Timber free-swinging vertical agrivoltaic fence

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1. Context

Vertical agrivoltaics (**APV**) is emerging globally as an **effective system for energy and agriculture**, proving competitive with traditional inclined setups in both cost, crop yield and energy production.

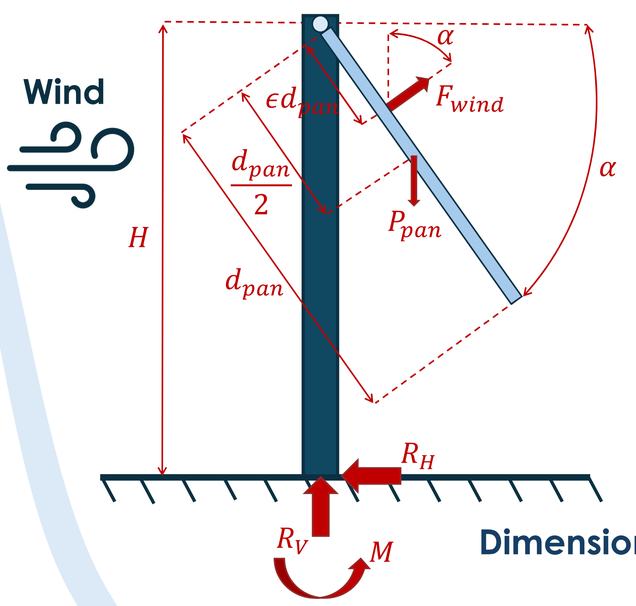
Steel is the standard for APV structures due to its strength and durability but is expensive and carbon-intensive. **Timber** – especially in log form – offers a **low-cost, sustainable, and socially accepted** alternative.

Though less robust than steel, **timber can be safely used with free-swinging systems** that greatly **reduce wind loads on panels**. More, our lab discovered that free-swinging fences can be designed without fixed wind model assumptions, **ensuring safe and cost-effective implementation** [1].

[1] *Dardenne B, Latteur P. Structural Optimisation of Free-Swinging Agrivoltaic Fences, Renewable and Sustainable Energy Reviews, 2024. https://doi.org/10.1016/j.rser.2024.115160.*

More on this here !

2. Theorical background



The supporting structure is designed to ensure that the posts can withstand the maximum values of the three reaction forces: R_H, R_V, and the most critical – The moment M. According to [1], their maximum values are:

$$\left(\frac{M}{HP_{Pan}}\right)_{max} = \frac{1}{4\epsilon} = \left(\frac{R_H}{P_{Pan}}\right)_{max}$$

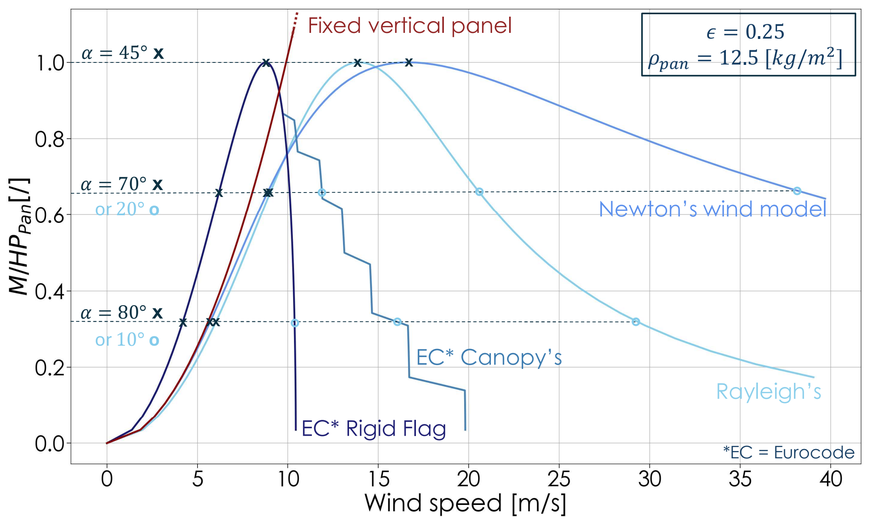
$$\left(\frac{R_V}{P_{Pan}}\right)_{max} = \frac{1}{2\epsilon} - 1 \quad \text{In traction}$$

$$= -1 \quad \text{In compression}$$

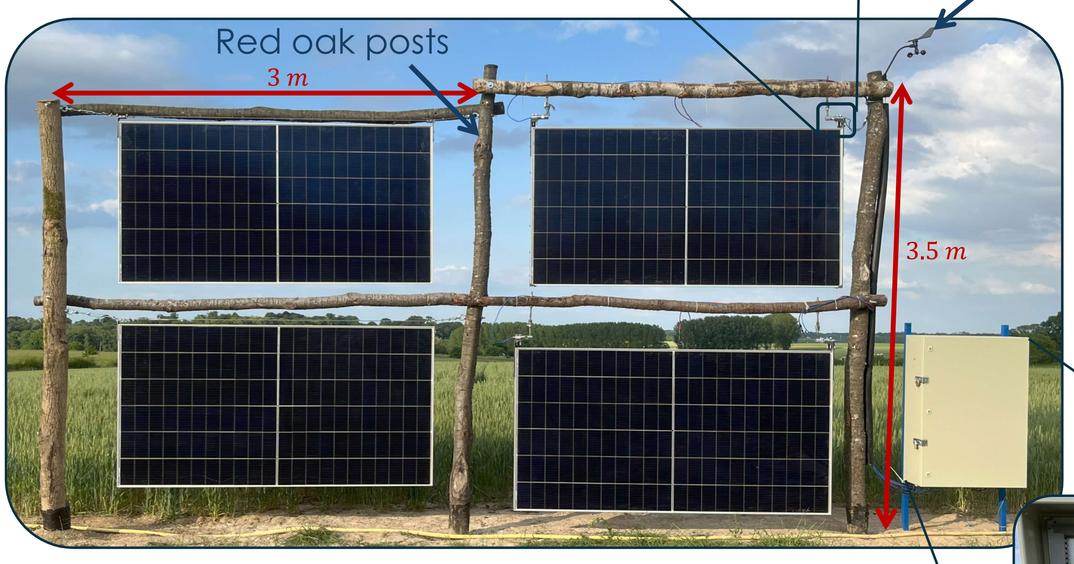
With:

- P_{Pan} weight of the panel.
- H the height of the hinge.
- ϵ the position of the wind force on the panel (can be safely chosen).

Dimensionless moment in the structure post in function of the wind speed



3. Outdoor prototype



Monitored since June 2025 with 4 force sensors, 2 inclinometers and 1 wind speed and direction vane.

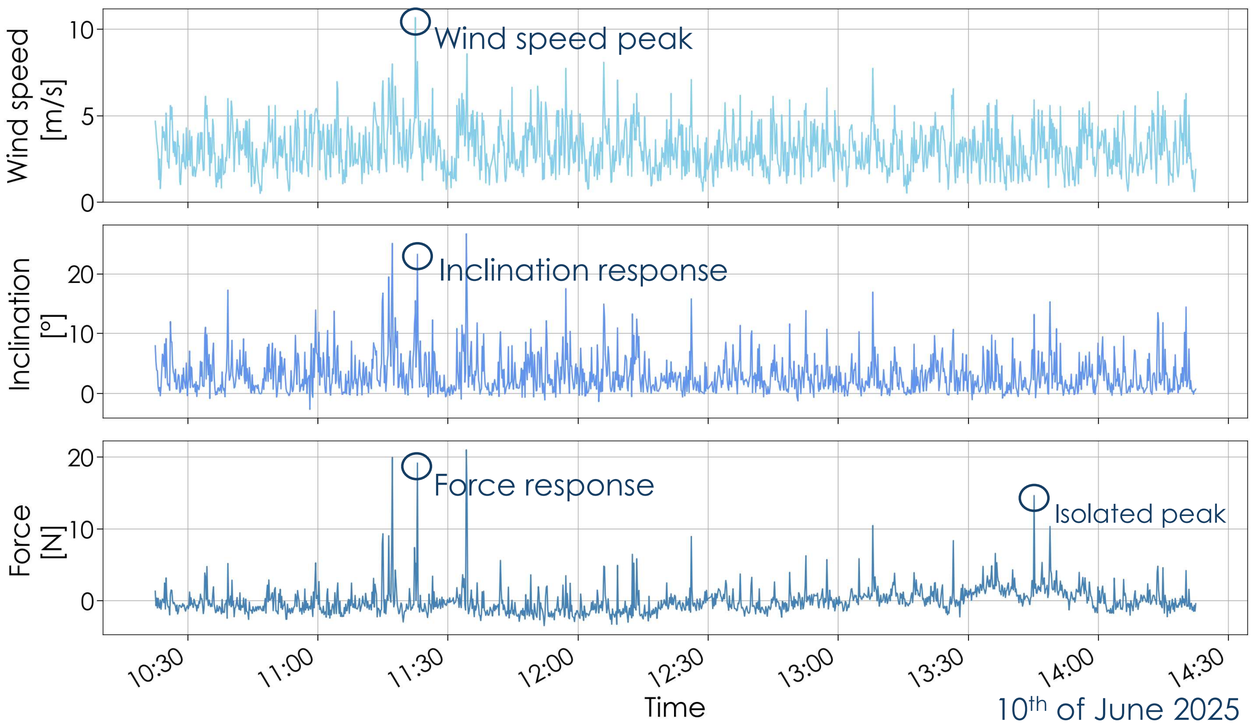
Powered by a 24V – 100Ah battery charged by two of the four PV panels.

Our lab !

Video of the construction

4. Results and conclusion

Force and inclination response to a wind gust

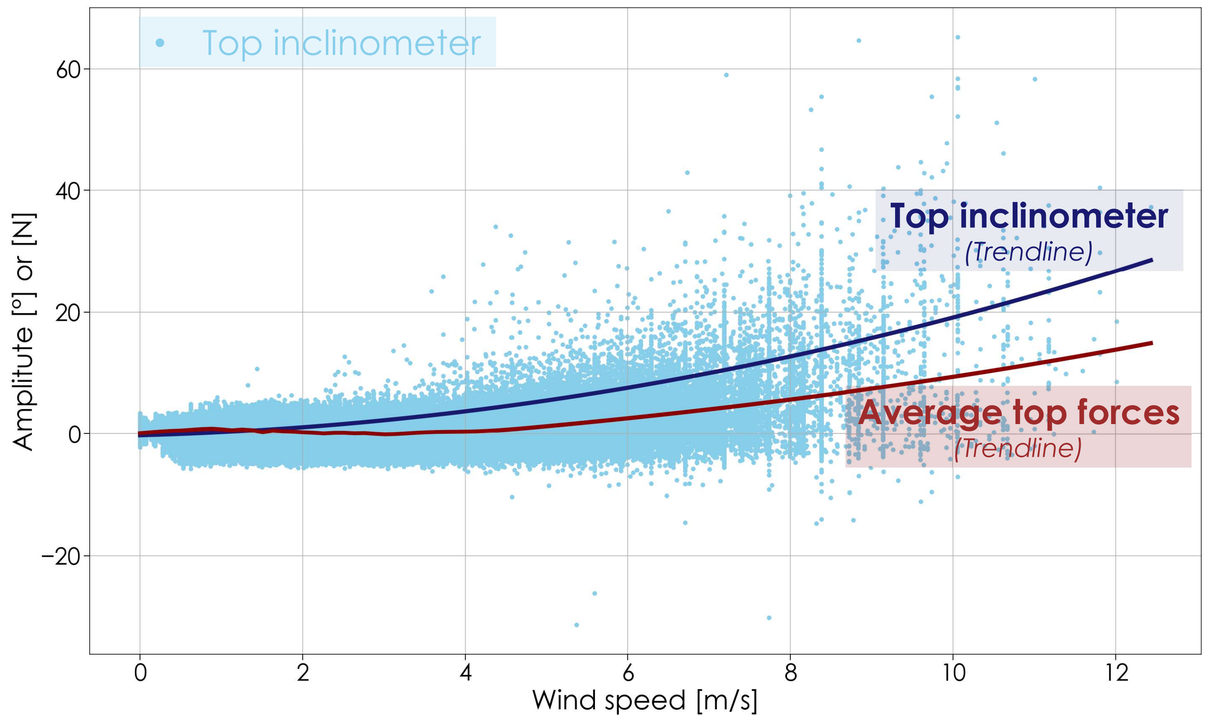


The experimental setup records data from seven sensors (4 force sensors, 2 inclinometers, and 1 wind vane) at $5\,Hz$. Recording is triggered when wind speed exceeds $2\,m/s$, with each session lasting 10 minutes.

Wind velocity peaks induce clear responses in both force and inclination. However, isolated force peaks not directly linked to gusts reveal a distinct dynamic behavior – indicating potential resonance effects within the system due to oscillations.

This study demonstrates that the maximum force in the panel's supporting structure is unaffected by the choice of wind model or standard (each curve reaches the same maximum value). Moreover, this force can be determined easily and conservatively, enabling safe and reliable structural design.

Force and inclination measured in function of the wind speed



A clear correlation is observed between wind velocity, panel inclination, and the forces measured at the suspension hinges. While the setup is still recent and data collection is ongoing, these initial results are promising and might just support the theoretical expectations.

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