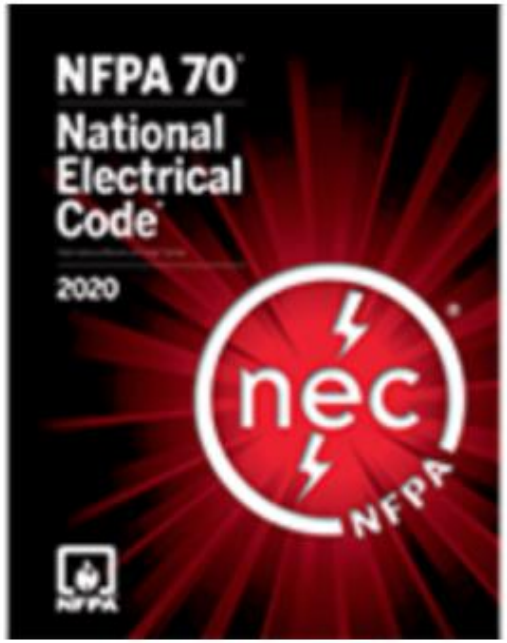
National Electric Code for Photovoltaic Electric Systems and Minnesota Policy Changes for 2020



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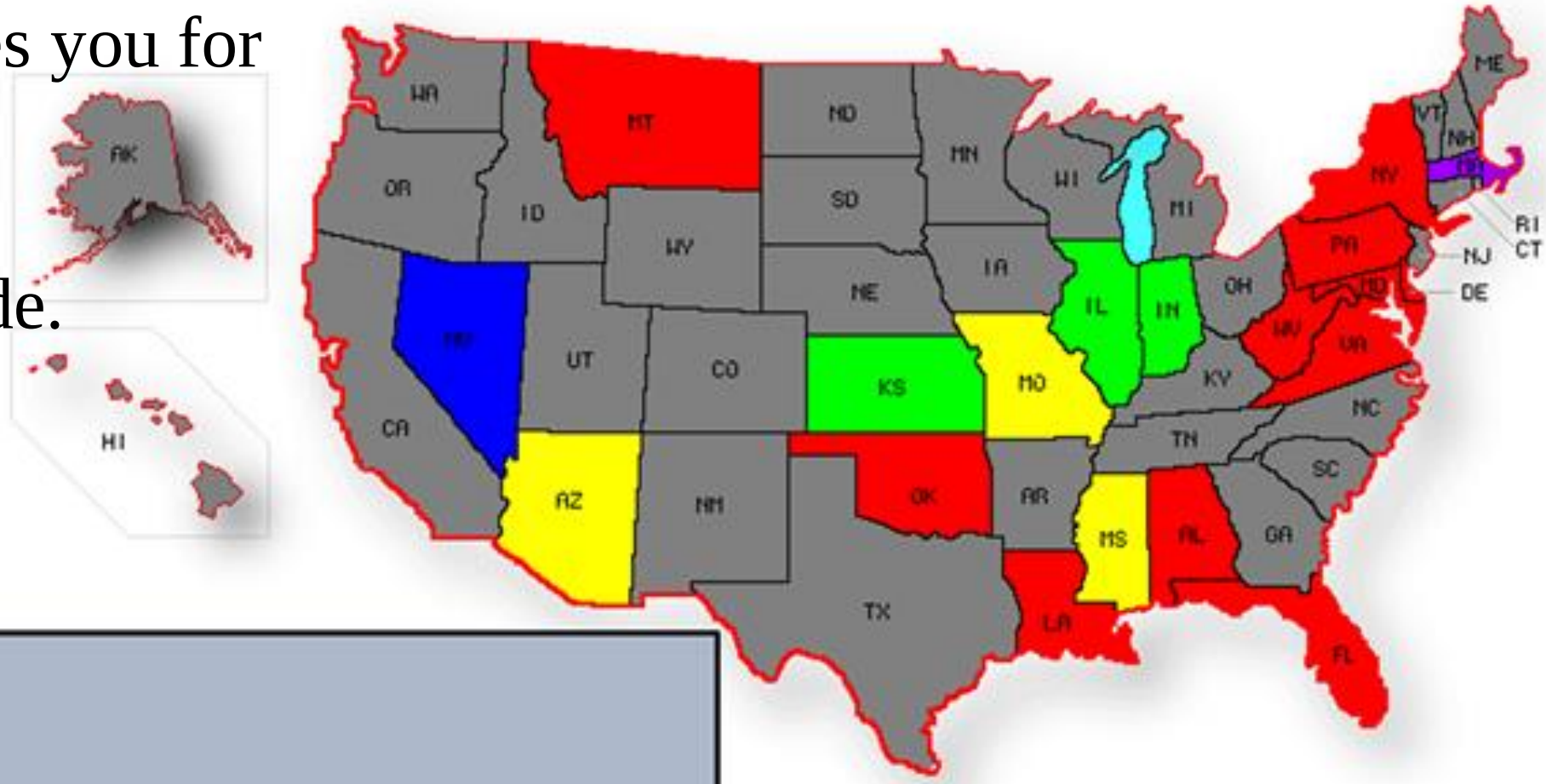
31 years Operating Great Northern Solar

28 years Training with MREA and other organizations

The new edition of the NEC code book is out and changes affect your designs. Today we review the current information surrounding changes in the NEC for Photovoltaic electric systems.

In addition policy in Minnesota and the mid-west is a moving target. We will hear about where policy is and some of the Renewable Energy activities at Minnesota power.

MN and WI are currently under 2017 NEC this update readies you for when your state adopts The 2020 code.

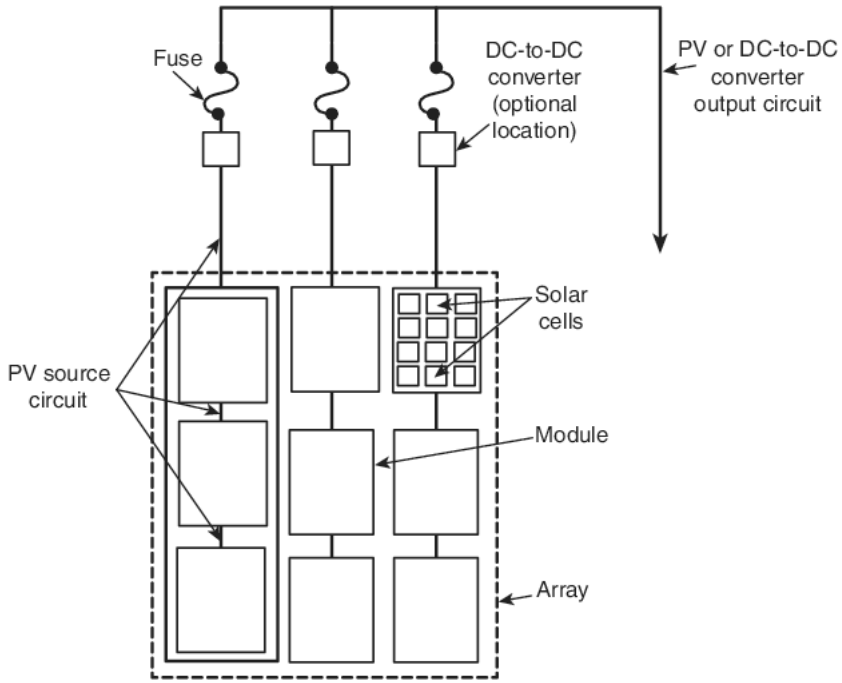


2020 NEC® - 1
2017 NEC® - 31
2014 NEC® - 11
2011 NEC® - 1
2008 NEC® - 3

Small Changes

Some changes the the NEC are small adjustments to the articles style and the use of certain terms. Several such changes were made in the 2020 code.

For instance minor changes made to Figures 1(a) and 1(b) located in the informational note to Section690.1. This removal of the word “Panel” in the figure pointing to a set of modules. This term is not in common use in our industry.



Note:
(1) These diagrams are intended to be a means of identification for PV power source components, circuits, and connections that make up the PV power source.
(2) Custom PV power source designs occur, and some components are optional.

Larger or Substantive changes are the changes that affect our work more seriously and the ones we focus on more greatly today.

One such change was in the adjustment of Section 690.8 including the addition of 690.8(A)(2). The new language allows the circuit current to be determined by the rated input current of the conversion equipment (commonly the inverter). Additionally a requirement that the conductors shall be protected by an overcurrent device rated not more than the circuit conductor ampacity. (The basic requirement that had been in use was that the maximum circuit current for a PV circuit is based on the maximum available output of the PV modules as corrected for temperature and irradiance.)

A typical array may have a combined output of the its strings at over 70 amperes according to 690.8(A)(1). Using 75°C terminals in the equipment this requires a minimum of 4 AWG copper conductors.

Using the new language in 690.8(A)(2), the design can use 8 AWG copper conductors protected with 50-ampere fuses to supply the inverter input current of 33 amperes x 125% (continuous duty) or 41 amperes.

As this is two standard conductor sizes smaller, requiring less than half the amount of copper mandated by the standard sizing method, on a large ground-mounted system this will lead to great savings in conductor and conduit costs.

Larger or Substantive changes:

Another substantive change is in Section 690.9. In the 2017 NEC, 690.9(A) consisted of one paragraph with two exceptions. For the 2020 NEC, much of the same language remains but the content is in three separate items and this language adds clarity.

690.9 Overcurrent Protection.

(A) Circuits and Equipment. PV system dc circuit and inverter output conductors and equipment shall be protected against overcurrent. Circuits sized in accordance with 690.8(A)(2) are required to be protected against overcurrent with overcurrent protective devices. Each circuit shall be protected from overcurrent in accordance with 690.9(A)(1), (A)(2), or (A)(3).

(1) Circuits Where Overcurrent Protection Not Required. Overcurrent protective devices shall not be required where both of the following conditions are met:

(1) The conductors have sufficient ampacity for the maximum circuit current.
(2) The currents from all sources do not exceed the maximum overcurrent protective device rating specified for the PV module or electronic power converter.

Larger or Substantive changes:

The new Section **690.9(A)(3)** addresses installations where conductor overcurrent protection can be provided at *either* the supply end or the load end of the circuit. The provisions provide length limitations to be complied with, and where installed in a building, physical protection must be provided by metal raceways or cable armor.

This is similar to the tap rules found in 240.21 but without a tap. For example a ground-mounted array with the PV output circuit entering a building, the overcurrent device for this circuit can be located within the disconnecting means located at the load end *inside the building*.

(3) Other Circuits. Circuits that do not comply with 690.9(A)(1) or (A)(2) shall be protected with one of the following methods:

(1) Conductors not greater than 3 m (10 ft) in length and not in buildings, protected from overcurrent on one end
(2) Conductors not greater than 3 m (10 ft) in length and in buildings, protected from overcurrent on one end and in a raceway or metal clad cable
(3) Conductors protected from overcurrent on both ends
(4) Conductors not installed on or in buildings are permitted to be protected from overcurrent on one end of the circuit where the circuit complies with all of the following conditions:

a. The conductors are installed in metal raceways or metal-clad cables, or installed in enclosed metal cable trays, or underground, or where directly entering pad-mounted enclosures.
b. The conductors for each circuit terminate on one end at a single circuit breaker or a single set of fuses that limit the current to the ampacity of the conductors.
c. The overcurrent device for the conductors is an integral part of a disconnecting means or shall be located within 3 m (10 ft) of conductor length of the disconnecting means.
d. The disconnecting means for the conductors is installed outside of a building, or at a readily accessible location nearest the point of entrance of the conductors inside of a building, including installations complying with 230.6.

Larger or Substantive changes:

In Section 690.12 working with rapid shutdown of the PV system much is modified.

Now conductors that are considered outside the array boundary, as defined in 690.12(B), are those that are 1 foot from the array in all directions. These requirements have not changed.

690.12 Rapid Shutdown of PV Systems on Buildings. PV system circuits installed on or in buildings shall include a rapid shutdown function to reduce shock hazard for firefighters in accordance with 690.12(A) through (D).

Exception: Ground-mounted PV system circuits that enter buildings, of which the sole purpose is to house PV system equipment, shall not be required to comply with 690.12.

(A) Controlled Conductors. Requirements for controlled conductors shall apply to the following:

(1) PV system dc circuits
(2) Inverter output circuits originating from inverters located within the array boundary

Informational Note: The rapid shutdown function reduces the risk of electrical shock that dc circuits in a PV system could pose for firefighters. The ac output conductors from PV systems that include inverters will either be de-energized after shutdown initiation or will remain energized by other sources such as a utility service. To prevent PV arrays with attached inverters from having energized ac conductors within the PV array(s), those circuits are also specifically controlled after shutdown initiation.

(B) Controlled Limits. The use of the term *array boundary* in this section is defined as 305 mm (1 ft) from the array in all directions. Controlled conductors outside the array boundary shall comply with 690.12(B)(1) and inside the array boundary shall comply with 690.12(B)(2).

Requirements for conductors inside the array boundary, as defined in 690.12(B)(2), have been changed to align with the new product standard being developed by Underwriters Laboratories (UL). UL 3741 standard will recognize these systems as “Hazard Control” systems. That terminology is incorporated into the requirements found in 690.12(B)(2)(1).

(2) Inside the Array Boundary. The PV system shall 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.

Informational Note: A listed or field-labeled hazard PV control system is comprised of either an individual piece of equipment that fulfills the necessary functions or multiple pieces of equipment coordinated to perform the functions as described in the installation instructions to reduce the risk of electric shock hazard within a damaged PV array for fire fighters. See UL 3741, *Photovoltaic Hazard Control.*

(2) Controlled conductors located inside the boundary 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 or conductive parts and be installed more than 2.5 m (8 ft) from exposed grounded conductive parts or ground.

Once the new standard is accepted, and products are developed, the installer will still have three choices:

1) A system that is listed to UL 3741
2) A system that reduces the voltage within the array to 80 volts within 30 seconds
3) Or a totally isolated system with no exposed wiring methods or conductive parts such as integrated roof shingles that constitute a PV system.

In Section 690.13(A) states that if a PV system disconnecting means is installed in a location where it is readily accessible to unqualified persons, and the conductors are energized at 30 volts or more, the disconnecting means shall be required to be lockable or require a tool to open the disconnecting means in order to limit accessibility.

690.13 Photovoltaic System Disconnecting Means. Means shall be provided to disconnect the PV system from all wiring systems including power systems, energy storage systems, and utilization equipment and its associated premises wiring.

(A) Location. The PV system disconnecting means shall be installed at a readily accessible location. Where disconnecting means of systems above 30 V are readily accessible to unqualified persons, any enclosure door or hinged cover that exposes live parts when open shall be locked or require a tool to open.

Informational Note: PV systems installed in accordance with 690.12 address the concerns related to energized conductors entering a building.

Section 690.13(E) was changed by referring to 110.25 and now requires a PV system disconnect to be lockable. This extends the requirements to remote operating devices that are used to *control* the disconnecting means.

Additionally the type of disconnecting means to be used was put into a list format as List Items (1) through (5).

(E) Type of Disconnect. The PV system disconnecting means shall simultaneously disconnect the PV system conductors that are not solidly grounded from all conductors of other wiring systems. The PV system disconnecting means or its remote operating device or the enclosure providing access to the disconnecting means shall be capable of being locked in accordance with 110.25. The PV system disconnecting means shall be one of the following:

(1) A manually operable switch or circuit breaker
(2) A connector meeting the requirements of 690.33(D)(1) or (D)(3)
(3) A pull-out switch with the required interrupting rating
(4) A remote-controlled switch or circuit breaker that is operable locally and opens automatically when control power is interrupted
(5) A device listed or approved for the intended application

Informational Note: Circuit breakers marked "line" and "load" may not be suitable for backfeed or reverse current.

The intention here is to clarify that the requirements located in 690.13 address how a PV system is isolated from all other systems in a building or structure.

Section 690.15 address the isolation of PV system equipment for safety purposes when servicing equipment. A single disconnecting means may be able to be used to satisfy both requirements of 690.13 and 690.15.

690.15 Disconnecting Means for Isolating Photovoltaic Equipment. Disconnecting means of the type required in 690.15(D) shall be provided to disconnect ac PV modules, fuses, dc-to-dc converters, inverters, and charge controllers from all conductors that are not solidly grounded.

(A) Location. Isolating devices or equipment disconnecting means shall be installed in circuits connected to equipment at a location within the equipment, or within sight and within 3 m (10 ft) of the equipment. An equipment disconnecting means shall be permitted to be remote from the equipment where the equipment disconnecting means can be remotely operated from within 3 m (10 ft) of the equipment. Where disconnecting means of equipment operating above 30 volts are readily accessible to unqualified persons, any enclosure door or hinged cover that exposes live parts when open shall be locked or require a tool to open.

Section 690.15(A) was also modified to add the requirement of requiring a lock or a tool to open *if accessible to unqualified persons*.

(B) Isolating Device. An isolating device shall not be required to have an interrupting rating. Where an isolating device is not rated for interrupting the circuit current, it shall be marked "Do Not Disconnect Under Load" or "Not for Current Interrupting." An isolating device shall not be required to simultaneously disconnect all current-carrying conductors of a circuit. The isolating device shall be one of the following:

(1) A mating connector meeting the requirements of 690.33 and listed and identified for use with specific equipment
(2) A finger-safe fuse holder
(3) An isolating device that requires a tool to place the device in the open (off) position
(4) An isolating device listed for the intended application

(C) Equipment Disconnecting Means. Equipment disconnecting means shall have ratings sufficient for the maximum circuit current, available fault current, and voltage that is available at the terminals. Equipment disconnecting means shall simultaneously disconnect all current-carrying conductors that are not solidly grounded to the circuit to which it is connected. Equipment disconnecting means shall be externally operable without exposing the operator to contact with energized parts and shall indicate whether in the open (off) or closed (on) position. Where not within sight or not within 3 m (10 ft) of the equipment, the disconnecting means or its remote operating device or the enclosure providing access to the disconnecting means shall be capable of being locked in accordance with 110.25. Equipment disconnecting means, where used, shall be one of the types in 690.13(E)(1) through (E)(5).

Equipment disconnecting means, other than those complying with 690.33, shall be marked in accordance with the warning in 690.13(B) if the line and load terminals can be energized in the open position.

Informational Note: A common installation practice is to terminate PV source-side dc conductors in the same manner that utility source-side ac conductors are generally connected on the line side of a disconnecting means. This practice is more likely to de-energize load-side terminals, blades, and fuses when the disconnect is in the open position and no energized sources are connected to the load side of the disconnect.

Much of 690.15 directs you to 690.15(D) to indicate the type of disconnecting means that is permitted to be used for isolating equipment. A change in 690.15 also that removes PV modules from the list of equipment requiring a disconnect for isolation purposes.

In some PV systems the listed modules include a junction box and are direct wired. In this case the *string* will have an isolation disconnect but not each module.

Installers can install modules with listed connectors to use them to isolate the modules individually rather than at the string level.

(D) Type of Disconnecting Means. Where disconnects are required to isolate equipment, the disconnecting means shall be one of the following applicable types:

(1) An equipment disconnecting means in accordance with 690.15(C) shall be required to isolate dc circuits with a maximum circuit current over 30 amperes.

(2) An isolating device in accordance with 690.15(B) shall be permitted for circuits other than those covered by 690.15(D)(1).

At This time we will enjoy a welcome break by bringing in my colleague from Minnesota Power - Paul Helstrom is a MP Customer Programs Representative and has kindly volunteered to give us a brief update on some additional policy and code issues to be thinking about…

Paul has led an interesting career working with solar companies in the region, including heading up management of my office when we were covering the retail, wholesale and training divisions of Great Northern Solar…

He has been a great man to work with and has kept his sense of humor through it all!

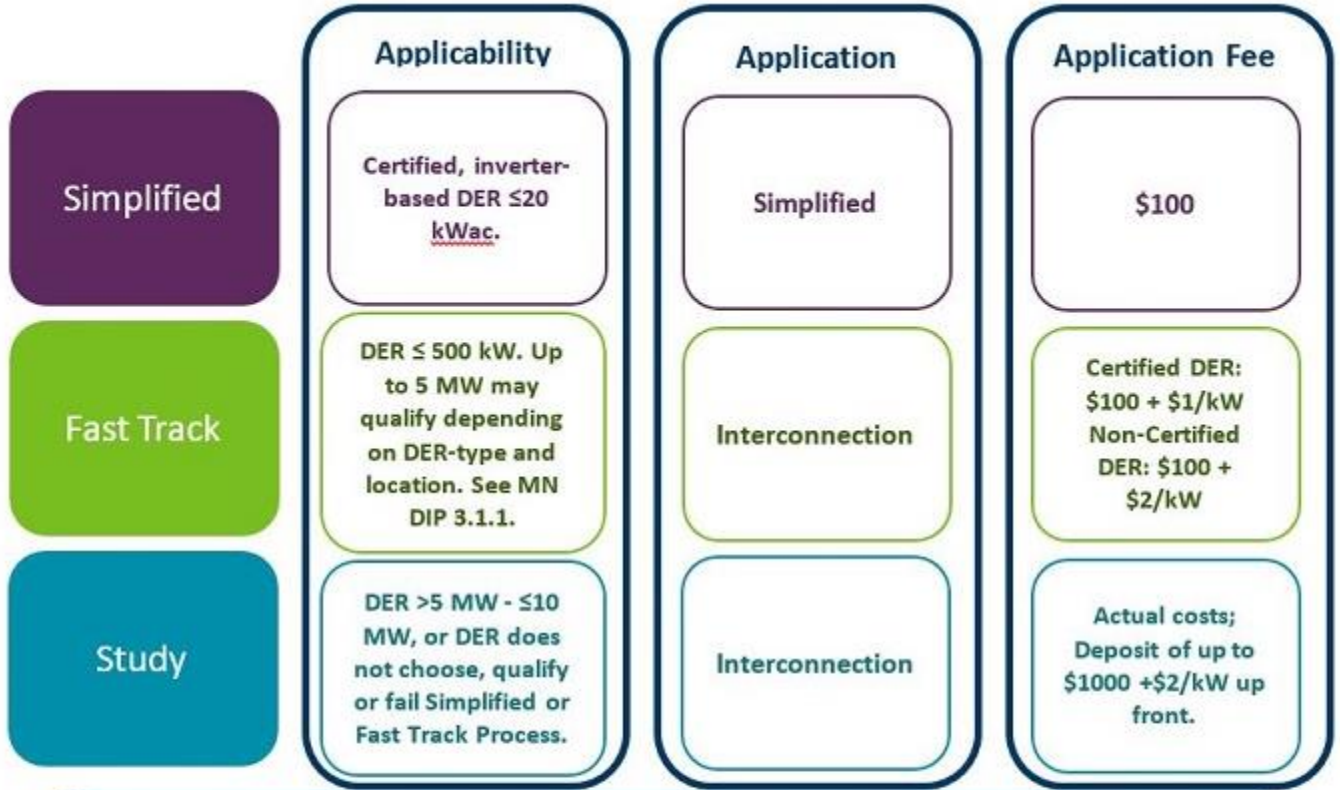
Greetings Paul -

Minnesota Distributed Energy Resource Interconnection Process (MnDIP)

218 496 5716

For a full flow chart of the Minnesota Distributed Energy Resource Interconnection Process (MN DIP), see Attachment 8 to the MN DIP.

https://mn.gov/puc/energy/distributed-energy/interconnection/



https://mn.gov/puc/energy/distributed-energy/interconnection/

Residential Code:

Rooftop set backs coming into effect

R324.6 Roof access and pathways.

- Roof access, pathways and setback requirements shall be provided in accordance with Sections R324.6.1 through R324.6.2.1.

- Access and minimum spacing shall be required to provide emergency access to the roof, to provide pathways to specific areas of the roof, provide for smoke ventilation opportunity areas, and to provide emergency egress from the roof.

Exceptions:

1. Detached, nonhabitable structures, including but not limited to detached garages, parking shade structures, carports, solar trellises and similar structures, shall not be required to provide roof access.

2. Roof access, pathways and setbacks need not be provided where the code official has determined that rooftop operations will not be employed.

3. These requirements shall not apply to roofs with slopes of two units vertical in 12 units horizontal (17-percent slope) or less.

R324.6.1 Pathways.

- Not fewer than two pathways, on separate roof planes from lowest roof edge to ridge and not less than 36 inches (914 mm) wide, shall be provided on all buildings.

- Not fewer than one pathway shall be provided on the street or driveway side of the roof.

- For each roof plane with a photovoltaic array, a pathway not less than 36 inches wide (914 mm) shall be provided from the lowest roof edge to ridge on the same roof plane as the photovoltaic array, on an adjacent roof plane, or straddling the same and adjacent roof planes.

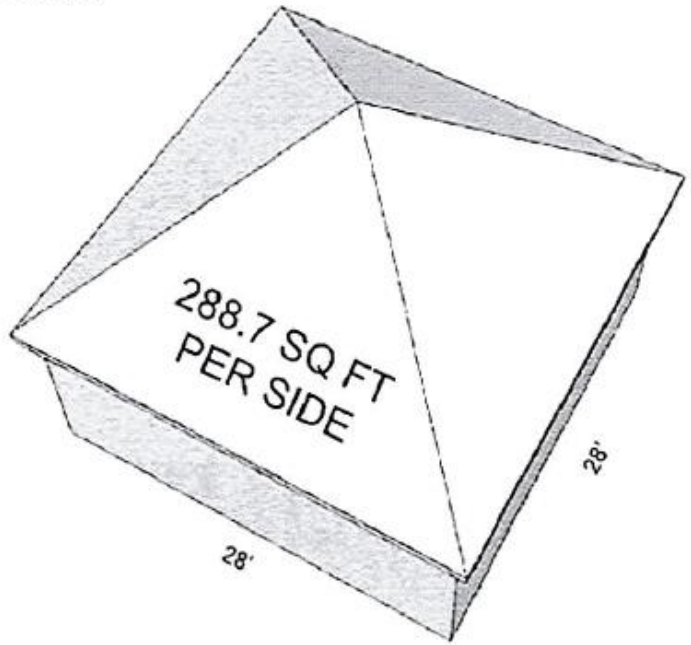
- Pathways shall be over areas capable of supporting fire fighters accessing the roof.

- Pathways shall be located in areas with minimal obstructions such as vent pipes, conduit, or mechanical equipment.

EXAMPLE LAYOUT

built

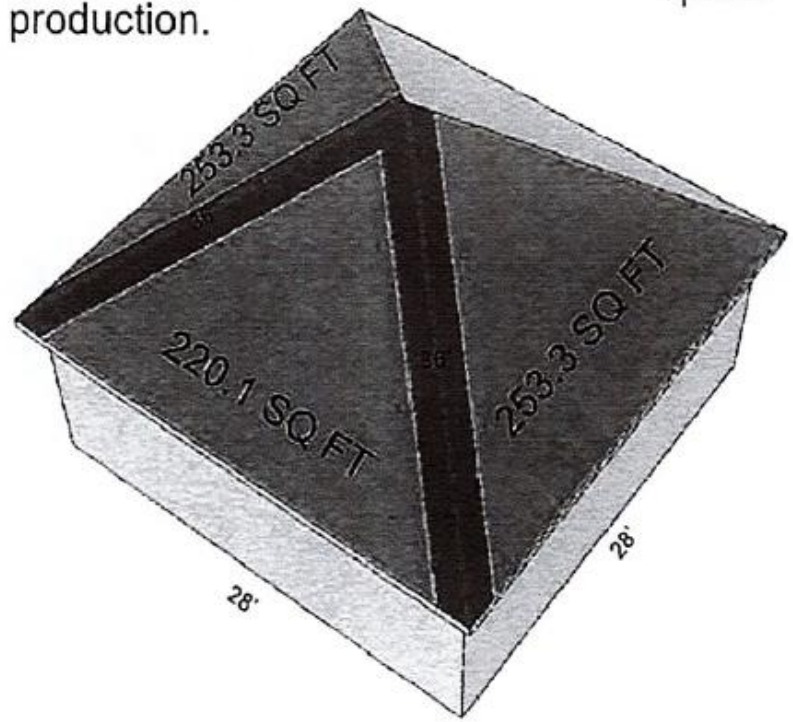
866.1 SQ FT of viable roof space for solar production.



SOUTH

726.7 SQ FT of viable roof space for solar production.

16.1% reduction in available roof space

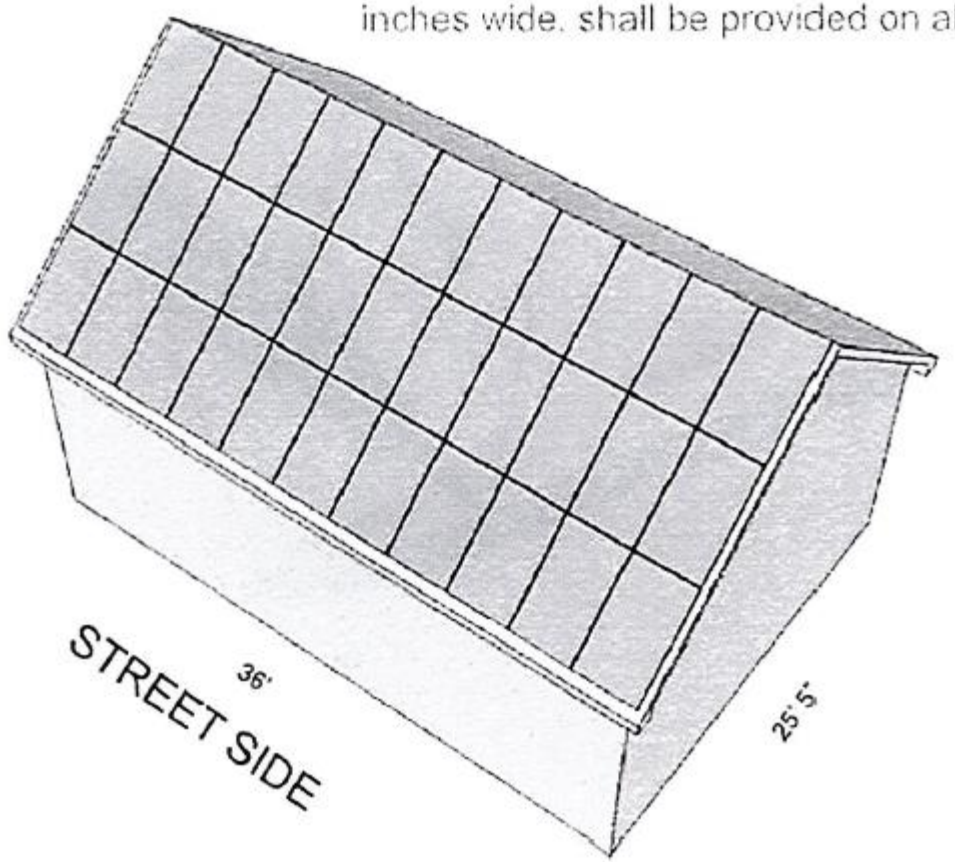


Mock-up courtesy of All Energy Solar

EXAMPLE LAYOUT

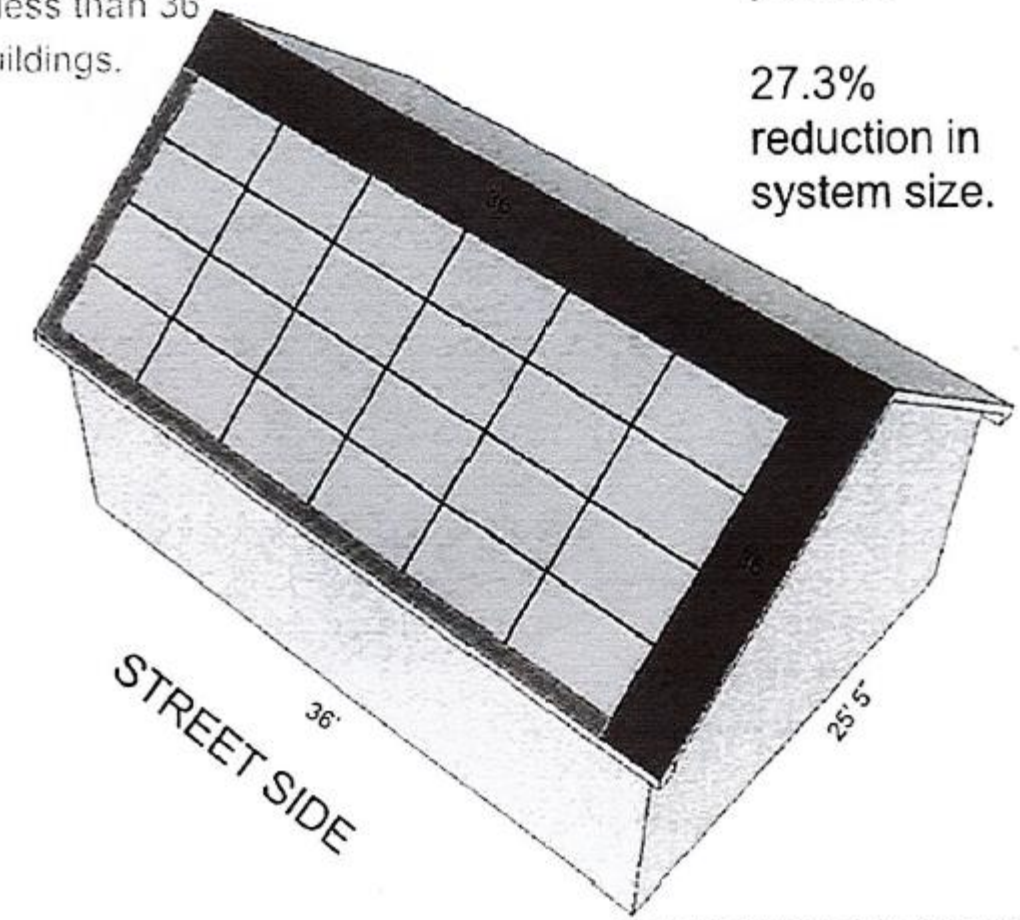
- Not fewer than one pathway shall be provided on the street or driveway side of the roof.
- Not fewer than 2 pathways. on separate roof planes from lowest roof edge to ridge and not less than 36 inches wide. shall be provided on all buildings.

33 total solar panels.



24 total solar panels.

27.3% reduction in system size.

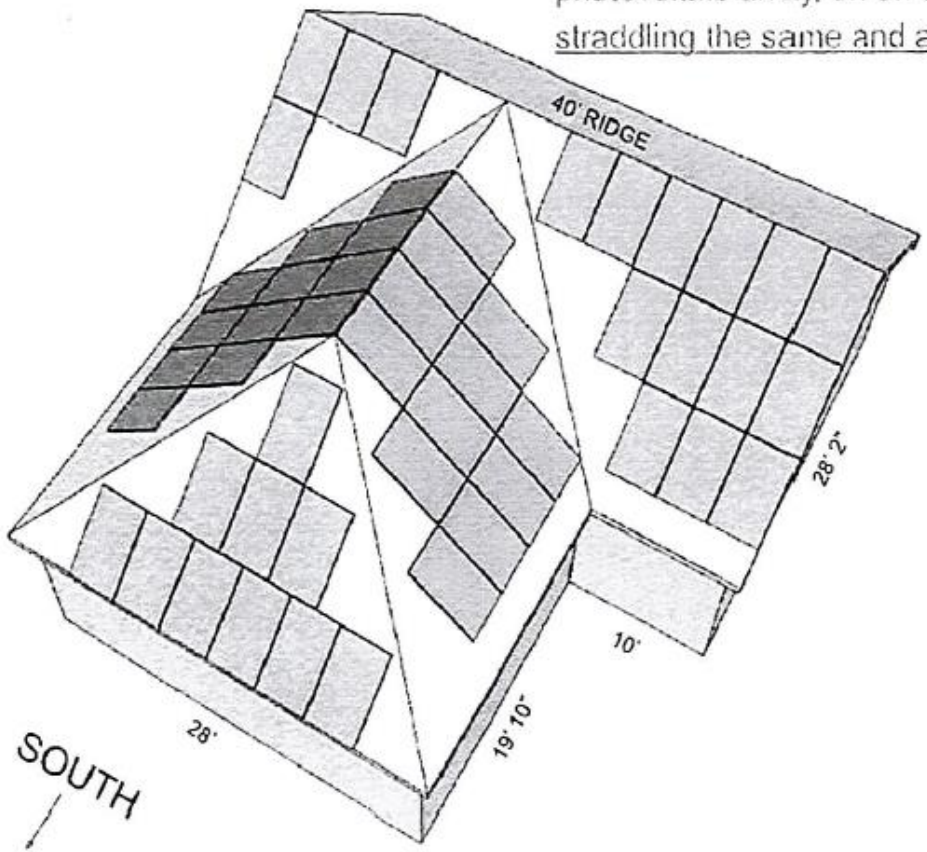


Mock-up courtesy of All Energy Solar

EXAMPLE LAYOUT

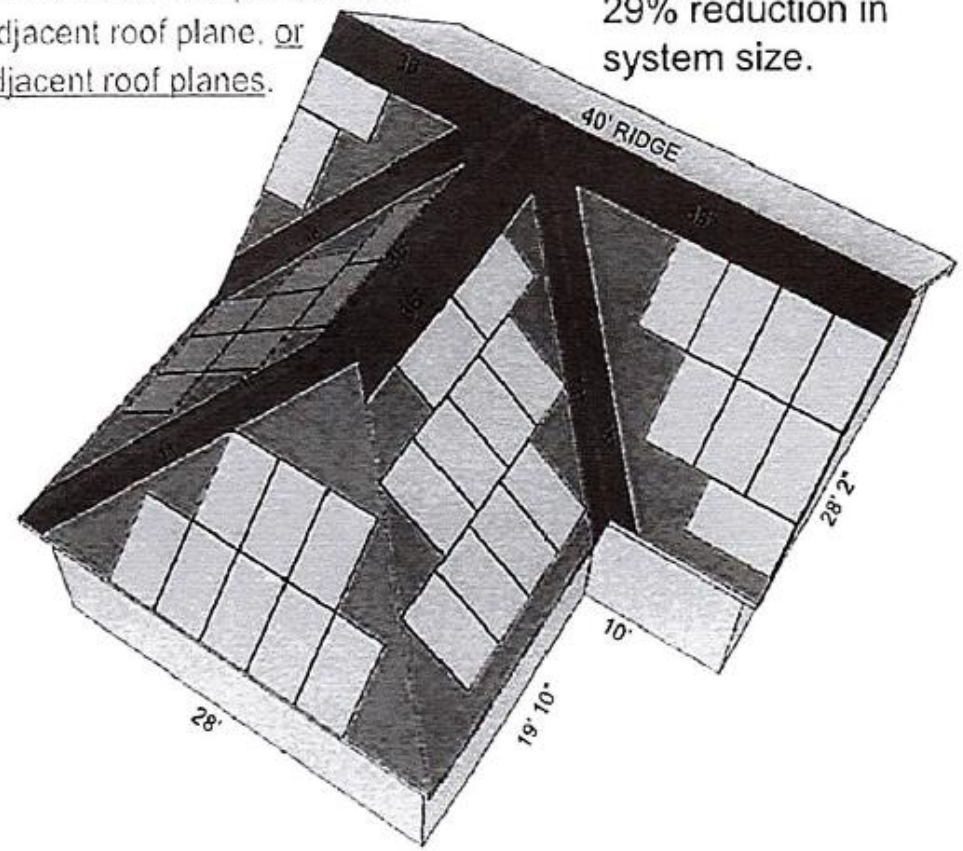
- For each roof plane with a photovoltaic array, a pathway not less than 36 inches wide shall be provided from the lowest roof edge to ridge on the same roof plane as the photovoltaic array, on an adjacent roof plane, or straddling the same and adjacent roof planes.

51 total solar panels.



36 total solar panels.

29% reduction in system size.



Mock-up courtesy of All Energy Solar

So now we return to the joys of the 2020 NEC up date…

Coffee in hand – here we go!

Section 690.31 includes several revisions:

In 690.31(A) the table has been changed to recognize correction factors that can be used when ambient temperatures exceed the values given in Table 310.16 and conductors that have higher temperature ratings are used.

This change does not encompass all conductors that are rated at higher temperatures.

In those instances, engineering supervision and/or manufacturer's instructions will be necessary. This change added Table 690.31(A)(b) for the ampacities of some high temperature rated conductors.

Table 690.31(A)(b) Ampacities of Insulated Conductors Rated Up To and Including 2000 Volts, 105°C Through 125°C (221°F Through 257°F), Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried), Based on Ambient Temperature of 30°C (86°F)

AWG	Types	
	PVC, CPE, XLPE 105°C	XLPE, EPDM 125°C
18	15	16
16	19	20
14	29	31
12	36	39
10	46	50
8	64	69
6	81	87
4	109	118
3	129	139
2	143	154
1	168	181
1/0	193	208
2/0	229	247
3/0	263	284
4/0	301	325

In 690.31(B) was revised to recognize integrated Class 1 circuits being placed in raceways and cable systems also used for PV system DC circuits.

An exception to the separation requirements was also added for jacketed and metal clad cable assemblies with a restriction of being rated for the highest voltage available for all of the contained circuits.

(B) Identification and Grouping. PV system dc circuits and Class 1 remote control, signaling, and power-limited circuits of a PV system shall be permitted to occupy the same equipment wiring enclosure, cable, or raceway. PV system dc circuits shall not occupy the same equipment wiring enclosure, cable, or raceway. as other non-PV systems, or inverter output circuits,

unless the PV system dc circuits are separated from other circuits by a barrier or partition. PV system circuit conductors shall be identified and grouped as required by 690.31(B)(1) and (B)(2).

Exception: PV system dc circuits utilizing multiconductor jacketed cable or metal-clad cable assemblies or listed wiring harnesses identified for the application shall be permitted to occupy the same wiring method as inverter output circuits and other non-PV systems. All conductors, harnesses, or assemblies shall have an insulation rating equal to at least the maximum circuit voltage applied to any conductor within the enclosure, cable, or raceway.

Section 690.31(B)(1) was modified to require a marking scheme for PV system conductors that consists of either color coding *or* labeling - to consist of either “+,” “POSITIVE,” or “POS” durably marked for the positive conductor and either “-,” “NEGATIVE,” or “NEG” symbol for the negative conductor.

This will, however, change to the marking required for a grounded conductor in Section 200.6 if the system contained a solidly grounded conductor.

(1) Identification. PV system dc circuit conductors shall be identified at all termination, connection, and splice points by color coding, marking tape, tagging, or other approved means. Conductors relying on other than color coding for polarity identification shall be identified by an approved permanent marking means such as labeling, sleeving, or shrink-tubing that is suitable for the conductor size. The permanent marking means for nonsolidly grounded positive conductors shall include imprinted plus signs (+) or the word POSITIVE or POS durably marked on insulation of a color other than green, white, or gray. The permanent marking means for nonsolidly grounded negative conductors shall include imprinted negative signs (−) or the word NEGATIVE or NEG durably marked on insulation of a color other than green, white, gray, or red. Only solidly grounded PV system dc circuit conductors shall be marked in accordance with 200.6.

Exception: Where the identification of the conductors is evident by spacing or arrangement, further identification shall not be required.

Section 690.31(C) now recognizes listed Type DG (Distributed Generation) cable as a recognized wiring method and the terminology for “Sunlight Resistant” was modified for better alignment with the product standards (UL 4703, Standard for Photovoltaic Wire, for PV wire and UL 3003, Distributed Generation Cables, for DG cable).

Additionally 690.31(C)(1)(2) was revised to recognize a distance of 24 in. between supports for single-conductor cable rather than the previous requirement to comply with 334.30 (12 in.).

The previous support requirement of 12 in. for module junction boxes is too close for the removal of modules.

The 4½ ft spacing between supports permitted by 334.30 is too long allowing conductors to sag.

(C) Cables. Type PV wire or cable and Type distributed generation (DG) cable shall be listed.

Informational Note: See UL 4703, *Standard for Photovoltaic Wire*, for PV wire and UL 3003, *Distributed Generation Cables*, for DG cable.

(1) Single-Conductor Cable. Single-conductor cable in exposed outdoor locations in PV system dc circuits within the PV array shall be permitted to be one of the following:

(1) PV wire or cable
(2) Single-conductor cable marked sunlight resistant and Type USE-2 and Type RHW-2

Exposed cables shall be supported and secured at intervals not to exceed 600 mm (24 in.) by cable ties, straps, hangers, or similar fittings listed and identified for securement and support in outdoor locations. PV wire or cable shall be permitted in all locations where RHW-2 is permitted.

Exception: PV systems meeting the requirements of 691.4 shall be permitted to have support and securement intervals as defined in the engineered design.

Also in 690.31 the use of multiconductor jacketed cables is covered.

In 690.31(C)(3) these cables are limited to the rooftop area unless contained in a raceway and listed for the application.

There are support requirements for these cables and language that permits their use underground if they are listed for underground installation.

(3) Multiconductor Jacketed Cables. Where part of a listed PV assembly, multiconductor jacketed cables shall be installed in accordance with the included instructions. Where not part of a listed assembly, or where not otherwise covered in this *Code*, multiconductor jacketed cables, including DG cable, shall be installed in accordance with the product listing and shall be permitted in PV systems. These cables shall be installed in accordance with the following:

(1) In raceways, where on or in buildings other than rooftops
(2) Where not in raceways, in accordance with the following:
   a. Marked sunlight resistant in exposed outdoor locations
   b. Protected or guarded, where subject to physical damage
   c. Closely follow the surface of support structures
   d. Secured at intervals not exceeding 1.8 m (6 ft)
   e. Secured within 600 mm (24 in.) of mating connectors or entering enclosures
   f. Marked direct burial, where buried in the earth

Another change occurs in 690.33(C) where a sentence was added to address the "intermatability" of connectors used for connection and splicing of PV conductors.

This new "intermatability" requirement will add an additional layer of safety similar to classified circuit breaker requirements.

690.33 Mating Connectors. Mating connectors, other than connectors covered by 690.32, shall comply with 690.33(A) through (D).

(A) Configuration. The mating connectors shall be polarized and shall have a configuration that is noninterchangeable with receptacles in other electrical systems on the premises.

(B) Guarding. The mating connectors shall be constructed and installed so as to guard against inadvertent contact with live parts by persons.

(C) Type. The mating connectors shall be of the latching or locking type. Mating connectors that are readily accessible and that are used in circuits operating at over 30 volts dc or 15 volts ac shall require a tool for opening. Where mating connectors are not of the identical type and brand, they shall be listed and identified for intermatability, as described in the manufacturer's instructions.

Section 690.41(B)(1) adds a sentence and an informational note relative to ground-fault protection in systems which employs DC to DC converters.

DC to DC converters are also being used as rapid shutdown or hazard control devices.

The problem addressed at 690.41(B)(1) is the fact that these devices are incorporated between the modules and the conversion equipment. This configuration may block the recognition of a ground fault.

Equipment manufacturers will have to address this issue.

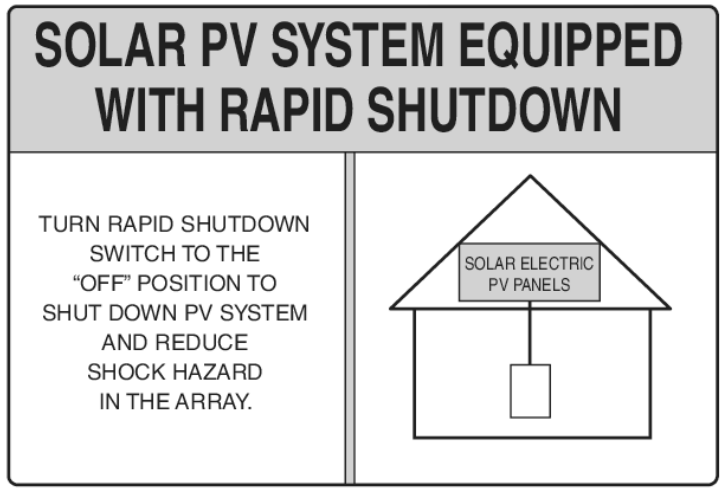
(1) **Ground-Fault Detection.** The ground-fault protection device or system shall detect ground fault(s) in the PV system dc circuit conductors, including any functional grounded conductors, and be listed for providing PV ground-fault protection. For dc-to-dc converters not listed as providing ground-fault protection, where required, listed ground fault protection equipment identified for the combination of the dc-to-dc converter and ground-fault protection device shall be installed to protect the circuit.

Informational Note: Some dc-to-dc converters without integral ground-fault protection on their input (source) side can prevent other ground-fault protection equipment from properly functioning on portions of PV system dc circuits.

Section 690.56(C) - requirements for the labeling of buildings with PV systems and “Rapid Shutdown” have been revised to reflect the delayed implementation date of January 1, 2019, that appeared in the 2017 NEC.

The labels will now read as follows: “SOLAR PV SYSTEM IS EQUIPPED WITH RAPID SHUTDOWN. TURN RAPID SHUTDOWN SWITCH TO THE ‘OFF’ POSITION TO SHUT DOWN PV SYSTEM AND REDUCE SHOCK HAZARD IN ARRAY.”

Other label arrangements and/or diagrams are acceptable.



Informational Note Figure 690.56(C) Label for Roof-Mounted PV Systems with Rapid Shutdown.

690.56 Identification of Power Sources.

(A) Facilities with Stand-Alone Systems. Plaques or directories shall be installed in accordance with 710.10.

(B) Facilities with Utility Services and Photovoltaic Systems. Plaques or directories shall be installed in accordance with 705.10 and 712.10, as required.

(C) Buildings with Rapid Shutdown. Buildings with PV systems shall have a permanent label located at each service equipment location to which the PV systems are connected or at an approved readily visible location and shall indicate the location of rapid shutdown initiation devices. The label shall include a simple diagram of a building with a roof and shall include the following words:

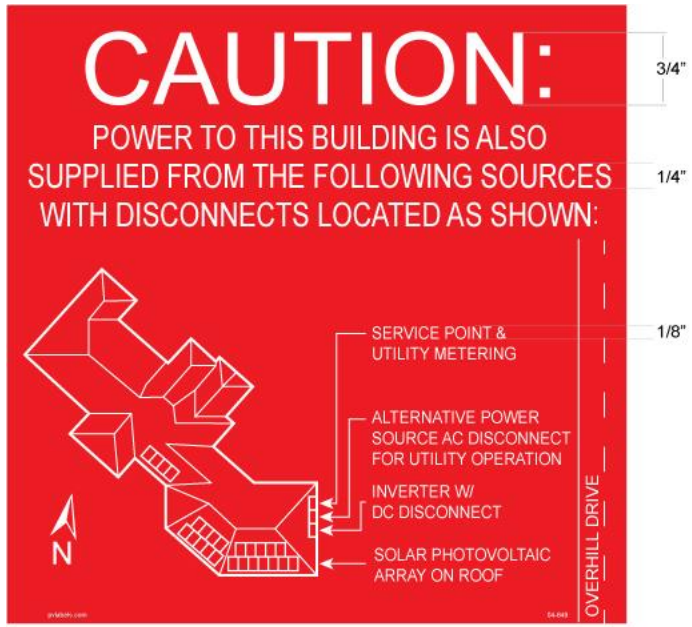
SOLAR PV SYSTEM IS EQUIPPED WITH RAPID SHUT-DOWN.
TURN RAPID SHUTDOWN SWITCH TO THE “OFF” POSI-TION TO SHUT DOWN
PV SYSTEM AND REDUCE SHOCK HAZARD IN ARRAY.

The title “SOLAR PV SYSTEM IS EQUIPPED WITH RAPID SHUTDOWN” shall utilize capitalized characters with a minimum height of 9.5 mm (⅜ in.) in black on yellow background, and the remaining characters shall be capitalized with a minimum height of 4.8 mm (³⁄₁₆ in.) in black on white background.

Informational Note: See Informational Note Figure 690.56(C).

The article continues to require placarding and a diagram if the building has *more than one type of system*.

The placarding is required to be placed at each service equipment location.

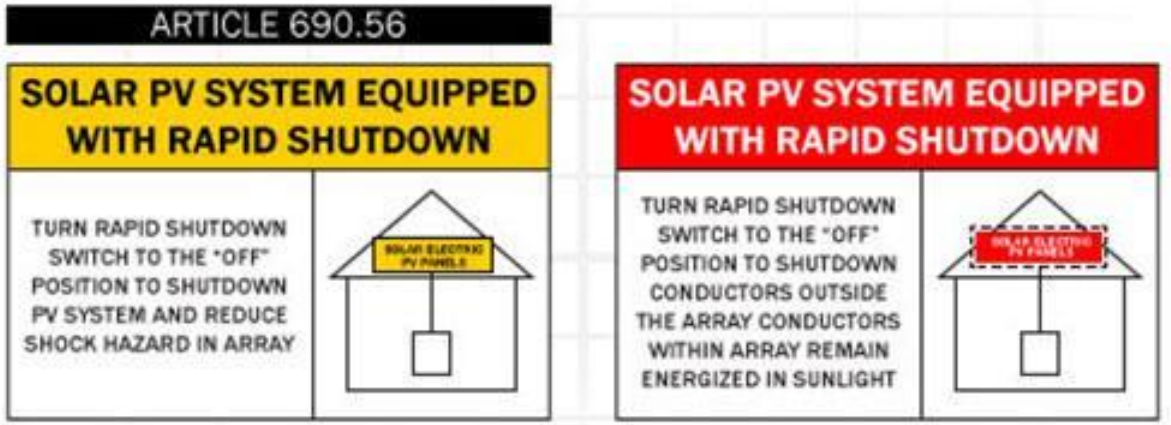


SDG&E LETTERS SIZE EXAMPLE

LADWP REQUIRES ALL 3/8" LETTERS-AVAILABLE IN THIS SIZE PLACARD OR ITEM# 04-648

6 ½" X 6 ½"

(1) Buildings with More Than One Rapid Shutdown Type. For buildings that have PV systems with more than one rapid shutdown type or PV systems with no rapid shutdown, a detailed plan view diagram of the roof shall be provided showing each different PV system with a dotted line around areas that remain energized after rapid shutdown is initiated.



Several additional articles apply to Solar Electric systems:

Article 705 - Interconnected Electric Power Production Sources.
The article is not limited to PV but any onsite power production source that is intended to interconnect with a utility power system.

Article 705 was revised in 2020 NEC which reduced the articles size. Part II for Interactive Inverters and Part III for Generators were consolidated into Part I to address all types of power sources and make it simpler to understand.

The definition of Power Source Output Circuit is defined as “the conductors between power production equipment or a power source and the service or distribution equipment.” This definition better describes what was referred to as an inverter output circuit. These conductors may or may not be from an inverter output.

A new Section 705.11 was created clearly define the installation of a supply-side disconnecting means, grounding and bonding requirements, conductor sizing, and wiring methods when interconnections are being made ahead of the service main disconnecting means as permitted in 230.82(6). This section is subdivided from 705.11(A) to 705.11(E).

705.11 Supply-Side Source Connections. 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).

(A) Output Rating. The sum of the power source continuous current output ratings on a service, other than those controlled in accordance with 705.13, shall not exceed the ampacity of the service conductors.

Informational Note: See Article 100 definition for Service Conductors.

(B) Conductors. The power source output circuit conductors from the service conductors point of connection to the first overcurrent protection device shall be sized in accordance with 705.28 and in no case sized smaller than 6 AWG copper or 4 AWG aluminum. These conductors shall be installed in accordance with 230.30 or 230.43.

(C) Overcurrent Protection. The power source output circuit conductors shall be protected from overcurrent in accordance with 705.30. If fuses are not integral with the disconnecting means, the disconnecting means shall be located on the service side of the fuses. Where the power source output circuit conductors make their connection to the service outside of a building, they shall be protected by overcurrent devices in a readily accessible location outside the building or at the first readily accessible location where the power source conductors enter the building. Where the power source output circuit conductors make their connection to the service inside a building, they shall be protected with one of the following methods:

(1) With an overcurrent device located within 3 m (10 ft) of conductor length in dwelling units and 5 m (16.5 ft) in other than dwelling units from the point of connection to the service

(2) In other than a dwelling unit, with an overcurrent device located within 20 m (71 ft)of conductor length from the point of connection to the service, provided that cable limiters installed in all ungrounded conductors are located within 5 m (16.5 ft) of conductor length from the point of connection to the service

(D) Connections. The connection of power source output circuit conductors to the service conductors shall be made using listed connectors as described in 110.14 and comply with all enclosure fill requirements Any modifications to existing equipment shall be made in accordance with the manufacturer's instructions or the modification must be evaluated for the application and have a field label applied. For meter socket enclosures or other equipment under the exclusive control of the electric utility, only connections approved by the electric utility shall be permitted.

(E) Ground-Fault Protection. For connections rated 1000 amperes or more to solidly grounded wye services exceeding 150 volts to ground but not exceeding 1000 volts, phase-to-phase, ground-fault protection meeting the requirements of 230.95 shall be provided.

Section 705.11(B) provides the minimum conductor size of 6 AWG copper or 4 AWG aluminum and requires wiring methods meeting the requirements of 230.30 (*underground service conductor installations*) or 230.43 (*wiring methods for 1000 volts, nominal, or less*).

Section 705.11(C) establishes conductor length limitations where the power source output circuit conductors make their connection to the service inside a building depending on whether the connections are made in a dwelling unit or other than a dwelling unit.

Note that the length specified is *total conductor length* not the distance between enclosures or the length of a raceway.

Section 705.13 defines the installation requirements for “Power Control Systems.”

Power control systems monitor and control multiple power sources, such as utility supply, energy storage systems, PV systems, and others. They are designed to control these systems for optimum energy conservation.

The systems also can prevent overloading of interconnections, whether made ahead of the service main or through the bussing of a panelboard.

705.13 Power Control Systems. A power control system (PCS) shall be listed and evaluated to control the output of one or more power production sources, energy storage systems (ESS), and other equipment. The PCS shall limit current and loading on the busbars and conductors supplied by the PCS.

For the circuits connected to a PCS, the PCS shall limit the current to the ampacity of the conductors or the ratings of the busbars to which it is connected in accordance with 705.13(A) through (E).

(A) Monitoring. The PCS controller shall monitor all currents within the PCS. Any busbar or conductor on the load side of the service disconnecting means that is not monitored by the PCS shall comply with 705.12. Where the PCS is connected in accordance with 705.11, the PCS shall monitor the service conductors and prevent overload of these conductors.

Finally Section 705.20 was revised to cover various requirements for disconnecting means that were located throughout Article 705.

This section covers the type of disconnecting means, simultaneous opening of all ungrounded conductors, ready access, external operability, the requirement for a tool to open if accessible to unqualified persons, indication (ON and OFF), ratings, and caution labels (if both sides are energized) all in one location.

705.20 Disconnecting Means, Source. Means shall be provided to disconnect power source output circuit conductors of electric power production equipment from conductors of other systems.

The disconnecting means shall comply with the following:

(1) Be one of the following types:
  (a) A manually operable switch or circuit breaker
  (b) A load-break-rated pull-out switch
  (c) A power-operated or remote-controlled switch or circuit breaker that is manually operable locally and opens automatically when control power is interrupted
  (d) A device listed or approved for the intended application

(2) Simultaneously disconnect all ungrounded conductors of the circuit

(3) Located where readily accessible

(4) Externally operable without exposed live parts

(5) Enclosures with doors or hinged covers with exposed live parts when open that require a tool to open or are lockable where readily accessible to unqualified persons

(6) Plainly indicate whether in the open (off) or closed (on) position

(7) Have ratings sufficient for the maximum circuit current, available fault current, and voltage that is available at the terminals

(8) Be marked in accordance with the warning in 690.13(B), where the line and load terminals are capable of being energized in the open position

Informational Note: With interconnected power sources, some equipment, including switches and fuses, is likely to be energized from both directions. See 240.40.

Additionally several other articles address other types of Renewable Energy Systems as well.

Article 691 covers Large-scale Photovoltaic systems (over 5000 Kw)

Article 692 covers Fuel cell systems

Article 694 covers Wind Systems

Article 706 covers Energy Storage Systems

Article 702 covers Optional Standby Systems

Questions?

Thank you for your interest in Renewable Energy and our Collective future!