# CALIFORNIA STATE SCIENCE FAIR
# 2016 PROJECT SUMMARY

**Name(s)**

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**Project Number**

**J0104**

**Project Title**

## Galloping Prisms: On the Optimal Design of a Novel Aeroelastic Energy Harvester for Remote Sensing

**Abstract**

**Objectives/Goals**

My research focuses on the design and optimization of a novel small-scale generator which extracts energy from flowing air. This work responds to the growing interest in monitoring the built and natural environments using self-powered wireless sensors. State-of-the-art sensors, operated sporadically can be sustained with only about 0.1 mW of power. Alternatives to solar power are needed to support such sensing applications indoors, in the shade and at night. Though airflow and wind are ubiquitous, research on efficient flow-based milliwatt-scale generators has just begun.

**Methods/Materials**

After a survey of existing devices, I prototyped a family of novel, inexpensive, low-maintenance flow energy generators based on principles of aeroelastic flutter. My device consists of a flexible metallic beam cantilevered at one end and fitted with a lightweight prism at its free end. The flow-induced periodic flexure of the beam generates AC power via a piezoelectric transducer (PZT) affixed to it.

The shape, orientation and dimensions of the prismatic attachment, beam length, flow speed and load resistance are the major design and operating parameters that determine the performance of my device. I designed and executed a matrix of experiments in which I varied each parameter individually while controlling the others. In addition to electrical data, I obtained mechanical data and flow visualization videos to optimize prism shapes for increased flow separation effects and flutter.

**Results**

With increasing beam length the power delivered by the PZT increased and then decreased, revealing the existence of an optimal design point. Similarly, the increased flow interception capability of bigger prisms is offset by their larger mass. In my experiments, I observed well over a 1,000 operating conditions, characterized competing effects and empirically narrowed the parameter ranges corresponding to superior designs. I show for instance that about 0.4 milliwatts of average power can be obtained on a sustained basis with a 14.7cm beam and a prism with a 10cmx6.5cm face. Several LEDs connected in series could be lit showing instantaneous power delivery in the several milliwatt range.

**Conclusions/Discussion**

I designed, built and tested a novel family of flexure-enhanced energy harvesters which can deliver sufficient power under modest wind conditions (< 5 m/s) to emerging low-power remote sensor nodes.

**Summary Statement**

Using inexpensive, easy-to-obtain materials I have demonstrated a novel family of miniature (volume ~ 0.0005 m^3) aeroelastic energy harvesters, which can power remote sensor nodes, without batteries and wired power, at modest wind speeds.

**Help Received**

I would like to thank my science teacher Mrs. H. Mackewicz for her helpful discussions, and my brother for explaining energy conversion concepts. I would like to thank my dad for his encouragement throughout the course of this experiment, and my mom for purchasing the necessary materials.