Assessing Feasibility of Small-Scale Wind Energy Harvesting Systems

Duke BASS CONNECTIONS

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Energy & Environment

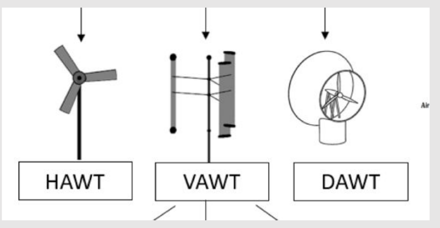
Motivation and Goals

- Identify potential wind energy production:
  - Urban-focused small scale generation
  - Generating clean energy
  - Harvesting wind generated by daily human activities
- Exhaust outlets release high speed hot air which is “wasted” into the atmosphere
  - Provides potential for energy harvesting
- Review relevant literature and previous papers published on this subject; synthesize findings and aim to fill in a gap in current literature
- Integrate previous material on capturing excess exhaust energy
  - Analyze and consider results
  - Research and build on areas where other sources fell short
- Gain clarity on economic, environmental, and social feasibility of small-scale wind harvesting systems
  - Determine potential for national and global expansion

Literature Review

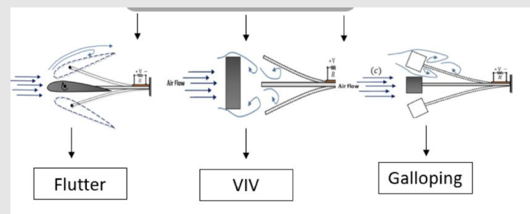
Existing Literature

- **Types of Turbines**
  - HAWT, VAWT, DAWT
- **Challenges**
  - Efficiency issues
  - Conformity to local regulations
  - Safety concerns



Potential Avenues

- Optimal duct/blade geometry
- Expansion within the US
- Microtechnologies
- **Feasibility**
  - **Environmental and Economic**
  - **National and Global Expansion**



Intended Impact

- Enhance generalizability
  - In-person data collection
- Determine feasibility on larger scale
- Attracting attention/resources to this field

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Data Collection, Design, and Testing

Kitchen exhaust outlets on the Broadhead Center roof

Data collection:

- Assessed ground level exhaust outlet wind speeds across Duke University campus for viability
  - Low wind speeds
  - Vulnerable to damage from pedestrians and weather
  - Extremely variable outlet sizes and shapes
- Assessed kitchen and restroom exhaust outlets on Duke Broadhead Center roof
  - Higher wind speeds
  - Vulnerable to weather but not pedestrians
  - Outlet sizes and shapes fell within a marketable range
  - Found to be ideal

Prototyping:

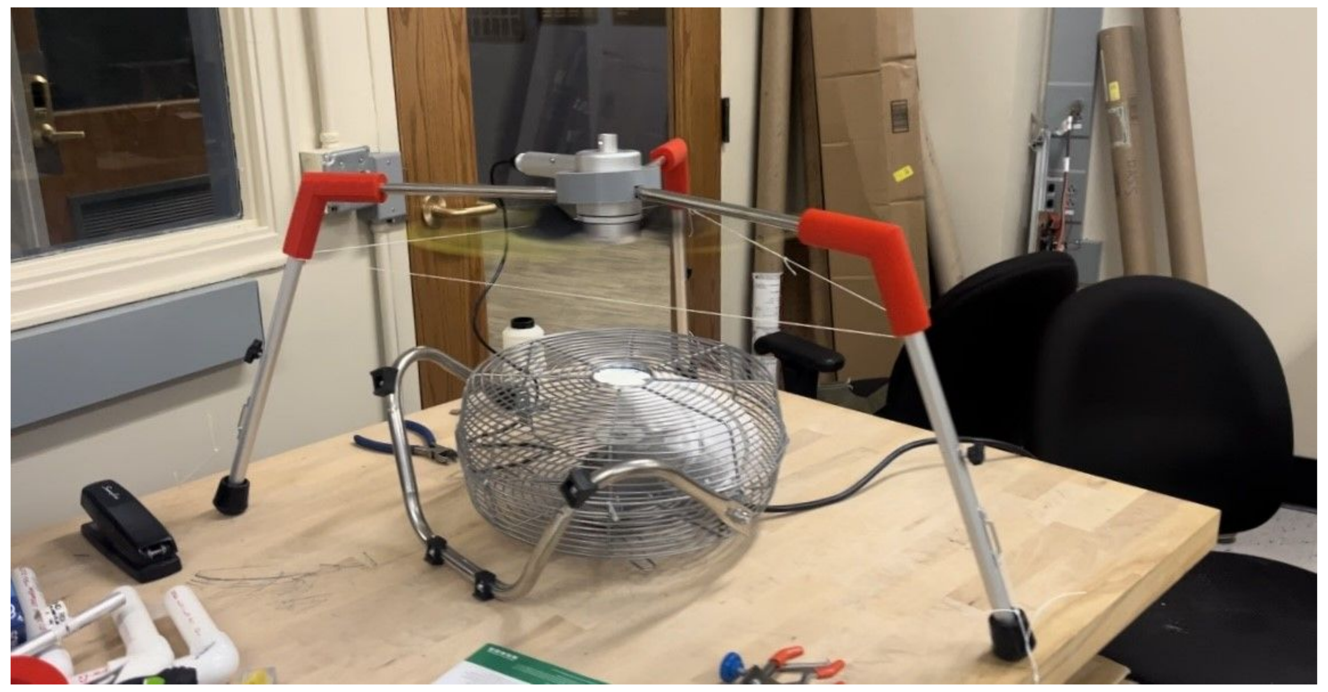
- Turbine mount developed for field testing developed
  - Wood plank modified to hold turbine safely over exhaust outlets by team member
- Nozzle developed for shroud design viability testing
  - Cardboard fitted to a box fan for in lab testing
- Tripod mount developed for commercial application
  - TexEnergy Infinite Air 18 horizontal axis wind turbine optimized for 3.5-20.5 m/s
  - Custom mount tripod with adjustable radius and elbows outside blade range to fit horizontal exhaust outlets of different shapes and sizes
  - Sandbags on legs, tensioner around legs, and rubber feet for stability

Turbine handle prototype developed to test energy output

Lab testing with box fan and nozzle

Testing and Results:

- 5V, >.5A achieved in lab and field applications with speeds as low as 6 m/s
- Shroud found to create negligible effect on speeds, yielding inviability for market purposes
- Sufficiently stable mounting created using under $8 in materials
- Stable power output values indicated a realistically viable product



Current turbine-mount system prototype during in-lab testing

Business Plan $$

🏢 **Target Clients:**

- Small to medium-sized businesses, including **laundromats, hotels,** and **restaurant kitchens**

💲 **Cost Reduction Plan:**

- Started with a **$395** turbine purchase. Our goal is to reduce turbine costs to **$150-$200** by:
  - material selection
  - design optimization
  - manufacturing improvement

🔌 **Targeted devices to power:**

- Monitoring equipment (sensors, surveillance cameras)
- LED lights
- Emergency power backup - batteries
- Display boards

💡 **Further considerations:**

- Public awareness
- Design cost efficiency
- Government incentives (tax credits)

Environmental Benefit Analysis

Our environmental benefit analysis was developed by calculating the system’s carbon offset considering comparative power calculations for conventional small devices such as security cameras and street lightings, and energy storage possibilities

Carbon Offset → The average power needed for a standard security camera or a street light is 25-40 watts, this often dirty grid power can be offset by implementing our clean energy system

Energy storage possibilities → The excess energy generated can be stored in batteries for later use, offering flexibility in energy utilization and enhancing overall efficiency

Social Benefit Analysis

Educational Benefits → The visibility and versatility of the system provides an opportunity to educate the public about renewable energy

Economic Benefits → The wide variety of applications for the harvested, otherwise unused, energy leads to an opportunity for widespread implementation with eventual economic benefits

Health Benefits → The use of wind energy instead of non-renewable energy aids in the reduction of emissions and pollution, offsetting the negative impacts of non-renewable energy sources

Conclusions

- The design provides the opportunity to begin closing the loop by powering small electronics such as security cameras and light bulbs
- The turbine design needs to be made in-house to drive down costs and increase economic feasibility
- While environmentally motivated, the project also uncovered social benefits to implementation of the system

Future Work

- Redesign turbine for in-house manufacture and optimization for the application
- Develop energy storage attachments for device
- Model how long term and widespread implementation would impact emissions and energy use
- Complete a full life cycle analysis