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Permit Guidelines for Solar Panels

Solar Photovoltaic (PV) Systems 2017 NEC Article 690

***Please Note**: Building and Electric permits are required for PV systems. The following information must accompany all building permit applications. Commercial systems must be designed, stamped and sealed by Missouri, P.E.*

1) Basic site plan diagram identifying location of major components – not to scale. This is a simple diagram to show where the equipment is located with the equipment clearly shown and identified on the plan. If PV array is ground-mounted, clearly show that system will be mounted within allowable zoned setbacks.

2) Electric diagram showing all major field-installed electrical components, wire identification and sizing, and grounding. This diagram needs to have sufficient detail to call out the electrical components, the wire types and sizes, number of conductors, and conduit type and size where needed. This will typically include detailed module information, series/parallel configuration of modules, details of the Photovoltaic Output Circuit, wire type and size of module wiring, type and size of any junction or combiner boxes, approximate length of conductors in PV array, approximate length of conductors from junction box to the photovoltaic power source disconnecting means. Other important information includes equipment grounding of the PV array and system grounding of the inverter. It will also include specific information on the PV inverter and all associated wire in and out of the inverter. The utility disconnect type and location and the means of connection to the building electrical system should be clearly identified. *Sample diagrams on pages 6-9*

Major component information:

a) Inverter information:

I. Model number and manufacturer's "*cut sheets*" for the specific model.

II. Listing. Is the inverter listed by a Nationally Recognized Testing Laboratory (NRTL) such as UL 1741 and labeled "Utility-Interactive"? If the utility interactive labeling is not provided, does the device comply with the requirements of IEEE Std. 929-2000 (ANSI) as verified by the instruction manual and validated by the listing agency. The 2014 NEC [690.13 C)] now requires labeling;

WARNING
ELECTRICAL SHOCK HAZARD
IF A GROUND FAULT IS INDICATED
NORMALLY GROUNDED CONDUCTORS
MAY BE UNGROUNDED AND ENERGIZED

This label is to appear on the inverter or near the ground fault indicator at a visible location

III. Maximum continuous output power at 40◦C

IV. DC input voltage range

V. AC output voltage range

b) *Module information*:

I. Manufacturer's *"cut sheets"* for the specific model.

II. Listing. The module(s) should be listed to UL 1703.
Explanation: All electrical devices and components must be listed to UL® (Underwriters Laboratories) North American Standards

III. Open-circuit voltage. Note: When open-circuit voltage temperature coefficients are supplied in the instructions for listed PV modules, they shall be used to calculate the maximum PV system voltage as required by [110.3(B)] instead of using Table [690.7]

IV. Maximum permissible system voltage. [690.7(A-E)]

V. Short-circuit current rating.

VI. Maximum series fuse rating.

VII. Maximum power at Standard Test Conditions.

VIII. Operating voltage.

IX. Operating current.

Alternating-Current Photovoltaic Modules:
Alternating-current modules shall be marked with identification of terminals or leads and with identification of the following ratings:

I. Nominal operating ac voltage.

II. Nominal operating ac frequency.

III. Maximum ac power.

IV. Maximum ac current.

V. Maximum overcurrent device rating for ac module protection.

c) *Battery information (if used):*

I. Manufacturer's "cut sheets" for the specific model. Note storage and venting requirements.

II. Nominal battery voltage for the system.

Array information:

a) Number of modules in series, number of parallel source circuits, and total number of modules.

b) Operating voltage (sum of series modules operating voltage in source circuit).

c) Operating current (sum of parallel source circuit operating currents). [690.8]

d) Maximum system voltage. [690.7]

e) Short-circuit current rating. [110.10]

Wiring and Overcurrent Protection:

a) *Wire Type:*
PV module interconnections should be 90◦C wet-rated conductors.
Allowable wire types are as follows:
USE-2 single conductor cable for exposed applications and single conductor cable listed and labeled for PV use. Type TC multi-conductor cable for exposed applications with THWN-2 or
XHHW-2 or RHW-2 or equivalent 90◦C wet-rated conductors in the cable. Type THWN-2 or
XHHW-2 or RHW-2 or equivalent 90◦C wet-rated conductors in high temperature conduit (conduit rated for a minimum of 75◦C wet conditions).

b) *Conductor Ampacity:*
Correct maximum current and ampacity calculations should be provided for each circuit. (Ampacity of conductors must be sufficient for application) [690.8]

I. The maximum PV source circuit current is the sum of parallel module rated short circuit currents multiplied by 125 percent [690.8(A)(1)].

II. The minimum source circuit conductor ampacity is 125 percent of the maximum PV source circuit current [690.8(B)(1)].

III. Minimum photovoltaic output circuit conductor ampacity is the sum of the maximum current of the parallel source circuits X1.25 [690.8(B)(1)]. Calculating ampacity of conductors used for the PV output circuit can be an involved process.

IV. Minimum inverter output circuit conductor ampacity must be equal to or greater than the inverter continuous output current rating times 1.25. *[690.8 (A)]*
Informational note: *Where the requirements of [690.8(A)(1)&(B)(1)] are both applied, the resulting multiplication factor is 156%.*

c) *Overcurrent protection:* Necessary fuses or circuit breakers must be properly sized and specified for each circuit.

I. PV source circuit, PV output circuit, inverter output circuit, overcurrent protection must be sized so that both the PV module and the conductor from the module to the overcurrent device are properly protected [690.9 (A), 240.15 (A)]. PV modules must be protected so that the maximum series fuse rating, printed on the listing label, is not exceeded. The module may be protected either by installing fuses or circuit breakers in a series string of modules or by the design

of the PV system. Inverters listed with a Maximum utility back feed current that is well above 1 amp (typically equal to the maximum allowable output overcurrent protection) must be assumed to provide back feed current to the PV array. Each source circuit must have overcurrent protection that is greater than or equal to the minimum PV Source Circuit current rating and less than or equal to the maximum series fuse rating.

For an inverter listed with a Maximum utility back feed current that is zero, two source circuits can be connected to the inverter without requiring overcurrent protection on either circuit. [690.9 (A) exceptions (a)&(b)]

II. Energy storage systems (if used) [690.21 A & B] Installation, [690.7] Disconnect and over current protection.

III. For requirements of Point of Connection of a *utility interactive* PV inverter to the building electrical system see [705.12].

Rapid shutdown of PV systems on Buildings

PV system circuits installed on or in buildings shall include a rapid shutdown function that controls specific conductors in accordance with [690.12 (A) through (D)]

Provisions for the photovoltaic power source disconnecting means

The 2017 NEC states in [690.13 A through F], *"Location. The photovoltaic disconnecting means shall be installed at a readily accessible location either outside of a building or structure or inside nearest the point of entrance of the system conductors...The photovoltaic system disconnecting means shall not be installed in bathrooms."*

I. Readily accessible—[Article 100] states, "*Accessible, Readily (Readily Accessible). Capable of being reached quickly for operation, renewal, or inspections without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, and so forth.*

III. A rooftop disconnect on a residential roof will normally not qualify as a readily accessible disconnect.

Grounding:

The NEC [690.41] requires all systems operating above 50 volts have one conductor referenced to ground unless the system complies with the requirements of [690.35 (A-G)] for ungrounded PV arrays. **All devices and components of grounding/bonding system must be listed for use.**

a) Equipment grounding conductor sizing. [690.45] The size of the equipment grounding conductor is dependent on whether the system has ground fault protection (GFP) equipment or not. The provisions for GFP equipment are stated in [690.5]. Many residential inverters have GFP equipment integral to the inverter and require that the PV array be grounded at the inverter only.

I. Systems with ground fault protection equipment. Size equipment grounding conductor according to NEC [Table 250.122].

II. DC System: Size grounding electrode conductor according to NEC [250.166].

Array Mounting information: ***You will need this information to obtain your building permit***

I. Provide two copies of the site plan showing the location of the house and PV equipment.

II. Provide two copies of the array layout and the supporting structure. ***If roof mounted;*** show anchorage to the roof and framing structure and schematic elevations. Identify methods of sealing all roof penetrations. ***If ground or pole mounted;*** show array supports, connection details, framing members, and foundation posts and footings. In either case the plans showing the supporting structure details must be signed and sealed by a Missouri Licensed Professional Engineer certifying the design is in accordance with the applicable codes in City of Nixa, MO.

Additional Ground Mounted Solar Panel Installation Requirements

For ground mounted Residential Solar Panels the following will apply:

For zoning purposes, Ground Mounted Solar Panels must meet the required setbacks for an accessory structure.

Inspections

a) *Building permit.*

I. Footing. (If applicable)

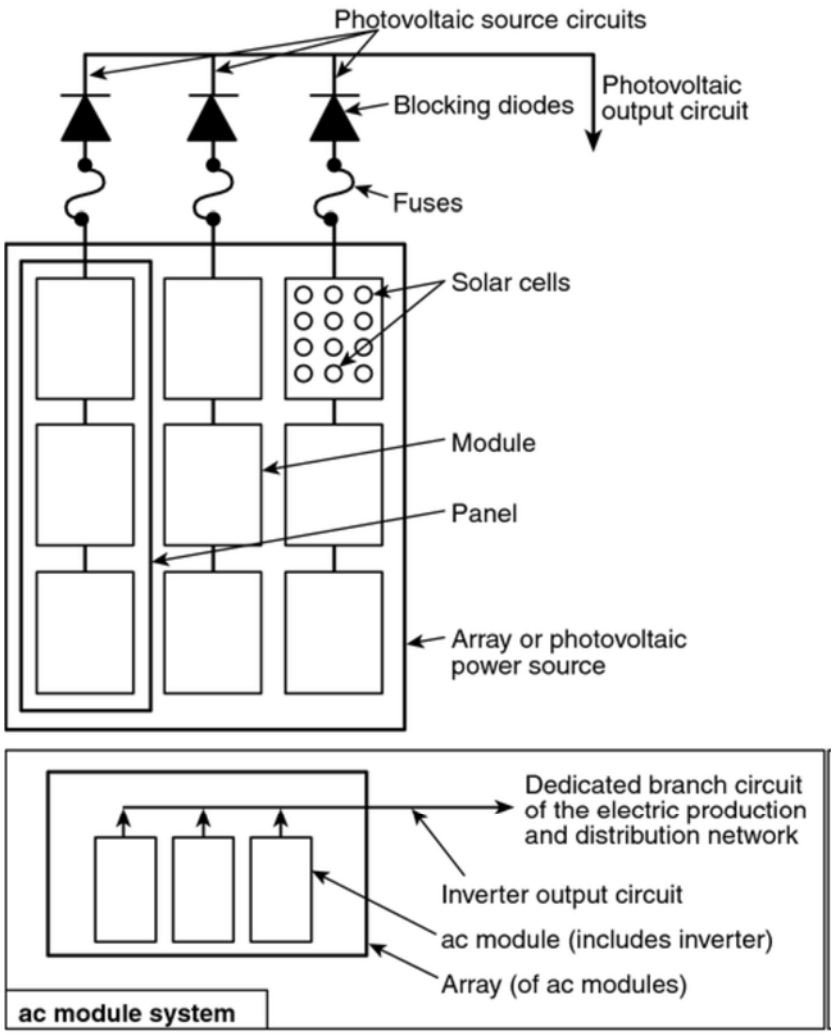
II. Framing. (If applicable)

III. Final.

b) *Electrical permit.*

I. Concealment, (For wiring in walls, ceilings and trenches).

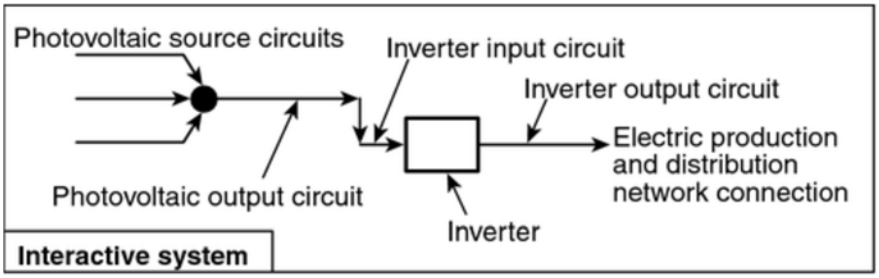
II. Final, Installer shall provide a 3rd party inspection to the Nixa inspector depicting the array support connections, module (PV panel) data plates, all electrical connectors, all ground connections, all conductor supports, and all sealed roof penetrations for all components that are not “readily accessible” (requiring ladder access)

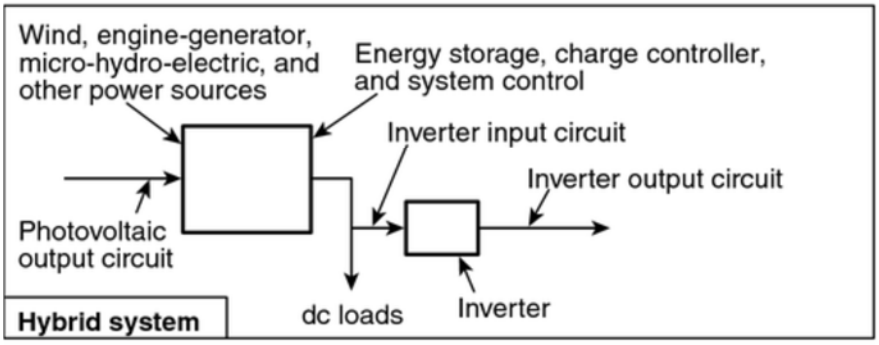


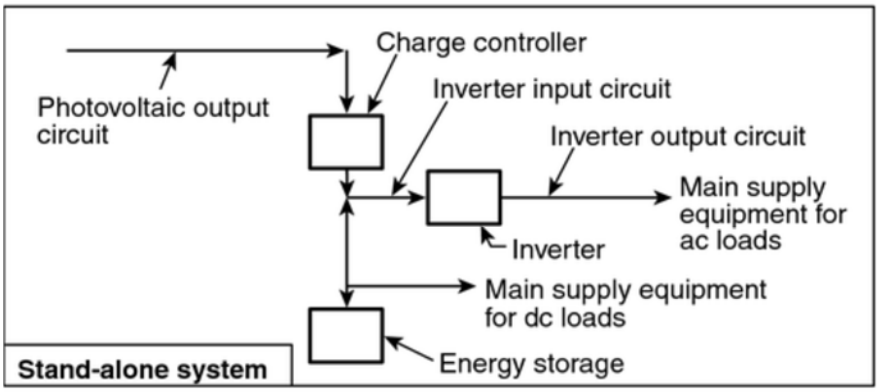
Notes:
1. These diagrams are intended to be a means of identification for photovoltaic system components, circuits, and connections.
2. Disconnecting means required by Article 690, Part III, are not shown.
3. System grounding and equipment grounding are not shown. See Article 690, Part V.

Figure 690.1(a) Identification of Solar Photovoltaic System Components.

Sample of Electrical Diagram (From NEC)



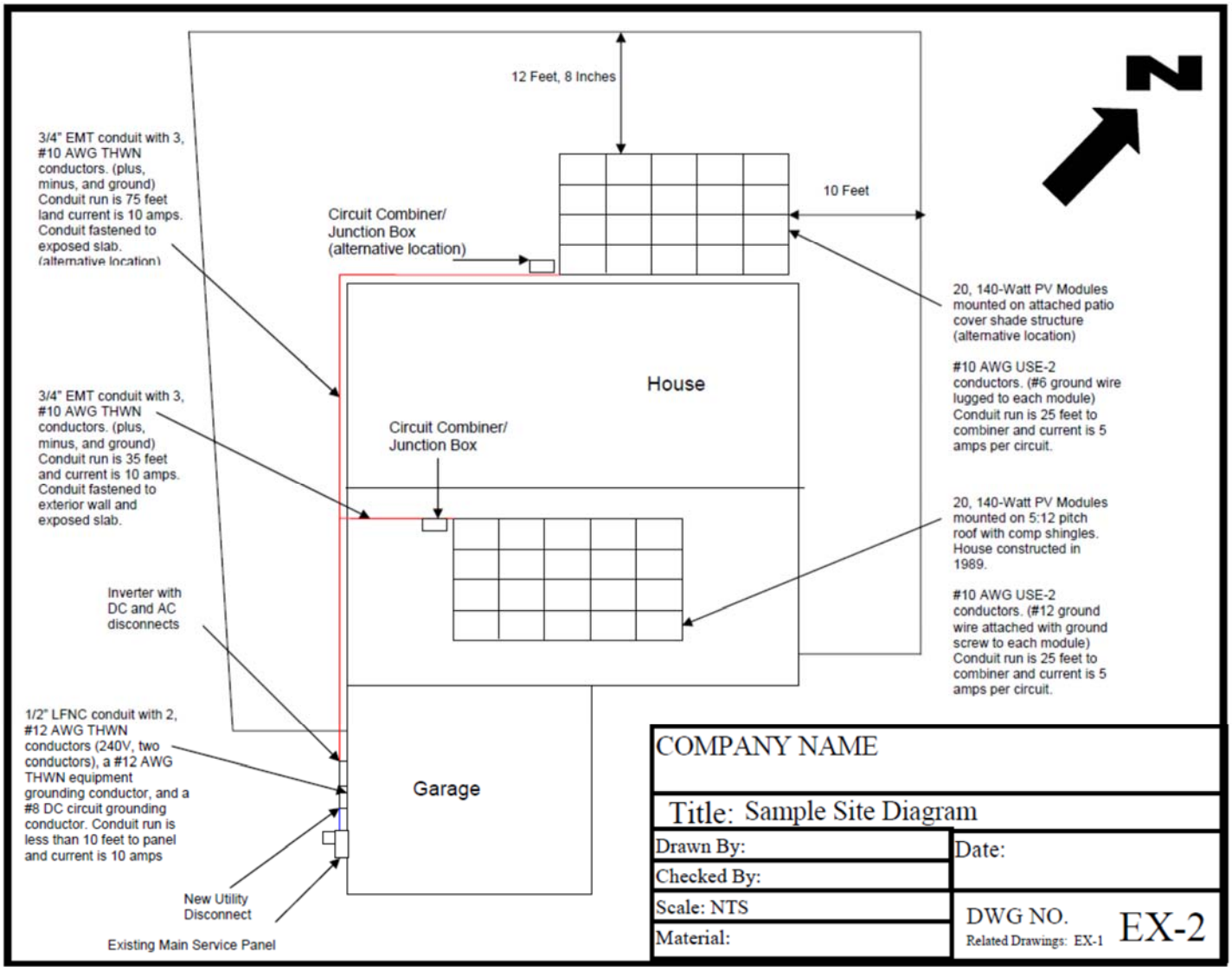




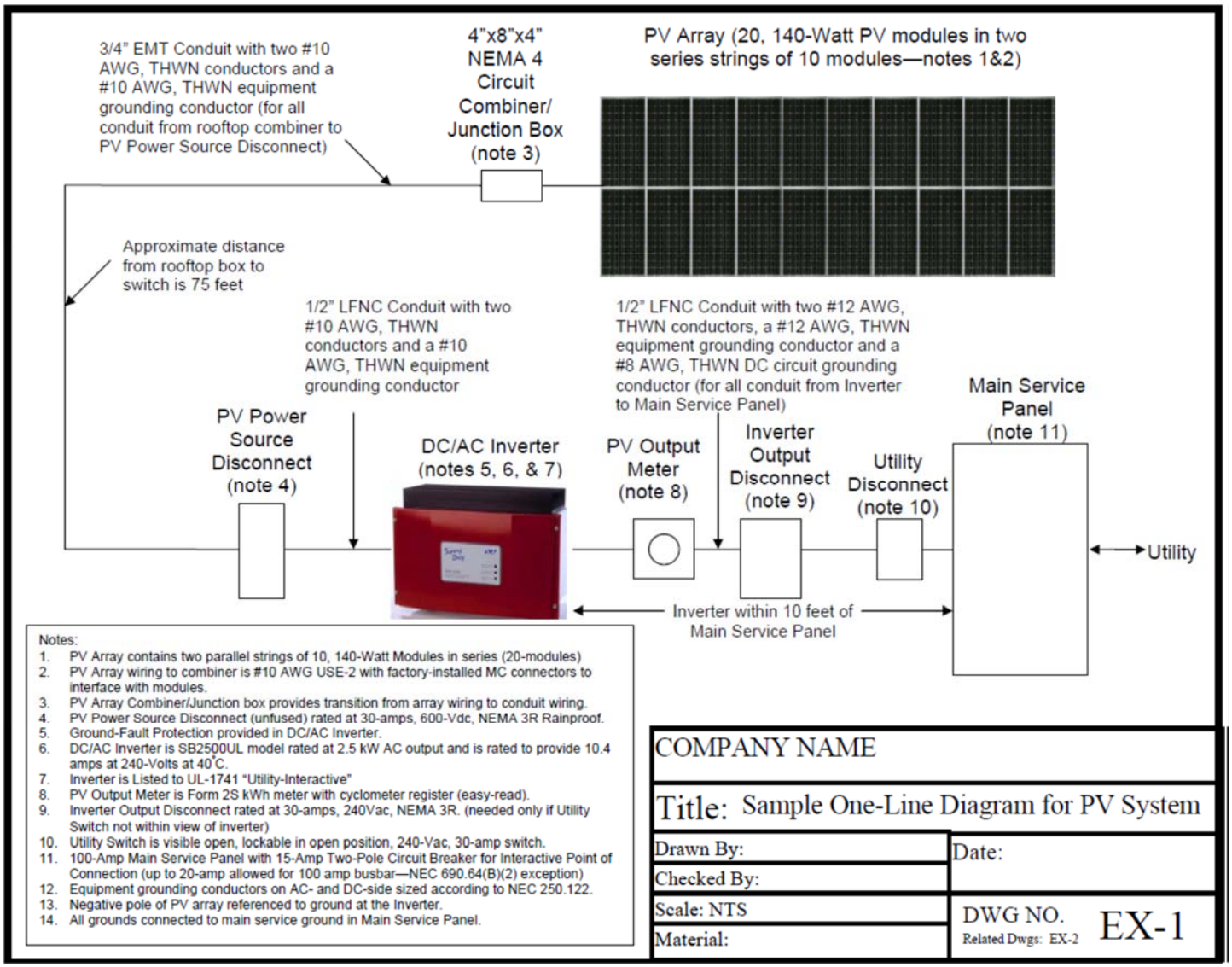
Notes:
1. These diagrams are intended to be a means of identification for photovoltaic system components, circuits, and connections.
2. Disconnecting means and overcurrent protection required by Article 690 are not shown.
3. System grounding and equipment grounding are not shown. See Article 690, Part V.
4. Custom designs occur in each configuration, and some components are optional.

Figure 690.1(b) Identification of Solar Photovoltaic System Components in Common System Configuration.

Sample of Electrical Diagram (From NEC)



Sample of Site Plan



Sample of One-Line Diagram