Code Update: SEIA Codes & Standards Working Group

September 17, 2015

Joe Cain, P.E.
Principal Civil Engineer

SEIA Codes & Standards Working Group

SEIA Solar Energy Industries Association®
Member

- Your national trade association advocating for removing barriers to rapid deployment
- Industry experts always needed and appreciated
- Get involved!

Thanks to Larry Sherwood and Solar ABCs!

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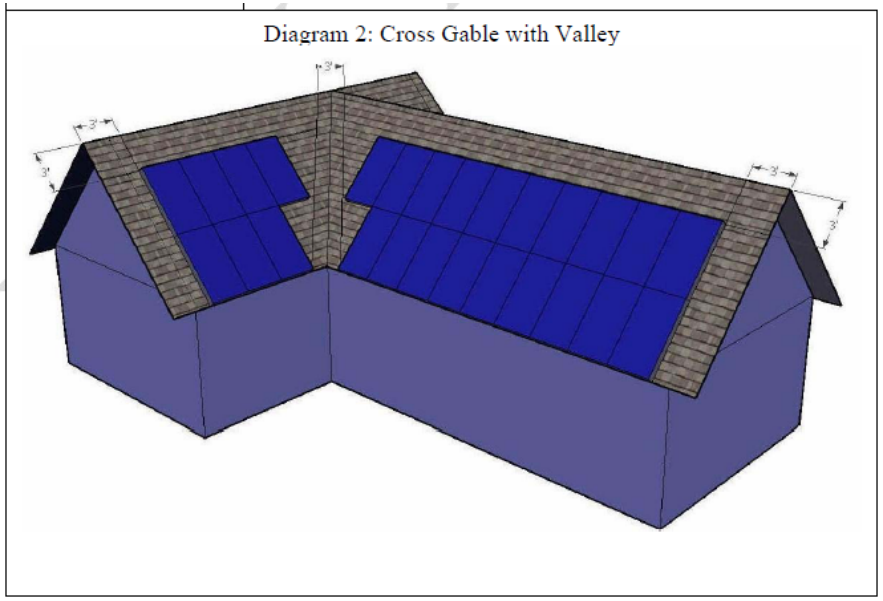
Fire Codes & Standards Update



Underwriters Laboratories

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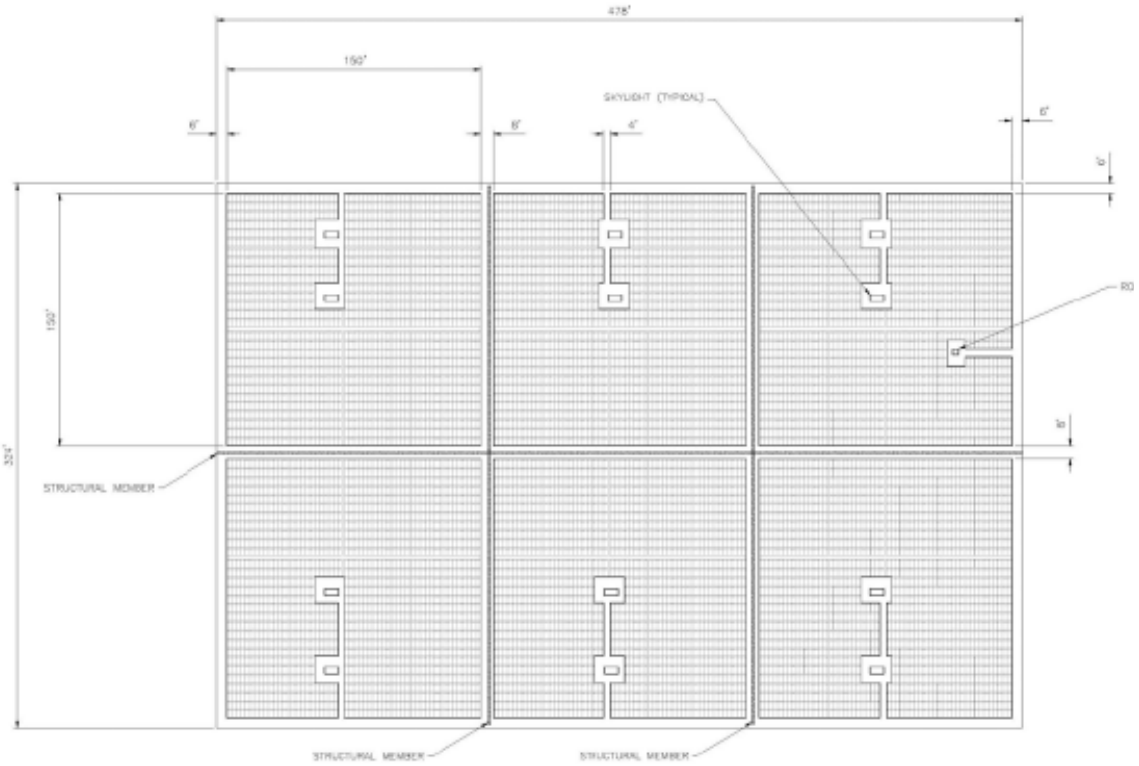
Review: 2015 International Fire Code (IFC)



SOLAR ARRAY EXAMPLE – LARGE COMMERCIAL

8' WALKWAYS

- Centerline Access Pathways
- 150-foot maximum array dimension
- 6-foot or 4-foot clear perimeter at parapets
- 8-foot pathways
- 4-foot clear pathway to sky lights and roof access hatch

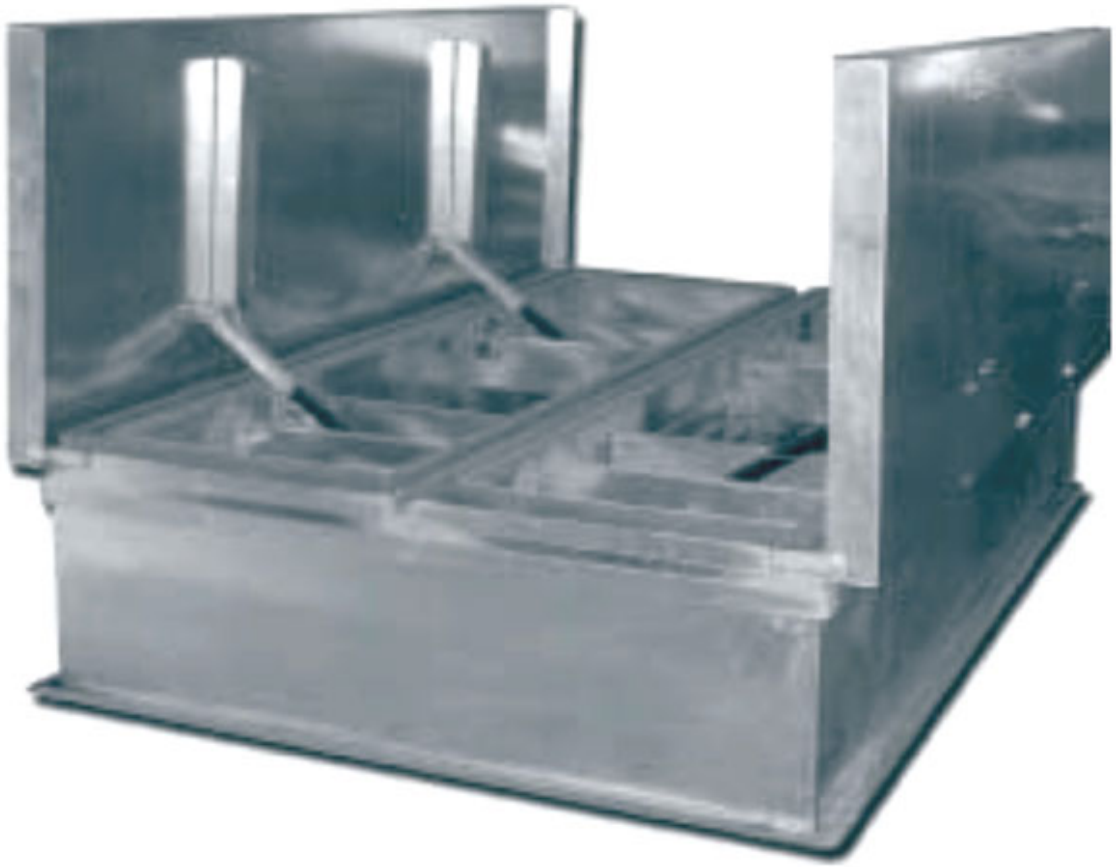
http://osfm.fire.ca.gov/pdf/reports/solarphotovoltaicguideline.pdf

Review: 2015 International Fire Code (IFC)

- Gravity Drop-Out Vent
- Access required on at least one side

Review: 2015 International Fire Code (IFC)

- Automatic Vent (non-gravity-dropout vent)
- Access required on all sides



Review: 2015 International Fire Code (IFC)

- Standard skylights
- Access required at 150 foot intervals only

Proposals for 2018 NFPA 1 Fire Code

- NFPA 1 Fire Code is adopted in 19 states
- 2015 NFPA 1 includes PV provisions similar to 2012 IFC

SEIA proposals for 2018 NFPA 1

- Harmonize with 2015 IFC
  - Broadened exception
  - Access pathways
- "Boulder Colorado compromise"
- Vegetation Management Plan in lieu of noncombustible base or gravel

Non-SEIA proposal

- Signage for rapid shutdown options

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Solar ABCs UL 1703 Industry Solutions

- Solar ABCs convening meetings
- SEIA Codes & Standards Working Group continued engagement
- Goal of reducing required number of tests for common configurations deemed compliant
- Industry Solutions efforts focusing on burning brand tests, owing to minimal funding for experiments

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Noncombustible Roof Coverings

- Current test protocol requires PV system on default base-case asphalt shingle roof decks
- Three distinct cases:
  - Tile on combustible deck
  - Metal roof covering on combustible deck
  - Metal roof covering on noncombustible steel framing
- Task group discussing alternatives
  - “Automatic pass” in some cases, where supported by data
  - SEIA proposal for exception(s) in 2018 IBC (ICC Group B)

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Energy Storage Systems

- Proposals to NFPA 1 and IFC
  - NFPA 1 – Chapter 52
  - IFC – Section 608

- ICC FCAC (Fire Code Action Committee) ESS/ Battery Storage Work Group
  - www.iccsafe.org (Codes & Tech Services)
  - FCAC meeting November 4-5, Chicago

Proposed Fire Code Changes for ESS

Adding requirements for:

- New chemistries/technologies
- Permits and inspection – reference to NEC
- Hazard mitigation analysis
- Locations within buildings
- Structural and seismic protection
- Listing and labeling (UL 9540 or UL 1973)
- Safety signage
- Fire detection and suppression
- Ventilation and thermal runaway protection

ICC Group A Development Update

- SEIA followed approximately 26 solar proposals
- Several proposals for Solar Heating & Cooling
- Guards or Exception for Permanent Roof Anchors:
  - Proposals to change language for requirement for rooftop guards
  - Proposal to remove spacing requirements for permanent roof anchors
  - SEIA submitted “floor modification” to strike out direct reference to guardrail requirement for all rooftop solar installations
  - SEIA submitted floor modification to strike out “permanent”
- Plumbing Vents
  - Proposal by SolarCity to allow plumbing vents cut down to 2 inches above roof surface and protected
  - Proposal approved IRC committee; disapproved by IPC committee
  - Two Public Comments received requesting disapproval
- Final Hearings are in October in Long Beach

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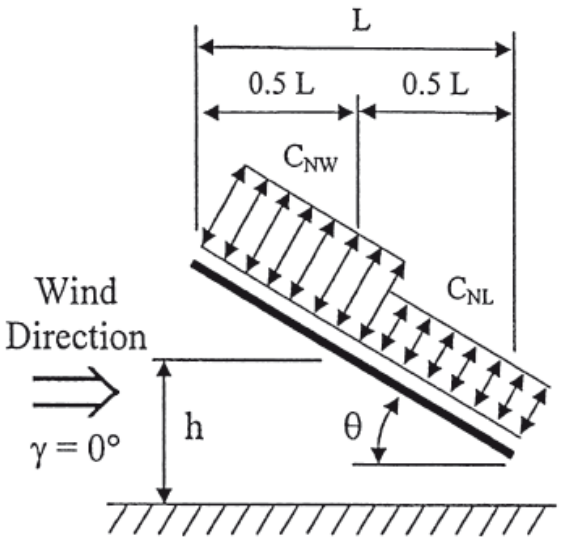
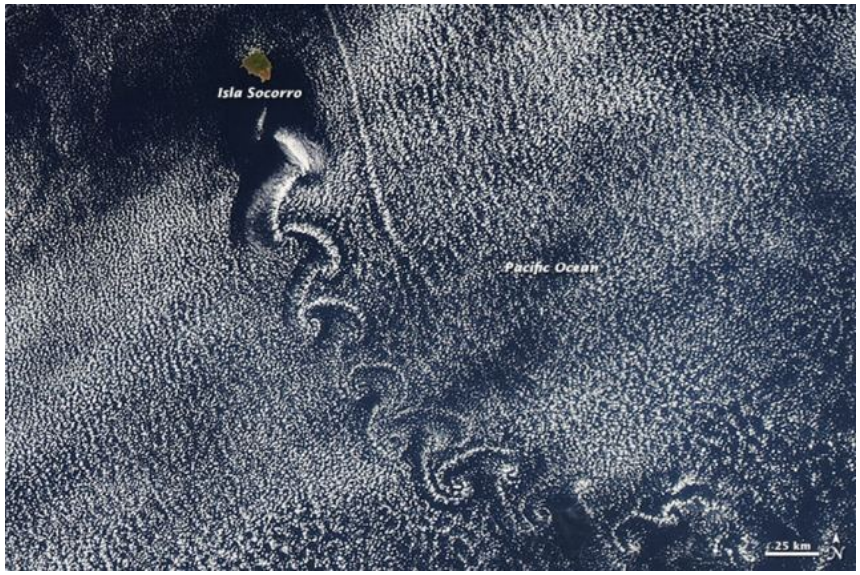
2018 International Building Code
Group A

- ICC BCAC (Building Code Action Committee)
- Proposal G211-015 - “Roadmap” for all the requirements for solar photovoltaic
  - Electrical – NFPA 70
  - Structural loading – IBC Chapter 16
  - Fire classification – IBC Section 1505
  - Access - IFC
  - Certification requirements – UL 1703, UL 1741
  - Manufacturer’s installation instructions

Structural Codes & Standards Update





cpp CERMAK PETERKA PETERSEN

$St = fL/U = 0.15$

1 Hz?

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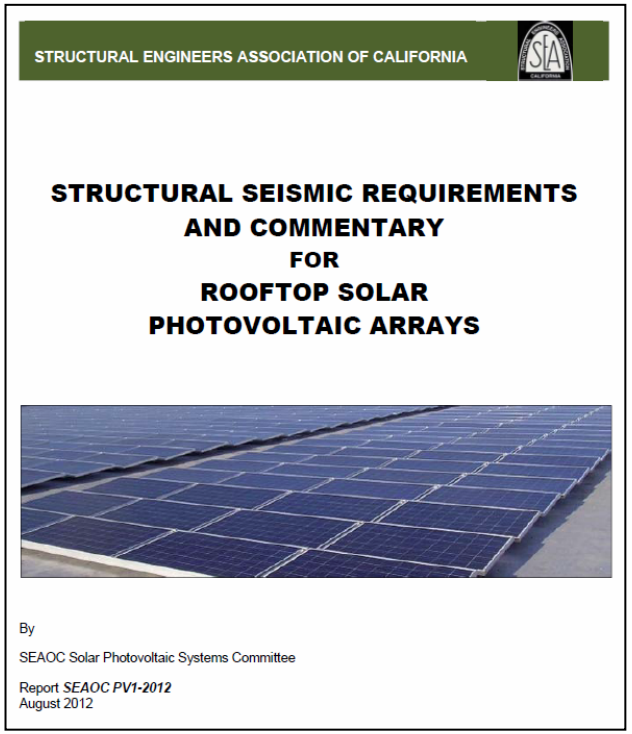
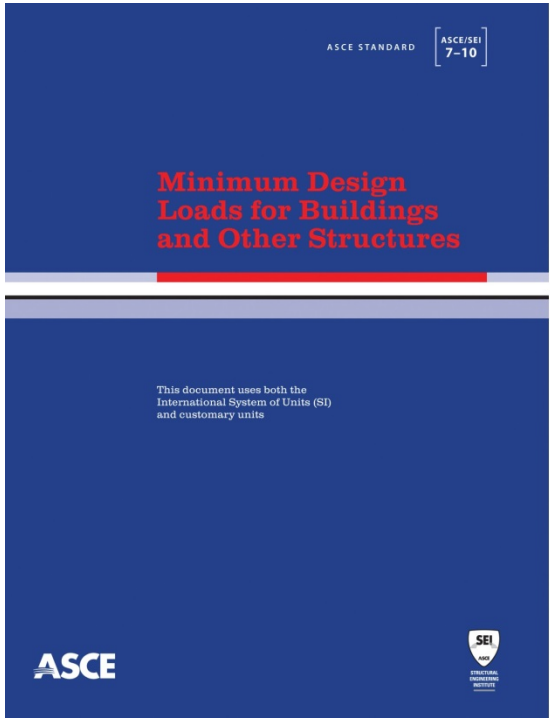
SEAOC Wind paper PV1, August 2012

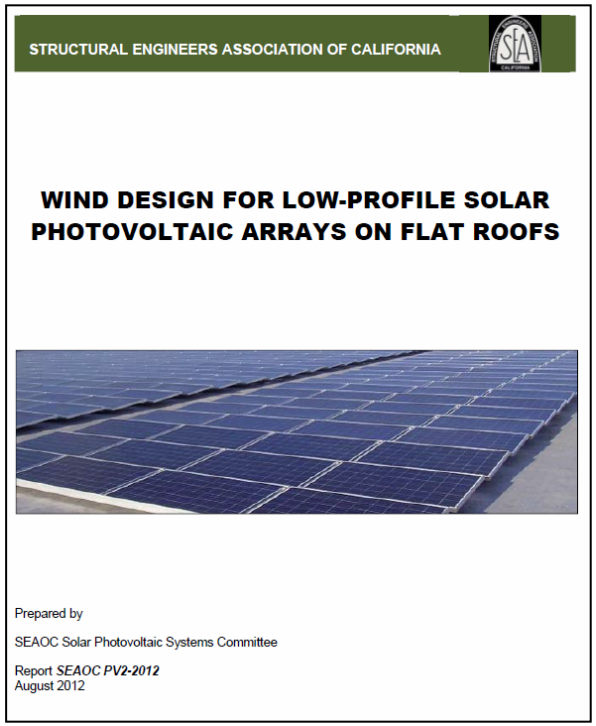


Proposed for ASCE 7-16

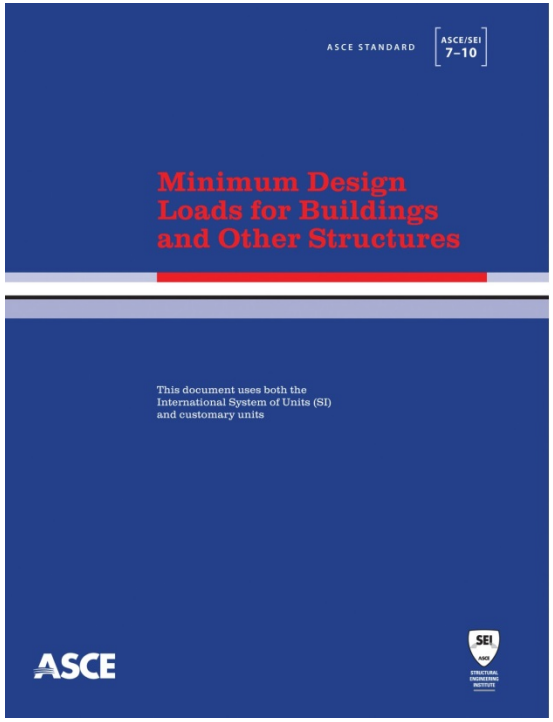


- SEAOC developed seismic method to justify use of ballasted, non-penetrating PV mounting systems.
- Primary research conducted by Joe Maffei, PhD, S.E. of Maffei Structural Engineering and Rob Ward, S.E. of SunLink.
- Based on displacement method of analysis.

SEAOC Wind paper PV2, August 2012

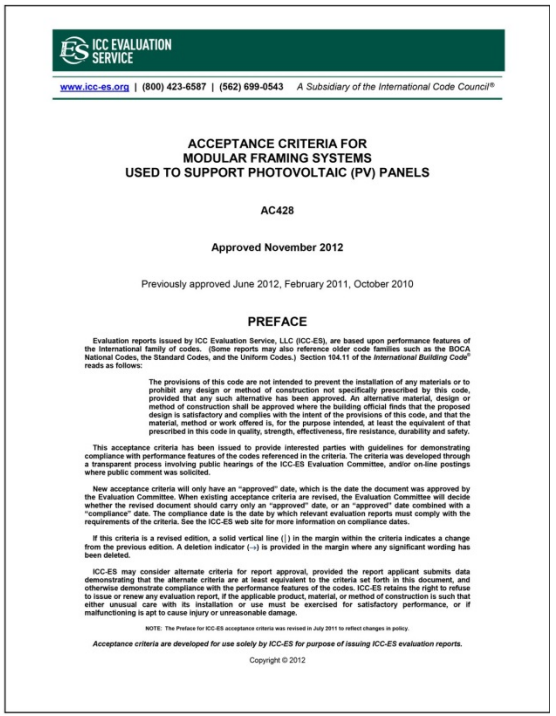


Proposed for ASCE 7-16



- SEAOC developed low-profile wind calculation method based on combined solar-specific wind tunnel data points.
- Wind Tunnel Researchers: David Banks, Gregory Kopp, Timothy Reinhold.
- Includes commentary on Effective Wind Area.

ICC Acceptance Criteria AC 428 Wind Method



ICC EVALUATION SERVICE

www.icc-es.org | (800) 423-6587 | (562) 699-0543 *A Subsidiary of the International Code Council®*

ACCEPTANCE CRITERIA FOR MODULAR FRAMING SYSTEMS USED TO SUPPORT PHOTOVOLTAIC (PV) PANELS

AC428

Approved November 2012

Previously approved June 2012, February 2011, October 2010

PREFACE

Evaluation reports issued by ICC Evaluation Service, LLC (ICC-ES), are based upon performance features of the International family of codes. (Some reports may also reference older code families such as the BOCA National Codes, the Standard Codes, and the Uniform Codes.) Section 104.11 of the *International Building Code®* reads as follows:

> The provisions of this code are not intended to prevent the installation of any materials or to prohibit any design or method of construction not specifically prescribed by this code, provided that any such alternative has been approved. An alternative material, design or method of construction shall be approved where the building official finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, at least the equivalent of that prescribed in this code in quality, strength, effectiveness, fire resistance, durability and safety.

This acceptance criteria has been issued to provide interested parties with guidelines for demonstrating compliance with performance features of the codes referenced in the criteria. The criteria was developed through a transparent process involving public hearings of the ICC-ES Evaluation Committee, and/or on-line postings where public comment was solicited.

New acceptance criteria will only have an "approved" date, which is the date the document was approved by the Evaluation Committee. When existing acceptance criteria are revised, the Evaluation Committee will decide whether the revised document should carry only an "approved" date, or an "approved" date combined with a "compliance" date. The compliance date is the date by which relevant evaluation reports must comply with the requirements of the criteria. See the ICC-ES web site for more information on compliance dates.

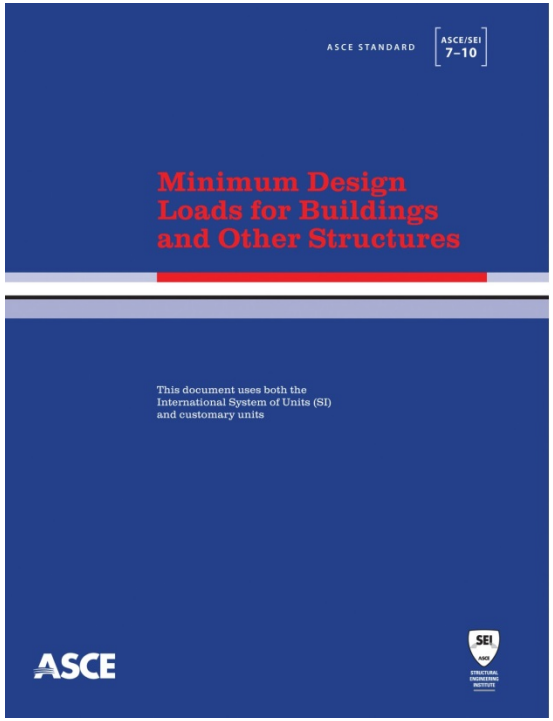
If this criteria is a revised edition, a solid vertical line (|) in the margin within the criteria indicates a change from the previous edition. A deletion indicator (→) is provided in the margin where any significant wording has been deleted.

ICC-ES may consider alternate criteria for report approval, provided the report applicant submits data demonstrating that the alternate criteria are at least equivalent to the criteria set forth in this document, and otherwise demonstrate compliance with the performance features of the codes. ICC-ES retains the right to refuse to issue or renew any evaluation report, if the applicable product, material, or method of construction is such that either unusual care with its installation or use must be exercised for satisfactory performance, or if malfunctioning is apt to cause injury or unreasonable damage.

NOTE: The Preface for ICC-ES acceptance criteria was revised in July 2011 to reflect changes in policy.

Acceptance criteria are developed for use solely by ICC-ES for purpose of issuing ICC-ES evaluation reports.

Proposed for ASCE 7-16



- Wind calculation method specific to "flush mounted" PV systems on sloping "pitched" roofs
- Primary development conducted by Dr. Tim Reinhold of IBHS and Todd Ganshaw, P.E., of Unirac
- Allows internal pressure set equal to zero (within constraints)

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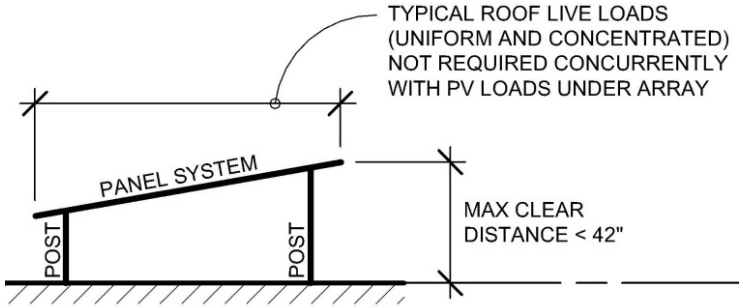
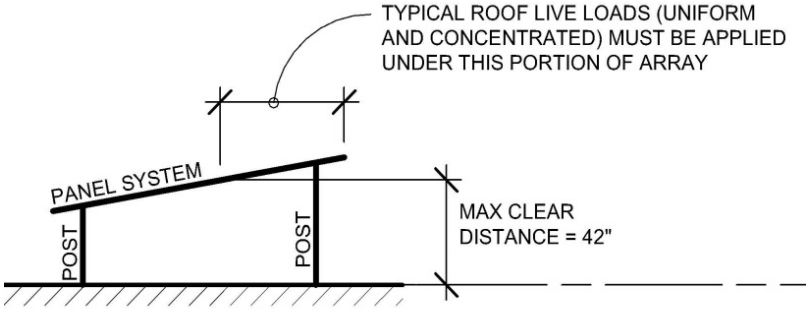
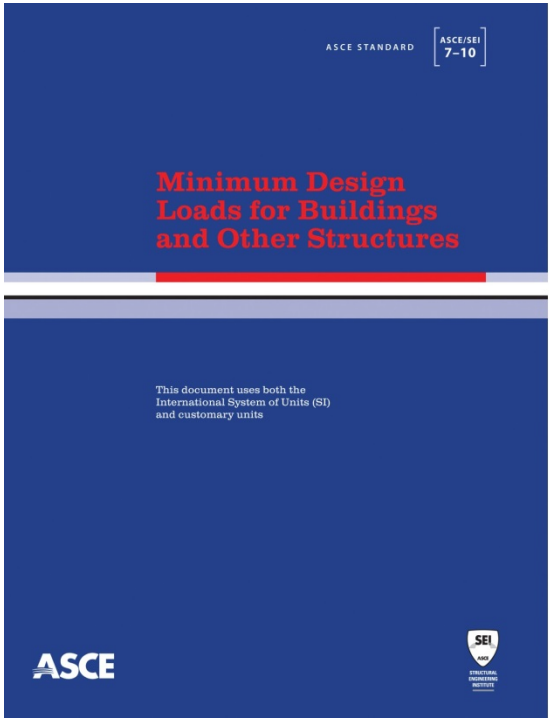
Live Load Offset for Roof Areas Covered by PV



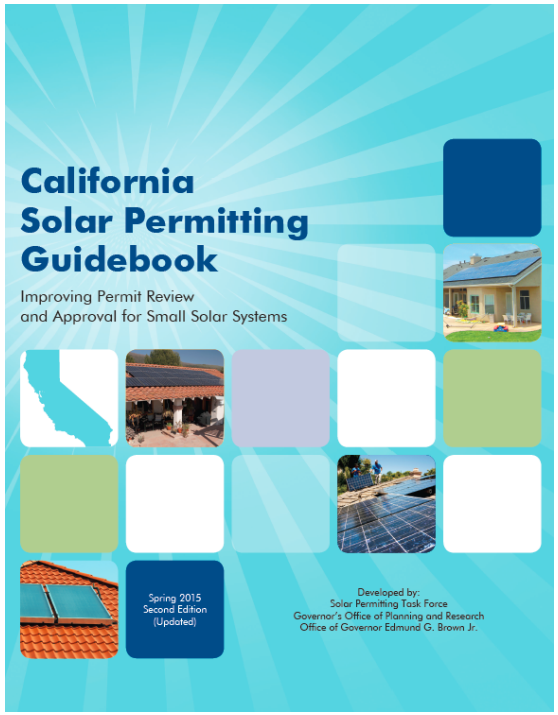


Proposed for ASCE 7-16

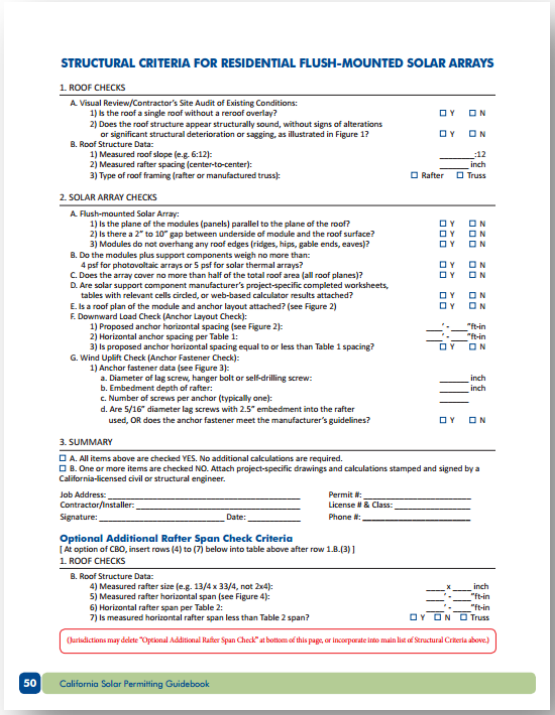


- Many engineers have assumed live load is fully displaced by PV (LL = 0); some are concerned about “storage”
- 2015 IBC & 2013 CBC include 24” threshold
- SEAOC proposed threshold increase to 42” as in diagrams
- ASCE 7 committee maintained 24” threshold

California Solar Permitting Guidebook



CSPG includes Structural Toolkit with Checklist



STRUCTURAL CRITERIA FOR RESIDENTIAL FLUSH-MOUNTED SOLAR ARRAYS

1. ROOF CHECKS

A. Visual Review/Contractor's Site Audit of Existing Conditions:
1) Is the roof a single roof without a reroof overlay? ☐ Y ☐ N
2) Does the roof structure appear structurally sound, without signs of alterations or significant structural deterioration or sagging, as illustrated in Figure 1? ☐ Y ☐ N
B. Roof Structure Data:
1) Measured roof slope (e.g. 6:12): _____:12
2) Measured rafter spacing (center-to-center): _____ inch
3) Type of roof framing (rafter or manufactured truss): ☐ Rafter ☐ Truss

2. SOLAR ARRAY CHECKS

A. Flush-mounted Solar Array:
1) Is the plane of the modules (panels) parallel to the plane of the roof? ☐ Y ☐ N
2) Is there a 2" to 10" gap between underside of module and the roof surface? ☐ Y ☐ N
3) Modules do not overhang any roof edges (ridges, hips, gable ends, eaves)? ☐ Y ☐ N
B. Do the modules plus support components weigh no more than:
4 psf for photovoltaic arrays or 5 psf for solar thermal arrays? ☐ Y ☐ N
C. Does the array cover no more than half of the total roof area (all roof planes)? ☐ Y ☐ N
D. Are solar support component manufacturer's project-specific completed worksheets, tables with relevant cells circled, or web-based calculator results attached? ☐ Y ☐ N
E. Is a roof plan of the module and anchor layout attached? (see Figure 2) ☐ Y ☐ N
F. Downward Load Check (Anchor Layout Check):
1) Proposed anchor horizontal spacing (see Figure 2): ___'-___"ft-in
2) Horizontal anchor spacing per Table 1: ___'-___"ft-in
3) Is proposed anchor horizontal spacing equal to or less than Table 1 spacing? ☐ Y ☐ N
G. Wind Uplift Check (Anchor Fastener Check):
1) Anchor fastener data (see Figure 3):
a. Diameter of lag screw, hanger bolt or self-drilling screw: _____ inch
b. Embedment depth of rafter: _____ inch
c. Number of screws per anchor (typically one): _____
d. Are 5/16" diameter lag screws with 2.5" embedment into the rafter used, OR does the anchor fastener meet the manufacturer's guidelines? ☐ Y ☐ N

3. SUMMARY

☐ A. All items above are checked YES. No additional calculations are required.
☐ B. One or more items are checked NO. Attach project-specific drawings and calculations stamped and signed by a California-licensed civil or structural engineer.

Job Address: _____ Permit #: _____
Contractor/Installer: _____ License # & Class: _____
Signature: _____ Date: _____ Phone #: _____

Optional Additional Rafter Span Check Criteria
[At option of CBO, insert rows (4) to (7) below into table above after row 1.B.(3)]

1. ROOF CHECKS

B. Roof Structure Data:
4) Measured rafter size (e.g. 13/4 x 33/4, not 2x4): ___x___ inch
5) Measured rafter horizontal span (see Figure 4): ___'-___"ft-in
6) Horizontal rafter span per Table 2: ___'-___"ft-in
7) Is measured horizontal rafter span less than Table 2 span? ☐ Y ☐ N ☐ Truss

(Jurisdictions may delete "Optional Additional Rafter Span Check" at bottom of this page, or incorporate into main list of Structural Criteria above.)

50 California Solar Permitting Guidebook

- Solar Permitting Guidebook updated and expanded
- California AB 2188 requires expedited permit process for solar
- Methods prepared by John Wolfe, S.E., of Mar Structural Design
- CSPG includes very detailed Structural Technical Appendix
- Many California building departments adopting structural checklist

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SEIA Structural Proposals for ICC Group B

- SEIA initiated task group under SEAOC PV Systems Committee to consider structural proposals for 2018 IBC
- SEAOC task group will develop proposals and then forward internally to other SEAOC committees, then to NCSEA
- Remove Effective Wind Area from IBC Chapter 15
- Modify seismic section in IBC? Or delete it?
- Simplified AC 428 wind method in IRC?
- Risk Category I (one) for ground mounted PV systems in IBC
- Special Inspection for steel piles (deep foundations) in IBC
- Solar structural provisions in International Existing Building Code (IEBC)

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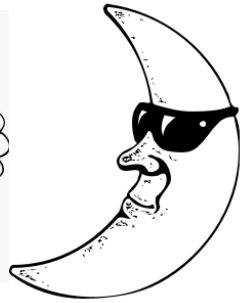
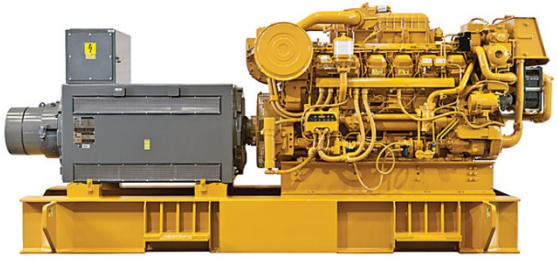
ASCE 7-10 Risk Category (RC) Table 1.5-1

- Risk Category I (one): Buildings and other structures that represent a *low risk to human life* in the event of failure
- ~~RC II: Not I, III, or IV~~
- ~~RC III: Buildings and other structures, the failure of which could pose a *substantial risk to human life*~~
- ~~RC III: Not RC IV, with potential to cause a substantial economic impact and/or mass disruption of day-to-day civilian life in the event of failure (IBC: "power generating stations")~~
- ~~RC IV: Essential facilities~~
- ~~RC IV: Required to maintain functionality of essential facilities~~





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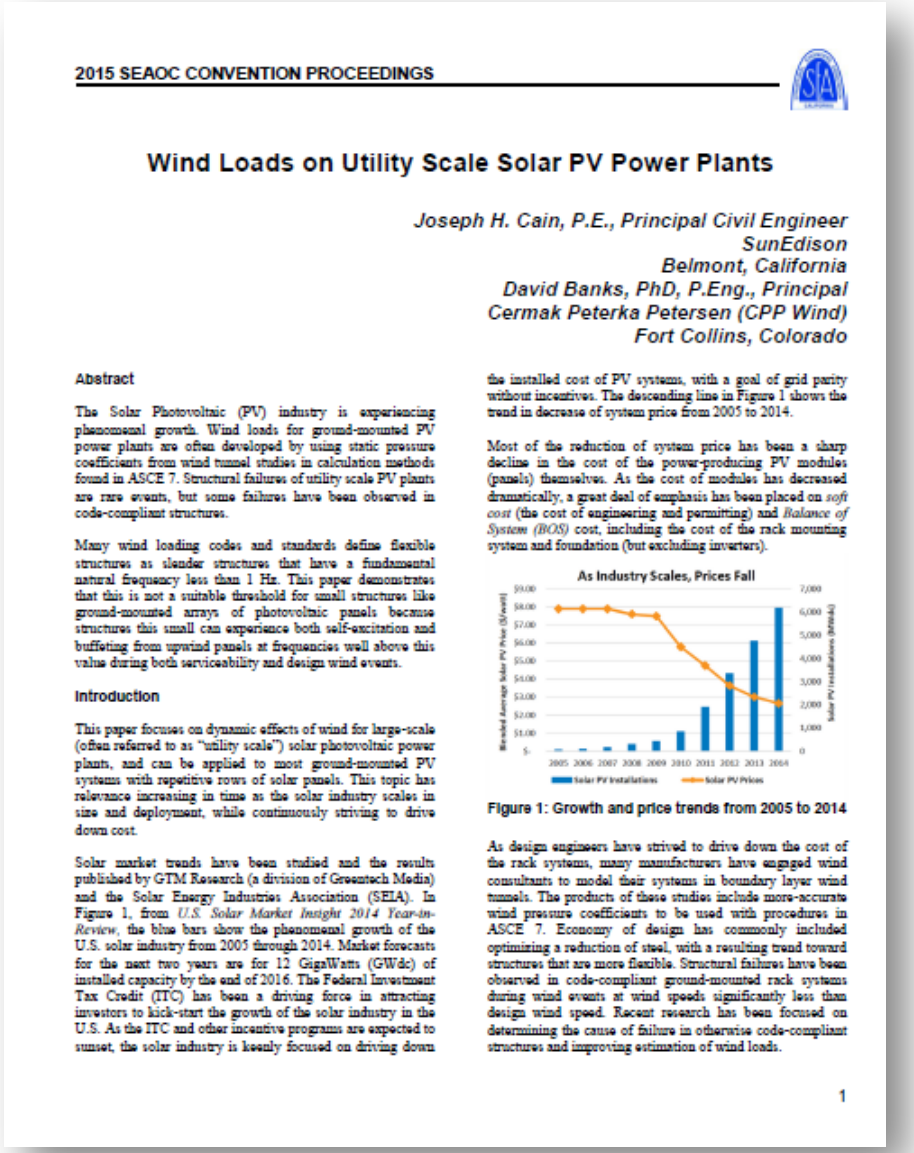
SEAOC Convention: Utility Scale Wind Loads



2015 SEAOC CONVENTION PROCEEDINGS

Wind Loads on Utility Scale Solar PV Power Plants

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SunEdison
Belmont, California
David Banks, PhD, P.Eng., Principal
Cermak Peterka Petersen (CPP Wind)
Fort Collins, Colorado

Abstract

The Solar Photovoltaic (PV) industry is experiencing phenomenal growth. Wind loads for ground-mounted PV power plants are often developed by using static pressure coefficients from wind tunnel studies in calculation methods found in ASCE 7. Structural failures of utility scale PV plants are rare events, but some failures have been observed in code-compliant structures.

Many wind loading codes and standards define flexible structures as slender structures that have a fundamental natural frequency less than 1 Hz. This paper demonstrates that this is not a suitable threshold for small structures like ground-mounted arrays of photovoltaic panels because structures this small can experience both self-excitation and buffeting from upwind panels at frequencies well above this value during both serviceability and design wind events.

Introduction

This paper focuses on dynamic effects of wind for large-scale (often referred to as "utility scale") solar photovoltaic power plants, and can be applied to most ground-mounted PV systems with repetitive rows of solar panels. This topic has relevance increasing in time as the solar industry scales in size and deployment, while continuously striving to drive down cost.

Solar market trends have been studied and the results published by GTM Research (a division of Greentech Media) and the Solar Energy Industries Association (SEIA). In Figure 1, from *U.S. Solar Market Insight 2014 Year-in-Review*, the blue bars show the phenomenal growth of the U.S. solar industry from 2005 through 2014. Market forecasts for the next two years are for 12 GigaWatts (GWdc) of installed capacity by the end of 2016. The Federal Investment Tax Credit (ITC) has been a driving force in attracting investors to kick-start the growth of the solar industry in the U.S. As the ITC and other incentive programs are expected to sunset, the solar industry is keenly focused on driving down the installed cost of PV systems, with a goal of grid parity without incentives. The descending line in Figure 1 shows the trend in decrease of system price from 2005 to 2014.

Most of the reduction of system price has been a sharp decline in the cost of the power-producing PV modules (panels) themselves. As the cost of modules has decreased dramatically, a great deal of emphasis has been placed on *soft cost* (the cost of engineering and permitting) and *Balance of System (BOS)* cost, including the cost of the rack mounting system and foundation (but excluding inverters).

Figure 1: Growth and price trends from 2005 to 2014

As design engineers have strived to drive down the cost of the rack systems, many manufacturers have engaged wind consultants to model their systems in boundary layer wind tunnels. The products of these studies include more-accurate wind pressure coefficients to be used with procedures in ASCE 7. Economy of design has commonly included optimizing a reduction of steel, with a resulting trend toward structures that are more flexible. Structural failures have been observed in code-compliant ground-mounted rack systems during wind events at wind speeds significantly less than design wind speed. Recent research has been focused on determining the cause of failure in otherwise code-compliant structures and improving estimation of wind loads.

1

- Joseph H. Cain, P.E. and Dr. David Banks, P.Eng.
- Structure failures have occurred in code-compliant PV systems
- Paper focuses on dynamic effects of wind, especially Von Karman Vortex Shedding
- 1 Hz threshold is not applicable to ground mounted PV systems

2018 International Building Code
Group B – ICC BCAC Proposals

- Section 1507.18 – add BIPV tile roofing
- Section 1510.7 – replace with reference to Section 3111
- Section 1512 – delete (already addressed by Section 3111)
- Chapter 16 – new requirements for structural loading
- Section 1503.2 – consider flashing alternatives

2018 International Residential Code
Group B – ICC BCAC Proposals

- Section R324
  - Add prescriptive structural from California Solar Permitting Guidebook (alternative method)
  - Consider other prescriptive requirements from California and Oregon
- Section R905.16 – Add BIPV tile roofing
- Section R902.4 – Add UL 2703 (for fire classification)
- Section R903.2 – Consider flashing alternatives

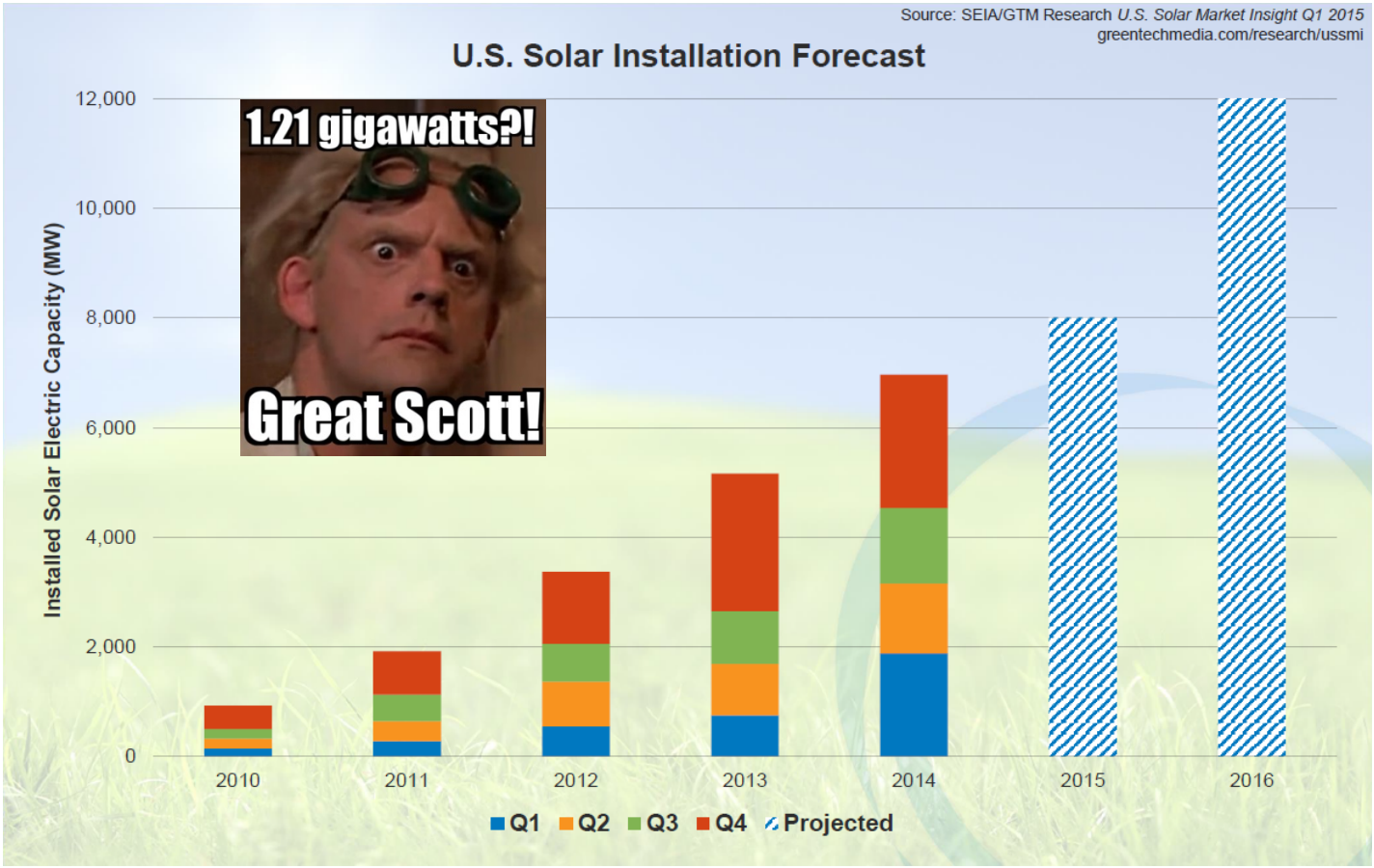
ICC Code Development Process
www.iccsafe.org/codes

- Group A Public Comment Hearing – Long Beach, CA, 9/30 – 10/5/15
- ICC BCAC and FCAC meetings – Chicago, 11/3-4/15
- Group B proposals – due January 11, 2016
- Group B Code Action Hearing – Louisville, KY, April 17-27, 2016
- Group B public comments – due July 22, 2016
- Group B Public Comment Hearing – Kansas City, MO, October 19-25, 2016

- Note – Code Action Hearings and Public Comment Hearings are webcast. Check for BCAC and FCAC working groups meetings

Projected Solar PV Industry Growth

- Federal Investment Tax Credit (ITC) expected to sunset
- Installed PV capacity in U.S. projected to be 12 GW by 2016



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What is the Problem? What have we learned?

- Industry efforts to reduce cost have resulted in reduced steel sections and rack systems that are more flexible
- Although structural failures are rare, failures have been observed in code-compliant solar PV structures
- Failures have occurred at wind speeds much less than design wind speed
- Common cause is dynamic resonance of PV system owing to frequency matching of natural frequency with vortex shedding frequency
- Vortex shedding frequency (Strouhal Number, aka “reduced frequency”) can be calculated
- Natural frequencies can be determined by computer modeling; frequency and damping ratio determined by testing
- Avoid frequency matching to avoid dynamic amplification

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Questions?

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