Harvesting Fluid Kinetic Energy to Generate Emission-Free Electricity via Piezoelectric Devices

Participating CSUB Students: Jese Martin Gutierrez, Sarah-Jean Boyd, Maximis Hidalgo, Jesus Quinonez
CSUB Faculty Supervisor: Dr. Dayanand Saini, Associate Professor of Engineering, Department of Physics and Engineering

Motivation

- To use fluid's kinetic energy for generating emission-free electricity.

Project Objective

- To design and test novel electricity generation systems that convert fluid's kinetic energy generated by a wobbling sprinkler into electrical energy using piezoelectric wafers.

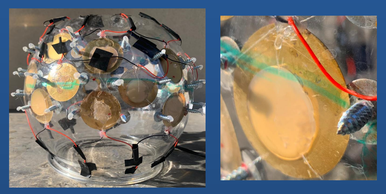
Testing Approach

- We tested electricity generation potential of:
  - Existing inverted plastic globe-based set up.
  - Designing and testing of new inverted plastic globe-based setups.
  - Best-performed wobbling sprinkler and array of piezoelectric devices (i.e., multiple wafers connected in a combined series and parallel circuit).

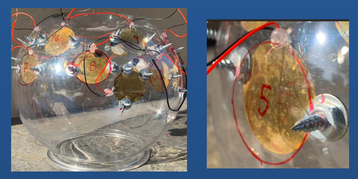
Experimental Testing Setups

Existing Design: a series circuit of thirty individual piezo wafers.

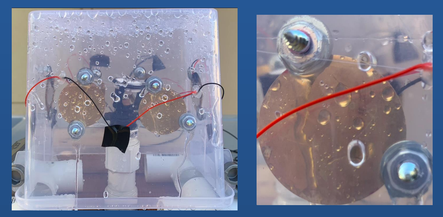
Design#1: an array (i.e., a combined series and parallel circuit) of three parallelly-connected rows consisting of eight individual piezoelectric wafers connected in series.

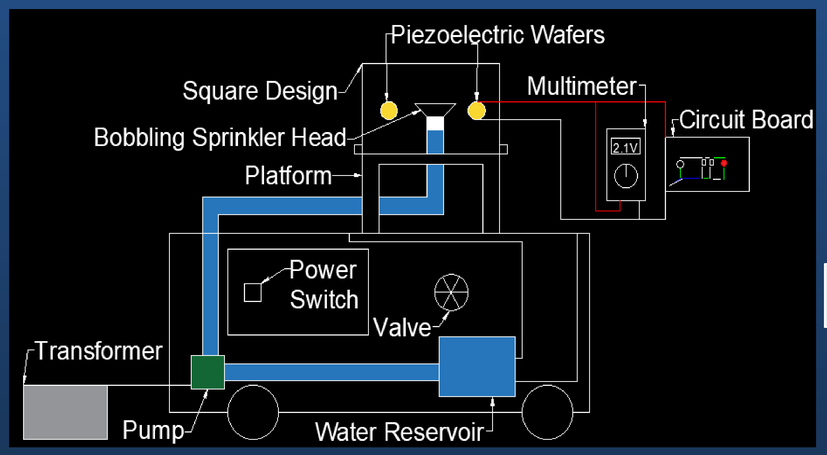


Design#2: an array of two parallelly-connected rows consisting six wafers in (row#1) and three in (row#2).These piezoelectric wafers were connected in series.



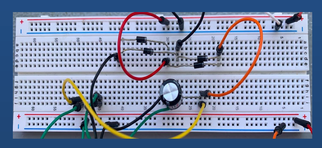
Design #3: a series circuit of six individual piezoelectric wafers housed in a rectangular plastic box.





Experimental Testing Setup Used in the Present Research

Wobble Sprinklers used for Harvesting Fluid Kinetic Energy



Energy Storage System

Data Collection

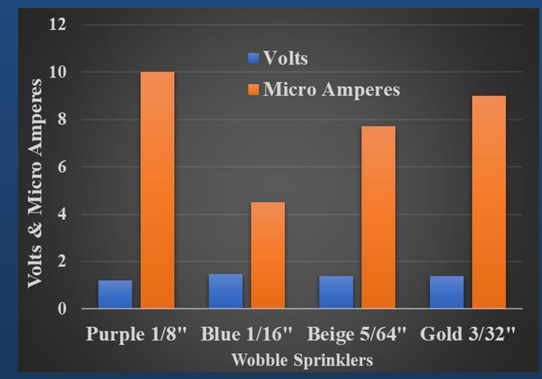
First, individual piezoelectric wafer were tested to make sure that we didn't include any defective wafer in the testing setup. This table is a list of 16 wafers and how they performed individually when using the water pump. We used a 1.5-gallon capacity plastic globe-type containers (our second design) for the tests.

Wafer number	Volts
1	0.35
2	0.24
3	0.1
4	0.15
5	0.17
6	0.19
7	0.23
8	0.37
9	0.22
10	0.21
11	0.35
12	0.26
13	0.32
14	0.33
15	0.27
16	0.25

Next, we tested four designs including last year's, our two fishbowl designs, and our box design. Please note that we also tested with different sprinkler heads, what is shown was the average results recorded with the best sprinkler head.

Designs	Volts	Volts with 10v 2200µF capacitor
Existing Design	**0.3**	**1.03**
Newly tested design (with glue)	**0.5**	**1.067**
Newly tested design (without glue)	**0.83**	**1.008**
Box design	**2.0**	**0.72**

Finally, we tested different arrays (i.e., piezoelectric wafers connected in a combined series and parallel circuits) housed in inverted 1.5-gallon capacity plastic globes and a rectangular plastic container. We found that connecting in parallel led to a higher amperage, but a lower voltage. Connecting in series had the opposite affect where we would get a lower amperage, but a higher voltage.



Electricity Generation Potential of Different Bench-scale Prototype Designed and Tested in the Present Research

Summary

- Utilized fluid kinetic energy to generate emission-free electricity using piezoelectric devices.
- Experimented with different orientations, shapes of containers, and circuit setups.
- Used an energy storage system (i.e., full bridge rectifier and capacitor) for storing the generated electric energy.
- Found that a small number of piezoelectric wafers used with the box design generated the highest voltage.

References

- "Piezoelectric Effect: What Is It?" *YouTube*, uploaded by Electrical4U, 13 Dec. 2016, www.youtube.com/watch?v=4nbBAG-848c.
- "Capacitors Explained - The Basics How Capacitors Work Working Principle." *YouTube*, uploaded by The Engineering Mindset, 25 Aug. 2019, www.youtube.com/watch?v=X4EUwTwZ110.
- "Diodes Explained - The Basics How Diodes Work Working Principle Pn Junction." *YouTube*, uploaded by The Engineering Mindset, 19 Jan. 2020, www.youtube.com/watch?v=Fwj_d3uO5g8.
- "How To Wire It! Piezo Disks." *YouTube*, uploaded by ItKindaWorks, 23 Aug. 2016, www.youtube.com/watch?v=sqHJ9tDC9IM.

Acknowledgements

- Chevron for the financial support given to engineering sciences program for SURE 2021 program.
- Team 2 of ENGR 4900 and 4910 (Academic Year 2020-2021) for providing the existing design used in the present research.
- Dr. Saini for leading our group and CSUB NSME Grants and Outreach Office for making our project possible.
- Dr. Cabrales for allowing the use of EC#102 used for group meetings.

Research Team