PROCEDURES FOR SOLAR ELECTRIC (PHOTOVOLTAIC abbreviated as PV) SYSTEM DESIGN AND INSTALLATION

Section 3: Scope of Work. Details for a Solar Electric (PV) System: Materials, Fabrication, Design, Installation, and Performance Testing

3.1. GENERAL REQUIREMENTS

3.1.1. Materials

The following are minimum recommended materials specifications:

- Materials used outdoors shall be sunlight resistant
- Urethane sealants shall be used for all non-flashed roof penetrations.
- Materials shall be designed to withstand the temperatures to which they are exposed.
- Dissimilar metals (such as steel and aluminum) shall not be used in direct contact with one another.
- Aluminum shall not be placed in direct contact with concrete materials.
- Only high quality fasteners are to be used (stainless steel is preferred).
- Structural members should be either:
    - hot dip galvanized steel per ASTM A 123
    - corrosion resistant aluminum, 6061 or 6063
    - stainless steel (particularly for corrosive marine environments)
    - coated or painted steel (only in low corrosive environments such as deserts)

3.1.2. Equipment requirements and installation methods

The following are equipment requirements and installation guidelines that, if carefully followed, will result in the installation of a PV system that will provide years of reliable service:

- All electrical equipment must be listed for the voltage and current ratings necessary for the application.
- PV modules must be listed to UL 1703 and warranted for a minimum of 20 years
- Inverters must be listed to UL 1741 and warranted for a minimum of 5 years
- All exposed cables or conduits must be sunlight resistant. PVC conduit is not recommended where exposed to long periods of direct sunlight.
- All required overcurrent protection must be included in the system and must be accessible for maintenance
- All electrical terminations must be fully tightened or secured and strain relieved.
- All mounting equipment must be installed according to manufacturers specifications and roof penetrations sealed with an acceptable sealing method that does not impact the roof warranty.
- Integral roofing products must be properly rated (e.g., class A roofing materials)
- All cables, conduit, exposed conductors and electrical boxes must be secured and supported according to code requirements.
- PV Array should be free of shade between 9:00 a.m. and 4:00 p.m. This includes even small obstructions such as vent pipes and chimneys. A small amount of shade can have a disproportionably high impact on system performance

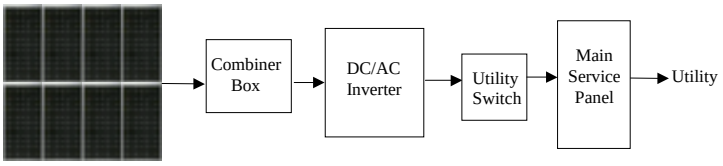

Figure 10 Simple PV System Diagram

3.2. PV SYSTEM DESIGN AND INSTALLATION

3.2.1. Select System

- Select a pre-engineered PV system that meets the goals of the project to ensure that the system components are properly matched and sized.
- Compare various product and system warranties between suppliers.
- Confirm that the PV equipment has the necessary listings required by the building officials (e.g. UL 1703, UL 1741, and any applicable evaluation reports from National Evaluation Services (NES) or International Conference of Building Officials (ICBO) Evaluation Services);

3.2.2. Sizing and Performance

The PV system supplier typically provides the builder with detailed sizing and performance information. Many tools exist to provide design guidance. The method in section 2 of this document is intended to provide a basis for the builder to identify those suppliers that are thorough in their design and those that are not. Knowing the physical size and dimensions of the system is critically important in determining where the PV array and ancillary equipment is to be mounted.

3.2.3. Lay Out PV Array

- Lay out PV array on roof plan and determine required location of PV modules on roof and any potential roof penetrations due to plumbing or combustion appliance vents that could effect array placement or shade the array;
- Potential obstructions that can be relocated to another roof surface should be specifically called out on the plans so that plumbing and HVAC contractors are adequately notified;
- Attempt to provide for an aesthetically pleasing layout by attempting to follow the dimensional shape of the roof section (example: if the roof is rectangular, try to maintain the same shape rectangle in the array layout). If modules are to be grouped in panels of several modules for ease of wiring and mounting, try to arrange the panels in symmetrical arrangements.

3.2.4. PV Array Wiring

- Size PV array wiring such that the maximum voltage drop at full power from the PV modules to the inverter is less than 3%. If array combiner box is located remote from the inverter, spread the voltage drop accordingly between the PV array-to-combiner wiring and the combiner-to-inverter wiring (example: with a 120-foot wire run from PV modules to inverter (3% total); with a 40 ft. wire run from PV modules to combiner box—use a maximum of 1% loss for this section, and with an 80 ft. wire run from combiner box to inverter—use a maximum of 2% loss for this section for a total of 3%);
- Size combiner box fuses according to the maximum series fuse rating specified on the back of the PV module.

3.2.5. Assemble and Install PV Array

Packaged systems should include detailed instructions on each phase of the installation process. If this information is not provided, serious consideration should be given to finding another supplier that will provide this information.

Some basic guidelines that may help in reviewing installation procedures are:

- Check modules visually and check the open circuit voltage and short circuit current of each module before hauling onto the structure to verify proper operation—see checklist
- Use plug connectors to connect panels together where listed products are available. This reduces installation time.
- Use only as many attachment points and roof penetrations as necessary for structural loading concerns. The number of attachment points and structural requirements of the roof must be specifically identified in the drawings.

3.2.6. Standby Power Systems (e.g., battery backup)

If the PV system chosen incorporates standby power features, those circuits operated by the standby system must be adequately designed to handle the anticipated electrical loads. The standby portion of the system is considered by the National Electrical Code to be an Optional Standby System covered by Article 702.

- Allow no multi-wire branch[1] circuits in a home to be wired with a $120V_{AC}$ optional standby system.
- All loads to be connected to the optional standby system must be carefully evaluated to determine if the actual power consumption and daily usage for each load can be met by the system in standby mode.
- All standby loads must be wired into a separate sub-panel for connection to the standby output of the inverter.
- Average power consumption for the standby power system loads must be calculated to determine how long the storage battery will provide uninterrupted power for typical electric usage.
- Article 702 of the NEC – "Optional Standby Systems" allows sizing based on supply of all equipment intended to be operated at one time (702-5). This means that all the 120-Volt loads could be run off of a single-pole 60-amp breaker from an optional standby system as long as the actual continuous load was below the 80% limit for continuous operation of a breaker (48 amps).

[1] This is the practice of using a three-wire, 240-Volt circuit to supply two 120-Volt circuits.

- It is recommended that the storage battery system consist of maintenance-free valve-regulated lead-acid (VRLA) batteries with absorbed glass mat (AGM) construction since these require no maintenance by the homeowner. Other types batteries may become available in the future that are equally suited to this application, but do not attempt to use any battery that has not been thoroughly tested in Uninterruptible Power System (UPS) applications.
- Battery storage cabinet must be kept out of the sun and in as cool a place as practical.
- Battery storage cabinet must be ventilated to the outdoors; vents need to be at the high and low points in the cabinet. For battery systems in utility rooms in the living space, follow ventilation requirements for gas-fired service water heaters.

3.2.7. Performance Test

The PV System Installation Checklist in section 4 of this protocol has a detailed performance testing procedure entitled System Acceptance Test.