MOBILE^2

A MECH/AMS/SEEDS collaboration to create an energy producing mobile

Background

- To design, manufacture and implement a vertically wind powered turbine that resembles a Calder's mobile.
- Collect, transform and store wind energy.
- Output power to charge at least one cell phone device around the UBC Nest Square.
- Educate the public about sustainable energy methods.
- Build a sense of community by providing seating space.

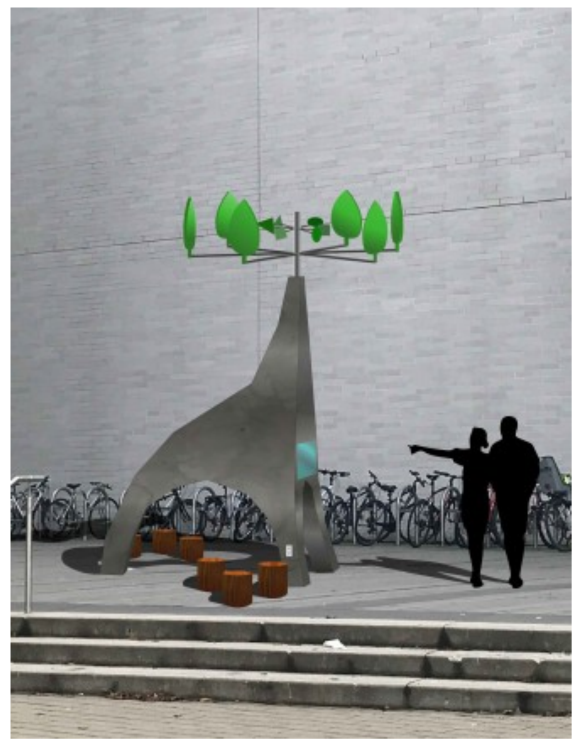


Figure 1. Final product

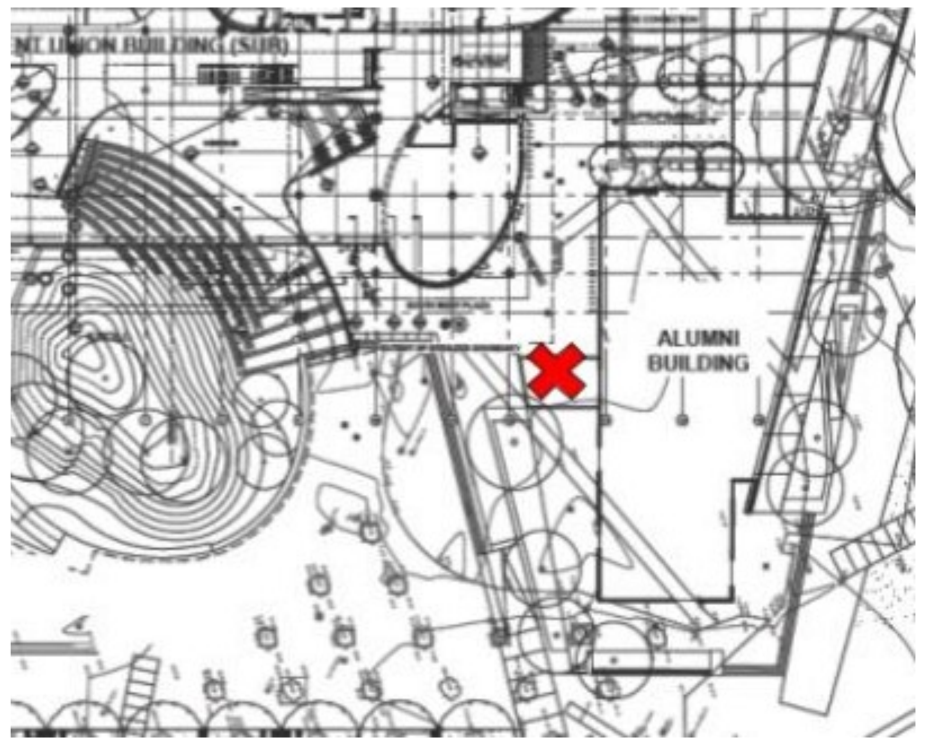


Figure 2. Selected location

Process

- Determine location
- Secure funding
- Design structure
- Detailed location to avoid underground services
- Footing designed based off of structure
- UBC consultations
  - Campus and Community Planning
  - Robert H. Lee Alumni Centre
  - UBC Building Operations
- Prototyping and design
- Development permit application
- Public open house
- Manufacturing methods
- Footing construction
- Structure fabrication and installation
- Fabrication of airfoils and mechanical system
- Installation of mechanical and electrical components
- Testing and commissioning

Figure 3. Diana creating airfoils to test

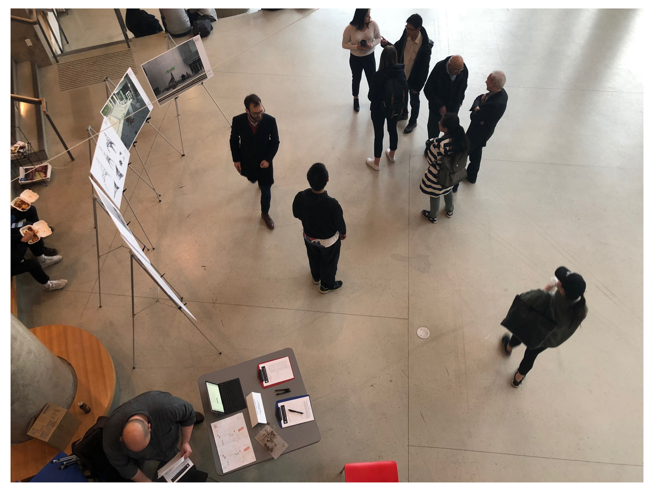
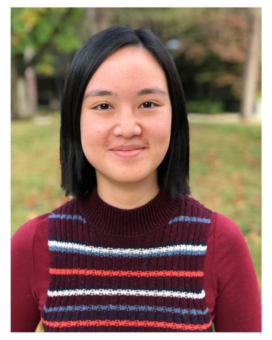


Figure 4. Public open house

Mechanical Engineering Capstone Team

Andrew Clayton

Diana Nino



Nerine Law

Chris Hii

System Components

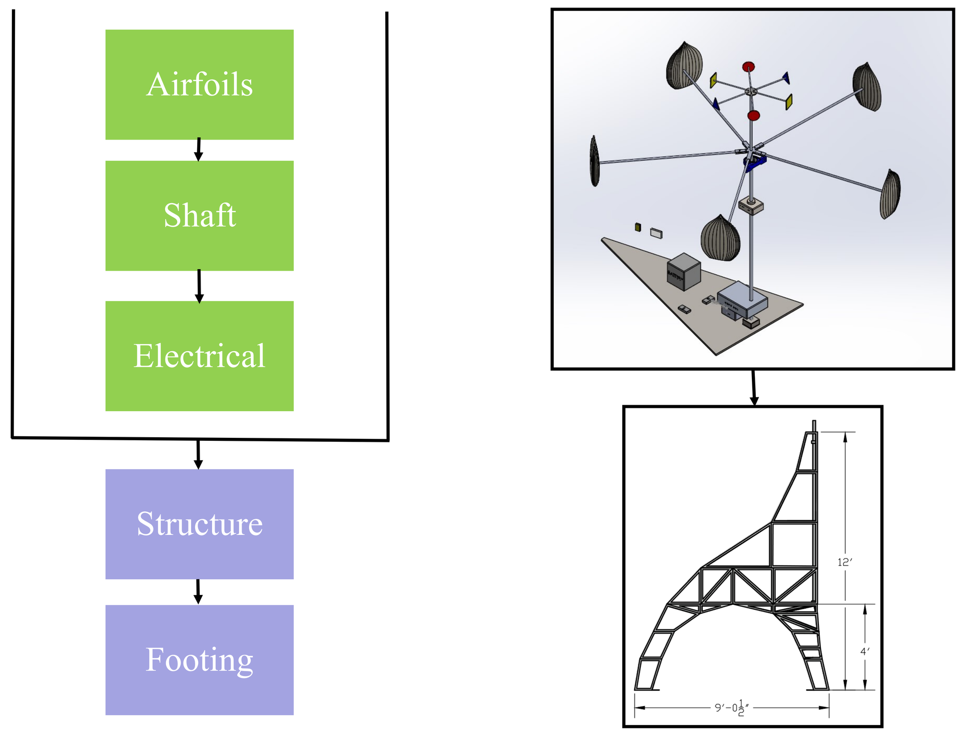


Figure 5. Left: system architecture, top right: mechanical assembly, right: structure

Technical Analysis

Airfoils

1. Mathematical model to compare theoretical power output between 4 and 5 airfoil configuration system for standard NACA 0021.

Results:

# of airfoils	Force (N)	Power (W)
4	19.54	9.77
5	15.48	7.74

Conclusion: The 4 airfoil configuration is 21% less efficient than the 5 airfoil configuration. This was verified with physical testing in the Boundary Layer Wind Tunnel.

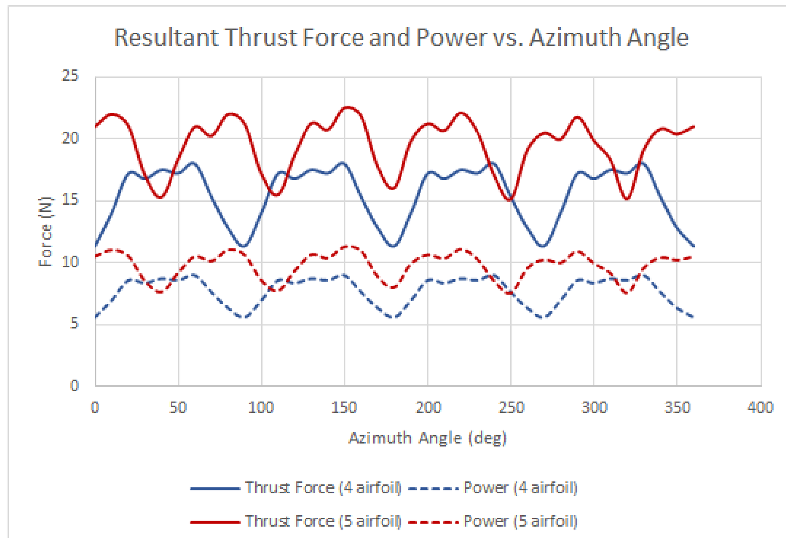


Figure 6. Graph of thrust force and power versus azimuth angle for 4 and 5 NACA 0021 airfoils

2. Testing in the Boundary Layer Wind Tunnel to compare performance between vertical and horizontal airfoil shapes for a 5 airfoil configuration (CFP).

Results:

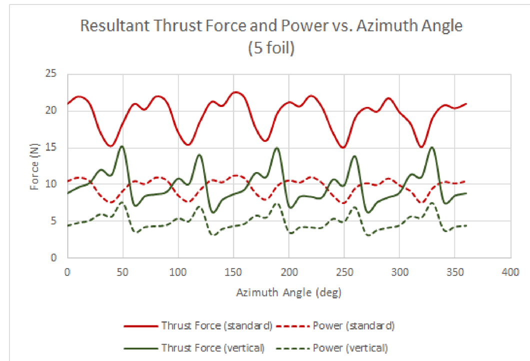
Wind speeds	Vertical airfoil shape	Horizontal airfoil shape
Starting (m/s)	8.8	11
Stalling (m/s)	6.1	6.7

Conclusion: Horizontal leaf shape has lower performance due to higher starting and stalling speeds.

Airfoils Continued

3. Mathematical model to compare the vertical leaf airfoil shape to the standard NACA 0021 airfoil.

Results:



Shape of airfoil	Power output (W)
Vertical leaf	4.92
Standard NACA 0021	9.77

Figure 7. Results of comparison between a standard NACA 0021 profile and a vertical leaf shaped design

Conclusion: vertical airfoil is less efficient by 50.4%.

Limitations and assumptions:

- Not accounting effect of wake and starting torque of actual system
- System was at steady state
- Leaf shape is not an standard airfoil design; therefore testing manufacturing methods were innovated

Shaft Design

The shaft design was analysed using *Shigley's Mechanical Engineering and Design* and by doing a finite element analysis using ANSYS.

Results: The shaft was verified to have a fatigue safety factor of 2, a yield safety factor of 2.7 and a maximum deflection of 0.00057mm.

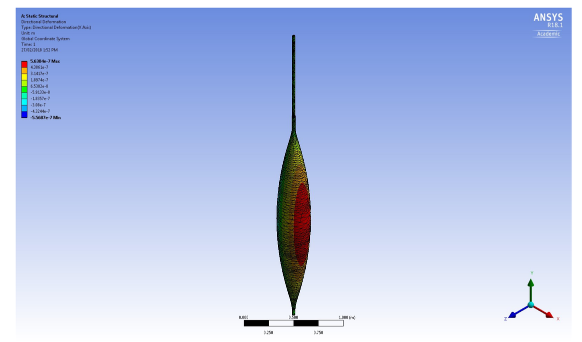


Figure 8. Deflection analysis done using ANSYS

Electrical Circuits

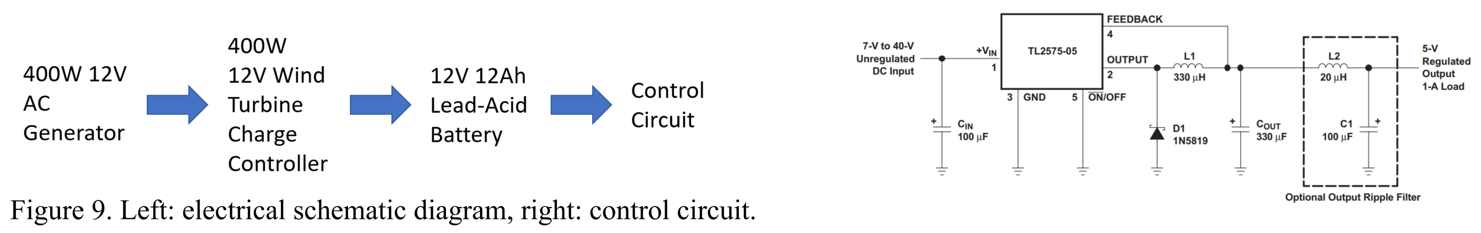


Figure 9. Left: electrical schematic diagram, right: control circuit.

Control circuit includes: input capacitor for stability, output capacitor for loop stability and ripple filtering, catch diode to filter noise, output inductor: continuous mode offers greater output power with lower peak currents and lower output ripple voltage. All components are specified. For detailed component specification, ask for an Electrical Specifications sheet from one of the team members

The Future

Phase 1: Initial engineering work complete

Completed engineering analysis of airfoils, power transmission system, electrical system, structural system and footing.

- Airfoils: 5 airfoil system with vertical leaf airfoil shape due to performance and aesthetic factors
- Power transmission system: completed sizing of shaft, rotor arms, keys and bolts
- Electrical system: specified components for charge regulation, energy storage and endpoint voltage regulation (control circuit)
- Structural system and footing: footing is ready to be constructed and structure is ready for manufacturing with assembly drawings

Phase 2: Additional engineering work required

- Airfoils: determine the best manufacturing method. Initial research suggests CNC machining of high density polyurethane foam with carbon fibre coating for durability to weather conditions
- Power transmission system: determine and manufacture gearboxes with optimal gear ratio for maximum power output
- Electrical system: optimizing energy conversion system through pulse width modulation (PWM) and maximum power point tracking (MPPT)
- Mechanical safety system: determine optimal mechanical brake mechanism. Initial research suggests using a centrifugal brake as it adjusts its braking strength according to the rotational speed of the object
- Aesthetic element: design and manufacturing of free-spinning artistic element on top of the energy-generating airfoils

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