

To The Point

Commercial Solar Photovoltaics (PV) – Wind and Hail Risk Management

CHUBB®



Solar photovoltaic (PV) renewable energy has evolved from a niche market of small-scale installations to become one of the main sources of renewable electricity. Solar's increasing price competitiveness has allowed it to expand its share of the power gen market. This expanded market share has naturally led to the geographical expansion of solar PV adoption to all corners of the globe.

Natural hazards such as windstorms, hailstorms, and tornadoes are quite common in growing markets, and evidence suggests these storms are increasing in severity and frequency. The International Electrotechnical Commission (IEC) 61215, the industry's long-accepted hailstone impact test, provides an example of the challenges posed by growth markets in severe storm-prone regions. This baseline test established a minimal hail impact rating from hailstones up to 1 inch in diameter. However, hailstone size regularly exceeds this diameter in certain target growth geographies, where hailstones exceeding 2 inches in diameter are commonplace.

Contributing Loss Factors for Solar PV Modules: Hail

There are three main factors to consider when evaluating the damage potential to solar PV modules by severe hailstorms:

1. **Hail Size:** The larger the hailstone, the greater the risk of significant PV damage. While most panels are designed to withstand impacts up to 1 inch in diameter, 1.5-inch hail is considered to have enough energy for glass breakage.¹ 2-inch diameter hailstones, which have become increasingly common in severe hail zones, would be considered well beyond the typical module breakage threshold.
2. **Hail Speed:** Conventional standards typically involve testing hailstones traveling between 40 mph to 60.9 mph. However, in a very severe storm, hailstones have an expected fall speed of up to 72 mph.² So, while these tests may offer a level of comfort, they are not truly representative of severe storm risk.

Risk Engineering Services

3. **Hail Strike Angle:** The hail strike angle and the PV panel angle are significant factors in terms of damage potential. Utilizing tracking technology to re-position PV panels can dramatically reduce hailstone damage potential.

Contributing Loss Factors for Solar PV Modules: Wind

Marketing materials produced by solar PV manufacturers and installers alike often boast that their solar panels are certified to withstand up to 140 mph winds. Yet solar panel wind ratings can be misleading, given that they are not typically the leading cause of loss. In fact, in most instances where wind causes damage to a solar array, failures occur due to weaknesses in the racking or mounting systems, not due to panel failure.³ This is often an indication of inadequate mounting and rigging during installation. PV module systems regularly experience wind failure under less severe conditions than the panel rating may suggest.

There are four main factors to consider when evaluating the damage potential to solar PV modules by severe windstorms:

1. **Design and Selection:** The right PV module systems must be selected based on the regional and environmental conditions in the area. The inadequate selection of materials and lack of pre-planning can make or break a solar farm's performance in a severe storm.
2. **Installation:** Windstorm failures can often be attributed to installation errors or the failure to take the appropriate storm-hardening measures to secure the modules. This can also include storing other materials, tools, and equipment at the site's "lay down" area.
3. **Maintenance:** Preventative maintenance is key to a solar PV module's performance during severe windstorms. The lack of an Operations and Maintenance (O&M) strategy or program enforcement can jeopardize

the preparedness of a PV farm. Failure to inspect and maintain these systems after storm events can lead to loose bolts and compromised connections.

4. **Windborne Debris:** Often, makeshift projectiles such as trees, poles, fencing, etc., can cause more damage than the wind itself. Unlike hailstones, no accelerated test can truly capture the threat of windborne debris.

Impact of Microcracking on PV Modules

Microcracks—also referred to as microfractures—are essentially a specific form of cell damage. Microcracking can significantly impact the performance of a solar PV array over time, often shortening its overall lifespan. It can also permanently reduce PV panel energy output or lead to erratic performance. Visual inspections fail to account for more widespread damages lurking under the surface. In fact, a study conducted by PV Evolution Labs (PVEL) found that widespread microcracking from hail and wind is possible even when less than 5% of modules have visible broken glass.⁴

Wind/Hail Mitigation Strategies

Module Selection: Numerous design features should be considered when selecting the proper PV module. Glass-glass layering, single or dual-axis tracking capabilities, monocrystalline silicon cell technology, and framed modules are examples of storm-resistant materials that can be utilized. As the ability of a module to withstand wind pressure varies greatly between manufacturers, choose modules with the highest ratings or greatest resistance to loading in wind zones.

Module Racking Systems: Inadequate support in a module's underlying frame elements can lead to bending, twisting, and ultimately breakage in high winds. Most racking systems provide two-frame rails for module mounting. In severe storm zones, a three-frame rail system will provide enhanced rigidity and support to reduce bending and twisting.

Solar PV Panel Hail Impact

Resistance: At the very least, solar PV panels should meet the IEC 61215 standard for hailstone impact resistance (1-inch diameter). However, PV farms in regions with the potential for severe hail activity should seek impact ratings that can withstand hailstones between 1.5 and 2 inches in diameter. PV installations in severe storm regions should also avoid using polycrystalline silicon or thin-film cell technology unless those modules are specifically rated for more adverse impact conditions. In addition, consider using glass-glass layered panels which offer more protection than conventional glass-foil layered systems.

Wind Testing and Analysis: This is crucial during the design phase. A static wind load test should be conducted and account for both exterior and interior array rows. In addition to static testing, projects should also focus on wind behavior at the project site. Site-specific wind climate analysis should utilize local weather data rather than simply measuring wind speeds over large regions.

Tracking Systems: While passive tracking systems may offer structural protection against wind loading, an active tracking system is more likely to address wind and hail events. A single or dual-axis tracking system is recommended over fixed-mount systems, which offer little protection from wind and hail. If a tracking system is carefully designed to withstand the wind in any position, the likelihood of system structural damage is minimized, and the long-term costs associated with maintaining the stow function are reduced.

Tracking Software: Tracking software allows the entire solar array to be placed into a safe stow position to increase wind resistance. Another option is to pursue a balanced design in which the PV array will return to the stow position under gravity. Stow speed should also be considered, as severe storms often come with little warning. The faster a tracking system's ability to go into stow position, the better protection it provides. Consider tracking technology that includes weather sensors



A proactive risk management strategy can help ensure that your PV farm operates efficiently and profitably while minimizing the potential for storm damage and disruption to operations.

that automatically detect and stow panels in real-time instead of solely relying on manual operation.

Backup Power Source: When storms cause power outages in the vicinity of a solar power plant, this can leave PV trackers vulnerable during wind events if they cannot get into a safe stow position. Consider using tracker systems with battery backup controllers to allow modules to stow without relying on power from the grid. It's important to note that batteries should be used as a backup and not the primary power source.

Operations and Maintenance (O&M) Strategy

An effective solar Operations and Maintenance strategy is crucial to mitigating hail and windstorm events. The O&M strategy should be a formal, written program that includes buy-in from all levels of company leadership. It should include company-wide and PV site-specific risk assessments to identify heightened exposures for all applicable force majeure events (hailstorms, windstorms, wildfires, etc.). The O&M program should be actively monitored and reviewed at least annually.

Non-Destructive Testing

Non-destructive testing methods such as infrared imaging (IR) and Electroluminescence Crack Detection (ELCD) should be utilized to identify microcracking in PV modules. The best practice would be to employ both methods using a drone flyover. Sites located in severe storm areas may benefit from more frequent testing. For example, severe storm areas may warrant full-scale IR and/or ELCD inspections after major storm events to identify microcracking.

Emergency Protection Plan

An EPP is beneficial for preparing for all types of natural disasters, including severe wind and hail.

An EPP should consist of:

- Continuous monitoring of storm events
- Storm preparation (storm hardening measures, site lock-down, equipment/material securement, etc.)
- Post-storm assessment of damage
- Provision of a backup power system to keep the plant on standby mode
- Training of personnel in EPP execution

An EPP should be reviewed and updated annually and modified as needed.

Importance of PV Protection

Renewable energy like solar power has a bright future. It continues to be promoted as a safe alternative to fossil fuels and a means of offsetting the carbon footprint associated with more traditional energy sources. A proactive risk management strategy can help ensure that your PV farm operates efficiently and profitably while minimizing the potential for storm damage and disruption to operations.

References

1. **Hail Durability Test (HDT)**, retc-ca.com/services/hdt
2. **Hail 101**, www.nssl.noaa.gov/education/svrwx101/hail/
3. **Solar Photovoltaic Systems in Hurricanes and Other Severe Weather**, www.energy.gov/sites/prod/files/2018/08/f55/pv_severe_weather.pdf
4. **PVEL & Heliolytics Team Up for Solar Disaster Investigation**, pv-magazine-usa.com/2019/09/26/pvel-heliolytics-team-up-for-solar-disaster-investigation/

Connect with Us

For more information about protecting your company, contact your local Chubb Risk Engineer, email us at RiskEngineeringServices@chubb.com, or visit www.chubb.com/engineering.

Chubb. Insured.SM