2015

Wind Energy Harvesters for Urban Small Scale Power Generation

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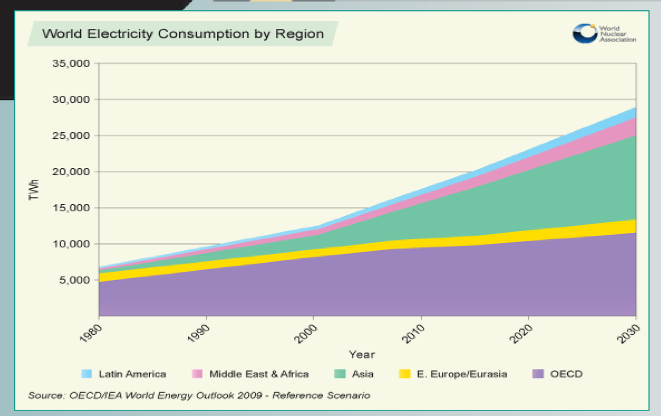
ELECTRICAL AND COMPUTER
Mark A. Sternheimer Senior Design Award

Wind Energy Harvesters

For Urban Small Scale Power Generation

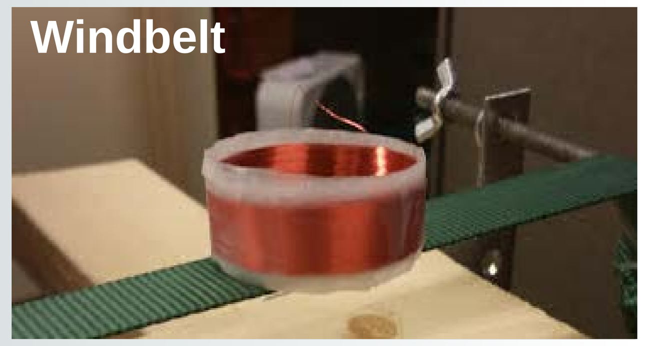
CAPSTONE DESIGN EXPO 2015

Motivation



- World energy needs increasing
- Turbines not feasible in all places
- Massive numbers of Windbelts can be installed in places turbines cannot

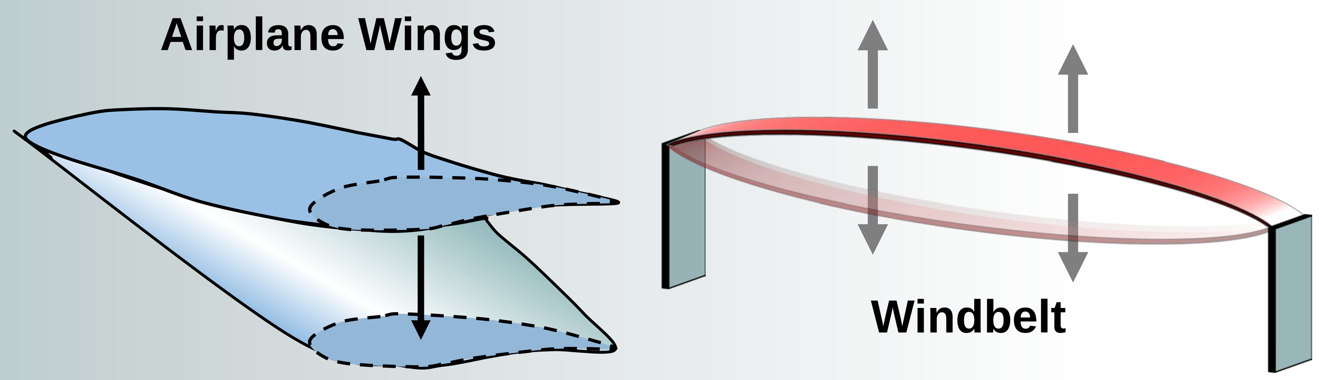
- Cost: $3 million (3 MW)
- Rotor Diameter: 77 m
- Sweep Area: 4600 m^2
- Cut-in Velocity: 3.5 m/s
- Power Density: 300 W/m^2



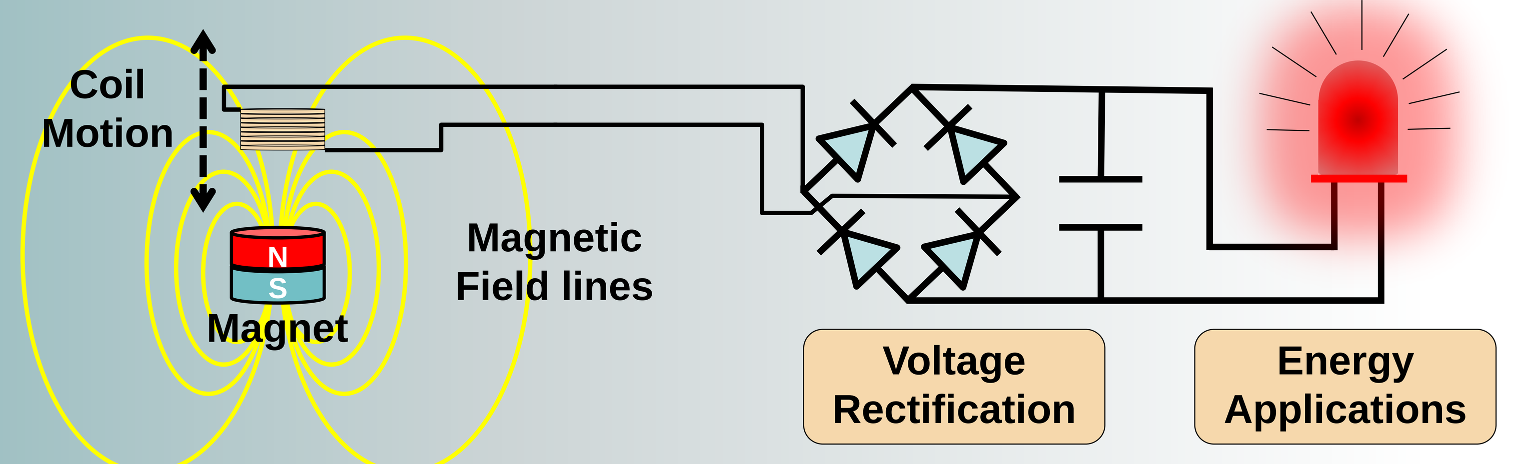
- Cost: $50
- Windbelt Length: 1 m
- Total Area: 0.03 m^2
- Cut-in Velocity: 2 m/s
- Target Power: 3 W

Principle of Operation

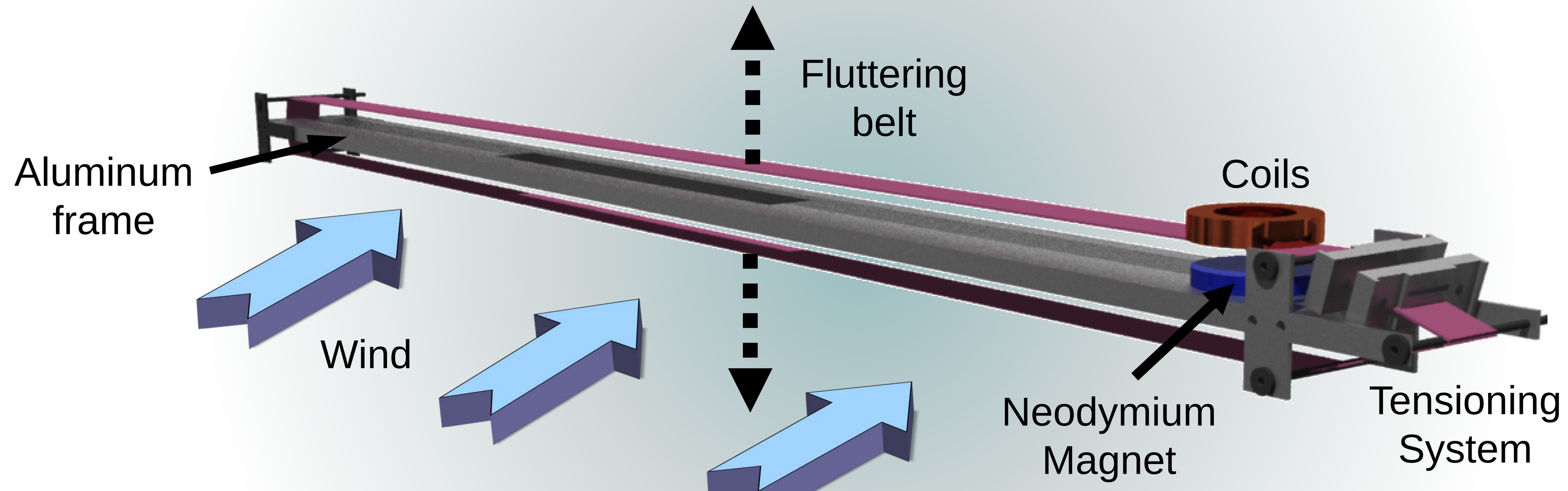
Aeroelastic Flutter: Flowing wind causes flexional vibration of the windbelt



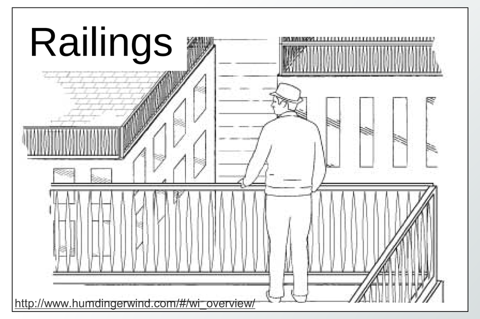
Faraday's Law of Induction: Change in magnetic flux through a coil mounted on the windbelt induces electric current in the coil

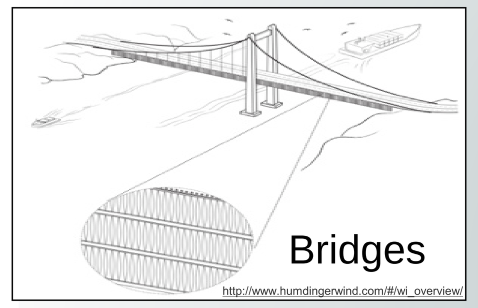


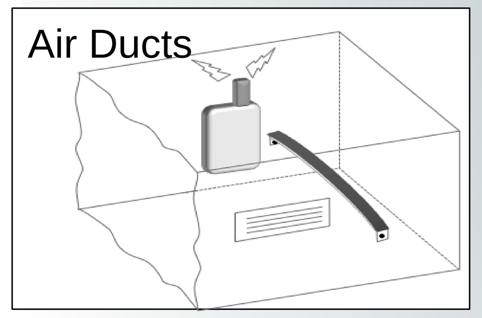
Adaptable Design



Advantages & Applications

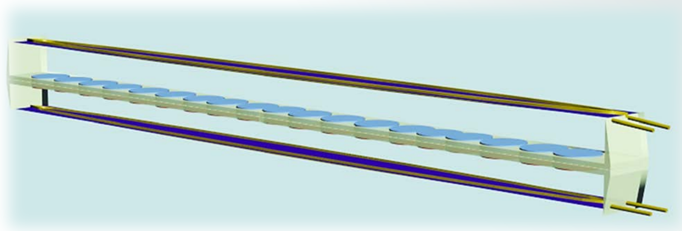




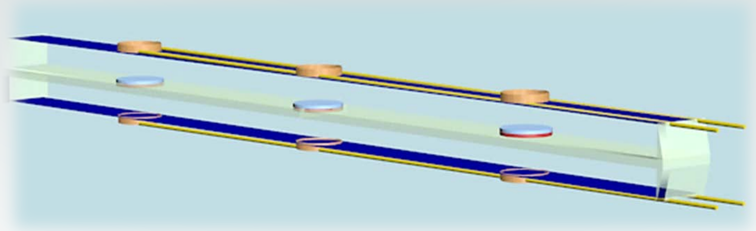


- **Invisible Power Generation**
  - Seamlessly integrated into architecture (railings, bridges, rooftops, etc.)
- **Remote Power Generation**
  - Install where having to replacing batteries is inconvenient (Air Ducts, Rural Areas, Dangerous Environments, etc.)
- **Modular**
  - Connect in Series or Parallel to meet specific needs (higher current or voltage, higher power)
- **Safe & Maintainable**
  - No moving parts prone to wear
  - Less likely to cause injury than Wind Turbine
  - More easily repaired than turbines or solar panels

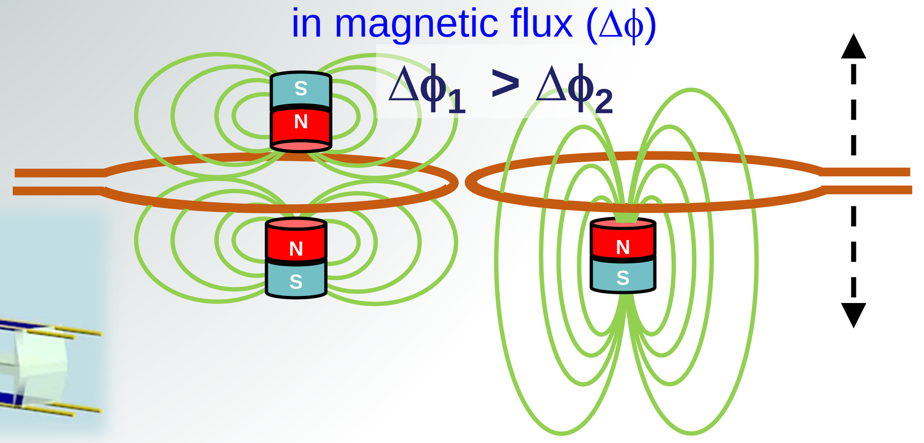
Optional Design Using a Longer Coil and Many Magnets



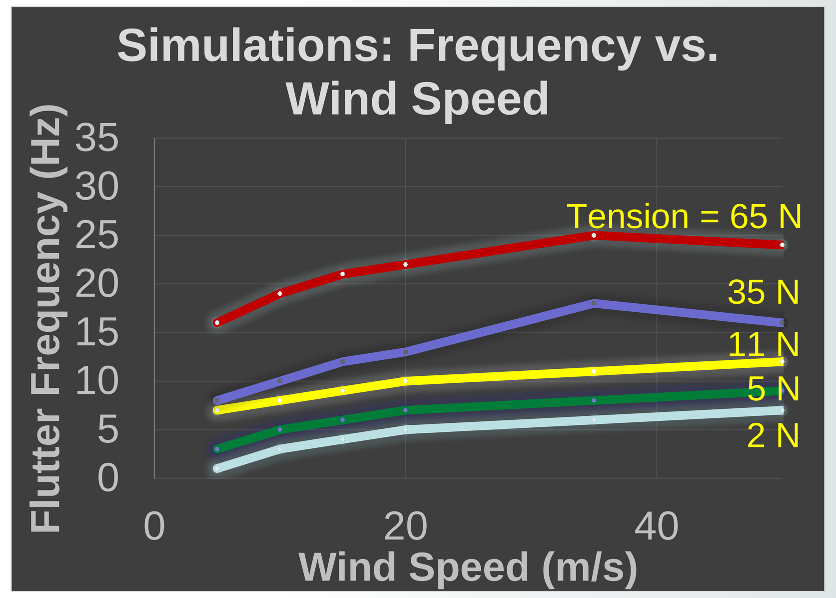
Optional Design Using Multiple Coils

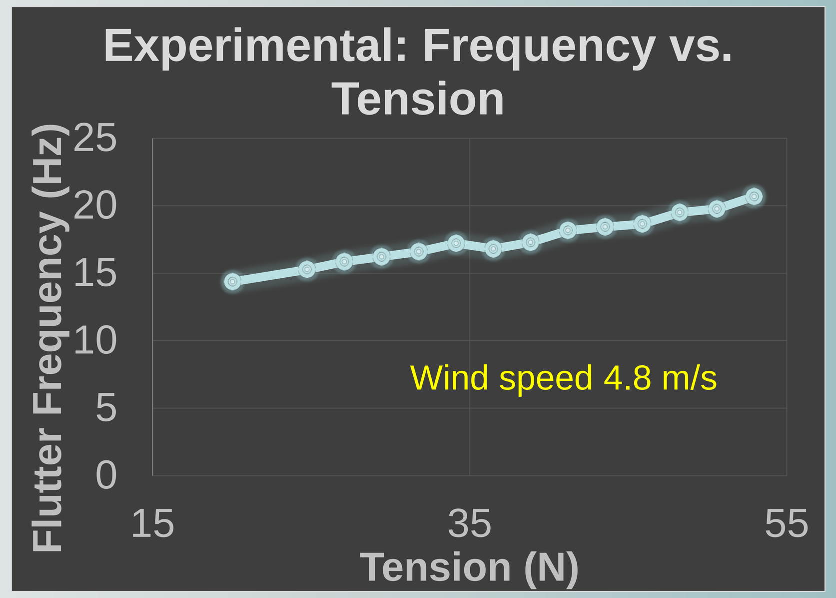


Additional Magnets increase change in magnetic flux ($\Delta\phi$)



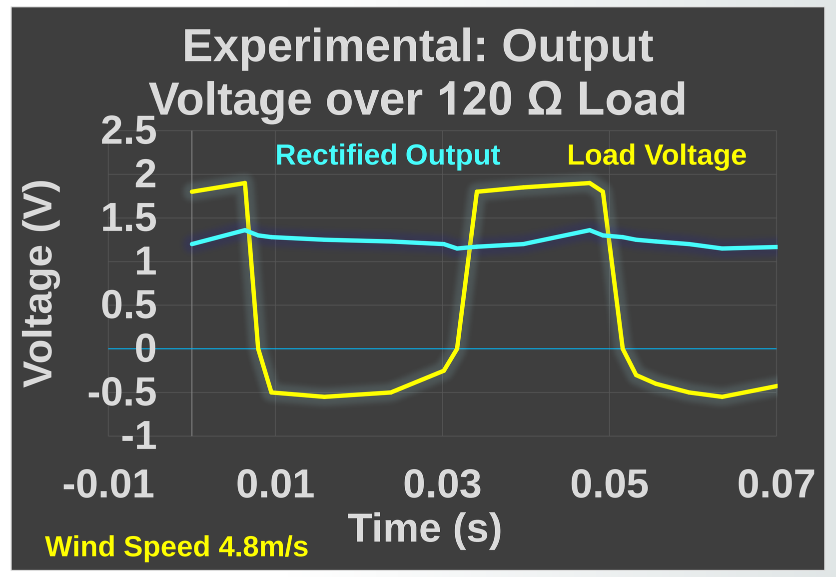
Simulation and Test Results

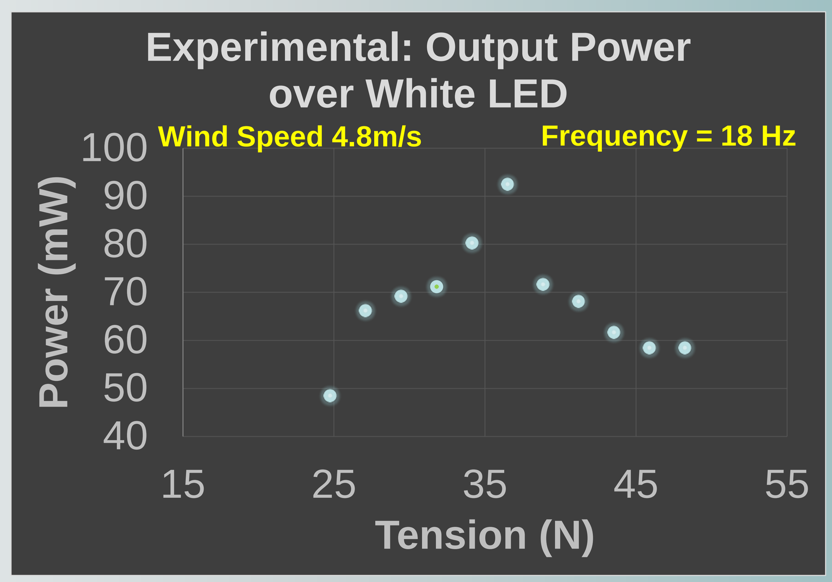




3D S Max physics simulation package

- Simulations conducted to determine the relationship between belt frequency, amplitude, tension, material strength, and wind speed
- As tension increases:
  - frequency increases approximately linearly
  - Amplitude reaches a maximum at a critical point, and then decreases
- Experimental results are consistent with trends in the simulations





Tests conducted to find peak voltages for changes in:

- Belt Material (Mylar, Taffeta Tape, Tow Belt)
- Belt Length and Tension
- Coil Size and Weight (wire gauge, diameter, number of turns)
- Coil Position (with respect to the edge of the belt, top vs. bottom belt)
- Magnet Orientation and Placement

Further research of dynamic tensioning and more magnets could yield improvements across variable wind speeds

Acknowledgments:

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VCU School of Engineering

Make it real.

VIRGINIA COMMONWEALTH UNIVERSITY