Conceptual Design II

Team 7

Personal Hydroelectric Generator

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ABSTRACT

For this project, sponsored by Dr. Devine from the FAMU-FSU College of Engineering, Team 7 is working on developing and marketing a personal hydroelectric generator suitable primarily for outdoorsmen or campers. Faced with the problem that electricity is inaccessible in remote locations, the team decided to design a portable hydroelectric generator that can be transported to different locations for quick setup and use. The team has spent the past semester meeting with Dr. Devine and Dr. Gupta to define the target market and refine the design to meet the needs of that market. This report details the background research and selection process that the team went through to decide upon the components for the final design. Upon direct investigation the team has decided to go with a 3 foot diameter hydrokinetic turbine to gather the energy of the flowing water. Additionally, the team has decided electrically to go with a permanent magnet 3 – phase AC alternator along with a charge controller and a wattmeter. These three components all come from the Wind Blue Power Company out of Kansas which will make things compatible and easy to hookup. Mechanically the team has decided upon a PVC housing with PVC end caps in order to seal the internal components. Furthermore a rail system and cage housing have been developed so that the internal components can be easily slid in and out to aid in maintenance. Important to note, Team 7 has also decided that it would benefit their cause to remove the battery from the device. Still up in the air, is the exact design for the anchoring system as well as the specifics of the gearbox design. Also detailed is the scheduling of the project for the coming weeks so that the team can stay on track with the progress of the 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 is produced in the conductor.[1]

Simple modern day generators have two major components: a stator and a rotor. 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: 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] Currently, hydroelectric power generation is quite common, but most, if not all, are in fixed locations like water dams. Water is not restricted to the time of the day. This provides a continuous duty cycle that converts usable electricity 24 hours a day 7 days a week and 365 days a year in comparison to PV cells which only operate under sunny conditions. This project 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 which have built similar devices. One such product currently available for purchase is the StreamBee (Figure 1) available by The HydroBee Company. The device can use the flow of the water in a stream to create electrical power. Their idea is similar to Team 7's, however their device works on a smaller scale than the market Team 7 intends to influence. The power output of this device is a mere 10W. In order to power essential electrical equipment, as Team 7's device intends to do, the power output would have to be on a scale of 50 times that of the StreamBee's.[4] The team's device intends to produce anywhere from 50W to 200W. To account for this huge difference in output power, the device will be designed to charge a battery provided by the customer. The team intends to create the product that lets the consumer apply any battery he or she wants for the job.

Figure 1 - StreamBee, powers small electronic devices with a USB port

In addition to the StreamBee, another competition on the market exists for a similar type of portable hydroelectric generator. One more closely related to Team 7's design, is the Back Pack Power Plant (Figure 2). 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. 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.[5]

Figure 2 - Back Pack Power Plant: 3 feet in length and weighs 30lbs

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 are few effective, simple, and quiet ways to get power in 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 enough power to satisfy the need of our target consumers.
    - Supplemental emergency power generation
    - Environmentally conscious recreational camper
    - Rurally indigenous communities
- Minimize the weight of the device to ensure portability.
- Produce a device that is safe to operate and leaves negligible ecological consequences.
- Produce a device that is conveniently set up and disassembled.

The desired wattage output of the system has changed from 1 kW to 200W due to background research of what is realistically achievable. Team 7 believes this wattage is capable of satisfying consumer needs because it has the ability to power several necessary components one might want in a remote location. This includes 5 LED lights that are equivalent to a 60W incandescent bulb and an electronic phone/GPS charger. These devices were shown to consume 50W and 50W respectively (totaling less than 200W). The main goal for the power output for our updated design is to effectively charge a battery hooked up to the system.

Portability is an important objective because a lightweight system is easier to transport in the naturally harsh conditions of remote locations. This device is trying to appeal to environmentally conscious individuals who want to use a power source that has no carbon foot print as well as individuals far from conventional power grids. The device also needs to be easy to set up and operate in order to appeal to a non-technical consumer and cut down on assembly time.

2.4 Constraints

- Device weight must not exceed 70lbs
- Compact (less than 3 ft^3)
- Unidirectional flow
- Water proof to protect the electrical components within the housing
- Durable and corrosion resistant
- Complies with all safety standards and has little/no environmental and human impact
- Operates under 50 dBa (moderate level of sound)

A comparison against the competition mentioned in Section 2.1, as well as the results from the created House of Quality, helped formulate many of the constraints found above. The device's desired weight is 70lbs, while the competitions are at 1lb and 30lbs. Although this is higher than the competition, the weight is still manageable to the average person with some assistance. The unit must be compact in order to be more streamline in the water as well as fit in the bed or trunk of a standard SUV. Waterproofing the housing is very important so submerged electrical components will not undergo damage while in use. Another important constraint pertains more to the marketability of the unit as an exciter, which includes operation under the sound level of 50 dBa. This was decided comparing moderate sound level of 50-65dB (equal to a normal conversation at 3ft) and unlike typical gas generators (70dB), would not be a nuisance to the user or the wildlife. Finally, our sponsor and the College of Engineering set the budget to be $1,500. This budget seems to be manageable throughout our research and does not appear to be a problem.

2.5 Customer Discovery Survey

Table 1 – Customer Survey

	< $350	$350 to $550	$550 to $750	>$750
If a generator could sustain all your lighting needs, run a small refrigerator, or power any TV, how much would you spend?	5	5	15	6
	Camping	**Hunting**	**Cabin**	**Fishing Trap**
Where would you mainly use this item?	13	16	4	10
	Power Output	**Price**	**Durability**	**Size**
What is the most important from the following: Power Output, Price, Durability or Size?	8	5	10	8
	Would buy	**Might buy it**	**Wouldn't buy**	**I don't know**
How likely are you to buy a hydroelectric generator if it meets your needs?	14	5	4	8

The table displayed above gives the results of a customer survey that was given while on a hunting trip by one of the members in the group. It is important to state that all of the numbers given above reflect all of the answers given during the survey and have not been tampered with in order to reflect a desired outcome. With that being said, the outcome of the survey was very successful in that the trends reflect that of the House of Quality that will be discussed in Section 2.6. These questions contributed to the characteristics made for the final product in order to add to the value proposition. In other words, these answers helped the team better understand what the customer wants so that it would sell if mass produced.

2.6 Quality Function Deployment

Table 2 - House of Quality

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

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 for the customer.[6] This makes sense since customers want a device that is cheap, does its job, and will not easily break during operation. As a company the most important engineering characteristics were determined to be to create a mechanism that is less mechanically complex, user friendly, and low in weight. This is because the company will not want to confuse the consumer with complex systems and not waste excess funding on material and labor.

3 Design and Analysis

3.1 Flow Characteristics

In generating potential designs, the group recognized that the flow characteristics of the river would heavily influence the project. The underlying principles governing flow characteristics are rooted in a fundamental law of physics, the law of conservation of energy. This law states that the total energy of an isolated system (e.g. the flowing water) remains constant, where energy is the capacity to do work. Building upon this, at higher elevations things such as resting surface water, snow, rain clouds, and ice contain potential energy. This potential is transferred to kinetic energy as the clouds start to rain, ice or snow starts to melt or the water starts to flow into collectively large flowing masses called streams, lakes, or tributaries. These sources converge at point of lower elevation which is known as a river headwaters. The area of land that encompasses said sources is called the drainage basin. From this, the drainage basin was determined to be one of the most influential factors of a river's flow due to the fact it dictates mass flow properties which are key to determining how fast a river can potentially flow. As seen in Figure 3, the Bradshaw model depicts how different characteristics correlate and contribute to flow.

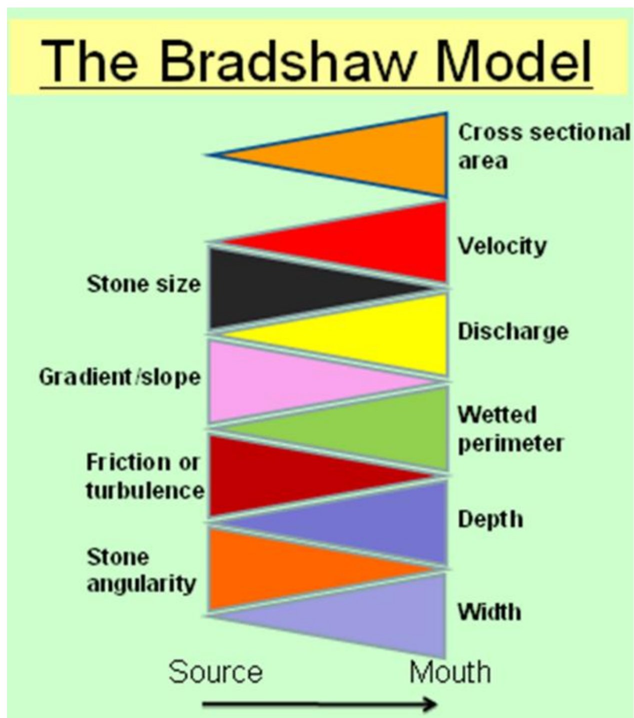

Figure 3 - Flow characteristics correlation graph (Bradshaw Model)

From this, it was clear that dimensional characteristics of the flow channel coupled with the discharge (otherwise known as the volumetric flow rate) were the primary factors that would determine the flow speed. Keeping in mind that elevation drops, size of a drainage basin, and dimensional characteristics of the flow channel would outline the velocity of flow. Five

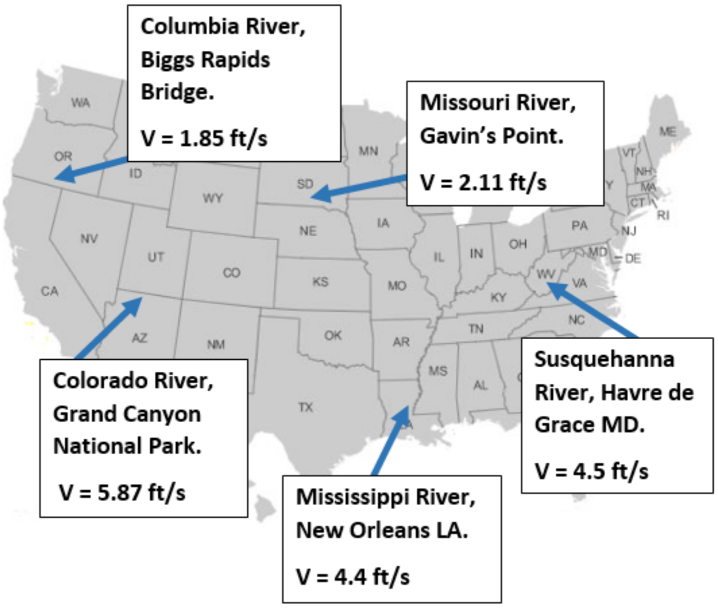

Figure 4 - River flow characteristics

different locations were chosen based on their geographical location, elevation, width, and depth to provide a variety of realistic flow velocity estimations for calculations to model the group's potential designs. As seen in Figure 4, the five selected rivers were analyzed at specific points based off the above characteristics to represent that area of the initial target market. From this, the velocities were averaged to one single value that was 3.75 ft/s for analysis. In the future, to provide a better representation for the potientual buyer a more indepth analysis could be conducted by taking into consideration multiple segments of rivers, seasons, flooding, and a similar analysis that was conducted above just on a much larger scale anaylsis. Idealing a map representing different flows for different rivers would be developed, similarly to the maps of solar irradiance that are avaiable.

3.2 Initial Conceptual Design

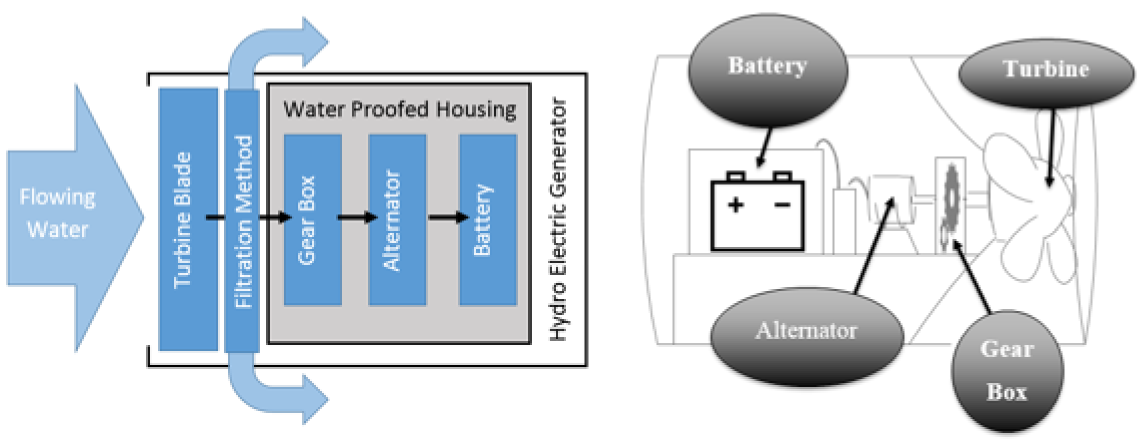

Figure 5 - Schematic showing the flow of our initial design

The initial conceptual design housed a battery, gearbox, and alternator. Also, the initial design contained a cylindrical housing that encompassed the entire apparatus including the turbine in order to direct the flow and give a place to attach a screen for filtration. The flow chart above in Figure 5 gives the general idea of how the system would work if our team decided to stay with this design.

3.3 Final Conceptual Design

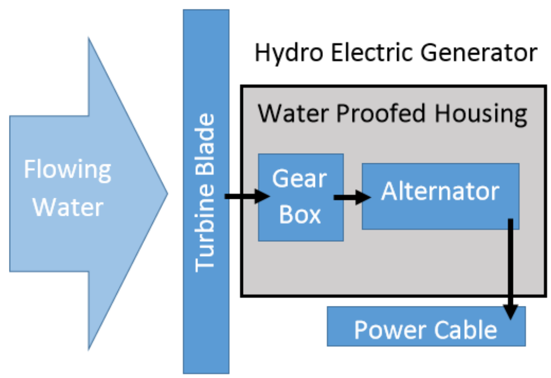

Figure 6 - Schematic showing the flow of our final design

The final design differs from the initial design on several characteristics. First, as an entrepreneurial project, our team wanted to make the product as marketable as possible and hold true to its value proposition. With that being stated, the battery was removed from the final product entirely. Removal of the battery made the overall weight of the system significantly lower and allows the customer to choose their own battery based on our recommendations and specifications. Another major change included the removal of the cylindrical piece that surrounded the entire system. Research showed that the flow would not be assisted with this characteristic in any way. In addition, the screen was found to be unnecessary because the speed of the turbine blade is not fast enough to harm wildlife. Just between these two major changes, the overall weight of the system will be much lower, the overall cost will be much lower, and the design is much more compact and portable.

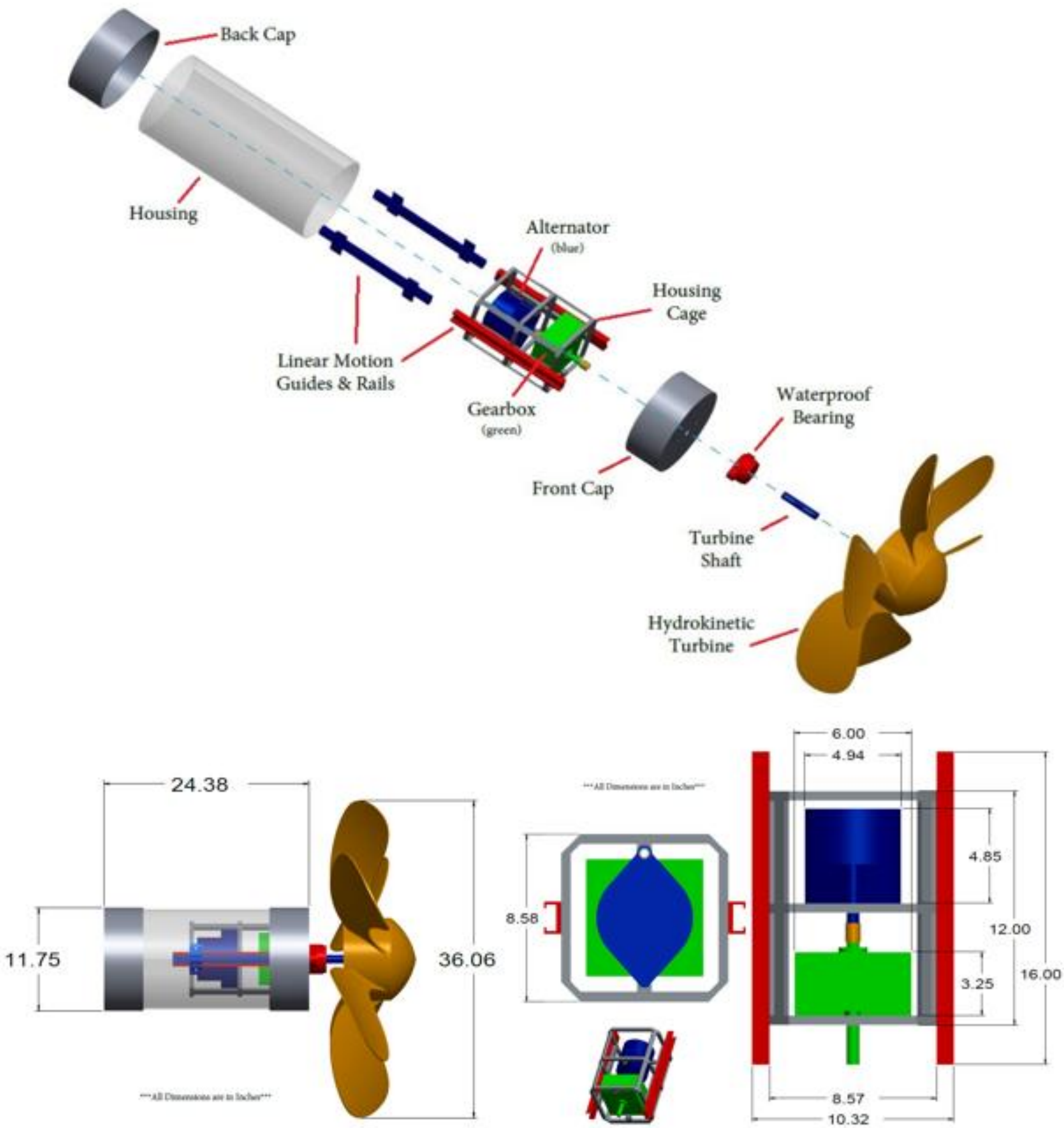

Figure 7 - Detailed CAD of the final design (all dimensions are in inches)

Figure 7 displays several views of the final design CAD assemblies. The overall length of the assembled structure is just under 3ft long with a turbine diameter of 3ft as well. This meets the constraint of being under $3ft^3$. The housing in made from cylindrical ducting and is 11inches in diameter. Inside the housing as a 12inch aluminum cage connected to linear motion guide rails. These rails allow the user to slide the cage out of the housing while still being attached to it. Finally, the gearbox and alternator are rigidly attached inside the cage.

3.4 Hydrokinetic Turbine

Hydrokinetic Turbines

Hydrokinetic turbines are those in which perform efficiently in free-flow environments; meaning that that require little to no head to operate. Instead they are designed to capture the kinetic energy of a flowing fluid. Some examples of these turbines are axial flow rotor turbines and helical turbines. As shown in Figure 8 the axial flow turbines closely resemble that of wind turbine blades and boat propellers. Figure 9 displays a vertical-axis helical turbine. These types of turbines can also be orientated such that their longitudinal axis is in line with the flow.

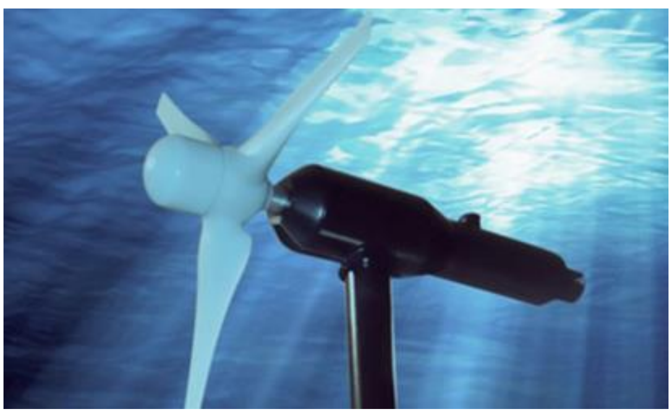

Figure 8 - Axial flow rotor turbine

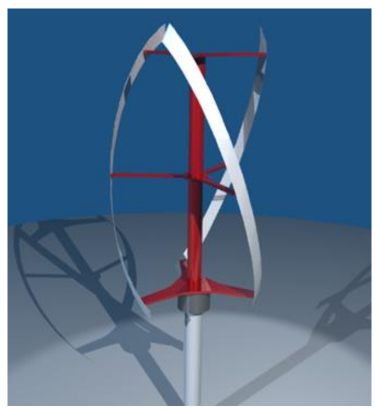

Figure 9 - Vertical axis helical turbine

When analyzing a flowing stream, the kinetic power of the water passing through a specific cross sectional area can be calculated. However, this total theoretical power can never be fully transfered to a turbine blade. Studys have shown in real world applications only 59% of total power can potentially be collected; this is known as Betz's Law. Nonetheless, this 59% is still never truly achieved due to effeciency factors in the turbine geometry and alternator. Figure 10 displays the power output of water at varying velocities at a given cross-sectional area of a 3ft diameter turbine blade. In order to achieve 200W with a 10% overall effiency, the system would have to be placed in a 6ft/s flow.

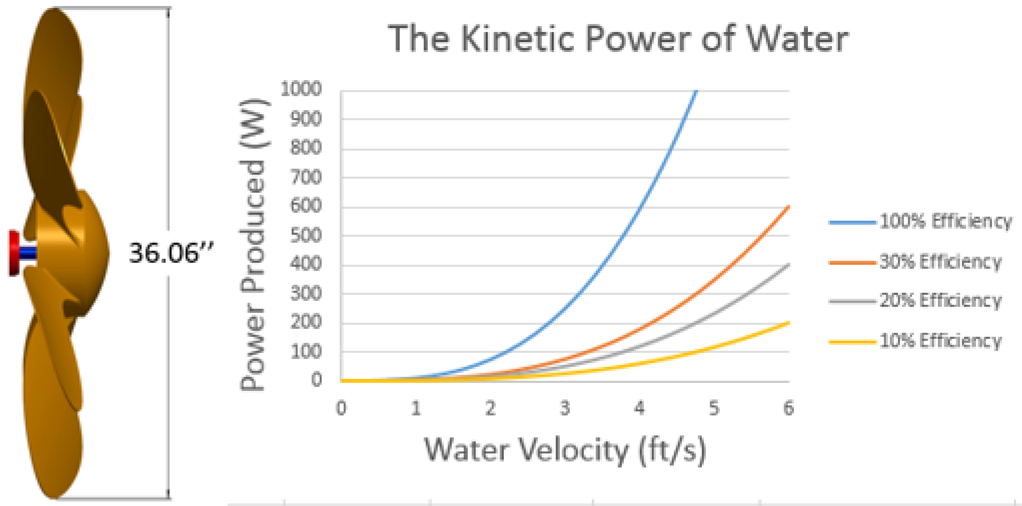

Figure 10 - A plot describing the kinetic power output of water at different velocities given a 3ft diameter blade. Power is plotted at 100%, 30%, 20%, and 10% efficiencies.

3.5 Alternator

Power generation can be produced through a generator or alternator. The decision to use an alternator has been determined due to the advantages 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.

Figure 11 - WindBlue Power DC-540 alternator

Alternators use a rotating magnetic field that induces a voltage in the windings. Since the currents in the stator winding vary in step with the position of the rotor, an alternator is a synchronous generator. The magnetic field can be produced by permanent magnets or a field coil electromagnet. A single cycle of alternating current is produced each time a pair of field poles passes over a point on the stationary winding.

For Team 7's design a 3-phase alternator was selected. The DC-540 alternator from WindBlue Power (Figure 11) was selected for its fit with the team's needs. At acceptably low RPMs the alternator produces the right amount of voltage and current for the job. For instance, at around three hundred RPM, the alternator produces 28 volts at 6 amps. This is good because it gives us enough voltage to charge a standard 12 volt battery and it gives us a current large enough to charge the battery to full capacity in an acceptable time frame. Figure 12 shows the alternators likeable statistics.

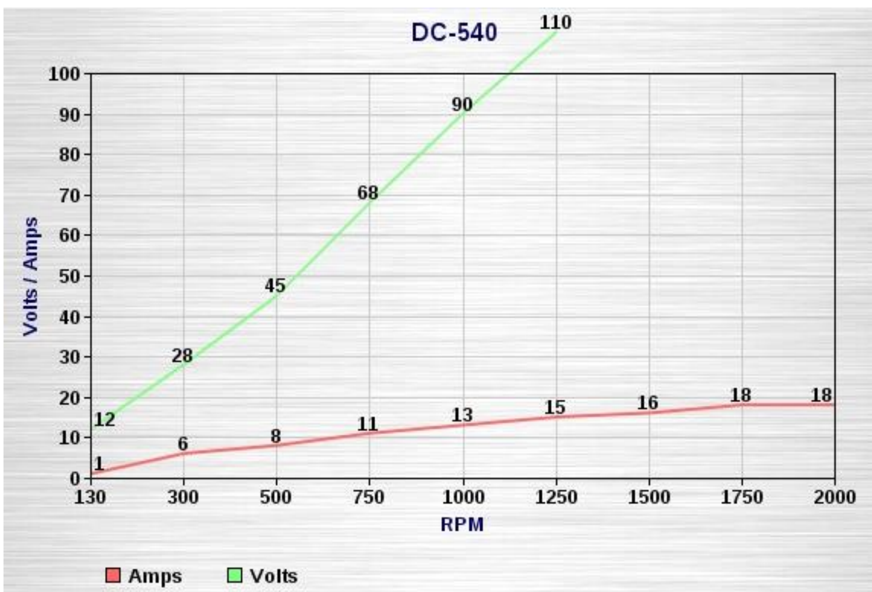

Figure 12 - WindBlue Power DC-540 alternator's data sheet showing current and voltage vs. RPM

A side-note, the alternator also outputs 3 phase AC power. This is another likeable feature because it means that the prototype will be able to transfer electrical energy more efficiently over longer distances. If a consumer has to set up the device over a mile or two away from his battery, it will be possible with considerably less loss than in DC power.

3.6 Charge Controller

Since the last update, the team had made further research into the electrical requirements of the project and decided that it will implement a charge controller into the design of the project. The team is going with a charge controller made also by the Wind Blue Power Company.

Figure 13 - 12 Volt 25 Amp Charge Controller

Figure 14 - LCD Digital 60V/100A Watt Meter

The attached charge controller in Figure 13 is very easily hooked up in the system and was chosen for these reasons. The device is easily hooked up to accept the three lines of the alternator's AC output. It then has a built in rectifier which outputs DC power at 14 V to charge a typical 12V battery. The device does exactly what is needed to make the design feasible for real world application. The charge controller conveniently has a built in procedure to stop a battery from overcharging. Called, the "alternator braking" procedure, the controller turns on a built in switch when the battery is at full charge that allows current to be directed away from the battery and towards the heat fins seen in the picture. This makes the electrical energy go to heat and not to overcharging and exploding the battery.

In addition to the charge controller, the device will have a wattmeter (Figure 14) at the end of the battery terminals that will give the user any type of necessary information for knowing what is going on electrically. The wattmeter can provide readings for the current voltage, current, power, as well as charge in the battery; all handy information.

3.7 Battery

After digging deeper into the analysis of this project's design, the team decided that the battery should not be included in the housing for several reasons. The first reason is the weight factor that it produces. Batteries are very heavy and contribute to the overall weight constraint of the project. Secondly, having the battery within the apparatus that will be submerged under the surface of the water leaves more room for failure in that if there were a leak, the battery would be destroyed. Lastly, if the submerged battery in the housing were to get wet, the battery could release charge that could be harmful to the surrounding wildlife. Therefore, the battery that will be needed for the personal hydroelectric generator will be expressed in the Instruction Manuel so that the customer will purchase the correct one, but will not be included with the end product.

3.8 Anchoring

The design for the anchoring system was yet to be finalized at this stage of the project. The conceptual design envisioned by the team included several components. First, the team needed to determine a method of securing the appartatus in place. the most effective method of securing the apparatus was determined to be from land. This was decided to be the best method because it provided benefits for the operator when deloying and retrieving the device. The team determined a cantilever type beam would be the best method of securing the generator in position for use. A collapsable feature ideally will be intergrated into the beam to increase portability. Additionally, a method of securing the beam to the land while supporting the generator also had to be designed. The team explorded several different possibilites to accomplish this goal, a manual ground screw as seen in the right side of Figure 15 was considered because it would effective in open areas where the land could be easliy drilled into and would provide a strong rigid fixture to

Figure 15 - Land Marks

support the rest of the design. A Ratchet mechanism asdepicted in the left side of Figure 15 was additionally considered. This mechanisms ability to tighten webbing around an existing structure was an appealing option due its weight and size being relatively light and compact as well as its flexability to as of where it could be utlitized. Next, the team looked into designing a custom collapsable platform to secure the appartus. Finally, A modular design which incorperates aspects of the previous concepts in Figure 15 inorder to maximize their benefits and minimize their weaknesses was proposed. Each of the above ideas would be designed or modified to connect and detach from the beam portion of the mechanism. The last portion of the anchoring system that needed to be designed was a method of positioning the generator at a desired depth. This portion of the designed lacked the most attention up to date. Several of the ideas introduced were the addition of a ratchet pawl mechanism to the beam portion of the anchoring system to lower the generator to a designed depth, a buoy system attached to the beam and generator via cables of desired lengths. A buoy as seen in Figure 16 was invisioned for this design. Lastly, a collapsable floating platform with an adjustable rod used to translate the generator up and down was also being considered at this point.

Figure 16 - Anchoring System Buoy

3.9 Gear Train

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 may maintain a linear input and output shaft rotation with the use of spur or helical gears. The output shaft may also be able to change orientation with the use of bevel gears.

3.10 Housing and Waterproofing

The mechanism in the water should 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. After researching what is available and cost efficient, PVC duct was chosen to be the material for housing the internal components. The housing will be capped with a PVC duct end cap on both ends. The back end cap will be permanently adhered to the main housing using a strong binding substance. The front end cap on the other hand is a little different. This cap will be held on by putting a rubber sleeve (like the one depicted in Figure 17) where the housing meets the cap with two screw bands used to tighten down the junction. Also, a waterproof bearing (Figure 18) will be mounted to the front cap to allow for the turbine shaft to enter the house while keeping out water.

Figure 17 - Rubber sleeve

Figure 18 - Waterproof flange bearing

3.11 Environmental Impact

A major concern with introducing a power system into a river or stream is the effect on the ecological system. Turbines that channel the kinetic energy of flowing rivers may interact with the wildlife like fish and snakes. A study showed that with a turbine that reached rotation speeds of 70 rpm in a subtropical river, fish movements were recorded to avoid collision with the turbine. In fact, the study showed that no fish collided with the turbines and only a few specimens passed through the turbine during the testing period. It was shown that fish slowed and then seemed to actively avoid the turbine fixtures.[7]

4 Entrepreneurial Aspects

In order to evaluate the business potential of this project. Team 7 has decided to enter into the InNolevation challenge sponsored by FSU. This challenge requires teams to evaluate their respective ideas through filling out a business model canvas and determining how to test the developed theories in each segment. A business model canvas is a strategic management tool that was developed in order to evaluate a company's value, customer segments, partners, and infrastructure. Our completed business model canvas is shown below with an in-depth overview of each segment including testing procedures. It should be noted that our cost structure and revenue streams are missing from our canvas. This is due to the team not having evolved enough as a company in order to accurately determine the financials associated with our product.

The Business Model Canvas

Team or Company Name:

Personal Hydroelectric Generator

Key Partners

- Service such as *paypal* to handle purchases
- Distribution partners – USPS, FedEx, etc.
- Suppliers –for various components
- FSU – (senior design) supplies initial funding for the project
- Kickstarter – entry level fundraising
- Grants from competitions such as InNolevation Challenge

Key Activities

- R&D – improve on hydroelectric generator design
- effective sales team management
- establish premium models with added and/or improved features

Key Resources

- Brand name
- Hydroelectric generator design
- Sales and support teams
- Sales of replacement parts and expanded features

Value Proposition

- Provide a constant, clean energy source with enough power to supply a small home or cabin with electricity
- Utilize the power of flowing water in order to generate electricity
- Significantly quieter than its gasoline counterpart
- Portability

Customer Relationships

- Dedicated sales for large purchase accounts
- Support staff
- Automation (where possible) – fund transfer etc.
- Periodic newsletter

Channels

- Global sales and support team
- Online website with product information
- Social media accounts

Customer Segments

- Developing countries – specifically villages and homes near bodies of water
- Humanitarian organizations
- Outdoorsmen – riverside camp sites
- Military – secluded camps, humanitarian aid

Figure 19 - Business Model Canvas

Value Proposition

Problem in question:

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, a secluded community in a third-world country, or military installations; 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 however most are bulky, loud, and require an energy source such as gasoline to function. Currently, there are few effective, simple, quiet, and clean ways to get power to remote locations. In order to supply energy to items such as lights, heaters, or USB chargers, a gas generator is most often used.

Problem Solution:

This 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. Generators in general use Faraday's principle of electromagnetic induction. This allows mechanical power to transform into a higher quality and more useful electrical power. The design of this product includes a turbine, a generator, a gear train, an anchor mount, and a battery. A house of quality developed, shows the importance of functionality, durability, and price as the most important characteristics of this project.

Value Proposition:

Research into hydroelectric generators have shown higher than 80% efficiency and other portable hydroelectric companies such as HydroBee and Bourne Energy have proven to provide 10W and 600W of energy respectively. This product will attempt to generate around 0.5kW of electricity, an amount deemed suitable to power a small home or cabin with electricity. This product's manufacturing cost is comparable to a gas generator. It should be noted that all few major competitors in the portable hydroelectric market are still listed on Kickstarter and are in the early stages of company development. Hydroelectric generators inherently have advantages over their gas counterparts. These advantages include quiet power generation (flowing water is the loudest noise), no carbon footprint as far as burning a fuel source is concerned, a similar power generation rate of 0.5kW, similar portability to gas generators, and competitive pricing.

Solution Validation:

The team will look into turbine design in order to find out how different orientations will affect the decided torque or rotational axel speed according to the constraints that match what a 0.5kW generator requires. The turbine design in question will be first produced as scaled prototypes and tested in order to determine which produces the most axial force. A mounting technique will be tested in order to show the most efficient form of anchoring for the generator and propeller in order to reduce chatter and movement while in use. A gearbox will be assembled in order to increase the rpm to a level deemed optimal by the generator. Testing of the machine will be done through a controlled stream where the team will be able to alter the rates of the fluid flow.

Customer Segments, Channels, and Relations Assignment

Customer Segments:

The customers being targeted for the personal hydroelectric generator are outdoor enthusiasts, third world countries, and humanitarian aid organizations including the department of defense (DOD) and the Red Cross. Outdoor enthusiasts and third world countries have similar needs for power in that the remote locations they frequent often do not have any power at all. Even a little bit of power in order to run basic appliances can be a game changer in areas like that. The Red Cross and DOD however spend a significant portion of their budget on urban improvements in locations mainly confined to underdeveloped countries. As an example when the DOD builds a school in Africa as is often done, a hydroelectric generator would become a great supplement to supply the necessary power to run a projector and other necessary utilities. In order to validate these customer segments, a survey of outdoor enthusiasts as they enter industry related shops will be done in order to see usefulness of such a generator and how much an average individual is willing to pay. When targeting third world countries and humanitarian aid organizations a comparison of our generator as compared with competitor’s versions that are currently in use will be shown to each company individually, so as to establish a competitive advantage.

Customer Channels:

When targeting consumers, both third world countries (including humanitarian organizations that service them) and outdoorsmen, a completely free installation and demonstration will be done in an area of great need of electricity. This serves to generate a positive opinion toward the company while simultaneously proving the usefulness of the product and it's potential to become a game changer in the power generation field. This demonstration will be featured on our website and when pitching the product to various organizations for bulk purchases. In order to validate a proper product - market fit surveys will be written and taken from outdoorsmen and people in the generator sales industry. This will validate a proper product – market fit for the outdoorsmen category; for other humanitarian organizations that tend to purchase in bulk orders, a direct comparison and demonstration will be necessary so that they can decide if the competitive advantages of our product outweigh those of our competitors. As a more detailed comparison will be necessary in order to secure large value contracts.

Customer Relations:

In order to retain a positive word of mouth the team's installation of the device, free of charge, in an impoverished area that has a need for electricity will be touted. In addition when the company has garnered more capital and is more established, more of those aforementioned projects can be undertaken. In order to retain customers, excellent customer service will be provided in which a support staff will be available at reasonable hours to assist with any complications the user may have with setup and repairs if necessary. In addition to a limited warranty protecting the purchaser from manufacturing defects, all replacement parts will be offered to the customer in the unfortunate circumstance of a failure within the device. Our method of validating that the customer wants to be treated in the manor specified above will be to send out a survey to anyone we have had contact with. This survey will serve to establish what the company did that the consumer appreciated and what the company needs to improve on in the future so that a pleasant purchasing experience is maintained in the future.

Key Activities, Partners, and Resources Assignment

Key Activities:

In order to deliver on the value proposition further R&D is required in order to give a greater generator efficiency so that it is on par with other competitors. In addition, other versions of the product need to be established so that an individual consumer can select the best unit based on the flow characteristics of the river the consumer has decided to purchase the unit for. Other versions can include more power generation from different generators, expanded turbine to better utilize the depth of the river, or a smaller and more compact housing for more portability. Lastly an effective sales team must be managed and held as a high importance so that customers are aware of our product and its competitive advantage as compared with competitive models. In order to validate that these are important key activities, a survey will be given that asks specific questions referring to what the consumer would most like to see improved and what they are satisfied with. The results of which will be analyzed and an appropriate company direction will be established.

Key Partners:

There are several key partners that are necessary in order to effectively deliver on our value proposition. Firstly, a service such as PayPal could be utilized to effectively handle online purchases as well as money transfers for individual purchasers. A second necessary partner will be a global shipping service such as FedEx in order to reach customers on a global level. Another partnership will need to be made with the various suppliers of the generator's components to ensure the lowest overall cost of the generator from a material standpoint. Lastly, an agreement with the FSU-FAMU College of Engineering is already in place for $1,500 of initial funding in order to develop a proof of concept prototype under the senior design program. In order to further the necessary fundraising of the project a Kickstarter program will likely need to be established in order to generate capital to expand the business. Additionally, venture capitalism would be a potential avenue of fund raising. In order to make sure these are the correct key partners a SWOT or strength, weaknesses, opportunities, and threat analysis will be done periodically. This will identify areas of the company that are strong as well as areas that need to be improved.

Key Resources:

An important key resource is brand name recognition, protected by trademark and copyright laws, it can invoke an opinion in a person through recognition and can become very valuable. Additionally another key resource is the design of the hydroelectric generator itself, protected through patents, can become very valuable in order to ensure exclusivity in the market. Also an effective sales and support team is a great key resource as their performance directly relates to customer satisfaction and customer retention. Lastly the sales of expanded parts and additional features contributes as a key resource due to the fact that expanded options increases the number of potential customers and potential market size. In order to validate that these are the key resources an analysis of the business with value and cost assigned to each department will be done. The results will be compared in order to determine what aspect of the business is the most valuable over time and generates positive value.

5 Scheduling

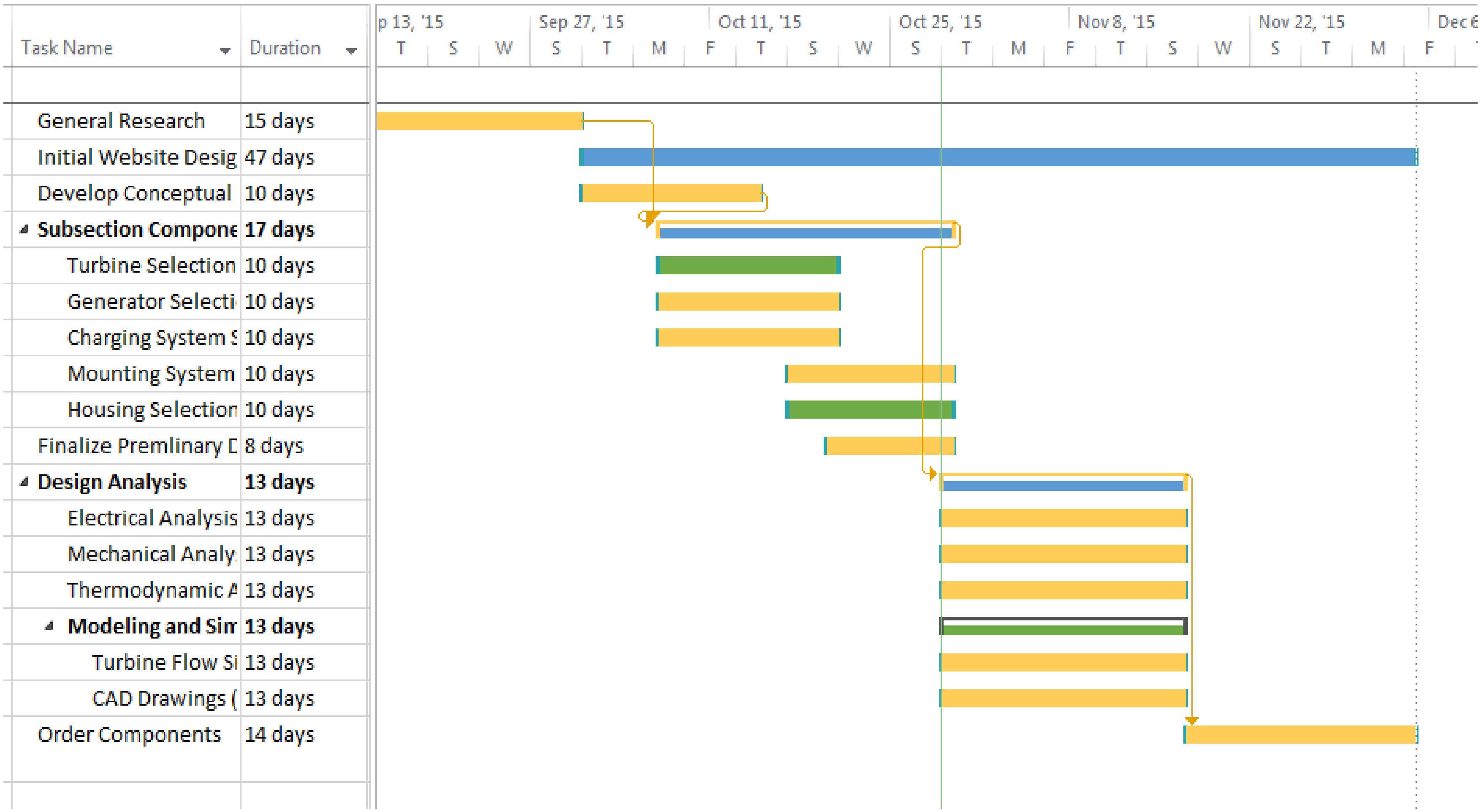

Figure 20 - Gantt Chart

The schedule was generated using a Gantt chart and covered the duration of the first semester of senior design. The schedule consisted of tasks that were determined to be critical to the completion of the project. The schedule was organized in a manner to maintain a pace that would ensure the team reached their ultimate goal by the end of the semester which was to order parts for the construction of the hydroelectric generator. The tasks were divided amongst the group according to the strengths of the individual members. Currently the group is on schedule and has already started the process of ordering parts.

6 Potential Challenges

As the design of the device becomes more refined, some of the same potential challenges still remain. Achieving the proper RPM is essential in harvesting the most energy available from the water. Because testing has not been completed at this time, the proper gear ratios necessary to spin the alternator at the highest rate are unknown. Once testing of the turbine blades and the alternator has been completed, gear design can begin. Heat dissipation inside of the PVC tubing will be a very important obstacle to overcome as the alternator will be spinning at high RPM inside of an enclosed space. Without a means of escaping, the heat produced during the process of converting the mechanical energy into electric energy may be enough to damage elements in the housing or the alternator itself. Dry testing of the alternator will reveal how much heat will be produced and this issue can then be addressed. As with every other electrical device that operates near water, keeping the electrical elements of the design dry will be crucial. Any water that comes into contact with the electrical systems inside the housing could be catastrophic and expensive. Extensive research has been completed on waterproof bearings and seals, but unexpected problems may still occur when working around water.

In order to utilize all of the energy available from the water, the turbine blade must be submerged in the water to a certain depth. Currently, the optimal depth of the turbine has yet to be determined. After this depth has been determined, determining how to lower the turbine to that depth will be yet another challenge. Overcoming this obstacle will go hand in hand with the anchoring mechanism design. This alone presents another hurdle to the team. Determining how to withstand the forces acting on the generator and submerge the turbine at the proper depth will require simulation, FEA, and testing, and will be a difficult challenge to overcome. Even harder will be maintaining the key objectives of the project. Compactness and ease of assembly are what make this product desirable to the target market. The design process so far has led to several alterations to the device, but keeping it small and simple has to be the first consideration when making changes. Addressing each of these challenges in the appropriate manner will be the key to developing a successful product.

7 Future Plans

In the coming weeks, the team will begin to finalize the designs for each of the main components of the device. The size and pitch of the turbine blades needs to be determined before one can be ordered and tested. Once this is finished, testing can be done to determine the speed at which the turbine will spin when exposed to different current speeds. This, in turn, will allow the team to finalize the design of the gearbox. Knowing the input RPM coming from the turbine will allow the team to determine the proper gear sizes required to get a desirable output that leads to the alternator. The design of the gearbox will finish the inside of the housing and begin the process of designing and testing an anchoring system. The team will work together to determine the best method of keeping the system stationary in the water. The final aspect of the design will be integrating electrical displays to output the current status of the generator. The display will relay the charge, power, current, and voltage of the generator. This will complete the design and physical testing of the apparatus will begin.

The team has begun ordering parts in order to begin assembly of a prototype. Once these components begin to arrive, testing will begin on several of them. First and foremost, the alternator will be subject to a dry spin down test to determine the amount of heat produced by the production of electricity. With the heat inside the housing at comfortable levels, the team will begin to machine and construct the rail system that the alternator and gearbox will occupy. This rail system will allow the team and the consumer easy access to the important elements inside the housing. The team will then investigate the best way to protect the turbine from debris, and the user from the turbine. Obviously, when the turbine is spinning at high speeds, any impact with a foreign object will be very damaging to both parties. Only when the safety of the user and the turbine has been ensured, can the team begin to test the entire device in a real world scenario.

This is an entrepreneurial project, and the end goal is to produce a commercially viable product. Therefore, it is essential that the team complete the commercialization business plan, and devote time to competing in the closing stages of the InNolevation challenge. The next stage includes validating the theories proposed in the previous two submissions.

8 Risk Assessment Summary

During the designing of the project, many risks have been brought into notice. While dealing with electrical equipment, like the alternator and battery, harm can come to the operators due to the system being within a water medium. The river water flow may also be fast enough to harm the operators where drowning is a possibility. While building the system, misuse of equipment like power tools an improper handling of heavy equipment can also be an issue. All of these issues will be remedied through the use of eye, ear, and hand protection as well as the use of safety flotation devices while working on testing the system in rivers. The use of PPE will help avoid accidents all together. A CPR certified individual will be present during the testing of the system in the case of an accident. All accidents will be dealt with seriously and the proper authorities will be alerted of any accidents during the project.

9 Conclusion

This team has been tasked with developing and marketing an effective method of getting clean electricity into remote areas. For the environmentally conscious outdoorsmen, hydroelectric energy can be an appetizing alternative to burning fossil fuels. Currently, the only viable way of producing hydroelectric energy is by installing permanent fixtures that can be costly, labor intensive, and damaging to the environment. After a semester of research, the team has decided upon a conceptual design that has been divided into several distinct components. These components have been selected and placed into the final CAD design that was discussed earlier in the paper. The critical parts included in this design have either been ordered and are in the process of being shipped, or we have at least contacted the vendor about our order and are in the process of purchasing the part needed. Team 7 is currently on track with the Gantt chart and will start assembly of the apparatus as soon as the parts arrive. With an apparatus to test, more important data will be noted through various testing and the results will be dealt with accordingly. Finalizing the turbine so that the gearing may be designed and purchased is our main objective at this point in time. Lastly, Team 7 will be following through in the next steps of the InNolevation Challenge in hopes to be a top contender.

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11 Biography

Joseph Bonfardino:

Joseph is a native of a small city in Central Florida called Spring Hill. From a young age he always had an inquiring mind wondering how and why things work the way they do, and this lead to a thirst for knowledge. Joseph graduated from Central High School in 2012 with his Associates of Arts Degree, and then moved to Tallahassee, FL to further his education. Currently, he is a Florida State Senior studying Mechanical Engineering with a technical track in Thermal Fluids. Upon graduation in May 2016, he plans to start his career in a renewable energy industry.

Galen Bowles:

Galen Bowles is a senior mechanical engineering student at Florida State University with a focus in Thermal Fluids. Galen was born in Alexandria, Louisiana but grew up in Panama City, Florida where he graduated from the local state college, Gulf Coast State College. After Florida State, Galen plans to remain in the Florida panhandle and continue work and research on renewable energy conversion systems.

Brendan McCarty:

Born in Kansas City, Brendan moved to South Florida at a young age and loved working on the family boat with his father. A senior at FSU, Brendan plans to graduate in the Spring of 2016 with a Bachelor of Science in Mechanical Engineering. Currently taking classes in the Material Science track, Brendan plans to get a job in the same field, hopefully somewhere in the Southeast.

Parth Patel:

Parth is a senior at Florida State University pursuing a Bachelor's degree in Electrical Engineering. Born in Atlanta, Georgia but my upbringings can be credited to Tallahassee, Florida. Growing up his fascination in how electronics and power tools were designed played a big role in pursuing an engineering degree. Since January of 2015 he has been working at Florida State University's Utilities and Engineering services, learning and managing the power distribution network within the university.

Shane Radosevich:

Shane Radosevich is a senior in Mechanical Engineering at Florida State University completing his final year. He plans on working after graduation for himself or in a management position for a large company. He hopes to combine his real world experiences with knowledge gained from his mechanical engineering degree to creatively design solutions to problems in life. Born in Allentown Pennsylvania and having lived up and down the east coast Shane has many experiences and real world knowledge about culture having traveled over most of the United States and numerous other countries.

Ilan Sadon:

Ilan is a senior graduating in May of 2016 with his BS in Electrical Engineering. He spawns from the wetlands of Miami Beach, FL. The man is one of the two electrical engineers on the project bringing his expertise in the subject to the team. Ilan's interest into the field began as a sophomore in his Physics II class, when he realized how much more electromagnetics appealed to him than the civil engineering track.

Brandon Shaw:

Brandon Shaw is a senior mechanical engineering student at Florida State University. Brandon was born and raised in Saint Johns, Florida until his move to Tallahassee for college. He has a held a sales management role since arriving in Tallahassee and continues to work at Ring Power Corporation in the heavy equipment parts department. Brandon has also had three internships during summers to further his understanding of the mechanical engineering field. These internships include the following: mechanical engineering intern at Phoenix Products which is the power systems division of Ring Power Corporation, a reliability and maintenance engineering internship at CEMEX USA, and a technical research and marketing internship with Polston Applied Technologies. Brandon's future career will involve either engineering sales or project management.

Mathew Vila:

Matthew is a born and raised Floridian who grew up in the South Miami area. He is a representative for the American Society of Mechanical Engineers (ASME) at the FAMU-FSU College of Engineering. His focus is on Materials Engineering and plans on working in the medical field with prosthetics and joint replacement design.

12 Appendix

12.1 Decision Matrices

Table 3 – Decision Matrix for Turbine Selection

Criteria	*Importance Rating*	*Francis*	*Kaplan*	*Hydrokinetic*
Weight	3	2	3	5
Cost	2	3	2	3
Manufacturability	3	2	2	4
Durability	4	2	3	3
Efficiency	4	3	3	5
Total		38	43	65

The axial flow rotor turbine was eventually selected due to its relatively high efficiency and its ability to be oriented with the flow of the stream. Additionally it is optimized for a low head and high flow application which are the conditions that our system will be under.

Table 4 - Decision Matrix for Anchoring Selection

Criteria	*Importance Rating*	*Water Based*	*Land Based*
Weight	2	2	1
Cost	2	3	2
Safety	3	1	4
Durability	4	3	2
Ease of use	3	2	4
Total		31	38

We determined that the best anchoring method for this application would be to use a land based cantilever system. This option gives the customer a safer method of setup without having to step into the water's stream thus reducing the risk of injury from fast currents taking someone off their feet. Additionally the ease of removal of the device from the river will be improved if one doesn't have to dive underwater in order to retrieve it.

Table 5 - Decision Matrix for Generator/Alternator Selection

Criteria	*Importance Rating*	*DC Generator*	*AC Alternator*
Weight	3	2	3
Cost	2	3	3
Safety	3	3	3
Durability	3	2	4
Efficiency	4	2	3
Total		35	48

An alternator was ultimately chosen over a DC generator due to the fact that it is more efficient in producing power under low rpm. Also alternators by design are lighter than DC generators on a weight per power generation basis. Also when producing the current and voltage by the alternator the use of brushes and slip rings are not needed which are prevalent in dc generators making the generator more cumbersome in maintenance.

Table 6 - Decision Matrix for Housing Selection

Criteria	*Importance Rating*	*Carbon Fiber*	*Polycarbonate*	*PVC Duct*
Weight	4	4	4	3
Cost	3	1	2	4
Durability	2	4	4	3
Manufacturability	4	2	2	4
Total		35	38	46

The biggest reasons PVC ducting was chosen as the housing type was because it was cheaper to buy and much easier to manufacture than carbon fiber and polycarbonate.