Harnessing Wind Energy with Recyclable Materials

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Team 03

Needs Identification Report

Document

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Introduction

The "Harnessing Wind Energy with Recyclable Materials" (H-WERM) design project is initiated and sponsored by Srinivas Kosaraju, a Mechanical Engineering professor at Northern Arizona University (NAU), located in Flagstaff, Arizona.

The customer of the design project cannot be specifically identified as an organization or a corporation: the final project design is intended for citizens of third world countries who are in need of relatively small quantities of electrical energy. The energy is intended to provide basic living "luxuries" such as lighting and the use of fan(s).

Needs Identification

To correctly identify and fully understand both the customer need and the design requirements for the H-WERM project, Design Team 03 contacted the project sponsor, Professor Kosaraju, to discuss the H-WERM project. The objective of this preliminary discussion was to discuss and clarify specific aspects of the design that were not clearly indicated in the provided project description. The results of this discussion were considered while defining the following need statement for the H-WERM design project.

Need Statement

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

Problem Statement

The following problem statement was taken from the Project Description provided for the H-WERM design project:

“One of the major developmental issues that plagues third world countries is the lack of electricity. This problem is particularly severe in rural parts which are away from major power production facilities and grid networks.”

Goal

The project goal statement is to provide inexpensive electricity to third world country citizens who are in need.

The scope of the goal statement to provide an inexpensive, portable wind turbine system to harness and store wind energy. The wind turbine system will include both a wind turbine to generate electricity, and a means of storing the electricity generated.

Objectives

The project objectives are to design a wind turbine system that is portable, easy to assemble, able to withstand high wind speeds, and can extract enough energy to store and/or provide 0.5 KWh per day.

The above objectives were determined by considering the following items:

- **Portable:** In third world countries (especially rural locations), there is limited access to vehicles, fuel, and paved roads. As a result, the wind turbine system must be designed such that two to three individuals can transport the system over long distances with varying terrain.
- **Easy to assemble:** Inhabitants of third world countries may have limited access to tools, especially tools that require power for operation. Therefore, the wind turbine system must have the ability to be easily assembled and disassembled, using basic tools, by a few individuals.
- **Withstand high wind speeds:** To ensure the structural integrity of the wind turbine system will be maintained during common storms found in third world countries, the turbine must be able to withstand high wind speeds.
- **0.5 kWh of energy generation/ storage per day:** This objective was determined based upon the use of a 60 W incandescent light bulb and a 40 W fan, both running 5 hours per day.

The basis of measurement for the above objectives is shown in Table 1 below.

Table 1: Design Objectives and Basis for Measurements

Objective	Basis for Measurement	Units
Portable	Total weight	kg
Portable	Total volume when disassembled	m^3
Easy to assemble and disassemble	Time required to assemble and disassemble without power tools	min
Withstand high wind speeds	Stress on turbine at 50 mph	MPa
0.5 kWh of energy extraction/storage per day	Energy generation rate and storage capabilities.	kWh
Low Cost	Cost Analysis of material used for design	$

Constraints

The following constraints are imposed on the wind turbine system:

- The total design budget must not exceed $50.
- The total design weight must not exceed 100 lbs.
- The system must generate and store at least 0.5 kWh per day.

Test Environment

In order to test the portability and ease of assembly and disassembly of the product, a population of NAU students will be recruited to physically relocate, assemble, and disassemble the prototype. The time in which the above tasks are completed will be recorded.

The prototype will be tested against high wind speeds utilizing computer simulations to determine the stress and strain on the model. The details of the computer simulation are yet to be determined.

To determine the optimal wind speed needed to operate the turbine such that it generates 0.5 kWh per day, and to test the device performance, "real-time" testing will be performed on the prototype. The testing location(s) will be determined based off of average wind speed data at various locations near Flagstaff, Arizona. Several test sites are preferred, with varying average wind speeds, so that the prototype may be tested under a range of conditions.

Also, the team has considered "real-time" prototype testing for various weather conditions as well. This type of testing will be performed outside near Flagstaff, Arizona during various weather conditions. However, the extent of this type of testing depends upon weather conditions during the spring 2013 semester.

Recapitulation of Problem Statement

Problem Statement: "One of the major developmental issues that plagues third world countries is the lack of electricity. This problem is particularly severe in rural parts which are away from major power production facilities and grid networks."

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

Goal: To provide inexpensive electricity to people living in third world countries.

Objectives: Table 1 above, containing the design objectives and measurement bases, is reproduced in Table 2, below. The design constraints are also listed below.

Table 2: Design Objectives and Basis for Measurements

Objective	Basis for Measurement	Units
Portable	Total weight	kg
Portable	Total volume when disassembled	m^3
Easy to assemble and disassemble	Time required to assemble and disassemble without power tools	min
Withstand high wind speeds	Stress on turbine at 50 mph	MPa
0.5 kWh of energy extraction/storage per day	Energy generation rate and storage capabilities.	kWh
Low Cost	Cost Analysis of material use for design	$

Constraints:

- The total budget must not exceed $50.
- The total weight must not exceed 100 lbs.
- The system must generate and store at least 0.5 kWh per day.

Design Criteria and Criteria Tree

The design team developed a list of design criteria based on the preliminary discussion with the H-WERM sponsor, the design objectives, and additional research performed in reference to the design problem statement. Table 3, below contains the design objectives with their corresponding quantified objective and criteria.

Table 3: Design Objectives, Quantified Objectives, and Criteria

Objective	Quantified Objective	Criteria
Low Cost	Maximum cost of $50.00	Cost
Recyclable	Available from local junkyards/stores	Recyclability Material availability
Energy Storage	0.5kWh per day stored	Electrical storage capability
Easily assembled, disassembled, moved	Time limit of 1 hour for two people setting it up; weight limit of 100 pounds	Physical construction Materials Set-up
Able to withstand high wind speeds	No breaking/deformation under speeds up to 50 mph.	Materials Design strength

The above criteria are best grouped into five subcategories: cost, recyclability, before operation, during operation, and after operation. The cost and recyclability are in their own categories. The before operation subcategory includes moving and assembling the unit. The during operation subcategory includes the ability to store 0.5 kWh per day and the ability to withstand high wind speeds. Finally, the after operation subcategory includes the disassembly of the unit. A compilation of the subcategories of criteria described above is illustrated in the criteria tree diagram shown in Figure 1.

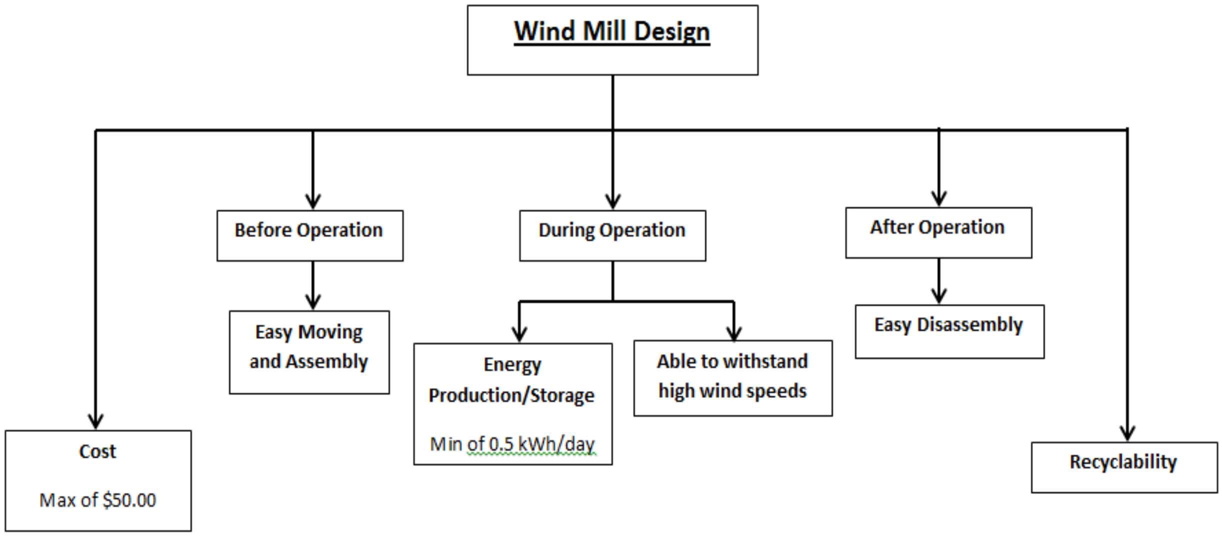

Figure 1: Criteria Tree Diagram

Quality Function Deployment and House of Quality

To relate the customer needs to the engineering requirements for the H-WERM project, Quality Function Deployment and House of Quality analyses was performed. The Quality Function Deployment Chart and House of Quality Diagram (see Figures 2 and 3 below, respectively) are visual tools that provide a cause and effect analysis of design requirements that directly correlate with either the customer requirements, and/or each other.

Specifically, the Qualify Function Deployment chart indicates the engineering design requirements that effect the customer requirements. The House of Quality diagram indicates the design requirements that affect each other. A positive sign on the House of Quality diagram indicates a positive relationship between design requirements, while a negative sign indicates an inverse relationship.

The conclusion of the following diagrams will be considered during the H-WERM design concept generation and selection process.

Customer Requirements	Weight	Energy efficient	Cost	Size	Strength	Surface Area
	Engineering Requirements					
Ease of Mobility	**X**			**X**		
Produces 0.5 kWh		**X**				**X**
Durability	**X**				**X**	
Ease of Assembly				**X**		
Recycled Material		**X**				**X**
Low Cost	**X**		**X**			
Units	lb	W	$	ft^2	psi	in^2
	Engineering Targets					

Figure 2: Quality Function Deployment Chart

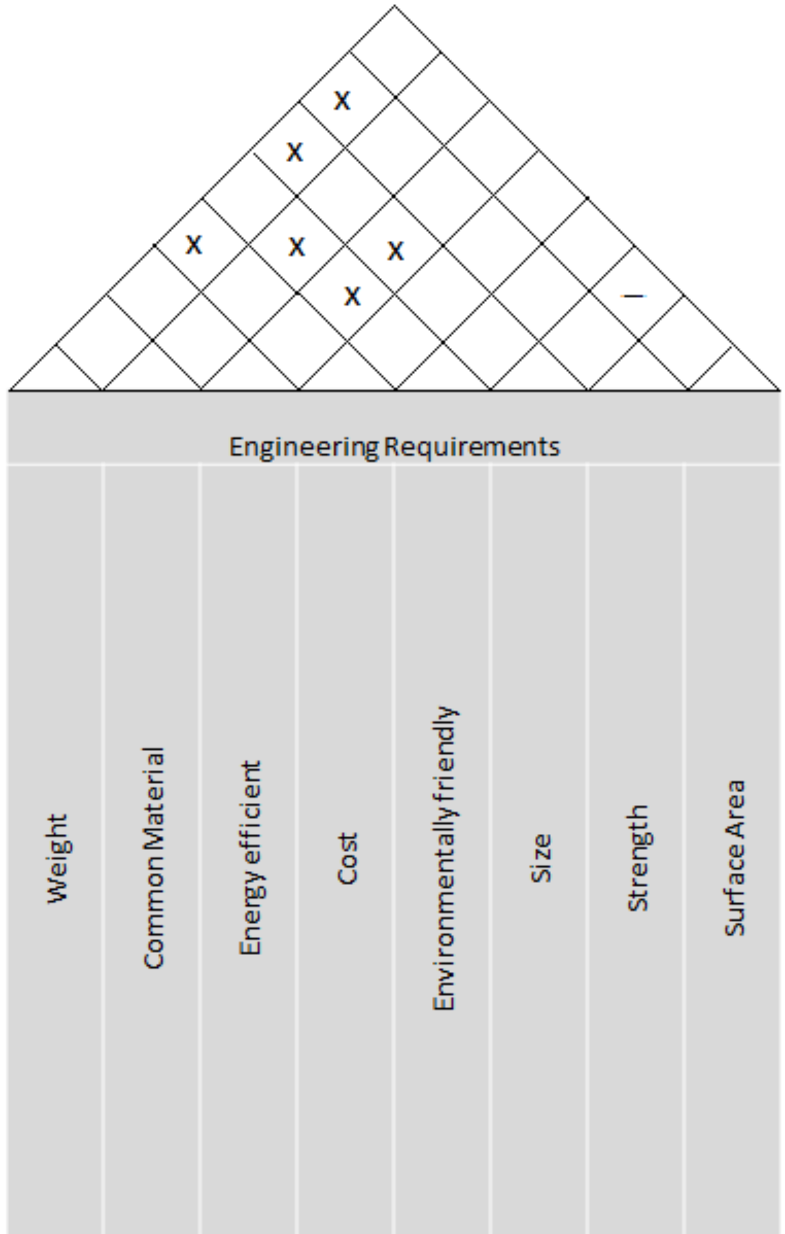

Figure 3: House of Quality Diagram

Project Gantt Chart

Figure 4, below, shows the timeline for the H-WERM project progression. The span of the timeline ranges from the project assignment date, to the (current) date this Needs Identification 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.

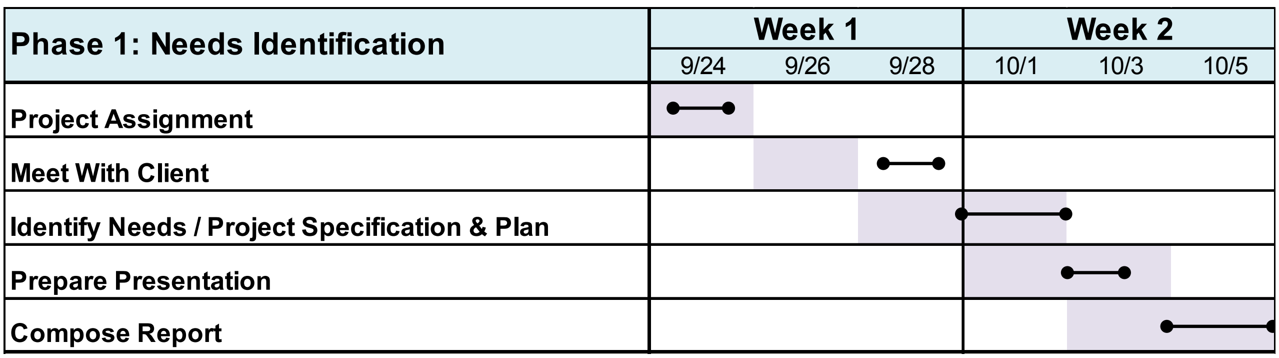

Figure 4: H-WERM Project Gantt Chart