Structural Loads for Solar PV Systems and Buildings
Solar ABCs Stakeholder Meeting

Solar Power International
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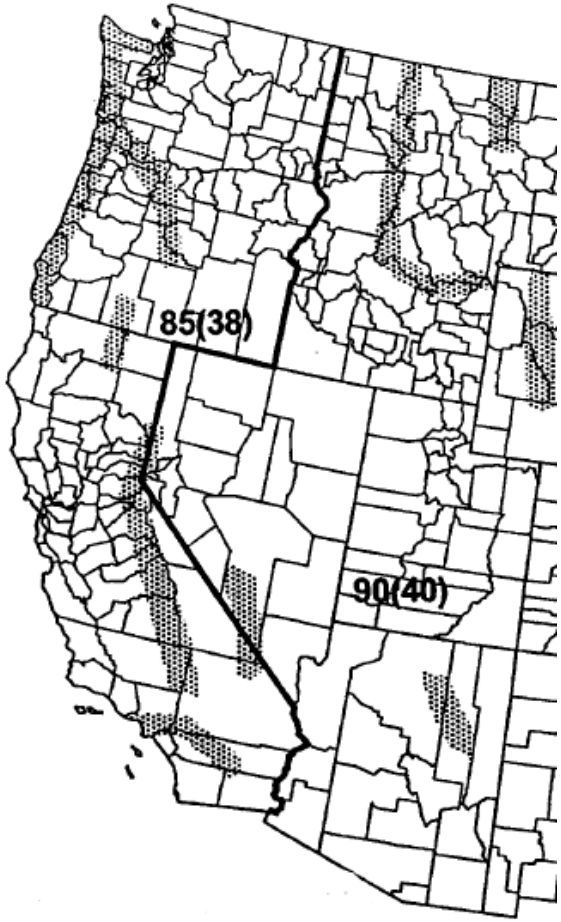
What Are the Loads on PV Systems and Buildings with PV?

Primary Structural Loads:

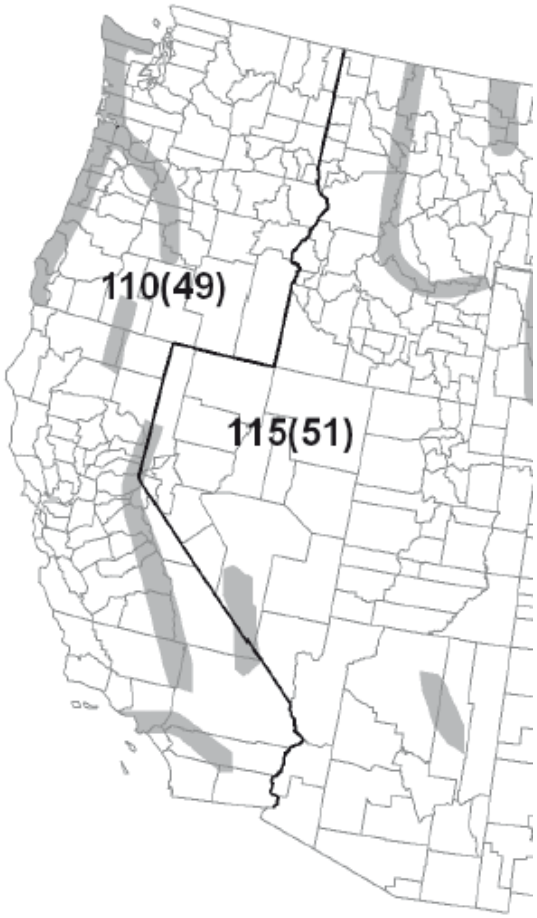
- Dead Load (self-weight), D
- Wind Load, W
- Earthquake (Seismic) Load, E
- Live Load, L or L_r (L_r is Roof Live Load)
- Rain Load, R
- Snow Load, S

Must also consider Combinations of Load

Why Did My Design Wind Speed Increase in ASCE 7-10?



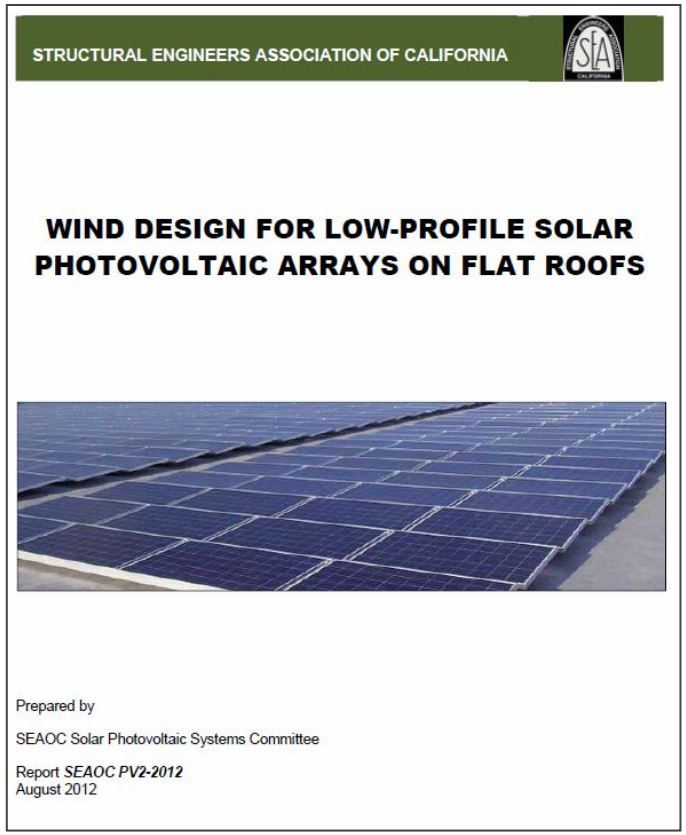
ASCE 7-05



ASCE 7-10

- ASCE 7-05 map based on 50-year recurrence interval
- ASCE 7-10 maps based on Ultimate Strength Design
- Calculation methods are different
- End results are similar
- Your PV system didn't get stronger

SEAOC Solar Photovoltaic Systems Committee, Wind White Paper Published August 2012.



- Structural Engineers, Code Enforcement Agencies, Solar Industry.
- Wind Tunnel Researchers: David Banks, Gregory Kopp, Timothy Reinhold.
- Developed calculation method based on combined solar-specific wind tunnel data points.
- Includes commentary on Effective Wind Area.

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- Boundary Layer Wind Tunnel.
- Scale model of building rotates to simulate varying wind direction.
- Results are *not* the same if not a *boundary layer* test.

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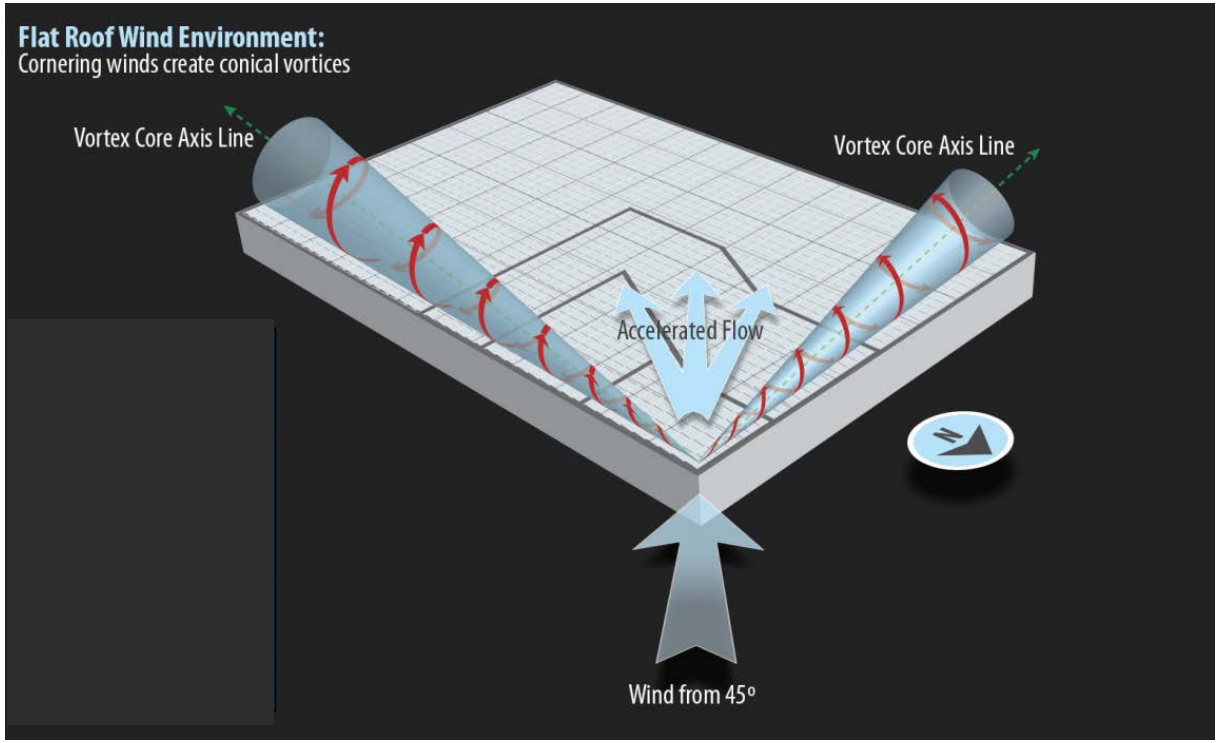

- Researchers observed higher wind pressures at paths of corner vortices.
- Lower wind pressures at interior zones and shielded rows of modules.

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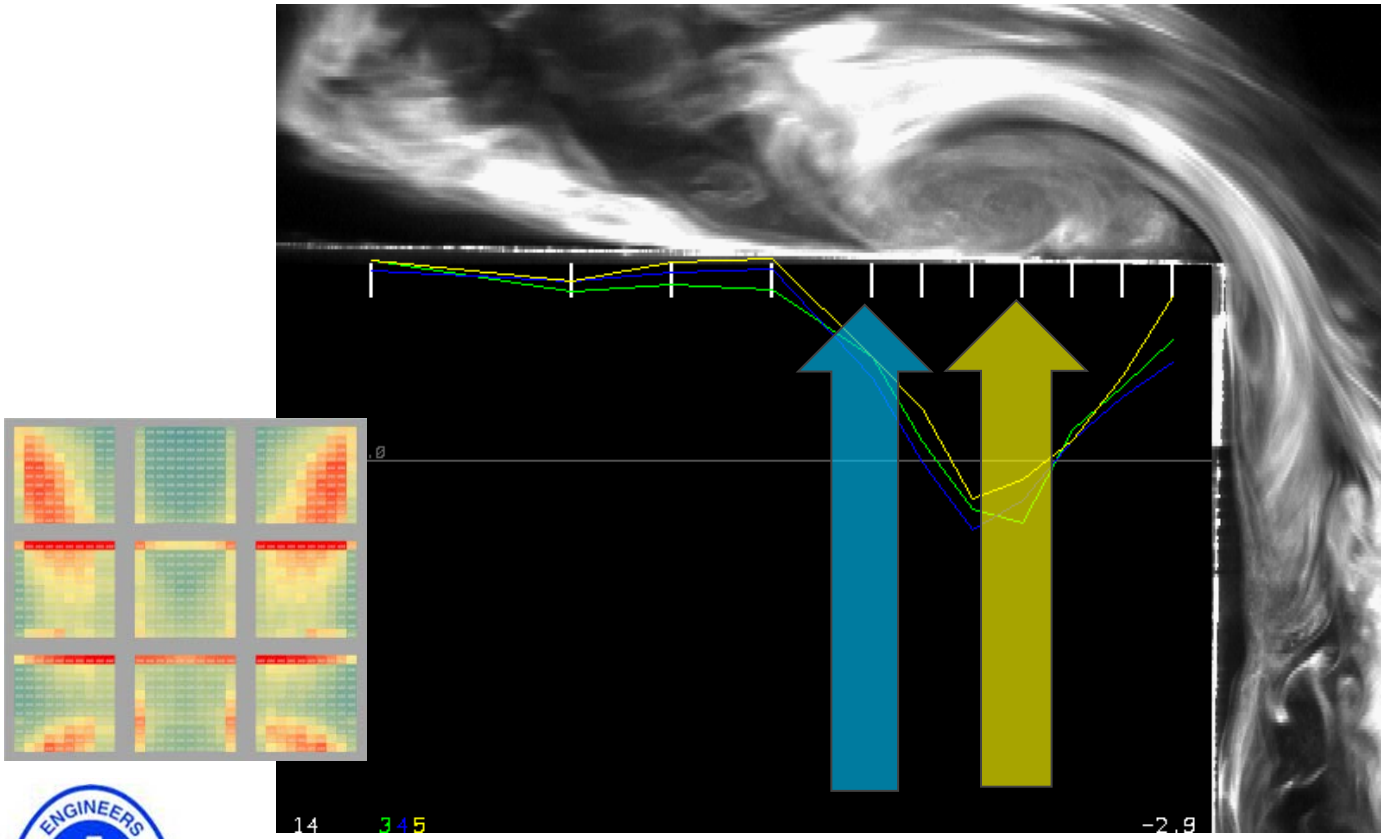
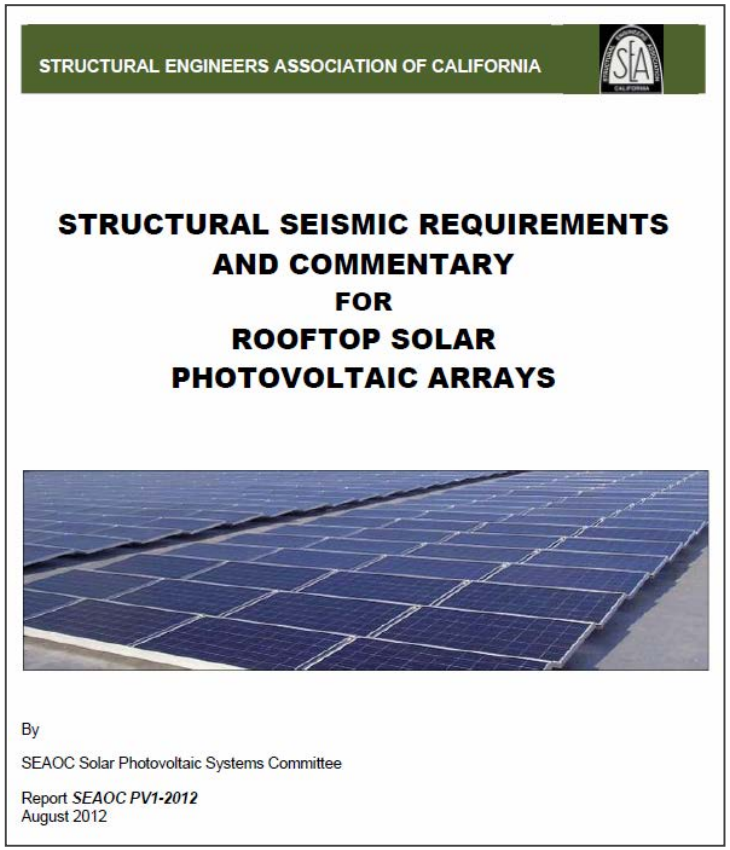


peak pressure on solar panels in NE corner

peak pressure on roof

SEAOC Solar Photovoltaic Systems Committee, Seismic White Paper Published August 2012.



- Primary research conducted by Joe Maffei, PhD, S.E. of Maffei Structural Engineering and Rob Ward, S.E. of SunLink.
- Shake table testing at Pacific Earthquake Engineering Research Center (PEER).
- Justifies use of ballasted, non-penetrating PV mounting systems.
- Based on displacement method of analysis.

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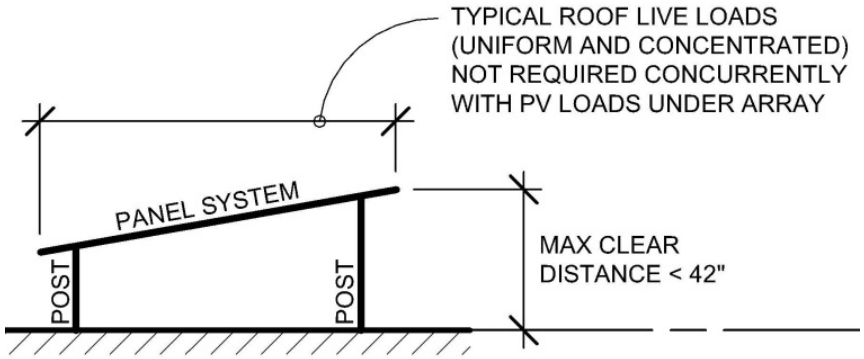
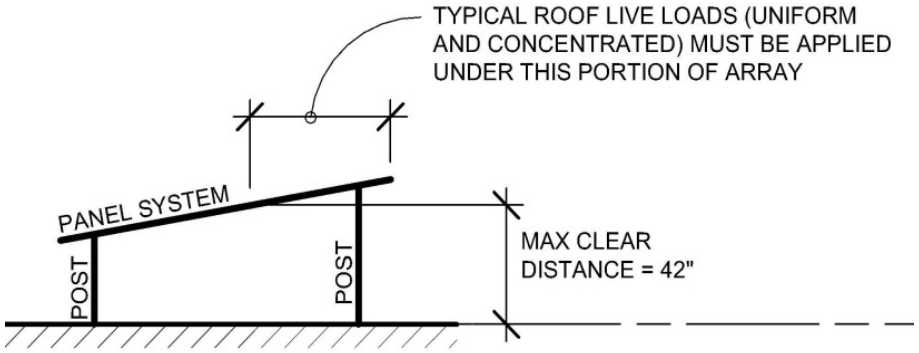
- Friction testing to determine Coefficient of Friction.

- Shake table testing to determine patterns of displacement during simulations of historic seismic events.

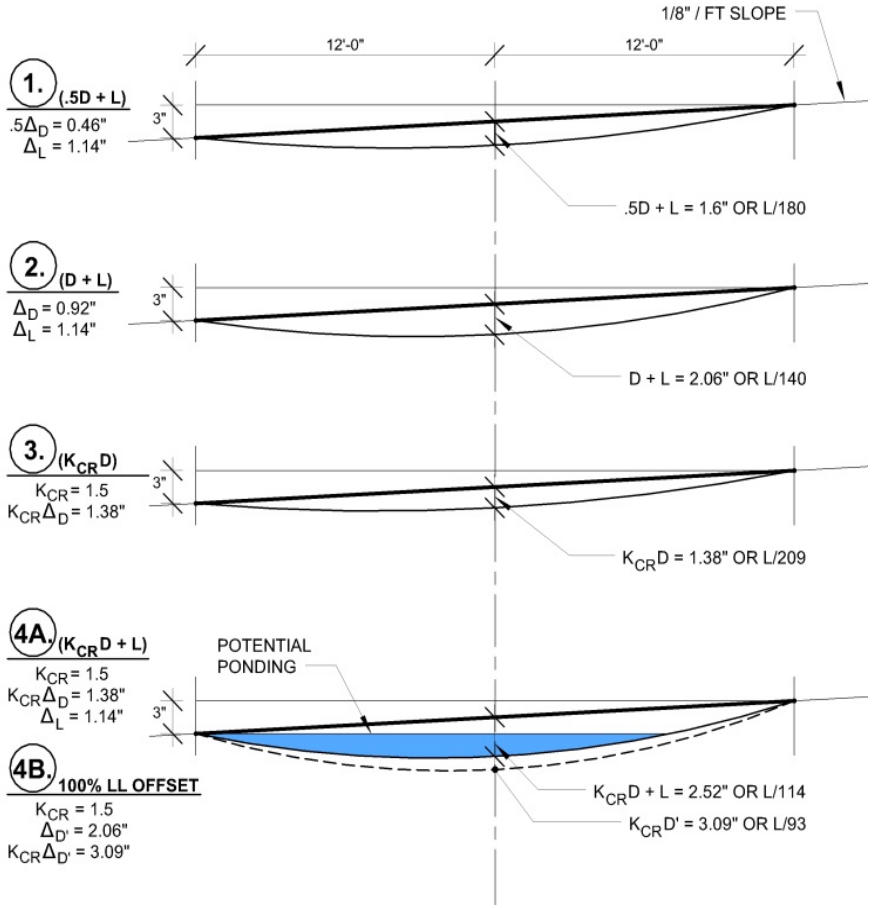
Proposal for Live Load on Buildings with PV

- Many engineers have assumed live load is fully displaced by PV (LL = 0)
- California DSA-SS IR 16-8 initiated 12” rule
- SEIA Codes & Standards Working Group promoted increase in threshold
- 2015 IBC & 2013 CBC threshold increased to 24”
- SEAOC now supports further threshold increase to 42”





Rain Load Ponding Check for Buildings with PV



- For very low-slope roofs, ponding of rainwater can cause excessive deflection, leading to progressive failure.
- Ponding check is required in 2013 California Building Code (CBC) and future 2015 International Building Code (IBC).
- Ponding Check required where roof slope is less than ¼" per foot.

Dynamic Effects of Wind for Ground Mounted PV Systems

- Vortex Shedding is a naturally occurring phenomenon.
- Flexible structures are at greatest risk of damage owing to dynamic excitation and amplified loads from wind.
- In ASCE 7, rigid structures are defined as having natural frequency greater than 1 Hz.
- PV Systems have experienced structural failure, even though designed according to ASCE 7.
- The 1 Hz threshold is not adequate for PV systems.

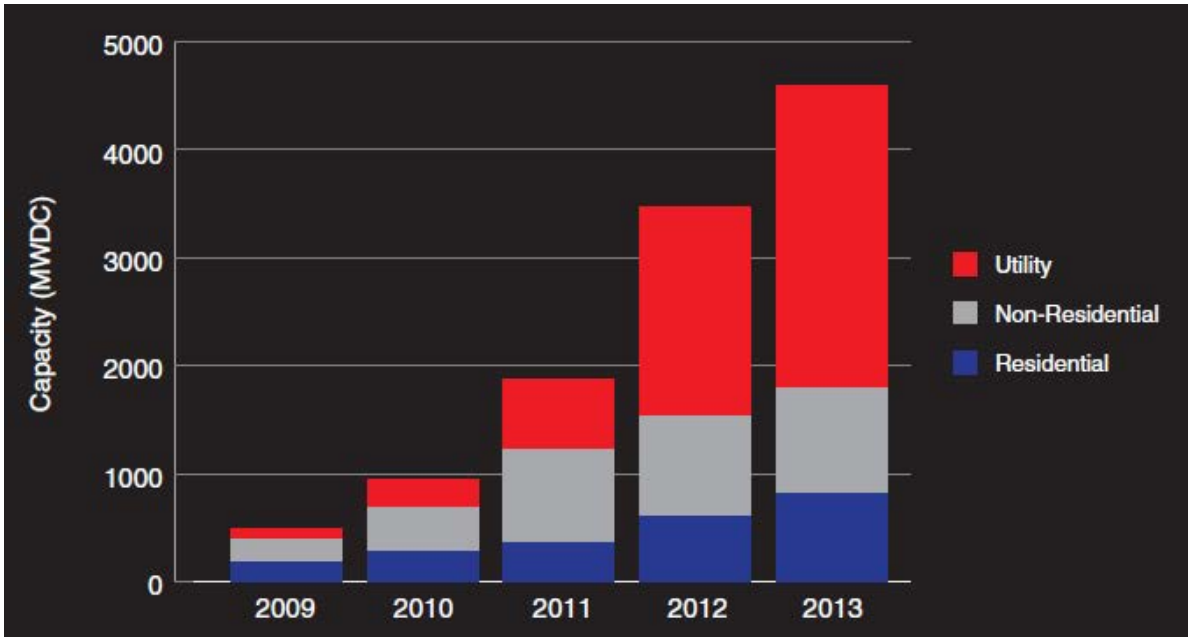
Snow Load on PV Systems and Buildings

- Roof Snow Load vs. Ground Snow Load
  - 30% reduction plus other possible reductions
- To Reduce or Not to Reduce?
  - Heated or unheated?
  - Slippery or Non-Slippery?
- Snow Drift from wind
  - Balanced Snow Load vs. Unbalanced Load
- To Retain or Not To Retain?
  - Possible hazard from sliding snow and ice
  - Increased snow load and drift load if retained

Additional Topics Under Consideration by SEAOC

- "Streamlined" / Expedited Permitting in California
  - Kudos to John Wolfe of Tipping Mar
  - Supported by research at Sandia Labs
- Structural load testing of PV system components
- For Ballasted rooftop systems:
  - Wind Averaging Area
  - Rack Stiffness
  - Load Sharing Capability
- Quality Assurance for structural concerns
- Other topics listed for future consideration

How Important is Structural Engineering for PV?



- Structural failures have already occurred.
- We would not want the quantity of structural failures to increase with the scale of the solar industry.

IREC Interstate Renewable Energy Council Inc.

Questions?

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