UCI Zephyr Project - Midterm Presentation

University of California, Irvine
MAE 189 - Capstone Project
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Problem Definition and Goals

• Problem Definition

A limited number of small, portable charging devices for camping applications exist in the current market. Our goal is to design a wind turbine that will be small enough to fit in a hiking backpack, be quickly assembled, and be capable of charging several small electronic devices overnight.

• Goals

• Create a design that is lightweight, small, and compact
• Allow the product to be quickly assembled
• Maximize energy output for charging
• Minimize the cost of manufacturing

*Current market Portable Wind Turbine*
## Design Attributes

### Key design principles:
- Reliability
- Ease of Assembly
- Ease of Operation
- Portability
- Capability

<table>
<thead>
<tr>
<th>Attribute</th>
<th>O</th>
<th>C</th>
<th>F</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Must be easy to manufacture and assemble</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Should be simple and compact</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
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<tr>
<td>Must be reliable</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
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<tr>
<td>Must be safe</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
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<tr>
<td>Should be easy to operate</td>
<td></td>
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<td>X</td>
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<tr>
<td>The packing size and weight should be very small to be added to a hiking backpack.</td>
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<td>X</td>
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<tr>
<td>Must be able to charge portable appliances of a camping family (2 Cell Phone, Camera battery Charger, flashlight, backup battery bank)</td>
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<tr>
<td>Might use an energy storage system</td>
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<td>X</td>
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<tr>
<td>Might be collapsible</td>
<td></td>
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<td></td>
<td>X</td>
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<tr>
<td>Must resist deterioration from natural elements (rain, dust)</td>
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<td>X</td>
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</table>
Key Mechanical Design Decisions

Wind Turbine Type

- Vertical versus Horizontal

Power Generated

\[ P = \frac{1}{2} C_p \rho \frac{A}{m^2} \]
\[ \rho = 1.225 \frac{kg}{m^2} \]
\[ V = 10 \text{ m/s} \]

<table>
<thead>
<tr>
<th>Type</th>
<th>Cp</th>
<th>Radius (ft)</th>
<th>Height (ft)</th>
<th>Wattage</th>
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<tbody>
<tr>
<td>H Type</td>
<td>0.38</td>
<td>0.5</td>
<td>1.25</td>
<td>27.0</td>
</tr>
<tr>
<td>D Type</td>
<td>0.40</td>
<td>0.5</td>
<td>1.25</td>
<td>28.5</td>
</tr>
<tr>
<td>Helical</td>
<td>0.43</td>
<td>0.5</td>
<td>1.25</td>
<td>30.6</td>
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<tr>
<td>HAWT</td>
<td>0.45</td>
<td>1</td>
<td>N/A</td>
<td>80.2</td>
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</table>

* (A) Vertical and (B) Horizontal Turbine types*
Key Mechanical Design Decisions

Portability Mechanisms

- Tower Subsystem
  - Telescoping vs Multiple Components Tower
- Blade Subsystem
  - Removable vs Retractable Blades
- Base Subsystem
  - Stake versus Tripod

H type turbine - Umbrella Cast concept

Andrew Lam
Other Mechanical Design Concepts

D type turbine - “Bend-a-Plastic” concept

“Collapsed HAWT” concept

Andrew Lam
Key Electrical Design Decisions

**Motor Type**
- Brushless DC
- Asynchronous AC
- Synchronous AC

**Power Conditioning**
- Rectification
- DC to DC conversion
- Inverter

**Criteria**
- Power/weight ratios
- Volts/rpm ratios
- Efficiency
- Maintenance Requirements
- Cost
Electrical Concepts Diagrams

*Brushless DC*

*Asynchronous AC*

*Synchronous AC*
Design Summary

• Design Features
  • Horizontal Axis Wind Turbine
  • Brushless DC Generator
  • Telescoping tower
  • Folding and telescoping tripod
  • Removable blades

*Detailed Sketch of PWT model*

Nausir Firas
Design Summary Cont.

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
<th>Opportunities</th>
<th>Threats</th>
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</thead>
<tbody>
<tr>
<td>• Incorporating the horizontal wind turbine allows for far greater</td>
<td>• The design would need to incorporate a method of facing optimal wind</td>
<td>• Provide more power than current market designs</td>
<td>• Potentially low demand for such a product because it would not provide enough power for extended camping trips</td>
</tr>
<tr>
<td>efficiency compared to vertical wind turbines</td>
<td>direction</td>
<td>• Provide a cheaper product than current market designs</td>
<td></td>
</tr>
<tr>
<td>• The telescoping base allows for the design to be small and compact</td>
<td>• Portability mechanisms are complex and add more failure points</td>
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<td></td>
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<tr>
<td>• The use of a BLDC generator allows for low maintenance and high</td>
<td>• Ability to generate enough power to support the charging of all the</td>
<td></td>
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<tr>
<td>durability while minimizing weight</td>
<td>requested items overnight</td>
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<tr>
<td></td>
<td>• Blade sizing can affect fit within a hiking backpack</td>
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Nausir Firas
Design Schedule

- Detailed Engineering Analysis
- 3D Modeling and Drawings
  - 5/2-5/12
- Prototype Plan
  - 5/9-5/12
- Design Verification
  - 5/9-5/12

- **Mechanical** (Brendan, Andrew, Nausir)
  - Blades
  - Tower and Tripod
  - Generator Housing
  - Portability Mechanism

- **Electrical** (Gerardo, Felix)
  - Generator
  - Control System
  - Circuit Board

Nausir Firas
Concerns

• Verification of power generated (ANSYS or MatLab)
• Tower material choice (Acrylic vs PVC Pipe)
• Wiring complications due to telescoping tower
• 3D printing blades and blade housing
• Orienting mechanism
Thank you for listening
Questions?