DESIGN TO ENHANCE ENERGY HARVESTING APPLICATION

Luisa Piccolo Serafim[1], Cece Jin[1], Haru Koga[2], Jolina Hsueh[2], Earl Dowell[1]

[1]Thomas Lord Department of Mechanical Engineering & Materials Science, [2]Nicholas School of the Environment .

Duke BASS CONNECTIONS

Energy & Environment

Introduction

Energy Harvesting: to obtain energy from external sources such as wind energy, solar power, mechanical vibrations, …, and use it to operate a wireless device, or store it in batteries.

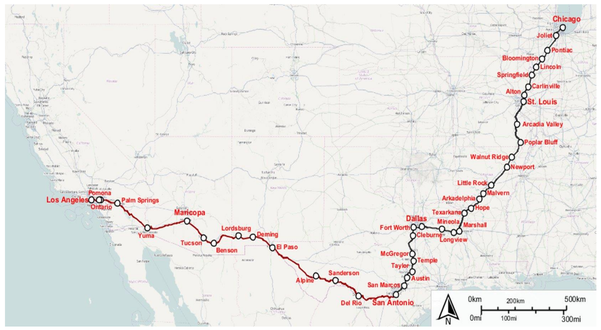
The design of an energy harvester, however, is still very empirical and mostly experimental, and very far from the broader user community.

Goal: to expand the application of energy harvesting solutions by developing a **computational program** than can predict how much energy we can harvest in a **generic application** and compare the performance with a simple **prototype** replicating the real-life scenario.

Field Application

Movement is energy ↔ Energy is movement: In other words, for this particular application, we can only harvest energy from a body that is moving.

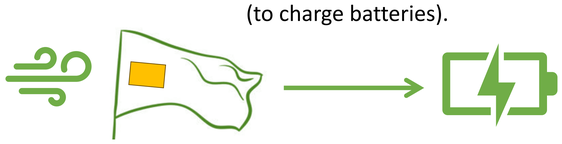
Real-life scenario: charging your phone while traveling in the **Amtrack Texas Eagle**.



How to extract energy from the wind outside the cabin? We can place a very thin plate outside with a piezoelectric element attached.

Piezoelectric components can convert mechanical energy (deflection) into electric energy (to charge batteries).

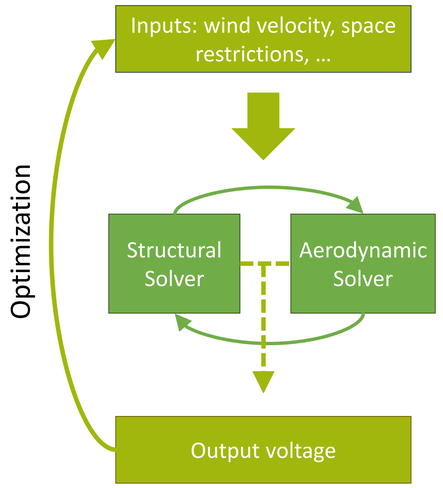
The plate vibrates due to the wind.
The piezoelectric element on the plate is attached to the plate: if the plate deforms, so does the piezo element.

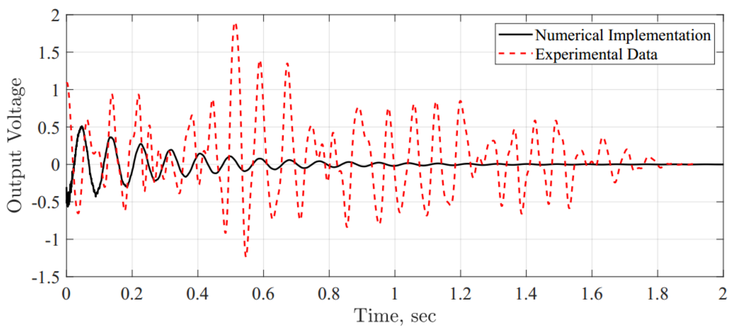


How we can predict energy out of vibration

Once we know how fast the train is going (which can be a good approximation on how fast is the wind oscillating the plate), we can obtain how much voltage, and consequently power, we can extract for a given design and travel duration.

With this information, we can predict how the plate, with the piezoelectric component, will behave for a given moment in time, and predict the amount of energy harvest in the same time length.





Prototype in the Duke Wind Tunnel

Parameters

Aluminum Plate: 175 mm x 25 mm x 0.3810 mm (6.8 in x 0.98 in x 0.015 in)

Wind tunnel air speed: 25 m/s (approx. 56 mph)

Experimental results compared with the numerical solution

Moving forward

- Continue working on the code development to include the optimization step → it will allow the design of the energy harvesting based on the physical restrictions of the space and availability of materials, for a given scenario.
- Expand the case study to include other scenarios and assess the performance on energy harvesters to substitute conventional energy sources.