Harnessing Wind Energy with Recyclable Materials

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Team 03

Concept Generation and Selection Report

Document

Submitted towards partial fulfillment of the requirements for
Mechanical Engineering Design – Fall 2012

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Problem Statement and Brief Background

The client, Dr. Srinivas Kosaraju, expressed the following need:

Inhabitants of third world countries, whom do not have access to electrical grid networks or power production facilities, are in need of electricity.

Based on this need statement, the goal of the "Harnessing Wind Energy with Recyclable Materials" (H-WERM) design team is to provide citizens of third world countries with inexpensive electricity. To accomplish this goal, the H-WERM team will design an inexpensive and portable wind turbine system to harness wind energy. The wind turbine system will include both a wind turbine to generate electricity, and a means of storing the electricity generated.

Concept Generation

Multiple types of wind turbines have been developed over the years to harness renewable wind energy. The most popular types of wind turbines rotate around either a horizontal or vertical axis. Most of the wind energy extracted in the United States is harnessed using horizontal wind turbines. However, the downside to horizontal wind turbines is that electricity is only produced when the turbine is facing into the wind. Despite this though, a horizontal wind turbine can achieve a higher rate of revolutions per minute than a vertical wind turbine can, and thus can produce more electricity overall. In contrast, a vertical wind turbine is more versatile because fewer components are used in the design, and wind flowing in any direction can generate power. These turbines can generate a substantial amount of electricity as well, since they have a large surface area. In reality, both styles of turbines can produce a wide range of electricity, but the determination of which style to use depends on the application and the costs associated with each design.

When designing a turbine to be used in a third world country, many factors must be considered in order to find the most cost and power effective solutions. A few of the design concepts the H-WERM team considered are described below.

Figure 1 – PVC Turbine Blades [1]

The first concept considered is a horizontal turbine with PVC blades cut to form a helix shape prop, as shown in Figure 1. The main advantage of this design is that the blades are made of recyclable materials that are easily obtained, lightweight, and fairly simple to assemble. However, since the wind direction significantly affects the operations of horizontal turbines, this design may not generate enough power, or may require additional components and assembly to allow the turbine to turn into the wind as the wind direction changes. Having inexpensive materials reduces cost, but the mechanical aspect of building this design may prove too complicated for a simple solution.

[1] http://www.mdpub.com/Wind_Turbine/images/blades1.jpg

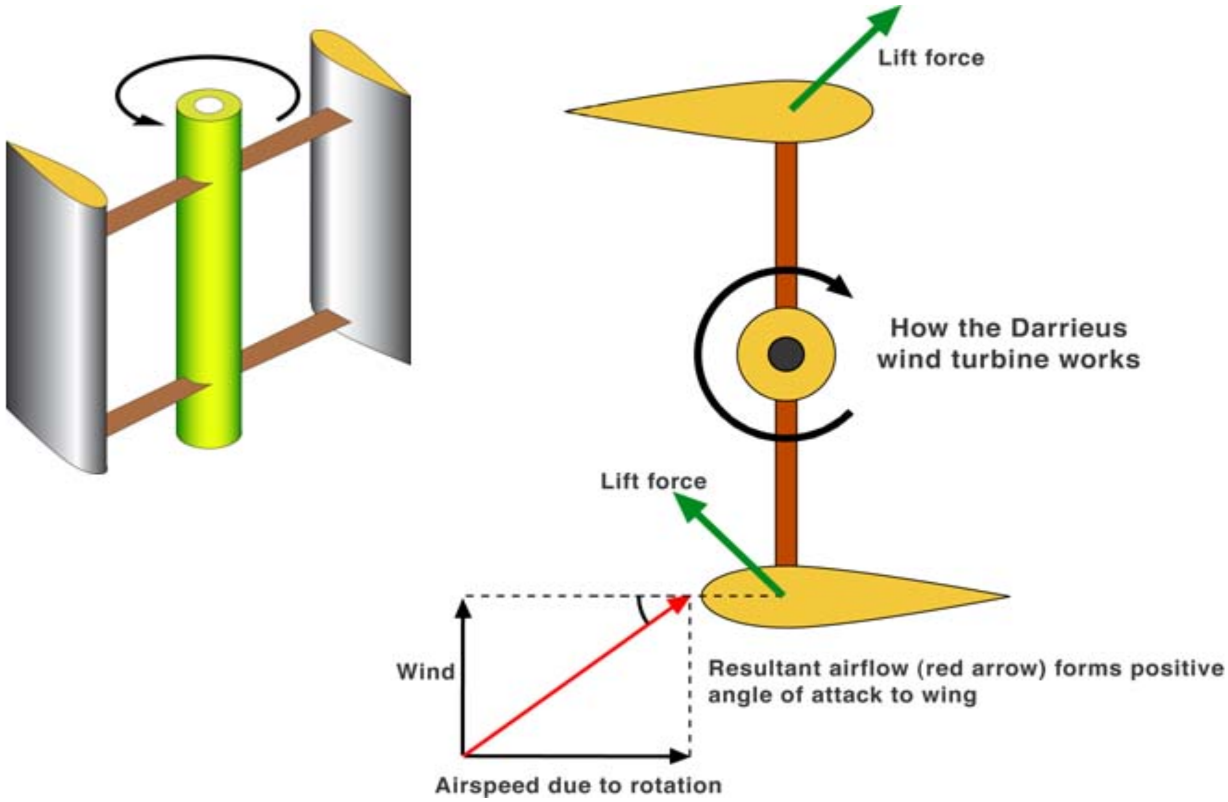

Figure 2 – Darrieus Turbine [2]

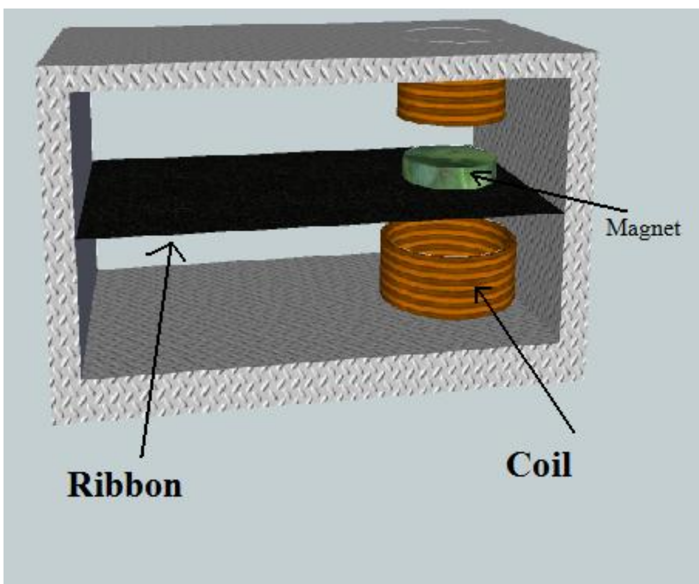

Figure 3 – Wind Belt [3]

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[2] http://2.bp.blogspot.com/-CxJjuGSbuiY/UAAO0MW5LBI/AAAAAAAAArU/62GzAOCH8aY/s1600/Darrieus.jpg

Other concepts researched were the Darrieus or "eggbeater" turbine, shown in Figure 2, and wind belt methods, shown in Figure 3. These wind energy devices have an intuitive design and are used to generate electricity in multiple countries. Although these types of devices have proved worthy in more advanced countries, the limited availability of specialized tools in third world countries makes implementing technology such as this difficult. While these wind turbines work quite well, the downside to technology as advanced as this is that reproducing the precise part dimensions and finding the specific materials required in third world countries may be near impossible. Ultimately, having the best idea may not be the best solution.

Another concept considered involves making a wind turbine out of a bicycle wheel, as shown in Figure 4. By wrapping sheet metal, foil, plastic, or another material around the spokes of a bicycle wheel in the orientation shown in Figure 4, one can very nearly replicate the blades of a wind turbine. Each wheel provides a convenient frame for a turbine. In addition, bicycle wheels have built in bearings, allowing them to spin easily, which is essential for a wind turbine.

Figure 4 – Bicycle Wheel Turbine [4]

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[3] http://wolvespage.yolasite.com/resources/wind%20belt.jpg
[4] http://3.cf.shn.m3cdn.net/wp-content/uploads/2012/03/3500bike-wheel-turbine.png.400x300_q85_crop-smart.jpg

The final concept considered consists of a 55-gallon oil drum and a stand, as shown in Figure 5. As with the PVC turbine blades, this design utilizes recycled materials, namely oil drums, which are readily available in many countries. Also, transporting the materials required for this design to rural areas will be simple, because an oil drum can be easily rolled cross a flat surface. While cutting a steel drum in half may require advanced tools, the overall design will require little assembly. Since this design features a vertical axis, this wind turbine can generate power regardless of the wind direction. In addition, the drum has a large surface area, which helps it catch more of the wind, yielding a higher rate of revolutions per minute, and thus more power generated.

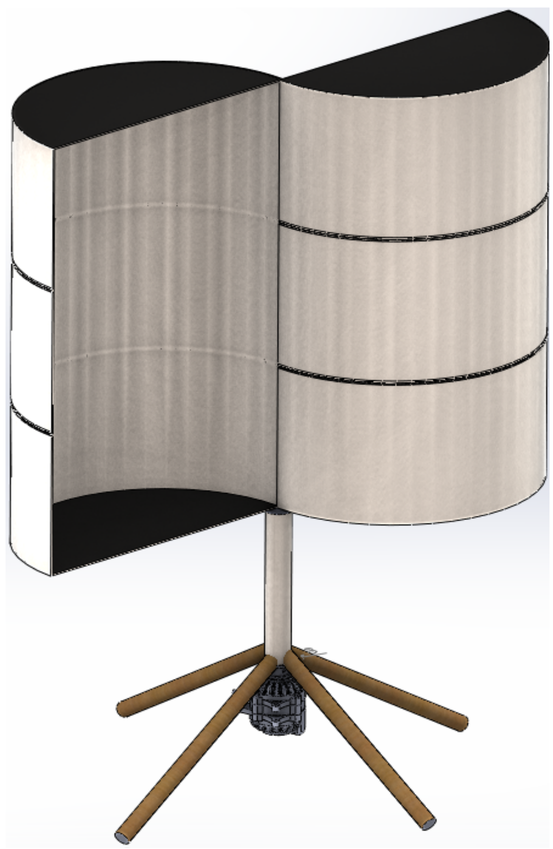

Figure 5 – 55 Gallon Drum Turbine

A generation device, as well as an electrical storage device, is necessary to harness and store the wind energy collected by the turbine. Based on research and available materials, the most readily available devices used for power generation are car, motorcycle stators, and bicycle dynamos. Based on research, motorcycle stators and car alternators are the most cost effective and readily available storage device that can be obtained in a third world country. However, the higher rpms required limits the usefulness of these devices for this application. Therefore, bicycle dynamos are the primary choice for this design.

Concept Selection

Based on the previous steps of the design process, several criteria were identified as being the most important focuses of the design. These main criteria were further grouped into three categories to represent the overall goals of the project. The criteria are listed in Table 1.

Table 1 – Overall Categories of Design Criteria

Portability	Cost	Operation
Weight	Purchased materials	Power produced
Number of parts	Found materials	Material strength
Dimensions		Directionality

These criteria were identified from the project need statement. Since it is necessary for the design to be easily moved, assembled, and disassembled, the team will have to consider the weight of the system, the number of parts, and the size of both the individual pieces and the fully assembled design. The problem statement did not address the issue of cost, but after further meeting with the client, a limitation of fifty dollars per unit was decided to be reasonable. This number includes the cost for items both found in junkyards (price paid by weight of the item) and items purchased in a store. Finally, the need of the client requires a certain operation threshold that must be met by the design. The directionality of the system (how the design will operate under different directions of wind) must allow for 0.5 kilowatt-hours of energy to be produced, and the strength of the materials used must allow for operation under high wind speeds without breaking.

After the design criteria were identified, weights were assigned to each criterion, based on overall importance to the project. The weights of each design criteria are shown in Table 2.

Table 2 – Weighted Criteria

Criteria	Weight
Portability	**0.3**

Weight	0.15
Dimensions	0.075
Number of parts	0.075
Cost	**0.2**
Purchased/found	0.2
Operation	**0.5**
Power produced	0.3
Directionality	0.1
Material strength	0.1

These weights were assigned based on what aspects of the project the team felt were most important. Operation received the largest weight of 0.5, because the main goal of a power system is producing power. For this same reason, the sub-criteria of power produced was given a higher weighting of 0.3, and the directionality and material strength criteria each received a rating of 0.1. Portability followed operation in weight, because it contained more criteria factors than the cost, so 0.3 was assigned to portability overall, and 0.2 to cost.

After the criteria were weighted, the team developed a decision matrix to determine which design was provided the best solution to the needs expressed in the problem statement. Each design was given a rating of 1-5 (1 being the worst and 5 being the best) for each of the criteria and the weighted amounts were summed. The decision matrix is shown in Table 3, below.

Table 3 – Decision matrix for various designs

Criteria	**Criteria Weight**	55 Gallon Steel Drum	PVC Turbine	Vertical Turbine	Rubber Wind Belt	Bike Wheel Turbine
Portability						
Weight	0.15	3	4	4	5	5
Dimensions	0.075	3	4	2	5	4
Number of parts	0.075	5	2	2	3	2
Cost						
Purchased/found	0.2	4	4	3	4	4
Operation						
Directionality	0.1	5	2	5	1	4
Power produced	0.3	5	5	4	1	5
Material strength	0.1	4	5	5	4	5
		4.25	**4.05**	**3.7**	**2.94**	**4.4**

The two designs with the highest scores from the decision matrix were the 55-gallon steel drum and the bike wheel turbine. These are the designs that the team will focus on as we move forward in the design process. Various ways to refine and improve these designs will be considered throughout the design process. For example, the team is considering using a plastic oil drum instead of a steel one to decrease the weight of the turbine.

Updated Project Timeline

Figure 6, below, shows an up-to-date timeline of the H-WERM project progression. The span of the timeline ranges from the project assignment date, to the (current) date this Concept Selection and Generation Report was composed. Note that the color-shaded regions indicate the time allotted for each task at the beginning of the project, while the bold lines with round endpoints indicate the actual dates each task occurred. Also, the bold line with the arrow on the right endpoint denotes the current progress to date.

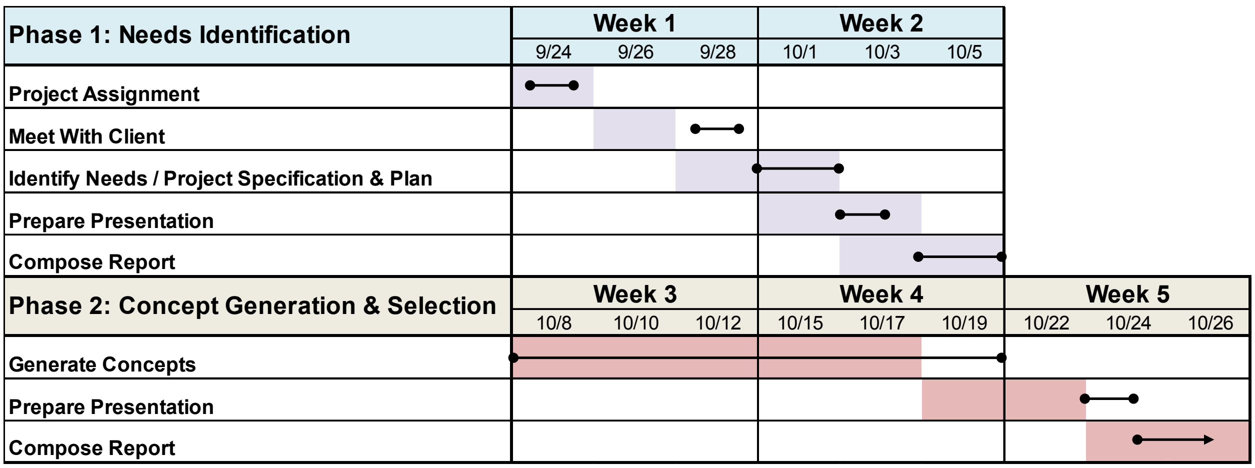

Figure 6 – Current Project Timeline