Develop Novel and Cost-Effective Way to Generate Renewable Electrical Energy

Background:

Aerovec is a start-up company based out of Buffalo, NY. They specialize in small-scale wind turbines for remote and mobile applications. This project has a focus on optimizing these units for rooftop applications to provide local power generation for commercial, industrial, and agricultural buildings. Small-scale wind energy generation can work alongside solar and is a relatively new field with little competition.

Project Description:

We have several main assumptions which Aerovec initially asked us to test which represent the company's important goals. These are as follows:

1. It is feasible to place wind turbines on rooftops and mitigate the effects of noise and vibration without making changes to the building.
2. Wind turbines which do not implement yaw motion can produce 75% of the power produced by turbines which do implement yaw motion.
3. The output airflow from a rooftop HVAC unit can be redirected to the inlet of the wind turbine and boost the turbine annual energy production (AEP) by 20%, while also offsetting the energy used by the HVAC system by 20%.
4. The optimum rotor diameter of the rooftop wind turbine is less than 2 m.

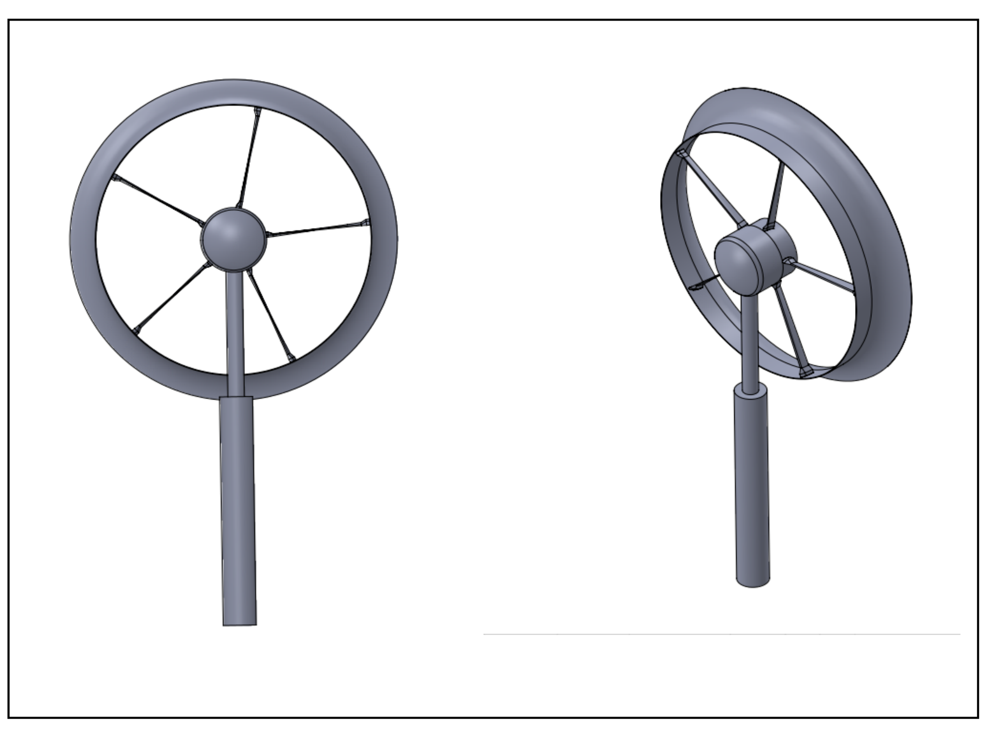
Beyond these assumptions, we have expanded the project to improve the design of the wind turbine itself. We are going to use wind tunnel testing and a small prototype of the Aerovec wind turbine to test several of the above assumptions. Aerovec currently uses a flat airfoil blade design, so we would like to optimize for blade design using computational fluid dynamics (CFD) analysis. Futher, we plan to compile wind data from airports in various cities to help analyze the ideal yaw motion.

Progress To-Date:

- Performed wind data collection and analysis from the Syracuse Hancock International Airport to determine the percentage of the total power that can be collected by implementing a no-yaw turbine design.
- Measured the output air from an HVAC unit at a local manufacturer for flow velocity and temperature. With this data, we will determine if the outlet air can be used to generate rotation of the wind turbine and boost AEP.
- Researched data collection of sound and vibration effects, which ultimately will be done with the use of accelerometers and decibel meters when the Aerovec turbine has been installed.
- Obtained CAD models of the Aerovec turbine with plans to 3-D print a small-scale model for testing in the wind tunnel.

Main Concepts

Wind Tunnel Testing:



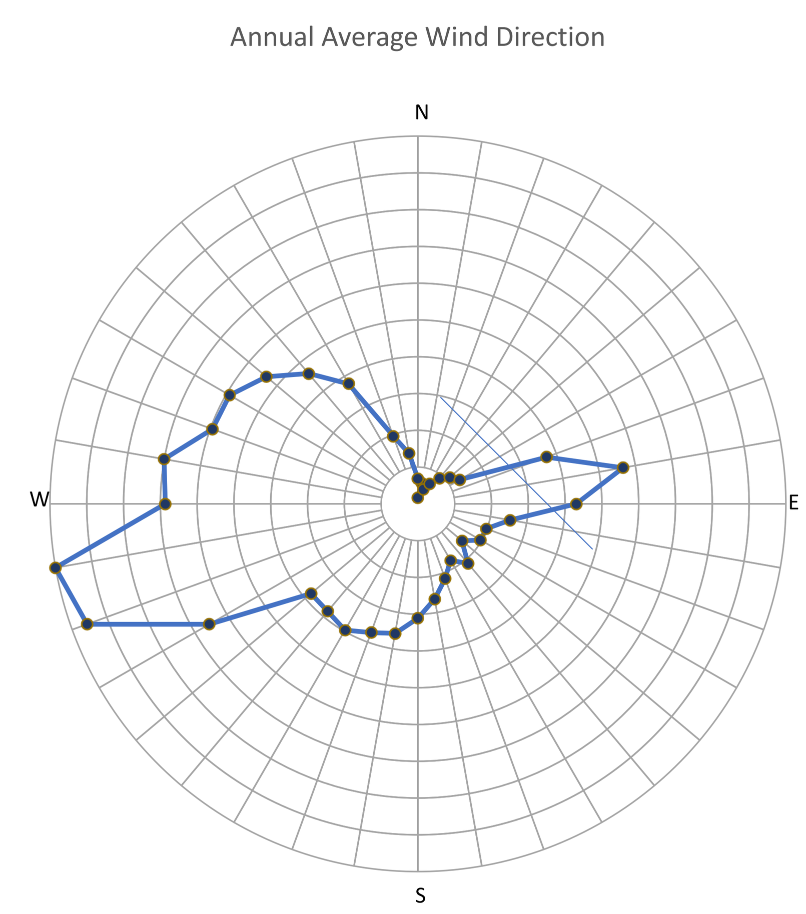
The CAD model shown above is the basic turbine and cowl design that will be optimized. The blades will be designed using CFD simulations, and a small-scale model of the rotor will be printed for physical experimentation.

Using the small-scale prototype and the wind tunnel (shown above), we will estimate power output under varying conditions.

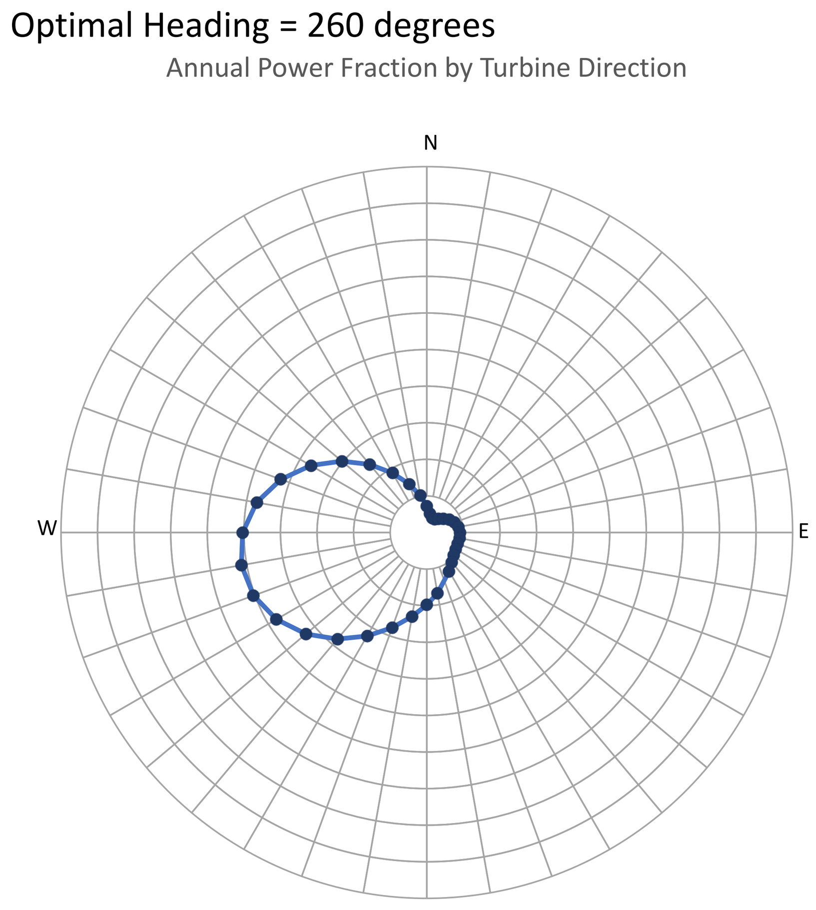
- Varying blade designs
- Verify results from wind data collection by testing varying angles of yaw
- Hollow vs solid material
- Varying rotor size

Wind Data Collection:

The data below has been compiled and analyzed from the Syracuse Hancock International Airport.



Duration x Strength of wind by degree heading (direction)
North = 0 degrees, East = 90 degrees
Optimal Heading = 260 degrees



Percentage of total potential power that would be collected for each direction that the turbine could face (Accounting for the aligned component of misaligned wind, and assuming power available is proportional to velocity cubed)
Optimal Heading = 260 degrees

Rooftop Turbine Study:

Our initial design to redirect outlet air from a rooftop HVAC unit involves the use of louvers like the ones depicted below. The angle of the panels on the louvers can be adjusted to redirect flow towards the turbine.

Beyond the use of HVAC output air, there are other constraints which we are testing to determine if a rooftop wind turbine is feasible.

- Gather accelerometer and decibel meter measurements from the Aerovec wind turbine once it is installed (decibel meter is displayed to the right)
- Compare data with sound and vibration caused by HVAC units, also considering noise and vibration regulations for buildings

It is also important to consider the space constraint which exists for a rooftop turbine. We would like to evaluate the kW of power generated compared to the square footage and weight requirements. This will help us to perform a side-by-side comparison with rooftop solar panels, which are already being used. Aerovec would like to use their turbines to supplement these existing solar panels and make up for power generation in the winter months and overnight.

Deliverables:

- Determine effective method for redirecting HVAC rooftop unit output to generate wind power
- Create small-scale wind turbine model to optimize rotor size, idealize yaw motion, and assess blade design
- Evaluate, and potentially mitigate, the effects of sound and vibration from a rooftop wind turbine unit

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