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Tracking Through the Storm: Outsmarting Hail in Solar PV Systems

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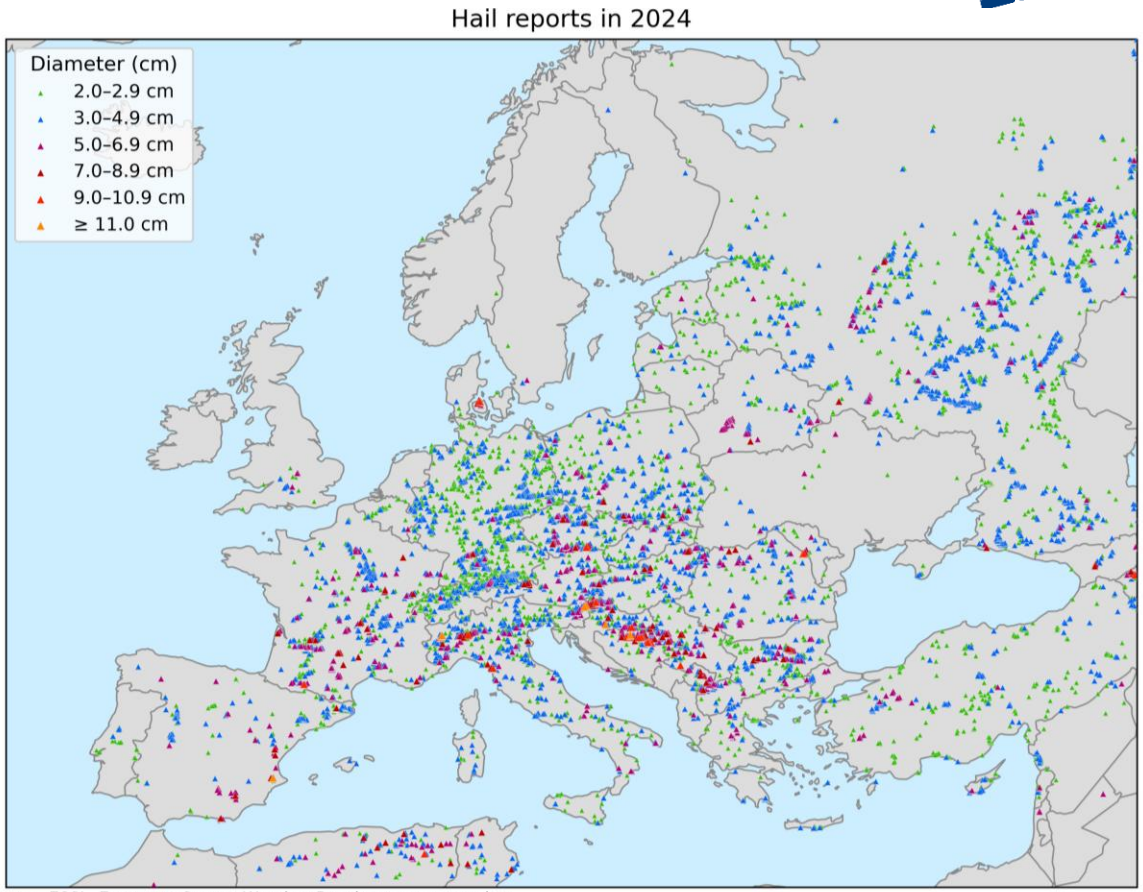
HAILSTORM: IS IT A CHALLENGE?

- In 2023, in Nebraska, a hailstorm destroyed an entire 5 MW PV plant in **less than ten minutes**. Ice balls the size of baseballs, hurled from the sky at 150 km/h.
- In 2024, in Texas, a hailstorm destroyed a 350 MW PV Plant

HAILSTORM: IS IT A CHALLENGE?

In 2024, also different regions of Europe were affected by hailstorms

Ice ball diameter >7.0 cm



Source: ESSL, European Severe Weather Database: www.eswd.eu

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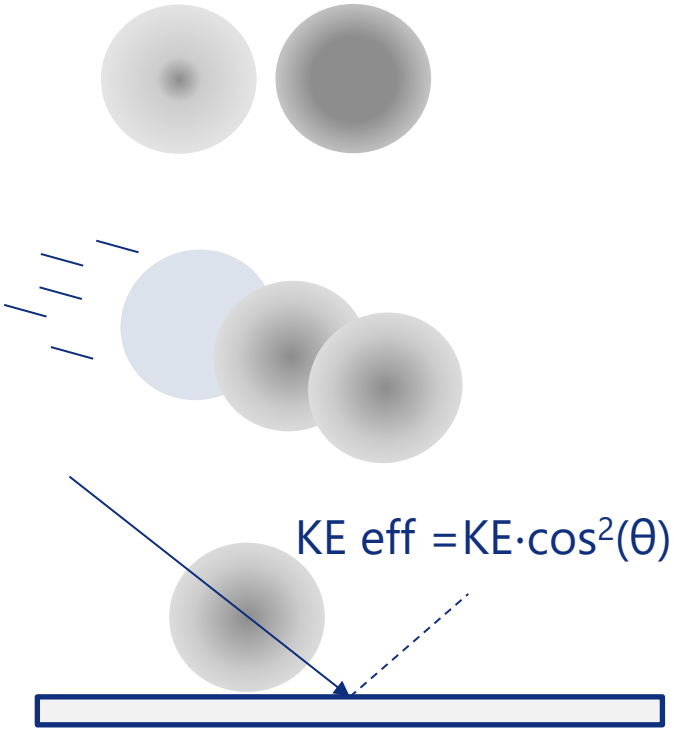
HAIL IS NOT THE ONLY FACTOR TO CONSIDER

- **Density**: hail can range from about 0.32 g/cm3 when slushy to almost 1.0 g/cm3 when solid.
- **Speed**: air pressure, density, and surface area can increase or decrease its impact energy
- **Angle of incidence**: at 0° higher impact energy than the same module stowed at a 30° or 60° tilt.



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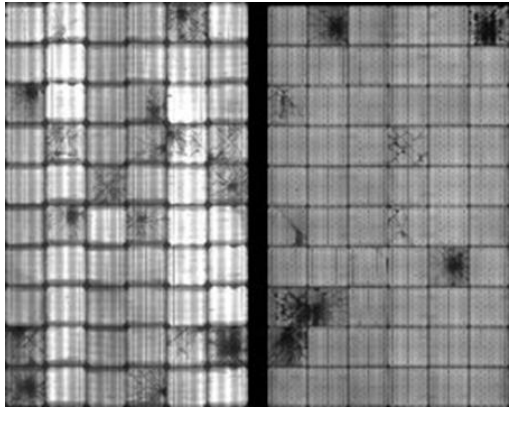
TECHNICAL EFFECT AND STANDARDS

- Minor storms: lead to cumulative damage over the time
- Severe storms: may lead to the end the life of modules: damages includes shattered glass, cell breakage, micro-cracks, cell dysfunction, and structural deformations

The IEC 61215 standard for c-Si technology:

[MQT 17] PV modules must withstand 11 impacts from 25 mm hailstones at a velocity of 23 m/s *(82.8km/h)*



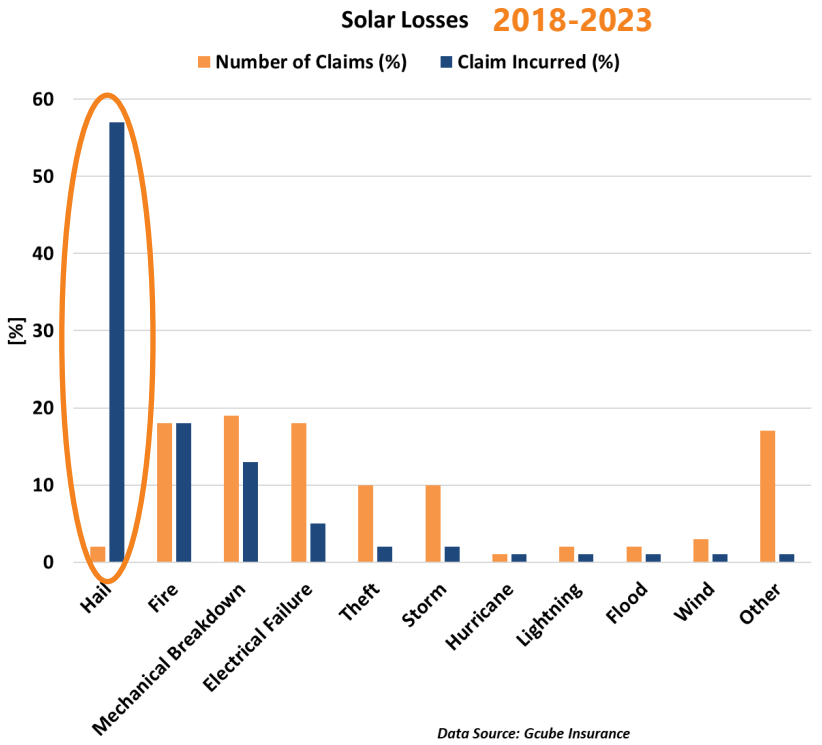
ECONOMIC IMPACTS

Hail = Low frequency, high impact

*Hail accounts for just 1.4% of solar insurance claims—but **is responsible for a staggering 54%** of total incurred costs" (GCube)*[1]

Main sources of economic losses

- **lost energy production**,
- **forensic** and advisory costs,
- **hardware compatibility**,
- **logistics**,
- legal disputes,
- rising insurance: ↑ up to 400%[2]



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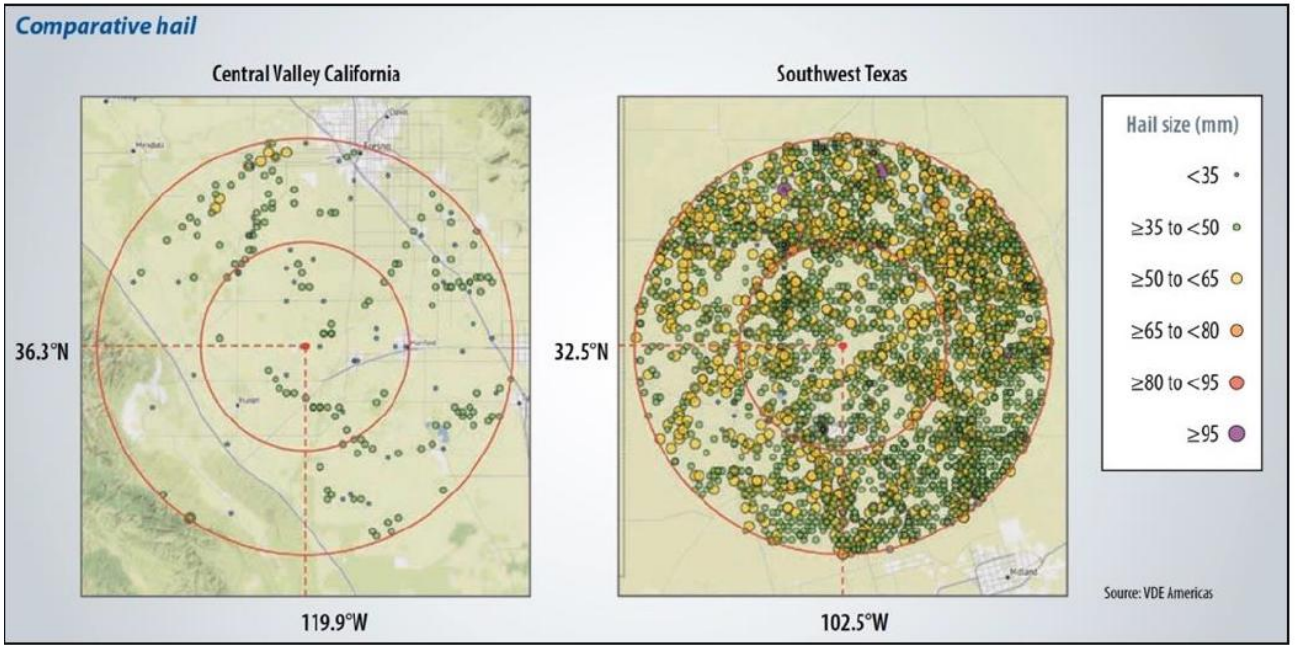
[1] GCube Insurance Report: 'Hail No! Defending Solar from Nature's Cold Assault'
[2] kWh Analytics

Probabilistic hail risk assessments

identify, quantify, and mitigate hail risk in solar assets and portfolios



VDE – Catastrophic risk Assessment
Comparative hail risk assessment for low- and high-risk locations

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Probabilistic hail risk assessments	identify, quantify, and mitigate hail risk in solar assets and portfolios

Characterize hail risk(low, moderate, high) on a location-specific basis

provide probable maximum loss (PML) and average annual loss (AAL) estimates based on site-specific meteorological characteristics

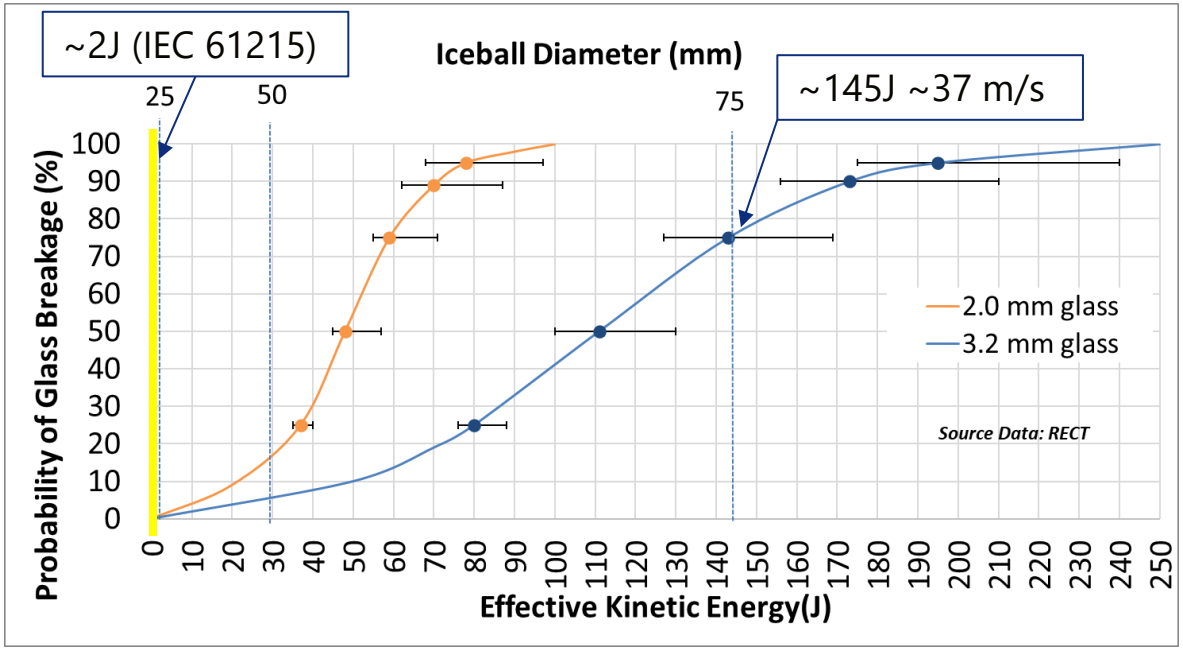
- Project-specific technical considerations
- Acceptable insurance terms and conditions
- O&M procedures i.e. stow protocols, hail stow alert trigger radius

OUTSMARTING HAIL IN SOLAR PV: GLASS THICKNESS

PV Module Glass Thickness

Modules with *thicker* front *tempered* solar glass (≥3.2mm)

Comparative iceball resiliency curves for common c-Si PV module packages: 3.2mm-Backsheet vs 2.0/2.0 dual-glass (a VDE: PRE ANALYSIS)



[1] https://retc-ca.com/news/module-glass-impacts-hail-resiliency

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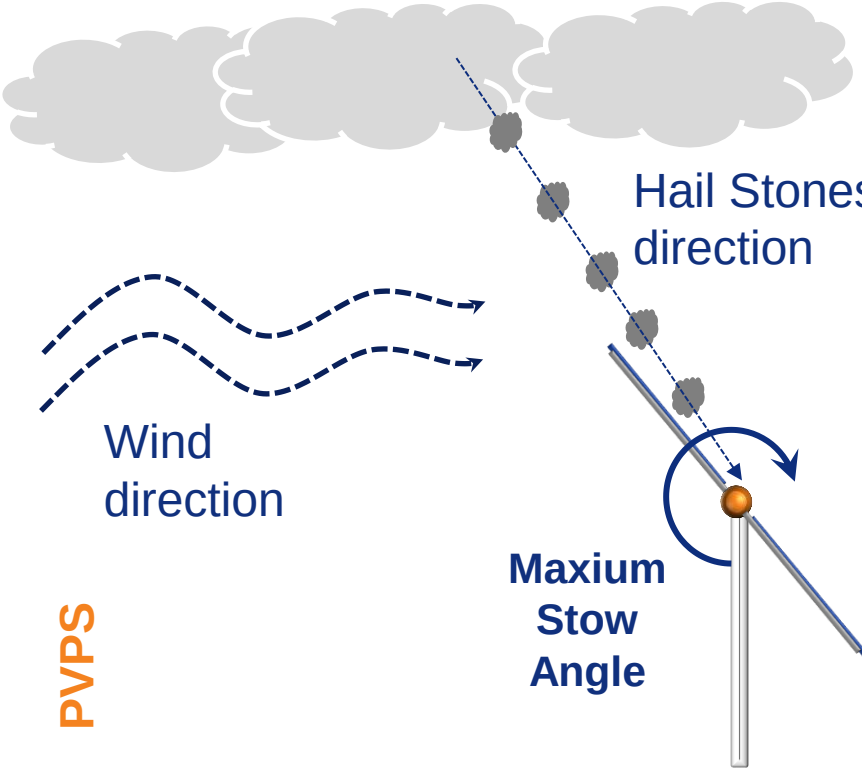
OUTSMARTING HAIL IN SOLAR PV: TRACKER OPTIMIZED FOR HAIL

Adoption of tracker with advanced stow capabilities

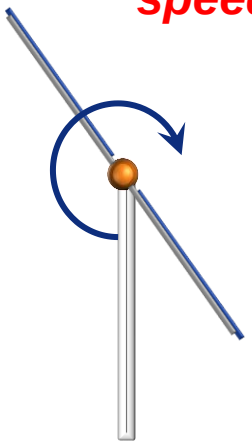
Trackers set to a stowage angle of ≥55° within 1-2 minutes



KE eff $=KE \cdot \cos^2(\theta)$

Keff(J)	KE(J)	$\cos^2(\theta)$
70	70	1(0°)
17.5	70	0.25(60°)

- Automated Hail Stowing
- Single-Click Manual Stowing
- ***High stowage speed!***



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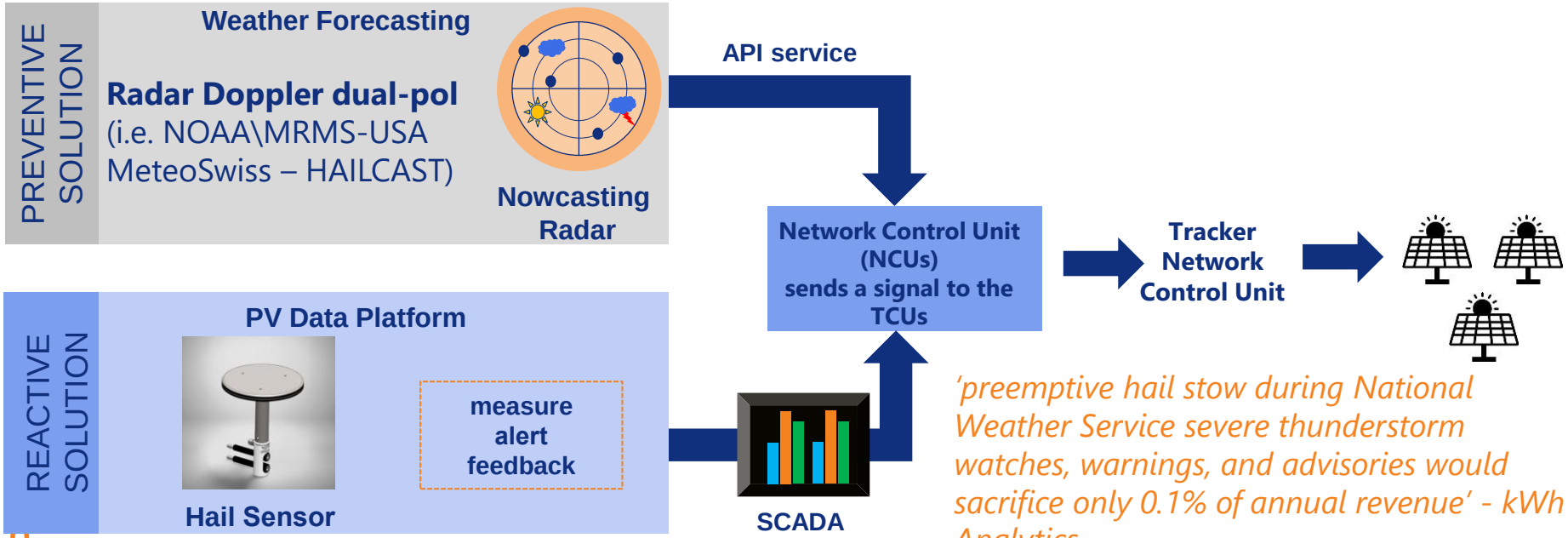
Adoption of alerting tools for tracker stow position

Weather station capable of forecasts hail: the NCU sends a signal to the TCU to activate hail stow mode.



'preemptive hail stow during National Weather Service severe thunderstorm watches, warnings, and advisories would sacrifice only 0.1% of annual revenue' - kWh Analytics

PROBABILISTIC HAIL RISK ASSESSMENTS

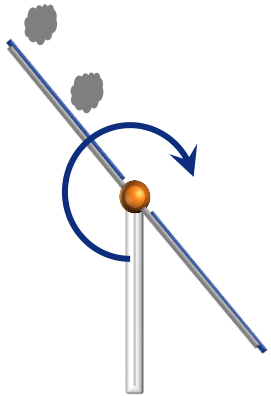
Estimated Losses: probable maximum loss (PML) and average annual loss (AAL)

MODULES RESISTANCE

PV Module Glass Thickness
Hail Certification

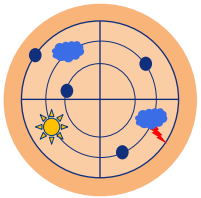
TRACKER PROTOCOLS

Tracker Stowing in a few min
Stow angle ≥55°



ALERTING TOOLS

weather station forecasts hail:
Automated signal to the TCU



OUTSMARTING HAIL IN SOLAR PV: LOWER INSURANCE COSTS?

“Proactive hail stow programs can reduce property insurance premiums”- kWh Analytics

pv magazine

Hail-prone Texas solar project cuts insurance costs 72%

A case study by kWh Analytics demonstrated the value of building a resilient, weather-hardened solar facility.

NOVEMBER 11, 2024 RYAN KENNEDY

OUTSMARTING HAIL IN SOLAR PV: CONCLUSION

- Hailstorms represent **just 1.4% of claims**, yet cause **54% of total losses**
- Site-specific hail **risk assessments**, based on local weather data, are essential **to define smart engineering choices** and **negotiate better insurance terms**
- **Mitigation** is possible through key technical strategies:
  - Use of **thicker**, tempered **glass PV modules**
  - **Trackers** optimized for **hail protection**
  - **Weather services** to detects or forecasts hail events for tracker automatic stow
- A proactive hail stow mitigation measures may led to a significative reduction in the insurance premium.

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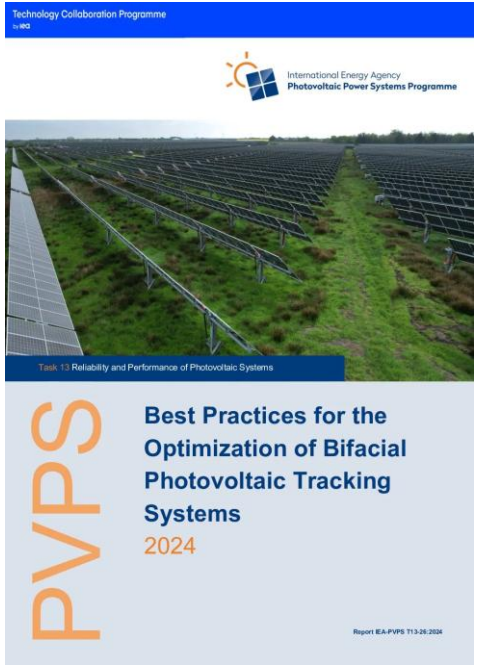
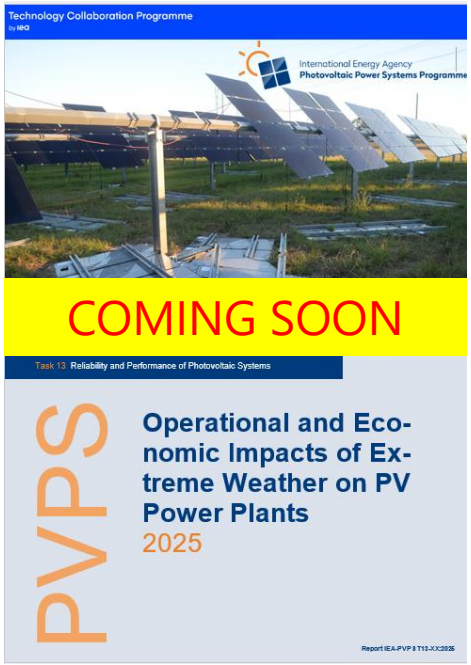


This report overviews currently known on best practices for the Optimization of Bifacial tracking System



"The report will highlight the most significant extreme weather events for PV systems and outlines best practices for design and mitigation strategies

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"..we still do not know one thousandth of one percent of what nature has revealed to us.." A. Einstein

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Thank You