Operation Manual

Team 7

Personal Hydroelectric Generator

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ABSTRACT

A complete understanding of the information provided in this operation manual is essential to proper and safe use of the personal hydroelectric generator. Specifications and detailed descriptions can help the consumer understand how and why the apparatus works, therefore, giving the user the ability to troubleshoot any problems that they may experience. Since the apparatus may be disassembled for ease of transportation, the steps provided for installation should be followed to every detail. By following these steps correctly, the consumer will experience proper power output values, will be less likely to have failures in the components, and will allow the apparatus to have a longer life expectancy. Routine maintenance should be followed to in order to avoid additional stresses on the components, which could cause early failure. A full components list with vendors is provided so that the consumer may replace any parts that fail or can order additional parts for use as spare parts. Safety is of the utmost importance to our team. Therefore, please understand all safety precautions given as well as follow the steps provided in detail.

ACKNOWLEDGEMENTS

Everyone in Team 7 would like to thank Dr. Gupta and Dr. Shih for their support and generosity in teaching the class. We would also like to thank Dr. Devine our sponsor, for bringing this project to fruition and analyzing our marketability every step of the way. Lastly we would like to thank Dr. Hahn for advising us on the best course of action to take in order to accomplish our project.

1 Introduction

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, remote areas, and campers. Faced with the problem that electricity is inaccessible in remote locations, the team decided to design a portable hydroelectric generator that may be transported to different locations for quick setup and use. The team has spent the past two semesters meeting with Dr. Devine and Dr. Gupta to define the target market and refine the design to meet the needs of the chosen market. A major component of the design includes a 3ft diameter hydrokinetic turbine to gather the energy of the flowing water. Additionally, the electrical components include a permanent magnet 3 – phase AC alternator along with a charge controller and wattmeter. These three components were all ordered from the Wind Blue Power Company out of Kansas, which allowed compatibility and easy installation. The housing was constructed using PVC with tubing and 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 easily be slid in and out to aid in maintenance. The battery that may be charged using this portable hydroelectric turbine is not included. Instead, recommendations of the battery that should be used will be provided so that the user may choose their own battery.

2 Functional Analysis

2.1 Project Function

Team 7 created a portable hydroelectric generator for those who need electricity by harnessing the power of flowing water. This portable system provides enough power to light several LED lights and charge electronic devices with no need for fuel, just a flowing water source. Other benefits of this device are its silent operation and its ability to perform in an environmentally friendly process with no harmful pollution produced.

2.2 Project Specifications

The portable hydroelectric generator is a system comprised of several components, which work together to produce the desired power. The overall length of the assembled structure is just over 2ft long with a turbine diameter of 3ft. This meets the constraint of being under $3ft^3$. The housing is made from cylindrical PVC piping and is 11inches in diameter. Inside the housing contains linear motion guide rails. These rails allow the user to slide the gearbox and alternator out of the housing while still being attached to it. The following subsections will break down in detail these components giving each part's importance, function, and construction.

2.2.1Turbine Blade

The turbine blade is one of the most important pieces of the apparatus. Due to the lack of vendors for hydrokinetic turbine of this scale, the blade used in this prototype was simply the fan blade taken from a floor fan purchased from the local hardware store. Researched showed that similar 4 blade wind turbine blades produced a tip-speed ratio of 2-3, which can be used to find input torque and input shaft rotation. Figure 1 shows the actual turbine blade that we used in our prototype. The turbine blade is attached to a shaft that connects the turbine blade with the gearbox after running through a waterproof bearing and front cap.

Figure 1: Turbine Blade

2.2.2 Waterproof Bearing

The inclusion of a waterproof bearing was vital to successfully run a rotating shaft through the front cap without having leaks into the housing. The waterproof bearing or spherical flange bearing in Figure 2 was ordered and installed because of its wide range of acceptable temperatures and waterproofing ability. This particular bearing is also easily maintained with an easily accessible zerc fitting on the outside so that it may be greased when needed.

Figure 2: Waterproof Spherical Flange Bearing

2.2.3 Gearbox

Figure 3: Inline Planetary Gearbox

Team 7 chose a gearbox based on calculated input speeds generated from the turbine rotation as well as the estimated torque input produced. With high torque and low input angular speed, the gearbox was used to speed up the input shaft of the alternator by a factor of ten. To clarify, the inline planetary gearbox shown by Figure 3 from Anaheim Automation is installed so that low input RPM is outputted at 10 times higher angular velocity.

2.2.4 Alternator

The alternator chosen for the final prototype was purchased from Wind Blue Power. This particular model (3-Phase DC-540) provided sufficient output power at low rpm.

Figure 4: 3-Phase DC-540 Alternator

2.2.5 External Housing

As seen in Figure 5, the housing is constructed from PVC pipe that measures a length of 2 feet and a diameter of 11 inches. In order to secure the gearbox and alternator to the guide rails, wood cages were built around the components. The back portion of the housing has a PVC cap over the end. This cap is sealed permanently onto the housing so that there is a lower chance for water to be introduced to the electrical components. The front cap differs in that it has a waterproof bearing attached to it with a gasket between the bearing and cap for more complete seal. When fully assembled, a thin piece of rubber is wrapped around the housing and the front cap and secured with two band clamps for water tight seal.

Figure 5: Housing assembly with sliding rails

2.2.6 Charge Controller and Watt Meter

The charge controller in Figure 6 is designed to accept the three lines of the alternator's AC output. It then has a built in rectifier which outputs DC power at 12 V to charge a typical 12V battery. The charge controller has a built in function that will stop a battery from overcharging. Alternator braking flips a switch when the battery is at full charge to direct the current away from the battery and towards the heat fins seen in Figure 6. In addition to the charge controller, the device will have a wattmeter at the end of the battery terminals. The wattmeter can provide readings for the voltage, current, power, as well as charge in the battery.

Figure 6: Charge Controller

3 Project Assembly

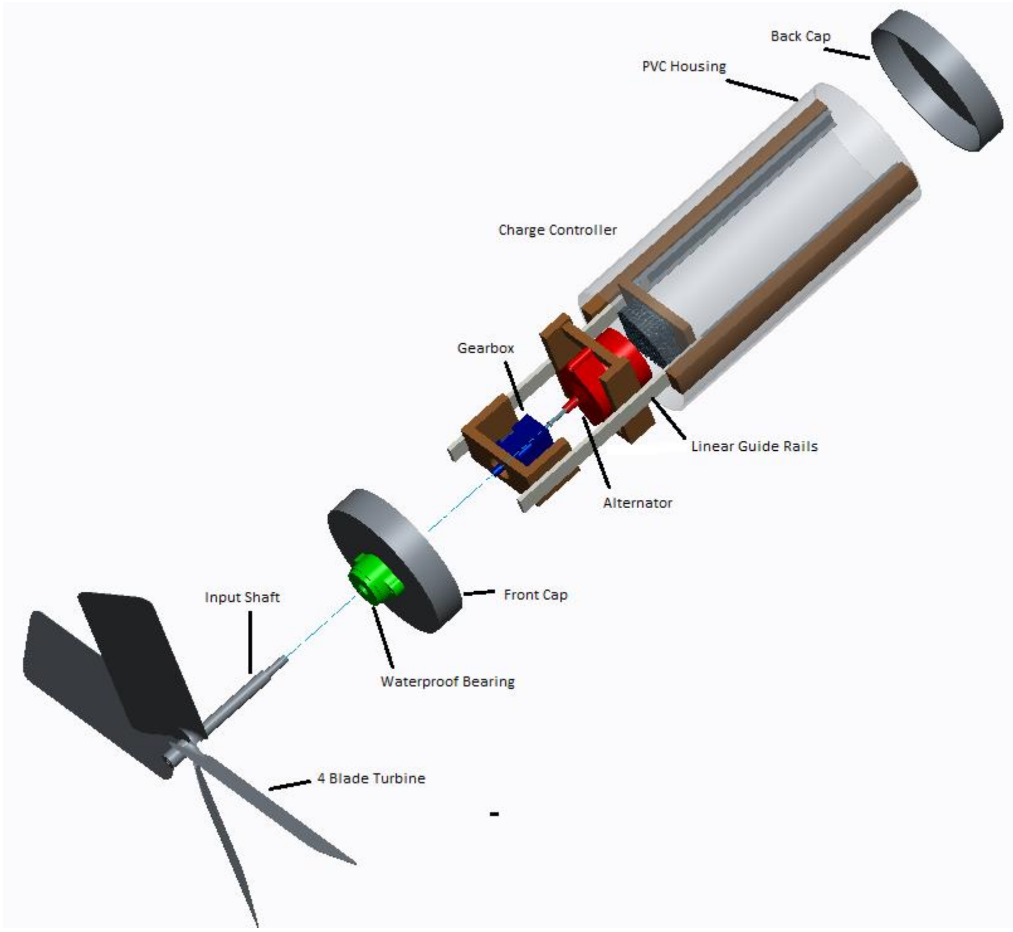

Figure 7Figure 7: Exploded CAD view of the device

3.1 Mechanical Components

Due to the modular design of the hydroelectric generator, assembly of the device is simple and straightforward. The first step in assembling the generator is to connect the alternator and gearbox by inserting the shaft of the alternator into the output of the gearbox. Both the alternator and the gearbox have frames that make it easy to attach the two of them to the sliding rails inside of the housing. The wiring on the back of the alternator should then be run through the waterproof conduit on the back end of the housing. Once the alternator/gearbox assembly is attached to the rail system, the turbine shaft should be fed through the waterproof bearing on the front cap, and attached via coupler to the input shaft of the gearbox. Using the set screw on the fan blade, connect the blades to the rest of the assembly. The front cap then needs to be sealed by placing it over the rubber seal and tightening the screw clamps.

3.2 Electrical Components

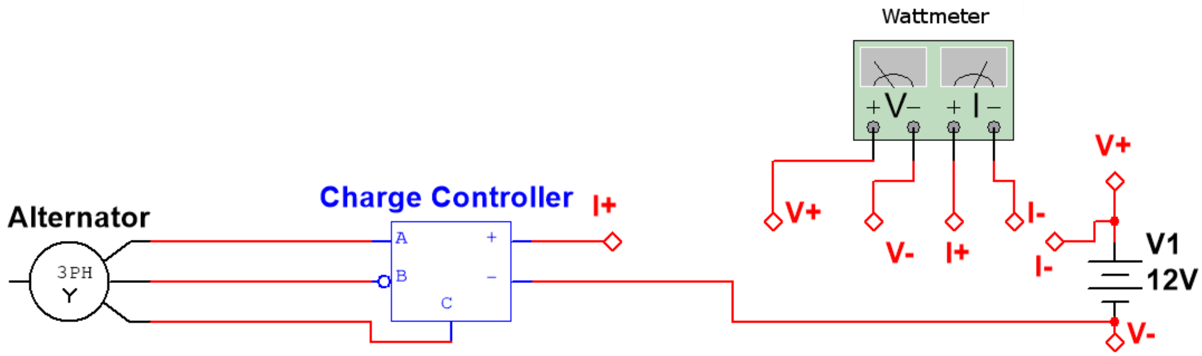

Figure 8: Wiring Diagram

Outside of the hydroelectric generator the electronic components consist of the wattmeter, wiring, and battery that is provided by the user. The wattmeter is conveniently attachable at the ends of the positive and negative cables coming outside the hydroelectric generator. As can be seen in the schematic, the wattmeter goes in between the cables out of the charge controller and the battery. For convenience, the wattmeter will plug into two 2 ft. long positive and negative leads that can be connected to any battery the user desires. Coming out of the PVC pipe is a hollow conduit made out of PVC and steel that will serve to waterproof electrical wiring coming out of the device. They will be adorned with fittings that will allow them to easily be screwed into the PVC housing of the hydroelectric generator. The wires will be housed in the conduit for twenty feet outside of the hydroelectric generator. On land, the wires in the conduit will be plugged into the wattmeter. From the wattmeter, wires will be plugged into the 2ft. long leads that shall go to the user's battery.

4 Operation Instruction

The following instructions for safe operation of the personal hydroelectric generator are designed to be carried out by a single person. However, when installing the generator on location, it is advised that another individual is present to supervise in the event that the user cannot manage the device alone. Take extreme caution when entering a flowing current of water and scout the installation location prior to taking the device into the water. Ensure that there are no underwater hazards present that may compromise footing and watch for floating debris that may be harmful to the user as well as the generator. Wear proper clothing and footwear to protect from flowing debris or spinning turbine blades.

4.1 Transport

The personal hydroelectric generator is unique in that it has a compact design that makes transporting the device much easier. The entire apparatus will fit easily into the bed of a pickup truck or on a small trailer, with plenty of space for other supplies to be packed. Removing the turbine blades by loosing the set screw on the hub of the turbine will allow the user to save more space. When loading and unloading the generator, take caution to avoid bending the turbine blades or unplugging wires/conduit.

4.2 Installation

Once the generator has been unloaded, determine the best location in which to install the device. Proceed cautiously into the water near the location in which electricity is desired. To give the turbine blades room to spin without risk of impacting the river/creek bottom, the device needs to be placed at a depth of at least four feet. Due to the length of the electrical conduit, the device also needs to be within 15 feet of dry land. Find a location that satisfies these two constraints, and ensure that there are no underwater obstructions or hazards. Before placing the generator in the flowing water, check thoroughly that both end caps are secured tightly and that the set screw of the turbine blade is tightened. Ensure that the conduit will not snag on anything and cautiously enter the water. It is important to keep the blades of the turbine above the water when maneuvering to the installation location. If the turbine blades enter the water, they may begin to rotate and present a hazard to the user. Be sure to point the turbine directly into the current, as this maximizes the amount of power that can be harnessed, and reduces the risk that the device will shift or come loose in the water.

4.3 Power Generation

Once the device has been installed in the river, connect the cables from the end of the conduit to a battery. When the turbine is spinning and the wattmeter is properly connected to the wiring and battery, the user will see the proper readings for amperage, voltage, and wattage to the battery. This allows the user to easily monitor what is going on electronically. It is imperative that the generator should not be used if the charge controller is not in place. Because the charge controller is set to output a maximum of 14V, it is important that the user only use a 12V battery in the system. The cutoff at 14V will ensure that the voltage in the battery never gets too high to cause damage. If a user installs a battery with a voltage that is too low or high, it is possible that the battery will overcharge or never reach its full capacity.

4.4 Deconstruction

When the user is finished using the Personal Hydroelectric Generator at the desired location and wants to remove it from the flowing stream for transportation, deconstruction must take place. The user must be mindful of the electrical attachments and be sure that the wires connected to the battery are disconnected and grounded. When the user begins removing the generator from the water, the user must remove it slowly and carefully to allow the turbine to slow or stop before being moved onto land for transportation.

5 Troubleshooting

Throughout the lifetime of any device, there are bound to be some small issues or problems that occur. The purpose of this section is to help the user with some of the more common issues that might be faced during the lifetime of the product.

5.1 Water is leaking into the housing

The introduction of water into the housing of the hydroelectric generator is the greatest threat to the operation of the device. If too much water leaks into the housing, the electrical components could be severely damaged and require replacement. At the first sign of any water leaking into the generator housing, the device should be immediately disconnected from any batteries or other electrical equipment. Remove the PVA sponge from the housing, then wring it out until it is dry. If the leak is significant, the source needs to be found and addressed immediately. Remove the interior components by taking the sliding rails off of their tracks. Place the housing and end caps in water to locate the leak, and use marine grade epoxy to repair the leaks.

5.2 The turbine is spinning, but no power is being generated

If the turbine blades are rotating and no power is being produced, this means that there is a problem with either the wiring in the device or the shaft connections. See Figure 8 to ensure that everything is connected properly inside and outside of the device. Improper connections will disrupt the flow of electricity and no power will be produced. Also, make sure all set screws to the shaft couplings are tightened.

5.3 The turbine blades will not spin

Without rotation of the turbine blades, no power can be produced. First, check the charge of the battery to ensure that it is not completely discharged. A dead battery puts a very large internal resistance on the alternator, which therefore requires much more torque to spin. Next, check the set screw on the turbine blade hub to verify that it is indeed tightened. If not, tighten the set screw to connect the turbine blades and the input shaft. Lastly, if the blades still do not turn, it is likely that the water is not moving fast enough to provide the required torque to spin the alternator. The only remedies to this problem are to either find a new location with faster flowing water, or wait for the flow at the current location to increase.

6 Regular Maintenance and Spare Parts

6.1 Maintenance

In order to extend the life of the device, it is imperative that routine maintenance is performed. Every time the device is removed from the water, check the interior for any signs of leakage and clean up any water that may have entered. Allowing water to collect inside of the housing will create fatal issues with the alternator and render the part useless. Check the PVA sponge regularly and dry it out to maintain its absorbent properties.

Check all connections, ports, and wires before each use to check for any corrosive damage that may have occurred. Damage to these components may disrupt current flow and prevent any energy from being produced. Disconnect the battery before doing any maintenance on any electrical components of the device.

Routinely check the turbine blades to make sure they have not suffered any damage. Any major nicks or bends in the blades will result in a loss of power production, so that is important to try to protect the blades at all times.

6.2 Spare Parts

The personal hydroelectric generator was designed so that it will operate with minimal user work required, however, it may be necessary to replace certain parts at various intervals. Some parts that may be useful to keep on hand are listed below. The bill of materials for the personal hydroelectric generator prototype is found in the appendix.

- Bolts for interior housing
- Rubber gaskets for end cap
- Screw Clamps
- Wiring

7 Appendix

7.1 Bill of Materials

Bill of Materials				
Team 7				
Personal Hydroelectric Generator				
Item(s)	**Vendor**	**Quantity**	**Price per Unit ($)**	**Total ($)**
DC 540 Alternator	WindBlue Power	1	239.00	239.00
12V/25A Charge Controller	WindBlue Power	1	44.00	44.00
60V/100A Watt Meter	WindBlue Power	1	24.00	24.00
5' of 11" PVC Pipe	Commercial Ind. Supply	1	170.00	170.00
External PVC End-Caps	Commercial Ind. Supply	3	74.80	224.40
Water-Proof Bearing	TNN-JEROS	1	101.36	101.36
Turbine Blade	Lowes	1	235.43	235.43
1' Aluminum Shaft	Grainger	1	16.17	16.17
Linear Guide Rails	HomeDepot	1	21.76	21.76
Assembly Hardware	HomeDepot	1	44.23	44.23
Assembly Hardware	HomeDepot	1	15.72	15.72
Gearbox	Anaheim Automation	1	330.00	330.00

7.2 CAD Drawings

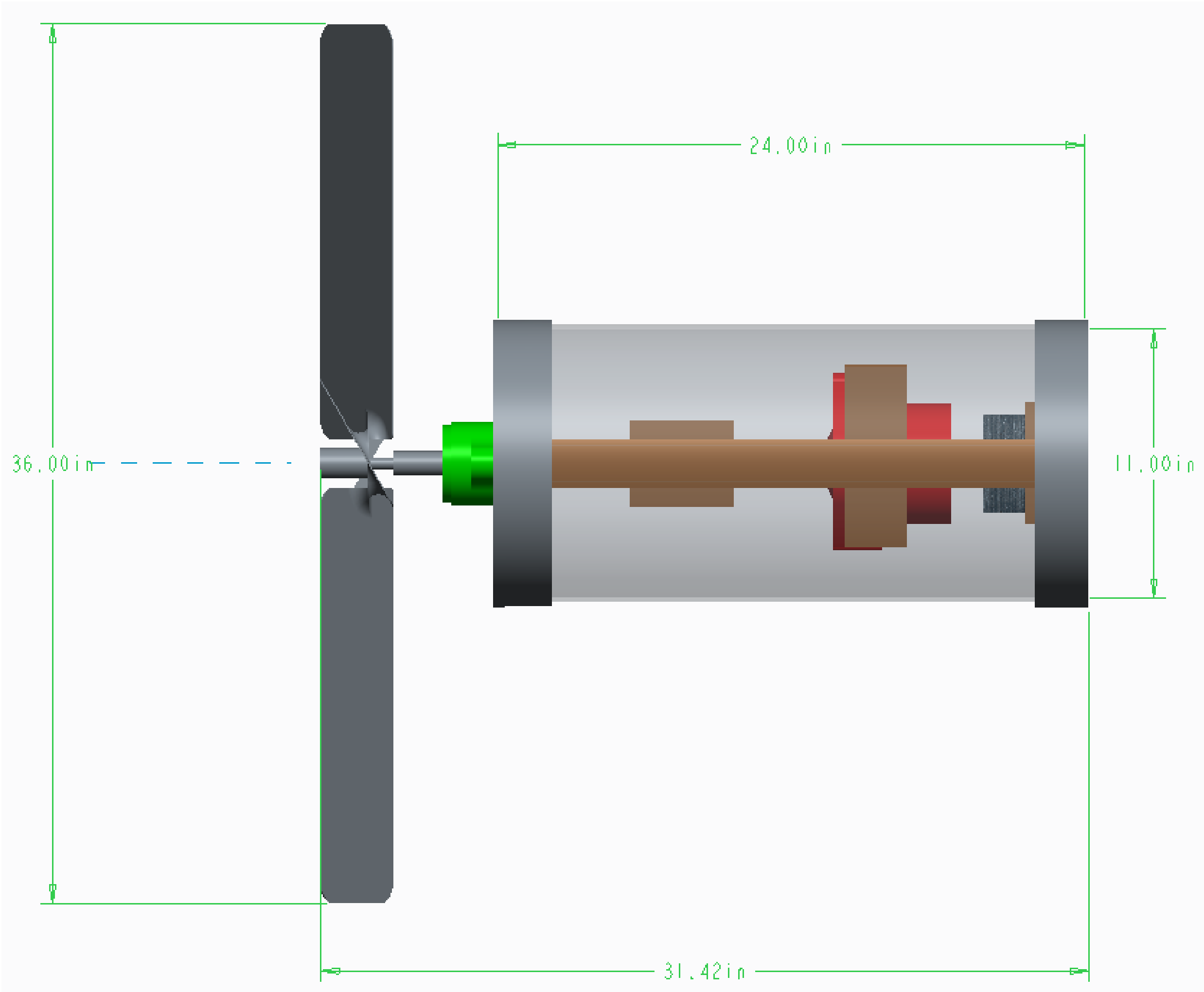

Figure 9-Dimensional CAD detail of PHEG

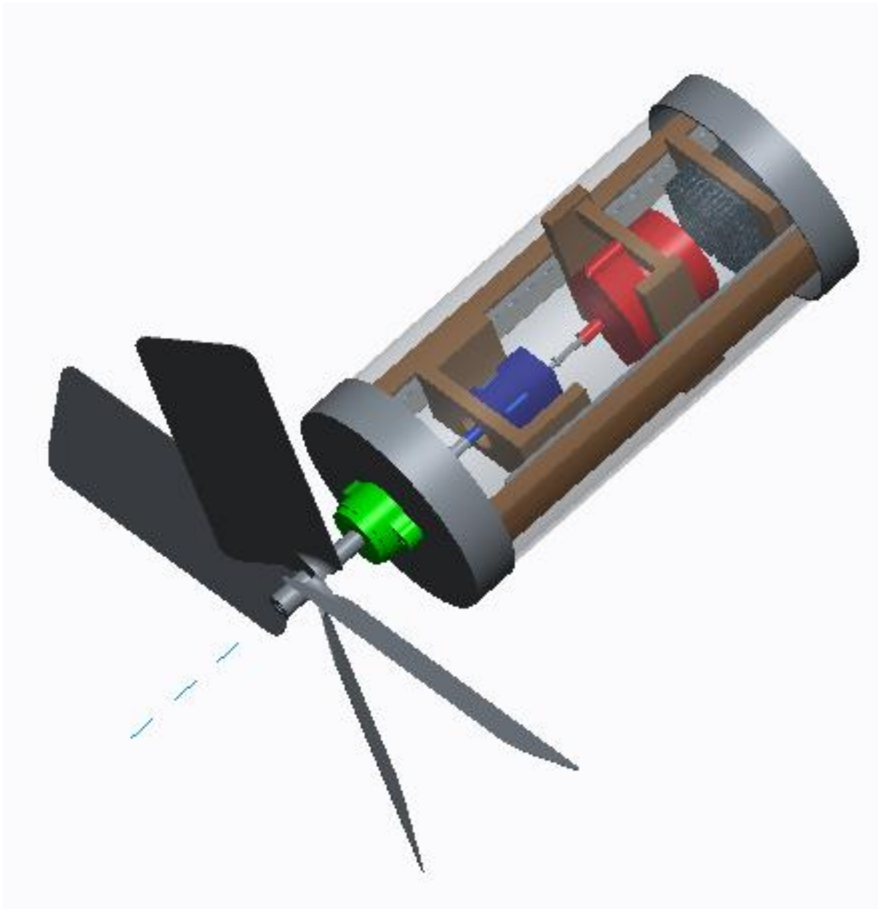

Figure 10: Tilted CAD View of PHEG