Hooper City
Residential Solar Photovoltaic
(PV) System Plan Review

For systems utilizing MICRO INVERTERS
(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 MICRO INVERTERS. 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), PV system disconnect(s), and other associated PV equipment on the property. Note: It is already known that there will be a micro inverter under each module and it is not necessary to show the micro inverters on the site plan but are required to be shown on the one-line diagram- see section 3.
- **1.2** If 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** Show the **<u>exact</u>** number and layout of the PV modules (solar panels) and how many micro inverters will be on each circuit.
- **3.2** Show all PV system components like: J-boxes, micro inverters, all disconnects, and other associated equipment. Indicate where all the components will be located in or on the home.
- **3.3** Indicate the home electrical panel that the PV system will tie into: to the home's 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 section **6.5** in this plan check for more details)
- **3.4** 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 6.5** in this plan check for more information.
- **3.5** 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 panels being tied into and the size of each breaker protecting any panel that will be backfed by the new PV system.
- **3.6** 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.
- **3.7** Show conduit types, sizes, and how many conductors will be in each conduit.
- **3.8** Show the ratings of all fuses and breakers.
- **3.9** 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 **STC** rated Watts (Pmp), rated Volts (Vmp), rated Amps (Imp), open circuit voltage (Voc), and short circuit current (Isc) of each module.

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. Micro Inverters:

5.1 If the PV system is going to tie into the home's electrical system, provide manufacture's info showing that the micro inverters 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).

5.2 PV inverters for residential use must be equipped with a ground fault protection device (GFPD). *NEC* 690.5

5.3 Inverter spec sheets must show the following:

a. How many micro inverters can be connected together on a single circuit and what the maximum size breaker they are allowed to connect to.

b. The inverters' rated AC output current (amps), and voltage.

5.4 Additional comments:_____

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6. Circuit Conductors and Overcurrent Protection Devices:

6.1 **Micro inverter and AC module systems.** Note: An AC module is simply a PV module where the micro inverter is mounted to the module at the factory and both the module and the inverter are a single unit.

6.1.1 All manufacture instructions must be followed when installing a micro inverter or AC module system.

6.1.2 Provide manufacture specs showing the recommended inverters' AC output conductor size.

6.1.3 The total combined AC output current (amps) from all the connected micro inverters on a single circuit cannot exceed 80% of the rating of the breaker (no more than 12 amps on a 15 amp breaker or 16 amps on a 20 amp breaker). *NEC* 690.8(A)(3) and (B)(1).

6.2 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).

6.3 All inverter AC output circuits must be identified 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)

6.4 All conductors that are readily accessible or subject to damage must be protected. *NEC* 690.31(A) and 300.4

6.5 PV point of connection breaker(s). This section applies to any breakers, conductors, or equipment busbars that are backfed from a PV system.

6.5.1 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 panel **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) **<u>and</u>** if the busbars are on the **service** side (utility side) of the service panel's main breaker(s). *NEC* 705.12(A)
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 PV backfed breaker cannot be located at the end of the panel's busbars as noted in 6.5.1(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) cannot 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)

6.5.2 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' main breaker rating. A load calculation as per article 220 in the *NEC* may need to be submitted showing that this is the case. *NEC* 705.12(D)(2)

6.6 Additional comments:_____
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7. Disconnects

7.1 A main PV system disconnect is required by the *NEC* 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, see *NEC* 690.14(D). Note: The PV system disconnect is the first readily accessible disconnect. This is usually the breaker that ties the PV system into the home's electrical system.
The utility company may require that a PV disconnect be accessible from the exterior of the home- contact utility for their additional requirements.

7.2 Additional comments:_____
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8**. Grounding**

8.1 Equipment grounding:

8.1.1 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

8.1.2 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)

8.1.3 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.

8.2 Equipment grounding conductors: *NEC* 690.43

8.2.1 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).

8.2.2 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, *NEC* 690.45(A).

8.3 Grounding electrode conductors: *NEC* 690.47. Note: some inverter manufactures may not require a grounding electrode conductor for transformerless inverters but if a grounding electrode conductor is specified by the manufacture it must be installed as per these requirements.

8.3.1 Show the grounding electrode conductor on plans. A grounding electrode conductor must originate at the grounding electrode conductor connection point located on the surface of the micro inverters, 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.

8.3.2 Show the size of the PV grounding electrode conductor on plans. The grounding electrode conductor must be sized per *NEC* 250.166 which for a micro inverter system would require at least a #8 AWG copper wire to be used. If the grounding electrode conductor will be exposed at any point, then a minimum of a #6 AWG copper wire must be used. If the <u>equipment grounding conductor</u> from the inverters to the existing **AC** electrical service panel is <u>also</u> going to be used for the PV system <u>grounding electrode conductor</u>, then the

larger required size of either *NEC* 250.122 or 250.166 must be used (note: please also read section 8.3.3 regarding combined grounding conductors.). 2011 *NEC* 690.47(C)(1)-(C)(3)

8.3.3 Grounding electrode conductors must be installed per *NEC* 250.64(E). **Notice**: *NEC* Section 250.64(E) makes it very difficult to use the **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)

8.4 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)

8.5 Grounding electrodes:

8.5.1 Note on plans the type of grounding electrode the PV system's grounding electrode conductor will be connecting to (Ufer, copper water pipe, ground rod, ect.). If no grounding electrodes are accessible then please 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.

8.5.2 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

8.6 Additional comments:_____

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9. Signage

9.1 Signs at the home's utility service panel:

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

9.1.2 A sign is required at the home's service panel giving the location of the main PV system disconnect (see section 7.1 in this plan check) if the disconnect is not located next to the utility electrical service panel. *NEC* 690.4(H) and *NEC* 705.10

9.2 Signs at main system disconnect(s):

9.2.1 A sign is required at the main PV system disconnect labeling it as such. *NEC* 690.14(C)(2)

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

9.3.1 A sign is required at the PV tie-in-breaker location giving the total maximum rated **AC** output current (amps) and voltage provided from the micro inverters, *NEC* 690.54.

9.3.2 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. See section 6.5.1(b) in this plan check for more information.

9.4 All signage must be securely mounted in place and be able to endure the environment they are located in.

9.5 Additional comments:_____

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

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11. Validity of Permit

11.1 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.

11.2 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.

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Contractor or Owner Signature Date