Time To Wind Down

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Sponsored by Mahmoud Abdelgalil
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UCI Samueli School of Engineering

Overview

Design a small-scale prototype wind turbine that outputs a minimum power of 10 watts irrespective of the wind direction and be compatible with a common power bank.

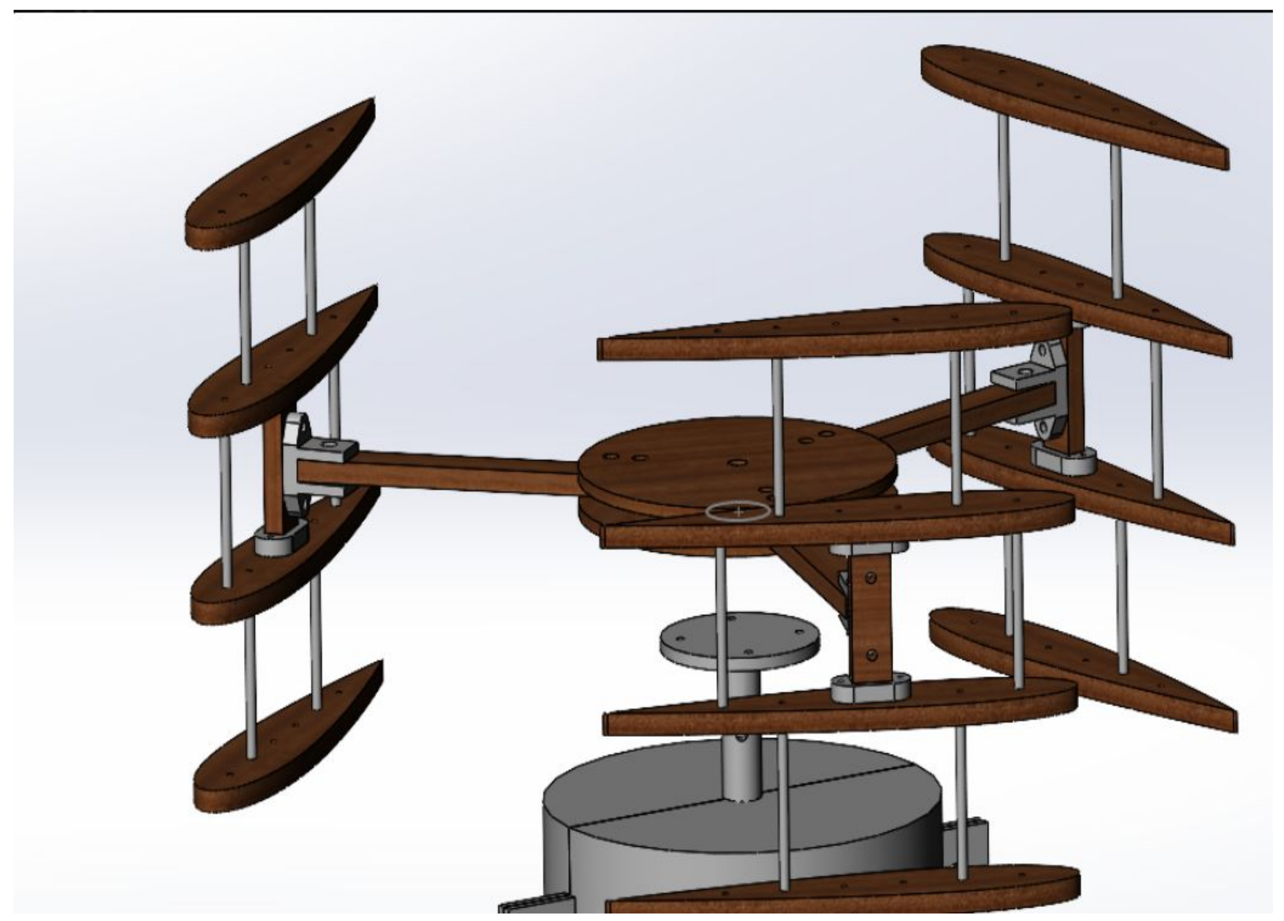
Challenges

- Must withstand wind speeds up to 18 m/s
- Must generate more than 10W between 5m/s and 11m/s wind speed
- Must fit within $50cm^3$ cube
- Must have a total weight <10 lbs
- Must have a total cost < $300

Existing solution

Company : BEVOGIE
Price : $53.99
Size: 42*22*9cm
Weight : 1.54lbs
Rated Power : 30W

Vertical-Axis Wind Turbine SolidWorks Design



Final Design : Key Dimensions
Rotor radius(R) : 20cm
Chord length(c) : 24cm
Blade length(s) : 30cm
Angle of attack(α) : 8 degree

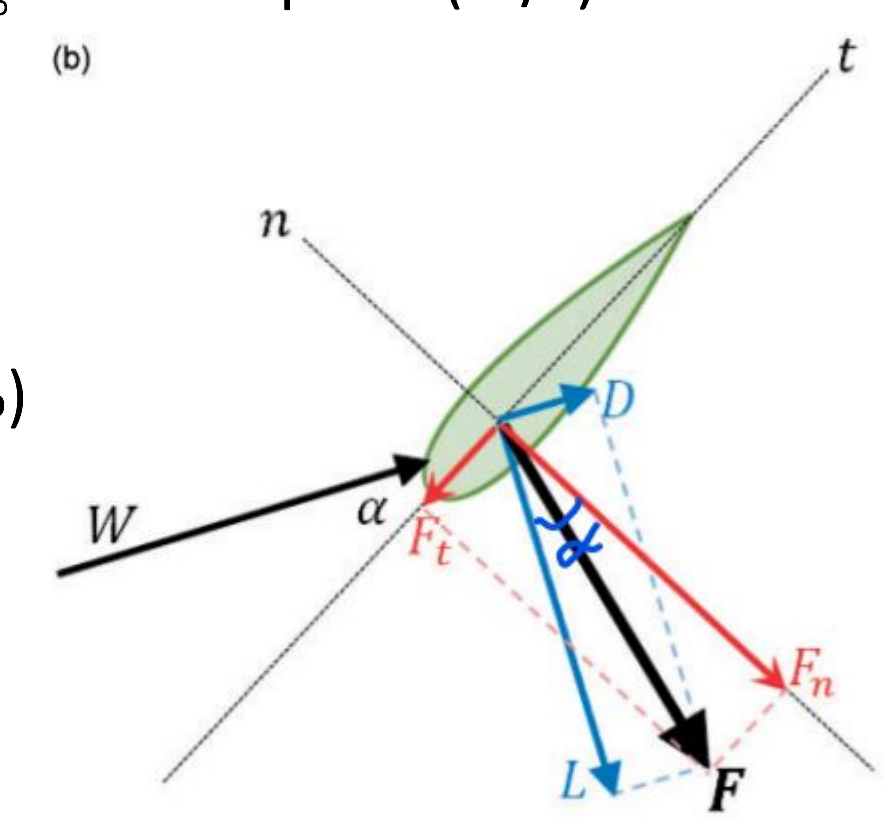
Final Design : Materials
Aluminum : Rod
¼ inch Wood : Blades, Arm, Disk

Analysis: Thin & Symmetric Airfoil [1]

$L = c_L \pi \alpha s c \rho_\infty V_\infty^2$
$c_L = 2\pi\alpha$
$F_L = L\sin(\alpha)$
$\tau = N F_L R$
$P = \tau\omega$

L = Lift force(N)
c_L = lift coefficient
c = Chord length
F_L = Tangential lift (N)
τ = Torque (N*m)

ω = Angular velocity (rpm)
P = Power (W)
ρ_∞ = Density of air (kg/m^3)
V_∞ = Wind speed (m/s)



Analysis : Wind Turbine Power [2]

$P = \frac{1}{2} c_p \rho_\infty A V_\infty^3$
$A = 2 * s * c$
$c_p = c_T * c_M$

c_p = Overall power efficiency (%)
A = Swept area (m^2)
c_T = Turbine efficiency (%)
c_M = Motor efficiency (%)

Performance

At V_∞ = 9 m/s
L = 87.3 N
τ = 2.19 N*m
ω = 112 rpm
P = 12.9 W

P_W = 53.6W
C_T = 26.6%
C_M = 90%
C_P = 23.9%

Impact on Society

- Clean and renewable source of energy
- Promotes keeping the environment healthy
- Reduces dependence on fossil fuels
- Energy self-sufficient

Team Contribution

Minsu Kim: Electrical Lead
David Luong: Electrical Team
Yushi Zhang: Mechanical Lead
Christian Lensang: Mechanical Team

Future Recommendations

1. HAWT
   a. higher efficiency
2. Lighter material
   a. allows turbine to rotate easier
   b. more convenient to transport

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Reference
[1] Anderson, John D., and Chris Cadou. *Fundamentals of Aerodynamics*. McGraw Hill LLC, 2024.
[2] Castillo Tudela, Javier. "Small-Scale Vertical Axis Wind Turbine Design." Pàgina Inicial De UPCommons, Universitat Politècnica De Catalunya, 2 Oct. 2013, https://upcommons.upc.edu/handle/2099.1/19136.