

Update to the 2014 *NEC*[®] Changes for PV

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INTRODUCTION

- The 2014 *National Electrical Code*®
 - A VERY BUSY CODE CYCLE – LOADED WITH CHANGES!
- This Cycle’s “Change Process” was VERY complex
- Today’s presentation focus’s on New and Changed PV installation requirements
- The most significant changes were centered on SEIA/Solar ABCs supported changes
- A few less significant changes are listed
- Impacts of some of the changes (economics, reliability, hardware) are briefly discussed

The Busy 2014 *NEC*[®] Cycle

- The *NEC*[®] is revised every three years.
- Proposals come from **VARIED AND MANY** sources.
- 2014 Article 690 and 705 proposals came primarily from:
 - Solar Energy Industries Association.
 - PV Industry Forum with Solar ABCs
 - Standards Groups (NRTLs, IEEE, Firefighters, Task Groups, AHJ Orgs, Manufacturers, Systems Providers.)
- Process involves “Proposal” submittals and “Public Comments”





THANK YOU

ACKNOWLEDGEMENTS



THANK YOU

- **SEIA (John Smirnow) Sponsors WB and BB**
- **Bill Brooks – Brooks Solar and my alternate**
- **John Wiles – SWTDI and Secy. Industry Forum**
- **Larry Sherwood – Solar ABCs**
- **Tim Zgonena – UL workshop host/member CMP4**
- **Ronnie Toomer – Chair CMP4**
- **PV Industry – Manufacturers, systems designers/
installers, AHJs, utilities, (and more)**
- **CMP4 members and NFPA staff etc.**

The 2014 *NEC*[®] By the Numbers

- 223 Proposals for 690 & 705
 - Several major proposals to reorganize 690
 - Included Fire (first responder) NFPA Task Group
 - Resulted in 10 Panel proposals from panel-appointed task groups
- The ROP contained some very contentious language and removed the battery section
 - Resulted in SEIA and Solar ABCs weekly conference calls and a workshop that further appointed 14 industry task groups to provide public comments. (PV industry responded!)
 - SEIA prioritized 5 topics that were submitted by SEIA along with the industry forum and others
- 88 Public Comments were submitted
- Multiple TCC Comments were submitted to clarify reorganization and panel proposals



Faults, Arcs, Fire Were Major Topics. Reorg was a major confusion factor

NEC PV Related Definitions

Green: Underline is New or Change, Red ~~Cross-out~~ is Deleted, Black is Current Code, Blue indicates a move

AC Module	Panel
Array	Photovoltaic <u>PV</u> Output Circuit
Bipolar PV Array	Photovoltaic <u>PV</u> Power Source
Blocking Diode (Def. only)	Photovoltaic <u>PV</u> Source Circuit
Building Integrated <u>PV</u>	Photovoltaic <u>PV</u> System Voltage
Charge Controller-(Diversion)	Solar Cell
<u>Hybrid System(Moved)</u>	Solar <u>Photovoltaic System</u>
Interactive System	Stand-alone System
Inverter	Electrical Prod. and Dist. Net
Inverter Input Circuit	<u>Direct Current (DC) Combiner</u>
Inverter Output Circuit	<u>DC-DC Converter</u>
Module	<u>Multimode Inverter</u>
Monopole Subarray	

The Parts of Article 690

Green indicates Significant 2014 Changes

- Part I (1-6) General (**Definitions**)- Reorg – (New)
- Part II (7-12) Circuit Requirements (**Reorg/New 1000V**)
- Part III (13-18) Disconnecting Means (**Major Reorg**)
- Part IV (31-35) Wiring Methods (**Major Reorg, and New**)
- Part V (41-50) Grounding (**Some New, Some Revised**)
- Part VI (51-56) Marking (**Some New**)
- Part VII (57-64) Connection to Other Sources
- Part VIII (71-74) Storage Batteries (**Reinstated with changes after attempted move to 480 was dropped**)
- Part IX (80-85) Systems Over 600 Volts (Note the **Proposals for EV Charging Rejected**)

690.4 ~~Installation~~ General Requirements- (Major Reorg)

2011 NEC

- A. Photovoltaic Systems
- B. Identification and Grouping
 - 1) PV Source Circuits (Moved)
 - 2) PV Output & Inverter Circuits
 - 3) Conductors of Multiple Systems
 - 4) Grouping
- C. Module Connect Arrangement
- D. Equipment
- E. Wiring and Connections
- F. Circuit Routing
- G. Bipolar Systems
- H. Multiple Inverters

2014 NEC

- A. Photovoltaic Systems
- B. Equipment
- C. Qualified Personnel
- D. Multiple Inverters

Exception. A directory shall not be required where all inverters and PV dc disconnecting means are grouped at the main service disconnecting means.

Most of what is missing went to 690.31 (Wiring Methods)

690.5(A) Ground-Fault Detection and Interruption.

Grounded dc photovoltaic arrays shall be provided with dc ground-fault protection meeting the requirements of 690.5(A) through (C) to reduce fire hazards. Ungrounded dc photovoltaic arrays shall comply with 690.35.

The ground-fault protection device or system shall:

~~(1) Determine the PV input circuit has isolation prior to export of current,~~ **(Many Variables in USA Systems)**

- (1) Be capable of detecting a ground-fault in the PV array “dc current carrying conductors” and components including any intentionally grounded conductors**
- (2) Interrupt the flow of fault current,**
- (3) Provide an indication of the fault, and**
- (4) Be listed for providing PV ground fault protection.**

690.7(C): PV Source and Output

- In one and two-family dwellings, PV source circuits and PV output circuits that do not include lampholders, fixtures, or receptacles shall be permitted to have a maximum PV system voltage up to 600 volts. Other installations with a maximum PV system voltage over ~~600~~ 1000 volts shall comply with Article 690, Part IX.

This is in response to NFPA High Voltage Task Group work to change the “Voltage Threshold Level” throughout the NEC from 600V to 1000V.

690.11. Arc-Fault Circuit Protection

(Direct Current) Photovoltaic systems with dc source circuits, dc output circuits, or both, ~~on or penetrating a building~~ operating at a PV system maximum system voltage of 80 volts or greater, shall be protected by a listed (dc) arc-fault circuit interrupter, PV type, or other system components listed to provide equivalent protection. The PV arc-fault protection means shall comply with the following requirements:

- (1) The system shall detect and interrupt arcing faults resulting from a failure in the intended continuity of a conductor, connection, module, or other system component in dc PV source and output circuits.
- (2) The system shall require that the disabled or disconnected equipment be manually restarted.
- (3) The system shall have an annunciator that provides a visual indication that the circuit interrupter has operated. This indication shall not reset automatically.

First Solar Agua Caliente 290MW



How does arc-fault protection requirements fit a 3miX4mi PV array

690.12 Rapid Shutdown of PV Systems on Buildings.

PV system circuits installed on or in buildings shall include a rapid shutdown function that controls specific conductors in accordance with 690.12(A) through (D).

(A) Requirements for controlled conductors apply only to PV system conductors of more than 1.5 meters (5 feet) in length inside a building, or more than 3 meters (10 feet) from a PV array.

(B) Controlled conductors shall be limited to no more than 30 volts and 240VA within 10 seconds of rapid shutdown initiation. Voltage and power shall be measured between any two conductors and between any conductor and ground.

(C) The rapid shutdown initiation methods shall be labeled in accordance with 690.56(B).

(D) Equipment that performs the rapid shutdown shall be listed and identified.

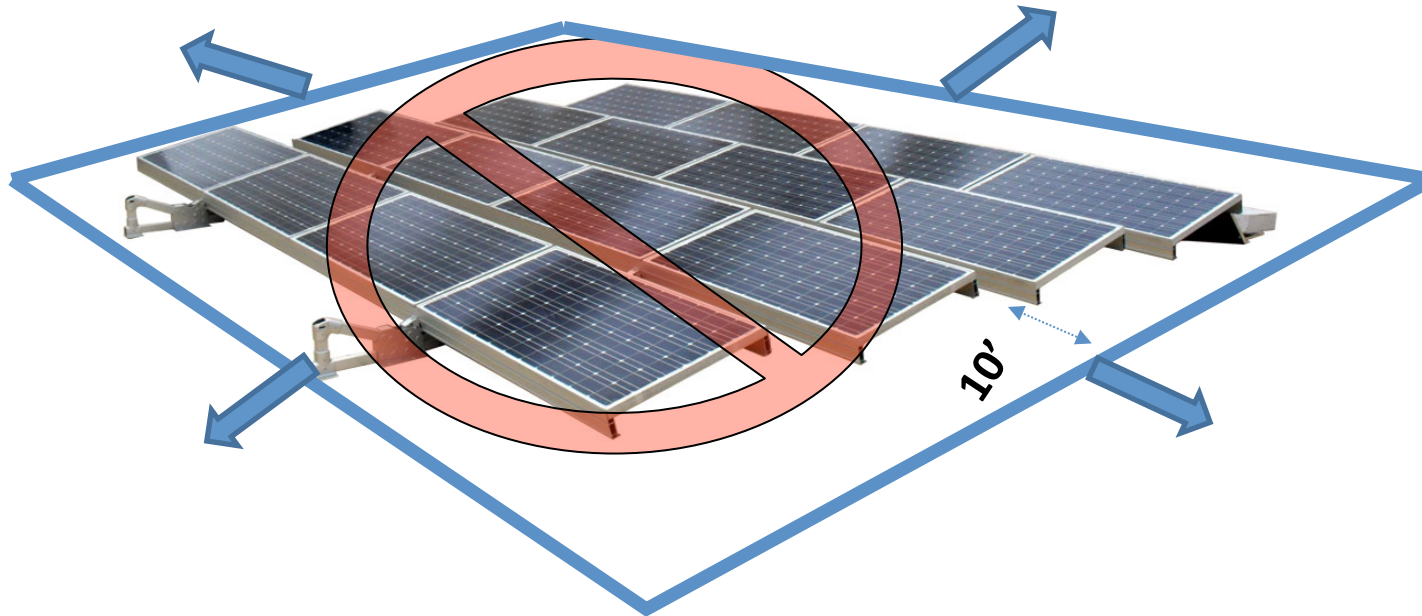
690.12 Does Not Reduce Array Voltage for Firefighters



Challenge for the Future: Make Module Level Disconnect Hardware Reliable and Economical for Future Installations

690.12 Rapid Shutdown of PV Systems on Buildings.

The area within the 10' boundary of the array is not reduced voltage



“Conductors more than 5 feet in length inside a building, or more than 10 feet) from a PV array are covered by 690.12”

690.35(C) Ground Fault Protection in Ungrounded PV Systems

All photovoltaic source and output circuits shall be provided with a ground-fault protection device or system that complies with (1) through (4):

~~(1) Determine the PV input circuit has isolation prior to export of current~~

(1) Detects ground fault(s) in the PV array dc current carrying conductors and components

(2) Indicates that a ground fault has occurred

(3) Automatically disconnects all conductors or causes the inverter or charge controller connected to the faulted circuit to automatically cease supplying power to output

(4) Be listed for providing PV ground fault protection

690.41. System Grounding

~~690.41. For a photovoltaic power source, systems shall comply with 690.35, or one conductor of a 2-wire system with a photovoltaic system voltage over 50 volts, but not greater than 300 volts, and the reference (center tap) conductor of a bipolar system shall be solidly grounded or shall use other methods that accomplish equivalent system protection in accordance with 250.4(A) and that utilize equipment listed and identified for the use.~~

690.41. System Grounding. Photovoltaic systems shall comply with one of the following:

(1) Ungrounded systems shall comply with 690.35

(2) Grounded 2-wire systems shall have one conductor grounded or be impedance grounded, and the system shall comply with 690.5

(3). Grounded bipolar systems shall have the reference (center tap) conductor grounded or be impedance grounded, and the system shall comply with 690.5

(4) Use other methods that accomplish equivalent system protection in accordance with 250.4 (A) with equipment listed and identified for the use.

More (but not all) Significant 2014 *NEC*[®] Changes

- Other “Significant Changes” Include:
 - 690.13 (Disconnects) and 690.15 (Disconnects of PV Equipment). Total Reorganization with the elimination of 690.14 (Additional Provisions)
 - 690.17 (Switches and Circuit Breakers)
 - 690.31 (Wiring Methods etc.)
 - 690.47 (Grounding) (Auxiliary Electrodes)
 - Chapter VIII (Battery Systems) Reinstated
 - 705.12 (Bus/Conductor Ampere Ratings)

Summary (2014 NEC)

- The PV industry provided excellent input to maintain economically & safe PV installation requirements
- There were many changes and technology improvements with needed advanced functionalities for PV systems are coming. (VAR support, voltage regulation, ride through, frequency support, microgrid, smart grid)
- Module level safety measures didn't make it in 2014 (but Technology CHANGE will likely lead to new applications with high reliability)
- Industry Participation was high and continues to be **HIGHLY ENCOURAGED**
- The 2014 NEC cycle provided several critical positive clarifications and advances for the PV industry.

Thank You!

- The Changes in the 2014 NEC related to PV systems and DG interconnects are just a start!
- “Smart Grid” interconnections are coming
- Demand response is here
- Micro-grids are here
- Hybrid systems DGs are ??
- Challenges and Opportunities Exist!