Dynamic façades towards greener energy efficient buildings

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**Introduction**

As more cities begin to urbanize and people spend more time indoors, the role of the buildings in which they inhabit becomes more significant. Improving building performance through increased energy efficiency, human comfort, and localized electricity production is an essential step toward the mitigation of climate change.

**Motivation:**
- Buildings in developed countries account for 20-40% of total primary energy consumption and 36% of CO2 total emissions.
- Urban wind turbines have many undesirable qualities such as "flaring light", size, and safety concerns.
- Equipping buildings with renewable energy harvesting technologies will decrease the building's demand for external electrical energy supply.

**Objectives**

- Review the state-of-art in dynamic façade applications and wind energy harvesting devices.
- Propose a wind-harvesting device able to equip such a type of façade.
- Test and validate the capacity of the proposed assembly.
- Numerically apply the solution to a building example and size the solution's energy/financial yields.

**Hypothesis**

- The motion of a membrane experiencing aero-elastic flutter may be characterized by its two-degrees-of-freedom, separately.
- Voltage generated by a harvester will decrease with increasing inclination angle.

**Theoretical Background**

Aero-elastic flutter – a phenomenon of self-feeding two-degree-of-freedom oscillations due to aeroelastic instability. Recently, researchers have been using this phenomenon to harvest energy from wind. Using electromagnetism, in a similar manner to a conventional wind turbine, the motion of a membrane in aeroelastic flutter can be used to produce electricity.

**Results**

*Fig. 2: Frequency vs Angle
Fig. 3: Voltage vs Speed
Fig. 4: Displacement vs Speed
Fig. 5: RMS Voltage vs Angle
Fig. 6: Displacement vs Speed*

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**Conclusion**

- **Inclination Angle**
  - Lower speeds produce more stable oscillations
  - Higher speeds cause unstable oscillations
  - In part by magnets contacting conducting coil spool
  - Figure 6 shows this contact
  - Inclination angle has more effect at higher wind speed
  - Voltage output increases for higher wind speeds

- **Motion Characterization:**
  - Displacement increases with wind speed
  - Displacement results are being compared to a flutter simulation in NASTRAN
  - Axis of rotation is aft of the center of the membrane

**Future Work and Recommendations**

- **Future Work**
  - Inclination angle testing at -15° could be tested again to verify anomaly
  - Motion characterization experiments should use multiple lasers to distinguish between rotational and translational motion and, find the axis of rotation
  - Motion characterization experiments should use a larger membrane

- **Recommendations:**
  - Automatic tension adjustment
  - Hemispherical magnets

**References**


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