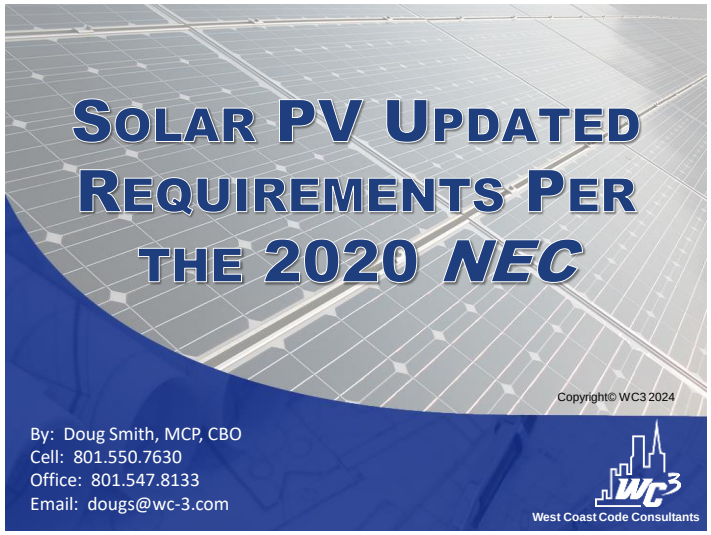


1

Doug Smith, MCP/CBO

- Inspector/Plan Reviewer for over 19 years
- 19 ICC certifications
- Certified Master Code Professional and CBO
- Taught electrical and solar PV classes for over 13 years
- Performed thousands of electrical, solar PV, and battery system (ESS) reviews
- Currently serve on *NEC* CMP 10 representing IAEI
- Currently serve as a Technical Committee (TC) Member for the following UL standards:
  - UL 61730 (1703) – Flat-Plate PV Modules and Panels
  - UL 1741 - Inverters, Converters, Controllers, and Int. equip…
  - UL 2703 – PV Mounting Systems/Clamps/Gnd. Lugs
  - UL 6703 – Connectors for Use in PV Systems
  - UL 9540 - Energy Storage Systems and Equipment

2

Course Objective/Intent

- The objective of this presentation is to explain some of the larger *NEC* changes in the **2020 *NEC*** related to solar photovoltaic (PV) systems.
- The intent of this information is to be used as a guide only. This presentation is not intended to indicate any change in any code or local requirements by inference or omission. Any diagrams are for illustration purposes only and actual wiring and installation may vary. This presentation is not intended to indicate if one piece or particular brand of equipment is better than another. Also, efficiency and ideal design considerations are not addressed herein. All codes and manufacture requirements must always be followed when designing, installing, and inspecting any electrical system, including solar PV and/or battery systems.

3

Outline

1. **Example Systems**
2. **Solar PV Systems (Article 690)**
3. **Services (Article 230 in the *NEC*)**
4. **Point of Interconnection Requirements (Article 705)**
5. **Important ESS Considerations**

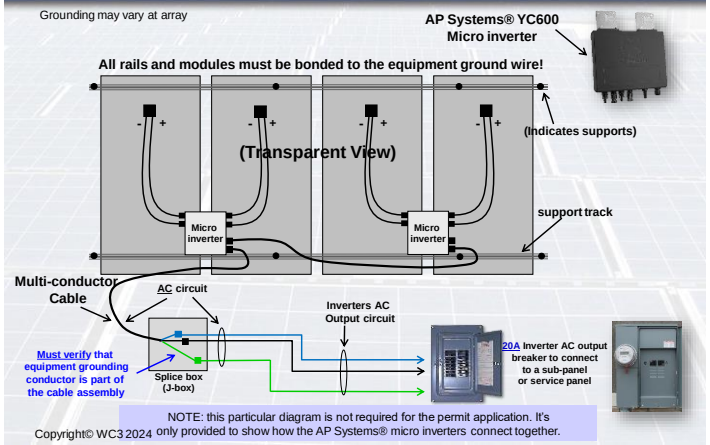
4

Example Systems

5

AP Systems® Micro Inverter System

Example Sys. #1

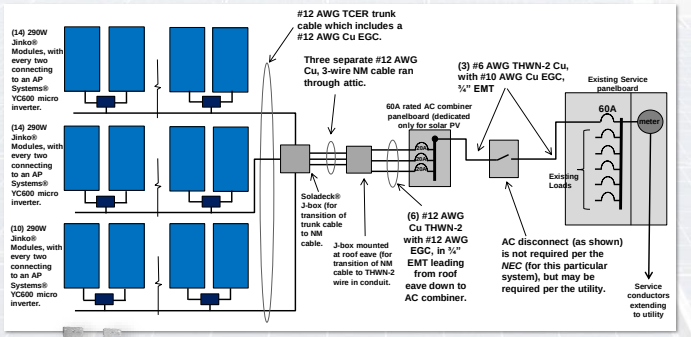


NOTE: this particular diagram is not required for the permit application. It's only provided to show how the AP Systems® micro inverters connect together.

6

Example System (for an AP Systems® YC600 micro inverter system)

Example Sys. #1

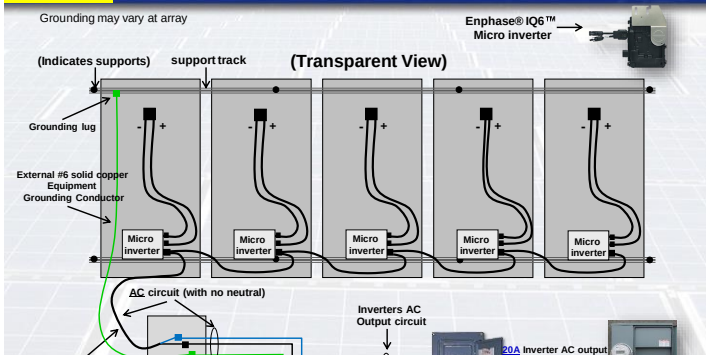


Note: this wiring diagram is simply an example and does not take into effect efficiency or ideal system design considerations. Diagrams may vary.

7

Enphase® IQ6™ Micro Inverter System

Example Sys. #2

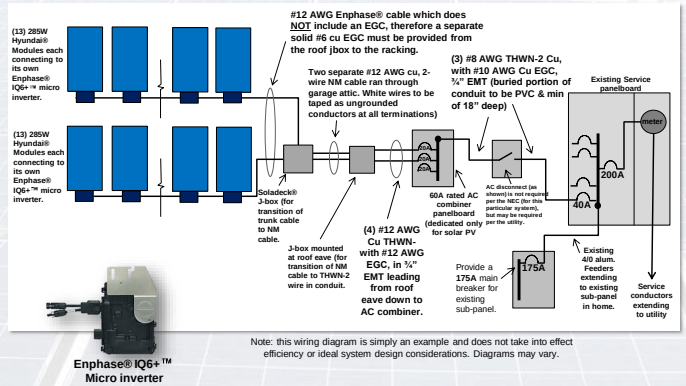


NOTE: this particular diagram is not required for the permit application. It's only provided to show how the Enphse® IQ6™ micro inverters connect together.

8

Example System (for an Enphase® IQ6+™ micro inverter system)

Example Sys. #2

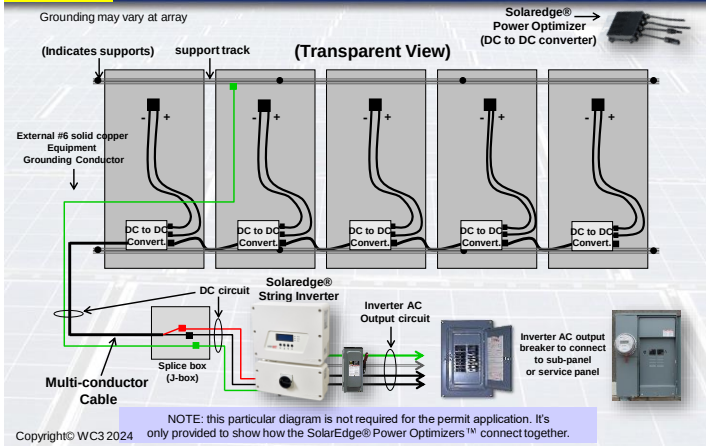


Note: this wiring diagram is simply an example and does not take into effect efficiency or ideal system design considerations. Diagrams may vary.

9

Solaredge® String Inverter With DC to DC Converters (Power Optimizers®)

Example Sys. #3

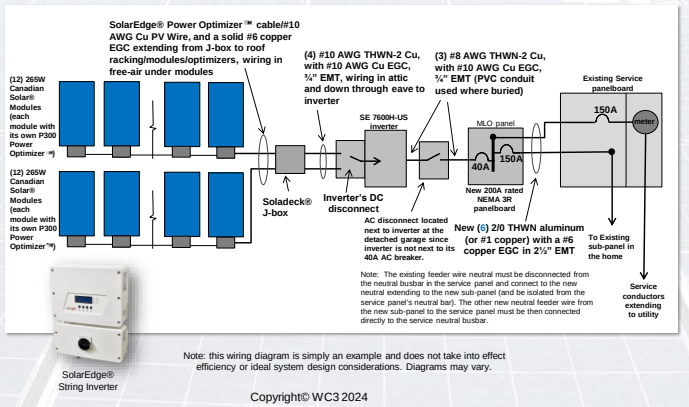


NOTE: this particular diagram is not required for the permit application. It's only provided to show how the SolarEdge® Power Optimizers™ connect together.

10

SolarEdge® String Inverter System

Example Sys. #3



Note: The existing feeder wire neutral must be disconnected from the neutral busbar in the service panel and connect to the new neutral extending to the new sub-panel (and be isolated from the service panel's neutral bar). The other new neutral feeder wire from the new sub-panel to the service panel must be then connected directly to the service neutral busbar.

Note: this wiring diagram is simply an example and does not take into effect efficiency or ideal system design considerations. Diagrams may vary.

11

Solar PV Systems (Article 690)

12

Electronic Power Converters

Electronic Power Converter: "A device that uses power electronics to convert one form of electrical power into another form of electrical power."

- The informational note says that such equipment could include (but not limited to) inverters, dc-to-dc converters, and charge controllers.

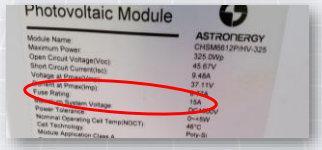
- **690.4(F)** says that electronic power converters and their associated devices are allowed to be mounted on the roof or other exterior areas that are not readily accessible.

13

Overcurrent Protection

690.9(A)(1) through (A)(3) note various options for providing overcurrent protection for circuits.

- (A)(1): Overcurrent protection devices are not required where both of the following is met:
  - The conductors (wires) have sufficient ampacity for the maximum current.
  - The currents from all sources don't exceed the maximum rating of the overcurrent protective device noted for the PV module (solar panel) or power converter. (Such information typically can be found on the spec sheets and sometimes the labels for the equipment)



14

Overcurrent Protection (continued)

- (A)(2): When one end of a circuit is connected to a current-limited supply, and the other end of the circuit is connected to sources having an available source of current higher than the ampacity of the circuit conductor, then the overcurrent protection for the circuit must be located at the point of connection to the higher current source.

15

Overcurrent Protection (continued)

- (A)(3): Circuits that don't comply with (A)(1) or (A)(2) are required to be protected with one of the following methods:
  - Conductors not longer than 10 feet and not in a building to have overcurrent protection on one end.
  - Conductors not longer than 10 feet and inside a building to have overcurrent protection on one end and wiring to be in a raceway or be MC cable.
  - Conductors protected on both ends with overcurrent protection devices.
  - See next slide for continuation….

16

Overcurrent Protection (continued)

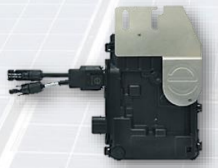
- (A)(3) continued:
  - Conductors that are not installed in or on buildings are allowed to be protected from overcurrent on one end of the circuit where the circuit complied with all of the following:
    - The conductors are installed in metal raceways, MC cable, enclosed metal cable trays, or installed underground, or where the conductors directly enter padmounted enclosures.
    - The conductors for each circuit terminate to a single breaker or a single set of fuses that limit the current to not more than the ampacity of the conductors.
    - The overcurrent protection device must be integral of the disconnecting means or must be located within 10 feet (measuring conductor length) of the disconnect.
    - The disconnect must be located outside of the building or be located at the nearest point of entrance in the building.

17

Rapid Shutdown

690.12 (A): The requirements for controlled conductors (for rapid shutdown) applies to both of the following:

- DC PV systems circuits.
- Inverter output (ac) circuits of inverters located at the array and within the array boundary.



Enphase® IQ6+™ Micro inverter

18

Rapid Shutdown

690.12(B) Controlled Limits:

- The use of the term **array boundary** in this section is defined as **(1 ft) from the array in all directions (and 3' into the attic)**. Controlled conductors outside the array boundary shall comply with *NEC* 690.12(B)(1) and inside the array boundary shall comply with 690.12(B)(2).

19

Rapid Shutdown

- **(B)(1) Outside the Array Boundary.** "Controlled conductors located outside the boundary or more than **(3 ft)** from the point of entry inside a building shall be limited to not more than **30 volts within 30 seconds** of rapid shutdown initiation. Voltage shall be measured between any two conductors and between any conductor and ground."

20

Rapid Shutdown

690.12(B)(2) Inside the Array Boundary:

- The PV system must comply with *one* of the following:
  - (1) "A PV hazard control system listed for the purpose shall be installed in accordance with the instructions included with the listing or field labeling. Where a hazard control system requires initiation to transition to a controlled state, the rapid shutdown initiation device required in 690.12(C) shall perform this initiation."
  - (2) "Controlled conductors located **inside the boundary** or not more than (3 ft) from the point of penetration of the surface of the building shall be limited to not more than **80 volts within 30 seconds** of rapid shutdown initiation. Voltage shall be measured between any two conductors and between any conductor and ground."
  - (3) "PV arrays shall have no exposed wiring methods, no exposed conductive parts, and be installed more than 2.5 m (8 ft) from exposed grounded conductive parts or ground shall not be required to comply with 690.12(B)(2)."

NFPE 70, National Electrical Code

21

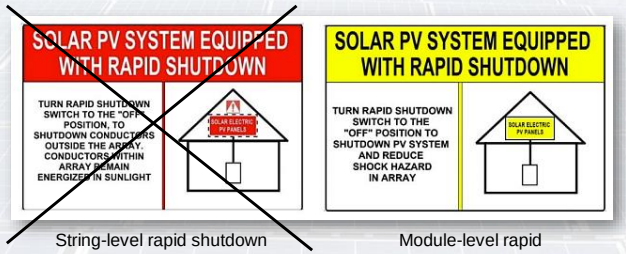
Rapid Shutdown

690.12(C) Initiation Device:

- New sentence added stating that rapid shutdown for a single system must occur by the operation of a single device.
- However, there can be up to six initiation devices for rapid shutdown on a single service (if grouped together). Such six initiation devices must shut down all PV systems on a service.

22

Rapid Shutdown Signage



String-level rapid shutdown systems

Module-level rapid shutdown systems

The sign with the red background (as shown above) has been removed from *NEC* 690.56(C) as a required sign.

23

Disconnects

- **690.13(A)** now requires that if a PV system disconnect operates above 30V and is/are readily accessible to unqualified persons, and has exposed live parts when open, such disconnect must be locked or require a tool to open.
- This requirement is similar to new equipment disconnect rules found in **690.15(A)**.

24

Disconnects (continued)

690.13(E) Type of Disconnect:

- The PV system disconnect is required to simultaneously disconnect all PV system conductors that are **not** solidly grounded from any conductors from other wiring systems.
- Such disconnecting means must be *capable* of being locked.
- The PV system disconnect is permitted to be one of the following:
  - A manually operable switch or breaker
  - A connector meeting 690.33(D)(1) or (D)(3)
  - "A pull-out switch with the required interrupting rating"
  - "A remote-controlled switch or breaker that is operated locally and opens automatically with control power is interrupted"
  - A listed device for the intended application.

Example of a pull-out switch

25

Wiring Methods

690.31(B) - Grouping:

- Class 1, signaling, and power-limited circuits for PV systems are permitted to be located in the same conduit (raceway), cable assembly, or enclosure as PV **dc** circuits.
- PV dc circuits are not allowed to be in the same conduit (raceway), cable assembly, or enclosure as non-PV system circuits or inverter output (ac) circuits (unless separated by a barrier or partition).
  - Exception: PV dc circuits are permitted to occupy the same wiring method as inverter output (ac) or non-PV system circuits as long as the dc wiring is part of multiconductor jacketed cables, MC cable, or listed wiring harnesses.

26

Violation(s)? Or does this meet the intent of the exception?

27

Wiring Methods

690.31(B)(1) – Identification:

- PV system dc conductors are required to be identified at all terminations, connections, and splices.
  - Methods used can be color coding, marking tape, tagging, or other approved means.
- When color coding is not used for identification of dc wiring, then permanent labels, sleeving, or shrink tubing must be used. Such permanent means must be as per the following (for **non**-solidly grounded conductors):
  - Positive wiring: imprinted plus signs (+), or word POSITIVE, or POS durably marked on insulation that's not a color that is green, white, or grey.
  - Negative wiring: imprinted negative signs (-), or word NEGATIVE, or NEG durably marked on insulation that's not a color that is red, green, white, or grey.

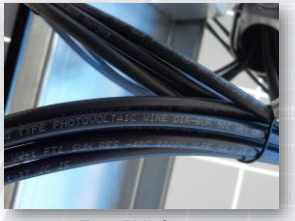
See exception

28

Wiring Methods

690.31(C) – Cables:

- Type PV wire and distributed generation (DG) cable must be listed (Informational Note references UL 4703 for PV wire, and UL 3003 for DG cable).



Type PV wire

Type DG cable

29

Wiring Methods

690.31(C)(1) – Single conductors/cables:

- PV system dc circuits in exposed outdoor locations and within the PV the PV array are permitted to be one of the following types:
  - PV wire or cable
  - Type USE-2 or RHW-2 single-conductor cable which is also marked as sunlight resistant.

30

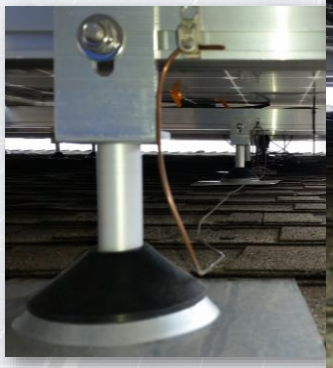
Wiring Methods

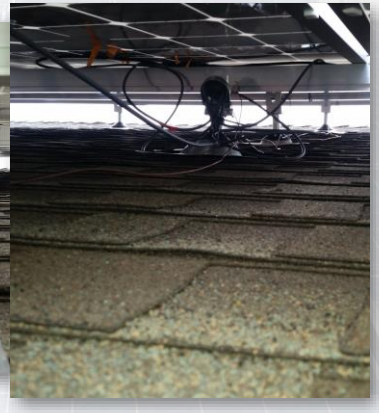
Single conductors/cables (continued):

- Exposed cables are required to be supported and secured every **24 inches** using cable ties, straps, hangers, or other similar listed and identified fittings (for supporting wiring in outdoor locations).
  - Exception: Supporting of wiring for large scale PV systems (over 5 MW) is permitted to meet the requirements of NEC 691.4.
- PV wire is allowed in any location where RHW-2 is permitted.

31

Installation Errors





32

Wiring Methods

690.31(C)(2) - Cable:

- Listed distributed generation (DG) and PV wire (of any size) can be used in cable trays *without requiring* to be cable tray rated as long as the cables are supported every 12" and secured every 4.5'.

33

Wiring Methods

690.31(C)(3) – Multiconductor Jacketed Cables:

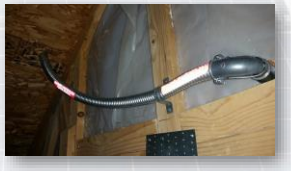
- Multiconductor jacketed cables that are part of a listed PV assembly must be installed per the installation instructions.
- Multiconductor jacketed cables (including DG cable) that are NOT part of a listed PV assembly must be installed per the product listing and are allowed for PV systems.
- The cables must be installed in raceways where on or in a building (other than the roof). If not in a raceway, then the following applies:
  - Marked as sunlight resistant (where exposed outside)
  - Protected or guarded from physical damage
  - Closely follow surface of structures that support the wiring
  - Secured every 6 feet
  - Secured within 24" of mating connectors or enclosures
  - Where buried be marked as suitable for direct burial

34

Wiring Methods

690.31(D) – DC Circuits in/on Buildings:

- Whenever dc circuits for PV systems operate over 30V or 8 amps and are inside a building, such circuits must be in metal raceways, MC cable, or metal enclosures.
  - New exception: Non-metallic enclosures, raceways, or cables that are part of a listed PV hazard control system are permitted at the point of penetration of the building to the PV hazard control actuator.



35

Wiring Methods

690.31(D)(2) – Markings/Labels:

- There must be provided labels on the exterior of all exposed raceways, enclosures, boxes, and conduit bodies. The wording of the labels must state either of the following: "PHOTOVOLTAIC POWER SOURCE" or "SOLAR PV DC CIRCUIT."

PHOTOVOLTAIC POWER SOURCE

Or

SOLAR PV DC CIRCUIT

36

Connectors for PV

690.33(C) – Types (of connectors):

- Mating connectors that are readily accessible and used in circuits operating over 30V dc or 15V ac, must require a tool for opening.
- Mating connectors can only be connected to other connectors of the same type and brand unless identified for intermatability with other types (per manufacture's installation instructions for the connectors).

37

Grounding and Bonding

690.43(D) – Bonding for Over 250V:

- Only PV system circuits that are solidly grounded must comply with the requirements of NEC 250.97 when operating over 250V.
  - Note: Most modern solar PV systems are not solidly grounded. Rather most are considered as "functionally grounded."

38

Grounding and Bonding

690.45 – Size of EGCs:

- The 2020 *NEC* added that it is not required to increase the size of the equipment grounding conductor (EGC) to address voltage drop considerations.

39

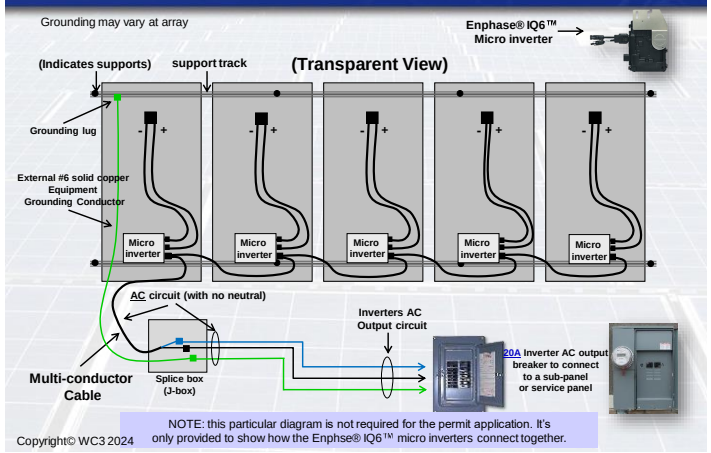
Grounding and Bonding

690.47(A) - Grounding Electrode System:

- A building or structure that supports a PV system must have a grounding electrode system (per Part III of *NEC* Article 250).
- For connection of the PV system to the grounding electrode system, either of the applicable following methods must be used:
  - PV systems that are NOT solidly grounded (such as functionally grounded systems) the equipment grounding conductor (EGC) of inverter's ac output circuit is permitted to be the only connection to ground for the PV system when such equipment ground wire is connected to a distribution system that is already connected to a grounding electrode system.
  - The second option applies to solidly grounded PV systems (see 690.47(A)(2). These systems are very rare.

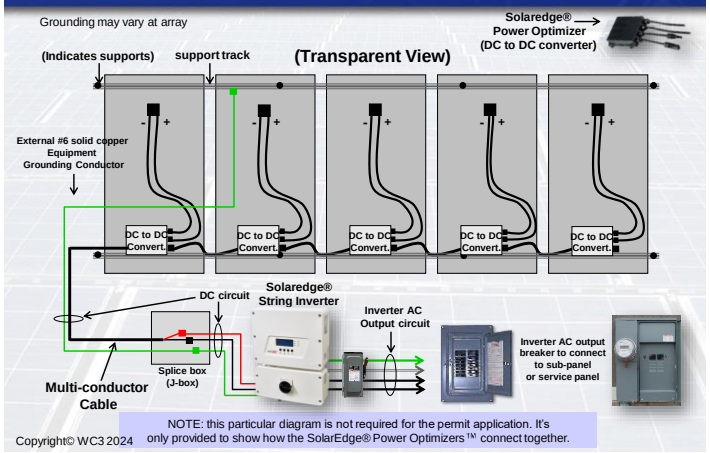
40

Enphase® IQ6™ Micro Inverter System



41

Solaredge® String Inverter With DC to DC Converters (Power Optimizers®)



42

Markings (signage)

690.53 – DC Signage:

- There must be provided a permanent and readily visible label noting the maximum dc voltage of the PV system. The label (or sign) must be located at one of the following locations:
  - The DC disconnect for the PV system (this is usually the dc disconnect mounted on the inverter, if it's a string inverter)
  - PV system electronic power conversion equipment (such as an inverter)
  - Distribution equipment associated with the PV system

43

Services

44

Splices and Taps

230.46 – Splices and Taps

- Effective January 1, 2023 any pressure connectors and devices for splicing or taps onto service conductors must be marked “suitable for use on the line side of the service equipment,” or equivalent wording.

45

Barriers

230.62(C) – Barriers (for service equipment)

- Barriers will be required in service equipment so that no uninsulated ungrounded busbars or terminals are exposed to accidental contact while someone is servicing load terminations.

46

Max # of Service Disconnects

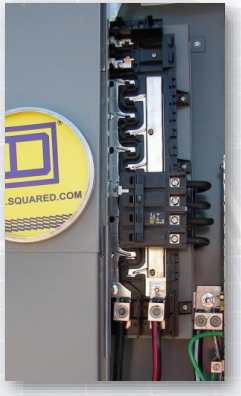
230.71 – Max Number of Service Disconnects:

- (A) Each service equipment is only allowed to have one disconnect. (This goes along with *NEC* 230.62(C))
- (B) Two to six service disconnects are allowed for a service (or for each set of service-entrance conductors per NEC 230.40). Such disconnecting means is permitted to be any of the following:
  - Separate enclosures which each have a main disconnect.
  - Panelboards which each having a main disconnect.
  - Switchboards where each separate vertical section has a main disconnect (and barriers separating each section).
  - Switchgear or metering centers where each disconnect is in a separate compartment.

Note: *NEC* 230.72(A) still requires the two to six disconnects to be grouped.

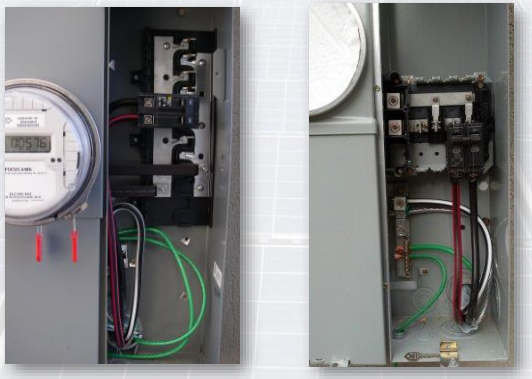
47

Service panels no longer allowed (for new installs) per the 2020 *NEC*



48

Examples of service panels no longer allowed (for new installs) per the 2020 *NEC*

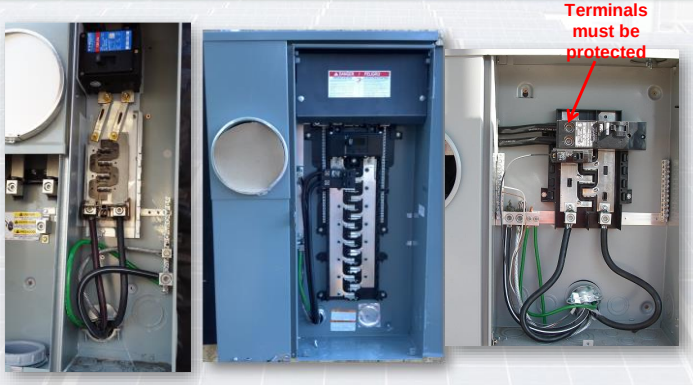


49

Service panels no longer allowed (for new installs) per the 2020 *NEC*

50

Examples of Service Panels that Will Work (for new installs) per the 2020 *NEC*



51

Metering Equipment

If this service equipment did not have an overall main service disconnect, then each of the downstream breakers (shown in this image) would be considered as service disconnects and each would be required to be in its own compartment [*NEC* 230.71(B)(4)].

52

Emergency Disconnects

230.85 – Emergency Disconnects

- One- and two-family dwelling units will be required to have an emergency disconnect located at a readily accessible location on the outside of the dwelling. If more than one emergency disconnect is provided, they must be grouped. (see also signage requirements)

The service disconnect in this outdoor readily accessible meter-main combo panel could count as the "emergency disconnect" for the dwelling.

53

Point of Interconnection Requirements (Article 705)

54

Multiple Sources of Power

705.10 – Identification of Power Sources:

- A permanent plaque or directory is required to be installed at each service equipment location (or other readily visible location). Such must denote the location of each power source disconnecting means for the building or structure and be grouped with any other plaques or directories.
- Such plaque or directory must be marked with the words "CAUTION: MULTIPLE SOURCES OF POWER."

55

Point Of Interconnection

Connecting The PV System To The Bld's Elect. System:

- There are 2 general places a PV system can *potentially* connect to a building's electrical system:
  - On the supply side (line side) of the building's main service disconnect.
  - On the load side of the building's main service disconnect.

56

Supply (Line) Side Connection (utility side of the main service disconnect)

***NEC* 705.11:**

- "An electric power production source, where connected on the supply side of the service disconnecting means as permitted in 230.82(6), shall comply with 705.11(A) through (E)."
  - Note: 230.82(6) specifies that solar PV systems are permitted to be on the supply side of the service disconnecting means if the PV system disconnecting means is listed as suitable for use as service equipment.

57

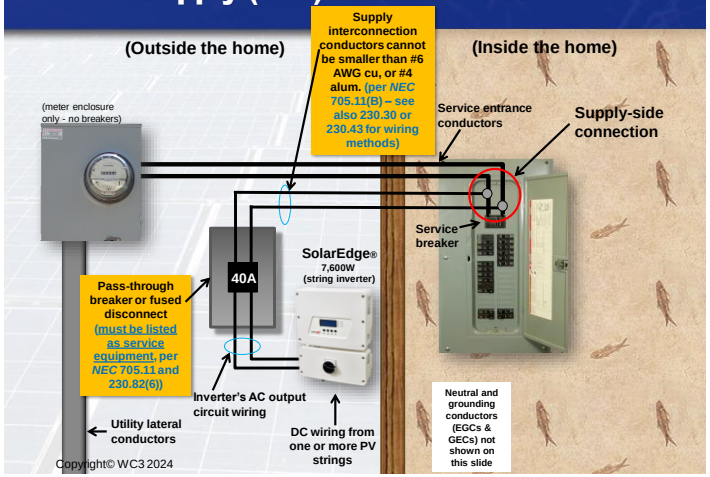
Supply (line) side connection continued…

705.11(A) – Output Rating:

- If a supply (line) side connection is going to be performed in order to tie the PV system in with the building's electrical system, the combined output current (amps) of all inverters multiplied by 125% cannot exceed the rating of the building's service.

58

Supply (line) side connection



59

Supply (line) side connection continued…

705.11(C) – Overcurrent Protection:

- The Power source (inverters) output ac circuit conductors must be protected from overcurrent per *NEC* 705.30 (ac output amps × 125%).
- Where the PV system connection to the building's electrical system is made **outside** the building, then the overcurrent protection device for the conductors must be readily accessible outside or be at the first readily accessible location inside the building.

60

Supply (line) side connection continued…

705.11(C) – Overcurrent Protection (continued):

- Where the PV system connection to the building's electrical system is made **inside** the building, the overcurrent protection device for the conductors must be per one of the following:
  - An overcurrent protection device located within **10 feet** (maximum conductor length) for a dwelling unit.
  - An overcurrent protection device located within **16.5 feet** (maximum conductor length) for a **non**-dwelling unit.
  - For **non**-dwellings, the overcurrent protection device can be located within **71 feet** (maximum conductor length) as long as cable limiters are provided for each ungrounded conductor. The cable limiters would need to be within **16.5 feet** of the point of connection (maximum conductor length).

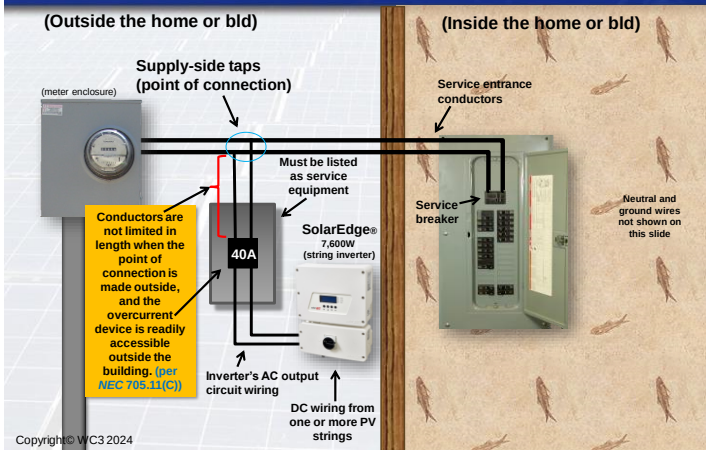
61

Supply (line) side connection continued…

Examples of cable limiters

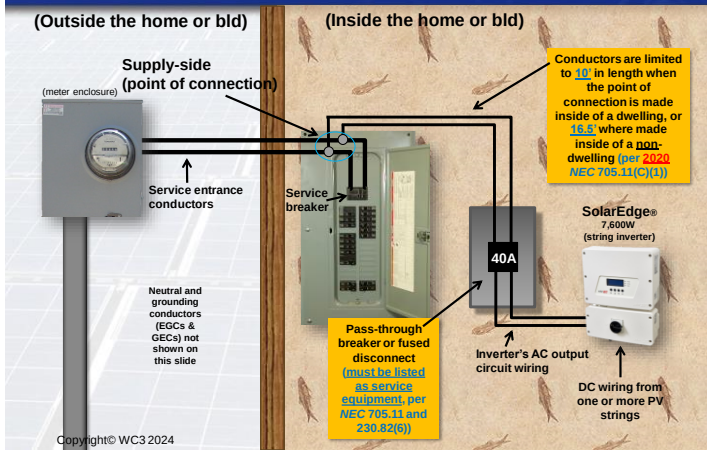
62

Supply (line) side connection – Made Outside of a Building



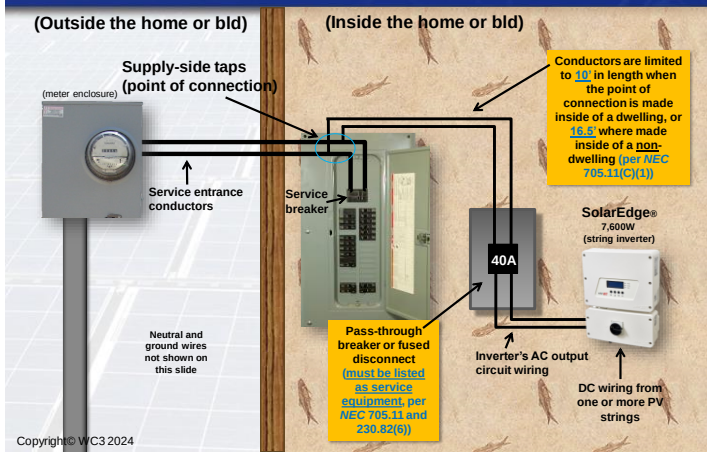
63

Supply (line) side connection (2020 *NEC*) – Made Inside of a Building



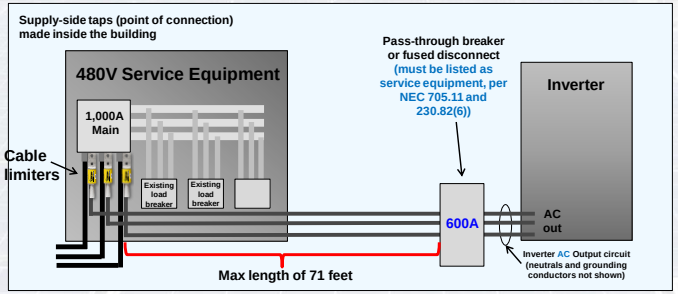
64

Supply (line) side connection – Made Inside of a Building



65

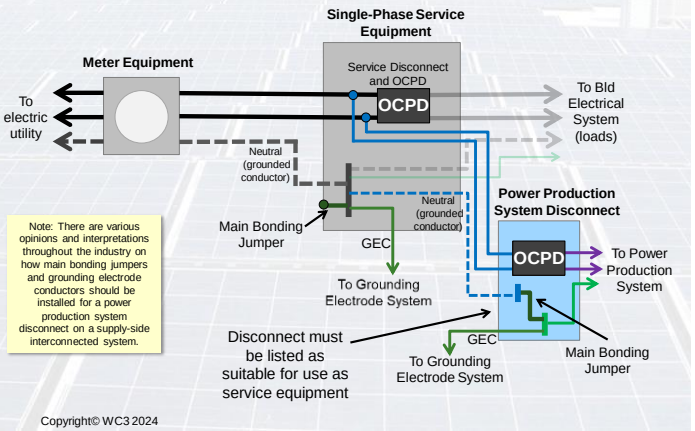
Supply (line) side connection – Made Inside of a Building



For non-dwellings, the overcurrent protection device can be located within 71 feet (maximum conductor length) as long as cable limiters are provided for each ungrounded conductor. The cable limiters would need to be within 16.5 feet of the point of connection (maximum conductor length).

66

Section 250.25 of the 2020 & 2023 *NEC* (example)



67

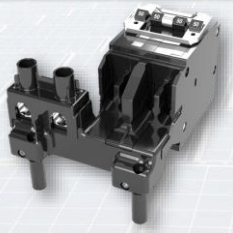
Supply (line) side connection continued…

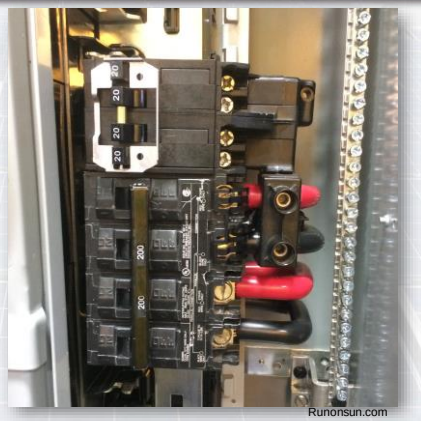
705.11(D) – Connections:

- Supply side connections must be made only with listed connectors and must comply with the enclosure fill requirements of the *NEC*.
- Modifications made to existing equipment must be per the manufacturer's instructions (and the listing of the equipment), or the connections must be field evaluated (by an approved agency) and a field label applied.
- Any connections in equipment under the exclusive control of the utility must be approved by the utility.

68

B3 Bypass Breaker® for Supply Side Interconnections





The B3 Bypass Breaker® must be installed exactly as per the manufacturer's installation instructions (and using the appropriate tools), and it can only be installed within approved service panelboards noted in B3's specification sheets.

69

Supply (line) side connection continued…

705.11(E) – Ground Fault Protection of Equipment:

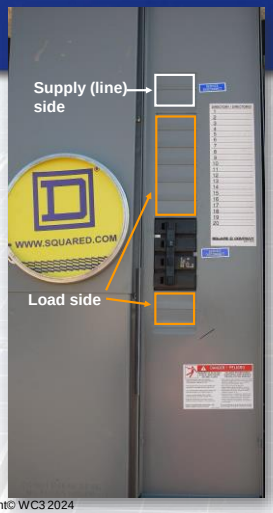
- When supply side connections are being made to a 480V service, if the rating of the overcurrent device for the PV system is rated 1,000A or more such disconnect must be provided with ground fault protection of equipment (GFPE) in accordance with *NEC* 230.95.

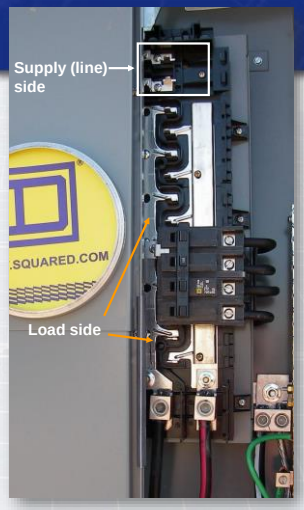
70

Supply (Line) side connection continued…

What about supply-side connections made with a breaker?

71





72

Load Side Connections – 705.12

- Load side connections occur on the building's side of the main electrical service disconnect(s).
- The requirements of *NEC* 705.12 in the 2020 *NEC* are very similar to those shown in 705.12(B) of the 2017 *NEC*, with a few minor changes.

73

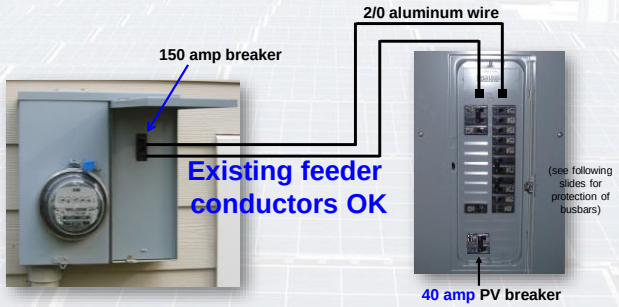
705.12(B)(1) – Feeders

Feeders

- New: When an inverter ("power source") connection is made to a feeder, the feeder is required to have an ampacity not less than 125% of the output current (amps) of the inverter(s).
- When the inverter ("power source") AC output connection is made to a feeder at a location **other than** the opposite end of the feeder from the primary source overcurrent device, the portion of feeder on the load side of the inverter ("power source") output connection must be protected by *NEC* 705.12(B)(1)(**a**) or (B)(1)(**b**).

74

But what if the PV connection *IS* made at the opposite end of the feeder?



The solar PV (125% of the AC output amps of the inverter(s)) cannot exceed the ampacity of the feeder wires.

75

705.12(B)(1) (Feeders) continued…

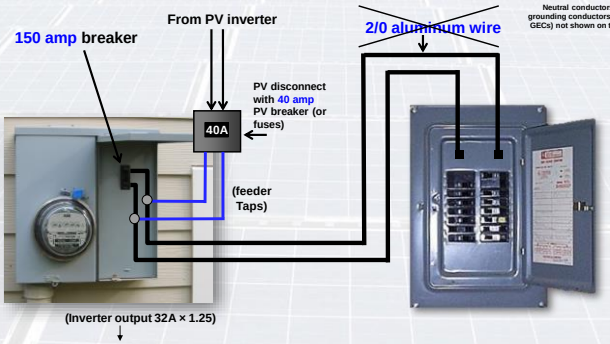
- If the PV connection to a feeder is not at the opposite end of the feeder from the feeder's main breaker (primary overcurrent protection device), the feeder's ampacity on the load side of the PV connection must be as per *NEC* 705.12(B)(1)(**a**) or (B)(1)(**b**):
  - a) The feeder ampacity must not be less than the sum of the primary source OCPD and 125% of the inverter(s) (power source) output current.

    OR
  - b) An overcurrent device on the load side of the inverter (power source) AC output connection must be rated not greater than the ampacity of the feeder.

76

Feeders – Example For Option "a" (*NEC* 705.12(B)(1)(a))

Option "a": The feeder must have an ampacity of the sum of the primary source OCPD and the inverter AC output amps × 1.25:

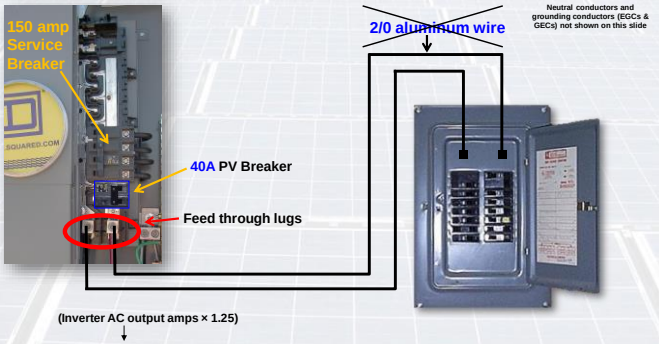


150A + 40A= 190 amps – 2/0 aluminum is too small!

77

Feeders – Another Example For Option "a" (*NEC* 705.12(B)(1)(a))

Option "a": The feeder wires must have an ampacity of the sum of the primary source OCPD and the inverter AC output amps × 1.25:

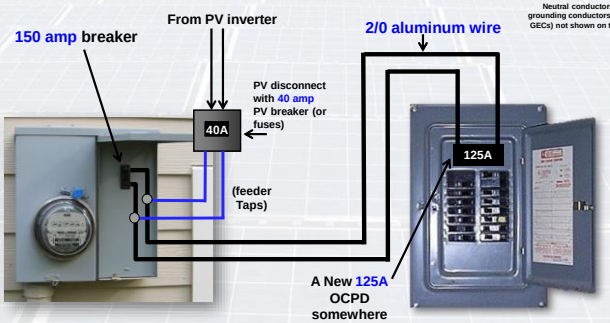


150A + 40A= 190 amps – 2/0 aluminum is too small!

78

Feeders – Example For Option "b" (*NEC* 705.12(B)(1)(b))

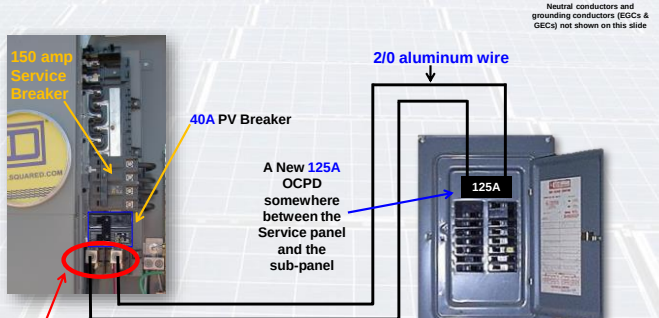
Option "b": An OCPD on the load side of the inverter (power source) connection must be rated not greater than the ampacity of the feeder.



79

Feeders – Another Example For Option "b" (*NEC* 705.12(B)(1)(b))

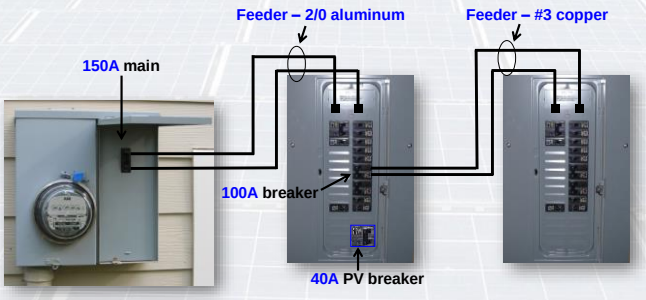
Option "b": An OCPD on the load side of the inverter (power source) connection must be rated not greater than the ampacity of the feeder.



80

Sizing Feeders – Another Example For Option "b" (*NEC* 705.12(B)(1)(b))

Option "b": An OCPD on the load side of the inverter (power source) connection must be rated not greater than the ampacity of the feeder.



Each set of feeders are protected as per 705.12(B)(1)

81

NEC 705.12(B)(3) – Busbars

Busbars

- *NEC* 705.12(B)(3)(1) through (B)(3)(6) must be used for determining the minimum ratings of panelboard busbars.

82

Method "5" (*NEC* 705.12(B)(3)(5))

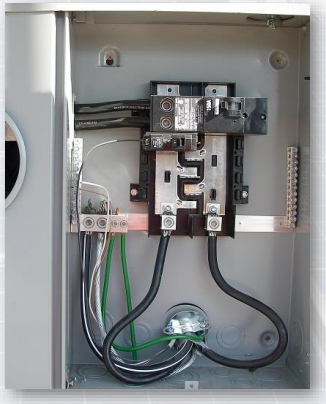
5) Connections made to switchgear, switchboards, and panelboards that are in configurations differing from *NEC* 705.12(B)(3)(1) through (B)(3)(4) are permitted as long as designed under engineering supervision that includes fault-current and busbar load calculations.

83

Method "6" (*NEC* 705.12(B)(3)(6))

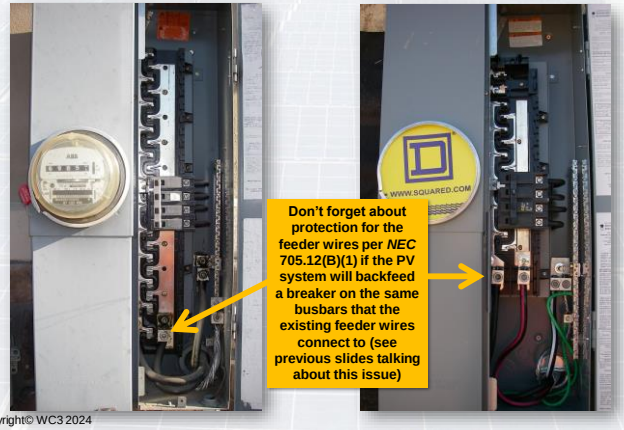
6) "Connections shall be permitted on busbars of panelboards that supply lugs connected to feed-through conductors. The feed-through conductors shall be sized in accordance with 705.12(B)(1).

Where an overcurrent device is installed at the supply end of the feed-through conductors [such as a main breaker for example], the busbar in the supplying panelboard shall be permitted to be sized in accordance with 705(B)(3)(1) through (B)(3)(3)."



84

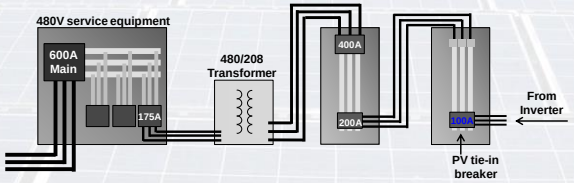
Center-Fed Busbars (Residential)



85

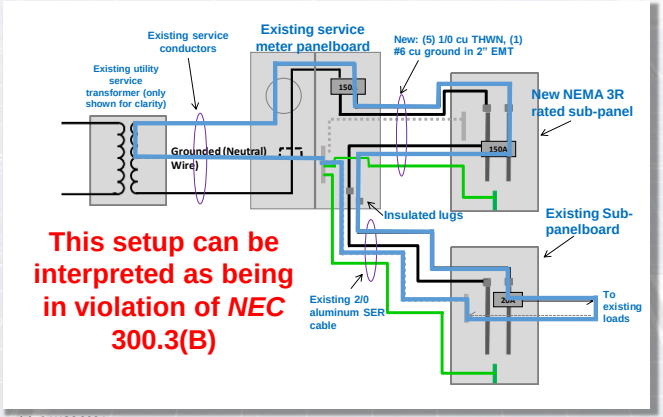
Back-fed Equipment

A PV system effects all equipment and conductors that are backfed by the PV system all the way back to the service equipment. *NEC* 705.12 applies to all equipment and conductors being backfed on the load side of main service disconnect.



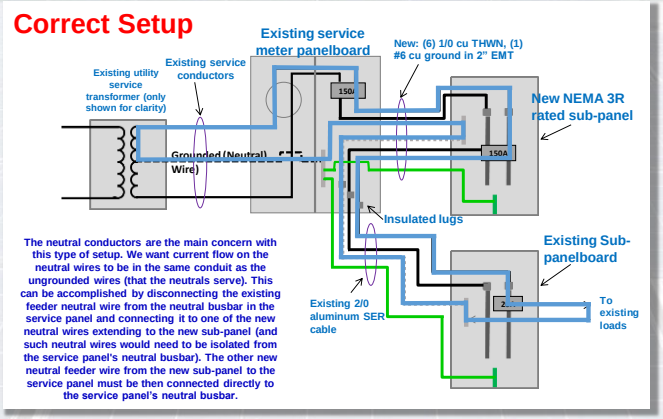
86

What About So-Called "Re-Feed" or "Re-Directed" Systems?



87

What About So-Called "Re-Feed" or "Re-Directed" Systems?



88

Important ESS Considerations

89

IRC Requirements for ESS

IRC R328.1 - General:

- Energy storage systems (ESS) shall comply with the provisions of this section.
- Exceptions:
  1. ESS listed and labeled in accordance with UL 9540 and marked "For use in residential dwelling units", where installed in accordance with the manufacturer's instructions and NFPA 70.

     (Note: the updated wording in UL 9540 says "Suitable For Use in Residential Habitable Spaces")
  2. ESS less than 1 kWh (3.6 megajoules)

ESS can't be located in the living space of the home, but other spaces such as garages, outdoors, storage rooms, etc are often permitted (if provisions of *IRC* are met)

90

Storage room example

91

IRC Requirements for ESS

IRC R328.2 – Equipment Listings:

- ESS shall be listed and labeled in accordance with **UL 9540**.
- Exception:
  - Where approved, repurposed unlisted battery systems from electric vehicles are allowed to be installed outdoors or in detached sheds located not less than 5 feet (1524 mm) from exterior walls, property lines and public ways.

92

Many violations!

93

Example of older battery backup PV system (does NOT have the UL 9540 listing)

94

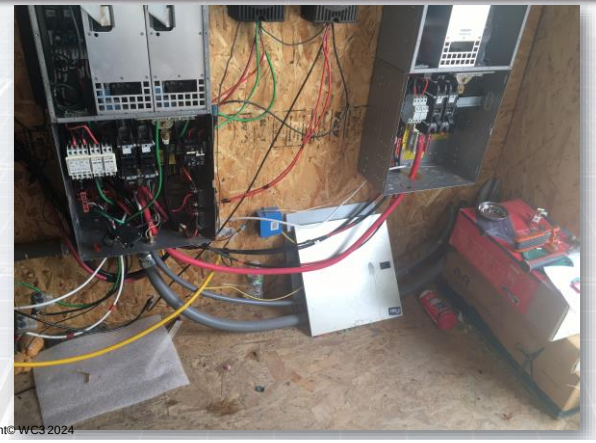
IRC Requirements for ESS

IRC R328.3 – Installation:

- ESS shall be installed in accordance with the manufacturer's instructions and their listing.

95

Lots of Violations!!!



96

IRC Requirements for ESS

IRC R328.3.1 – Spacing:

- Individual units (see also R328.5) shall be separated from each other by not less than **three feet** except where smaller separation distances are documented to be adequate based on large scale fire testing complying with Section 1207.1.5 of the International Fire Code.

"Large-scale fire" testing is referring to testing in accordance with UL 9540A

97

Violations?

98

Violations?

99

Example of a Good Install

The Enphase® ESS has been tested per UL 9540A and is permitted to have units spaced less than 36" (but still must follow installation instructions).

100

Example of a Good Install

The SolarEdge® ESS has been tested per UL 9540A and is permitted to have units spaced less than 36" (but still must follow installation instructions).

101

IRC Requirements for ESS

IRC R328.4 – Locations:

- ESS shall be installed only in the following locations:

1. Detached garages and detached accessory structures.
2. Attached garages separated from the dwelling unit living space in accordance with Section R302.6.
3. Outdoors or on the exterior side of exterior walls located not less than 3 feet from doors and windows directly entering the dwelling unit.
4. Enclosed utility closets, basements, storage or utility spaces within dwelling units with finished or noncombustible walls and ceilings. Walls and ceilings of unfinished wood-framed construction shall be provided with not less than 5/8-inch Type X gypsum wallboard.

ESS shall not be installed in sleeping rooms, or closets or spaces opening directly into sleeping rooms.

102

Violations!!!

103

Violations?

104

IRC Requirements for ESS

IRC R328.5 – Energy Ratings:

- Individual ESS units shall have a maximum rating of **20 kWh**. The aggregate rating of the ESS shall not exceed:
  1. 40 kWh within utility closets, basements, and storage or utility spaces.
  2. 80 kWh in attached or detached garages and detached accessory structures.
  3. 80 kWh on exterior walls.
  4. 80 kWh outdoors on the ground.

ESS installations exceeding the permitted individual or aggregate ratings shall be installed in accordance with Section 1207 of the adopted International Fire Code.

105

IRC Requirements for ESS

IRC R328.6 – Electrical Installation:

- ESS shall be installed in accordance with NFPA 70 (*National Electrical Code*). Inverters shall be listed and labeled in accordance with UL 1741 or provided as part of the UL 9540 listing. Systems connected to the utility grid shall use inverters listed for utility interaction.

106

IRC Requirements for ESS

IRC R328.7 – Fire Detection:

- Rooms and areas within dwelling units, basements, and attached garages in which ESS are installed shall be protected by smoke alarms in accordance with Section R314.
- A heat detector (heat ALARM), listed and interconnected to the smoke alarms, shall be installed in locations within dwelling units and attached garages where smoke alarms cannot be installed based on their listing.

107

108

IRC Section R314

R314.4 Interconnection. Where more than one smoke alarm is required to be installed within an individual dwelling unit in accordance with Section R314.3, the alarm devices shall be interconnected in such a manner that the actuation of one alarm will activate all of the alarms in the individual dwelling unit.

Physical interconnection of smoke alarms shall not be required where listed wireless alarms are installed and all alarms sound upon activation of one alarm.

109

IRC Section R314 (continued)

R314.6 Power Source. Smoke alarms shall receive their primary power from the building wiring where such wiring is served from a commercial source and, where primary power is interrupted, shall receive power from a battery. Wiring shall be permanent and without a disconnecting switch other than those required for overcurrent protection.

Exceptions:

1. Smoke alarms shall be permitted to be battery operated where installed in buildings without commercial power.
2. Smoke alarms installed in accordance with Section R314.2.2 shall be permitted to be battery powered.

R314.7 also allows the use of a full fire alarm system.

110

IRC Requirements for ESS

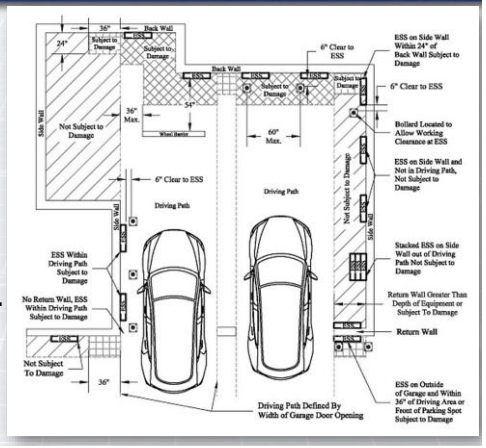
IRC R328.8 – Protection from Impact:

- ESS installed in a location subject to vehicle damage shall be protected by approved barriers.

111

Protection from Vehicle Damage

Figure R328.8.1 from the 2024 IRC helps provide guidance on what locations in a garage could be considered as subject to damage.



112

Protection from Vehicle Damage

Figure R328.8.1 from the 2024 IRC also helps provide guidance on *how* to protect equipment from physical damage.

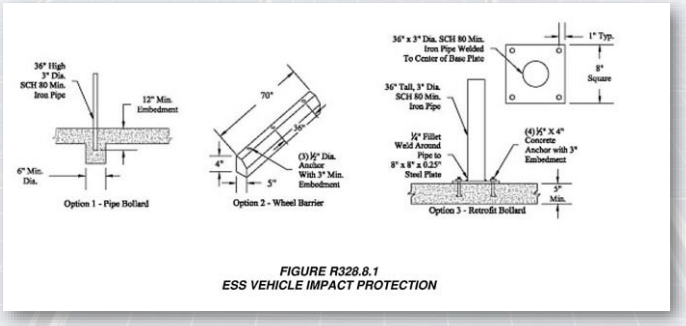


FIGURE R328.8.1
ESS VEHICLE IMPACT PROTECTION

113

IRC Requirements for ESS

IRC R328.9 – Equipment Listings:

- Indoor installation of ESS that include batteries that produce hydrogen or other flammable gases during charging shall be provided with mechanical ventilation in accordance with Section M1307.4.

Note: most sealed batteries do not require ventilation per manufacturer's requirements.

114

IRC Requirements for ESS

IRC R328.10 – Electric Vehicle Use:

- The temporary use of an owner or occupant's electric powered vehicle to power a dwelling unit while parked in an attached or detached garage or outdoors shall comply with the vehicle manufacturer's instructions and NFPA 70 (*NEC*).

115

IRC Requirements for ESS

IRC R328.11 – Documentation & Labeling **(NEW)**

- The following is required to be provided:
  - A copy of the manufacturer's installation, operation, maintenance and decommissioning instructions shall be provided to the owner or placed in a conspicuous location near the ESS equipment.
  - A label on the installed system containing the contact information for the qualified maintenance and service providers.

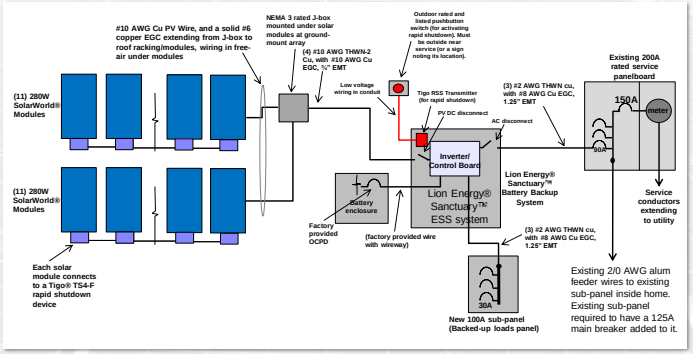
116

NEC 706.15 – Disconnects

- For all one-family and two-family dwellings, there must be provided on the outside of the home, and at readily accessible location, a disconnect (or its remote control) for the ESS.

117

Example Shutoff Switch



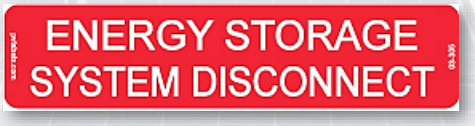
Note: this wiring diagram is simply an example and does not take into effect efficiency or ideal system design considerations. Diagrams may vary. ALWAYS FOLLOW MANUFACTURER'S REQUIREMENTS and APPLICABLE CODES.

118

NEC 706.15 – Disconnects Continued

706.15(C):

- Each ESS disconnect must clearly indicate on (closed) or off (open) positions.
- Such disconnect(s) must be marked "Energy Storage System Disconnect."



119

NEC 706.15 – Disconnects Continued

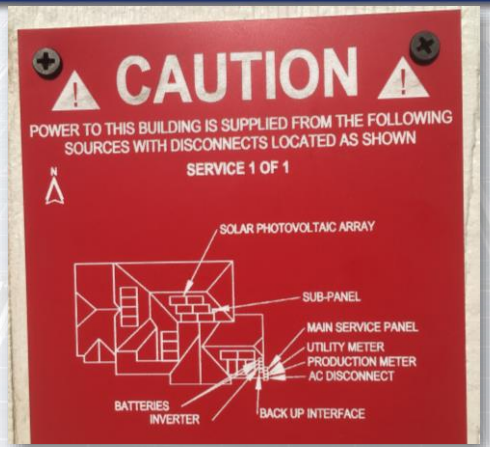
706.15(C) continued:

- The disconnect(s) must be marked with the following:
  - Nominal ESS AC voltage and maximum ESS DC voltage.
  - Available fault current derived from the ESS
  - Arc-flash label per acceptable industry practice (for example, see 130.5(H) of NFPA 70E)
  - Date the calculation was performed

These items are not required for one- or two-family dwelling ESS system signage (see exception of 706.15(C))

120

Identification of Other Power Sources (*NEC* 705.10)



121

Violations!

122

Questions?

The end

123