Hooper City
Residential Solar Photovoltaic
(PV) System Plan Review

For systems utilizing a STRING OR CENTRAL INVERTER
with or without battery backup
(Revised 3/20/13)

BUILDING ADDRESS_____
SUBDIVISION_____LOT_____
OWNER'S NAME_____
CONTRACTOR_____

This checklist is compiled for plan checking purposes for residential solar photovoltaic (PV) systems utilizing a **STRING OR CENTRAL INVERTER** (non-micro inverter systems) with or without battery backup. The information contained herein is compiled from the *2011 National Electrical Code (NEC)*, manufacture and PV industry standards, and Hooper City requirements. This checklist is not intended to indicate any change in any code or ordinance by inference or omission.

Items circled on this checklist shall be corrected on the plans and the requested information shall be provided before a permit shall be issued. This checklist shall be attached to and become a part of the approved plans. Next to the item circled, put the page number of the plans or submitted info where the corrections were made.

Items checked on this checklist shall be corrected during construction and installation and will be verified during field inspection(s).

1. Site plan shall contain the following information:

- **1.1** On the site plan, show the location of the following: the home relative to property lines, all PV modules (solar panels), inverter(s), PV system disconnects, batteries (if used), and other associated PV equipment on the property.
- **1.2** If PV modules (solar panels) are going to be mounted on a detached structure, provide the size of the structure and distances to property lines in addition to all PV system components.
- **1.3** Additional comments:_____

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2. PV Module System Mounting shall meet the following requirements:

- **2.1** If PV modules (solar panels) are going to be mounted on the roof, the following must be provided:
  - 2.1.1 Note the type of roof covering on the home and how many layers.

2.1.2 Indicate what type of rafters the roof is composed of (engineered trusses, dimensional lumber, TJI ect…), and the size and spans of the rafters.

2.1.3 Provide manufacture info that shows the mounting system is listed for the mounting of PV modules on the roof.

2.1.4 The mounting system manufacture requirements must be submitted and all connections, support sizes, and support spacing noted. The manufacture specs must also show that the support system (with modules installed) can handle 3 second wind gusts up to 90 mph (in exposure B) and snow loads of 30 psf.

2.1.5 Provide manufacture info on weight of all supports and modules. The total combined weight of all supports and modules must not exceed 5 lbs per square foot (divide the total weight of all components by the amount of square footage area that the modules cover) and no more than 45 lbs per support (divide the total weight of all components by the number of supports). If loads exceed these numbers, or if the home's roof rafters are other than engineered trusses that do not meet the minimum requirements of the code, or if the roof covering is a heavy material (like tile), then an engineer analysis of the roof must be submitted and the roof deemed adequate to handle the new loads.

2.1.6 Provide information on how all roof penetrations (supports, J-boxes, conduit ect…) are going to be properly flashed.

2.1.7 Modules cannot be installed over or block any attic vents, plumbing vents, furnace or water heater vents ect…

2.2 If PV modules are going to be mounted on a detached structure the following must be provided:

2.2.1 A plan of the structure indicating that all associated requirements of the code are met (setbacks, square footage, footings, connectors, snow loads, wind loads ect…).

2.2.2 If a prebuilt manufactured structure designed for the mounting of PV modules is going to be used, then a complete set of manufacture instructions must be provided and all requirements followed.

2.2.3 The structure must be designed to handle 3 second wind gusts of up to 90 mph (in exposure B) and snow loads of 30 psf.

2.3 Additional comments:_____

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3. <u>Single-Line or Three-Line Diagram</u> must contain the following:

3.1 Please specify whether the PV system will have battery backup or not. Also indicate if the inverter is the "ungrounded" type (if applicable). Note: See also section 12 in this plan check if system will have battery backup, and see section 13 if system will have an "ungrounded" inverter (transformerless inverter).

3.2 Show the **<u>exact</u>** number and layout of the modules and how they are connected together (in series or parallel).

3.3 Show all PV system components like: J-boxes, combiner box, inverter(s), all disconnects, and other equipment like charge controllers and batteries if used. Indicate where all the components will be located in or on the home.

3.4 Indicate the home electrical panel that the PV system will tie into: to a sub-panel or to the home's electrical service panel. Give the amperage rating of that panel, the rating of the main breaker protecting that panel, and what breaker slot the PV tie-in-breaker will be located in that panel. *NEC* 690.64 and *NEC* 705.12 (see also **7.8** for more details)

3.5 A PV system will backfeed the home's electrical service panel regardless of where on the home's electrical system the PV circuits will be connected, because of this please note what type of service panel it is, the name of the manufacture, model #, and where in the service panel the backfed breaker is located: on the service (utility side) of the home's main breaker, or on the load (house side) of the home's main breaker. Please also provide a picture of the panel with the front panel door open, <u>and</u> pictures of interior labels if possible (due to safety concerns removing covers exposing live connections is **<u>NOT</u>** required). Detailed panel manufacture diagrams and info can be submitted in lieu of pictures. Please see **section 7.8** in this plan check for more information.

3.6 Show <u>all</u> wire sizes, and wire types. Please also include info for the size and type of existing feeder conductors for the electrical panel(s) being tied into and the size of each breaker protecting any panel that will be backfed by the new PV or battery system.

3.7 Indicate on plans where in or on the home each group of circuit conductors will be ran. If exposed outside, wires must be type USE-2 or listed "PV" conductors (*NEC* 690.31(B)). Wires installed outside (even if in conduit) must be listed for wet locations (*NEC* 300.9). All wires are strongly recommended to be rated 90°C (for example: RHW-2, THWN-2, and XHHW-2) due to deration issues.

3.8 Show conduit types, sizes, and how many conductors will be in each conduit.

3.9 Note that any **DC** circuits that penetrate and enter the home will be ran in metal conduit or be MC cable until the first readily accessible disconnect is reached. *NEC* 690.31(E)

3.10 Show the ratings of all fuses and breakers.

3.11 Additional comments:_____

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4. PV Module Information:

4.1 All PV Modules (solar panels), including any building-integrated PV (BIPV) modules, must be listed as per UL 1703 and be installed as per manufacture's requirements. *NEC* 690.4(D)

4.2 PV Module manufacture spec sheets must be provided giving the rated Watts (Pmp), rated Volts (Vmp), rated Amps (Imp), open circuit voltage (Voc), and short circuit current (Isc) of each module- **Must use Standard Testing Condition (STC) ratings**.

4.3 Building-integrated PV (BIPV) modules must be compatible with, and have equivalent strength and durability of that as is required for the type of exterior covering or roof system they are installed with.

4.4 Additional comments:_____

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5. Total System DC Power:

5.1 Provide the **total system DC** rated Wattage (Pmpp), rated Voltage (Vmpp), rated Amperage (Impp), max open circuit voltage (Voc) that has also been increased for coldest outside temperature (see *NEC* 690.7), and the max short circuit current (Isc). **Must use STC ratings only**.

5.2 The total system open circuit voltage (Voc), figured for the coldest possible outside temperature, cannot exceed 600 volts for a residential system. *NEC* 690.7

5.3 Additional comments:_____

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6. Inverter(s):

6.1 If the PV system is going to tie into the home's electrical system, provide manufactures info showing that the PV inverter(s) is/are the "utility interactive" type having anti-islanding protection, and be listed as meeting UL 1741 (*NEC* 690.4(D) and 690.60- 690.61).

6.2 PV inverters for residential use must be equipped with a ground fault protection device (GFPD). A listed detached GFPD is permitted to be used if one is not provided as part of the inverter and must be installed as per manufacture's instructions. *NEC* 690.5

6.3 Any PV system with **DC** circuits on or penetrating a building operating at 80 volts or more must be protected by a listed DC arc-fault circuit interrupter (AFCI) that is the "PV type" or have other components listed to provide equivalent protection, *NEC* 690.11. This device is permitted to be a detached device if not provided as part of the inverter and if installed as per manufacture's requirements.

6.4 Inverter manufacture spec sheets must be provided.

6.4.1 The manufacture spec sheets must show the following:

a. The maximum allowable current, voltage, and wattage (produced by the PV array or batteries) that the inverter can safely handle.

b. The inverter's AC max continuous output current (amps), and voltage.

c. How many strings (source circuits) can be combined together inside of the inverter. Note: see also section 7.1.1 for more info on source circuits.

d. If each string (source circuit) is protected by a fuse internal of the inverter please show the rating of each fuse. Also show whether the inverter allows backfeed or not if no fuses are provided for only one or two strings of modules.

6.5 Additional comments:_____

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7. <u>Circuit Conductors and Overcurrent Protection Devices</u>:

7.1 Circuit sizing and ratings:

Informational Note: As a general concept, PV modules (solar panels) connected in <u>series</u> have their voltages from each added together but the amps for the whole string (circuit) stay the same. Any parallel connections result in amps adding together, but voltage staying the same. These basic electrical concepts can also be applied to batteries.

7.1.1 The string or "source circuit" conductors' ampacity and its breaker or fuse rating must meet *NEC* 690.8(A)(1), (B)(1) and (B)(2). This would require that the short circuit current (Isc) STC rating of the source circuit be multiplied by 1.56 (note: 1.56 is used because 1.25 is applied twice). Use the final figured ampacity to size the conductors and to size the fuse or breaker protecting the string (source circuit). If the final figured ampacity does not correspond with a standard fuse or breaker size, then use the next size up, *NEC*

240.4(B). If the conductors' ampacity must be adjusted or corrected due to conduit fill, ambient temp., or in conduit exposed to sunlight on the roof, then *NEC* 690.8(B)(2) must be followed (see also 7.2 in this plan check for ampacity corrections and adjustments of conductors).

The string circuits (source circuits) may not be required to be protected by a fuse or breaker when only 2 strings are combined together at an inverter and if the inverter does not allow backfeed, *NEC* 690.9(A).

Note: the string or "source circuit" is the circuit(s) between the modules and a combiner box if a detached combiner box is used, or the circuit(s) between the modules and inverter if a detached combiner box is *not* used.

7.1.2 The PV output circuit (the circuit between a combiner box and the inverter) conductors' ampacity and its breaker or fuse rating must meet *NEC* 690.8(A)(2), (B)(1) and (B)(2). This would require simply adding together all the combining strings' (source circuits') Isc rating that has already been multiplied by 1.56 (as figured from section 7.1.1). If the total added Isc ratings of all combining strings (source circuits) does not correspond with a standard fuse or breaker size, then use the next size up. If the PV output circuit conductors' ampacity must be adjusted or corrected due to conduit fill, ambient temp., or for conduit exposed to sunlight on the roof, then *NEC* 690.8(B)(2) must be followed (see also section 7.2 in this plan check for conductor ampacity corrections and adjustments).

Overcurrent protection for the PV output circuit may not be needed if all of the following is met: each string circuit (source circuit) is protected by it's own fuse or breaker, there is only one PV output circuit connecting to the inverter, the PV output wires are sized to handle the combined short circuit currents (Isc) from all strings, and if the inverter does not allow backfeed, *NEC* 690.9(A).

Note: if the string (source circuit) conductors tie directly into the inverter and are not combined in a detached combiner box, then the system will not have a PV output circuit.

7.1.3 Breakers or fuses protecting **DC** circuits must be listed for **DC** use and be rated for the maximum cold temperature voltage (Voc) on that circuit, *NEC* 690.9(D).

7.1.4 The inverter's **AC** output circuit (the circuit between the inverter and the tie-in-breaker at the home's electrical panel) conductors' ampacity and breaker or fuse rating must meet *NEC* 690.8(A)(3), (B)(1) and (B)(2). This is figured by taking the inverter's rated continuous AC output amp rating and multiplying it by 1.25. Use the final figured ampacity to size the conductors and breaker. If the final ampacity does not correspond to a standard fuse or breaker

rating, use the next size up. See section 7.2 in this plan check if conductors' ampacity must be adjusted or corrected.

7.2 All conductors for **any** electrical system must be installed within their temperature range based on ambient temperature or the conductors' ampacity (as per *NEC* table 310.15(B)(16)) must be corrected and adjusted for the conditions of use. If more than 3 current carrying conductors will be ran in the same conduit, the ampacity of the wires must be adjusted as per *NEC* table 310.15(B)(3)(a). If wires are ran in conduit exposed to sunlight on the roof, the wires ampacity must be adjusted further as per **2011** *NEC* table 310.15(B)(3)(c), and table 310.15(B)(2)(a).

7.3 All PV source circuits, PV output circuits, and inverter AC output circuits must each be identified separately from one another by an approved marking or color coded tape at all points of terminations, connections, and splice points. All conductors from different PV systems entering the same enclosures must be grouped separately. *NEC* 690.4(B)(1-4)

7.4 Any conduits, enclosures, or MC cable that contain **DC** circuits shall be marked with the wording "Photovoltaic Power Source." The markings shall be provided at every enclosure, every 10' along conduit or MC cable, and at each side of where the conduit or cable passes through a wall, floor, or any other partition. The markings shall be permanently affixed and visible after installation. *NEC* 690.31(E)(3-4)

7.5 Any **DC** circuits that are ran in an attic must be installed at least 10" or more below the roof deck unless installed directly under the PV modules, *NEC* 690.31(E)(1).

7.6 All conductors (both AC and DC circuits) that are readily accessible or subject to damage must be protected (in conduit). *NEC* 690.31(A) and 300.4

7.7 The voltages of any DC circuits that feed DC utilization equipment must meet the requirements of *NEC* 210.6. *NEC* 690.7(B)

7.8 **PV point of connection breaker(s). This section also applies to any breakers, conductors, or equipment busbars that are backfed from a PV and/or battery system.**

7.8.1 All panel busbars and conductors in the home's electrical system that are backfed by the PV system must comply with a, b, c, and d. **Important: A PV system that is tied into a sub-panel not only effects the panel it is being connected to, but also <u>every</u> additional panel or conductors that are backfed all the way back to the electrical service panel. Compliance with all of 2011 *NEC* 705.12(A) & (D) is required for all panel busbars and conductors being backfed from the PV system- see *NEC* 705.12(D)(7) for panels in series.**

a. If the PV system is going to backfeed the home's electrical service box **on the supply side** (utility side) of the home's main service breaker(s), then the rating of the PV tie-in-breaker cannot exceed the rating of the service panel's busbars or the ampacity of the utility service conductors.

For example: if the service panel busbars are rated for 200 amps and the utility service conductors to the home are also rated for 200 amps, then up to a 200 amp PV tie-in-breaker could backfeed the service panel **if** the busbars in the panel would allow that size of a breaker to be plugged into it (see service box manufacture's limitations) **and** if the busbars are on the **service** side (utility side) of the service panel's main breaker(s). 705.12(A) in the 2011 *NEC*.

NOTE: IF THE SERVICE SIDE CONNECTION IS GOING TO BE MADE BY TAPPING THE SERVICE CONDUCTORS, THE POWER COMPANY MUST GIVE FULL PERMISSION BEFORE DOING SO.

Note: For compliance with b or c: the home's existing electrical loads calculated per article 220 in the *NEC* cannot exceed the following: the rating of the panel being tied into (*NEC* 408.30), the ampacity of the panel's feeder wires (*NEC* 215.2(A)(1)), and the rating of the breaker protecting the feeder wires (*NEC* 215.3). A calculated load *may* be required to show that this is the case.

b. If the PV tie-in-breaker(s) are going to backfeed any panel **on the load side** (house side) of the home's main service breaker(s) **and** the backfed breaker(s) are located at the end of the panel's busbars, opposite to the main feeder wire connections to that panel, then the sum of the PV tie-in-breaker(s) rating(s) and the panel's main breaker rating cannot exceed **120%** of the rating of the panel being backfed. For example: if a 100 amp rated panel is protected by a 100 amp main breaker, then a 20 amp PV tie-in-breaker is allowed to backfeed that panel if the backfed breaker is located at the end of the busbars (last breaker slot furthest from where the panel receives its power). *NEC* 705.12(D)(2) and (D)(7)

c. If the PV tie-in-breaker(s) are going to backfeed any panel **on the load side** (house side) of the home's main service breaker and the backfed breaker cannot be located at the end of the panel's busbars as noted in 7.8.1(b), then the sum of the ratings of the PV tie-in-breaker(s) and the rating of the main breaker protecting that panel cannot exceed **100%** of the rating of that panel. For example: If the panel being tied into is rated for 100 amps and is protected by a 100 amp main breaker; in order for a 30 amp PV tie-in-breaker to backfeed the panel, the main breaker protecting the panel must be reduced down to 70 amps (30+70=100). In order for this to be allowed, the home's existing electrical loads on that panel (calculated as per *NEC* 220) do not exceed the rating of the new 70 amp breaker. *NEC* 705.12(D)(7).

d. Conductor (wire) protection. The sum of the ratings of all overcurrent protection devices supplying power to any conductor cannot exceed 120% of the rating of that conductor (the regular conductor breaker rating + the PV breaker(s) rating cannot exceed 120% of the ampacity rating of the conductor being fed by both sources). *NEC* 705.12(D)(2)

7.8.2 Feeder taps. If a feeder tap is going to be performed in order to tie the PV system into the home's electrical system, the following must be submitted or noted on the plans and complied with during installation:

a. The PV breaker or fused disconnect must be located **immediately next to** where the conductors tap the feeder wires (the feeder tap distance rules of section 240.21(B) in the *NEC* were not designed for PV systems and should not be used).

b. The sum of the rating of the main breaker protecting the feeder conductors and the rating of the PV breaker (or fuses) cannot exceed **120%** of the ampacity rating of the feeder conductors being tapped, *NEC* 705.12(D)(2). Note: the 120% allowance rule can only be utilized if the home's existing electrical loads on the feeder wires do not exceed the ampacity of the feeder wires (*NEC* 215.2(A)(1)) or the feeder wires' breaker rating. A load calculation (based on article 220 in the *NEC*) may need to be submitted showing that this is the case. *NEC* 705.12(D)(2)

7.9 Additional comments:_____
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8. Disconnects

8.1 A main PV system disconnect is required to be able to completely disconnect the PV system from the home's AC electrical system and must be located at a readily accessible location nearest the point of entrance of the PV system conductors into the house. If the disconnect is located further inside the home from the nearest point of entrance of any **DC** circuit conductors, then those DC conductors must be installed in **metal conduit** or be **MC cable** until the first readily accessible disconnect is reached. *NEC* 690.14(C) and 690.31(E)

8.2 Equipment such as inverters, batteries, and charge controllers for batteries all require disconnects to be able to shut off all sources of power to the equipment. For example: an inverter must have a DC disconnect to be able to disconnect the PV power source to the inverter, and must also have an AC disconnect to be able to disconnect the utility power to the inverter. If batteries are installed, the inverter must be able to be disconnected from them as well. **If multiple disconnects for a piece of equipment are required, then <u>they must be grouped together</u> in the same area**. *NEC* 690.15

8.3 Fuses are required to be able to be disconnected from all sources of power provided to them. For smaller DC fuses, the disconnecting means is permitted to be the fuse holders if the holders are listed and permitted to be used as a disconnect, and the fuse holders are also the "finger safe" type that do not have any exposed current carrying metal parts when changing the fuses. *NEC* 690.16

8.4 When fuses are to be used for any 240v **AC** circuits, provide information showing that the disconnecting means for both fuses is simultaneous. *NEC* 210.4(B)

8.5 Additional comments:_____

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9. <u>Equipment and Connectors</u>

9.1 Provide manufacture info showing that inverters (UL 1741), PV modules (UL 1703), AC modules (UL 1703 and 1741), combiner boxes (UL 1741), and charge controllers (UL 1741) for batteries used in a PV system are all indentified and listed for the application. *NEC* 690.4(D)

9.2 Provide info showing that all equipment is listed and rated for wet locations and is listed as "rain tight" if installed outdoors. *NEC* table 110.28

9.3 Provide info showing all equipment is listed and rated for the **type** of voltage (AC or DC), the maximum **amount** of voltage (Voc that has been increased for the coldest possible outside temperature), and the maximum amount of short circuit current (Isc) that it could be subjected to. *NEC* 110.3 and 110.4

9.4 If fine stranded cables are going to be installed only terminals, lugs, devices, and connectors that are listed and marked for such use can be installed. *NEC* 690.31(F) and 110.14
Note: All fittings for fine stranded cables must also meet UL 486 A&B.

9.5 Additional comments:_____

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10. Grounding

10.1 Equipment grounding:

10.1.1 All metal parts of all modules (solar panels), module supports, system equipment, and conductor enclosures shall be bonded together and connected to the grounding system. Provide detailed info on the types of connectors and/or devices that will be used for bonding modules, supports, and boxes to the equipment grounding conductor. All devices used for bonding frames of PV modules or other equipment to the grounding system must be listed and identified for the purpose. *NEC* 690.43

10.1.2 Provide info showing that if the metallic mounting structures (rails, supports ect.) for the PV modules that are also going to be used for grounding purposes are identified as equipment grounding conductors or shall have identified bonding jumpers connected between each separate metallic section and be bonded to the grounding system. *NEC* 690.43 (C)

10.1.3 Lugs for bonding aluminum rails and modules must be listed for outdoor use and also for bonding PV rails and modules. Burndy CL50.1TN lugs, ILSCO GBL4 DBT lugs, and WEEBL 6.7 lug and clip assemblies are all ok for this purpose *if* installed per manufacture requirements. Must provide info on any other types of connectors if used.

10.2 **DC** system grounded conductor:

Note: Either the positive conductor or the negative conductor that is connected to earth by the grounding electrode conductor, is considered as the grounded conductor of the DC system.

10.2.1 All grounded conductors must be isolated from ground except at the point where the conductor is connected to the ground bonding point (which is usually located in the inverter at the GFPD for PV systems), *NEC* 690.42.

Note: See also the informational note in section 690.47(C) in the 2011 *NEC* for clarification.

10.2.2 Grounded conductor marking. Grounded conductors of size #4 AWG or larger shall be indentified at the time of installation by distinctive white markings at all terminations (this also applies to grounded conductors smaller than #4 AWG if the conductors are USE or "PV type" conductors installed at the PV array). All other grounded conductors must be marked white or grey as per *NEC* 200.6(A). *NEC* 200.6(A) and (B)

10.3 Equipment grounding conductors: *NEC* 690.43

10.3.1 Equipment grounding conductors shall be ran with the associated circuit conductors when those conductors leave the vicinity of the PV array, *NEC* 690.43(F).

10.3.2 Show the size of all equipment grounding conductors on plans. Equipment grounding conductors shall be sized per *NEC* table

250.122 based on the size of the fuse or breaker protecting the circuit. If there isn't a breaker or fuse used in a circuit, an assumed breaker or fuse rating that is sized per *NEC* 690.8(B) shall be used for sizing the equipment grounding conductors. *NEC* 690.45(A)

10.4 Grounding electrode conductors: *NEC* 690.47

10.4.1 Show the grounding electrode conductor on plans. A grounding electrode conductor must originate at the grounding electrode conductor connection point located on or inside of the inverter(s) (for PV systems), and ran to the building's grounding electrode per one of three methods listed in *NEC* 690.47 (C)(1)-(C)(3). If the building's grounding electrode (Ufer, ground rod, metal water pipe, ect.) are not accessible then the grounding electrode conductor can connect to the electrical service panel's grounding busbar.

10.4.2 Show the size of the PV grounding electrode conductor on plans. The grounding electrode conductor must be sized per *NEC* 250.166 based on the size of the largest **DC** conductor feeding the inverter. However, the grounding electrode conductor does not have to be larger than #6 copper if connecting to a ground rod, or a #4 copper if connecting to a Ufer. If the equipment grounding conductor from the inverter to the existing **AC** electrical service panel is also going to be used for the PV system grounding electrode conductor, then the larger required size of either 250.122 or 250.166 must be used (note: please also read section 10.4.3 regarding combined grounding conductors.). 2011 *NEC* 690.47(C)(1)-(C)(3)

10.4.3 Grounding electrode conductors must be installed per *NEC* 250.64(E). **Notice**: Section 250.64(E) makes it very difficult to use **AC** equipment grounding conductors as also the PV system grounding electrode conductor due to the fact that the wire must be bonded every time the conductor enters, and bonded again when it leaves a ferrous metal (containing iron) conduit or enclosure-see *NEC* 250.64(E) for full requirements. The conductor must also remain continuous or be irreversibly spiced. *NEC* 690.47(C)(3)

10.5 Ground wire protection. Indicate how the equipment grounding conductors and the grounding electrode conductor will be ran and protected from damage. If grounding conductors are exposed then a minimum of #6 copper conductors must installed. All grounding conductors must be protected from damage or be installed in conduit. *NEC* 690.46, 250.120(C), and 250.64(B)

10.6 Grounding electrodes:

10.6.1 Note on plans the type of grounding electrode the PV system's grounding electrode conductor will be connecting to (Ufer, metal water pipe, ground rod, ect.). If no grounding electrodes are accessible then note that the conductor will be ran to the home's service panel and connect to the grounding busbar. Grounding electrodes are required to be one of the types given in *NEC* 250.52.

10.6.2 If a new grounding electrode is installed for the PV system, then it must be bonded to the home's existing grounding electrode to form a grounding electrode system. *NEC* 250.50

10.7 Additional comments:_____

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11. <u>Signage</u>

11.1 Signs at the home's utility service panel:

11.1.1 A sign is required at the service panel stating that the home has a PV system as an additional power source. *NEC* 705.10

11.1.2 A sign is required at the home's service box giving the location of the main PV system disconnect (or main disconnect of any other power production system) if the disconnect is not located next to the utility service panel. *NEC* 690.4(H) and *NEC* 705.10

11.2 Signs at main system disconnect(s):

11.2.1 A sign is required at the main PV system disconnect (and at any other power production main system disconnect) labeling it as such. *NEC* 690.14(C)(2)

11.2.2 A sign is required at the main PV system disconnect (usually at the inverter) giving the total **<u>DC</u>** system **<u>STC</u>** rated max current (Impp), the rated max voltage (Vmpp), the open circuit voltage (Voc) which has been increased for coldest possible outside temperature, short circuit current (Isc), and the rated max output of a battery charge controller (if a charge controller is installed). *NEC* 690.53. See also section 5 in this plan check for more info.

11.2.3 Any PV system employing battery storage must also have a sign giving the max operating voltage (including any equalization voltage), and the polarity of the grounded circuit conductor (positive or negative). *NEC* 690.55

11.3 Signs at the interconnection point between the PV system and the home's electrical system:

11.3.1 A sign is required at the PV tie-in-breaker location giving the rated **<u>AC</u>** output current (amps) and voltage of the inverter(s). *NEC* 690.54

11.3.2 A sign is required at the PV tie-in-breaker if the breaker is located at the end of the panel opposite to the panels main feeder wire connections, and the 120% rule of *NEC* 705.12 (D)(2) and (D)(7) is utilized.

11.4 Signs at equipment:

11.4.1 Where all terminals of any disconnecting means may be energized in the open position, a warning sign shall be mounted on or

adjacent to the disconnection means and state the following: "WARNING ELECTRIC SHOCK HAZARD. DO NOT TOUCH TERMINALS. TERMINALS ON BOTH THE LINE AND LOAD SIDE MAY BE ENERGIZED IN THE OPEN POSITION." *NEC* 690.17

11.5 Additional comments:_____
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12. <u>Battery Backup Systems</u> (These requirements, where applicable, shall be in addition to those already covered in this plan review.)

12.1 Inverter:

12.1.1 Detailed manufacture's installation instructions and requirements for the inverter or a listed PV center (if used) must be submitted for plan review and all requirements must be followed when installing the system.

12.1.2 Provide manufacture's info that the inverter is specifically designed and listed for the use, and also be designed for the types of systems that will be connecting to it.

12.1.3 Provide manufacture's info indicating that the battery inverter is listed as being utility interactive meeting UL 1741 if grid tied. *NEC* 690.60, 690.61 and 705.40

12.1.4 Show that a ground fault protection device (GFPD) is provided for the DC portion of the PV system **<u>if</u>** the PV system and the battery system share the same inverter. Note: Only the DC portion of <u>PV systems</u> mounted on a house require a ground fault protection device (GFPD), not battery systems that use a separate inverter than the PV system. *NEC* 690.5

12.1.5 Any **<u>PV systems</u>** with **DC** circuits on or penetrating a building operating at 80 volts or more must be protected by a listed DC arc-fault circuit interrupter (AFCI) that is the "PV type" or have other components listed to provide equivalent protection, *NEC* 690.11. Note: Only the DC portion of the <u>PV system</u> requires arc-fault protection (AFCI), not battery systems that use a separate inverter than the PV system.

12.1.6 Provide information showing the maximum allowable voltage and amperage from the PV array and/or the batteries that the inverter can safely handle.

12.1.7 The inverter's AC output circuit conductors and overcurrent protection device (OCPD) must be sized as per *NEC* 690.8(A)(3), (B)(1) and (B)(2).
Note: For sizing PV source circuits and PV output circuits see sections 7.1.1 and 7.1.2 in this plan check.

12.1.8 The AC output circuit overcurrent protection device (as noted in 12.1.7) shall be located at the output of the stand alone or battery backup inverter, *NEC* 690.10(B). If this overcurrent device is a plug-in type breaker, it must be secured in accordance with *NEC* 408.36 (secured in place by an additional fastener that requires other than a pull to release the breaker from the panel busbars), *NEC* 690.10(E).

12.2 Batteries:

12.2.1 Indicate what types of batteries are going to be installed and if they are the flooded/vented type or sealed type.

12.2.2 Provide info that the battery type is compatible with the inverter and also that the inverter will **not** "equalize" or overcharge sealed batteries.

12.2.3 Show on plans how many batteries are to be installed, how they are connected (in series or parallel), the voltage of each battery, and the total battery bank voltage. Total battery system voltage in a residential home is typically limited to 48 volts unless the live parts of the batteries are not accessible during routine battery maintenance (*NEC* 690.71 (B)(1)). An example of a 48 volt battery system would be four-12 volt batteries connected in series per string (more than one string can be parallel connected together if the total battery system amp-hours is within the limits of the inverter).

12.2.4 Show the size of the conductors from the batteries to the inverter and also the rating of the overcurrent device protecting those conductors. The size of conductors from the battery bank to the inverter must be as per *NEC* 690.8(A)(4) and (B)(2), and the breaker or fuse rating protecting the conductors as per *NEC* 690.8(B)(1).

Note: the formula for figuring the max current of 690.8(A)(4) is taking the inverters rated continuous AC output wattage and dividing it by the lowest battery voltage that can sustain that wattage, and also by dividing by the inverters AC to DC conversion efficiency %. For example: 5,000 watts ÷ 44 volts ÷ .85= 133.68 amps. The conductor ampacity and the rating of the breaker are then figured by increasing the 133.68 amps by 125%, which is 167.1 amps. The next size up breaker would be 175 A. The size of the conductors would be based on the 167.1 amps if no ampacity correction or adjustments are required (see also 12.2.6 for minimum conductor size if fine stranded cables used).

12.2.5 Provide information to show that the batteries' overcurrent protection device(s) protect all other equipment or conductors in the system from any overcurrent from the batteries and also be rated for the available short circuit current that could be produced by the batteries. These breakers or fuses must be located **as close as possible** to the batteries (no more than 4 or 5 feet is usually

required by manufacture's instructions, but closer is better) and cannot be located in a different room than the batteries. *NEC* 690.71(C), 240.21(H), and 480.5

12.2.6 If flexible (fine stranded) cables are going to be used to connect the batteries together, then a minimum of 2/0 copper conductors must be used. The conductors must also be listed for "hard-service" and be identified as moisture resistant. The cables can only be ran between the batteries and from the batteries to a nearby junction box where there they must be connected to an approved wiring method. *NEC* 690.74

Important: Flexible, fine-stranded cables must be terminated with terminals, lugs, devices, and connectors that are listed for such (UL 486 A&B). Consult manufacture of all equipment involved with the fine stranded conductors and provide detailed info on listing and installation requirements concerning them.

12.2.7 Batteries must be located inside a lockable enclosure or room (guarded against accidental contact by persons), and cannot be installed in the inverter's working space area. Please indicate this on plans. *NEC* 690.71(B)(2)

12.2.8 Working space must be provided per *NEC* 110.26 around any battery enclosure or electrical equipment. *NEC* 480.9(C)

12.2.9 Battery ventilation:

a. Provide information on how the battery enclosure will be ventilated. *NEC* 480.9(A) requires "provisions to be made for sufficient diffusion and ventilation of the gases from the battery to prevent the accumulation of an explosive mixture" (see manufacture's recommendations). Note: The 2011 *NEC* or 2009 *International Residential Code* (*IRC*) do not specifically require *mechanical* ventilation to be provided for batteries, but may be required if no other ventilation options exist. The battery manufacture's recommendations should always be followed.

b. The conduit for the battery conductors must enter the enclosure at a point lower than the tops of the batteries and must be sealed to prevent hydrogen gas from entering the conduit.

12.2.10 If a battery system over 48 volts is going to be installed, the batteries cannot be installed on or within conductive cases or racks. This requirement does not apply to VRLA or other types of sealed batteries. *NEC* 690.71(D)

12.2.11 If a battery system over 48 volts is going to be installed, all requirements of *NEC* 690.71(E) and (F) (battery disconnect requirements) must be followed.

12.2.12 If an ungrounded battery system <u>over</u> 48 volts is going to be installed, all requirements of 690.71(G) must be followed.

12.3 Charge controllers:

12.3.1 Provide manufacture's installation requirements and specifications for the charge controller(s).
Charge controllers are required for battery backup systems to regulate the charge of the batteries (*NEC* 690.72(A)). Note: charge controllers should also be listed to meet UL 1741.

12.3.2 One or more charge controller(s) are required to prevent over-charging and excessive discharging of the batteries. There must be a charge controller between the batteries and any source of power (utility, generator, PV, wind turbine ect.) that is directly connected to the batteries in order to control the charge of the batteries (this may sometimes require multiple charge controllers). *NEC* 690.72

12.3.3 When buck/boost charge controllers and other DC to DC power converters that increase or decrease the output current or output voltage with respect to the input current and input voltage are installed, the ampacity of the output conductors shall be based on the maximum rated continuous output current (max output current multiplied by 125%) of the controller or converter, and the output circuit conductors must be rated for the maximum output voltage of the controller or converter, *NEC* 690.72(C).

12.4 Grounding:

12.4.1 Detailed information from the inverter manufacture on the requirements for grounding the battery system must be provided. Note: Some battery inverter manufactures require a grounding electrode conductor to be connected to the negative conductor at a single point external of the inverter, and others may require a grounding electrode conductor to connect within the inverter (<u>always</u> follow manufacture's requirements). See also section 10 for additional grounding requirements.

12.5 Additional comments:_____
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13. <u>Ungrounded Inverter/Transformerless Inverters:</u> (These requirements, where applicable, shall be in addition to those already covered in this plan review.)

13.1 System equipment:

13.1.1 Provide manufacture's info showing that the inverter(s) and charge controllers (if used) in an ungrounded PV system are listed for the purpose. *NEC* 690.35(G)

13.1.2 If the inverter(s) are going to be grid tied, provide information showing that it/they are listed as "utility interactive" having anti-islanding protection. *NEC* 690.61 and 690.62

13.1.3 Provide info showing that the PV inverter(s) have GFPD protection. *NEC* 690.35(C)

13.1.4 Provide info indicating that the PV system is protected by an arc-fault device (AFCI). *NEC* 690.11

13.2 Batteries:

13.2.1 If an ungrounded battery system is going to be used with a PV system (whether the PV system is grounded or ungrounded), all requirements of *NEC* 690.71(G) must be followed.

13.3 Conductors and overcurrent protection:

13.3.1 In an ungrounded PV system (transformerless inverter), all **DC** current carrying conductors are considered as ungrounded and shall have disconnects where disconnects are required (NEC 690.35(A)), **and** each conductor (both positive *and* negative **DC** conductors) are required to be protected by a breaker or fuse where overcurrent protection is required (*NEC* 690.35(B)).

13.3.2 Since there are not any grounded circuit conductors in an ungrounded system (transformerless inverter), the color white cannot be used to identify any wire. *NEC* 310.12(C)

13.4 Grounding. Equipment grounding conductors must still be required to bond all metal parts and equipment of the PV system and be installed with the circuit conductors they are associated with, even though neither the positive conductor nor the negative conductor is connected to ground (no grounded **DC** conductor). Also, a grounding electrode conductor may be required by the inverter manufacture and if so must be installed as per manufacture's requirements. The equipment grounding conductors and grounding electrode conductor must be installed as per article 250 in the *NEC* (see also *NEC* 250.169).

13.5 Required signs:

13.5.1 A sign is required at each junction box, combiner box, disconnects, and devices where energized ungrounded conductors may be exposed while being serviced and must state: "WARNING, ELECTRIC SHOCK HAZARD. THE DC CONDUCTORS OF THIS SYSTEM ARE UNGROUNDED AND MAY BE ENERGIZED." *NEC* 690.35 (F)

13.6 Additional comments:_____

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14. Any Additional Comments Concerning This Proposed PV System:_____

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15. <u>Validity of Permit</u>

15.1 The issuance or granting of a permit or approval of plans, specifications, and computations shall not be construed to be a permit for, or an approval of, any violation of any of the provisions of any state adopted code or of any other ordinance of the jurisdiction. Permits presuming to give authority to violate or cancel the provisions of this code, national codes, or other ordinances of the jurisdiction shall not be valid.

15.2 The issuance of a permit based upon plans, specifications and other data shall not prevent the building official from thereafter requiring the correction of errors in said plans, specifications and other data, or from preventing building or installing operations being carried on thereunder when in violation of this code, national codes, or of any other ordinances of this jurisdiction.

_____ _____

Contractor or Owner Signature Date