DRONE INSPECTIONS CAN PREVENT

MILLION-DOLLAR LIGHTNING LOSSES

For nearly a decade, researchers have studied lightning activity across 67,000 wind turbines to produce the most comprehensive assessment of lightning risks in U.S. wind farms. (Courtesy: Kathrine Birch, https://www.pexels.com/photo/clouds-and-rain-over-a-wind-turbine-farm-on-the-hills-12506601/)

The shift toward drone-based lightning protection system inspections represents more than just an operational upgrade – it is a fundamental evolution in how wind-energy infrastructure is safeguarded against one of its most persistent threats.

By ADRIANA NAJERA

Wind turbines stand as towering symbols of progress in the global renewable energy landscape. However, their height and exposure make them particularly vulnerable to lightning strikes. Each turbine is designed with a Lightning Protection System (LPS) to safely channel electrical energy into the ground, but these systems require regular inspections to remain effective. Without proper maintenance, damage from lightning strikes can cost the wind-energy industry more than $100 million annually, with blade losses accounting for 60 percent of these expenses.

For nearly a decade, researchers have studied lightning activity across 67,000 wind turbines to produce the most comprehensive assessment of lightning risks in U.S. wind farms. Data from Vaisala Xweather reveals that lightning strikes occur more frequently in taller turbines. A 115-meter turbine experiences an average of 0.2 strokes per year, while a 200-meter turbine may be hit as often as 1.2 times annually. As reliance on wind energy grows, ensuring effective LPS inspections becomes increasingly important to maintain turbine longevity and operational stability.

HIGH LIGHTNING DENSITY RISK

Figure 1 illustrates the concentration of in-cloud and cloud-to-ground lightning occurrences per square kilometer in 2023, referred to as lightning density. Wind farms in regions with a high lightning density face a greater risk compared to those in areas with lower lightning density, such as the Northeast and the West Coast.

One of the most lightning-prone wind farms in the United States is in Pushmataha County, Oklahoma, where turbines face an average of 10 lightning strokes per year. In fact, one turbine in this location has been struck an astonishing 111 times since 2019. Nationally, about a quarter of wind farms experience at least one lightning strike per turbine annually, underscoring the need for systematic inspections and maintenance.Regular LPS inspections are crucial for minimizing turbine downtime and preventing costly repairs. International standards, such as IEC 61400-24, recommend full resistance testing twice annually. Additional inspections are also required after significant weather events such as thunderstorms or hurricanes. Without proper monitoring, LPS damage can go undetected, leading to catastrophic failures and significant financial losses.

TRADITIONAL INSPECTION VS. DRONES

Traditionally, LPS inspections have required teams of certified climbers scaling turbines, a time-consuming and hazardous task. Ohmmeter testing, which measures resistance between LPS components, also demands direct contact with turbine elements, making it a labor-intensive process. However, the industry is shifting toward drone-based inspections to enhance safety and efficiency.

Drone technology, like the Voliro T equipped with an LPS inspection probe, is transforming wind-farm inspections. Designed specifically for LPS testing, the Voliro T features a Micro-Ohmmeter VG-BAT-150, enabling precise 4-wire measurements using currents of 0.30A. It delivers high-accuracy readings across a broad 0.001-1,000 Ω measurement range, regardless of the turbine rotor's orientation.

By completing an LPS assessment in just 30 minutes — compared to the half-day required for rope access inspections — drones provide a faster, safer, and more cost-effective solution. This advanced technology allows resistance measurements and early issue detection, preventing costly failures. Companies that have integrated drone-based inspections into their maintenance routines report significantly reduced operational costs and turbine downtime.

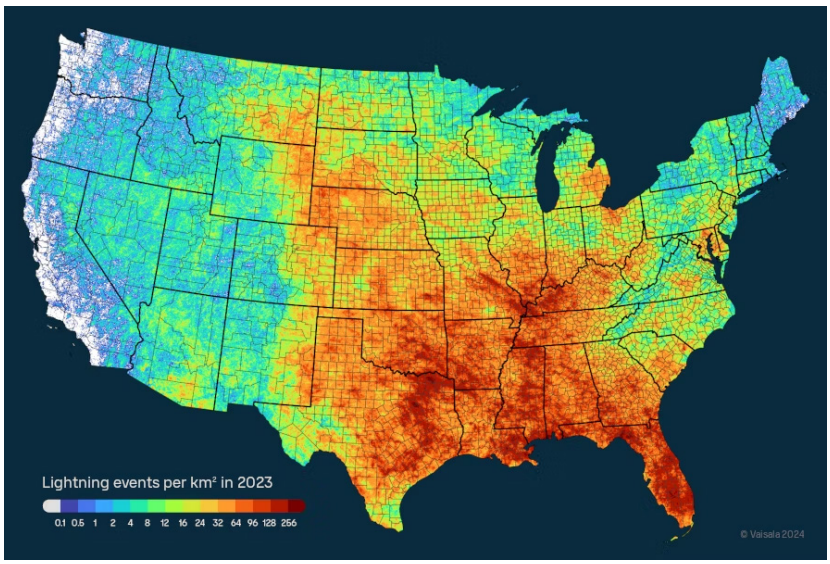
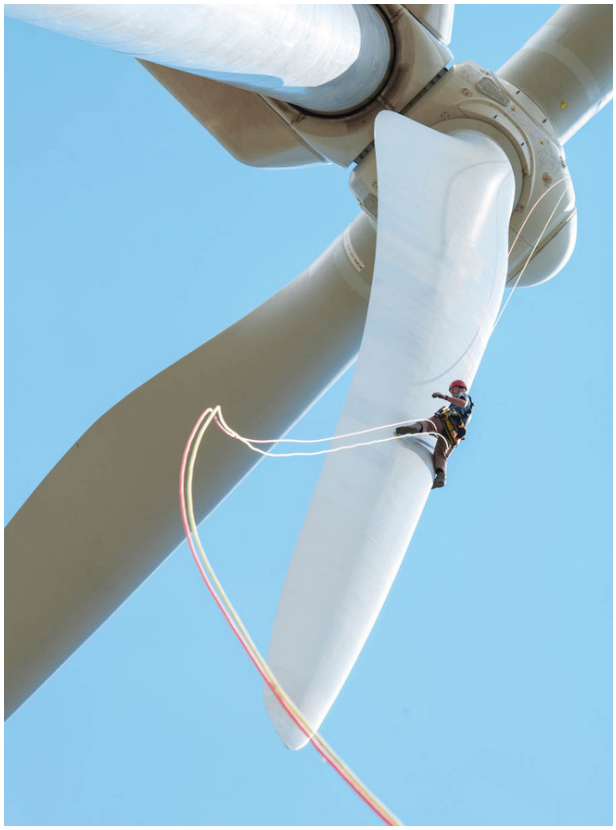


Figure 1: The concentration of in-cloud and cloud-to-ground lightning occurrences per square kilometer in 2023. (Courtesy: Vaisala)

UAV Voliro pilot Morten Pedersen prepares the Voliro T drone equipped with an LPS inspection probe on the right to conduct inspection. (Courtesy: Indonesia Suprabakti)



Traditionally, LPS inspections have required teams of certified climbers scaling turbines, a time-consuming and hazardous task. (Courtesy: Dennis Schroeder/NREL)

CASE STUDY

With Voliro's technology, Skyspecs, a provider of autonomous drone inspections and asset management solutions for the wind-energy industry, tested 210 wind turbines across Germany and the U.S., inspecting eight to 18 turbines per day. Inspections are faster and safer, as the staff doesn't need the use of rope access methods.

The process of drone-based LPS inspections begins with a thorough pre-flight check to ensure the drone is fully operational. The Voliro T drone then is piloted close to the turbine, making contact with LPS receptors to measure resistance and test grounding connections. Data collected during the inspection is available immediately for reporting and interpretation analysis of the wind turbine's LPS system, allowing wind-farm operators to address any detected defects quickly.

Embracing drone technology for LPS inspections is not just a matter of convenience — it is a necessity for the future of wind energy. High-precision inspections are vital for maintaining efficiency and preventing costly damages. By integrating modern LPS inspection techniques, wind -arm operators can improve reliability, enhance safety, and reduce long-term operational expenses.

CONCLUSION

The shift toward drone-based Lightning Protection System (LPS) inspections represents more than just an operational upgrade — it is a fundamental evolution in how wind-energy infrastructure is safeguarded against one of its most persistent threats. By replacing labor-intensive, high-risk manual inspections with precision-driven UAV technology like the Voliro T, wind-farm operators can transition from

A Voliro T drone inspects the lightning protection system of a wind turbine in Indonesia. (Courtesy: Indonesia Suprabakti)

reactive maintenance to proactive resilience. This shift not only reduces costs and turbine downtime but also extends the lifespan of critical assets, ensuring the sustainability of clean-energy production.

RESOURCES

[1] IEC 61400-24 Standard.

[2] Best Practices for Wind Turbine Maintenance.

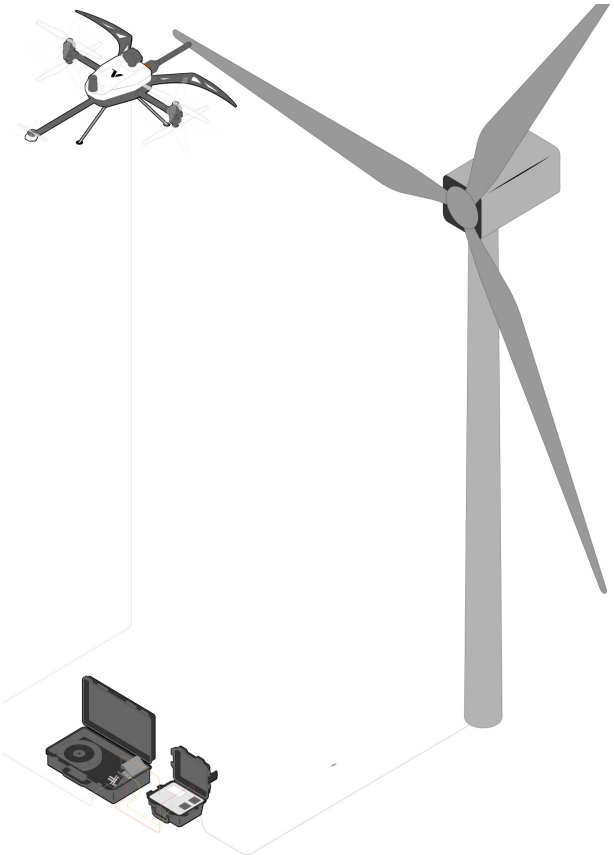
[3] www.xweather.com/blog/article/xweather-reveals-lightning-risk-for-wind-farms.

[4] Drone Technology for Wind Turbine Inspections.

[5] Lightning Protection for Renewable Energy Systems.

ABOUT THE AUTHOR

Adriana Najera is the marketing and communications specialist at Voliro, leveraging her journalism background to craft impactful brand stories and marketing strategies. With expertise in digital marketing, PR, and content creation, she drives Voliro's global visibility and industry presence in aerial robotics. Voliro is a Swiss company pioneering advancements in aerial work at height with its innovative solution, the Voliro T. Engineered for precise, contact-based operations, the Voliro T enables industry leaders such as Chevron, Holcim, and global inspection specialists such as Acuren and Mistras to achieve new standards of safety and operational excellence. Equipped with five advanced tools for Non-Destructive Testing (NDT), it serves a wide range of sectors, including oil and gas, power, chemicals, wind energy, construction, maritime, and infrastructure. By revolutionizing contact-based inspections, Voliro is setting a new benchmark for safety, productivity, and innovation worldwide. For more information, go to : www.voliro.com



In the air: Voliro T with needle probe payload. On the ground: Cable management system and ohmmeter. (Courtesy: Voliro)