Hail risk mitigation strategies for solar projects

in collaboration with

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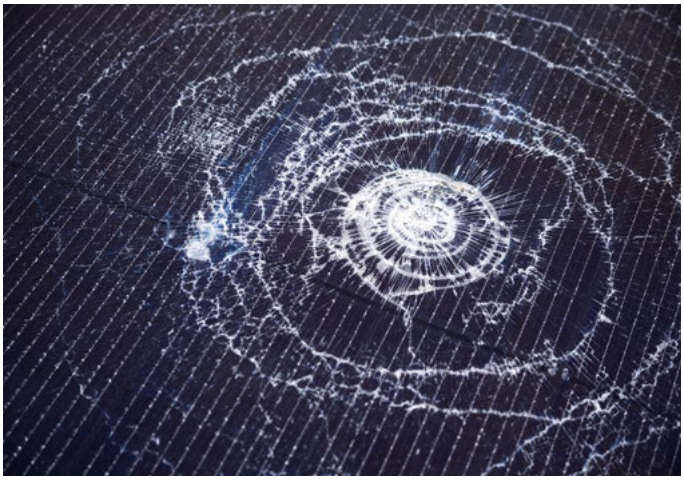

Introduction

Hailstorms are an increasing threat to solar photovoltaic ("PV") projects in several regions of the United States, particularly across the Plains and Midwest. In states like Texas, a national leader in renewable energy development, severe convective storms during the spring and early summer months can produce hailstones larger than 2.5 inches in diameter. These events pose a significant risk of damage to solar panels through glass breakage or microcracking, which can result in power degradation, costly repairs, and extended project downtime.

The frequency, size, and wind-driven speed of hailstones vary by region, but the risk of impact is a consistent concern for developers and asset owners in high-exposure areas. In the Southern Plains, solar projects must be designed and operated with this threat in mind.

While the risk is substantial, solar projects can remain viable in hail-prone areas by combining resilient technology, accurate forecasting, and proactive mitigation. This paper outlines best practices for managing hail risk, including:

➜ Early threat identification through real-time and forecast-based weather monitoring

➜ Use of robust modules and tracker technologies

➜ Implementation of site-specific stow strategies to reduce exposure

When deployed effectively, these measures can significantly reduce hail-related losses while preserving long-term system reliability and financial performance.

Key mitigation strategies

1 Module technology

➜ Install modules with tempered front glass between 3.2 mm and 4.0 mm for improved hail resistance.

➜ Request hail-specific stress testing during procurement. The IEC 61215-2 hail impact test (using 25 mm ice spheres at 23 m/s) is a baseline; supplement with larger ice balls and environmental stress simulations where feasible to understand module durability.

When enhanced modules are unavailable, implement proactive stow procedures to minimize strike angles during severe storms.

2 Racking and tracker technology

➜ Trackers can stow in < 2 min to > 30 min depending on manufacturer and configuration; every second counts. Choose systems with automated or quick-response stowing.

➜ Select trackers capable of rotating to a tilt angle between 60 and 77 degrees. Higher tilt angles reduce hail impact energy by minimizing strike angles and lowering kinetic force from large hailstones. Ensure that hail and wind stow angles are coordinated, as hail events are often accompanied by high winds.

3 Comprehensive Hail Mitigation Plan

An effective plan engages all stakeholders, is documented, and is practiced before hail season.

3.1 Early-Warning Systems

Leverage the SPC (Storm Prediction Center) Day-1 hail outlook, updated five times daily, which pinpoints ≥ 1-inch hail and flags ≥ 2-inch threats. Commercial weather providers such as Indji Watch overlay these forecasts onto exact asset locations, offering targeted threat intelligence.

3.2 Real-Time Monitoring

➜ Forecast integration: Use NOAA high-resolution convection models, accessible through platforms such as Indji Watch, to obtain hourly updates predicting severe storms with possible large hail up to 12 hours in advance.

➜ Storm watches: Monitor Severe Thunderstorm and Tornado Watches issued by the National Weather Service as indicators of escalating storm conditions.

3.3 Customized Alerts

➜ Geo-fencing: Define spatial buffers around the site to detect approaching hail threats while minimizing false positives. Buffer size should consider tracker stow response time, storm approach speed, and any delays associated with manual stow procedures or system latency.

➜ Hail thresholds: Customize alert triggers based on hail size, probability, and storm trajectory, ensuring alignment with the mechanical design limits of the trackers and modules deployed at the site. Using smaller hail diameter thresholds can provide a more conservative approach.

➜ Alert dissemination: Deliver real-time alerts and "all-clear" notifications via text, email, or API to key personnel, including control center operators, and O&M teams.

➜ System integration: Ensure that alerts are integrated into SCADA or asset management platforms where possible to support automated or semi-automated responses.

➜ Ongoing review: Regularly review and adjust alert parameters based on observed storm performance, stow success rates, and evolving site risk profiles.

3.4 Implementing Stow Strategies Based on Tracker Capabilities

➜ Manual Stow: Manual stow refers to the process where O&M or control center staff manually initiate tracker stow commands in response to hail alerts. Effective hail mitigation requires close coordination between O&M staff, the control center, asset managers, and field operations. Timely decision-making is critical, and alert thresholds and buffer times must be carefully evaluated to ensure there is enough lead time to complete stow actions before hail impacts occur.

➜ Automated Stow via Tracker Provider: Automated stow functionality provided by the tracker manufacturer typically relies on real-time weather alerts from a third-party provider using API integration. Stow commands are issued automatically when predefined hail risk parameters are met. Communication with stakeholders should be maintained to verify that stow actions were successfully executed. Stow trigger thresholds such as hail size, probability, or proximity should be reviewed and adjusted based on site-specific risk.

➜ In-House Automated-Stow: Some owner or operator teams develop their own automated stow systems by integrating third-party hail forecasting APIs directly with the site SCADA platform. This approach requires sufficient in-house technical expertise to implement, monitor, and maintain the integration. As with tracker-provided systems, stow trigger parameters must be validated and adjusted based on the specific hail risk profile of the site. Ongoing communication between SCADA engineers, asset managers, and operations teams is necessary to confirm system performance and response.

3.5 Defined Roles & Responsibilities

➜ Designated personnel: Assign staff responsible for initiating and monitoring stow commands. In hail-prone regions, nighttime stowage is considered best practice, particularly at sites without 24/7 monitoring.

➜ Training: Provide annual hail protocol training to key personnel and conduct refresher sessions when staffing changes occur.

➜ Drills: Schedule hail response drills before each hail season to ensure systems function properly and that roles and communication pathways are well understood.

3.6 Post-Event Inspections

➜ Review Hail Event Data: Examine hail data from the event to immediately assess the likely hail size and the impact to the asset. This can be assessed through hail sensors, radar-based hail size estimates or storm reports.

➜ Visual inspection: Examine modules for signs of impact, such as cracked glass, delamination, or moisture ingress.

➜ Tracker evaluation: Confirm tracker alignment, structural integrity, and drive system performance post-stow.

➜ Documentation: Record damage assessments and coordinate with insurance providers as needed to support claims or warranty actions.

A conservative policy—stowing for severe thunderstorm warnings rather than hail warnings alone—offers an added safety margin.

4. Insurance and Financial Considerations

Despite strong mitigation efforts, hail damage can still occur. For projects in hail-prone regions, securing adequate hail insurance is essential to managing financial risk. Developers should work with insurers experienced in renewable energy to ensure the policy reflects the project's specific exposure. Hail stow procedures can reduce the risk of damage and, according to some studies, have minimal impact on overall energy production. Together, proactive mitigation and comprehensive insurance provide the most effective protection against hail-related losses and present limited risk to generation.

5. Natural Power's Approach to Hail Risk Assessment

At Natural Power, we combine detailed site-specific hail risk analysis with practical mitigation recommendations. Our approach to hail risk assessment includes evaluating historical hail events, assessing module technology and tracker capabilities, and developing project-specific stow strategies. By leveraging our expertise in climate risk and renewable energy, we help clients protect their investments and promote long-term project resilience.

6. Conclusion

Hail mitigation is a critical consideration for solar projects in high-risk regions. By implementing resilient technology, fast-acting and robust tracker systems, and comprehensive stow strategies—supported by real-time monitoring—developers can reduce hail-related risks, with minimal impact to production. Proactive planning and continuous monitoring are key to protecting solar investments and helping to ensure long-term success in hail-prone areas.

About Natural Power

Natural Power is an independent consultancy and service provider that supports a global client base in the effective delivery of a wide range of renewable projects including onshore wind, solar, energy storage, hydrogen, and offshore wind technologies. It has a global reach, employing more than 500 staff across 14 international offices. Its experience extends across all phases of the project lifecycle from initial feasibility, through construction to operations, and throughout all stages of the transaction cycle. Learn more at **naturalpower.com/us.**

About Indji Systems

Indji Systems delivers advanced environmental threat monitoring and alerting solutions to the energy sector, with a focus on renewable energy and utility-scale operations. Its flagship platform, Indji Watch, is trusted by nearly 80 leading energy companies globally to anticipate and respond to hazards including hail, lightning, wildfire, and high winds. For more information about the Indji Watch service, visit: **indjiwatch.com**, or contact the company at **info.indjiwatch@indji.net**

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