2017 NEC Changes for Renewable Energy Systems – Session one

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The 2017 NEC Changes for Renewable Energy (RE) Systems represent a major overhaul of the NEC with regard to solar and other RE systems.

This two part seminar will cover the changes and provide background for why the changes were made and their effects on solar installations.

Your participation is invited throughout the seminar… questions during the presentation are welcome and there will be a brief Q&A period at the end of each session…

Welcome to the new NEC for RE Systems!

nec CHANGES

Within the whole of the NEC
5 New Articles

- Article 425- Fixed Resistance and Electrode Industrial Process Heating Equipment
- Article 691 – Large Scale PV Electric Supply Stations.
- Article 706 – Energy Storage Systems (ESS)
- Article 710 – Stand Alone Systems
- Article 712 Direct Current Microgrids

Article 691

- This article covers the the installation of large scale PV electric supply stations operated for the sole purpose of providing electric supply to a system operated by a regulated utility for the transfer of electric energy with a generating capacity of no less than 5,000kw (generating stations, substations, associated generator, storage battery, transformers, and switchgear areas)

Article 706- ESS

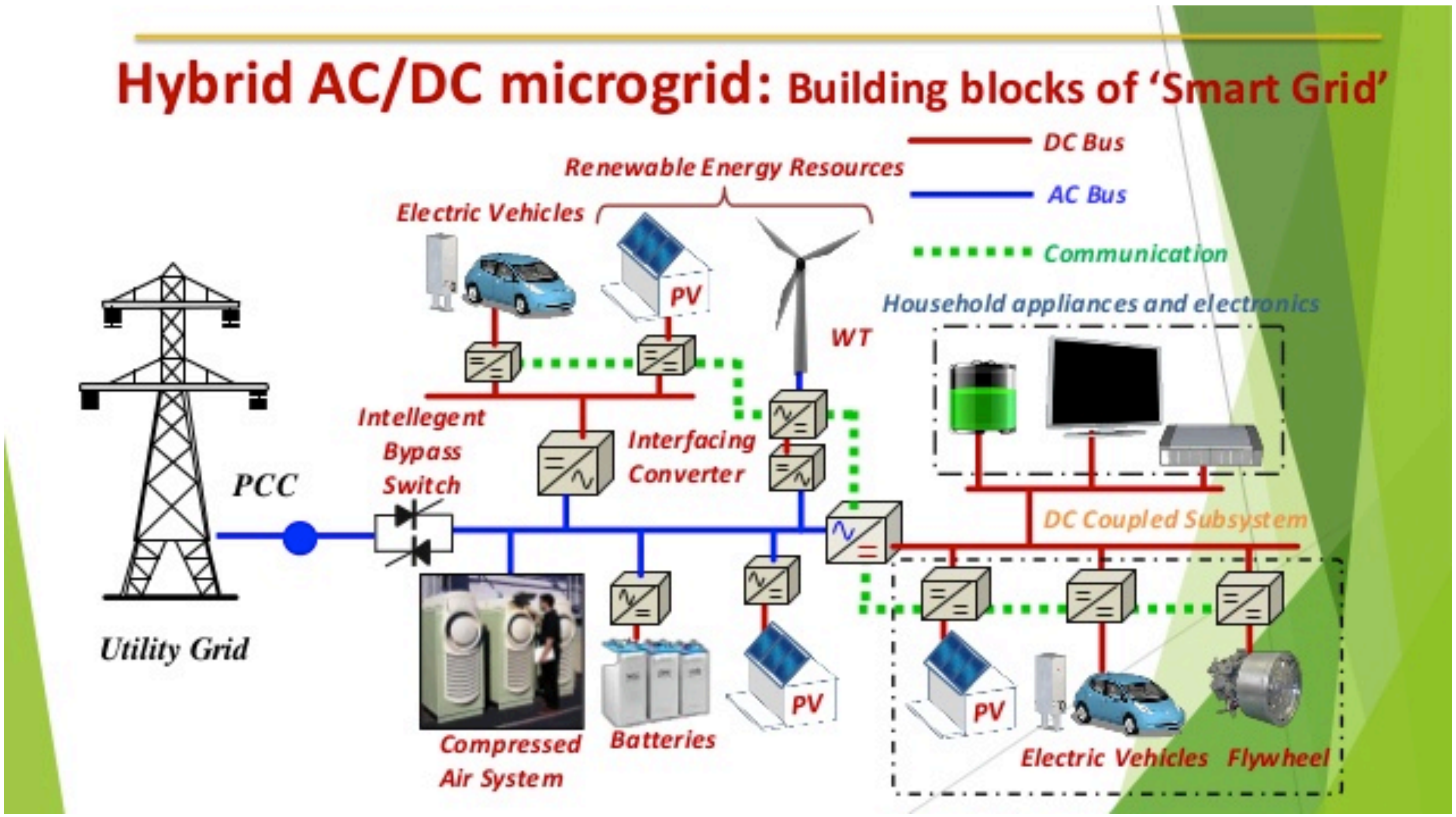
- This article applies to all permanently installed energy storage systems (ESS) operating at over 50 volts ac or 60 volts dc that maybe stand-alone or interactive with other electric power production sources.

Article 710- Stand Alone Systems

- This article covers electric power production sources operating in standalone mode.


Article 712 – DC Microgrids

• This article applies to direct current microgrids, which is a power distribution system consisting of more than one interconnected dc power sources, supplying dc/dc converter(s), dc load(s), and/or ac load(s) powered by dc-ac inverter



2017 NEC Article 690

- Whole article was reduced from 11,000 words to about 8,000 words.
- Rapid shutdown increased from 133 words to over 1100 words.
- Dc loads, stand-alone systems (ac loads), and battery storage systems have historically been considered part of Article 690.

- With the advent of a whole new articles on energy storage systems [Article 706], stand-alone systems [Article 710], microgrids [new Part IV of Article 705], and dc microgrids [Article 712]all these sections were removed from 690.

SECTION 2017 NEC CHANGE

- 690.1 Scope Remove Large-Scale PV systems from 690
- 690.1 Figures Revised figures to clarify the end point of a PV system
- 690.2 New and revised definitions
- DC-to DC Circuits, PV System DC Circuit, Generating Capacity,
- Inverter Input/Output Circuit, Functional Grounded PV System

690.2 -Inverter Input/Output Circuit,
Functional Grounded PV System

- Functional Grounded PV System.
- A PV system that has an electrical reference to ground that is not solidly grounded.
- Informational Note: The reference A functional grounded PV system is often connected to ground is often through a fuse, circuit breaker, resistance device, non-isolated grounded ac circuit, or electronic means that is part of a listed ground-fault protection system. Conductors in these systems that are normally at ground potential may have voltage to ground during fault conditions.

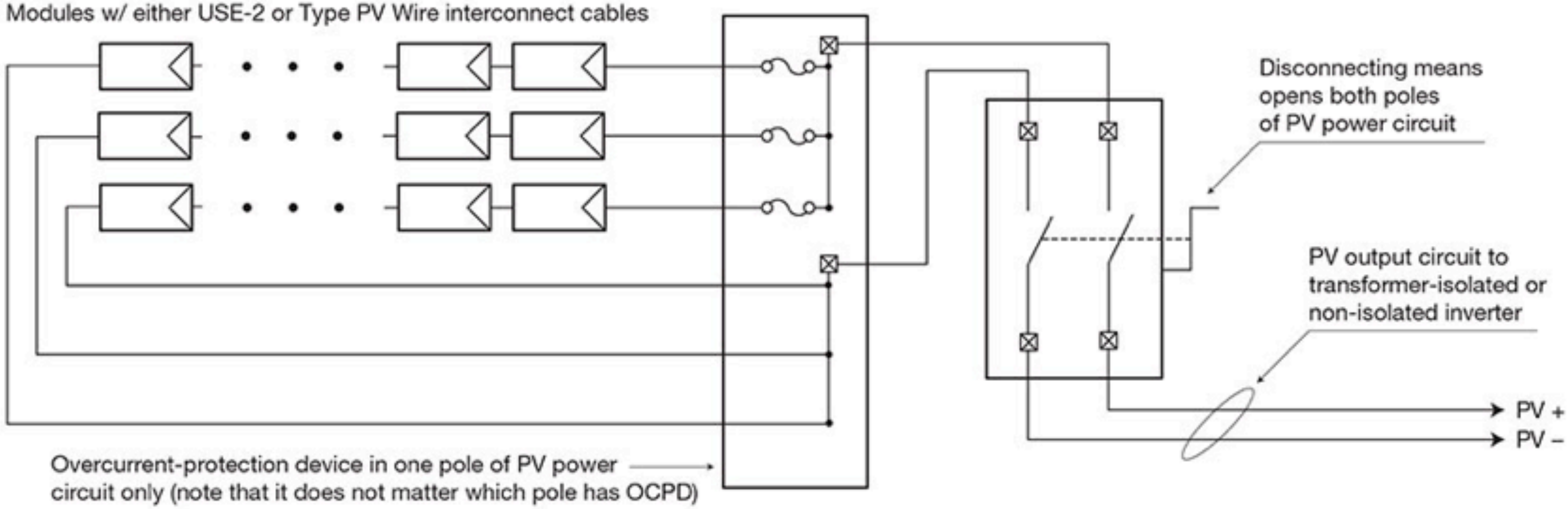
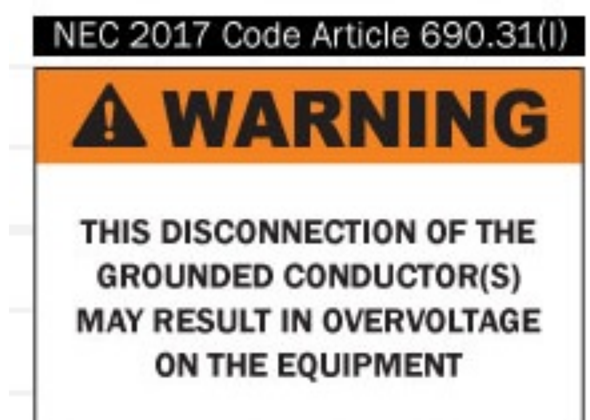


Figure 3 The line drawing illustrates the new design standards for functional grounded PV systems. *NEC 2017* allows for both USE-2 and PV Wire single-conductor cable, regardless of inverter topology. It requires that disconnecting means open both poles of the array, even though overcurrent protection is required in one side only.



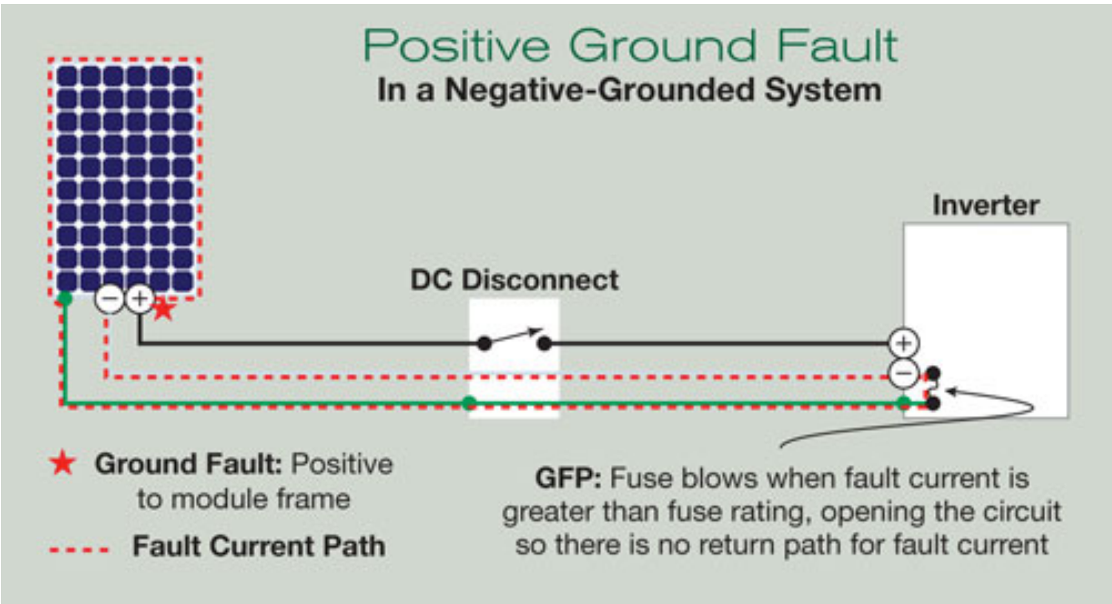
Design Changes Related to Functional
Grounded PV System Definition

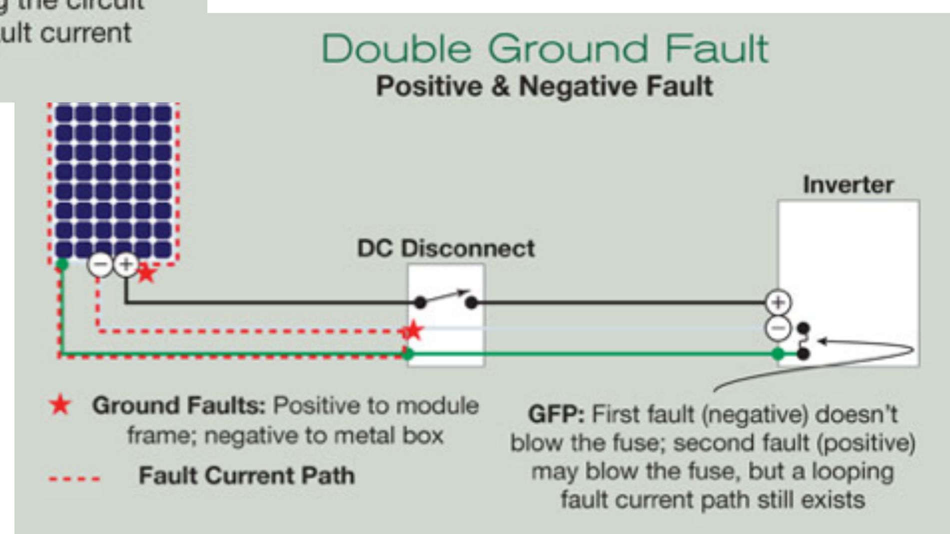
• The requirements for the dc side of a PV system have been unified. Functionally grounded or ungrounded systems have same requirements.
• • 1) only one overcurrent device required per circuit (previously only allowed on grounded systems) [690.9(C)];
• 2) disconnecting means in both dc legs to disconnect equipment or a dc PV system (previous requirement for ungrounded PV systems) [690.15];
• 3) single-conductor cable in PV array can be either USE-2 or PV Wire (previously PV Wire required on modules and home runs for ungrounded PV systems)[690.31(C)(1)];
• 4) ground-fault detection details covered by listed
• equipment (much of detail removed from NEC) [690.41(B)].

SECTION 2017 NEC CHANGE

• 690.4(D)- Clarify that multiple PV systems are allowed on a single building, not just multiple inverters.

- 690.5 and 690.35(C) Moved to 690.41(B) to consolidate grounding and ground fault protection issues.





- 690.7 Maximum Voltage- Reorganized and added voltage calculation method for larger PV systems. Section 690.7(A) allows for a simulation to be performed to calculate the maximum PV source and output circuit voltage.

When an engineer uses a simulation for current, the calculated value may not be less than 70% of the value as determined by the traditional approach (1.25 x Isc).

The benefit of simulating voltage and current is that it enables much more accurate calculations. Array ampacity, for example, is based on continuous load, defined in Article 100 as “the maximum current expected to continue for 3 hours or more.” Computer modeling can accurately simulate this maximum 3-hour current value for a specific PV array based on its location and orientation. By comparison, the traditional method of calculating PV circuit currents significantly oversizes conductors, especially given recent improvements in short-circuit protection. The new calculation method will reduce conductor and conduit costs, which make up an increasing percentage of the overall costs in large PV systems.

SECTION 2017 NEC CHANGE

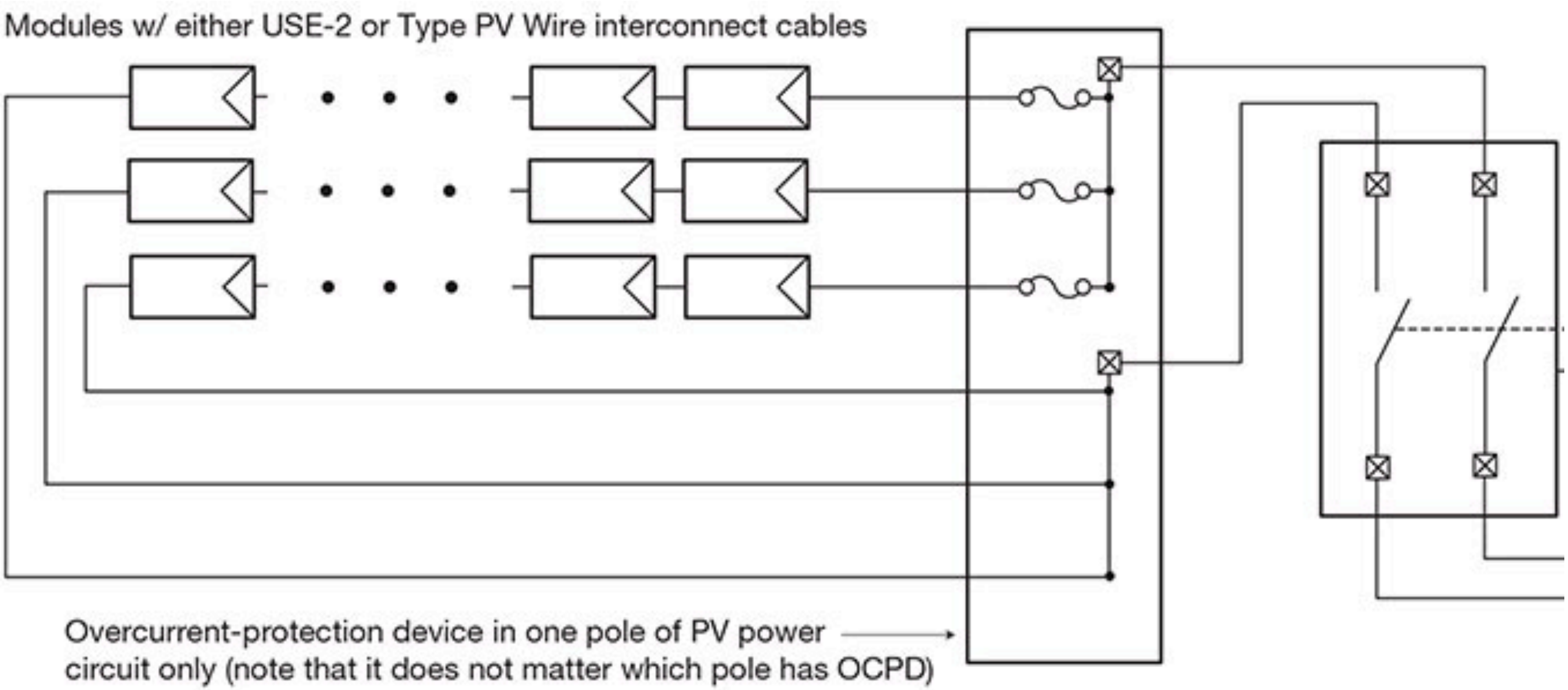
- 690.8 Circuit Sizing and Current
- Revised to cover dc-to-dc converter circuits and allowed for additional calculation of PV circuit currents.
- Section 690.8(A) allows a simulation to be performed to calculate the maximum source and output circuit current
- [690.8(A)(1)(b)]. The calculated current is not permitted to be less than 70% of standard old-school calculation of 1.25 x Isc [690.8(A)(1)(a)].

690.8(b) Conductor Ampacity

- Larger of 125% of current calculated in 690.8(A) before adjustment or correction or current determined in 690.8(A) after adjustment and correction Where protected by a listed adjustable electronic overcurrent protective device as per 690.9(B)(3), not less than the current in 690.8(B)(3)
- (3) The rating or setting of the adjustable electronic overcurrent protective device installed in accordance with 240.6

SECTION 2017 NEC CHANGE

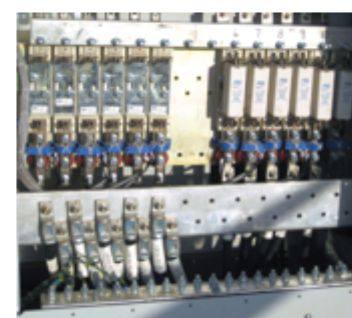
• 690.9 Overcurrent Protection Revised to cover all PV systems, including ungrounded systems. Only requires one overcurrent device per circuit.



690.9 (B)

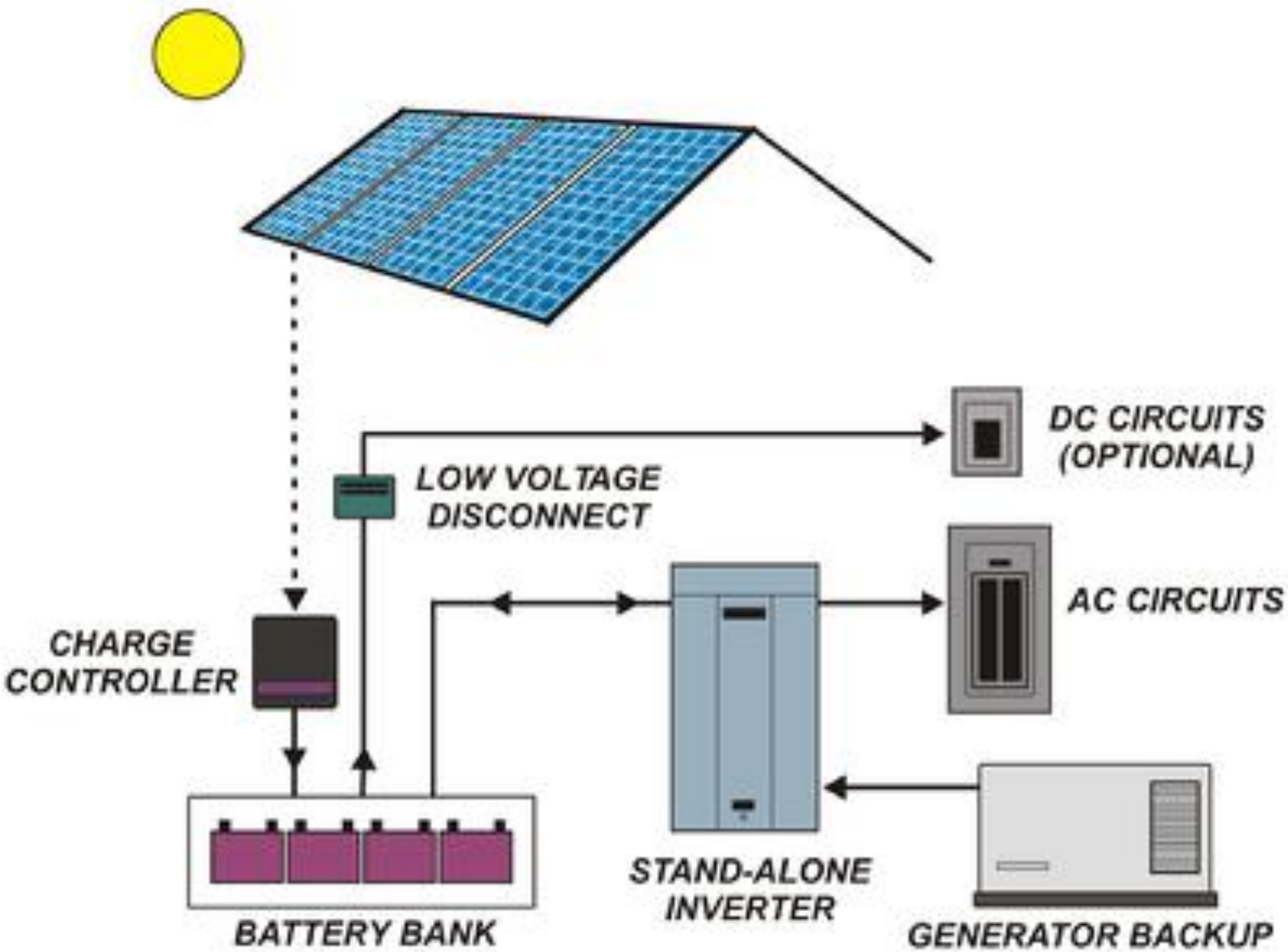
- Overcurrent devices, where required, shall be rated in accordance with one of the following:
- (1) Not less than 125 percent of the maximum currents calculated in 690.8(A).
- (2) Circuits containing an assembly, together with its overcurrent device(s), that is listed for continuous operation at 100 percent of its rating shall be permitted to be used at 100 percent of its rating.
- (3) Adjustable electronic overcurrent protective devices rated or set in accordance with 240.6.

Informational Note: Some electronic overcurrent protective devices prevent backfeed current.



SECTION 2017 NEC CHANGE

- 690.10 Stand-Alone Systems Moved to new Article 710



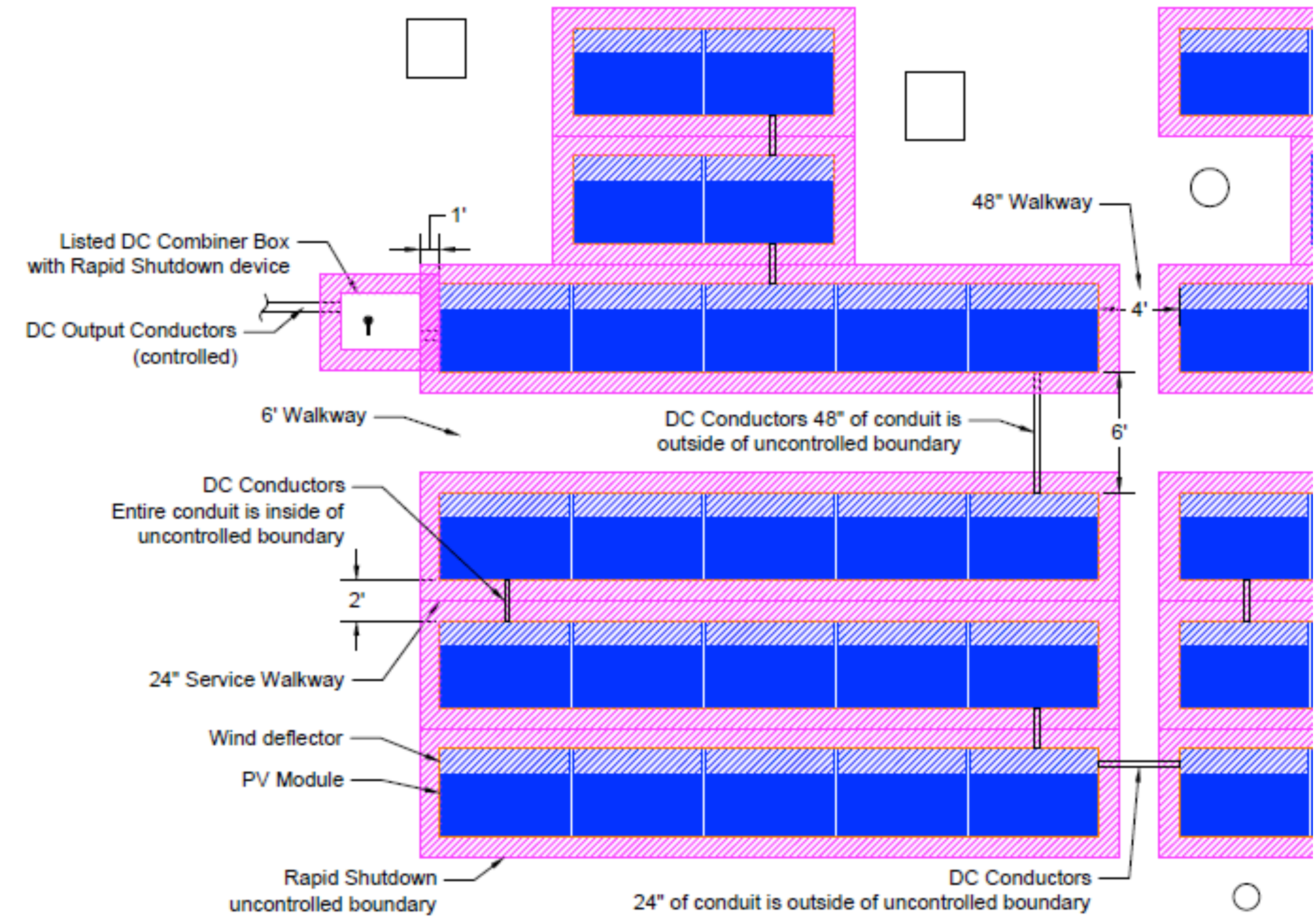
• 690.11 Arc-Fault Detection Revised to exempt PV output circuits on ground-mounted systems from arc fault protection when using specific wiring methods

• 690.12 Rapid Shutdown Dramatically increased the detail in 690.12 and included requirements for Rapid Shutdown within the array. Detailed marking requirements are added to 690.56(C)

690.12

- Several Significant Changes Proposed:
- 1. Greatly increased detail of rapid shutdown switch including location and signs
- 2. Define array zone-within 1’ of modules
- 3. All 3 options for reducing shock hazards within the array boundary.

- 1. Listed Rapid Shutdown PV Array
- 2. Curtail voltage of conductors within array zone to 80V
- 3. No exposed metal or conductors in PV array and array more than 8’ from grounded metal.
- 4. Require equipment to be certified for rapid shutdown



1'
Listed DC Combiner Box
with Rapid Shutdown device
48" Walkway
4'
DC Output Conductors
(controlled)
6' Walkway
DC Conductors 48" of conduit is
outside of uncontrolled boundary
6'
DC Conductors
Entire conduit is inside of
uncontrolled boundary
2'
24" Service Walkway
Wind deflector
PV Module
Rapid Shutdown
uncontrolled boundary
DC Conductors
24" of conduit is outside of uncontrolled boundary

690.12 (C)

The rapid shutdown initiation device(s) shall consist of at least one of the following:

- (1)Service disconnecting means
- (2) PV system disconnecting means
- (3) Readily accessible switch that plainly indicates whether it is in the "off" or "on" position

Informational Note: One example of why an initiation device that complies with 690.12(C)(3) would be used is where a PV system is connected to an optional standby system that remains energized upon loss of utility voltage.

690.12 (D)

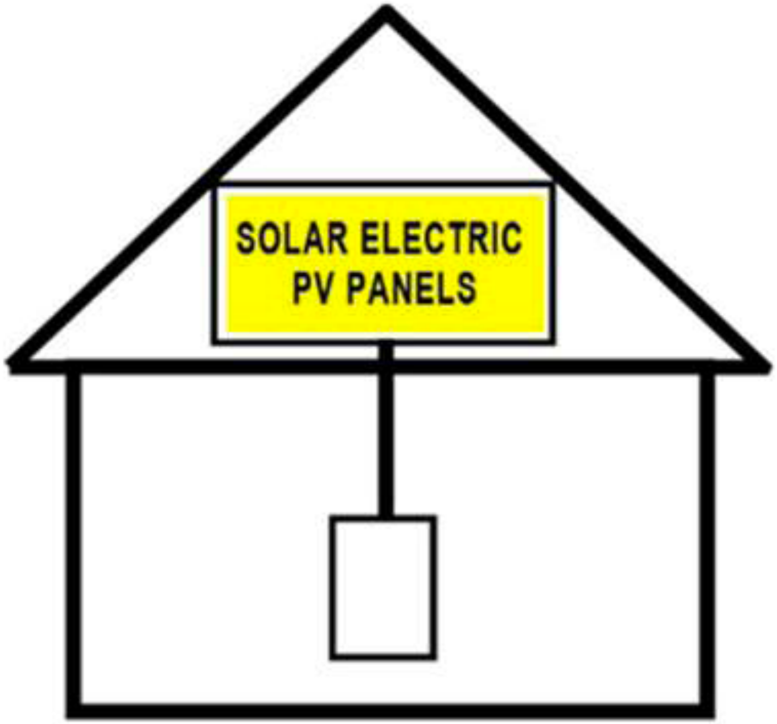
- Equipment that performs the rapid shutdown functions, other than initiation devices such as listed disconnect switches, circuit breakers, or control switches, shall be listed and labeled, and identified for providing rapid shutdown protection.

Informational Note: Inverter input circuit conductors can remain energized for up to 5 minutes with inverters not listed for rapid shutdown.

690.56 (C)
Buildings with Rapid Shutdown
For PV systems that shutdown the array and conductors leaving the array
Signage next slide

SOLAR PV SYSTEM EQUIPPED WITH RAPID SHUTDOWN

TURN RAPID SHUTDOWN
SWITCH TO THE
"OFF" POSITION TO
SHUTDOWN PV SYSTEM
AND REDUCE
SHOCK HAZARD
IN ARRAY



690.56 (C)

Buildings with Rapid Shutdown

For PV systems that only shutdown conductors leaving the array

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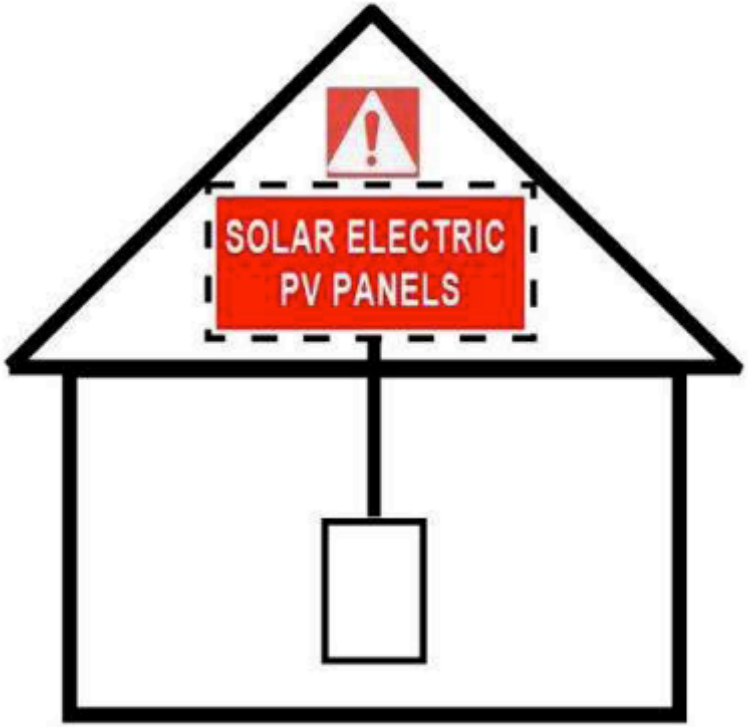
SOLAR PV SYSTEM EQUIPPED WITH RAPID SHUTDOWN

TURN RAPID SHUTDOWN SWITCH TO THE "OFF" POSITION, TO SHUTDOWN CONDUCTORS OUTSIDE THE ARRAY. CONDUCTORS WITHIN ARRAY REMAIN ENERGIZED IN SUNLIGHT



690.56 (C)

Buildings with Rapid Shutdown

For buildings with both types of PV systems

Signage will be presented at Session 2!!!

Questions?

Thank you for your participation in interest in Clean Renewable energy…

Christopher LaForge

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