Restated Project Definition and Project Plan/Scope

Team 15

Portable Wind Turbine

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Abstract

This report contains information on updates regarding the development of a Portable Wind Turbine. Based on calculations and engineering specifications design changes were necessary in order to optimize the wind turbine for increased portability and efficiency. One of the initial design adjustments would be an overall reduction in weight to a maximum limit of 200lb. Some structural design changes include a telescoping tripod base, an anchoring system, as well as custom nacelle and blade mounting features. Environmental aspects such as global wind speeds, the wind flow profile along the earth's surface, and sloped surfaces have been included into design modifications in order to achieve maximum efficiency, portability, and structural stability of the Portable Wind Turbine. With the given design constraints of an maximum height of 2m, and 4 m/s wind speed operation. A key component of the wind turbine is the alternator, based on research and probable location of the wind turbine the WindBlue Power DC-540 Permanent Magnet Alternator was selected for power generation purposes. Following the conclusion of the mechanical/structural design process and alternator selection all required parts will need to be ordered to begin assembly and testing of the Portable Wind Turbine.

1. Project Overview

The purpose of this project is to create a lightweight, portable wind turbine capable of supplying power in remote, rural areas. The design must be easy to assemble and disassemble so that inexperienced operators may use the device. In addition the assembly and disassembly of the design must be safe for the operator. Because of these restraints, the design must be able to generate power using $4ms$ winds at a height of only 2m. The sponsor of the project has allotted $2,000 for the turbine design and construction. Background research on pre-existing small-scale wind turbines has been conducted to better familiarize the team with designs that are already known to work. However it was discovered that no pre-existing designs for a “portable” wind turbine were available.

As previously mentioned the wind turbine is to operate in wind speeds of 4 m/s. In order to determine a proper location where the turbine could function in the desired conditions, the wind profile along the earth’s surface was analyzed using the log wind profile ratio at 80m above the surface in correlation with maps displaying average annual wind speeds of potential locations at the same height. Based on the wind profile data results the location of the wind turbine was chosen to be in a central portion of the United States such as Nebraska or Kansas.

Regarding the mechanical and structural design of the portable wind turbine there are numerous elements that were taken into consideration. Using Betz Limit the suitable number of blades was decided, which would be a 3-blade system due to the fact that a 5-blade system showed very minimal increase of the power coefficient in comparison to the 3-blade system. The selected blades are made of UV-Stabilized polycarbonate and are 28 in. in length. The blades will be attached using a modified standard 3-blade wind turbine hub for ease of assembly. The base of the turbine will be a telescoping tripod comprised of aluminum tubing with steel retainer pins for secure height adjustment. A screw anchor will also be used in the design of the wind turbine base in order to provide more resistance to overturning. The nacelle will be mounted using a steering quick release system. Mounted to the bottom of the nacelle, the quick release will mate to a shaft that will be fit into a set of bearings, fit into the base of the turbine. There are still components of the system that may require design such as the nacelle housing.

The generator selected for the portable wind turbine is the WindBlue Power DC-540 Permanent Magnet Alternator. Details concerning the selection are mentioned later in the report. The design stages of the project are now beginning to conclude and the time for ordering of parts and assembly approaches in order to initialize testing of the portable wind turbine. It is essential that all detailed design be completed in correlation with the gantt chart, so that the assembly phase proceeds without error.

2. Objectives and Constraints

2.1 Need Statement

Team 15 is designing a portable wind turbine for the sponsor, Dr. Sungmoon Jung. Dr. Jung desires that the team create a small turbine that can produce enough power to charge a small device, while being easy to transport. The turbine must operate in 4[Equation] winds, be lightweight, easy to assemble and disassemble, cost under $2000, and be able to handle a variation of wind and climate conditions at the height of two meters. There is a need for portable, renewable energy. Current small wind turbines cannot produce energy efficiently from 4[Equation] winds or be relocated easily.

2.2 Goal Statement & Objectives

Due to the fact that wind speeds are lower at ground level, the two meter, portable turbine will have to utilize energy from only four meter per second winds.

"Design a lightweight and portable wind turbine that may be easily assembled and produce enough energy at low wind speeds to charge a small device."

The objectives of this project are to design a wind turbine that meets the following criteria:

- Produce enough energy to charge a small device.
- Operate at lower wind speeds than current models.
- Assemble more easily than current models.
- Structurally stable on various surfaces and in various situations
- Light enough to allow easy transport.

2.3 Constraints

The following are the constraints for the project as defined by the sponsor. Team 15 will be utilizing skills gained in the courses taken in the College of Engineering to come up with the proper performance and design for the portable wind turbine.

- Must be easy to assemble and disassemble
- Structural stability in various locations with different terrains
- Lightweight for portability and ease of use
- Operational in low wind speeds (4 m/s)

- Height of turbine will be no more than 2m

2.3.1 Design Specifications

The following are the design specifications for the portable wind turbine:

1. Turbine must operate in an average wind speed of 4 m/s at a maximum height of 2m.
2. The design must be lightweight. Team 15 desires to keep the total weight under 80lbs
3. The design must be easy to assemble and disassemble.
4. The prototype construction has a maximum budget of $2,000.

2.3.2 Performance Specifications

The following are the performance specifications for the portable wind turbine:

1. The power output of the wind turbine will be a minimum of 5W.
2. The turbine will be able to handle a variation of wind and climate conditions.
3. The turbine will not break or overturn due to anticipated, reasonable conditions.
4. The turbine will generate enough power to charge a small device such as a cell phone.

3. Current Progress

3.1 M.E. Students

The mechanical engineering students of Team 15 have been focused on developing systems for the mounting of the turbine blades to the nacelle of the turbine, mounting the nacelle of the turbine to the base and determining what electrical components are needed in order for the turbine to be able to generate power and charge a small, electronic device.

Basic concepts for the mounting of the blades to the nacelle have been proposed, but this work is still ongoing. Better concept generation will be possible once the selected turbine blades have been ordered and received by the team.

Conceptual designs and drawings have been developed for the mounting of nacelle to the base. Team 15 has settled on using a steering wheel quick release system for this purpose and is in the process of sourcing a quick release for this purpose.

Although many difficulties were encountered, the mechanical engineering students have been able to determine several components that may be needed for the electric circuitry of the turbine. An alternator has been selected (discussed later in this report) and is ready to be ordered. Upon receiving this alternator the mechanical engineering students of Team 15 will be order to conduct tests on the actual output voltage and current of the alternator at a range of input rotational speeds and make a final determination of what other components will be needed for effective power output from the Portable Wind Turbine.

3.2 C.E.E Students

Until now, the civil engineering students have spent time researching previous designs and locations where the turbine could be implemented. They have selected the design concepts for the body and base of the turbine and have determined a reasonable size for the parts. They have also determined the material that the parts will most likely be composed of. After completing several sets of calculations, they should be able to determine more precise required sizes and material properties, which will be used to select and order the parts.

4. Moving Forward and Potential Challenges

4.1 M.E. Students

The three mechanical students are working on finishing the design of everything north of the legs and base. This includes selecting blades, selecting a generator, choosing the elements of the electrical circuit that will allow for battery charging as well as device charging. Currently, the blades and generator have been selected. The first step in determining which diodes, charge controllers, and battery to select is to first run tests on the selected generator. This output of power from the generator, which can be determined individually as an output of voltage and current, will help to first establish which charge controller to buy, as well as selecting which battery to use. The team is still doing research and deciding whether a Lithium-ion battery or a Nickel-Cobalt battery would be the most ideal to use. There are obvious pros and cons to both, so the team will have a better idea which to use once the generator is tested and the current and voltage output is established.

In addition to the electrical system being established, the mechanical students have one other major job to complete, which is the force analysis on all the other new parts and connections. This is done by recreating each part in Creo and running different stress situations on the assembled parts.

Potential challenges that the team needs to be aware of are ordering parts and getting them on time. Most of the vendors the team has been looking at seem to get things delivered in a timely manner, but obviously unforeseeable things can still happen and the team must be aware of this potential challenge as well as have a course of action if it happens. Another significant potential challenge is that the electrical system could malfunction, and the team is still learning electrical engineering, so problems could be more major than normal. That being said, steps are being taken one at a time with thoughtful calculation and selection so not to choose the wrong part or to spend more money than necessary.

4.2 C.E.E Students

The three civil engineering students are currently working towards deriving the equations for the forces in the body and base of the turbine. These equations will be used to calculate the minimum size of parts required to prevent failure, in order to minimize the overall size of the turbine as a whole. These equations will account for wind loads and self-weight loads acting on the blades, body, and base at all slopes of the land. These equations will also account for loads that the turbine might encounter if it were to be bumped. The civil engineering students are also looking into soil capacities to determine the added factor of safety an anchoring system could provide against overturning.

After the equations have been derived, several expected loading scenarios will be analyzed. A variance in wind speed and slope of ground surface will have to be accounted for to ensure the turbine will not fail in situations that differ a reasonable amount from the expected. After these scenarios have been analyzed, the material properties, geometric properties and sizes of parts will be evaluated, through trial and error, to determine whether the parts would be acceptable, and the factor of safety that they could provide.

5. Procurement Updates

Team 15 has made final selections for the turbine blades as well as the alternator to be used in the Portable Wind Turbine design. After ordering and receiving these parts, Team 15 will be able to complete the analysis and source the other materials needed for the prototype.

As presented in previous deliverables and presentations, Team 15 decided on the WindyNation three blade set of 28in HyperSpin P Wind Turbine blades, made of UV-stabilized polycarbonate blades. These blades can be purchased from WindyNation's website for $54.98.[1]

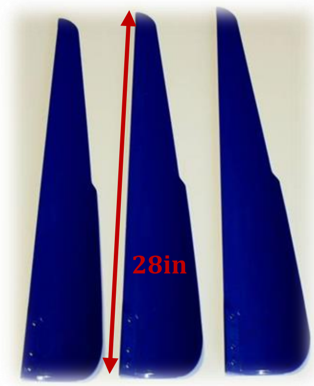

Figure 1. The selected blades for the Portable Wind Turbine.[1]

After careful research, Team 15 decided to pair these blades with the WindBlue Power DC-540 Low Wind Permanent Magnet Alternator. According to the provided specifications, this alternator will be able to easily meet the project's needs at the expected 250RPM (calculated using the given wind speed and tip speed ratio of the selected blades). This alternator can be purchased from WindBlue Power's website for $239.00.[2]

Figure 2. The WindBlue Power DC-540 Permanent Magnet Alternator.[2]

6. Resource Allocation

During the fall semester, Team 15 developed a system of task allocation for the project in an attempt to evenly distribute work amongst the team members. Table 1 shows a revised version of this task assignment list.

Table 1. The task assignment list developed by Team 15.

Task	Team Member(s) Responsible
• Background Research – Wind Power	• Stephanie McLellan • Stephen Freeman • Rishad Walker
• Background Research – Suitable Locations for Wind Speed Constraint	• Katelyn Bamundo
• Background Research – Existing Small Scale Wind Turbines	• Rishad Walker • Stephen Freeman
• Background Research – Structural Design and Material (Body and Nacelle)	• Katelyn Bamundo • Stephanie McLellan
• Background Research – Blade Material	• Stephen Freeman • Matthew Hutchisson
• Background Research – Generators	• Garrett Rosenthal • Stephen Freeman
• Preliminary Structure Design	• Katelyn Bamundo • Matthew Hutchisson • Stephanie McLellan
• Blade Selection	• Matthew Hutchisson • Stephen Freeman
• Generator Selection	• Garrett Rosenthal • Stephen Freeman
• Development of Blade-Nacelle Attachment	• Rishad Walker
• Development of Nacelle-Base Attachment	• Stephen Freeman
• Structure CAD Drawings	• Garrett Rosenthal • Stephen Freeman • Rishad Walker
• Structural Force Analysis	• Katelyn Bamundo • Matthew Hutchisson • Stephanie McLellan
• Part/Material Procurement	• All Team Members
• Cost Analysis	• Garrett Rosenthal • Stephanie McLellan
• Design Selection	• All Team Members
• Project Scheduling/Gantt Chart	• Matthew Hutchisson

7. References

1. WindyNation. 28in HyperSpin Aluminum Wind Turbine Generator Blades, Web, Accessed Jan. 14, 2016. http://www.windynation.com/Blade-Sets/28-inch-HyperSpin-Aluminum-Wind-Turbine-Generator-Blades-Set-of-5/-/651?p=YzE9NQ==
2. WindBlue Power DC-540 Low Wind Permanent Magnet Alternator, Web, Accessed Jan. 14, 2016. http://www.windbluepower.com/Permanent_Magnet_Alternator_Wind_Blue_Low_Wind_p/dc-540.htm

Appendix

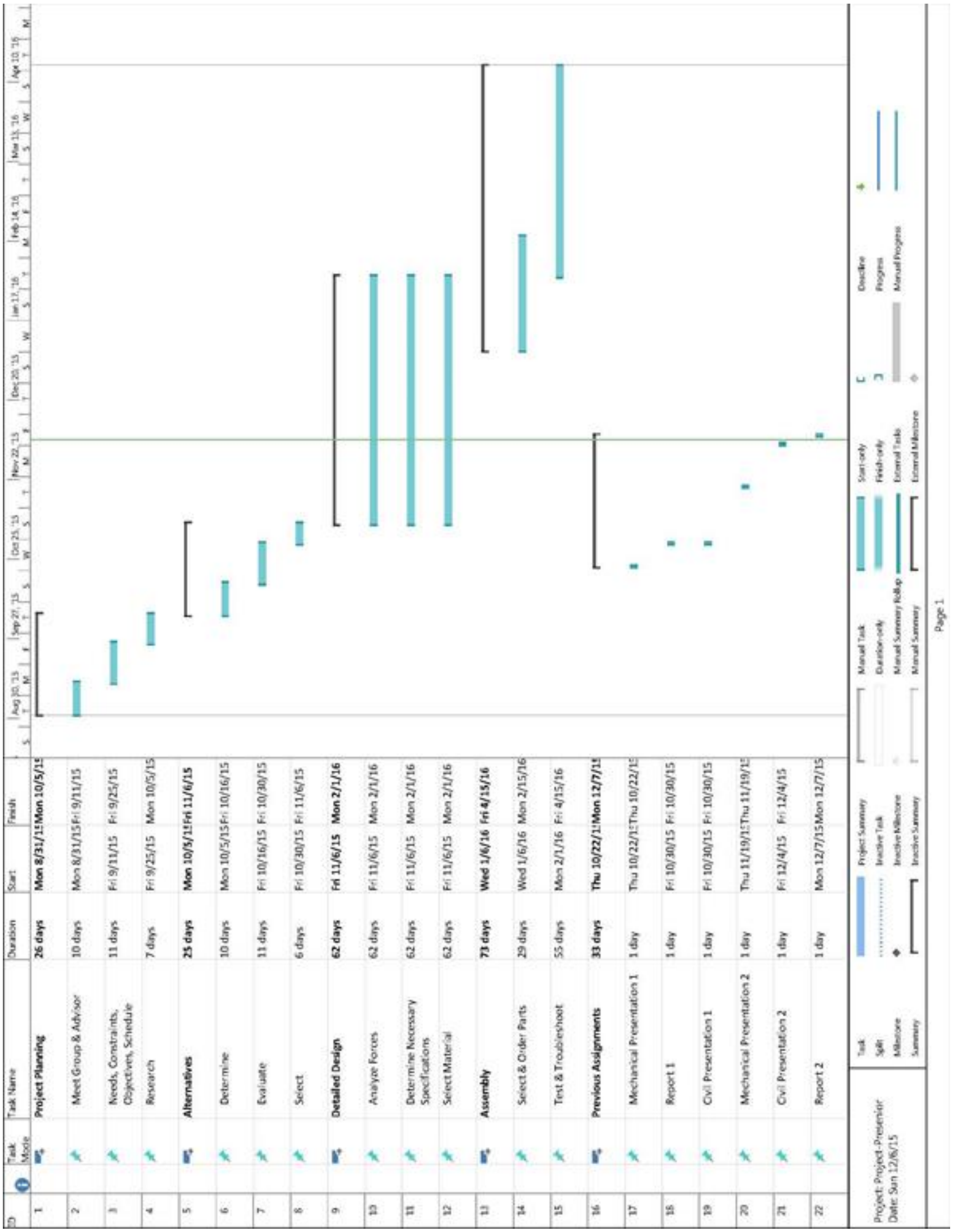

Figure 3. Team 15's Gantt chart for the spring semester.