

SECTION 26 30 05

PHOTOVOLTAIC SYSTEMS

PS2 / RADIOLOGY

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

- A. This section specifies the design, furnishing, complete installation, connection and testing of the Photovoltaic system. This includes PV modules, PV arrays, inverters, Balance of System components, monitoring and communications.
- B. The drawings indicate general layout, connection, and configuration of Photovoltaic system. Provide engineered system that conforms, as much as practicable, to the system basis shown on the drawings. Obtain approval from VA for any substantial deviations from contract documents, including but not limited to size and quantity of inverters, panels, and means on connecting to the electrical distribution system.
- C. The following outlines general requirements of the project. Additional details are provided throughout this document.
  - 1. Design, furnish and install complete photovoltaic (PV) power systems, including all support structures necessary to mount the systems on structural framing systems as shown on the drawings.
  - 2. Deliver, assemble, and install the equipment at the site.
  - 3. Conduct acceptance testing on each system and a minimum of two, three hour training sessions for the site on the operation and maintenance of the system.
  - 4. Provide required documentation and System Manual (System Design, Review, and Approval required).
  - 5. Minimize the risk of vandalism, theft, and personal injury in the installation and operation of the systems.
  - 6. Systems shall require minimal maintenance.

**1.2 RELATED WORK**

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General requirements that are common to more than one section of Division 26.
- B. Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS & CABLES (600VOLTS AND BELOW): Cables and wiring.
- C. Section 26 05 26, GROUNDING & BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- D. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits and outlet boxes.

### 1.3 QUALITY ASSURANCE

- A. Each photovoltaic power system shall include an array of PV modules and secondary support structures, inverters, and associated balance-of-system (BOS) components including wiring, conduit, DC disconnects, AC disconnects, Combiner Boxes, fuses and over-current devices, surge suppression and grounding equipment, and metering panel; i.e., all components and parts for a complete and operating system.
- B. PV Balance-of-System (BOS) design solution must have minimum three years operating experience in at least three systems of 500 kW or larger. BOS design may not have moving parts except for cooling systems in the inverter.
- C. The PV power system supplied for this project must have a design review and approval from the Veteran Administration and Electrical Engineer of Record.
- D. The Authority Having Jurisdiction (AHJ) must also approve the system. Criteria for system approvals are based on applicable codes and standards, and consistency with industry accepted design practices. Evidence to support these criteria must be contained in the supplier's System Manual, which shall contain all applicable information concerning the equipment and installation.
- E. All systems installed under this project shall have a complete System Manual at the time of acceptance tests and end-user training.

### 1.4 SUBMITTALS

- A. Submit in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- B. Shop Drawings:
  - 1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
  - 2. Data shall be submitted in the following form:
    - a. Technical data sheets (TDS): These include published performance, rating, catalog cuts, pictures, manufacturer's specifications, material composition, and gauge thickness.
    - b. Description of operation (DO): Manufacturer's literatures and, if suitable, diagrams.
    - c. Calculations (CALC): Detailed engineering calculations with all equations, graphs, assumptions, and approximations shown, and data sources referenced.
    - d. Certification (CERT): Written confirmation as to the document's accuracy, and genuineness.
    - e. Shop Drawings (SD): Scaled drawings showing plan views, side views, elevations and cross sections.
    - f. Diagrams (DGM): These include control system diagrams, elementary diagrams, wiring diagrams, interconnections diagrams, wireless connection diagrams, illustrative diagrams, and other like items.

## 1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. Institute Of Electrical And Electronics Engineers (IEEE);
1. IEEE 519-2000 Recommended Practices And Requirements For Harmonic Control In Electrical Power
  2. IEEE 929-2000 Recommended Practice for Utility Interface of Residential and Intermediate Photovoltaic (PV)
  3. IEEE 1262-1995 Recommended practice for Qualifications of Photovoltaic Modules
  4. IEEE 1547-2003 IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems
- C. American Society for Testing and Materials (ASTM):
1. ASTM E 1328, Standard Terminology Relating to Photovoltaic Solar Energy Conversion.
- D. Underwriters Laboratories, Inc. (UL):
1. UL 1703, Standard for Flat-Plate Photovoltaic Modules and Panels.
  2. UL 1741, Standard for Inverters, Converters, and Controllers for Use in Independent Power Systems.
- E. National Fire Protection Association (NFPA):
1. NFPA 70-2008 National Electrical Code (NEC)

## PART 2 - PRODUCTS

### 2.1 PV MODULES

- A. PV modules specified must be certified by the Consumer Energy Center's Emerging Technologies Buy down Program.
- B. All modules shall meet or exceed the requirements of IEEE Standard 1262-1995 Recommended Practice for Qualifications of Photovoltaic (PV) Modules and Underwriters Laboratories (UL) Standard 1703 Standard for Safety for Flat-Plate Photovoltaic Module, or equivalent standards.
- C. PV modules using Cadmium must include an environmental impact statement including any special maintenance requirements, and proper disposal/recycling of the modules at the end of their useful life. Modules containing Cadmium must comply with the EPA Landfill Disposal Requirements. Any additional costs related to PV modules containing Cadmium must be clearly identified.

- D. Rated PV system capacity must be specified in Direct Current (DC) kilowatts (both STC and PTC ratings) and in Alternating Current (AC) kilowatts CEC.
  - 1. The STC rating, or Standard Test Conditions rating, is also referred to as the kilowatt peak (kWp) DC output. Specific PV module manufacturer maximum and minimum power data must be specified for this rating.
  - 2. For the PTC rating use current ratings from the CEC listing.
  
- E. AC Loss Assumptions - Loss factors are used to convert theoretical DC output at PTC to actual AC output at PTC. The effective AC output of the proposed PV system is calculated from the PTC rating taking into effect system losses.
  - 1. Provide the AC loss assumptions with kWh output calculation.
  - 2. The effective AC output must include losses for: DC Cabling, Connections, Inverter Module, Coefficient of Temperature, Module Mismatch, Soiling, Shading Losses, Tracking Losses, Transformer Losses, AC Wiring, and Auxiliary Loads.
  
- F. The mathematical method for specifying PV system output in kWh must be specified for each of the following steps:
  - 1. Calculate the expected annual kWh of the system using the CSIEPBB tool (<http://www.csi-epbb.com/>). In addition, provide another model with justification of why it more accurately portrays the expected system performance.
  - 2. Specify annual degradation expected over 20 years

## 2.2 PV ARRAY

- A. Requirements:
  - 1. Unless otherwise specified or dictated by site condition, all PV arrays should be tilted to achieve maximum kWh production. Orient panels parallel and perpendicular to building structure as seen in plan view.
  - 2. PV arrays should be located to prevent shading from trees, poles, or other structures at any time, and any day of the year.
  - 3. PV arrays must be securely installed as dictated by site conditions to accommodate for high wind loads, and subsequent potential for damage from flying debris.
  - 4. PV array and supporting structure must comply with wind uplift requirements per the American Society of Civil Engineers Standard for Minimum Design Loads for Buildings and Other Structures (ASCE7), and must be able to withstand design wind speeds of at least 100 mph (3-second gusts).
  - 5. PV array and auxiliary equipment must meet all seismic requirements
  
- B. The weight of the PV array must not exceed structural requirements. In general this means the array should average less than 10 pounds per square foot.

### 2.3 INVERTER/ISOLATION TRANSFORMER

- A. The system shall include inverters (power conditioning units) with AC output rated as shown and described on the plans. The inverters shall be capable of automatic and continuous operation.
- B. Inverters must be compliant with IEEE 929-2000 (Recommended Practice for Utility Interface of Photovoltaic Systems) and be listed to UL Standards 1741 (Standard for Static Inverters and Charge Controllers for use in Photovoltaic Power Systems) by a NRTL.
- C. Any ancillary equipment or modifications of inverter hardware required to install the inverter in parallel with the utility grid to meet the above standards must be provided with the inverter.
- D. The inverters must be certified by the CEC's Consumer Energy's Center.
- E. The output of the system shall not exceed the harmonic distortion levels as specified in IEEE 519-1992.
- F. The inverter must be rated for outdoor use with safety enclosure and cover protection minimum.
- G. Inverter shall include integral transformer to connect to the building electrical system at 480 volts three phase. External and supplemental transformers are not acceptable.

### 2.4 BALANCE OF SYSTEM

- A. All enclosures shall be at minimum rated NEMA 3R.
- B. All equipment and work shall comply with Occupational Health and Safety Administration (OSHA) directives.
- C. Any BOS system components should achieve Uniform Building Code (UBC) fire code rating of "B" or better.

### 2.5 ~~MONITORING AND COMMUNICATIONS~~

- A. The system must be able to provide the following data in real time: energy production and kW output, and weather data including solar insolation and air temperature,
- B. Information for the system must be available off site through a commercial internet site. The site shall provide real time data as well as a summary of daily, weekly, monthly, and annual output. The monitoring service should extend at least five years with pricing included in the bid. An internet connection or phone line on site will be provided. Supplier must provide all other equipment on and off site to collect, organize, and display the data on the internet site. Data from the solar system and weather system must be provided in a digital or scalable analog output (0-5 Volt or 0-5 milliamperes) compatible with DNP, RS 485, or RS 232 Mod Bus communication protocols.

## 2.6 REPLACEMENT AND SPARE PARTS

- A. All system components must be clearly specified as to the type, manufacturer, and model number for later needs for replacement and service as required, and documented in the System Manual. Sources for this equipment should also be identified. It is required the supplier/installer either maintain or have a ready source for replacement components as needed for required warranties or service.
- B. A complete set of replacement fuses of the same type and rating for all fuses in the system must be supplied with each system.

## 2.7 SYSTEM DOCUMENTATION REQUIREMENTS

- A. It is required that the installer and system supplier provide two copies of a Systems Manual at the completion of the project. At a minimum, the following items must be supplied as part of the System Manual:
  - 1. Overview of major system components, principles of operation, and safety considerations.
  - 2. Location of equipment on property or building.
  - 3. Complete parts list and specifications for the overall system and individual components, including all electrical components, mechanical hardware, and other equipment required for installing the system.
  - 4. Diagram indicating overall layout of entire system, including PV array, and location of BOS (Balance of System), hardware and inverter with respect to the array and building facilities.
  - 5. Electrical schematics and diagrams including: all equipment locations, and ratings, array ratings in kWp, kW-PTC, and kW-AC, number, manufacturer, and model of PV modules, number of modules per string, number of strings, string amperage nominal and ISC, array nominal voltage, voltage open circuit, nominal current, current short circuit (ISC), terminal boxes; locations, and number of strings, combiner boxes; fuse ratings and number of strings, string locations and number, all conduit size and type, wire sizes number and designations, fuses and disconnect ratings, inverter and isolation transformer manufacturer and models, location, and ratings, data collection system; manufacturer and model number and electrical location of weather station, data acquisition system, meter(s), communication links (modems, phone lines), power supplies if needed, grounding, job information including customer, location, date, designer, legend with symbol descriptions if not labeled.
  - 6. Mechanical drawings showing details of module/array mechanical support structure and instructions for assembling/disassembling and installing arrays on rooftops or the ground as required.
  - 7. Procedures for operating, disconnecting, servicing, and maintaining complete system and individual components.
  - 8. Warranty information on individual components as required in this bid document.

9. All equipment manufacturers' specifications and operations manuals, including those for PV modules, inverters, and BOS equipment.
10. The as-built drawings will be turned over upon completion (within 10 days of commissioning) and shall be signed and dated by the contractor.

### **PART 3 - EXECUTION**

#### **3.1 ELECTRICAL DESIGN AND INSTALLATION REQUIREMENTS**

- A. The electrical design and installation of the PV system shall conform to the 2008 National Electrical Code (NEC, NFPA 70). Article 690 of the NEC applies specifically to photovoltaic system safety, protection, control, and interface with other sources. Other articles of the NEC also apply.
- B. The PV system electrical design shall also comply with the IEEE std.1374 (Guide for Terrestrial Photovoltaic Power System Safety).
- C. The following are specific electrical requirements for this system and installation:
  1. All equipment and electrical hardware used in the system, including overcurrent protection, disconnects, surge suppression devices, conduit, wiring and terminals, must be approved, recognized, or listed for the intended application by a NRTL, and have appropriate voltage, current, and temperature ratings for the application.
  2. Inverters, controllers, and PV modules must have specific listings as noted elsewhere in this document.
  3. All circuit breakers, fuses, and disconnects must be listed or recognized for use in DC circuits where applicable. Equipment only rated for use in AC circuits will not be permitted for use in DC circuits.
  4. All wiring (conductors) must be properly sized and rated for the application, including ampacity and voltage drop. Conductor ampacities for all PV array source circuits must be based on both NEC and UL de-rating factors (156 percent). All other system conductors must be de-rated 125 percent per the NEC. Voltage drop in array DC source circuits should be limited to no more than 3 percent including losses in conductors, and through all fuses, blocking diodes, and termination points as applicable. All wiring shall be listed for a minimum operation of 600 Volts and temperature rating of 90 degree Celsius in wet locations. With an exception of the PV module interconnect wiring, the use of any exposed conductors or cabling (excluding grounds) is not acceptable. All conductors must be installed in conduit. Metallic conduit is not allowed for use when in contact with soil.
  5. PV module interconnect wiring must be sunlight-resistant USE2, or equivalent rated conductor, and must be attached to module junction boxes using weather-tight strain relief. The module wiring interconnections shall use a connector device that allows quick assembly and disassembly of the arrays under no load conditions. These

- connectors must be listed by a NRTL, and be weather-sealed, guarded and polarity protected.
6. With the exception of the module interconnect wiring, all terminations must use listed box terminal or compression type connections, and must be made with an appropriate junction box or enclosure. Exposed, field splices between conductors will not be permitted. Twist on wire splices, crimped, soldered, or taped connections are not permitted for the required field installed wiring of DC circuits. Proper torque specifications should be provided for all of the required field connections, and all the termination points should be liberally coated with an anti-corrosion spray to preserve the quality of all connections over time.
  7. All system conductors must have appropriate means for disconnecting and overcurrent protection, and require the use of switches, fuses or circuit breakers as applicable. All overcurrent devices shall have trip ratings no greater than the de-rated ampacity of the conductors that it protects.
  8. All series connected strings of modules (source circuits) must include a series fuse as required by UL and NEC Standards to prevent excessive reverse current flow through modules in source circuits under fault conditions, and diodes must be contained in a listed junction/combiner box. Parallel connections of modules in individual source circuits are discouraged, and are only allowed as long as the module listing allows for a series fuse with high enough capacity required for this configuration. All series source circuit fuses shall be rated for at least 1.56 times the source circuit short-circuit current rating, and no greater than that specified on the module listing. Blocking diodes for array source circuits are optional. If used, these diodes must have voltage and current ratings (at temperature) at least twice the open-circuit voltage and short-circuit current ratings of the source circuits.
  9. All metallic modules frames, panel/array support structures, metal enclosures, panel boards and the inverter cabinets must be properly bonded to a common equipment grounding conductor and terminate at the grounding electrode at the utility service point. If a grounding electrode is not already in place, a grounding electrode, such as a ground rod, must be installed at the system with a preferred maximum earth resistance of 25 ohms. All grounding connections and terminations should be made accessible for routine inspections and maintenance as required.
  10. Surge suppression on the DC and AC side of the inverter must be provided. Silicon oxide varistors (SOVs) commonly used to protect electrical panels and equipment may be used for this purpose, and may be provided and/or required by the inverter manufacturer.
  11. All equipment installed outside shall have enclosures rated as NEMA 4, NEMA 3R or better and have superior strength and corrosion resistance properties.
  12. An outdoor rated disconnect device must be installed in all systems at the interface between the PV system inverter and the connection to the utility grid. This disconnect device shall be a visible break,

- lockable device, and shall be installed at convenient location on the outside of premises near the service point/point of common coupling.
13. A standard utility watt-hour meter socket enclosure shall be provide on the PV system side of this disconnect.
  14. All electrical equipment, enclosures, disconnects, and overcurrent devices must be clearly marked and identified. A one-line diagram of the system must be kept on site for reference.

### 3.2 MECHANICAL DESIGN AND INSTALLATION REQUIREMENTS

- A. All hardware required for installing PV arrays and other system equipment must be provided for the installations.
- B. The following are requirements for mounting the PV arrays, equipment, and other materials and mechanical design considerations associated with these projects.
  1. The array mounting systems and overall installation must meet all applicable local building codes and be capable of withstanding winds of Category 2 or greater (100 mph. -3second gust) for all attachment points, which are consistent with the module manufacturer's installation instructions, and the requirements of ANSI/ASCE 7-98. Calculations or certifications from a licensed professional engineer or NRTL verifying that the system can withstand these wind forces, as installed on the ground or a building structure is required.
  2. PV array and any auxiliary equipment must meet all seismic requirements.
  3. The PV arrays should be protected from flying debris.
  4. The system installation and equipment layout should be considered with respect to the need for access, maintenance and future expansion of the system.
  5. Array mounting hardware supplied for this installation should be compatible with site considerations and environment. Special attention should be paid to minimizing the risk from exposed fasteners, sharp edges, and potential damage to the modules or support structure. Corrosion resistance and durability of the mechanical hardware is emphasized. All materials should be selected to avoid corrosion and degradation. The use of ferrous metals, contact of dissimilar metals, and the use of wood or plastic components are prohibited. Aluminum and stainless steel components and hardware are preferred. This installation will be high profile. Tile aesthetics of the overall installation are extremely important. To create a uniform appearance of the array, spacing between individual modules and panels should be kept to the minimum and overall layout in keeping with the overall architectural features of the buildings and properties. As much as possible, all mechanical hardware, Conduit, junction boxes, and other equipment should be concealed beneath and/or behind the array, and all other electrical work performed neatly and as inconspicuously as possible.
  6. The array layout should be consistent with the electrical ordering (and labeling) of source circuits in the array combiner boxes. Ease of access for array troubleshooting and maintenance is desired by

allowing access to the back of the array for module junction box servicing, and removal/replacement of individual source circuits (panels) and modules if necessary.

**3.3 INSPECTIONS, ACCEPTANCE TESTING, AND USER TRAINING**

- A. All system installations must be properly plan checked, permitted, and inspected by the AHJ. Evidence of these permit(s) and inspections shall be provided at the time of acceptance testing and before final payment will be authorized.
- B. Acceptance testing will verify that the system and equipment specified in the bid was installed in a safe, workman-like, and code-compliant manner, and is operating properly under all conditions.
- C. Final contract payment will be tied to successfully completing acceptance testing, and delivery of the complete System Manual.
- D. The Contractor will also be required to provide a minimum of two, three-hour training sessions. Topics to be covered in this training include theory of operation, operating requirements, component descriptions and specifications, maintenance requirements and schedule, safety precautions, and overview of the System Manual and recordkeeping.

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