

## PHOTOVOLTAIC SYSTEMS

### Commissioning

1. Contractor shall commission all equipment and portions of the PV System included in their s Work. Commissioning shall be defined as: “The processes of ensuring systems are designed, installed, functionally tested, and capable of being operated in conformity with the design intent.” Actual commissioning tasks, test forms, and checklists shall be based on final design and equipment selections and shall be subject to Owner review and approval.
2. Contractor shall prepare a complete Commissioning Plan for the Project which identifies all tasks and procedures to be completed during installation, set-up, programming, testing, tuning, calibration, etc. of each piece of equipment and PV System component as well as the entire system.
  - a. The Commissioning Plan shall clearly identify the interface of the Contractor’s commissioning efforts including other subcontractors for portions of the Project that are related to, but not contained, within this Scope of Work.
  - b. Contractor shall submit three (3) copies of the Commissioning Plan to the Owner for review and approval with the Design Documents.
  - c. Approval of any submittals shall not relieve the Contractor of their responsibility to fulfill all requirements of the Contract Agreement.
  - d. Commissioning tasks and milestones shall be identified in Contractor’s Project schedules to allow Owner adequate notice to participate.
3. Contractor shall coordinate and make available any required personnel required to complete or witness commissioning tasks. If contractor uses specialized (manufacturer, vendor, etc) personnel to perform certain commissioning tasks, contractor shall be physically present to supervise these personnel whenever they are at the project site. Contractor shall support and participate in commissioning integrated systems where contractor’s system interfaces with work of others.
4. Contractor’s Commissioning Plan shall include clearly-written narratives describing each commissioning task as well as checklists, data entry forms, and test forms for these tasks. Checklists and data entry forms can be provided in manufacturer’s standard format, or Contractor standard format as long as they include the following supporting information for each piece of equipment:
  - a. Name of Project.
  - b. Name or description of equipment.
  - c. Location of equipment.
  - d. System served.
  - e. Manufacturer.
  - f. Model Number.

- g. Serial Number.
  - h. Date and time of each test.
  - i. Parties involved with and/or witnessing each test.
  - j. If applicable, results of all measurements (Voltage, Temperature, etc.).
  - k. Results of all observations (A yes or no checkbox for items that are confirmed visually).
  - l. Description of any abnormalities or issues discovered during testing.
  - m. Documentation that indicates any abnormalities or issues resolved.
  - n. Supporting data needed to quantify test; outside air conditions, time of day, etc.
  - o. Copies of all programming values or tuning parameters entered into unit.
5. The following list is provided as an example of the types of commissioning tasks and degree of rigor that need to be addressed in the contractor's site-specific Commissioning Plan:
- a. Verify that equipment was constructed, shipped, and installed with all options specified (panel rating, rack configuration, instrumentation, accessories, control interface, safety devices, etc.).
  - b. Provide a complete list of all equipment nameplate data and serial numbers. This should include any available panel, inverter, control system, etc., data.
  - c. Document dates, times, operating conditions and names of parties involved with any tests performed.
  - d. Document that all equipment manufacturer recommended startup and check-out procedures have been completed by an authorized technician and documented on the manufacturer's forms.
  - e. Confirm that wiring has been completed and protection devices (fuses, heaters, breakers, etc.) have been installed in accordance with applicable codes and specifications for the equipment installed.
  - f. Verify that all disconnect and/or H-O-A (Hand=On, Off=Off, Auto=EMCS state) switches have been installed and tested.
  - g. Ensure that all pilot lights, control switches, touch pads, and operating displays are fully functional.
  - h. Measure and document voltages, amperages, and temperatures to establish an operating baseline and ensure that they are within manufacturer's specifications.
  - i. Confirm proper operation of all EMCS interfaces with equipment (remote monitoring, remote start/stop, alarm monitoring, data collection, etc.).
  - j. Test operation of all safety or protection devices (temperature, voltage, amperage, etc.) to ensure they have been adjusted or programmed to meet specifications and are operating as intended.
  - k. Document that equipment control panels have been programmed for the specific equipment purchased and actual configuration (panel wiring, facility interface, etc.).

- l. Verify that equipment failure modes (power failure, anti islanding, etc.) have been reviewed with an Owner's representative to ensure that they meet facility standard operating procedures.
- m. Test all anticipated equipment failure modes, if possible, and document test results.
- n. Provide a list of all control panel programming parameters and settings.
- o. Verify that equipment has been installed and supported (housekeeping pads, vibration isolators, seismic restraints, etc.) per specifications.
- p. Confirm that all enclosures, shrouds, guards, or access panels are securely in place.
- q. Ensure that adequate clearances exist for routine service of all panels, controls, inverters, etc.
- r. Confirm that equipment, component, and device labels, tags, or signs have been installed per specifications or painted per applicable color code.

Additional commissioning tasks may be required, depending on final design, project specifications, or manufacturer requirements.

- 6. The Contractor shall be responsible for documenting the results of all PV system controls and data collection system commissioning tasks and procedures.
  - a. Hardware point-to-point checklists shall include point name, point type, sensor type, signal type, range of signal, controller number, controller address, wire number, date of tests, calibration procedure, calibration adjustments or offsets, and test participants for each individual point.
  - b. Electrical checklists shall be provided to document the proper operation of all Hand-Off-Auto switches, disconnect switch interlocks, hard-wired interlocks, etc.
  - c. Control panel checklists shall be provided to document the installation of all batteries, grounding of all cabinets, termination of all cable shielding, etc.
  - d. Functional performance test forms for software shall consist of specialized cause and effect tests for each individual operating sequence, control loop, feedback signal, hardware or software interlock, failure mode, and associated output. These test forms shall outline the test procedure, indicate the expected system responses, and document the actual system response observed.
  - e. Test forms shall be provided to document response of all system workstations and control panels to power failures and system network communication failures.
  - f. If control or data collection system has provisions for remote dial-up or Internet access, test forms shall include all phone numbers, access codes, TCP/IP settings, passwords, addresses, etc.
- 7. The Contractor shall coordinate the commissioning process and associated commissioning test forms with the sequence of construction and work of other sections. An example would be pre-functional point-to-point testing of control hardware prior to equipment availability,

followed by functional performance testing of system software and sequences during equipment startup.

8. The Contractor shall provide all tools, equipment, and technicians required to complete and document all commissioning tasks contained in the approved Commissioning Plan.
9. The Contractor shall participate in a coordination meeting with the Owner after the Commissioning Plan has been submitted and before any commissioning takes place. The purpose of this meeting will be to review control system commissioning activities.
10. Prior to commissioning any portions of the system, the Contractor shall verify that the portion to be commissioned has been installed per plans, specifications, and approved shop drawings. All cabinet doors, J-boxes, sensors, controllers, etc., shall be labeled per specifications prior to commissioning.
11. During commissioning, the Contractor shall review the results of commissioned portions of the controls system with the Owner on no greater than a weekly basis through written progress reports and preliminary copies of completed checklists or test forms.
12. The Contractor shall provide any recommendation for controls system modification in writing to the Owner Project Manager. No system modifications, including operating parameters and control settings, shall be made without prior approval from Owner.
13. The Contractor shall, in the presence of the Owner, demonstrate the proper operation of each control sequence and stable operation of each control loop.
14. The Contractor shall submit to the Owner for each archived data point a 24-hour trend with hourly readings. These trends shall show that the system is producing and exporting power as intended and that this data is being collected and stored in proper format.
15. One week after Substantial Completion, the Contractor shall submit one complete Commissioning Report to the Owner for review. Upon Owner review and approval, the Contractor shall provide two (2) printed copies and one (1) electronic copy in Microsoft Word and/or Microsoft Excel format to the Owner.
16. The Commissioning Report shall include all completed test forms, equipment checklists, manufacturer startup forms, functional test forms, point-to-point checklists, set points, or other commissioning documentation agreed upon during Commissioning Plan review.
17. Completed checklists, data entry forms, and test forms will be used as supporting documents in the final Commissioning Report, and therefore must be neat and legible. Scanned copies of actual forms that have been filled out by hand in the field are acceptable.