EnerHarv 2024

PSMA International Workshop | 26-28 June, 2024 | Perugia, Italy

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EnerHarv 2024 Workshop:

The future of wind/wave energy harvesting

Presented By –

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OVERVIEW

- **Energy sources in the natural environment**
- **The wind harvesters**
- **The wave harvesters**

The available sources in natural environment

- **Solar → PV cells : well established technology**
- **Wind → in the typical EH dimensional scale, most devices are based on aeroelastic phenomena:**
  - **Fluttering**
  - **Galloping**

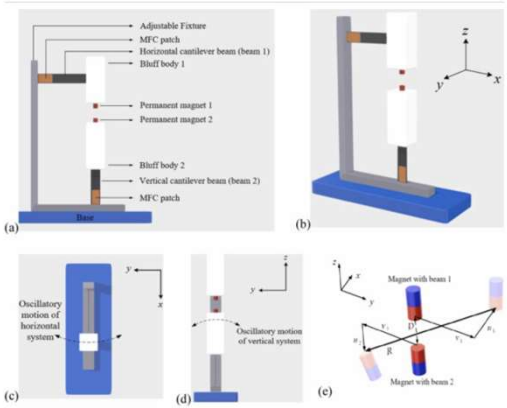
- **Methods: magnetic, piezo, triboelectricity**

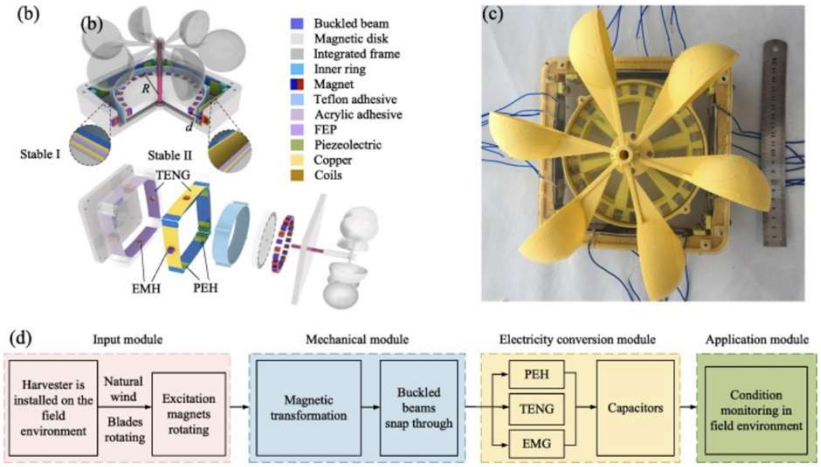
Requirements

- **Small (10 x 10 x 10 cm^3)**
- **Mechanically simple (few or zero rotating parts)**
- **Cheap**
- **Working at low speed**
- **Power output in mW range**

Some example

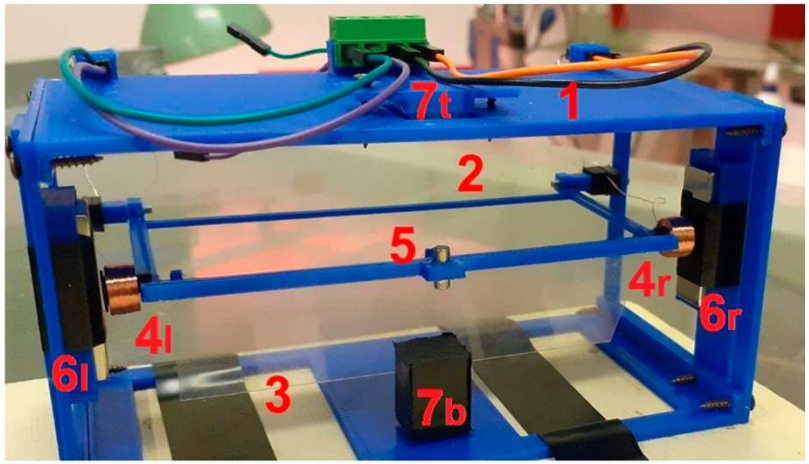
- **Double beam galloping – piezo**
  P output:
  4 mW in 4 m/s [1]
- **Multi elements**
  EH device – magnetic piezo TENG [2]

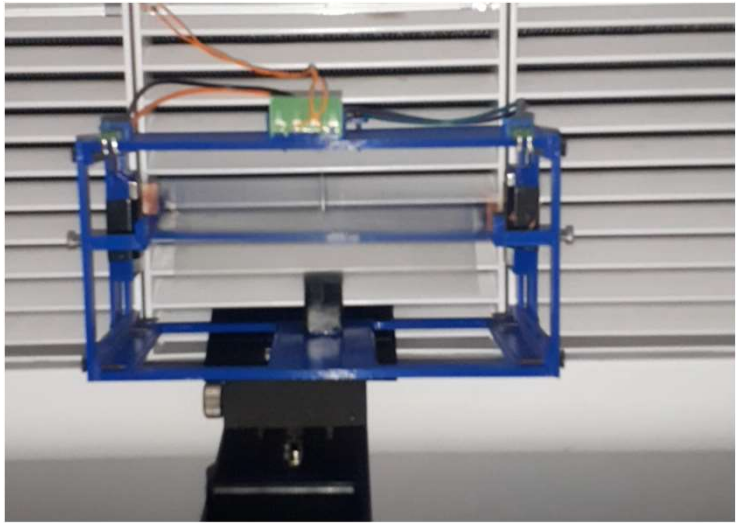




FLEHAP-M

Fluttering effect

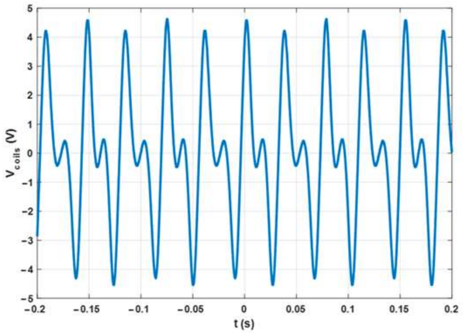


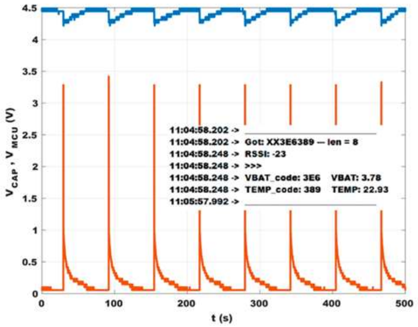


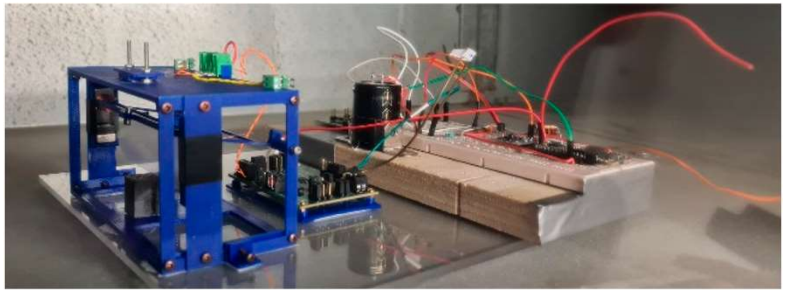
Simple – Cheap – Robust [3]

Application of wind EH devices

- **Smart agriculture**
- **Fire alarm in forest**
- **HVAC [4]**







Wave devices

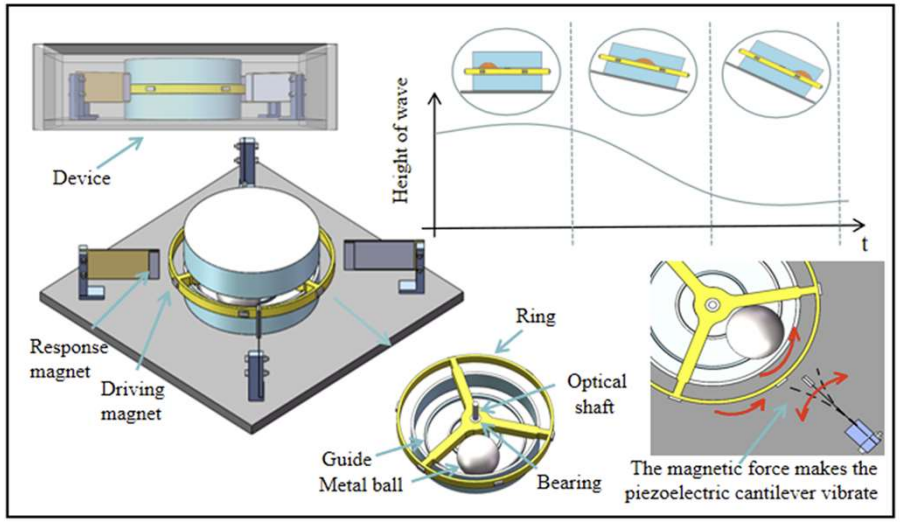
- **Sea waves are characterized by a low frequency (max 2 Hz) and a crest angle of max 20°**
- **Ocean waves have a height of several metres and a period of several seconds**
- **Useful source for big devices**

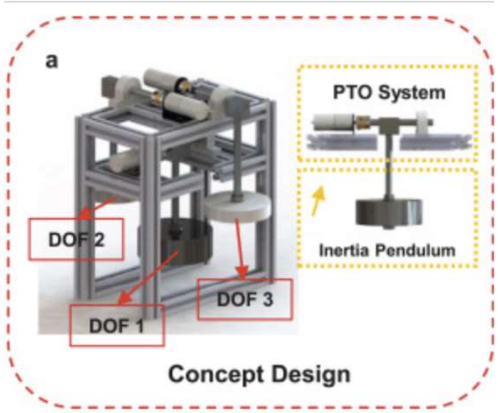
Small wave EH devices

- **Exploit the small oscillations induced by waves with mechanical methods**
- **Generally, the movement of a mass is coupled to a piezo or magnetic generator**
- **Difficult to build in small dimensions**
- **Mechanically complex**

Small wave EH devices

- **Iron ball circulating along a guide output P ≈ 2 mW [5]**
- **Inertial pendulum [6]**

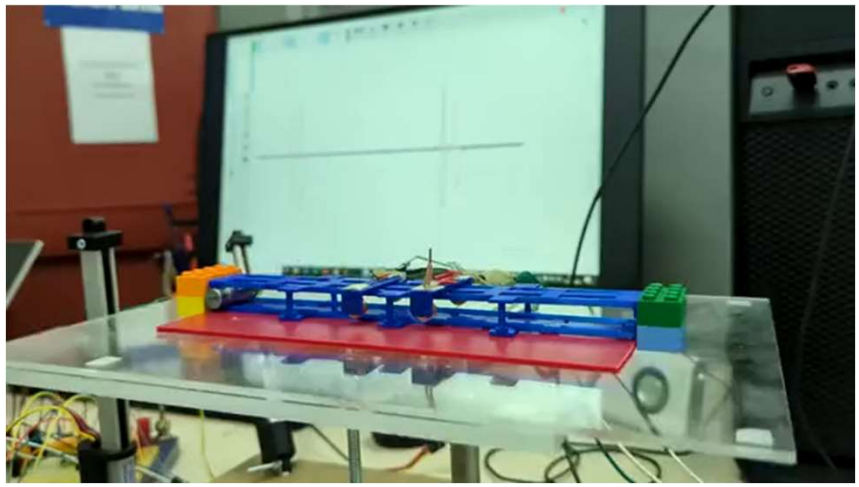




WaH device

WaH is based on a magnet rolling along a rail

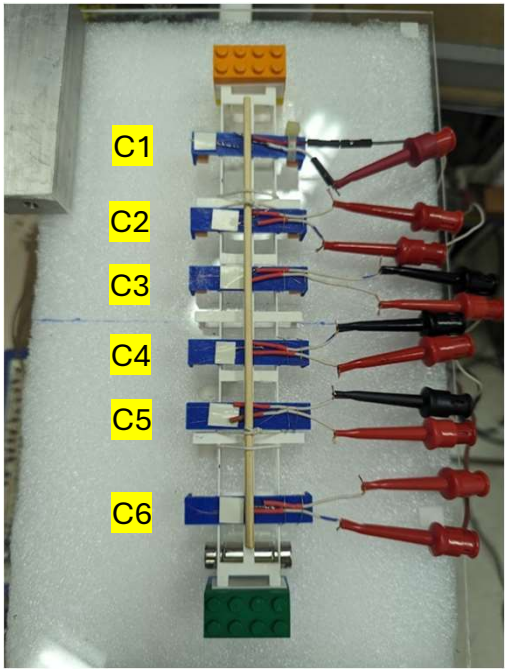
- A series of coils is placed along the rail
- Under the wave action, the rail tilts and the magnet rolls, acquiring velocity
- The length of the rail is related to the wave period
- Actual design : L 20 cm, magnet OD 10 mm, length 32 mm, 1.32 T

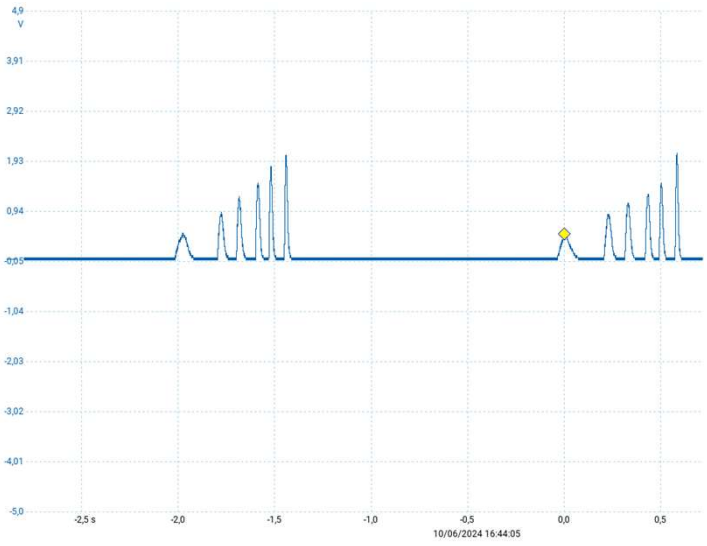


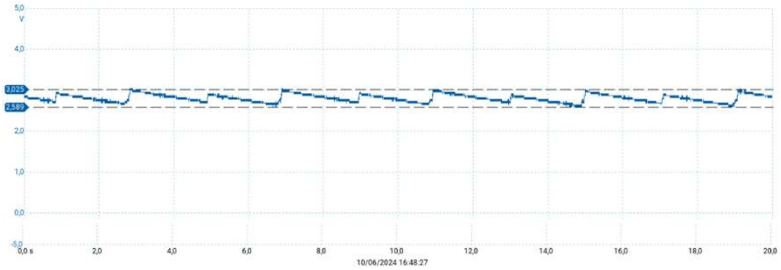
WaH

Test with 6 couples of coils

- OD coils 9 mm, ID coils 5 mm, H 5 mm
  R 150 Ω , L 2 mH (not yet optimized)
- Angle 12° , period ≈ 3 s







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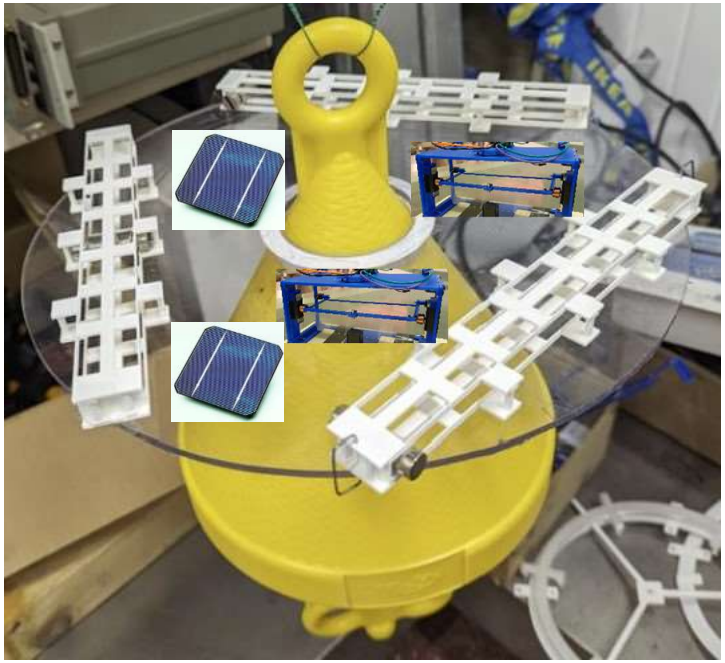
WaH

- **Work in progress !**
- **Next step:**
  - Test in a wave generator tank
  - Low-power electronics
  - Test in real conditions



Application of wave EH devices

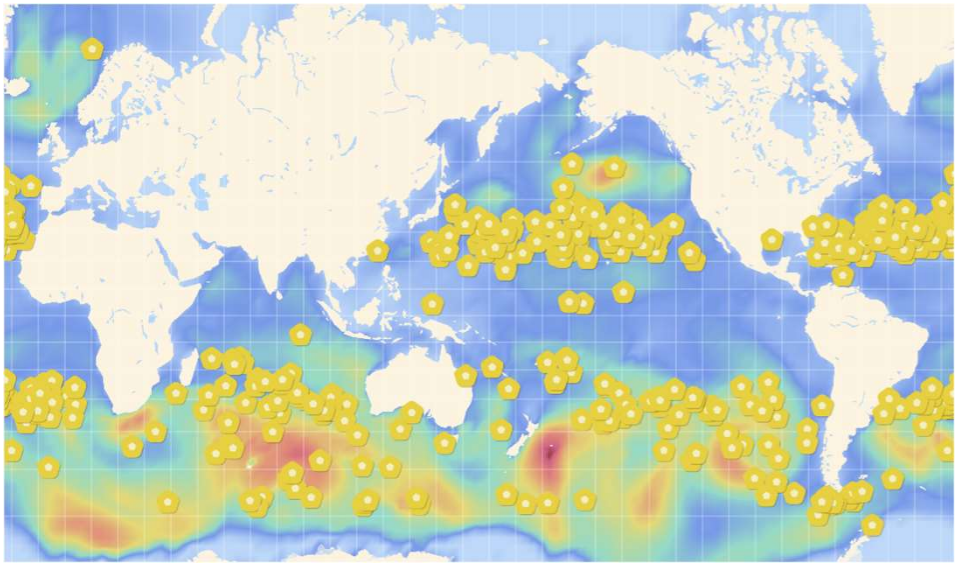
- **Monitoring of marine or river waters**
- **Navigational help (Sofarocean [7])**

Wave & Wave Spectra

Wind

Surface Temp.

Atmospheric Pressure



Conclusions

- **Wind and wave EH devices can be applied in natural environment for various purposes**
- **Must combine robustness, economy, simplicity, versatility**
- **Multi-source devices can offer greater versatility of use**

Collaborators:

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- **F.Nicora DIFI – UNIGE**
- **A. Lo Schiavo Eng. Dept. – Univ. “Luigi Vanvitelli”**
- **G.Besio DICCA - UNIGE**

Funds:

- **RAISE – PNRR UNIGE**
- **PRIN 2022**

Q & A

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Thanks very much for your time and attention!

Questions/comments???

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References

- [1] Sabzpoushan, S.; Woias, P. *Adaptivity of a leaf-inspired wind energy harvester with respect to wind speed and direction,* BIOINSPIRATION & BIOMIMETICS **2024,** 19 4 DOI: 10.1088/1748-3190/ad475a
- [2] Quan B et al. , *A Triboelectric-Piezoelectric-Electromagnetic hybrid wind energy harvester based on a snap-through bistable mechanism* Energy and Conversion Management **2024** 306 118323 DOI: 10.1016/j.enconman.2024.118323
- [3] Olivieri, S.; Boccalero, G.; Mazzino, A.; Boragno, C. *Fluttering conditions of an energy harvester for autonomous powering* RENEWABLE ENERGY, **2017** 105 530 DOI: 10.1016/j.renene.2016.12.067
- [4] Boragno, C.; Aiello, O.;Caviglia, D.D. *Monitoring the Air Quality in an HVAC System via an Energy Harvesting Device*, Sensors **2023**, 23, 6381 DOI 10.3390/s23146381
- [5] Ge S. et al., *A piezoelectric vibration energy harvester for multi-directional and ultra-low frequency waves with magnetic coupling driven by rotating balls* **2022** Applied Energy 310 118511 DOI: 10.1016/j.apenergy.2021.118511
- [6] LiGuo W. et al. *Achieving efficient power generation for an enclosed drifting buoy by multi-DOF wave energy harvesting* Ocean Engineering **2024** 305 117834 DOI: 10.1016/j.oceaneng.2024.117834
- [7] https://www.sofarocean.com/