Winderness Charger

Group 18

MAE 189 Capstone Fall 2022

UCI Samueli School of Engineering

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Executive Summary

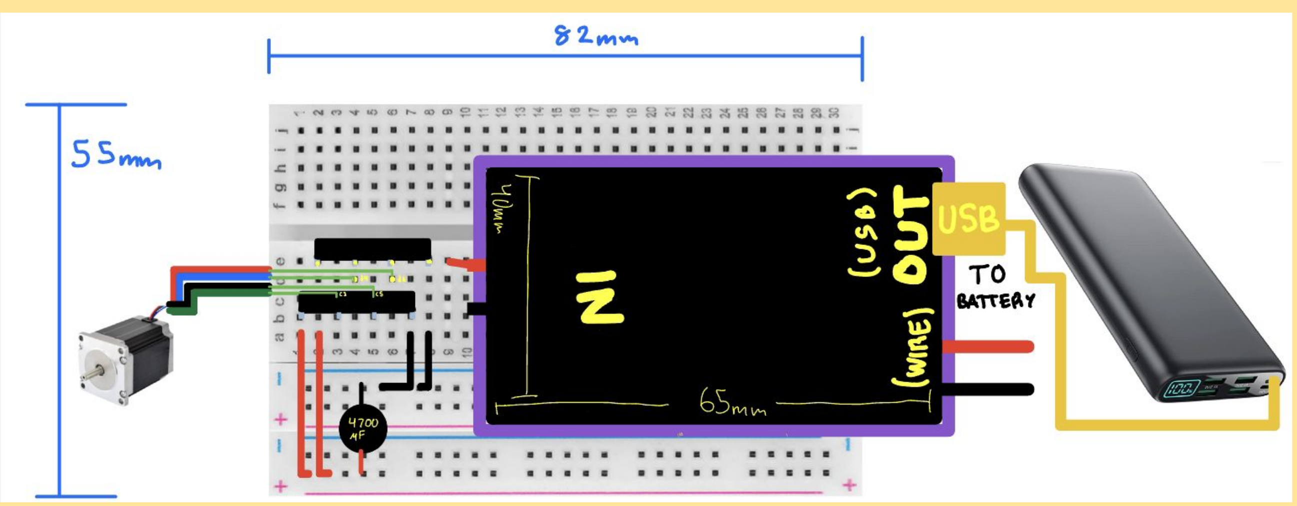
Modern campers rely on electronics to navigate, survive, and document their adventures away from civilization. They need a way to charge their devices in the wild. Problem Statement: Design a small-scale wind turbine capable of charging 2 phones, a flashlight, and a camera battery overnight

Design Criteria

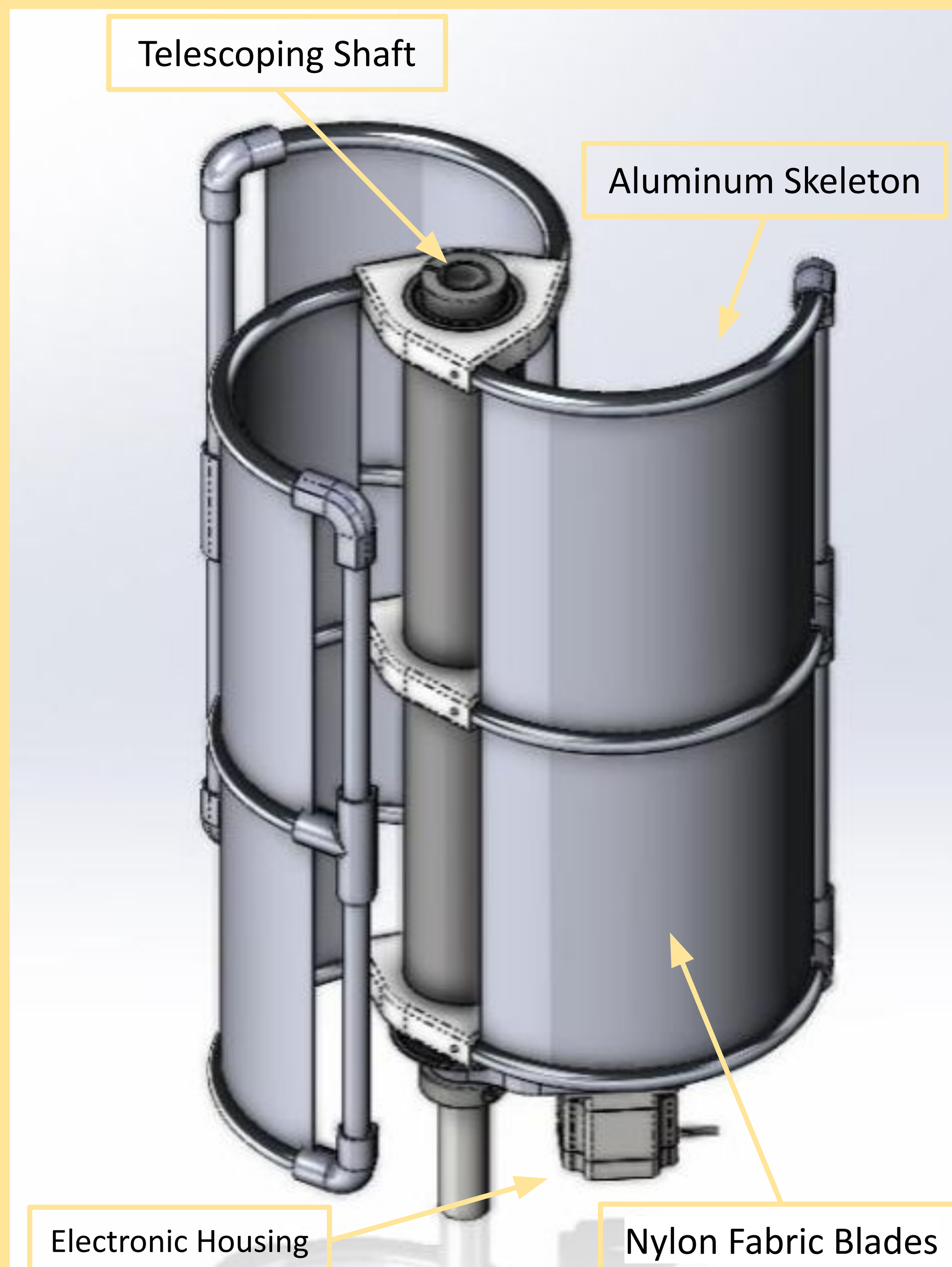
Can be carried in a hiking backpack	Less than 5 kg and 10 liters
Capable of charging the 4 electronics	Produce an average power of ??? Watts
Easily deployed and assembled	Parts can be assembled and installed by 1-2 people

Prototype Assembly

Final Design & Performance



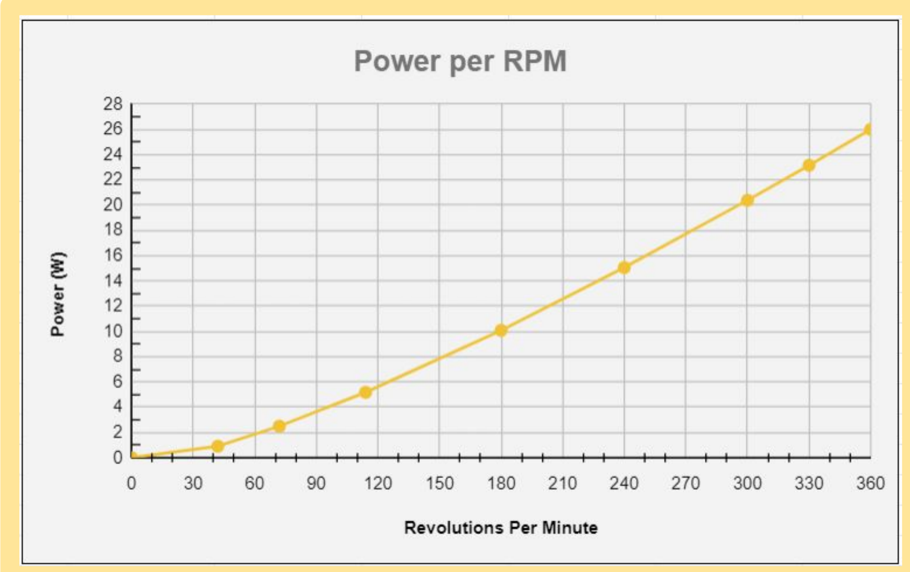
Requirements/Objectives:	Compliance:	Description:
Must output 5.4W of electricity to charge 4 devices over 8 hours	Yes	Complies under wind conditions of ~8m/s
Must generate required energy in 5m/s wind	No	Complies in our models and calculations, testing shows 8m/s wind is needed
Must withstand 10 m/s wind conditions	Yes	Each individual component can withstand these forces, physical testing at slower wind speeds suggest compliance at 10m/s
Must be weather proof (electonics must be protected from water)	No	Prototype 3d printed parts not water resistant, injection molded plastic housings would be
Collapsed turbine must be <= 60cm tall	Yes	Exactly 60cm tall prototype
Collapsed turbine must be <= 20L volume	Yes	~10L collapsed volume
Turbine myst be <= 5kg mass	Yes	~4.3kg not including 4 devices



CAD Model of Wind Turbine Design

Electrical Subsystem

- Stepper Motor Generator converts torque to electricity
- Bridge Rectifiers[5] convert AC to DC to charge a battery pack
- Capacitors to smooth rectified output
- A Voltage Regulator stabilizes the power input to the battery and protects from overcharging
- Battery Pack charges 4 devices with USB cables



Tested power output versus RPM for the stepper motor.

Mechanical Subsystem

- Vertical Wind Turbine can operate at low altitudes and low wind speeds[3]
- Three Curved Savonius blade design is the most efficient[4]
- Nylon Fabric blades are strong, lightweight, and collapsible for storage
- Aluminum Skeleton for high strength and lightweight
- Spring buttons for detachable blade arms
- Telescoping Shaft for easy extension and assembly
- Tent Spikes and Cables for lightweight structural support
- Gear Belt Drive to increase RPM at the generator

Analysis: Static Torque

This is the calculation for the torque required by the turbine to rotate and overcome static friction.

- $\tau = F * L_{arm} * \sin(\theta)$
  - Torque = Force * Lever arm * Sin(Angle of Applied Force)
- Avg force applied: 4.65N | Lever arm length: 60mm | $\theta = 90° \pm 10°$
- Torque required = 4.65N * 0.06m * Sin(90° ± 10°) = 0.279 N*m ± 0.0042

Future Recommendations and Improvements

- Purchase a voltage regulator that can improve average turbine power output
- Using a smaller stepper motor that weighs less than 2lb and requires less than 0.27925 N*m of torque to turn
- Use a battery pack with lower internal resistance or higher maximum voltage input
- If a group chose a drag-driven blade design, we recommend increasing the size of the blades.
- Using bearings with less friction
- Consider a design where there is no gap in between the blade and the rotating shaft.

Safety

- ANSI, ISO, RoHS, and UL standards reviewed to ensure safety in terms of electric circuitry, materials, and fire safety.

References

[1] "Horizontal axis wind turbine," *Horizontal Axis Wind Turbine - an overview | ScienceDirect Topics*. [Online]. Available: https://www.sciencedirect.com/topics/engineering/horizontal-axis-wind-turbine

[2] "Performance investigation of a mix wind turbine using a clutch ..." [Online]. Available: https://iopscience.iop.org/article/10.1088/1757-899X/217/1/012020

[3] "Urban wind generation: Comparing horizontal and vertical axis wind ..." [Online]. Available: https://commons.clarku.edu/cgi/viewcontent.cgi?article=1158&context=idce_masters_papers

[4] "Two-dimensional study of blade profiles for a Savonius wind turbine," *Docslib*. [Online]. Available: https://docslib.org/doc/13079767/two-dimensional-study-of-blade-profiles-for-a-savonius-wind-turbine

[5] "How I home-built an electricity producing Wind turbine", Micheal Davis. (2014). [Online] http://www.mdpub.com/Wind_Turbine/