High Wind Loads and Model Code for PV Arrays

Solar ABC's Project

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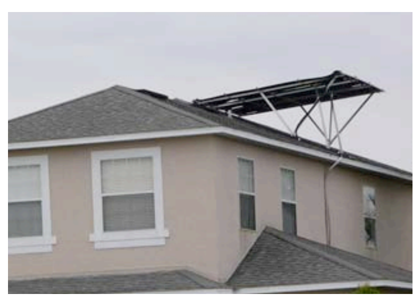
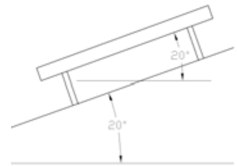
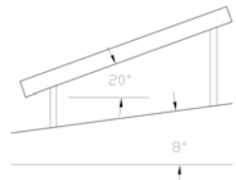
Problems:



- Existing codes lack guidelines for PV systems
- Designers use codes intended for buildings
- Many interpretations are possible for same design
- ***Many PV systems are significantly over-designed or under-designed to withstand expected wind speeds.***

Approach





- Phase I (complete): Review the most widely used code (ASCE-7) to develop a recommended approach to calculate wind loads on PV modules mounted parallel to the roof surface.

- Phase II: Expand code based approach to sloped PV systems. Ideally conduct wind tunnel testing, but need up to $500K, which is not in ABC budget.

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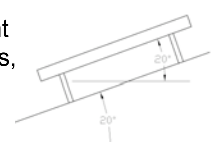
Results – PV Parallel to Roof Surface

- We outline ten (out of ~30!!) justifiable approaches for the same PV system, based on ASCE-7, Section 6

- Pressure on modules
  - Pressure = q*(GCp-GCpi)
  - q = velocity pressure; not a point of contention – depends on building shape, surrounding terrain, wind velocity
  - GCp, GCpi = external and internal pressure coefficient (pressure above and below PV) – hundreds of choices, none clearly for PV



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Results – PV Parallel to Roof Surface, 90 MPH

Uplift Pressures (PSF) - Middle of Roof

GCpi	C & C	MWFRS
0	-17	-13
+/-0.1	-19	-15
+/-0.18	-21	-17
+/-0.3	-23	-19
+/-0.55	-28	-24

Uplift Pressures (PSF) - Edge of Roof

GCpi	C & C	MWFRS
0	-32	-20
+/-0.1	-34	-22
+/-0.18	-36	-24
+/-0.3	-38	-26
+/-0.55	-43	-31

Uplift Pressures (PSF) - Corner of Roof

GCpi	C & C	MWFRS
0	-49	-20
+/-0.1	-51	-22
+/-0.18	-53	-24
+/-0.3	-55	-26
+/-0.55	-60	-31

Location: Phoenix, AZ(90 mph gust wind speed)
Terrain: Open desert, very few buildings.
Building height: 15' at the eave, 25' at the ridge
Building shape: Gable roof with a 20º pitch
Building type: Residential
Building dimensions: 60' (along the ridge) x 30' (perpendicular to the ridge)
Module orientation: Parallel to roof, 5" above roof surface, minimum 3 ft from the roof edge.
PV array area: 100 square foot array (10' x 10')

C&C = PV modules, clips, fasteners that secure PV module, individual members of rack (on "large" rack)

MWFRS = loads on "large racks" and reaction force from rack at roof penetrations

GCpi: up to engineer's discretion; +- 0.1 to +/- 0.3 is reasonable for systems ***with limited restrictions to air flow below module***, but no data available to support this.

Some AHJ's or engineers may require use of +/- 0.55 but it is more likely that many will accept a GCpi as low as 0.

•Results are conservative because they don't account for pressure equalization, which could reduce loads by ~80%; ASCE method does not address this
•Some PV modules rated for max 45-50 psf
•Lack of test standards for dynamic & nonuniform loading

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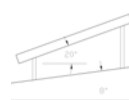
Recommendations for Future Work

- Develop analytical approach for *sloped PV*



- Publish Solar ABC guidelines to broader audience – peer review
- Develop specifications for custom / private *wind tunnel testing* procedures for PV systems
- *Generic wind tunnel testing and updates to ASCE to address loads on roof-mounted PV* is drastically needed :
  - ASCE will over-predict loads for some systems = *increased system cost*
  - ASCE will underpredict loads for some systems = *possible failures*
- How to participate
  - Locate or share applicable wind tunnel data
  - Identify sources of funding for wind tunnel testing - $200 – 500K
  - Email suggestions to barkaszi@fsec.ucf.edu or colleen.obrien@bewengineering.com.

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