CEA

CLEAN ENERGY ASSOCIATES | Investment Confidence

- Hail now costs the U.S. as much as $22 billion a year in damage to homes, cars, crops, people and more.
- Baseball-sized hail stones are common, but the biggest this year was the size of a grapefruit and weighed more than half a pound.
- The bigger they are, the harder they fall: A dime-sized hailstone falls at 20 miles per hour, while a baseball-sized one of 3 to 3½ inches can reach between 80 and 110 mph.

Ed Leefeldt, CBS News
April, 2019

https://www.cbsnews.com/news/hail-damage-costs-this-year-could-hit-new-annual-high-in-u-s/

https://www.glassusa.com/blog/hail-damage-repair-windshield-hail-damage-covered-by-insurance/

CEA
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HAIL

Company Snapshot

Clean Energy Associates is a technical advisory company that provides unrivaled insight into the solar PV and storage manufacturing industries to ensure the success of solar PV and storage projects worldwide.

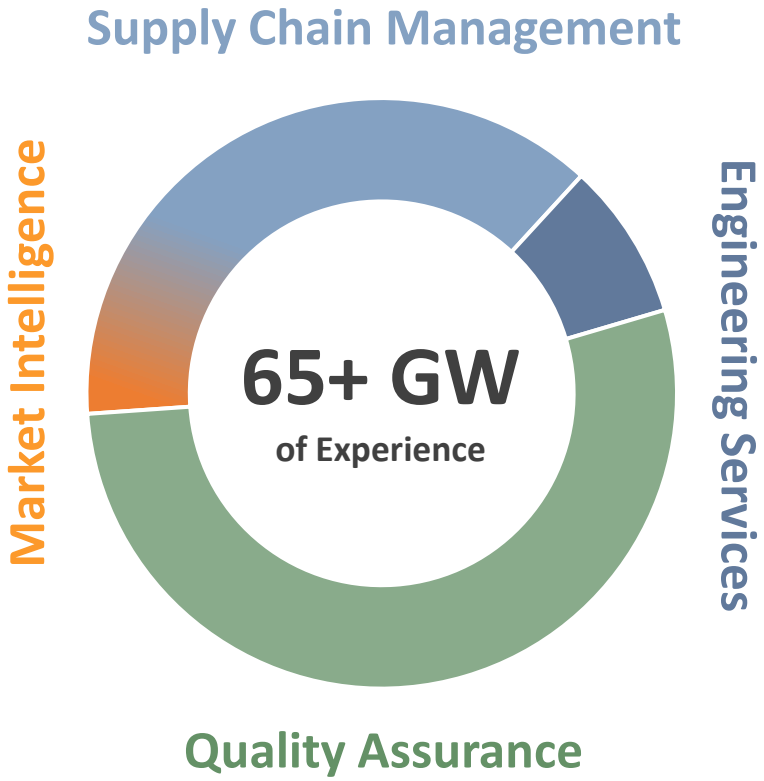
1,000+
Years of industry experience

135+
Professionals

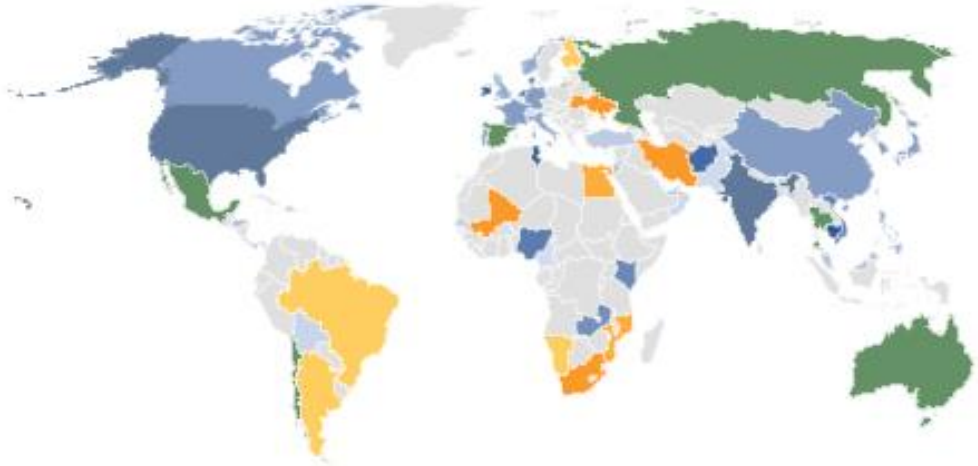
85+
Engineers

12+
Year track record

12
Countries with a physical presence



Client engagements in **55+** countries



Engagements in **350+** solar and storage factories worldwide

Proud member of

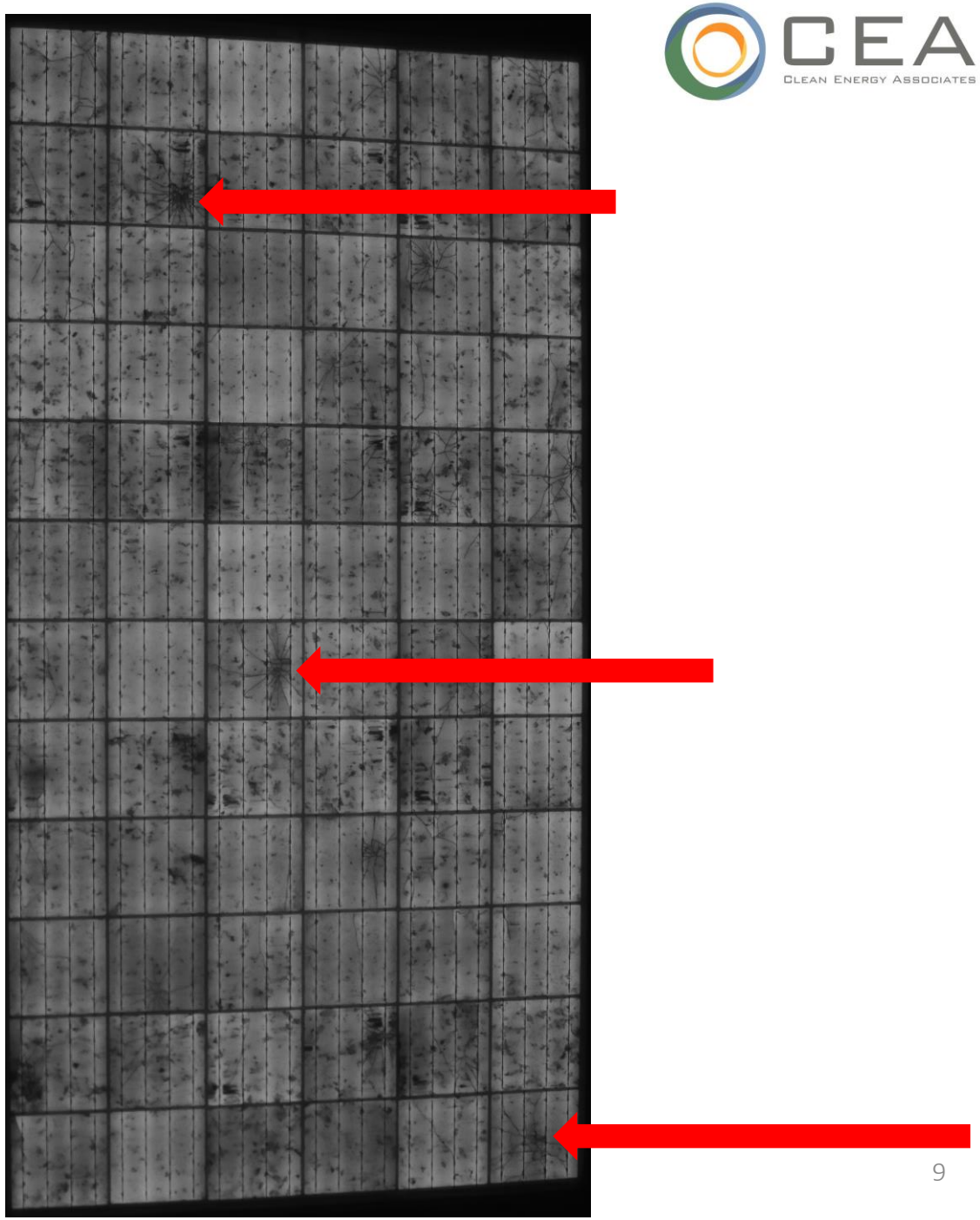
SEIA Member · SolarPower Europe · CESA

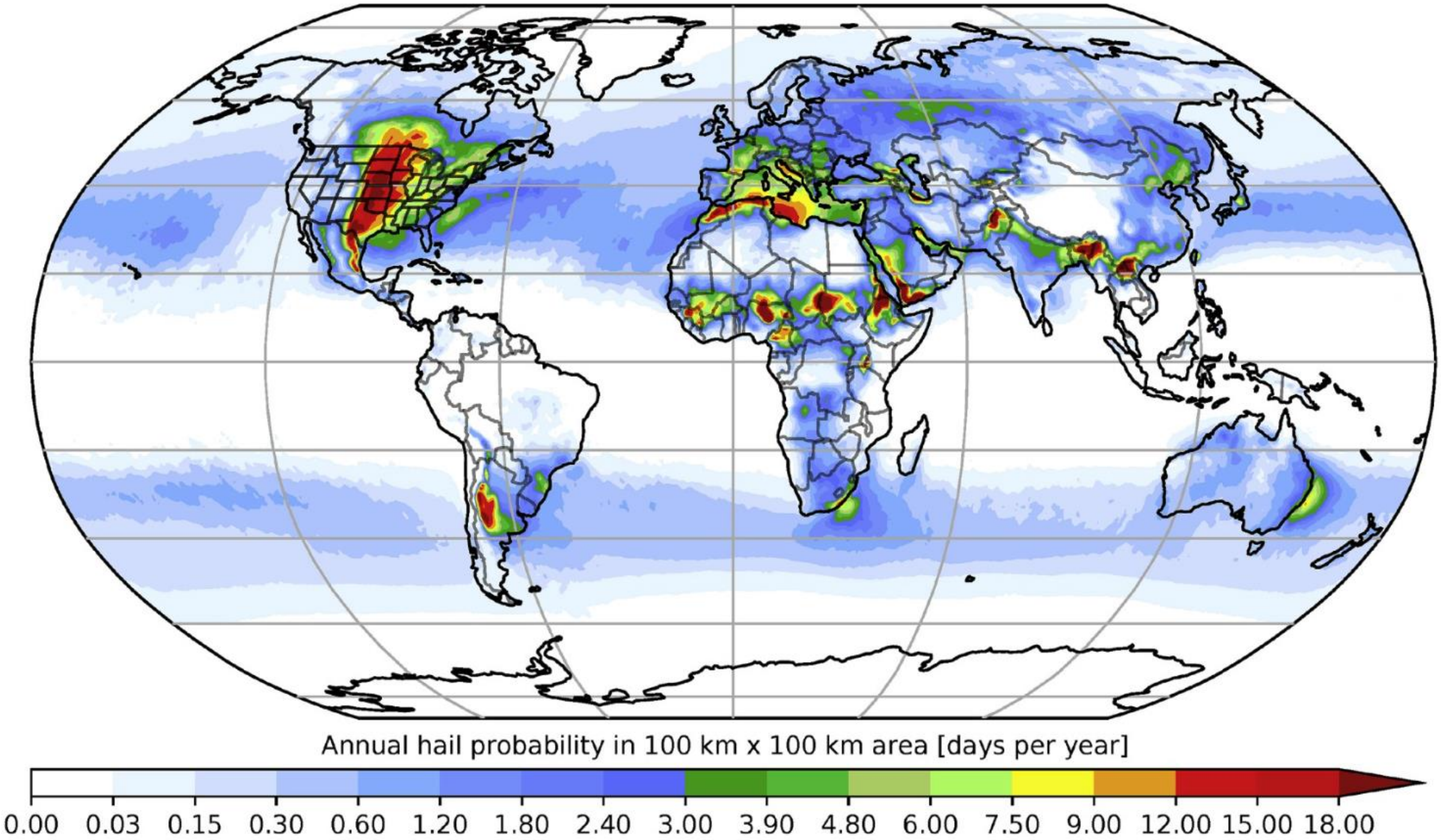
May, 2017: “Only 1 module was damaged out of 3,000”

Calgary – June 2020 - $ 1 B Storm

PV rooftop project:

- Zero modules with broken glass
- 100 % with cracked cells
- Between 2 and 9 cells were damaged in each module
- Hail: ~ 2” diameter
- 72-cell ca. 2017; 3.2 mm fully tempered glass
- Well known manufacturer




Annual hail probability in 100 km x 100 km area [days per year]
0.00 0.03 0.15 0.30 0.60 1.20 1.80 2.40 3.00 3.90 4.80 6.00 7.50 9.00 12.00 15.00 18.00

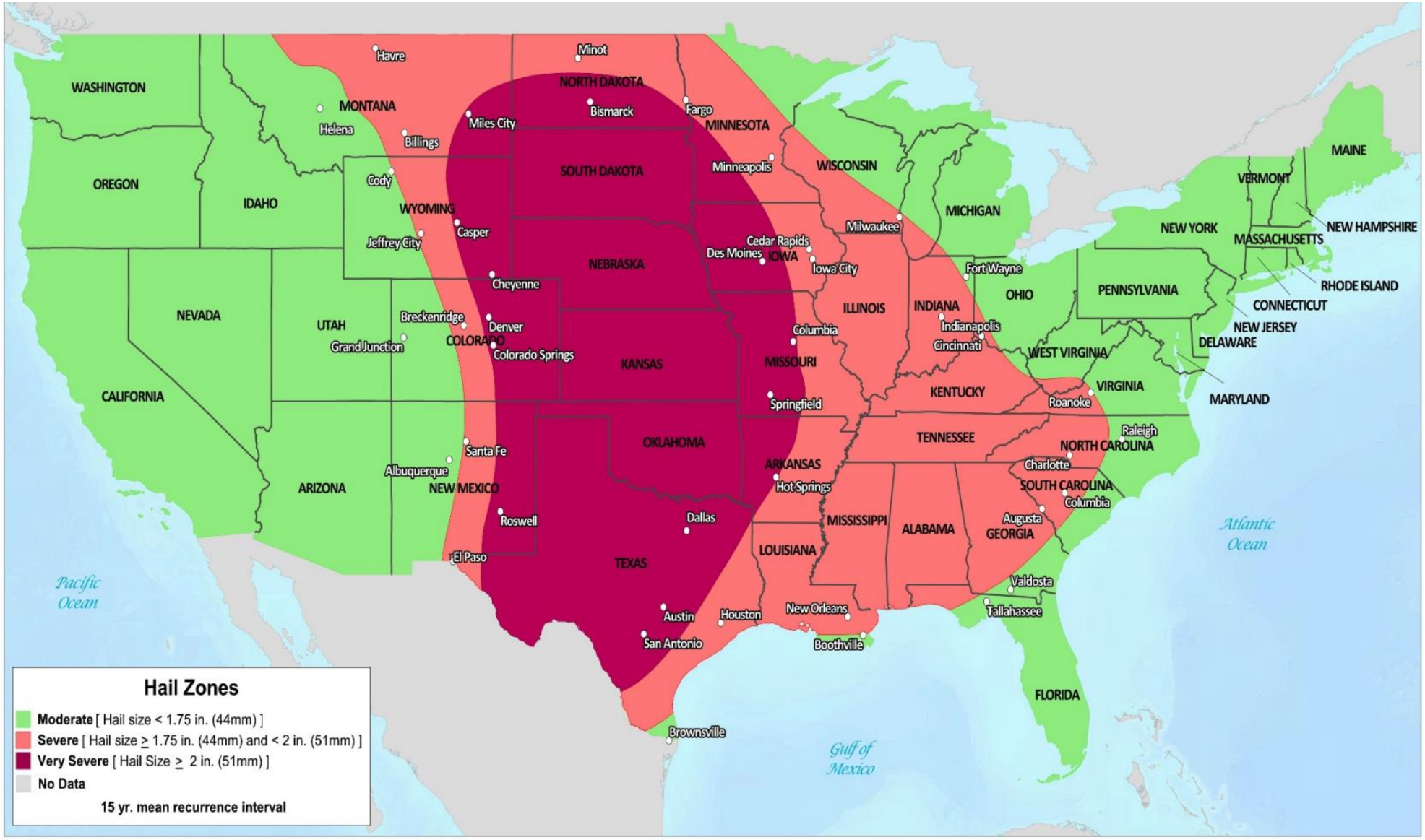


Fig.C-1. Hailstorm hazard map for the contiguous United States (ρ= 0.7g/cm³)

Source: https://www.fmglobal.com/research-and-resources/fm-global-data-sheets

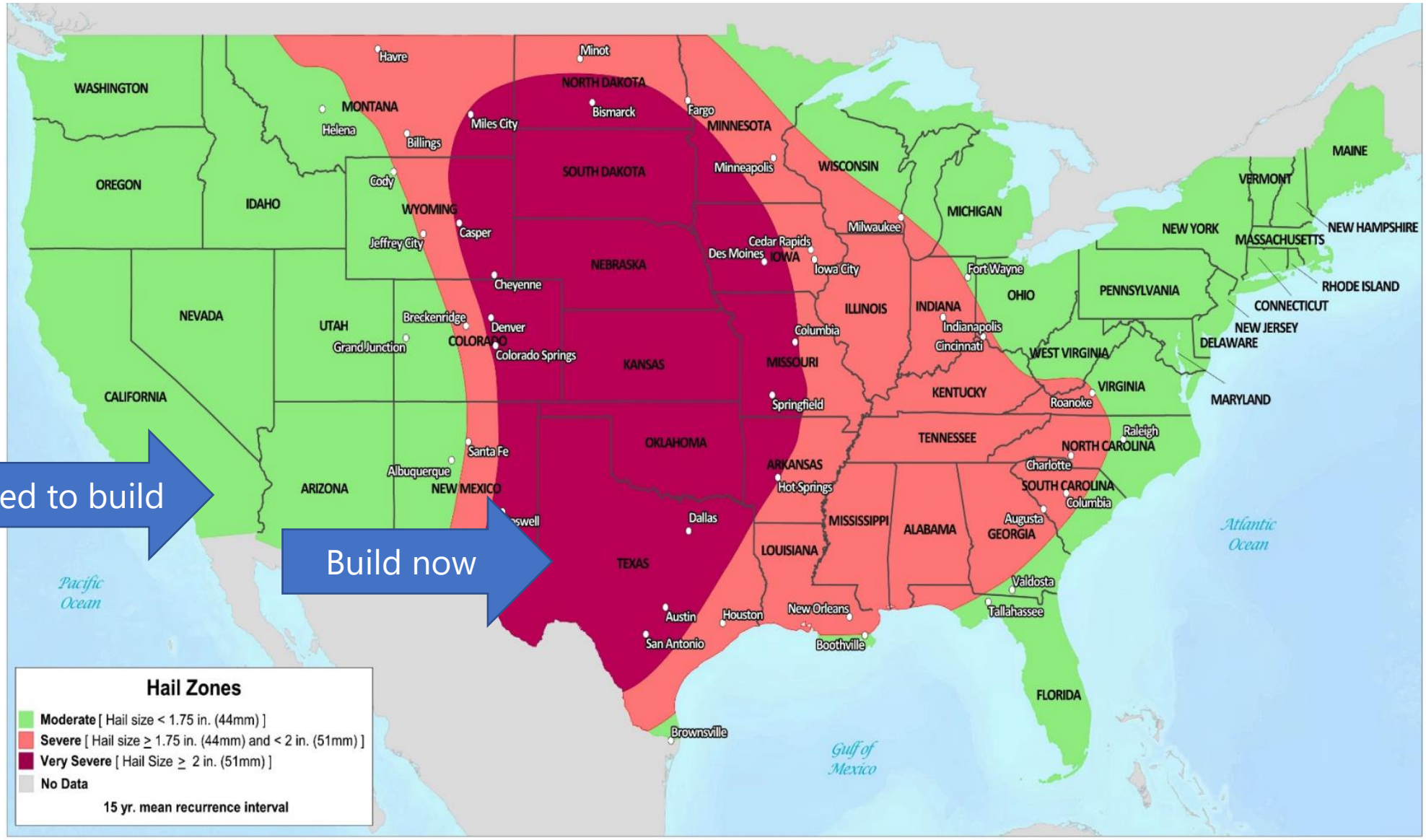
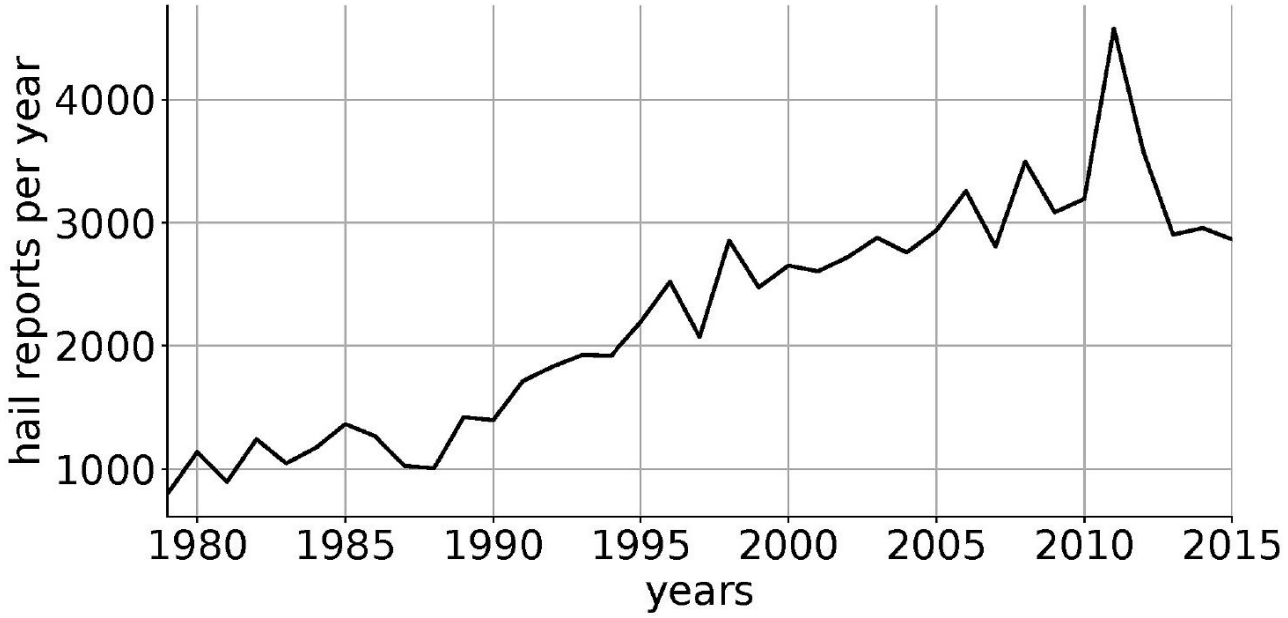


Fig.C-1. Hailstorm hazard map for the contiguous United States (ρ= 0.7g/cm³)

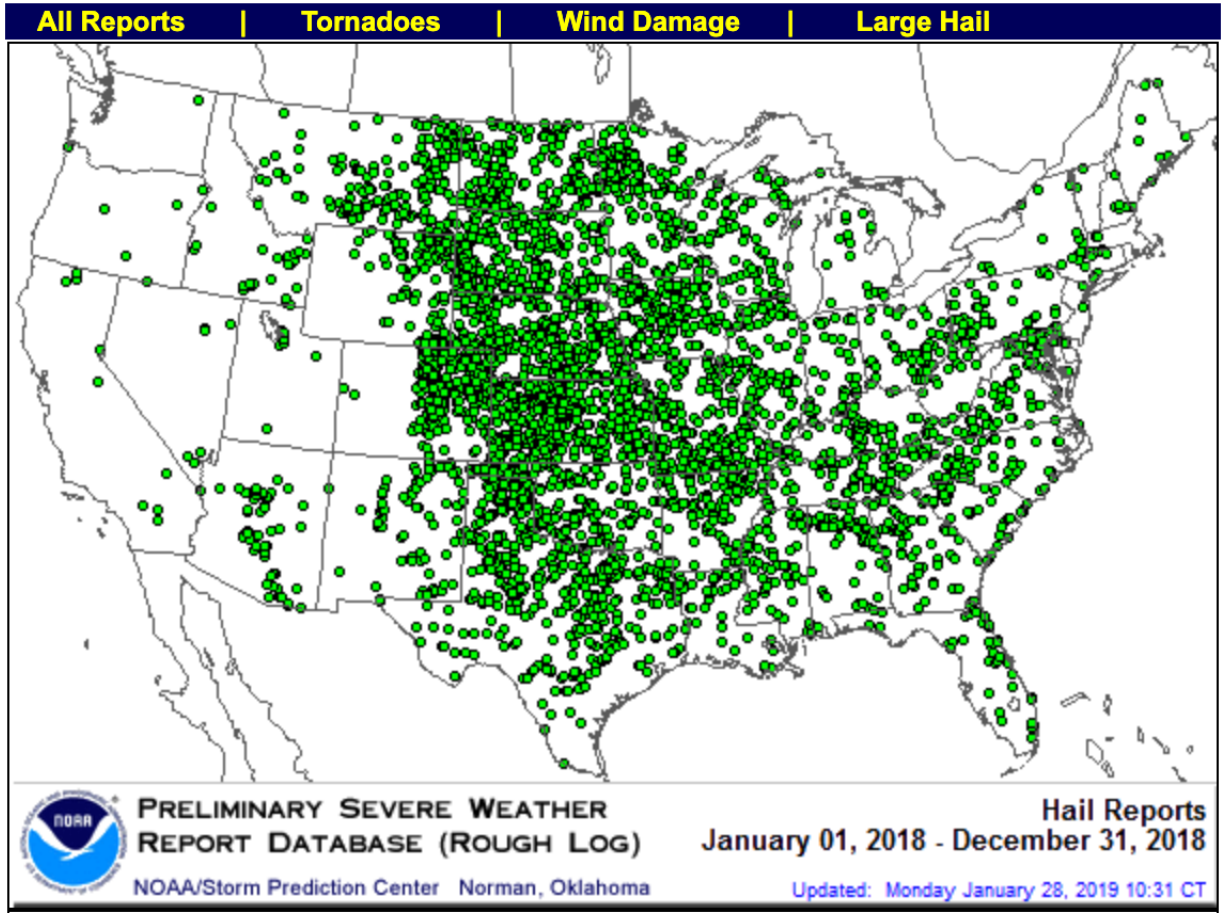
Source: https://www.fmglobal.com/research-and-resources/fm-global-data-sheets

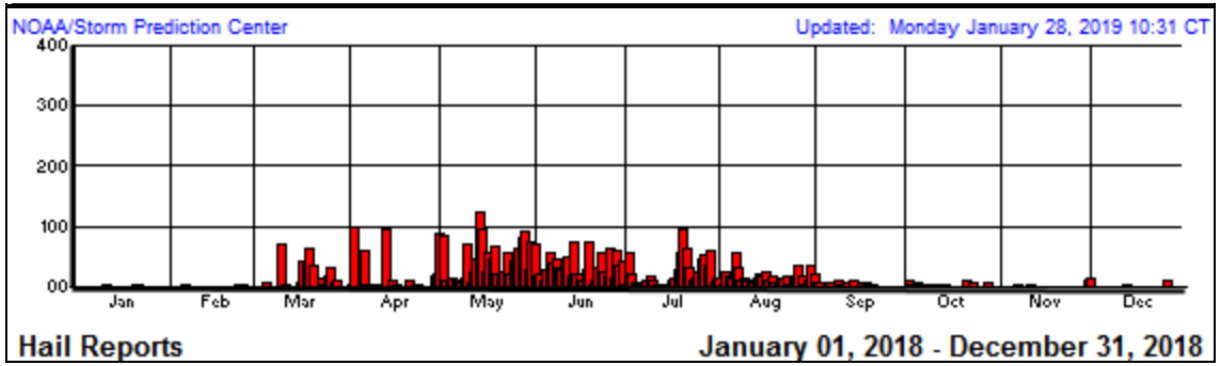
Frequency Increasing



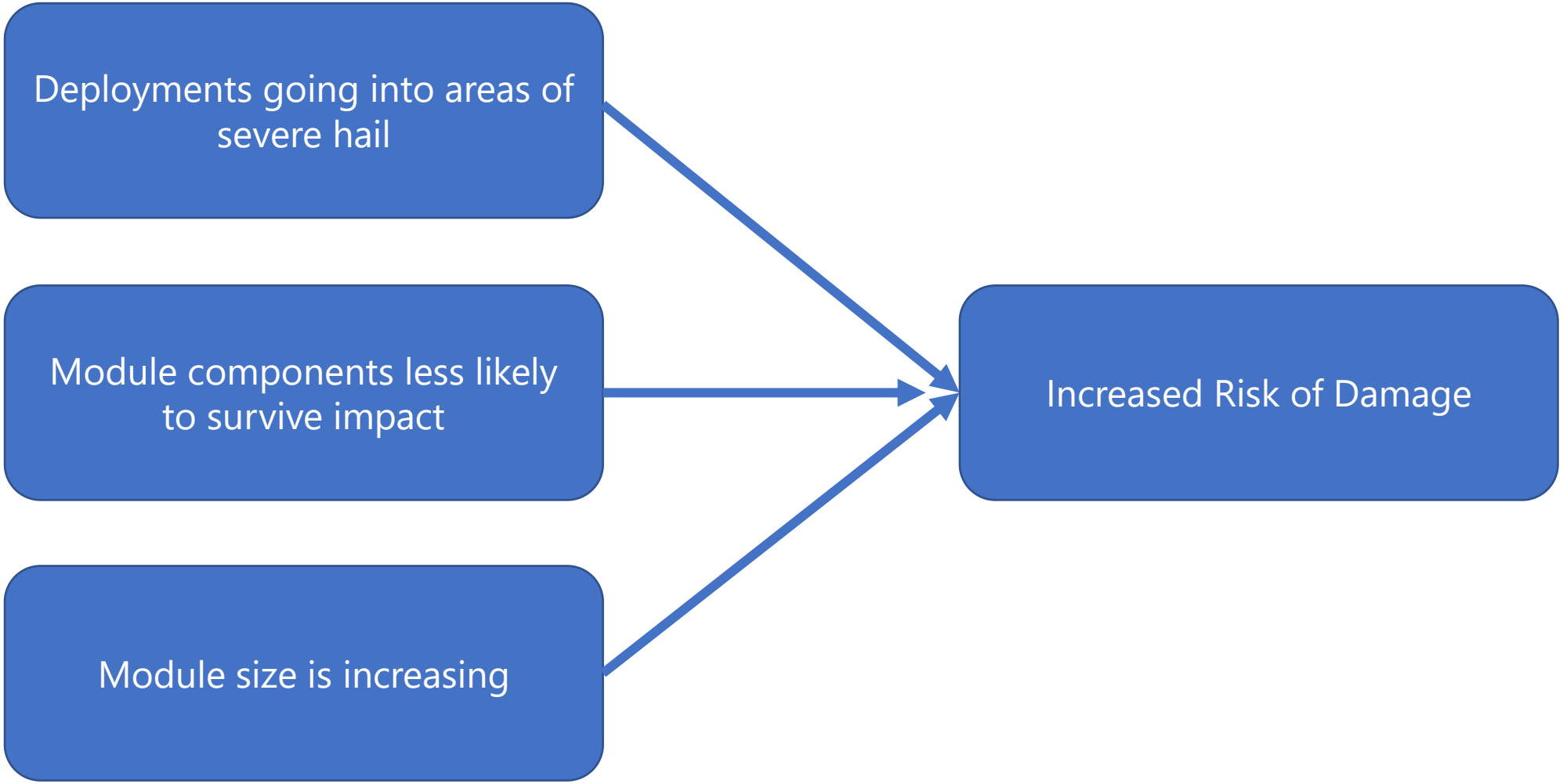
Hail is not just a winter event

Annual Severe Weather Report Summary
2018





Industry Trends → Increased Risk



Module Architecture is Changing

- Bifacial modules are rapidly taking share
  - Most suppliers offer a glass-on-glass format
    - To keep weight down (and cost), they are using thinner glass than what the industry has used for years for a glass-backsheet module
    - Thinner glass is not fully tempered (it is heat-strengthened – with half the strength of fully tempered glass)

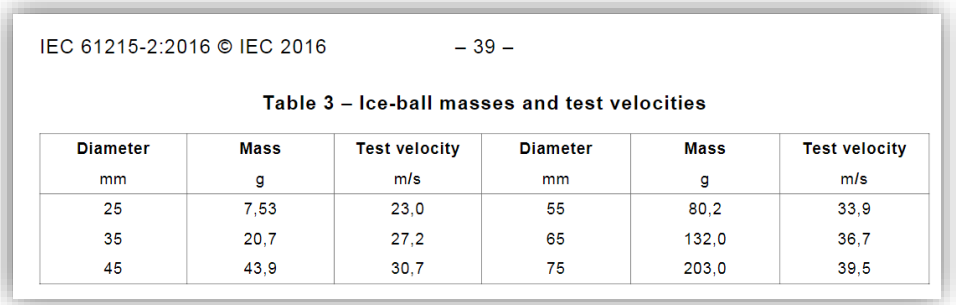
Hail Testing

IEC includes hail testing with ice-ball sizes ranging from 25 mm - 75 mm. AND -- Certification testing is typically done at the minimum 25 mm size.

Pass/Fail: only visual inspection and wet leakage test are done. No explicit analysis of cracked cells.

Virtually nobody fails the 25 mm ice ball test.

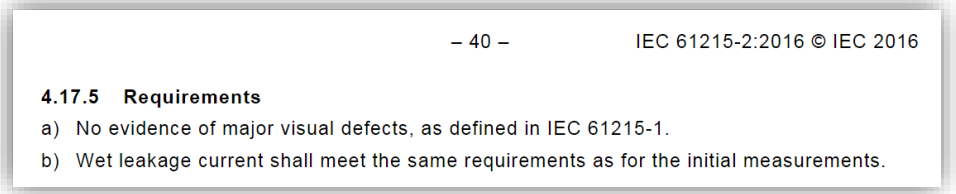
Very few projects request more rigorous testing.



IEC 61215-2:2016 © IEC 2016 – 39 –

Table 3 – Ice-ball masses and test velocities

Diameter	Mass	Test velocity	Diameter	Mass	Test velocity
mm	g	m/s	mm	g	m/s
25	7,53	23,0	55	80,2	33,9
35	20,7	27,2	65	132,0	36,7
45	43,9	30,7	75	203,0	39,5



– 40 – IEC 61215-2:2016 © IEC 2016

4.17.5 Requirements

a) No evidence of major visual defects, as defined in IEC 61215-1.

b) Wet leakage current shall meet the same requirements as for the initial measurements.

IEC does not look at cell cracks and does not add additional stress conditions that could highlight damage

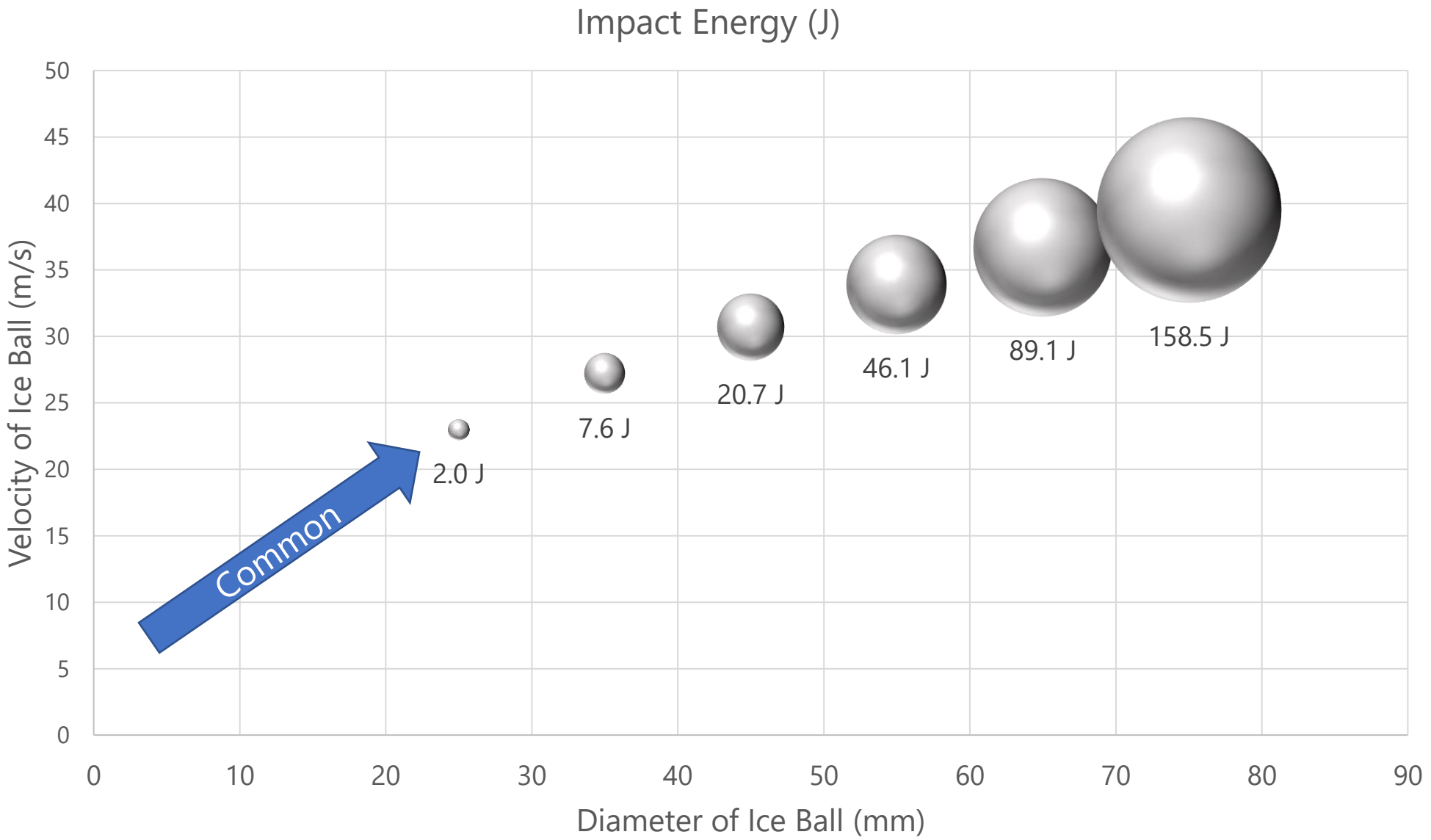
No correlation between hail risk zone and test severity (ice-ball diameter).

There are lab initiatives (RETC, PVEL, TÜV Rheinland) to develop better tests, but they do not constitute a standard at this time.

Test Labs are considering alternatives

- RETC as a Hail Durability Test
- PVEL has a protocol

Impact Energy of IEC Hail Test

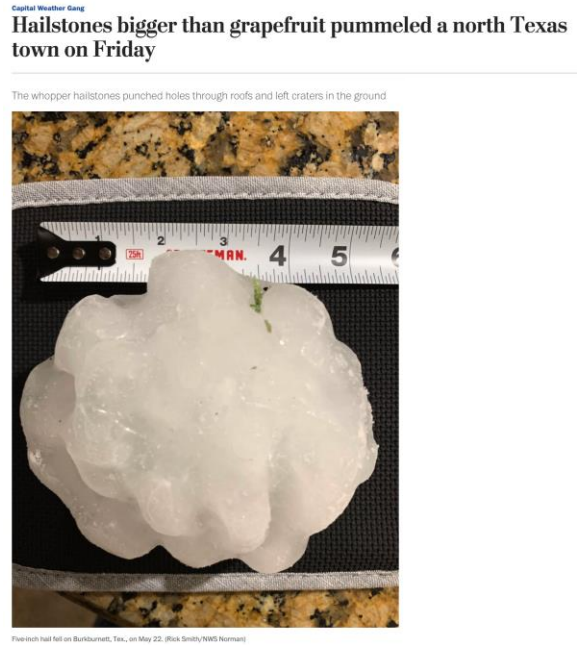


Watershed Event: Texas Project

Event

- ~ $75 million claim

- "Terms and conditions are also coming under scrutiny, especially "micro-cracks" for solar panels from hail… Deductibles are also being extended, especially with hail limits for solar."*



Capital Weather Gang

Hailstones bigger than grapefruit pummeled a north Texas town on Friday

The whopper hailstones punched holes through roofs and left craters in the ground

Five-inch hail fell on Burkburnett, Tex., on May 22. (Rick Smith/NWS Norman)

*Insurance Insider – October, 2019

Finding Damage: Elusive

If the glass is not broken AND there is underlying damage

- Likely can't see it without EL, IR, photoluminescence
- Assessment of damage is time consuming
- Impact of damage might be intermittent (based on temperature, wind load)
- Impact of damage might take "time" to manifest

Module Warranty

Typical Exclusion:

- “Damage has been caused by extreme natural phenomena (earthquakes, typhoons and tornados, volcanic eruptions, flood and storm tides, lightning, hailstorms and heavy snowfalls, tsunami, etc)”

Module Installation Manual

"Modules cannot be used in environments with too much hail, snow, flue gas, air pollution and soot or in places with strong corrosive substances such as salt, salt mist, saline, active chemical steam, acid rain, or other substances corroding modules, affecting module safety or performance. "

Does the module manufacturer have any responsibility?

Is the manufacturer "representing" fitness for purpose when they knowingly sell modules to a project in a severe hail area??

Risk Mitigation Steps

- Consider location and historical weather events; predict future event possibility
- Specify a more severe impact test condition
- Link prediction to a test that establishes capability / resistance
- Choose rack and module wisely
  - Get the module out of the way (e.g. high tilt)
  - Use impact-resistant glass (thicker, fully tempered) → cost increase
  - Support the glass (stronger frame, support bars, smaller modules) → cost increase

Procurement Recommendations

- Get a representation of fitness for purpose at the location (very difficult)
- Get a specification above the IEC minimum (difficult → less difficult)
- Specify more rigorous lab testing to reveal hidden damage
- Get reports of impact testing
- For known severe hail locations:
  - Module construction is key
    - For overlapping cell-to-cell interconnection – don't skip extra testing
    - Beware of shallow frames and the adhesive that holds the frame in place
    - Beware of thinner glass that is also likely strengthened rather than tempered
    - Explore (with Supplier) the option of a more robust module
  - Tracker algorithm
    - Look for a tracker that can get the module "out of the way"
  - Get insurance coverage and premium in-hand before final selection
  - Get Investors' view on testing and coverage

Takeaways

- Risk of major damage from hail is real – and cells can break even though glass doesn't
- We're in the stage of identifying what we don't know and filling in the gaps
  - Current norms are not working
  - Insurance only covers some of the risk
  - And you're about to hear more from the perspective of understanding the risk and then insuring against the risk
- If you're building in a hail zone, choose wisely – module, racking
  - Consider augmenting the impact test specification, risk transference, insurance

Thank you

Clean Energy Associates

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