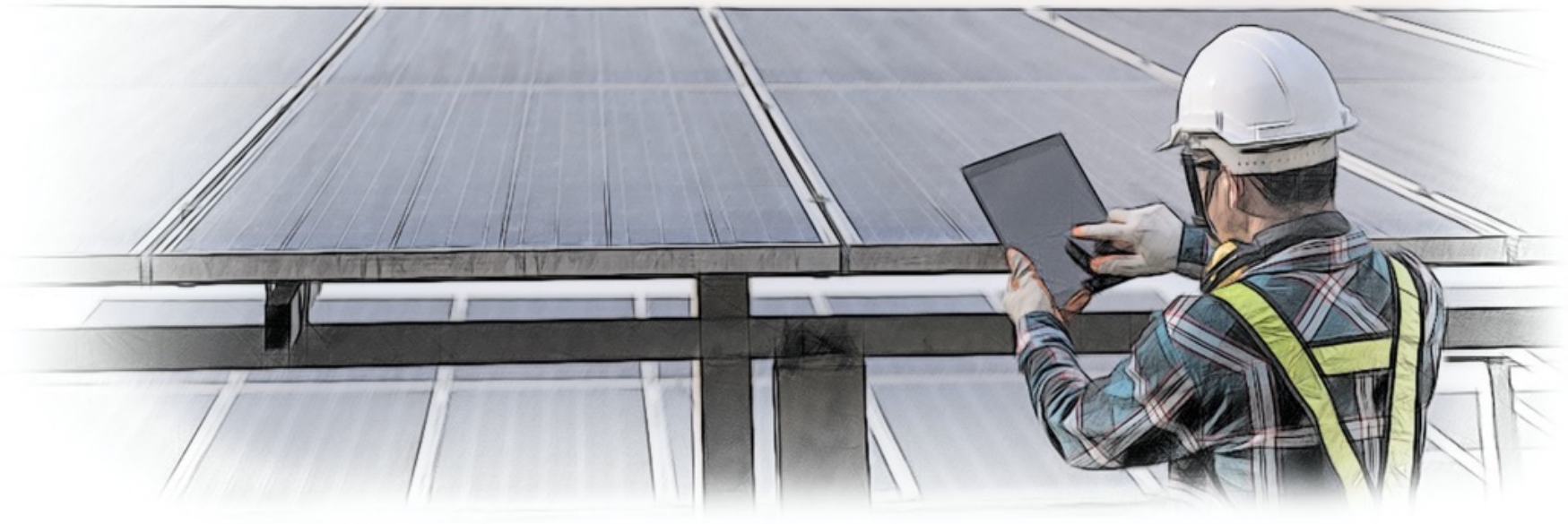
Hail risk mitigation strategies

for solar assets and investment portfolios

**When all hail breaks loose—
have a plan.**



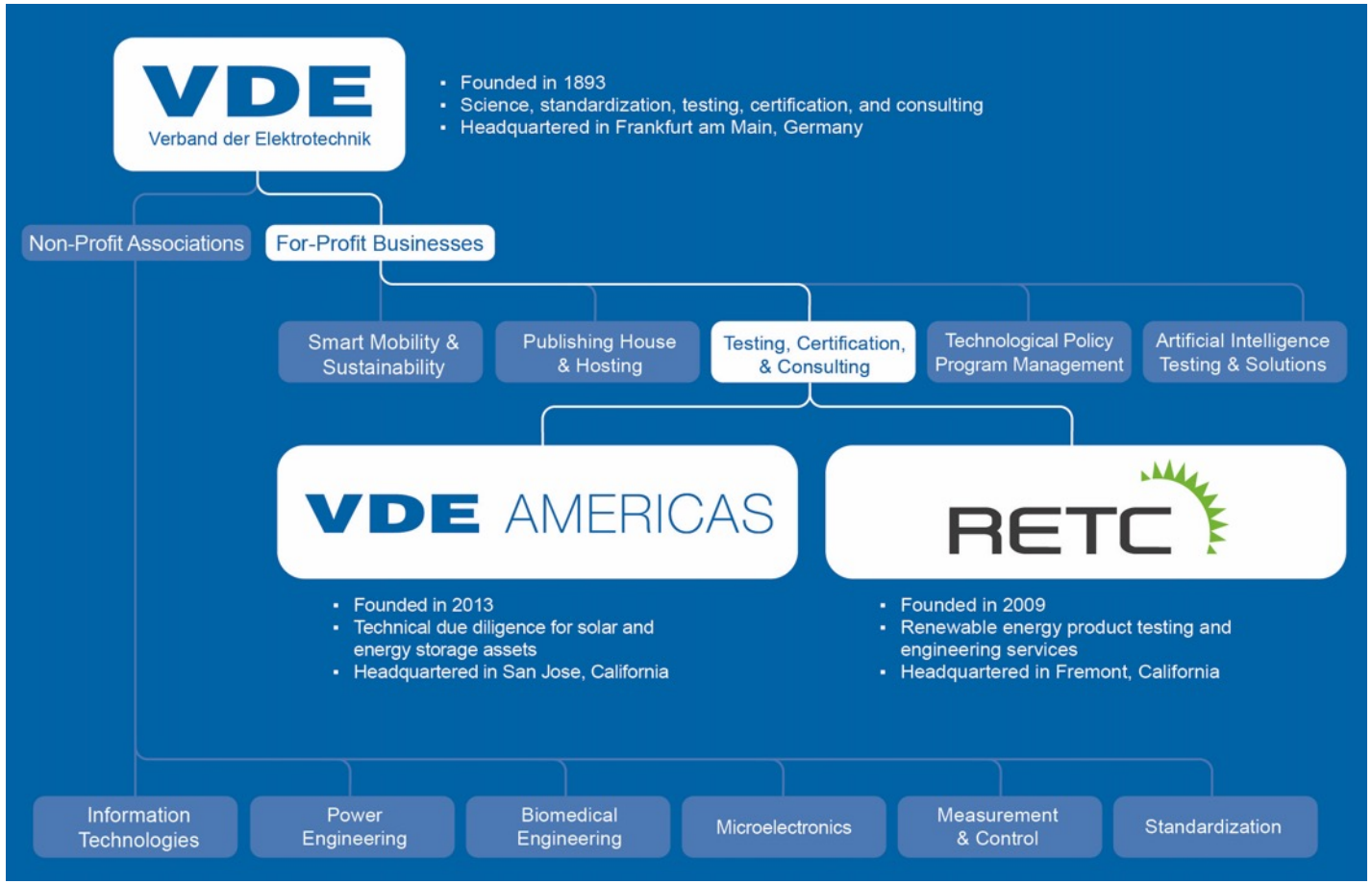
John Sedgwick
President,
VDE Americas

VDE

About VDE Americas' technical advisory services

Founded in 2013, **VDE Americas** is a wholly-owned subsidiary of the VDE Group, one of the largest technology organizations in Europe. Our goal is to advance the deployment of financeable and insurable clean energy projects. We support this goal by independent and owner's engineering services to support large-scale solar, energy storage, and solar-plus-storage transactions.

We are the world's leading experts on hail risk assessment for solar farms.

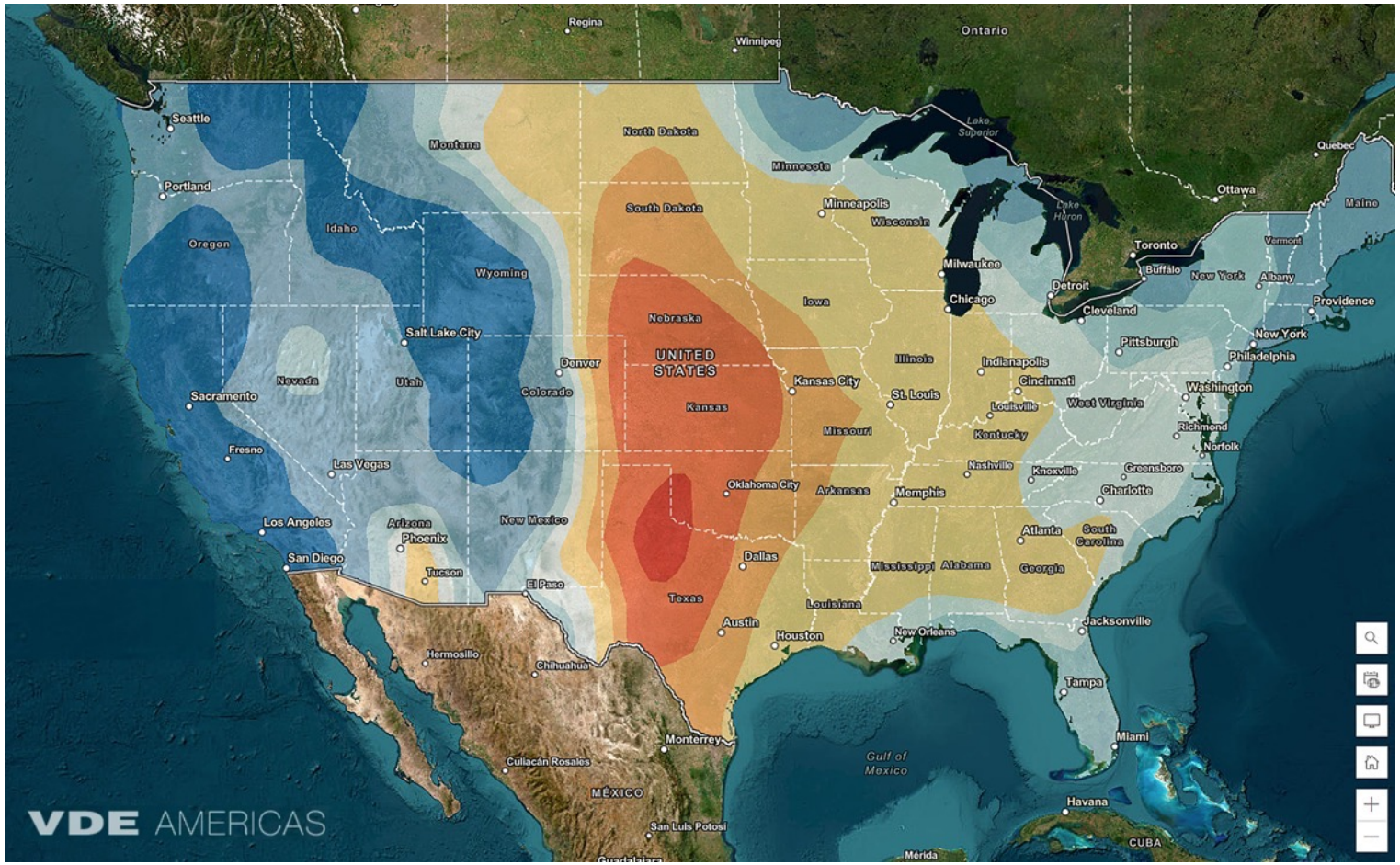


About VDE Americas' hail risk assessment capabilities

- IP includes meteorological models developed by Central Michigan University's Dr. John T. Allen, a leading expert in severe convective storms and hail forecasting over operational timescales
- Proprietary financial loss models are informed in part by beyond-qualification hail-impact testing data from our sister company RETC
- Primary **use cases** are to inform:
  - **Best practices** related to site selection, equipment specification, plant construction, and asset operation
  - **Cost-benefit analyses** for hail-hardened product and project designs
  - **Financial exposure** outside of insurance
  - **Insurance** pricing and terms

High-level overview of VDE Americas' hail risk advisory products

- Subscription-based ArcGIS maps
  - Naturally occurring hail return interval maps *(shown on right)*
  - Technology-specific financial hail loss maps
- Hail risk engineering reports
  - Probable maximum loss (PML) reports
  - Average annual loss (AAL) reports
  - **Poisson risk exposure (PRE) reports**
- Other advisory services
  - Forensic investigations
  - Remote operations center audits
  - Consulting for manufacturers



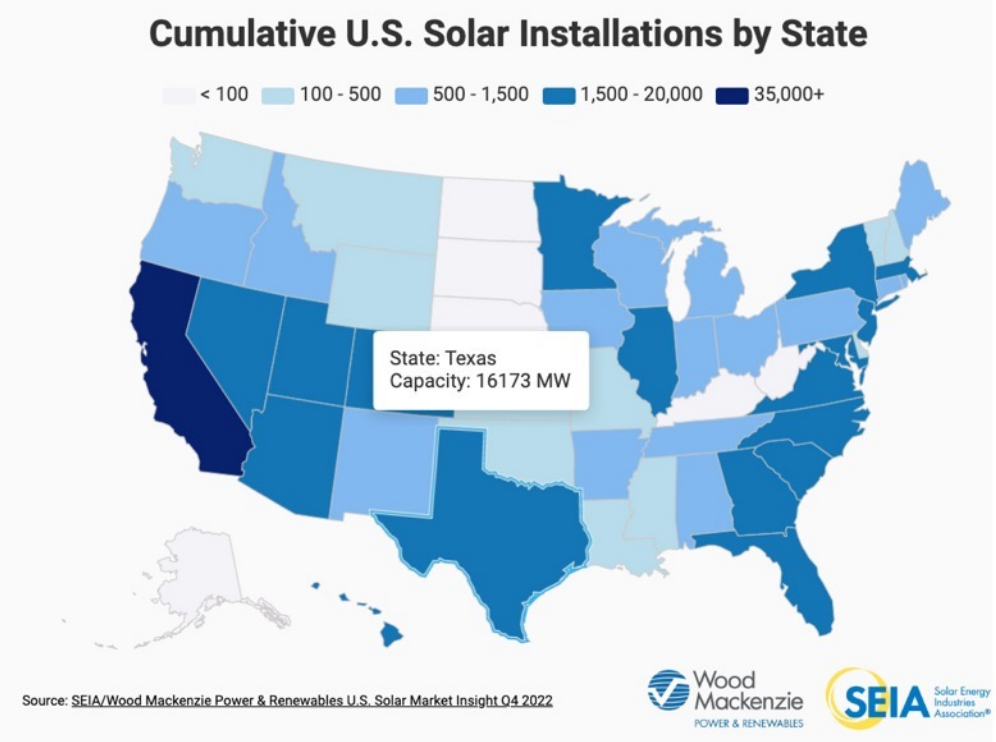
Record hail losses are an “existential threat” to solar project development

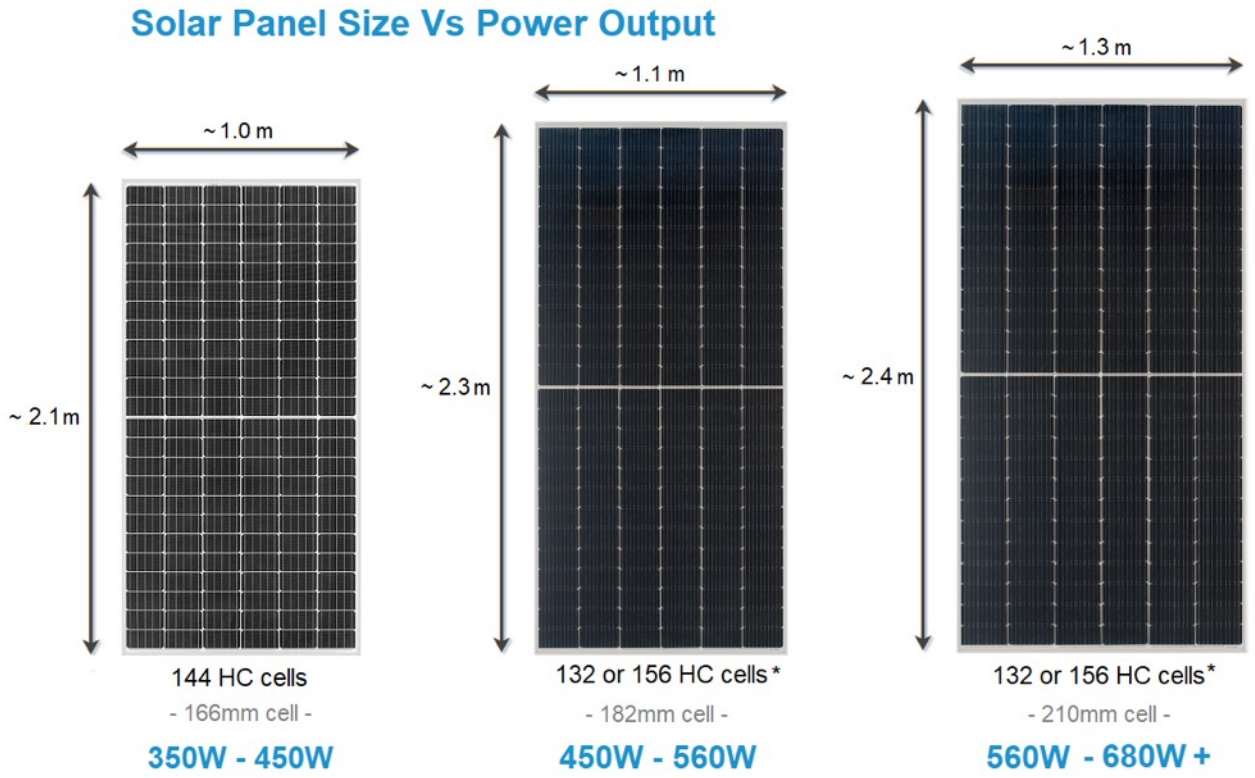
Hail accounts for less than 2% of solar project insurance claims volume—but **more than 50% of total solar losses.**

Notable hail loss events

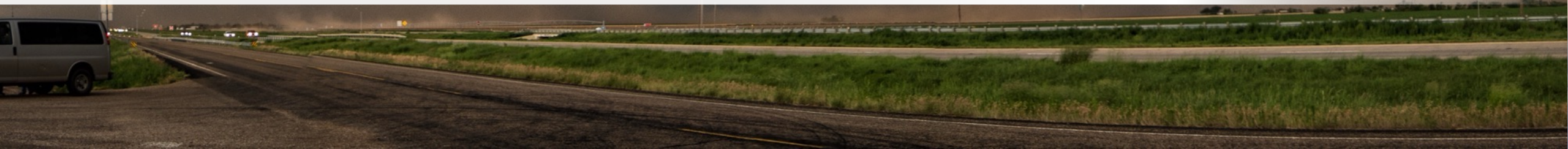
- Midway Solar Farm
  - $75M loss event in West Texas (May 2019)
- Multiple large solar farm losses
  - >$300M of losses in three Texas counties (2022)
- Scottsbluff Community Solar Array *(shown on right)*
  - 5-MW PV array totaled in Scottsbluff, NE (October 2023)
- Fighting Jays Solar Farm
  - Catastrophic losses in near Houston, TX (March 2024)

Hail risk is increasing due to a ‘perfect storm’ of market and technology trends





Location- and technology-specific hail risk considerations

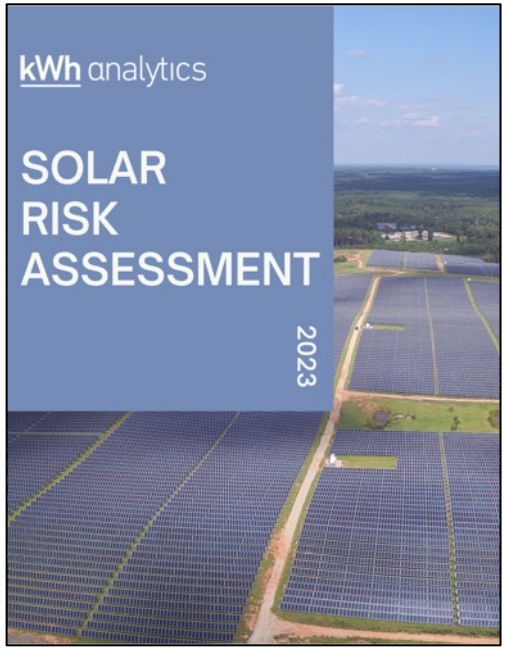


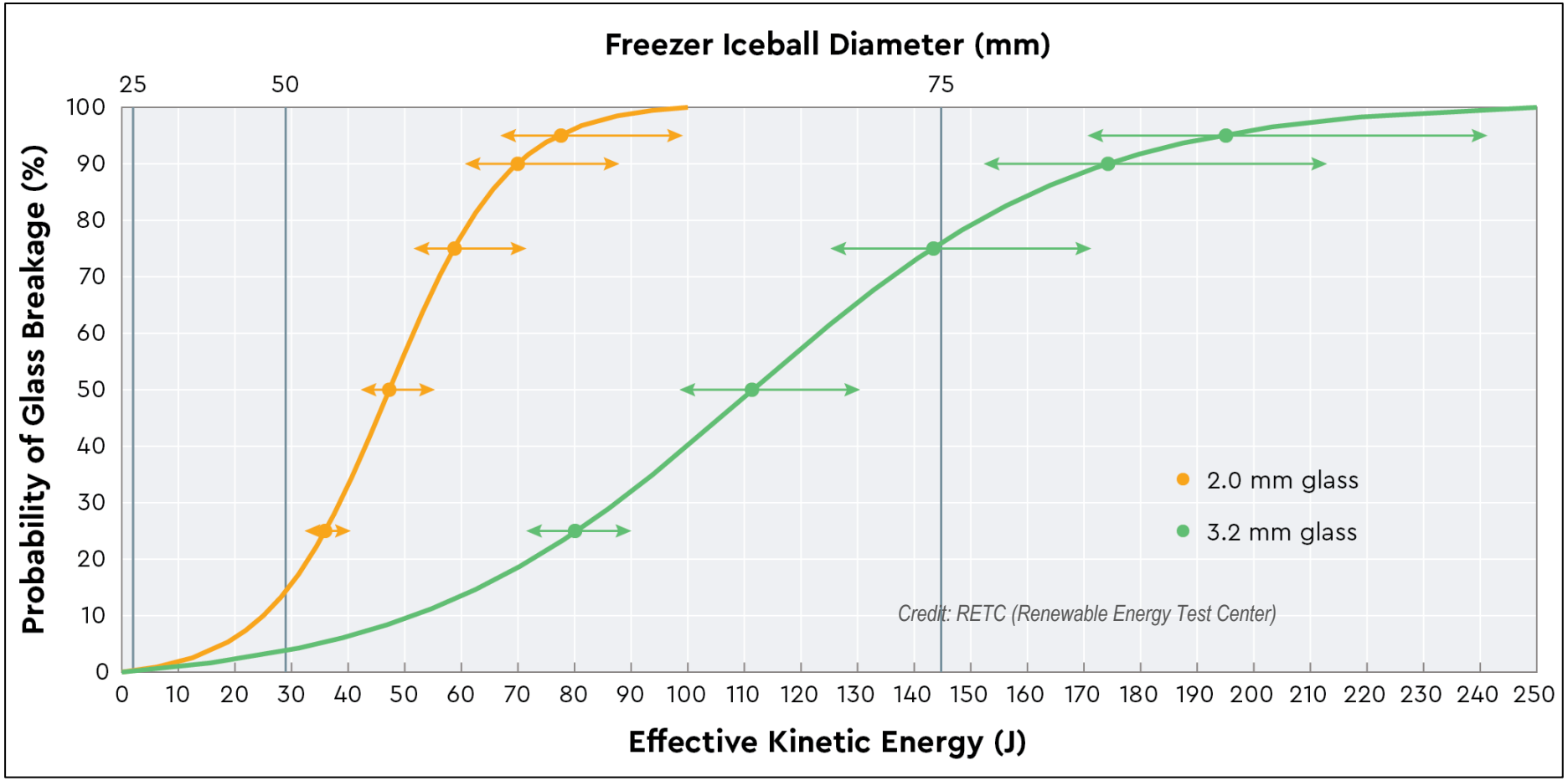
Damages vary based on hail swath intensity across the solar plant

- Damage is localized based on the path of the hail swath and variation in hail intensity across the swath
- Severe convective storms generally move from west to east with the largest hail forming in supercells
- Strong winds before during and after an event are hard to forecast and do not correlate to storm direction

Catastrophic hail loss at Fighting Jay's solar farm SE of Houston, TX

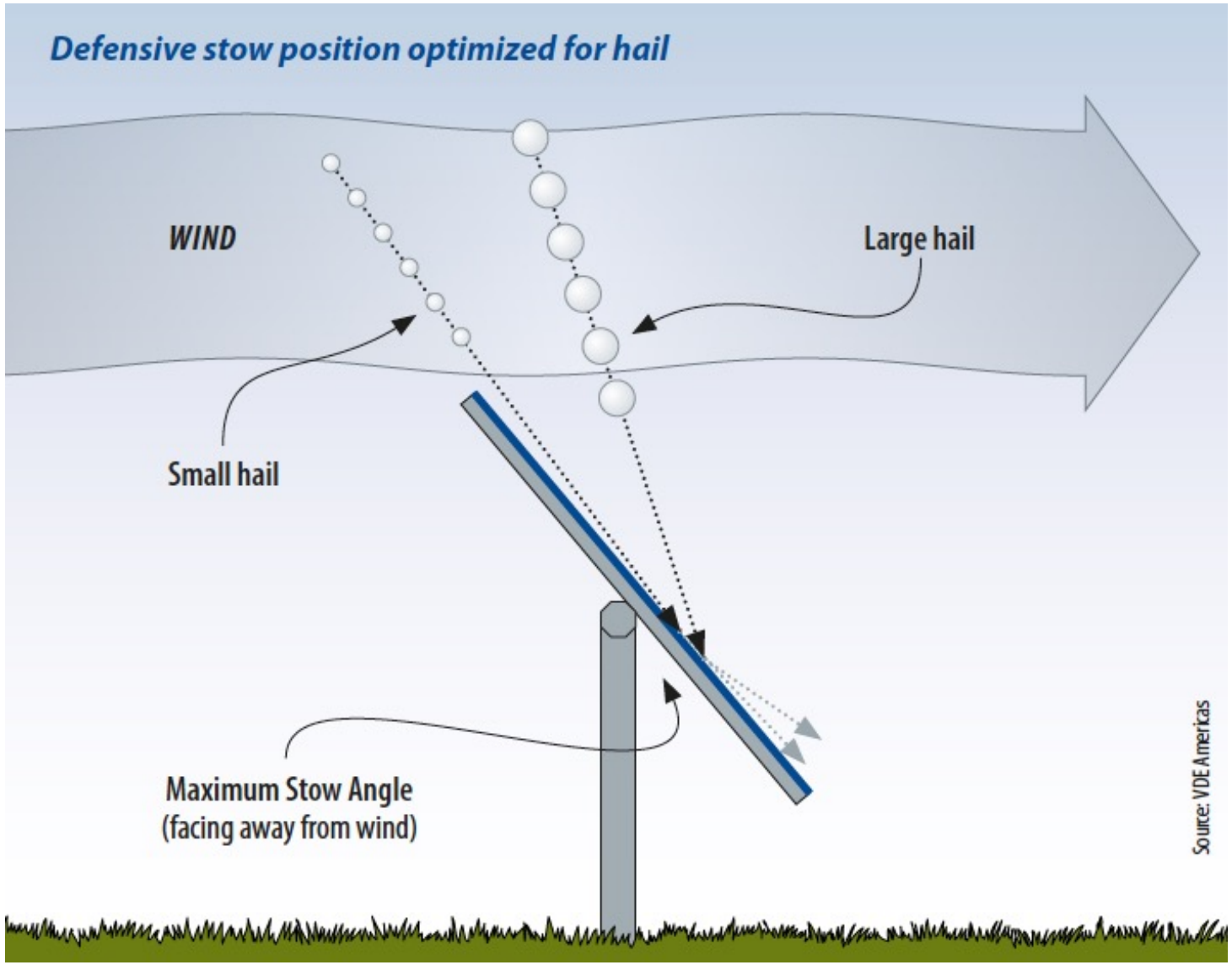
Representative PV module hail resiliency curves (based on beyond-qualification test data)





Single-axis tracker defensive stow capabilities and response times

- Maximum tilt angle
  - Defensive hail stow position
- Wind resilience
  - Based on wind speed and direction
- Response capabilities
  - Time required to execute hail stow
- Reliability and availability
  - Tracker on target percentage
- Hail stow confidence
  - Will passive or automatic wind stow protocols override defensive hail stow?



Practical solutions are available to prevent catastrophic hail losses

Hail risk mitigation strategies

- Identify and quantify hail risk
  - Based on project location
  - Based on fielded technology
- Mitigate risk via strategic technical adaptations
  - Specify hail-hardened modules in hail-prone regions
  - Automate defensive stow protocols *(shown on right)*
- Improve hail-impact characterization testing
  - Improve the fidelity of financial loss modeling
  - Facilitate cost-effective hail-hardened designs

Poisson risk exposure (PRE) report

Intro to VDE Americas' Poisson risk exposure (PRE) report (financial loss estimate)

Technical Inputs
based on location & project details

Proprietary Risk Model
Poisson Risk Exposure (PRE)

Final Report

Meteorological analysis

- **Project location** (latitude-longitude coordinates)
- Statistical methodology to estimate local hail risk
- Return interval of naturally occurring hail (RI_{NOH})

System design analysis

- System capacity
- Module replacement costs
- **Single-axis tracker metrics** (if known)
- Module type, dimensions, & **hail resiliency curves**

Event probability distribution

- Customer-specified hold period (e.g., 10 or 40 yr.)
- Cumulative RI_{NOH} at the customer-specified site
- Discrete RI_{NOH} within specific hail size ranges
- Probability of the number of events per size range

Financial loss estimates

- 10,000+ Monte Carlo iterations to characterize discrete event probabilities over specified hold period
- Cumulative loss calculated based on module the number of events per specific hail size ranges

Comparative hail risk assessment

- NOH return intervals
- Discrete event probability (# of events per hail size)
- **Probabilistic cumulative loss estimates** based on various module types and tilt angles (P50/P90/P95)

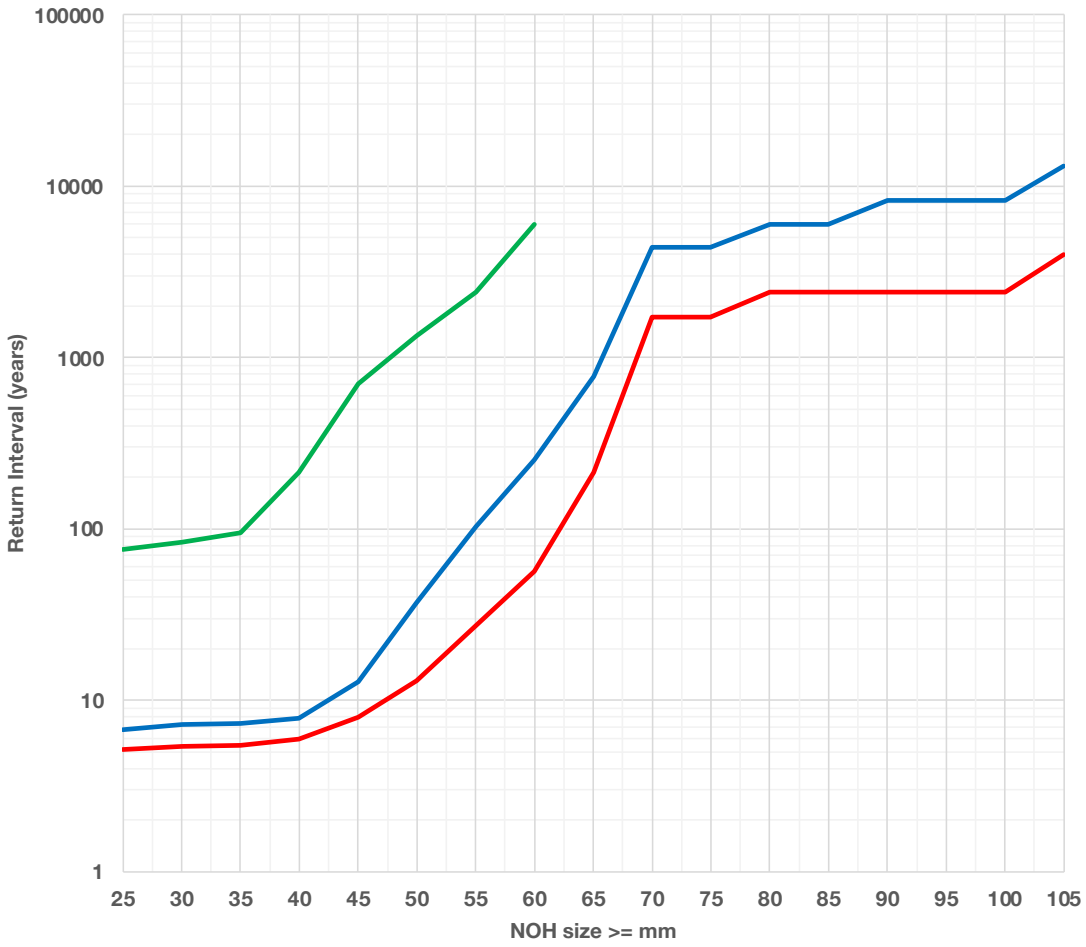
Output of the financial loss model is informed by both 1) site-specific meteorological data and 2) product-specific technical characteristic (i.e., tracker stow angle and module hail resiliency)

Poisson distribution is a discrete probability distribution—named after French mathematician Siméon Denis Poisson—that is used in probability theory and statistics to show how many times an event is likely to occur over a specified period.

Statistical analysis of the cumulative hail event probability (at customer-specified site)

- Characterizes hail risk at the local scale of a solar asset
  - Characterizes the frequency and severity of damaging hail
  - Characterizes naturally occurring hail (NOH) size as reported by radar and calibrated by SPC (spotter) observations
- Significant variation based on project location
  - Green line = Central Valley California (low-risk reference location)
  - Blue line = Sample site (client-requested location)
  - Red line = Southwest Texas (high-risk reference location)

Return Period (years)	Sample Site (mm)	SW Texas (mm)	CA (mm)
100	54.8	61.4	35.2
250	59.9	65.1	40.4
500	62.4	66.0	42.90
1000	65.3	67.6	47.3

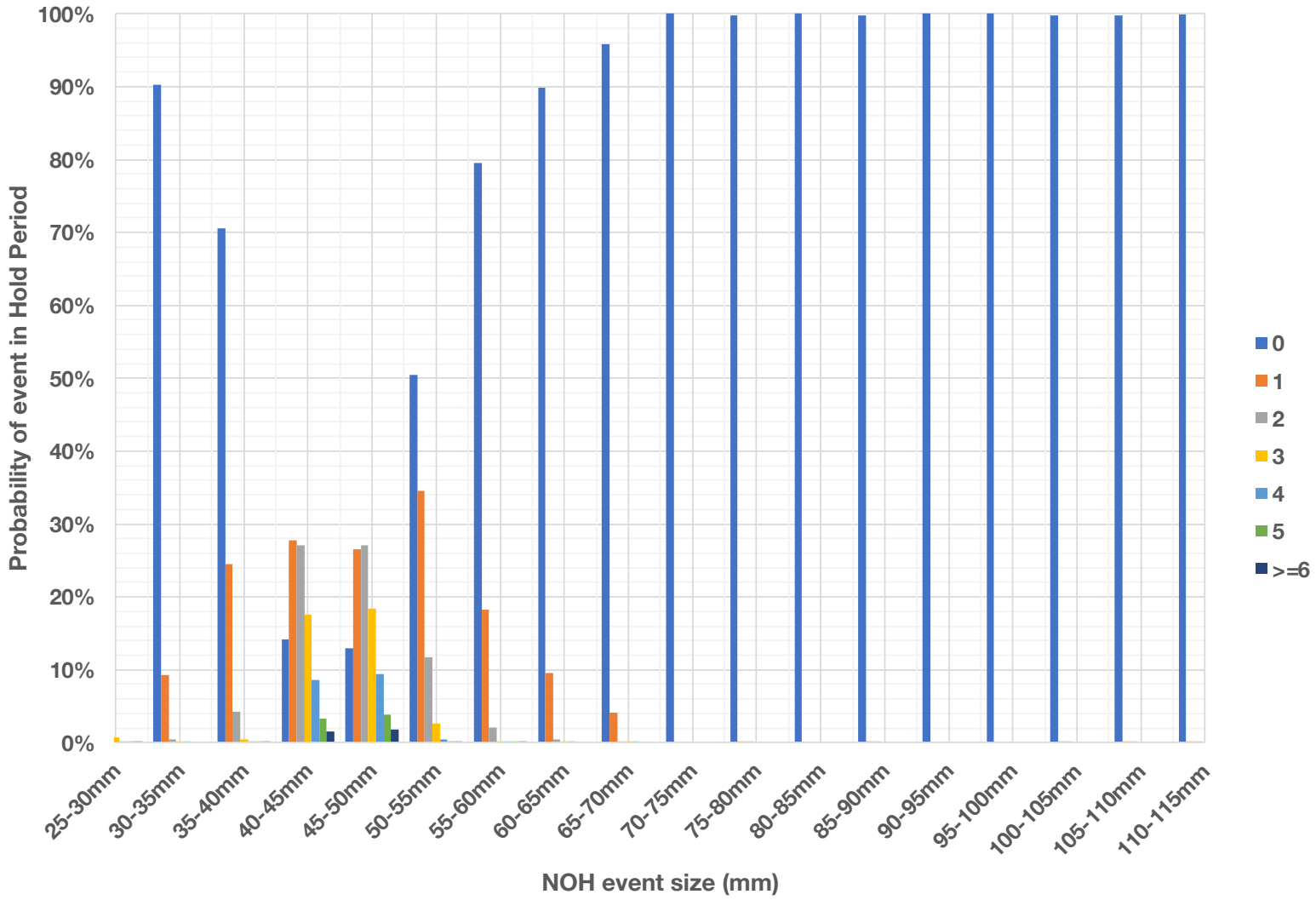


Return interval (RI) is the estimated amount of time between discrete events. Mathematically, it represents the value of a given quantity that is expected to be equaled or exceeded on average once every time interval (t) with an event probability in any given year of 1/t.

Probability of the number of discrete hail-size events of a 40-year hold

Hail-size probability distributions

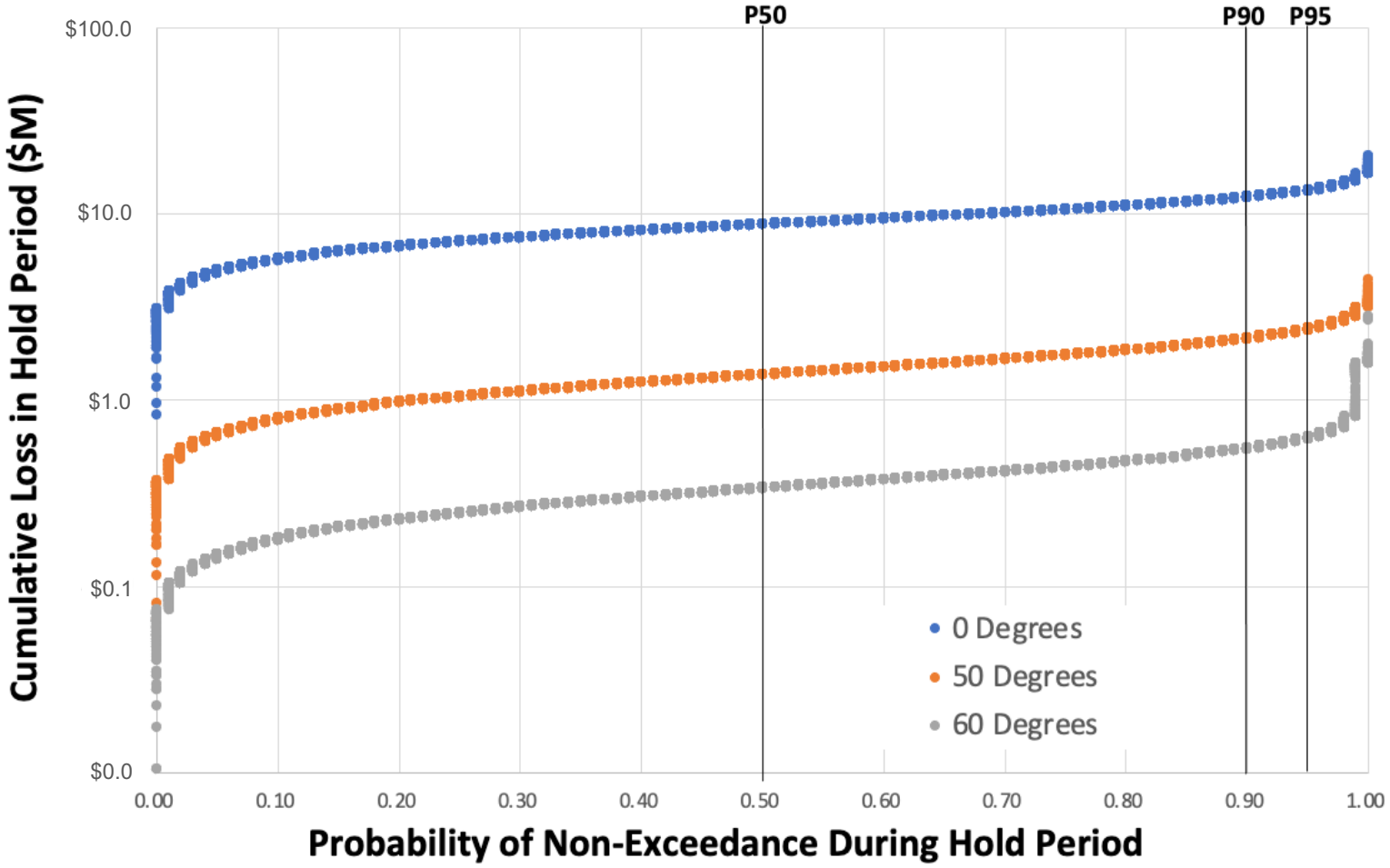
- Number of NOH-size events
  - 50 mm–55 mm NOH events, for example
    - ≈50% probability of no events (blue bar)
    - ≈34% probability of one event (red bar)
    - ≈11% probability of two events (gray bar)
    - ≈5% probability of three events (orange bar)



Cumulative financial exposure estimated over a 40-year holding period

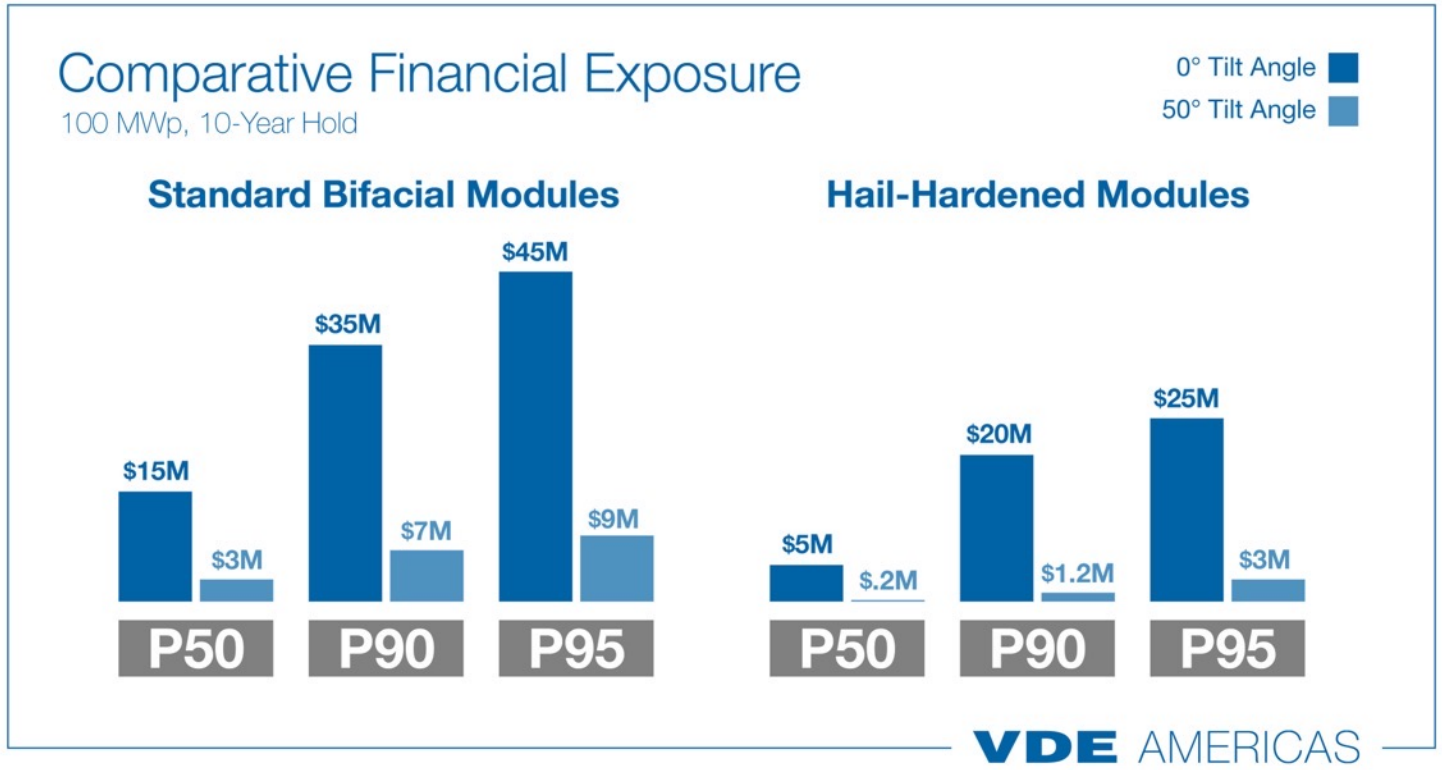
- Site-specific
  - Based on historical weather observations
- Product-specific
  - Based on actual fielded technology and remote operations center capabilities
- Holistic risk assessment
  - Based on coincident wind and hail—facing into wind, out of wind, and averaged
- Statistically significant
  - Based on 10,000+ Monte Carlo iterations

Hail Stow Tilt Angle	Probability Scenario		
	P50	P90	P95
0° Tilt	$8.83 M	$12.31 M	$13.43 M
50° Tilt	$1.38 M	$2.15 M	$2.42 M
60° Tilt	$0.34 M	$0.56 M	$0.62 M



Use cases for VDE Americas' Poison risk exposure (PRE) reports

- Inform PV project development and pro forma assumptions (owners and developers)
- Mitigate investment risk (tax-equity investors)
- Characterize **value proposition of hail-hardened products** (owners, developers, OEMs)
- Optimize **insurance terms and conditions and evaluate risk transfer options** (owners, developers, insurers)
  - For example, the PRE report is an ideal tool to support **parametric insurance** payout structures



Financial exposure outside of insurance supports comparative cost-benefit analyses by quantifying the value proposition associated with hail-hardened product or project designs.

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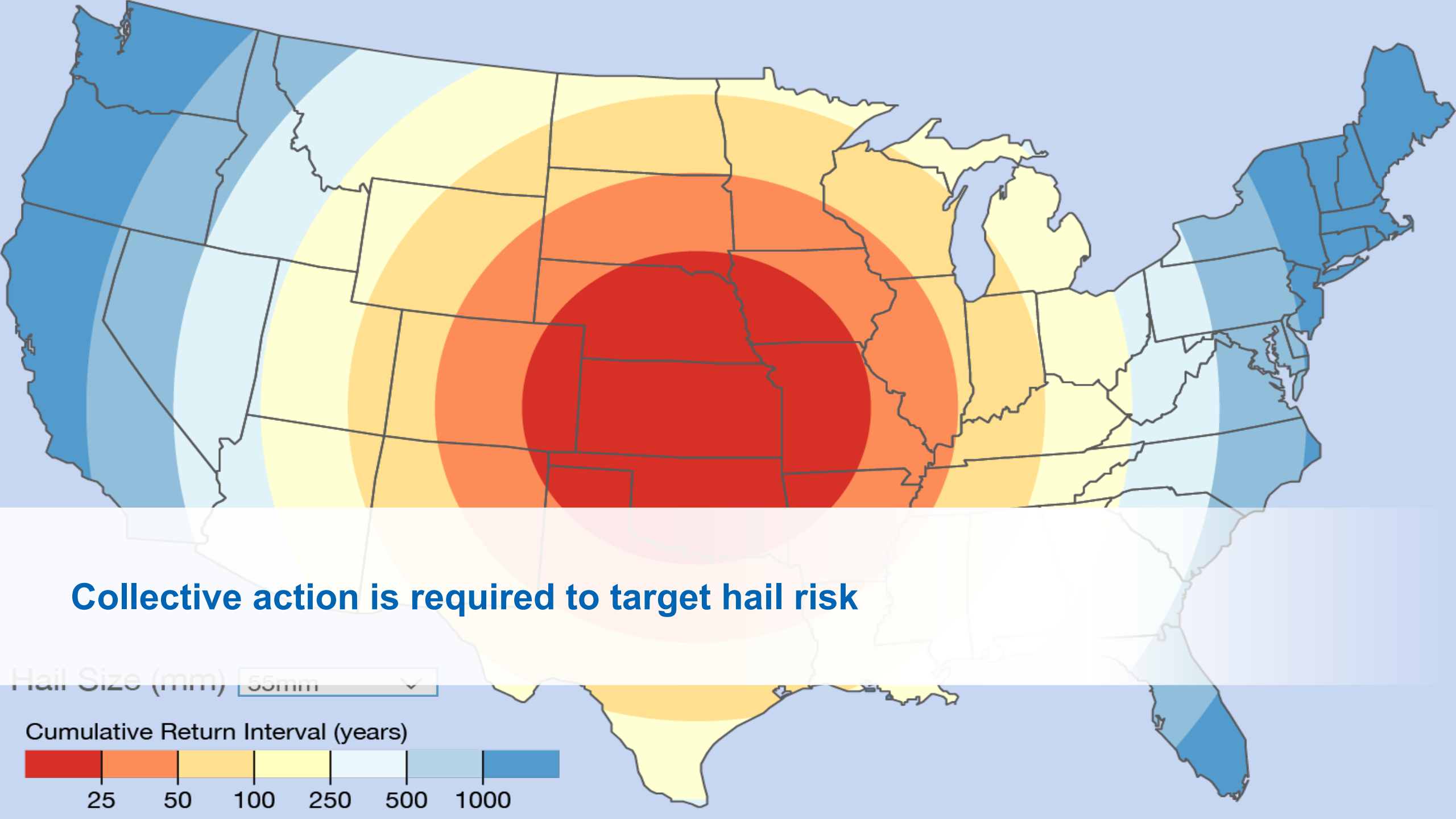
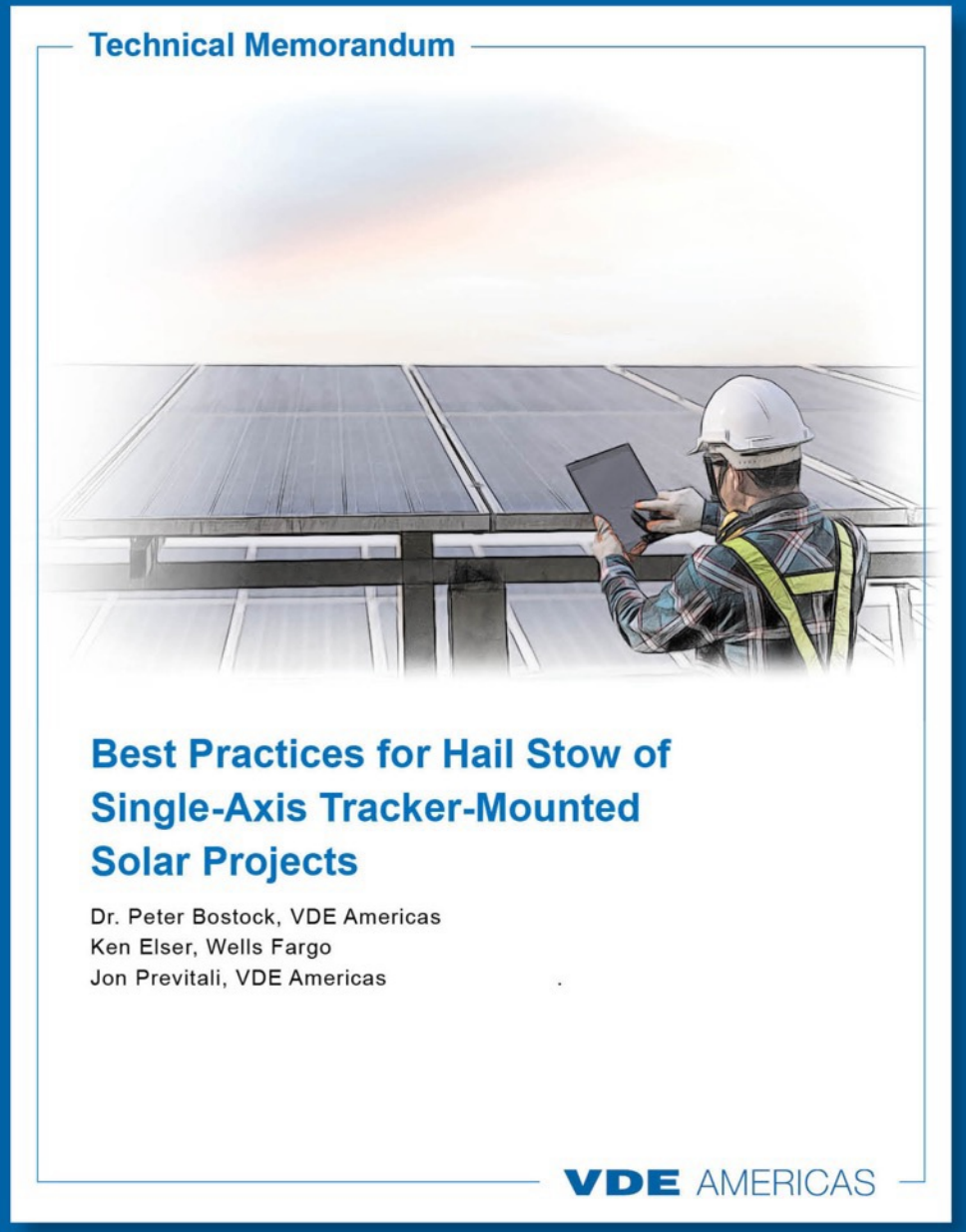
then we close with the final call-to-action slides.



Collective action is required to target hail risk



Learn More

Download Our Technical Memo

Best Practices for Hail Stow of Single-Axis Tracker-Mounted Solar Projects

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