production of electricity in these types of regions is necessary. Several methods for generating electricity have been around for over a century, most of which depend on the use of an electromagnetic generator. Electromagnetic generators work under the principle of electromagnetic induction developed by Michael Faraday in the early 1800's. His principle declares that as a conductor is moved through an electric field a current in produced in the conductor.[1]

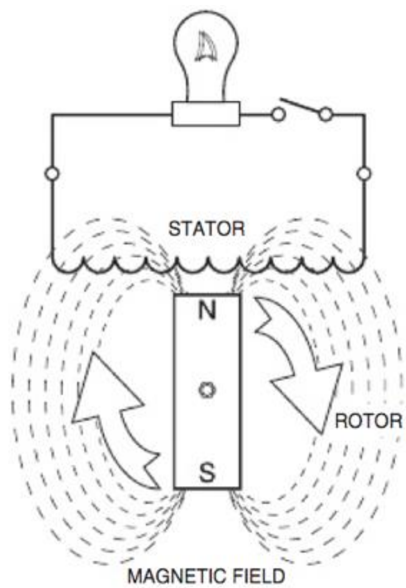


Figure 1: Simple AC generator schematic

Simple modern day generators have two major components: a stator and a rotor. As shown in Figure 1 the stator is composed of a stationary conducting material, usually copper coiling. The rotor has one or multiple north-south permanent magnetics. A mechanical force is provided to rotate these magnetics, thus producing an electromotive force (EMF) in the stator. This voltage drives a current through the conducting material that can be can directly used or stored in battery.[2]

In order to drive the rotor, some form of mechanical input is necessary. This input can supplied in several ways, by a motor, flowing wind or water, a hand crank, et cetera. When faced with trying to supply this mechanical input in an isolated environment it is beneficial to select a form that is renewable. For this project, a device shall be developed which transforms the kinetic energy of a flowing water stream into usable electricity. This is referred to as hydroelectric generation. Hydropower (controlling water to perform work) has been around for thousands of years, and in the late 1800's it was first used to generate electricity to power lights.[3] Nowadays hydroelectric generation is quite common, but most to all are in fixed locations at water dams. This project will is orientated to design and build a generator which is light weight and portable and works efficiently in moderately flowing streams and rivers; thus meeting the needs of a personal consumer.

2 Project Definition

2.1 Background research

The idea being proposed is not entirely original to the team. The gathered research suggests that there are a number of other companies and institutions which have built similar devices. One such product currently working and available on the market is the StreamBee available by the HydroBee company. The device can be put in a stream and with the flow of the water, creates electrical power. Their idea is similar, however their device works on a smaller scale than the market we intend to influence. The power output of this device is a mere 10W. In order to power essential electrical equipment, as our device intends to do, our power output would have to be on a scale of 50 times of the StreamBee. The team's device intends to produce anywhere from 200W to 1000W. To account for this huge difference in output power, the device will have a capable electrical storage device similar in size to a car battery.[4]

In addition to the StreamBee, other competition on the market exists for a similar type of portable hydroelectric generator. One more closely related to the possible implementation of the team's design, is the Back Pack Power Plant. The Back Pack Power Plant designed by Bourne Energy of California, is a 30lb portable device carried on one's back. The product claims it can generate 600W which is in the same range as the device the team intends to create. Really this device seems like it will conquer all of the obstacles that the team plans to overcome with its' design except for some little things. The Back Pack Power Plant needs to be anchored on both sides of a river for proper functionality. Additionally, it does not seem to have the common ports on it for easy access to US standard electric sockets as will be found in the team's design.[5]

2.2 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."

2.3 Goal Statement & Objectives

Goal Statement:

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

Objectives:

- Produce 1kW 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.

2.4 Constraints

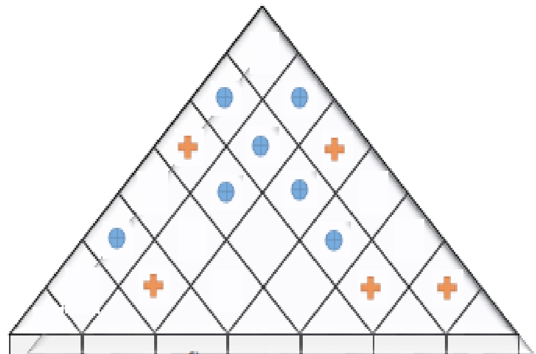
- Device weight must not exceed 50lbs
- Compact (less than 3 ft^3)
- Single directional flow
- Water proof / (resistant to corrosion)
- Durable
- Operate in the confines of the provided budget
- Meet with all effected safety standards applicable
- Operates at most 50 dBa (moderate level of sound)

2.5 Methodology

The team will look into propeller designs to try and find out how different orientations of the propeller will affect the decided torque or rotational axel speed the constraints require. The designs of the propellers will be manufactured as scaled down prototypes and tested to provide a solid decision. 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. A gearbox will be created to account for a faster rotational axel speed if the generator requires it. A gearbox will be required if the slow moving stream cannot provide heightened rotational axel speeds through a direct propeller-generator connection. The size of the generator will be decided upon the constraint of power output for the project. Three items will be used to test the power output of the project design, including the following: light bulbs, portable room heater, and electronic chargers for a phone or GPS. Testing of the machine will be done through a controlled artificial stream where the team will be able to alter the rates of the fluid flow.

2.6 Quality Function Deployment

Table. 1 House of Quality



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

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.[6]

2.7 Schedule

	Task Mode	Task Name	Duration	Start	Finish
1		Bi-Weekly SM and Dr Devine meeting	1 day	Tue 9/29/15	Tue 9/29/15
2		Dr. Hahn Meeting	1 day	Thu 10/1/15	Thu 10/1/15
3		Needs Assessment	2 days	Thu 9/24/15	Fri 9/25/15
4		Project Plans and Product Specs	12 days	Thu 9/24/15	Fri 10/9/15
5		Initial Web Page Design	7 days	Thu 10/8/15	Fri 10/16/15
6		Midterm Presentation I: Conceptual Design	14 days	Tue 10/6/15	Fri 10/23/15
7		Midterm Report I	14 days	Fri 10/16/15	Wed 11/4/15
8		Peer Evaluation	1 day	Tue 11/3/15	Tue 11/3/15
9		Midterm Presentation II: Interim Design Review	14 days	Tue 11/3/15	Fri 11/20/15
10		Final Web Page Design	14 days	Tue 11/10/15	Fri 11/27/15
11		Peer Evaluation	1 day	Tue 11/24/15	Tue 11/24/15
12		Final Design Poster Presentation	14 days	Tue 11/17/15	Fri 12/4/15
13		Bi-Weekly SM and Dr. Devine Meeting	1 day	Tue 10/13/15	Tue 10/13/15
14		Bi-Weekly SM and Dr. Devine Meeting	1 day	Tue 10/27/15	Tue 10/27/15
15		Bi-Weekly SM and Dr. Devine Meeting	1 day	Tue 11/10/15	Tue 11/10/15
16		Bi-Weekly SM and Dr. Devine Meeting	1 day	Tue 11/24/15	Tue 11/24/15
17		Bi-Weekly SM and Dr. Devine Meeting	1 day	Tue 12/8/15	Tue 12/8/15
18		Dr. Hahn Meeting	1 day	Thu 10/15/15	Thu 10/15/15
19		Dr. Hahn Meeting	1 day	Thu 10/29/15	Thu 10/29/15
20		Dr. Hahn Meeting	1 day	Thu 11/12/15	Thu 11/12/15
21		Dr. Hahn Meeting	1 day	Thu 11/26/15	Thu 11/26/15
22		Dr. Hahn Meeting	1 day	Thu 12/10/15	Thu 12/10/15
23		Dr. Hahn Meeting	1 day	Thu 10/1/15	Thu 10/1/15

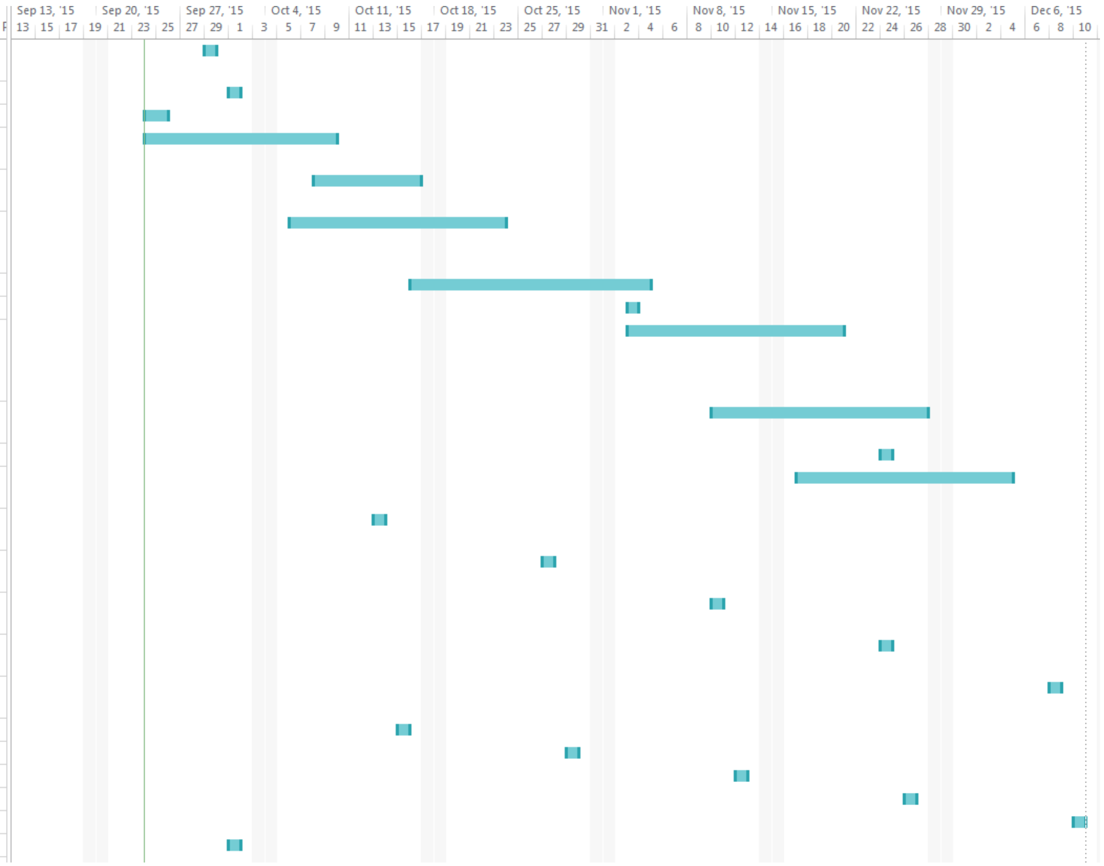


Figure 2: Gantt chart for Team 7's proposed schedule

3 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] Generators produce electricity through the use of Faraday's principle of electromagnetic induction.[1] 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.

4 References

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