Wind lidar: Protect solar farms, reduce costs, avoid needless stowing

Digital Guide

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Wind ramps: A serious and growing risk

Wind ramps — sudden, sharp changes in wind speed — are a serious threat to solar power plants around the world. Climate change is only exacerbating these unforeseen wind events, which can cause extensive damage from shattered heliostats to twisted tracker arms. The result is costly damages, lost production, and even higher insurance premiums.

Early stowing is critical for reducing structural loads and protecting the site, but high-gradient wind ramps can be difficult to anticipate with most stow strategies. Knowing exactly when to stow for wind ramps is much easier today, thanks to precise long-distance wind measurements with modern scanning wind lidars.

The long-term costs of wind ramp damages

The impacts of wind ramps extend far beyond physical damage. Unplanned stowing of trackers to protect equipment can significantly reduce energy production and revenue.

At the same time, the insurance landscape is shifting as premiums rise sharply and coverage limits are reduced in response to the increase in wind-related claims. This leaves solar asset owners increasingly exposed to the financial consequences of these disruptive events.

Common causes of wind ramps

Convective storms

- Intense thunderstorms create powerful downdrafts and outflow winds
- Concentrated columns of sinking air produce destructive straight-line winds

Cold fronts

- Temperature differentials cause rapid wind shifts and gusty conditions

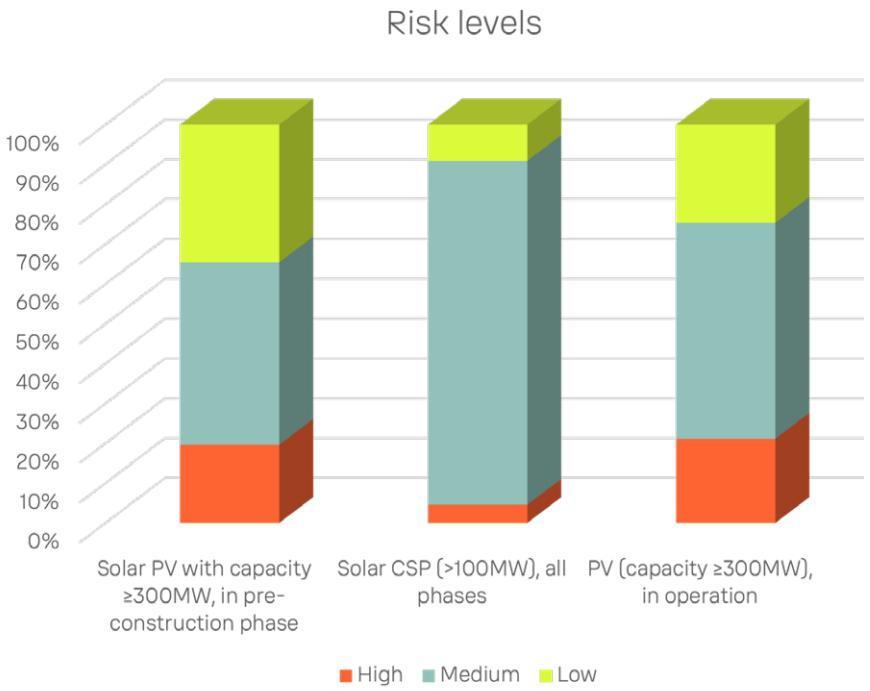
How many solar power plants are at risk?

Vaisala conducted a risk assessment study of solar projects to categorize sites based on their wind hazard exposure. The results, illustrated in the accompanying graph, reveal that:

- 68% of large-scale solar plants (planned & operational) fall into high or medium risk categories. This confirms that wind hazards affect both developers and operators.

- CSP plants are often in areas with medium to low wind. However, they are sensitive to wind because precise heliostat alignment is crucial, making moderate gusts a threat to performance and justifying effective mitigation strategies.

In other words, a wind ramp is not just a rare occurrence. It's a widespread challenge that solar energy plant developers and operators must address.



Stowing: The hidden cost of playing it safe

The best way to avoid wind ramp damage is to stow the trackers before the gust hits, which reduces the wind loads and protects the solar field. But stowing too often or unnecessarily negatively impacts energy production and profitability. The challenge is how to act early enough to prevent damage but not so early that you lose power generation.

The stowing threshold you choose has a direct effect on the revenue generated. Selecting lower thresholds, which is a more cautious approach, can lead to frequent and sometimes unnecessary production losses.

A study[*] by Arctech Solar looked at a 100 MW solar power plant and discovered:

- At a stow threshold of 22 meters per second, the energy loss is minimal: less than 0.1%, or about US $6,000 per year.
- However, if the threshold is lowered to a cautious 12 meters per second, the loss jumps to over $260,000 per year — 4% of the annual energy production.

What if we had more reliable wind data and a system that could accurately predict gusts and stow only when necessary? Advanced remote sensing technology makes this possible.

[*] López, César Hidalgo, Magalhães, Pedro, and Sylvia, Tim. "Are you tracking or stowing? – A financial analysis of stow strategies." Webinar, pv magazine, April 26, 2022. https://www.pv-magazine.com/webinars/are-you-tracking-or-stowing-a-financial-analysis-of-stow-strategies

Mitigating wind ramp risks with WindCube Scan

Scanning wind lidar monitors real-time current and upcoming wind conditions remotely over long distances. Today, it is the most effective method for mitigating wind hazards at a solar power plant.

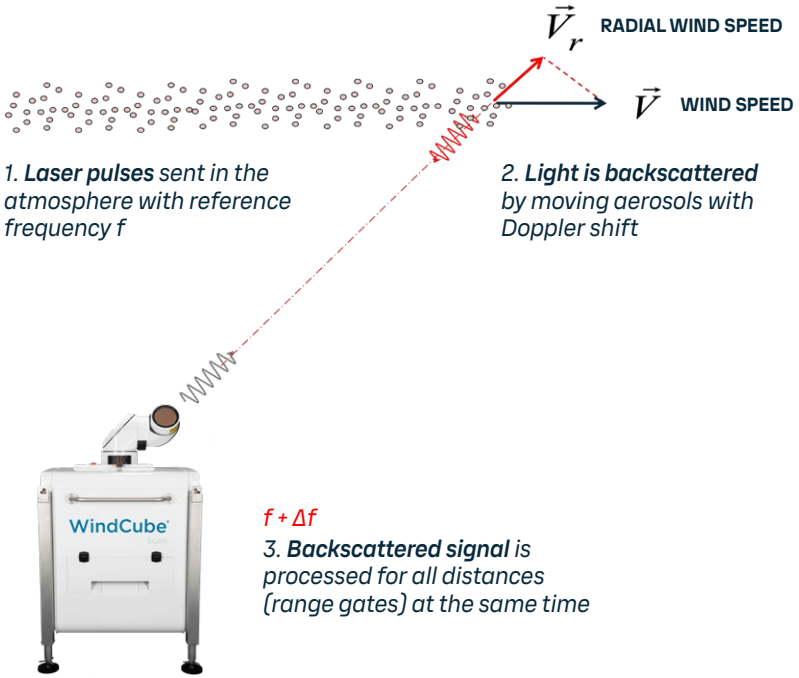
WindCube® Scan is the most trusted and reliable 3D scanning wind lidar. Worldwide deployments range from mission-critical aviation safety to high-precision wind energy applications Unlike single-point anemometers, WindCube Scan provides a comprehensive, real-time view of the wind field across more than 350 km^2, allowing you to pinpoint the timing, speed, and direction of incoming wind ramps. This level of wind data granularity enables you to make more informed, precise decisions about when to stow your trackers, optimizing energy production while safeguarding your solar assets.

Key features

- Powerful range: 10 km typical, up to 19 km
- Accurate and reliable over long service life
- Robust, all-weather performance
- Autonomous thermal regulation
- Eye safe and easy deployment

How it works

WindCube Scan operates with the pulsed heterodyne Doppler lidar principle.



→ The Doppler shift is proportional to the radial wind speed.

Nowcasting: Case study with RayGen

Presented at American Clean Power 2024, this paper discusses the use of WindCube Scan to predict and mitigate wind hazards at renewable energy power plants. A case study at the RayGen Hi-Tech Solar and Thermal Storage Plant in Carwarp, Australia, demonstrates the effectiveness of this approach, with the lidar detecting a cold front and providing advance warnings of about 15 minutes. The key benefits include reducing damage to heliostats, lowering design costs, and maximizing plant yield.

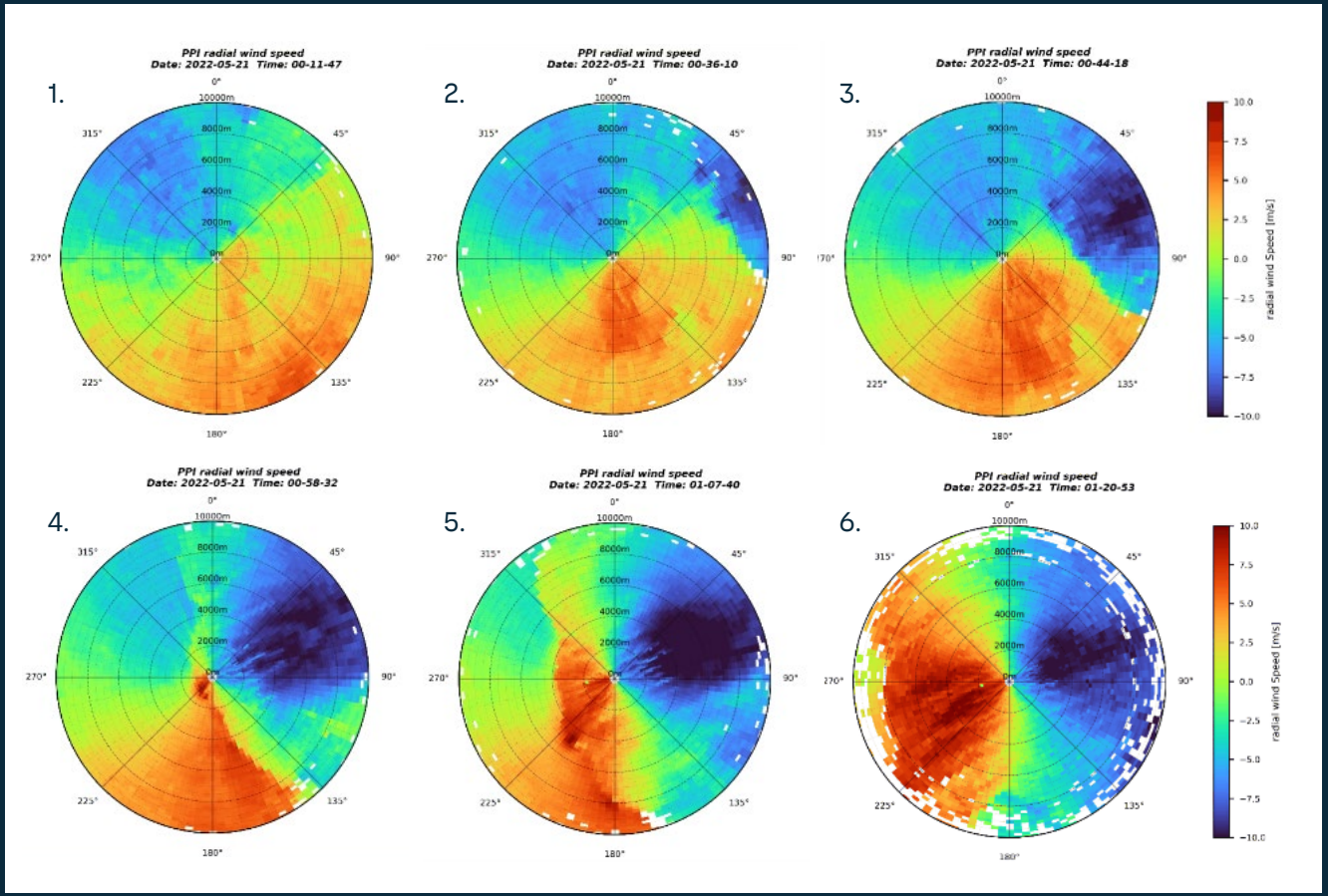
Read the paper: Nowcasting Wind Hazards for Renewable Power Plants Protection with a Doppler Wind LiDAR

Example: Measuring and tracking a large wind ramp

These images show a bird's eye perspective of an approaching wind ramp. This sudden change in wind conditions is visible about 15 minutes before it reaches the center.

The WindCube Scan is positioned in the center of these images, and it performs a 360-degree scan in azimuth — performing a flat scan all around itself, covering a radius of 10 km. Dark blue indicates wind moving towards the lidar, while dark red indicates wind moving away.

In the first image, you can clearly see the wind coming in from the northwest, following the arrow. The second scan shows that a new wind is approaching at the western edge. Progressing through the scans, it becomes clear that a new wind direction and speed are moving in.



Quantify the benefits at your site

Don't let unforeseen wind ramps jeopardize the performance and profitability of your solar farm. Discover how WindCube Scan provides the visibility, predictability, and control you need to safeguard your assets and maximize your solar energy potential.

To help solar operators understand the full impact of WindCube Scan, Vaisala offers a comprehensive performance evaluation service. By conducting a six-month measurement campaign on your site, we can correlate dangerous stowing events with the lidar data, quantifying key metrics like the wind ramp alert true positive ratio, false positive ratio, and forecasting time.

This analysis allows you to calculate the tangible return on investment, from increased energy production to reduced wind-related damages and equipment repairs. With a clear understanding of the wind ramp hazard mitigation benefits, you can make data-driven decisions to optimize your operational strategy and protect the long-term viability of your solar investment.

Go in-depth with the LiveCast

See the full presentation to learn more about these topics discussed by our solar energy and WindCube experts.

Watch the recording

Why Vaisala?

We are innovators, scientists, and discoverers who are helping fundamentally change how the world is powered. Vaisala elevates wind and solar customers around the globe so they can meet the greatest energy challenges of our time. Our pioneering approach reflects our priorities of thoughtful evolution in a time of change and extending our legacy of leadership.

Vaisala is the only company to offer 360° of weather intelligence for smarter renewable energy, nearly anywhere on the planet. Every solution benefits from our nearly 90 years of experience, deployments in 170+ countries, and unrivaled thought leadership.

Our innovation story, like the renewable energy story, continues.

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