Gone with the Wind(storm):
Keeping Your PV Systems Grounded in Extreme Weather

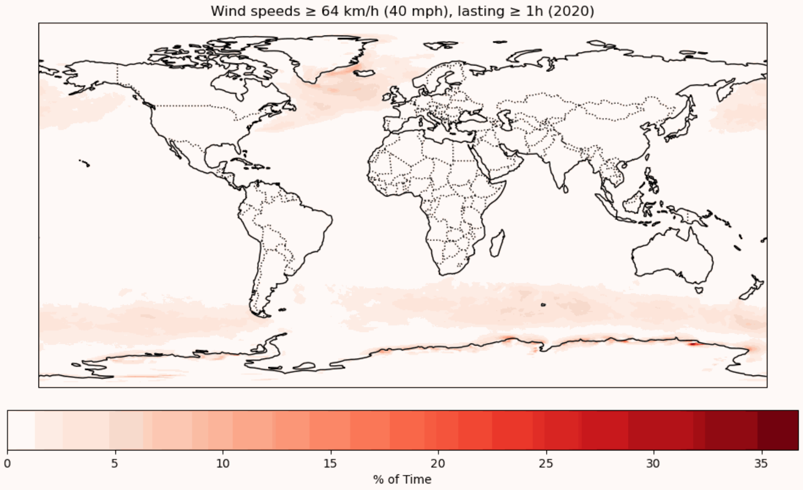
Leonardo Micheli, Sapienza University of Rome (Italy) & experts from Task 13

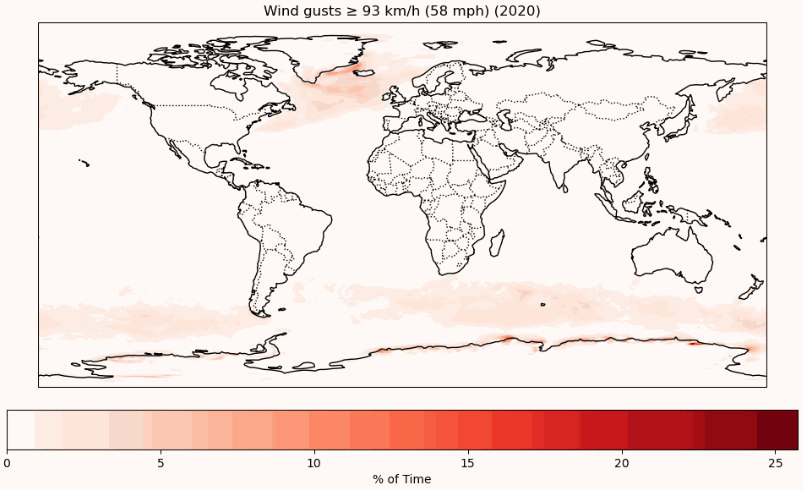
Intersolar, 7 May, 2025

Introduction: Definition

High Winds:

1. **Wind speeds of 64 km/h (40 mph) or greater** lasting for **1 hour or longer**,
2. **Wind gusts of 93 km/h (58 mph) or greater** occurring **at any duration**.





PVI

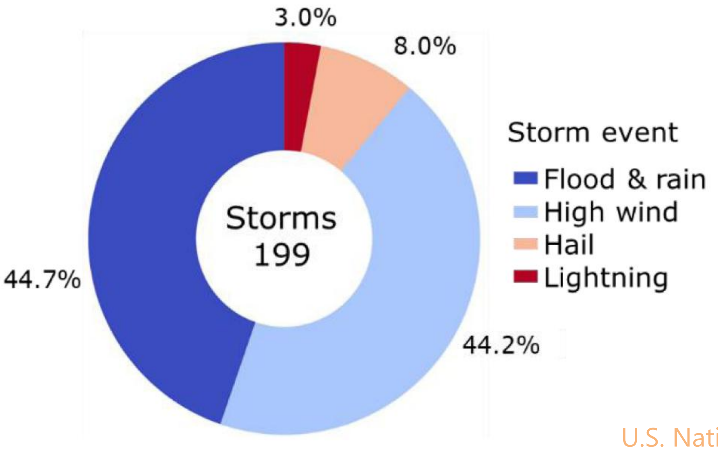
U.S. National Weather Service Glossary

Introduction: Associated Events

Straight-line winds. Winds that have no rotation.

Tornado. A rotating column of air with circulation reaching the ground.

Severe thunderstorm. A thunderstorm that produces a tornado, winds of at least 93 km/h, and/or hail with a diameter of more than 25 mm.



44.2% of the severe weather events impacting PV systems in the U.S. involved high winds.

➔ **wind is one of the two most frequent extreme weather events for PV systems in the U.S.**

U.S. National Weather Service Glossary

D.C. Jordan, K. Perry, R. White, and C. Deline, "Extreme Weather and PV Performance," IEEE J. Photovoltaics **13**(6), 830–835 (2023).

Impacts: Failures and Damages

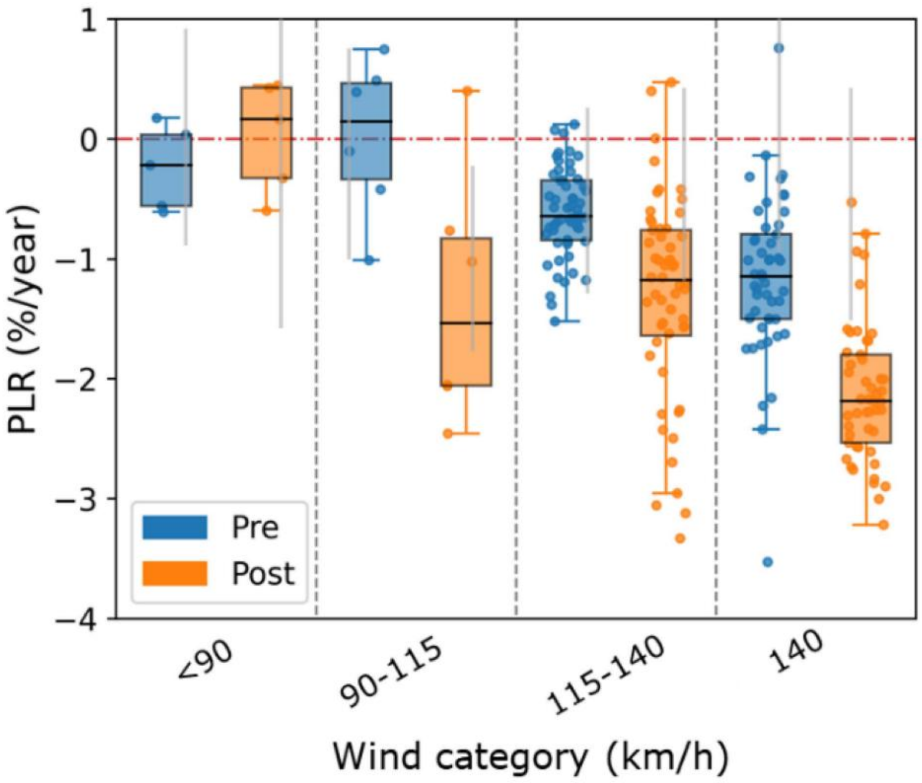
Windstorm:

wind strong enough to cause at least light damage to trees and buildings.

Laurie Burnham,
Sandia National Laboratories

Laurie Burnham,
Sandia National Laboratories

Impacts: Long-Term Losses



- **Long-term performance loss rates (PLR) worsen** after exposure to high wind events.
- A **threshold effect** is visible: wind speeds **> 90 km/h** correlate with **significant degradation**.

PVPS

D.C. Jordan, K. Perry, R. White, and C. Deline, "Extreme Weather and PV Performance," IEEE J. Photovoltaics **13**(6), 830–835 (2023).

Mitigation

Site Selection

- Use historical wind data, terrain information and wind maps to classify **high wind risk**.
- Estimate key metrics (**Probable Maximum Loss, Average Annual Loss**) using recurrence intervals: 1-in-10, 1-in-40, 1-in-500-year events.

System Design, Construction and Operation

Under Construction

Pre Storm

- Secure cables and fasten exposed connectors to protect from **dust and turbulence**
- Store loose items to prevent **flying debris**

Post Storm

- Check for **racking shifts** from wind erosion
- Inspect open trenches and **exposed cables**
- Replace **exposed, dirty, or wet connectors**

Commissioned System

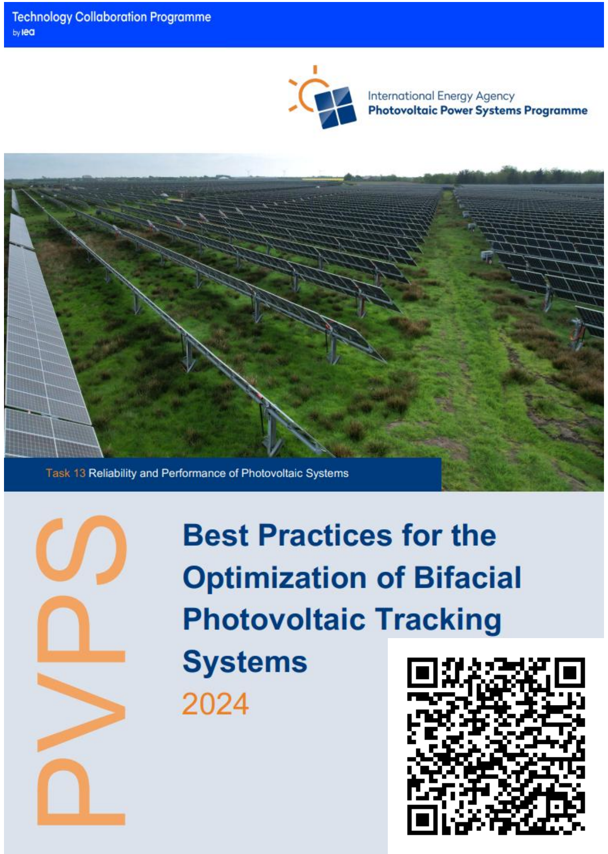
Pre Storm

- **Stow tracker** systems per manufacturer specs
- Clear and secure loose materials near arrays
- Conduct **torque audits**

Post Storm

- Inspect for **module damage, cable abrasion,** and **mounting integrity**
- Test for **faults** (e.g., connectors)

Mitigation: Wind Stow



Wind stow thresholds range from **54** to **79 km/h** with stow angles of **5** to **30°** toward the prevailing wind.

Perimeter trackers may require different strategies compared to interior arrays.

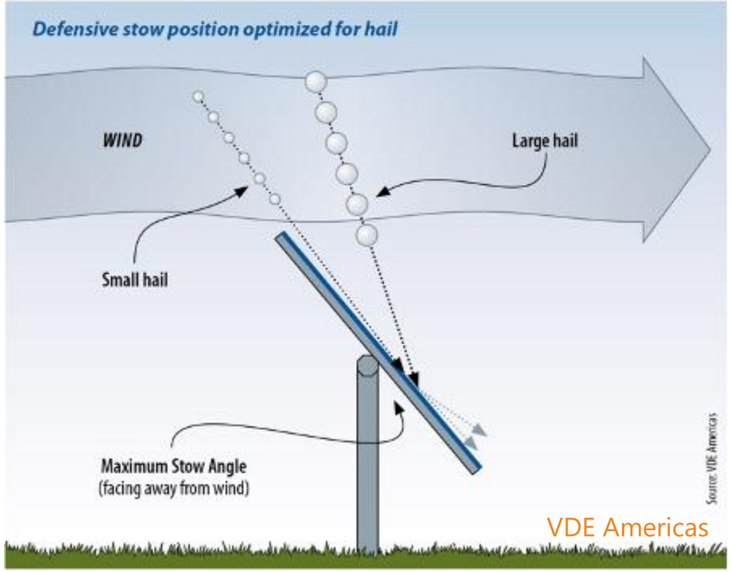
For tracker stow activation, **sensor placement matters** more than high accuracy.

> **50% of users reported damage** due to inadequate tracker response to extreme weather events.

PVPS

J.S. Stein, G. Maugeri, N. Riedel-Lyngskær, S. Ovaitt, T. Müller, S. Wang, H. Huerta, J. Leloux, J. Vedde, M. Berwind, M. Bruno, D. Riley, R. Santhosh, S. Ranta, M. Green, K. Anderson, and L. Deville, *Best Practices for the Optimization of Bifacial Photovoltaic Tracking Systems [IEA-PVPS T13-26:2024]* (2024).

Mitigation: Wind Stow



VDE Americas

Tilting the panels into the wind is **not ideal for hail**.

- **Prioritize hail stow when possible**: where the tracker manufacturer allows, hail stow should take precedence over wind stow.
- **Account for wind limits**: make sure the tracker system can physically withstand the wind load at that position.

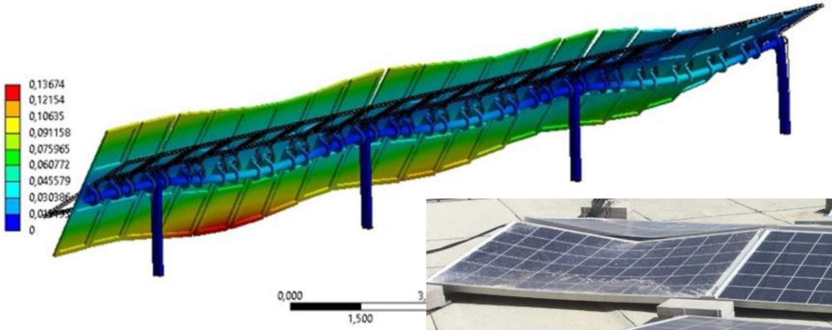
PVPS

P. Bostock, K. Elser, and J. Previtali, *Best Practices for Hail Stow of Single Axis Tracker-Mounted Solar Projects* (2024).

High Winds… and Beyond!

Dynamic Wind Effects

Wind can induce **torsional galloping** in tracker structures, leading to increased fatigue, even in **non-extreme events**.



Snowdrift Accumulation

Wind can **redistribute snow**, leading to **uneven loading** on PV structures.

Sand Transportation & Abrasion

In arid regions, wind can transport **sand**, accelerating soiling and abrasive wear.

Key Takeaways

- Wind is both **common and potentially catastrophic** for PV. Strong winds can also accelerate long-term damage.
- Damage may also extend beyond mechanical failures to include a **heightened risk of electrical hazards**.
- Even with stow protocols in place, poor implementation can lead to **real-world failures**.
- Designing for wind means accounting for both extreme wind events, as well as **dynamic structural loading and other secondary effects**.

Thank You for Your Attention!

Leonardo Micheli
leonardo.micheli@uniroma1.it