Technical Specifications

San Diego Gas & Electric Co.

Solar Energy Project

Final
Prepared by

Sacramento, CA

San Diego, CA

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Contents

1 SCOPE OF WORK

1.1 PURPOSE

This technical specification (Specification) is intended to define the minimum requirements which will form the basis for the detailed design, engineering, procurement, construction, and commissioning of a complete photovoltaic power system (System), as well as the supporting accessories, interconnections, and infrastructure as described herein (the Project). These Specifications are not intended to be all-inclusive, but should provide sufficient detail to enable the preparation and execution of a fixed-price Agreement to fulfill the described scope of work (Work). Any deviations from these criteria must be approved, in writing, by San Diego Gas and Electric Company (SDGE). The criteria herein have been formulated to ensure that the System design, engineering, procurement, construction, and commissioning will meet the following goals:

- Provide for a safe construction and operating environment
- Provide quality construction and equipment selection to ensure efficient operation
- Optimize initial capital costs to minimize overall life-cycle costs
- Provide convenient access to equipment to ensure ease of maintenance
- Maximize System performance through equipment layout and selection
- Utilize environmentally sound practices.
- Be constructed of non-combustible materials to the maximum extent practicable
- Provide comprehensive design, engineering, construction, and commissioning documents to SDGE for their records

1.2 SUMMARY

1.2.1 General System Description

The System will consist of ground mounted fixed-tilt systems with attached photovoltaic (PV) modules located on each Site. The PV modules will be connected to one or more inverters with an individual net AC output of 100kW to 1,000kW. The System will have one interconnection between the inverter(s) and the associated utility substation via a step-up transformer at each Site. Refer to Attachment 1, Minimum System Performance Requirements for minimum performance requirements.

The Seller shall be responsible for the complete design, procurement, construction, and commissioning of a complete PV System with accessories and all supporting work (Project), except as specifically excluded in these documents.

1.2.2 Site and Facility Descriptions

The System will be constructed on the following site(s) (Site).

Property Name	Facility Nameplate Capacity ($kW_{DC\ STC}$)[1]	Jurisdiction	Interconnection Point

[1]For DC to AC conversion, use 0.85

1.2.3 **System Equipment and Accessories**

The following list is not all inclusive but summarizes the common items expected to be procured and installed by the Contractor as part of the complete System:

1. PV modules
2. PV module support system
3. Combiner boxes
4. Electrical disconnects
5. Inverter(s) with enclosures and/or shade structures
6. System electrical protection
7. Switchgear
8. Revenue grade AC metering
9. Metrological (MET) stations
10. Control and monitoring systems
11. Communications Enclosure
12. Outdoor rated equipment enclosures
13. Cables, wires, jumpers, connectors, system grounding and associated trenching and/or boring
14. Equipment foundations
15. Lighting
16. Signage
17. Security fencing with access gates

1.2.4 **Site Environmental Approval Support Services**

The Seller shall be solely responsible for appropriately documenting and providing necessary environmental evaluation of each Site through the California Environmental Quality Act (CEQA) process

and complying with all requirements, restrictions, reports, and actions required for the Project to be completed. The impact and scope of the CEQA process will depend on various factors specific to each Site, and will be at the discretion and best judgment by the Seller as to the extent of the Project type and if categorical exemptions or a negative declaration may be applied to a Site. Upon review of the environmental significance at the Site, the Seller shall then be responsible for the full implementation of the CEQA process including, but not limited to, public notices, report and plans, form submittals, presentations, and all other contact with the Lead Agency, or Authority Having Jurisdiction..

1.2.5 **Engineering Design Services**

The Seller shall be solely responsible for the detailed design and coordinated functioning of all goods, equipment and material furnished under this Specification. The Seller shall conform to industry standard engineering practice for the operating conditions specified. All component parts of the equipment shall be so designed as to facilitate correct and ready field assembly, maintenance and servicing operation; and to ensure their proper coordinated functioning and operation.

1.2.6 **Work Provided by SDGE**

Seller will be responsible for building the generation and interconnection from each Site's main step-up transformer(s) to the Point of Interconnection (POI). As part of the Distribution System Upgrades, SDG&E will procure and install a SCADA-controlled 12kV main circuit breaker at the POI. SDG&E will also install portions of the Telemetering, as described in the SDG&E Electric Distribution Interconnection Handbook. The cost of the system upgrade work will be charged to the Seller as part of the Project cost. The Electric Distribution Handbook can be accessed at http://sdge.com/documents/distribution-interconnection-handbook.

1.2.7 **Documentation Submittals**

The following list is not all inclusive but defines the Project documents that are required to be submitted by the Seller for review and approval by SDGE. Time periods and dates for documentation submittals shall be in compliance with those defined in the BTO Agreement. At the Seller's option, documentation may be submitted earlier than the dates listed.

1. Copy of the Approved Major Use or Administrative permit from the Authority having Jurisdiction (AHJ) including all documents submitted for the permit together with the ruling and the conditions from the AHJ.
2. Copy of the Approved Building Permit from the AHJ with plan documentation and all required submittals,
3. As-Builts (Record Drawings)
4. O&M Manual with specifications, startup, commissioning and testing procedures for relevant equipment
5. Final PV syst Model of the System and system power production calculations based on the site.

6. Turnover package and test documentation
7. Professional Engineer Wet Stamps and signatures on final design documents:

1.2.8 **Procurement Services**

- The Seller shall be responsible for delivery to the Site of all equipment and materials procured by the Seller for completion of the Project.
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1.2.9 **Testing**

All equipment provided under this Specification shall be tested to demonstrate the ability to operate under the conditions as set forth in this Specification and to fulfill all warranties, guarantees and requirements. If the tests indicate that the equipment fails to meet the Minimum System Performance Requirements or other specified requirements, the Seller shall correct any defects in accordance with the procedures stated in the Agreement and this Specification.

1.2.10 **Equipment Documentation Services**

The Seller shall provide the following product supporting documents:

- Spare Parts Lists. The Seller shall provide all commissioning and start-up spares and parts as necessary. In addition, as part of the procurement process the Seller shall obtain recommended operational spare parts from each vendor. The Seller shall incorporate this into a recommended Spare Parts List for each item of equipment..
- Special Tools List. The Seller shall provide all special tools and other items necessary for commissioning, start-up, dismantling of equipment, and on-going maintenance requirements for the duration of the System. In addition, as part of the procurement process, the Seller shall obtain a price for all special tools required from each vendor. The Seller shall incorporate this into a recommended Special Tools List for each item of equipment. .
- Engineering Data Submittals: The Seller shall submit drawings and engineering data in accordance with the schedule.
- Operation & Maintenance Manuals. The Seller shall furnish O&M Manuals for all equipment and systems within the System prior to start-up and commissioning.

1.2.11 **Project Management Services**

The Seller shall provide project management services:

- Time is of the essence in completion of the Work. This includes the completion of various activities in accordance with milestone dates in addition to the timely delivery of equipment and materials. The Seller is solely responsible for developing and maintaining a schedule to meet all contractual milestone dates provided in the Agreement.

- The Seller may request meetings with SDGE at any time during the project in order to expedite the Work.

- After the Effective Date of the Agreement, the Seller shall provide to SDGE a proposed design, manufacturing, and shipping schedule indicating the proposed plan to meet the Project's scheduled milestone dates. This Schedule shall be delivered to SDGE no more than one (1) week from Effective Date. The Schedule shall be updated and submitted by the first of each month.
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1.2.12 **Construction Management Services**

- On-Site Manager: The Seller shall provide his own Construction Manager who shall be responsible for coordinating the activities of the Seller's personnel and that of all Subcontractors..
- The SDGE Project Manager and their Independent Engineer will be allowed on site at any time, with prior notification to the Seller's Construction Manager, to review work and/or testing.

1.2.13 **Manufacturers Field Representatives Services**

The Seller shall provide manufacturers' field representatives for certification of the condition of equipment prior to initial operation. Representatives shall be technically competent, factory-trained, experienced in the installation and operation of the equipment under each representative's jurisdiction, and authorized by the equipment manufacturer to perform the work stipulated for equipment certification.. Representatives shall furnish written certification to SDGE's Program Manager that the equipment has been inspected and adjusted by them or under their direction and supervision and that it is ready for service. This certification shall be completed before initial operation of the equipment.

1.2.14 **Additional Equipment and Equipment Services**

The Seller shall provide the following equipment and equipment services in addition to the equipment directly required for the Project:

- Any special tools required for maintenance or dismantling of the equipment provided
- All test equipment and services for checkout and calibration of all control, metering, instrumentation, and protective devices
- Testing and start-up services for all electrical and control systems. Testing shall include all pre-operational functional tests, equipment calibration, and insulation resistance tests.
- Lawful disposal of all chemicals and waste material resulting from work under these specifications
- All miscellaneous consumable materials, including weld filler rod, sealants, solvents, joint compounds, and other items required to erect the System

- Primer and/or finishing paint and application services for material and equipment furnished and erected under this Agreement in accordance with these Specifications
- Vendor recommended spare parts such as fuses and filters for operation & maintenance.

1.2.15 **Operation and Maintenance Services**

The Seller, as part of the construction scope, shall provide all necessary operational and maintenance services recommended by the various equipment manufacturers during the construction, testing, and startup period. Following project completion, acceptance, and turnover, and the contractor shall provide ongoing services as detailed in the BTO document.

END OF SECTION

1.3 OVERALL SYSTEM AND PROJECT CONFIGURATION

The System will consist of ground mounted fixed-tilt rack systems with attached PV modules located at each Site. The modules will be connected together in series to form strings which will produce DC power at 1,000V (or highest voltage allowed by Authority Having Jurisdiction) or less. The DC power generated by PV panels will be collected and converted to AC by photovoltaic inverters. The inverters will have a typical net AC output of 100kW to 1,000kW. The System will have one interconnection between the step-up transformer and the associated substation switchgear at each Site. All equipment shall be supplied in accordance with Attachment 3, Approved Equipment Manufacturer List.

All types of PV module technologies are acceptable provided that they meet the requirements described in Attachment 4, Photovoltaic Module Requirements.

The overall Project consists of the PV System and all supporting equipment and structures. The panel arrays shall be arranged to allow for convenient maintenance of the panels, inverters, modules, transformers, etc., and for the optimal power generation capability of the Project.

The site will have access via a gravel perimeter road and internal gravel roads as required for ease of inspection and maintenance. The entire site will be surrounded by a security fence.

As a minimum, the design of the System and Project shall conform to all of the requirements of this Specification in its entirety.

1.4 SITE-SPECIFIC CONDITIONS

1.4.1 Climate Conditions

The System shall be designed for start-up, shutdown, and continuous operation throughout the full range of weather conditions and temperatures as shown in the general Site data included in Attachment 2, Site Conditions. Seller to provide specific hourly climatic data to SDGE as a Typical Meteorological Year 3 (TMY3) file for design purposes.

All structures and equipment included in the Project shall be designed for outside location and for the normal annual cycle of ambient conditions typical to the Project location. The Seller shall provide a shade structure to cover the inverters, switchgear, disconnects, and other similar electrical equipment.

1.4.2 Seismic and Geotechnical Conditions

A site specific Geotechnical Report shall be prepared for the Project by a Geotechnical Engineer with current registration in California, at the expense of the Seller. The Seller is responsible for the overall geotechnical design basis of the Project.

All seismic requirements shall be detailed in the above Geotechnical Report. The Project shall be designed in accordance with the specified seismic design values per all applicable Codes, including the California Building Code (CBC).

1.4.3 **Electrical and Communications Interconnections**

The System will be electrically connected to the associated substation switchgear. The System communication shall interface with the SDGE's existing communication network.

1.5 PERFORMANCE REQUIREMENTS

1.5.1 **Design Life**

The System and its components shall be designed for a minimum life of twenty-five (25) years.

1.5.2 **Typical Inverter Description**

The inverter(s) shall convert the DC electricity generated by the PV modules into AC electricity. The California Energy Commission (CEC) weighted efficiency of the inverter shall be greater than or equal to 96.5%. The inverter shall have integrated Maximum Power Point Tracking (MPPT) and AC and DC disconnects

Minimum Performance Requirements

> Seller shall design and install a system with a total Nameplate Rated Capacity as specified in Attachment 1, Minimum System Performance Requirements. Aggregate Nameplate Capacity of installed modules shall be no less than 100% of Project Nameplate Capacity.

Nameplate Rated Capacity shall be calculated using the PV panel nameplate ratings at standard temperature conditions (STC).The System shall be designed to the following Minimum System Performance Requirements:

1. The Actual System Performance shall be equal to or greater than ninety-three percent (93%) of the Expected System Performance determined in the performance modeling, at STC-DC.
2. The Maximum System Losses as defined in 9.6.1, from and including PV panels through the System revenue meter shall not exceed fifteen percent (15%).

The Seller shall be responsible for designing, procuring, constructing, testing, and commissioning of the complete System. The Seller shall also perform the modeling and analysis requirements of Section 8, Performance Modeling and Analysis Requirements.

As part of the testing and commissioning activities, the Seller shall plan, conduct, and certify an Acceptance Test of the completed System, witnessed by SDGE's Program Manager, Engineer and/or

other designated representatives. This Acceptance Test shall demonstrate reliable operation of the System and compliance with all parameters as listed in Section 9.7.

1.5.3 **Operation and Maintenance**

The Seller shall be responsible for the performance of Operation and Maintenance (O&M) activities in accordance with the O&M Agreement. The O&M Plan will ensure that the Minimum System Performance Requirements and Power Output Guarantee will be met throughout the life of the Project, minus degradation factors as specified in this Specification.

1.6 CODES, STANDARDS, AND SPECIFICATIONS

The following Codes, Standards, and Specifications of U.S. organizations will be consulted to establish a basis for quality and safety in Project design and operation. Systems and equipment will be designed in accordance with the latest edition and addenda in effect on the Effective Date of the Agreement, unless noted otherwise.

AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASNT	American Society for Nondestructive Testing
ASTM	American Society for Testing and Materials
AWS	American Welding Society
CBC	California Building Code
CBSC	California Building Standards Codes (including Mechanical, Plumbing)
CMAA	Crane Manufacturers Association of America
ICEA	Insulated Cable Engineers Association
IEEE	Institute of Electrical and Electronics Engineers
IES	Illuminating Engineering Society of North America
ISA	International Society of Automation
ISO	International Standards Organization
LPC	Lightning Protection Code
NACE	National Association of Corrosion Engineers
NEC	National Electric Code
NEMA	National Electrical Manufacturers Association
NERC	North American Electrical Reliability Council
NESC	National Electrical Safety Code

NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Administration
SFC	State Fire Code
SSPC	Steel Structures Painting Council
TIMA	Thermal Insulation Manufacturers Association
UL	Underwriters Laboratories
WECC	Western Electricity Coordinating Council

Design specifications and construction of the Project will also be in accordance with all applicable local, state, and federal laws, including but not limited to those set forth below.

Americans with Disabilities Act
California Porter-Cologne Water Quality Control Act
California Public Utilities Commission
CAISO Small Generator Interconnection Procedures (SGIP)
Comprehensive Environmental Response, Compensation, and Liability Act of 1980
Code of Federal Regulations, Title 29
Environmental Protection Agency Regulations
Federal Aviation Administration Regulations
US Federal Water Pollution Control Act, as amended by the Clean Water Act of 1977 and subsequent amendments
Federal Energy Regulatory Commission Regulations
Federal Power Act
Noise Control Act of 1972
Occupational Safety and Health Act
Occupational Safety and Health Standards
Resource Conservation and Recovery Act (RCRA)
Safe Drinking Water Act
San Diego County Building and Development Standards and Codes
SDG&E Electrical Distribution Engineering Standards
SDG&E Electric Distribution System Interconnection Handbook
Solid Waste Disposal Act
Superfund Amendments and Reauthorization Act of 1988
Toxic Substances Control Act
Wholesale Distribution Access Tariff

In the event of a conflict between the Codes, Standards, Specifications or manufacturer recommendations described herein and Codes, Laws, Rules, Decrees, Regulations, Standards, etc., of the locality where the equipment is to be installed, the more stringent code will apply. In the case of fire

codes, the Authority Having Jurisdiction shall rule on which code is applicable for each Project design feature.

1.7 BANNED MATERIALS

No materials or products containing the following materials are allowed in the Project:

- Asbestos
- PCB's
- Hexavalent Chrome
- Mercury (exception: standard commercial lighting applications)
- Lead or Copper Based Paint

END OF SECTION

2 CIVIL AND STRUCTURAL REQUIREMENTS

2.1 GENERAL

This Section describes the civil and structural design basis for the System, including buildings, structures, and general civil work. All civil/structural work shall be designed in accordance with applicable Codes; industry standards; and local, state, and federal Regulations. Unless noted, specified, or directed otherwise in these Specifications, the Contractor shall comply with the *Standard Specifications for Public Works Construction* and *Standard Plans for Public Works Construction* (Greenbook), latest edition, Regional Supplemental documents, San Diego County Department of Public Works Design Standards, City of San Diego Standard Drawings, other City standards, and/or County or City building codes and development standards applicable to each specific Site for all pertinent standard plans and specifications related to typical civil details necessary to complete the Work for the System. Due to various locations, the Seller is responsible to determine the appropriate design standards to apply to the Project. The Seller shall comply with all requirements specified by any applicable laws, codes, and permits regarding the protection of biology and wildlife. The Seller shall obtain all building permits required by the Authority Having Jurisdiction.

The System will generally consist of, but is not limited to, solar photovoltaic module arrays, module support structures, inverters, transformers, switchgear, and applicable enclosures. The Project includes the System, as well as all ancillary supporting equipment, site improvements, a perimeter security fence and gate, foundations, and site work.

The Seller shall provide all materials and equipment necessary to perform Work and shall perform all labor and supervision services required to provide a complete and operational System..

2.2 CIVIL REQUIREMENTS

2.2.1 **Surveying**

The Seller shall perform all surveying necessary to establish and maintain control points and to provide basic measurement control for the Project during construction.
Prior to any site work, the Seller shall engage the services of the local utility locating authority to properly locate and mark all underground utilities and structures. Failure to do so shall make the Seller solely liable and responsible for damage to such underground items.

2.2.2 **Excavating and Trenching**

Site excavation shall consist of the removal of earth, sand, gravel, vegetation, organic matter, rock boulders, and debris to the lines and grades necessary for construction.

The Seller shall be responsible for the removal of all organic matter and debris as soon as practicable following the completion of backfill and grading operations. Clean soil shall be disposed of onsite. For

onsite disposal, the current site drainage patterns shall be maintained, and all fill shall be properly placed, graded, compacted, and protected from erosion and adherence with applicable grading permit(s).

Prior to any excavation, the proper utility locating services shall be engaged to identify all underground utilities. Care shall be taken during excavation to avoid damage to any existing underground utilities or structures.

2.2.3 **Backfilling**

All fill material shall be free of organic matter and foreign material such as large rocks (greater than ¾ inches), metal, concrete and trash. Fill shall be placed in lifts not to exceed six inches in thickness after compaction and shall be compacted with a mechanical roller, tampers, or other vibratory equipment which will provide uniform compaction throughout the depth of fill. Soil in each layer shall be properly moistened to obtain its specified density, and representative field density and moisture-content tests shall be taken during compaction to verify compliance with these Specifications. Compaction test results shall be transmitted to SDGE for review and record.

All structural and general site fill shall be in accordance with the recommendations of the site-specific Geotechnical Report and the following compaction requirements:

- For structural sub grades and all structural fill, the material shall be compacted to a minimum density of 95% of the maximum dry density, as determined by Modified Proctor Test (ASTM D 1557). Moisture content at the time of compaction shall be maintained within ± 2% of the optimum moisture content.
- For all other areas, the material shall be compacted to a minimum density of 90%of the maximum dry density, as determined by the Modified Proctor test (ASTM D 1557). Moisture content at the time of compaction shall be maintained within ± 2% of the optimum moisture content.

2.2.4 **Grading**

Site grading shall comply with all applicable regulations and governing County or City grading requirements. Graded areas shall be smooth, compacted, free from irregular surface changes, and sloped to drain. Final earth grade adjacent to equipment and buildings shall be below finished floor slab elevations and shall be sloped away from foundations as necessary to maintain proper drainage. Unless shown otherwise on the Project drawings, the Seller shall return all areas disturbed by construction to their previous grade elevations and shall replace any finished paving in those areas disturbed during construction.

2.2.5 **Access Roads**

The Seller shall design and construct gravel access road(s) as required for equipment access. Gravel road shall be constructed with California Department of Transportation (Caltrans) Class II Aggregate base

material. Gravel shall be compacted to a minimum of 95% of maximum dry density. Aggregate samples shall be delivered for inspection and approval prior to delivery on site.

The provision of road access shall include, at minimum, from the point of entry from an approved public access point to the PV site, a site perimeter loop, and the area immediately around transformers, inverters, switchgear, enclosures, and other similar structures. All transitions between the public access point, loop, and other intersections shall be constructed with appropriate smooth transitions. No large grade changes will be accepted.

Gravel road(s) shall be at least 24' wide and crowned or consistent side slope (between 0.5% and 2%, maximum) to provide proper drainage off of designated road section(s). Gravel road section shall be designed per the recommendation of the site-specific Geotechnical Report and per governing Regional, County, or City standard design specifications. . Road must meet all requirements by the Authority Having Jurisdiction and any required services such as fire protection

Limited asphalt or concrete paving may be required for some sites. Paved areas shall be designed and constructed in accordance with applicable Caltrans road surface specifications.

2.2.6 **Perimeter Fence**

The Seller shall design and construct a security fence surrounding each Site with a nominal 8-foot minimum height security fence. . For access to the Site, one (1) double gate shall be provided at the designated point of entrance to the Site. The perimeter security fence and gate shall be provided in accordance with the following guidelines.

- Fence posts, top and brace rails to be in accordance with ASTM A1083, galvanized. Line post size to be 2-inches, nominal, spacing not to exceed 10 feet. Corner, terminal, and gate posts to be 3.5-inches nominal size. Top and brace rails to be 1-1/4 inch minimum nominal size.
- Fence fabric to be 8-foot nominal height, 2-inch diamond mesh galvanized interwoven wire, 11 gauge, top selvage twisted tight, bottom selvage knuckle end closed, galvanized, per ASTM A392. Fabric placement to provide 3-inch gap, maximum, between finished grade and bottom of fabric.
- Gates to be welded construction, galvanized, using 1-1/2 inch minimum size materials in accordance with ASTM A1083. Gate hardware to include a fork latch with gravity drop for single gates; center gate stop and drop rod for double gates; two 180 degree hinges per leaf; and hardware for padlock, each gate. Minimum gate opening for main drive access shall be 12 feet for single gates, or 10 feet, each side gate, for double gates.
- Extension arms shall be galvanized steel, single arm, sloped to 45 degrees, and accommodate 3 strands of barbed wire.
- All other accessories, including caps, sleeves, bands, clips, rail ends, tension bars fasteners, and other fittings shall be galvanized steel, sized correctly for application.

- All gates and fencing shall be grounded in accordance with applicable electrical codes.

2.2.7 **Perimeter Road and Module Row Spacing**

- The Seller shall provide an alignment of the perimeter security fence to allow a road access path, with a minimum of 12 feet between the security fence and next nearest obstruction (e.g., solar array frame).
- The Seller shall provide a minimum of 7 feet between PV module rows to allow access for cleaning and maintenance.

2.2.8 **Security**

- Photovoltaic panels shall be mounted with theft-resistant bolts or screws.
- Security fence gate shall be equipped with an Alarm System to sense unauthorized entry. Alarm System shall be internet-based via a phone line or cellular system and alert designated SDGE personnel. SDGE will be responsible for monthly charges.
- A minimum of four (4) video cameras shall be strategically placed on the security fence for surveillance of majority of PV facility area. Video cameras shall utilize an internet-based communications system via a phone line or cellular system. Seller shall arrange installation of phone lines or cellular system. SDGE will be responsible for monthly charges.

2.2.9 **Storm Water Management**

- Seller shall prepare and certify to SDG&E that all related permit documents (e.g., inspections, sampling results, reports) are true, accurate, and complete.

- The Stormwater Permits and SWPPPs shall cover SDG&E's work to extend the electric from the PV site to the designated connection point.

- All documents shall be provided to SDG&E in a form (hard-copy, electronic) as requested by SDG&E.

2.2.10 **Vegetation Replacement/Landscaping**

Upon final grading and completion of the System construction activities, the Seller shall include replacement of vegetation, hydro-seeding, and/or soil surface stabilization as applicable to the Project Site and in accordance with all permits. Replacement/installation of vegetation and/or seed mixes shall meet the native species type and/or San Diego County standard specifications for vegetation species.

2.2.11 **Standard Urban Storm Water Mitigation Plan**

For Sites that are within the jurisdictional coverage of the Standard Urban Stormwater Mitigation Plans (SUSMPs), it is the responsibility of the Seller to incorporate permanent storm water BMPs into the design of the Project and all associated costs in compliance with the SUSMPs. If necessary, the Seller shall prepare and submit a *Water Quality Control Plan* to the City Engineer of the respective Site. The *Water Quality Control Plan* shall also identify any conditions of concern that impacts the design of the mitigation plan in conformance with the applicable SUSMP requirements. It shall be the Seller's responsibility to determine if a SUSMP is required for the Site. As applicable, the sites shall comply with the post-construction standards contained in the CGP.

2.3 STRUCTURAL DESIGN

2.3.1 **General**

All Project structures shall be designed in accordance with the requirements of the California Building Code 2010 (CBC), the Geotechnical Report, and local code requirements.

The design of the PV support modules shall account for the cyclical effects of wind over time and shall minimize structural deflection so that module efficiency is not impacted. If direct-buried steel posts are used, the design shall consider any detrimental structural impacts at the soil-structure interface due to soil shrink-swell and soil compaction. All structures shall include a warranty for design life as described in the Agreement.

Reinforced concrete structures shall be designed in accordance with the design requirements for concrete buildings and structures published by the ACI.

All Site improvements shall be designed and configured to meet OSHA requirements contained in Part 1910 of the U.S. Code of Federal Regulations.

2.3.2 **Foundations**

The inverter and other equipment foundations shall be designed in accordance with the manufacturer's recommendations and the site-specific Geotechnical Report. Both static and dynamic loading criteria set forth by the manufacturer shall be considered. The general structure shall be a reinforced concrete mat foundation with concrete pier/pedestals provided as needed to match the equipment supports and anchorages.

2.3.3 **Design Loads**

1. Dead load shall consist of the weight of all permanent construction including, but not limited to, fixed equipment, framing, floors, walls, roofs, and any other structures.
2. Live load is the load superimposed by building use and occupancy. It does not include wind load, snow load, earthquake load, or dead load. The minimum live load design basis shall comply with ASCE 7-05 Table 4-1.
3. Ground floors (floors at grade) shall be designed for 250 pounds per square foot or the actual equipment, storage, or laydown weight imposed.
4. Equipment operating load shall be the normal operating load in excess of the dead load.
5. Dynamic loads shall be considered and applied in accordance with the manufacturer's specifications, criteria, or recommendations, and industry standards.
6. Seismic loads shall be calculated based on the CBC and the Geotechnical Report, and shall apply to all equipment and structures. Equipment anchorages and supports shall be designed to prevent overturning, displacement, and dislocation in accordance with the governing building code and local requirements.
7. Wind pressures and shape factors shall be applied to all System components and exposed equipment in accordance with governing building code and local requirements. No allowance shall be made for the shielding effects of other structures. The overturning moment calculated from wind pressure shall not exceed two-thirds of the dead load resisting moment. The uplifting forces calculated from the wind pressure shall not exceed two-thirds of the resisting dead loads and adequate structural foundation ties shall be designed to resist wind forces.

2.3.4 **Mounting Structures and Structural Steel**

PV module support structures shall be designed in accordance with current building code and best industry practice. Structural elements shall be steel or other SDGE-approved materials. Steel structures shall be designed, fabricated and erected in accordance with ANSI/AISC 360-05 Specification for Structural Steel Building. Structural and miscellaneous steel shall conform to the requirements of ASTM A36, A572 Grade 50, and/or A992 or other materials as required and accepted by AISC. High strength bolts shall conform to ASTM A325 or A490.

All structural components shall be corrosion resistant, using anti-corrosive paint, powder coating, hot-dip galvanizing, or other method approved by SDGE. Any structural steel penetrating the ground shall be hot-dip galvanized or powder coated. The Seller shall consider soil conditions and corrosivity and provide a detailed submittal of the proposed anti-corrosion treatment. Galvanized hot-dip coating, or equivalent if approved by both Parties, shall be considered a minimum for mild steel corrosion protection.

High-strength bolts shall conform to ASTM A325 or A490. All other bolts shall conform to ASTM A307 Grade A. All bolts shall be designed to resist rust for a minimum of thirty (30) years. ASTM A325 bolts

shall be galvanized for corrosion protection. ASTM A490 bolts shall be of the most corrosion resistant type material and not galvanized. Embedded anchor bolts shall conform to ASTM F1554.

Anchor bolts shall be in conformance with ASTM A307, A36, or F1554 as applicable. Hex nuts shall conform to ASTM A563, Grade A or Grade DH heavy hex, and washers shall conform to ASTM F346. Anchor bolt sleeves, if required, shall conform to ASTM A501.

All structures shall include grounding tabs or similar, as required, to accommodate connection to earth grounding, in accordance with applicable electrical codes.

The Seller shall submit PE stamped wind loading calculations for all PV structures, inverter shade structures, shelters, and anchors.

2.3.5 **Structural Concrete**

Structural concrete shall comply with ACI 318 Building Code Requirements for Reinforced Concrete. Concrete strength shall be 3000 psi minimum at twenty-eight (28) days. Materials shall be handled and stored as recommended in ACI 304. Mixes shall be formulated to produce durable concrete of the required strength for the anticipated exposure conditions. Seller shall refer to the Geotechnical Report for additional criteria required on the concrete mix.

Additives may be included in the concrete mix at the discretion of the Seller, provided that the intended strength and durability is not compromised. Calcium chloride and admixtures containing calcium chloride shall not be used.

When concrete is to be placed by pumping, special consideration shall be given to the concrete mix to provide the workability, quality, and strength required for the pumping operation.

All slab-on-grade foundations shall bear on prepared, compacted, non-expansive fill of 2-feet minimum depth unless specified otherwise in the Geotechnical Report.

2.3.6 **Shade Structure**

Each Site shall be provided with a Shade Structure or shelter for the purpose of protecting inverters, communications enclosure, switchgear, and other electrical equipment from direct sunlight. Materials and construction details shall comply with the structural steel requirements listed above in Section 3.3.4.

The shade structure may be designed to support the mounting of electrical equipment. In this case, load calculations and design for the enclosure and foundation shall take into consideration the dead load of the supported equipment and maximum wind loads imposed on the structure and equipment surfaces. The Seller shall properly specify all loads in the associated design documentation.

The shade structure shall be designed and sized so that all equipment can be removed in the future using standard maintenance practices and without having to remove the shade structure itself. Location of the shade structure shall take into account other obstructions, including but not limited to, security fence, solar array, etc. The top roof of the shade structure shall also have a constant slope (1/12 pitch minimum) to allow precipitation to run-off the structure and away from the equipment intended to be protected. The lower point of the structure's roof shall be in the South direction. A three-foot overhang, all directions, shall be provided. A two-foot minimum clearance, or minimum required by the equipment manufacturer for the equipment under the structure, shall be provided between the top of the highest equipment to be shaded and the lowest point of the shade structure.

2.3.7 **Communications Enclosure**

The Project shall have a communications enclosure. The enclosure shall contain the communications, storage, System control, and station battery/UPS equipment. The Enclosure shall maintain proper temperature control for the electronic equipment.

The Enclosure shall be provided with fire protection and detection, and shall include a local fire alarm module capable of transmitting a remote alarm signal to an off-site location that will be defined by SDGE.

Loads for the Enclosure shall take into consideration the added dead load for items such as batteries, HVAC and other items that will hang from the building structure. The Contractor shall properly specify all loads.

2.3.8 **Permits**

The Seller is obligated to contact and coordinate with all Authority Having Jurisdiction for inspections and approvals as required to comply with the CBC and permit requirements.

2.3.9 **Signs and Labels**

The Seller shall provide and install all primary Project signs including System identification, safety, and warning signs. Signs shall be located throughout the site in accordance with applicable OSHA requirements and these Specifications, and as required by the AHJ.

At a minimum, the following signs shall be provided by the Seller:

1. System Identification: Minimum one sign on each access gate. Sign shall be 12"x18" with black lettering on white field, .080" Aluminum, ASTM B-209. Sign shall list name of Site and contact information as provided by SDGE.
2. Private Property/No Trespassing: Installed on gate and every 100' minimum on fence, 10"x14" black lettering on white field, Aluminum.
3. High Voltage - Keep Out: Installed on gate and every 100' minimum on fence. Sign shall be 10"x14" with standard format black and red lettering on white field, Aluminum.

4. High Voltage: Installed on each inverter, transformer, and other applicable equipment. Sign shall be weatherproof, adhesive label or heavy gauge plastic mechanically affixed, sized as appropriate for each unit.

2.3.10 **Testing**

The services of an independent, qualified materials testing laboratory shall be engaged by the Seller for sampling, testing and certifying that the following construction work and materials are installed as specified:

- Concrete slump and strength
- Grout and mortar strength
- Structural steel bolting and welding
- Additional testing as required to conform with the CBC and local government requirements

END OF SECTION

3 MECHANICAL SYSTEMS AND EQUIPMENT

3.1 FIRE PROTECTION SYSTEM

The Seller shall provide fire protection systems and equipment to meet the requirements of NFPA 850, the California Fire Code, and the local Fire Marshal. The design criteria in this Section shall be considered minimum standards, which may be superseded or supplemented by specific requirements of the local Authority Having Jurisdiction.

If fire protection is required by the local Authority Having Jurisdiction, the Seller shall utilize carbon dioxide (CO_2) based fire suppression systems to minimize damage to the electrical equipment. Additionally the system shall be equipped with a Fire Alarm that alerts designated SDGE personnel via an internet based system. Seller shall arrange for Fire Alarm telecommunications via phone line or cellular system. SDGE will pay monthly charges after Acceptance.

END OF SECTION

4 ELECTRICAL SYSTEMS AND EQUIPMENT

4.1 GENERAL

This section describes the primary electrical equipment and systems of the Project, their functions, and the general criteria of the design basis. Additional requirements included in the scope of this Work are provided in the SDG&E Electric Distribution System Interconnection Handbook and the SDGE Electric Services Standards and Guide Manual.

As a general description of the electrical system, power shall be generated by photovoltaic (PV) modules, rated 1,000 VDC or less, converted to AC through photovoltaic inverters, connected through a step-up transformer, measured by utility grade metering, then connected to an existing substation associated with the Site, as required by the Authority Having Jurisdiction.

The Seller shall provide equipment specification data sheets with detailed information and shall make them specific to the Project. All major equipment shall be approved by SDGE prior to procurement. The Seller shall also provide project-specific electrical drawings, including single-line diagrams, schematic diagrams, and wiring diagrams.

4.1.1 **Interconnections**

Generated power shall be delivered to the SDGE medium voltage distribution line. The Point of Interconnection shall be defined as the point at which the System generation tie connects to the SDGE medium voltage (12kV or 12.47 kV) distribution lines. As part of the Distribution System Upgrades, SDG&E will procure and install a SCADA-controlled 12kV/12.47kV main circuit breaker at the POI. SDG&E will also install portions of the Telemetering, as described in the SDG&E Electric Distribution Interconnection Handbook. The cost of this system upgrade work will be charged to the Seller and is included in the Contract Price. The design and procurement for all hardware and equipment on the generation side of the ground-level main circuit breaker switch shall be the responsibility of the Seller, except as noted in the Interconnection Handbook.

4.1.2 **Design Criteria**

The SDG&E Electric Distribution System Interconnection Handbook, SDGE's Electrical Distribution Engineering Standards, and the CAISO Small Generator Interconnection Procedures shall be used as references for design criteria and can be accessed at:

http://www.caiso.com/240d/240dbed434030.pdf

1. Electrical systems, equipment, materials, and installation must be designed and constructed in accordance with applicable sections of the NEC Code, IEEE standards, local codes and regulations, local utility guidelines and standards, the SDG&E Electric Distribution System Interconnection Handbook, and the Project design criteria as described in these Specifications.

2. All equipment shall be sized to carry 120% of the maximum calculated load to provide spare capacity.
3. Equipment short-circuit ratings shall be based on the maximum short-circuit currents under all operating conditions and shall account for equipment design margins.
4. Electrical system studies shall be based on maximum system operating limits to ensure that the System will be operable under all conditions without starting limitations or exposure of the System or Facility electrical equipment to voltages in excess of stated operating limits.
5. All electrical and controls equipment requiring access for normal operation and/or maintenance shall be accessible from permanent floors or grade without scaffolding, portable ladders, or lifts. Access space and clearance for electrical equipment shall be in accordance with the manufacturer's recommendation and NEC requirements.
6. The Seller's design for the protective relaying, metering, and control parameters shall be in accordance with the SDG&E Electric Distribution System Interconnection Handbook, and reviewed and approved by SDGE prior to construction.
7. The Seller shall perform Arc Flash studies and design the electrical system for a hazard/risk category of two or less as defined in NFPA 70E using standard available equipment and relaying schemes. In no case shall the arc flash energy level exceed 18 cal/cm^2 at 18" from live parts. If temporarily instantaneous settings are used with an operator initiated switch, the uncoordinated circuit protection shall be limited to only the area in which the operator is working.
8. The PV System shall meet all NEC requirements including, but not limited to NEC Articles 690 and 705.
9. All equipment shall be UL listed unless otherwise approved by SDGE.
10. The physical layout of the PV Modules shall be arranged to minimize cabling losses and mismatching of string sizes and loads.
11. PV Module string length and cable sizing shall be designed to maintain the voltage at the Inverter DC terminals within the inverter maximum power point tracking window at PTC and at the site maximum historical temperature.
12. Unless otherwise specified, all equipment shall be manufactured by one of the approved manufacturers listed in Attachment 3, Approved Equipment Manufacturer List. Equipment and material groups supplied for the Project shall be consistently from the same manufacturer whenever possible.

4.2 EQUIPMENT

4.2.1 Photovoltaic (PV) Modules

1. PV modules supplied shall meet performance requirements and equipment criteria as describe in Attachment 4, PV Module Requirements.

2. PV modules supplied shall be procured from a vendor included on the approved vendor list as described in Attachment 3, Equipment Manufacturer List. Specific module model to be approved by SDG&E.
3. All of the PV modules in a site shall be from a single vendor and all PV modules attached to the same inverter shall utilize the same technology, and provide equal peak DC power.
4. Refer to Attachment 4 of the Specification for Module Warranty, including Defects and Degradation.
5. The actual power production of each module shall be within 5% of the power specified by the manufacturer.
6. Each PV module shall be certified nationally by UL 1703 or internationally by IEC 61215 unless otherwise specified by SDGE.
7. Each module string shall have a typical deviation of less than 5% from the manufacturer's specified power when no part of the string is shaded. The actual power of the System will be equal to or greater than the theoretical power for the System based on clean panel power rating.
8. Each module and string design shall be sorted by I_{mp} to reduce module mismatch losses.
9. PV modules shall be mounted with theft-resistant screws or bolts.

4.2.2 **Inverters**

1. Inverters supplied shall meet performance requirements and equipment criteria as describe in this Specification.
2. Inverters supplied shall be procured from a vendor included on the approved vendor list as described in Attachment 3, Approved Equipment Manufacturer List.
3. Inverters shall have an output rating of 100kW or greater.
4. Inverters supplied shall be utility-interactive for synchronization and anti-islanding capability unless otherwise specified by SDGE.
5. Inverters shall have adjustable set points for power factor.
6. Inverters shall meet or exceed the most current revision of UL1741, unless otherwise specified by SDGE.
7. Inverters shall meet or exceed all requirements of IEEE 1547, most current revision. The voltage and frequency set points shall be programmable to meet SDGE's operating requirements.
8. Inverters shall be capable of meeting the requirements of FERC 661/661A Low Voltage Ride Through standard.
9. Inverter CEC weighted efficiency shall be greater than 96.5%.
10. Inverters located outdoors shall be enclosed in lockable, NEMA 3R powder coated enclosures. Inverters located indoors shall be in an enclosure that meets NEMA 1 requirements.
11. Inverter enclosures shall be provided with a door interlock system and lockable switches to prohibit the door(s) and switches from being opened while energized.

12. Inverters shall incorporate a no-load, 2-pole disconnect switch for main DC power disconnect for maintenance personnel safety. Disconnect shall be lockout-tagout capable.
13. Inverter output shall be protected by a circuit breaker with short- and long-time adjustable over-current protection. This circuit breaker shall be externally operated or shall be provided with an external on/off (start/stop) switch.
14. Inverter enclosures shall be climate controlled as required to maintain inverter operating temperatures within the manufacturer's specifications for all expected Site conditions.
15. Fire systems, if required, shall comply with the requirements of the Authority Having Jurisdiction.
16. Inverters shall employ a Maximum Power Point Tracking (MPPT) scheme to optimize inverter efficiency over the entire range of photovoltaic panel output for the given Site conditions provided in Attachment 2, Site Conditions.
17. The inverter monitoring and communications package shall incorporate control and data collection points as described in Section 5 of this Specification.
18. The Inverter communication switch shall contain additional ports to accept a link to the tracker controllers, if required.
19. Inverter enclosures shall be provided with a Control Power Transformer (CPT) with fused disconnect, sized as required, feeding an AC panel to supply power for convenience receptacles, inverter climate control equipment, and fluorescent lighting, as required.
20. A separate Control Power Transformer (CPT) shall be included to supply Inverter control power.
21. The Seller shall provide the specific model and technical specifications of the Inverter for approval by SDGE prior to equipment procurement. Inverters shall be manufactured by one of the approved suppliers as listed in Attachment 3, Approved Equipment Manufacturer List.
22. Inverter(s) DC power input to be no greater than the lesser of 130 % of the inverter nameplate rating or the inverter manufacturers recommendation.
23. Inverter functionality must meet the Inverter Specifications listed in Section 3.5 of the current SDG&E Electric Distribution System Interconnection Handbook.

4.2.3 **Station Batteries**

1. The emergency power for the plant switchyard and other plant critical loads such as communications and data storage will be supplied by a station battery system.
2. The station system shall consist of one (1) 100% capacity battery bank and one (1) 100% capacity battery charger.
3. The batteries shall be flooded cell, lead calcium type. This system shall supply DC power requirements for the communications, controls and data acquisition equipment and the System protective hardware.
4. The battery system shall be sized for a continuous and non-continuous load current time period of 8 hours. The battery system sizing shall include an adjusted rating for a design factor of 10% and an aging factor of 25 years.

5. The battery charger shall be sized to supply the normal DC loads while simultaneously recharging a fully discharged battery in 12 hours or less. The charger shall be designed such that it may be operated as a battery eliminator with the battery disconnected.
6. The batteries shall be connected to the DC panel board through a disconnect switch. The panel board shall be designed in accordance with NEMA PB-1 and PB-2. Each panel board shall be provided with 20%spare breakers and shall be fully equipped.
7. The battery system shall be located in an enclosure. The battery enclosure shall have positive pressure air exchange systems to prevent dangerous accumulations of hydrogen in accordance with IEEE 484. Based on the Site condition, the installation of an air temperature controller might be necessary per the battery manufacturer recommendation. The installation shall be in accordance with NFPA and IEEE standards.
8. The Seller shall be responsible for producing battery and battery sizing calculations in accordance with these design criteria.
9. Batteries and battery cells shall be easily accessible for maintenance or removal.
10. Battery mounting rack shall be no more than 2 tiers and shall meet all state and local codes.
11. A battery drip pan shall be provided under the battery system.

4.2.4 **Step Up Transformers**

1. Transformers shall be radial style, liquid filled or dry type.
2. The nominal high-side voltage shall be 12.47 kV grounded wye, unless noted otherwise by SDGE. Transformer low voltage windings shall be delta connected and shall be rated according to the Inverter manufacturer's recommendations.
3. Transformers shall be rated for continuous operation of the Inverters.
4. Transformers shall be supplied by one of the manufacturers listed in Attachment 3, Approved Equipment Manufacturer List.
5. Liquid filled Transformers shall contain a listed less-flammable dielectric coolant meeting the requirements of NEC Section 450-23 and the requirements of the National Electrical Safety Code (IEEE C2-1997), Section 15. The dielectric coolant shall be readily available and completely biodegradable per EPA OPPTS 835.3100. Transformer insulating oil shall be Biotemp® or an approved equivalent. Transformer cooling class shall be ONAN. Spill containment shall be provided for liquid filled transformers. Liquid filled transformers shall meet or exceed the standards as described in IEEE C57.12.
6. Dry type transformers shall have copper windings and be built and tested in conformance with ANSI C57.12.01, ANSI C57.12.51, ANSI C57.12.55, ANSI C57.1291, IEEE C57.12.60 and IEEE C57.96 Annex A standards. Dry type transformers shall be ventilated dry-type cast coil, Class AA suitable for outdoor use. The insulation shall be Class H, 220 degrees C rated for an 80°C average temperature rise by resistance over the ambient temperature of 50°C maximum. Vacuum impregnations of the transformer coils shall be treated with an epoxy resin by a vacuum pressure impregnation process.

4.2.5 **Communications Enclosure**

1. A communications enclosure shall be provided to house the Inverter Master Controller, SCADA and telecommunications equipment, power and lighting panels, DC station batteries and DC panel board.
2. The communications enclosure shall be provided with HVAC equipment or shade structure to maintain proper temperature control for the electronic equipment
3. The communications enclosure is not intended for full-time personnel occupancy.
4. A fire detection/suppression system shall be installed in the communications enclosure and the inverter enclosures as required by the Authority Having Jurisdiction.

4.2.6 **Medium Voltage Switchgear**

1. The medium voltage switchgear and telemetering shall be designed and constructed in compliance with the SDG&E Electric Distribution Interconnection Handbook. Handbook requirements shall override any possible conflicts with other specifications. Medium voltage is defined as 12.0 kV or 12.47 kV, as necessary depending on site location.
2. The medium voltage switchgear lineup shall be located outdoors and shall be rated to continuously carry nominal Plant generation. The lineup shall contain power metering and voltage transformers, fused switches and circuit breakers as necessary to collect and interconnect full plant generation.
3. The medium voltage switchgear shall be protected with a SCADA-controlled breaker at the Point of Interconnection (supplied by SDGE at Seller's expense), and a ground-level "visible status" disconnect switch.. Switchgear feeders may be protected with breakers or fused disconnects.
4. Breakers shall be drawout type and provided with remote racking mechanisms. Breakers shall be vacuum interrupter type.
5. Switchgear circuit breakers shall have an ANSI rating structure based on a K factor of 1.0 and interrupting rating of 25 kA and a minimum BIL rating of 95 kV.
6. Switchgear shall include an auxiliary compartment containing all instrument transformers associated with the protective relays and a 120/240 V Control Power Transformer (CPT). The CPT shall be fused and disconnectable. The CPT shall be sized to supply the expected continuous load, with approximately 20 percent margin for future load growth. The transformers shall be air-cooled, dry type, with a 150°C rise.
7. Switchgear shall be provided with a metering section containing provisions for utility and CAISO meters.
8. Protective relaying, metering, and control parameters shall be in accordance with the SDG&E Electric Distribution System Interconnection Handbook, and reviewed and approved by SDGE prior to construction.
9. Switchgear control voltage shall be 48 VDC.
10. Switchgear shall be supplied by one of the Vendors listed in Attachment 3, Approved Equipment Manufacturer List.

4.2.7 **Power Cables**

1. All System PV cabling shall be type USE-2, THWN-2 or RHW-2 with XLPE insulation listed and labeled as PV wire in accordance with NEC article 690.31(B) and as defined in UL 4703. Cables shall be listed as sunlight (UV) resistant, and listed for operation at 1,000 V unless otherwise noted.
2. The cable circuit sizing and current shall be in accordance with NEC Article 690.8 and 310.15.
3. Low voltage cables other than PV cables shall meet NEC and industry standards.
4. Cables shall be sized to allow a voltage drop of 3% or less.
5. Medium voltage conductors shall be rated for 12.47kV, type MV-105(dry or wet), single compact conductor, 133% TRXLP or EPR insulation, copper tape shield.

4.2.8 **Combiner Boxes**

1. PV string combiner boxes shall be certified by a nationally recognized testing laboratory and listed for maximum System voltage and maximum System continuous and short circuit currents.
2. Enclosures for combiner boxes shall be rated NEMA 3R or NEMA 4 and shall have integral key lock or provisions for padlocking.
3. DC inputs shall be fused with finger-safe fuse holders. Fuses shall be listed for use on PV source circuits.
4. Combiner boxes shall be mounted underneath PV modules on panel mounting structures.

4.2.9 **Disconnecting Means**

1. Disconnecting means (AC or DC) shall be provided in accordance with Part III of NEC article 690.
2. Disconnect switches shall be certified by a nationally recognized testing laboratory and rated for maximum System voltage and maximum System continuous and short circuit currents.
3. Disconnect switches shall have provisions for lockout-tagout procedures.
4. Enclosures for disconnect switches shall be rated NEMA 3R or NEMA 4 and shall be lockable.

4.2.10 **Conduit and Fittings**

1. All cabling transitioning from underground to above ground shall do so through conduit.
2. Above ground conduit and conduit transitioning from underground to above ground shall be galvanized rigid steel in accordance with UL 6.
3. Above ground fittings shall be in accordance with UL 514B, and rated for outdoor use.
4. All underground conduit shall be PVC, Schedule 40 minimum, in accordance with NEMA TC-2.
5. Underground DC power cabling from DC combiner boxes to Inverter shall be installed in conduit with marker ribbon installed a minimum of 12 inches above the cable or conduit, as appropriate.
6. All underground AC power cabling shall be placed in conduit and encased in concrete slurry with marker ribbon installed a minimum of 12 inches above the conduit.

7. All underground conduit carrying control or communications cable shall have a marker ribbon installed a minimum of 12 inches above the conduit.
8. All underground conduit fittings shall be in accordance with NEMA TC-3.
9. DC Cabling from the module string to the combiner box between module rows shall be installed in underground conduit.
10. Cabling installed between the main circuit breaker switch and the System POI shall be installed in underground conduit or mounted above ground on poles. Design of this cabling shall be approved by SDGE.
11. Junction boxes, pull boxes or handholes shall be installed as required per NEC Article 314.

4.2.11 **Electrical Equipment Enclosures**

Control Cabinets, pull boxes and junction boxes shall be in accordance with NEMA Standards and type number and shall be suitable for the location conditions. Base design shall be NEMA 1 for indoor installation and NEMA 3R or NEMA 4 for outdoor installation. All enclosures shall be provided with pad locking provisions.

4.3 ELECTRICAL PROTECTION

4.3.1 **General**

1. To the extent feasible, protective devices shall be coordinated to interrupt electric disturbances (fault, overload, abnormal operating condition, etc.) with the device nearest the fault.
2. Protection of PV source circuits shall be in accordance with Part II of NEC article 690.
3. The Seller shall perform and provide detailed protective relay calculations and relay settings inclusive of all system protection, including inverter output protection. Additional settings for system backup protection functions such as device 21, 51 V and 78 shall be calculated and issued by the Seller as required.
4. The Seller shall coordinate with the interconnecting utility on interface and protection requirements, including protection philosophy, signal exchange, relay settings and relay selection as appropriate.
5. The Seller is responsible for producing Site specific control and protection schemes.

4.3.2 **Protection Systems**

1. Seller shall develop and implement relay protection settings in accordance with the SDG&E Electric Distribution System Interconnection Handbook.
2. The Seller shall provide inverters with protection in accordance with industry standard.
3. The Seller shall develop and implement inverter protection and operational set-points as required.
4. Ground fault for solar arrays must be capable of detecting low-level ground faults by monitoring methods such as insulation resistance and/or differential measurement.

5. The Seller shall provide combiner boxes with protection in accordance with industry standard and solar module manufacturer's requirements.
6. All other panels, circuits, and System loads shall have thermal-magnetic molded-case circuit breaker protective devices.
7. Protective devices shall be in accordance with the NEC Article 240 and 690.
8. Transformers shall include high voltage winding fuse protection in accordance with NEC Article 690.9(B). The fuse shall be properly sized and shall coordinate with the upstream relays in the medium voltage switch gear.

4.4 METERING

4.4.1 Revenue Metering

1. Revenue metering equipment for both the utility and CAISO (if required) shall be provided in the metering cubicle of the medium voltage switchgear, and shall have a single communication link for the metering data from both meters to the Project communication equipment as required per the SDG&E Electric Distribution System Interconnection Handbook.
2. New revenue metering current and potential transformers shall be electrically located in accordance with local utility requirements.
3. Meter(s) supplied shall be procured from a vendor included on the approved vendor list as described in Attachment 3, Approved Equipment Manufacturer List.
4. Further metering requirements are included in the SDG&E Electric Distribution System Interconnection Handbook.

4.4.2 Indication Metering

1. Indication metering shall be provided in the following locations:
    - Inverter input volts and amperes
    - Inverter output amperes, voltage, and frequency
    - Inverter voltage [each phase], current, kW, kVAR, kWHr, kVARHr, power factor, and frequency will be metered with a multifunction meter.
    - Each medium voltage switchgear feeder (voltage, current, kW, and kVAR) will be metered with a multifunction meter.
2. Multifunction switchgear power meters shall be furnished with a data link to the Project communication equipment.
3. Shorting-type terminal blocks shall be provided to allow meters to be removed without disrupting current transformer circuits.
4. Relaying class accuracy voltage and current transformers are acceptable for panel indication meter applications.
5. ABB FT-1 type test switches shall be provided for the voltage and current inputs to each meter.

4.5 GROUNDING

4.5.1 General

1. The System grounding shall consist of ground rods as required.
2. Grounding shall comply with the requirements of NEC Articles 690 and 250, the NESC, and recommendations contained in ANSI/IEEE Standards 80, 142, and 367.
3. All major electrical equipment, metal fences, structural steel, and metal conduit shall be grounded directly to an earth ground.
4. All exposed non-current-carrying metal parts on the DC side of the PV system, i.e., PV metal module frames, structural racks, combiner boxes, etc. shall be bonded together and the point of system grounding connection shall be made at the inverter grounding electrode.
5. All mounting structures associated with each combiner box shall be bonded in accordance with NEC requirements to the System ground.
6. The communication, instruments, and control cable shields shall be grounded per IEEE 789 and the instrument supplier requirements as applicable.
7. The calculated earth ground resistance shall be verified by measuring final grounding resistance by Fall-of-Potential method per IEEE 81.
8. All grounding conductors shall be 12 AWG or larger.
9. Equipment grounding conductors shall be installed with all feeders and branch circuits. These ground conductors shall be terminated on each end on a suitable lug, bus or bushing.

4.6 PROJECT ELECTRICAL SERVICES

4.6.1 Lighting Systems

1. At a minimum, permanent lighting shall be provided in the following areas:
    - Enclosure interiors
    - Outdoor equipment access areas, such as at the inverters and switchgear
    - Under equipment shade structures
    - At the Site entrance
2. Lighting levels shall be as recommended in IES standards.
3. Suitable fixtures shall be specified and installed according to the hazardous area classification, if applicable.
4. Emergency enclosure lighting shall incorporate integral battery packs and shall provide for safe egress from all enclosures, if applicable.
5. Lighting circuits shall use minimum #12 AWG stranded copper or #10 AWG stranded aluminum conductor. Cables used for lighting circuits shall be XHHW-2. In exposed areas, the circuits shall be provided with rigid steel galvanized conduits with weatherproof fittings.
6. Outdoor lighting circuits shall incorporate dusk-to-dawn photocell controllers, occupancy sensors, and/or switches as appropriate.

7. Outdoor lights shall be tamper resistant.
8. Light poles shall be galvanized steel or aluminum, located to avoid shading of PV panel arrays.
9. To reduce the visual impact created by outdoor lighting, Project site lighting shall be directed and/or shielded to avoid nighttime backscatter illumination and glare.
10. All light switches shall be clearly identified.
11. The low voltage distribution panelboard for lighting and receptacles shall be sized for at least the full load capacity of the supply transformer. The panelboard shall include a minimum of 20% spare breakers and all spaces shall be equipped with labeled breakers. The panelboard shall include a main breaker.
12. The Seller shall submit preliminary Site lighting system design drawings and specifications to SDGE for approval as part of the Building Permit review.

4.6.2 **Convenience Receptacles**

1. Convenience receptacles (120 V, 20A) shall be provided within 15' of all inverter and switchgear locations. Outdoor convenience receptacles shall be the weather proof while-in-use GFCI type.

4.6.3 **Video Monitoring Systems**

The Seller shall provide, install, and configure a complete and fully operational video surveillance and monitoring system in accordance with the scope and specifications of this section.

Equipment

The following minimum equipment shall be furnished and installed:

- Camera(s) rated for outdoor use and having night vision capability
- Media Converter
- DVR Unit with internet connectivity
- Hard Drive with 1 month minimum video storage capacity
- Power supplies and adapters for DVR and camera(s)
- Heavy duty mounting hardware with tamper-resistant fasteners
- Operating Software
- Secure, weatherproof enclosure for system if outdoor installation
- Wall mount rack system if indoor installation
- Power circuits, including breakers, wiring, conduit, fittings, junction boxes, and accessories
- UPS system providing 30 minutes minimum system operating time following power failure
- Cabling as required to connect all system components
- Network switch/router, cabling, and connectors as required for connection of system to internet.

Video equipment and software shall be procured as a complete package from a single vendor to ensure compatibility of system components and simplify information requests and service. The vendor selected shall have available technical support and service capabilities.

Installation

The video monitoring system shall be installed as follows:

- Location and quantity of cameras shall be enough to cover surveillance of all areas of the Project Site. Minimum of four (4) cameras per site.
- Surveillance shall be located to not allow access to the video monitoring equipment from outside the Site fence.
- All underground system cabling shall be installed in Sch 40 PVC conduit, 3/4" minimum size.
- All aboveground system cabling shall be installed in weathertight EMT.
- Exposed cabling shall not be used to avoid deterioration and exposure to tampering.
- Power circuit(s) shall be dedicated for video system, unless otherwise shown on the plans.
- Internet connection shall be shared with PV system monitoring equipment.

Following system installation and operational testing, the Seller shall demonstrate the system and provide training to SDGE representative on complete system operation, including remote internet access.

END OF SECTION

5 SYSTEM CONTROLS AND COMMUNICATIONS

5.1 GENERAL

5.1.1 System Description

1. Seller shall provide a commercially available, internet based Performance Monitoring and Reporting Service (PMRS) system. System must be capable of interfacing with SDG&E's SCADA system.
2. Seller shall furnish the hardware internet connection for these Sites, and shall provide all other hardware and software for a complete, functioning system.
3. Seller shall arrange for installation of internet connectivity. Wired, optical fiber, or cellular is acceptable dependent on approval from SDG&E.
4. SDGE will be responsible for paying for the internet service provider monthly charges.
5. SDGE shall furnish and install a remotely operated main disconnect for each Site.
6. The PMRS vendor shall have the capability of data output in OSIsoft PI format.
7. The PMRS system shall be supplied by an approved data monitoring vendor per Attachment 3, Approved Equipment Manufacturer List.

5.2 METEOROLOGICAL STATION

The Seller shall provide and install a minimum of one (1) Meteorological (Met) Station installed on each Project Site. Projects exceeding ten acres shall have a redundant meteorological station with active recording capability but not reporting connectivity. The Met Stations shall be connected to the same network as the System Inverters.

The Met Stations shall measure the following parameters:

- Ambient Air Temperature
- Ambient Relative Humidity
- Rainfall Amount (precipitation)
- Wind Speed
- Wind Direction
- Barometric Pressure
- Solar Irradiation (direct, diffuse, plane of array and global)
- Photovoltaic Panel Temperature

5.3 I/O DATA POINTS

I/O data points shall be monitored according to utility metering standards, including, but not limited to the VDC system, AC revenue meter points, meteorological data, inverters, switchgear and isolation disconnects. The following I/O data points are considered to be minimum requirements:

5.3.1 **Communications Enclosure**

- Building Environmental Condition
- Building HVAC/Climate Control Status
- Building Door Position Switch
- Hydrogen Alarm

5.3.2 **VDC System**

- One common trouble alarm from the battery charger
- One common switch alarm from each VDC switchboard

5.3.3 **AC Revenue Meter Points per Utility Metering Standards**

- Net System KW export
- Net System KW import
- Net System KVAR export
- Net System KVAR import
- Net System KWHr export
- Net System KWHr import
- Net System KVARHr export
- Net System KVARHr import
- System Voltage
- System Current
- Frequency

5.3.4 **PV Modules**

- PV modules shall be monitored at string level for all System Sites 500 kW and larger.

5.3.5 **Inverters**

- Gross watts
- Gross watt-hours
- Gross amperes
- Gross VARS
- Gross VARHr
- Voltage
- Status and Diagnostics
- DC String Currents
- Real Power Output Control
- Stop Control

5.3.6 **Switchgear**

- Breaker status
- Breaker trip/close
- Relay status, alarms and other outputs

5.3.7 **Isolation Disconnect**

- Switch Status
- Switch open/close

END OF SECTION

5.4 QUALITY ASSURANCE/QUALITY CONTROL

5.4.1 Quality Control Program

The Seller shall establish, implement, and maintain a comprehensive Quality Control (QC) Program. The QC Program shall be capable of assuring that the design, construction, purchasing, manufacturing, shipping, storage, testing, inspection and examination of all equipment, materials, procedures, and services shall comply with the requirements of the Contract Documents and building code requirements.

The Seller shall provide all equipment, materials, and labor required to perform all work in support of QA/QC. As a minimum, this applies to soil density, concrete, welding, and any laboratory tests. Documentation shall be provided as part of the Turn Over Package.

5.5 CIVIL/STRUCTURAL/ARCHITECTURAL

5.5.1 Sitework, Excavation, Fill and Grading

The Seller shall furnish all equipment and labor required to complete all excavation, dewatering, compaction, backfill, imported fill, and grading required for the general Sitework, and for the placement of all underground utilities, etc. This Work includes the import of suitable fill and the off-site disposal of any excess material excavated as required to achieve a balanced Site. This includes, but is not limited to, import of fill necessary to replace on-site material that does not meet the specification criteria for its reuse.

5.5.2 Concrete

Forms shall be fabricated using sound industry standards typically employed and recognized and in accordance with the CBC, ACI, and the US Product Standard for Concrete Forms. All forms shall be carefully removed and properly disposed of from the Site. Care shall be taken during removal of forms as to not damage the concrete.

All exposed concrete projected edges shall have a 3/4” chamfer. Permanently exposed vertical concrete surfaces shall receive a smooth form finish per ACI 301, with all tie holes and surface defects patched and all fins exceeding 1/8” removed. Filling of minor surface defects and “rubbing” of exposed concrete surfaces will not be required. Concrete surfaces not exposed to view shall receive a rough form finish. Top surfaces of foundations shall receive a float finish. Interior floor slabs, if applicable, shall receive trowel finish. Concrete surfaces that are to receive a protective coating (i.e. battery area floor), if applicable, shall be finished in accordance with the coating manufacturers recommendation.

5.5.3 **Grouting**

Concrete foundations shall be bush hammered and saturated with clean water for 24 hours prior to grouting, or as recommended by the grout manufacturer. Water on the surface to be grouted shall be removed by controlled jetting or absorption with rags.

5.5.4 **Grout Mixes**

Grout mixes for equipment bases and other bearing applications shall be proprietary epoxy non-shrink grout meeting the requirements of ASTM C-1107 Grade C, such as Masterflow 928, Five Star Grout (U.S. Grout Corp.), or equal. The mix shall be chosen, placed, and cured in strict accordance with the equipment and grout manufacturers' recommendations.

Iron powder, aluminum powder additives, and chemical grouts using cementing materials other than Portland cement and natural mineral aggregates are not permitted.

5.5.5 **Structural and Miscellaneous Steel**

Welded structural members shall meet the requirements of AWS D1.1. Exterior structures shall be shop welded and sealed to the maximum extent possible to minimize field welding required. All exterior exposed steel structures shall be protected from corrosion by hot-dip galvanizing or other approved method after fabrication. Field welds and other coating damage shall be repaired with a coating system compatible with and equivalent to the original approved coating.

5.6 ELECTRICAL

The Seller shall furnish and install all electrical equipment and components, including but not limited to modules, inverters, switchgear, transformers, panels, electrical and communication cable, conduit and other raceway, lighting, grounding, fire protection and detection, and other related components, with the exception of interconnection work to be performed by SDGE. The Seller shall furnish all items required to provide a complete functional operating System. The Seller shall handle, set, level, assemble, check, connect, ground, clean and perform preliminary tests for all electrical equipment.

5.6.1 **General**

All electrical equipment shall be supplied and installed in accordance with the National Electrical Code, NFPA 70, and the local Authority Having Jurisdiction. The Seller shall define hazardous classification area types, locations, and boundaries as applicable.

5.6.2 **Panelboards**

Panelboards shall be installed level and plumb and shall utilize all provided mounting holes. Conduits shall be connected and all wiring shall be pulled before any panelboard internal hardware is mounted. Wiring shall be neatly and symmetrically arranged in the gutters with all unnecessary conductor lengths

eliminated. The panelboard shall be kept covered to protect the unit from contamination and damage until the permanent faceplate or cover is installed. All panelboards shall contain a complete printed or typed directory detailing the exact location of all loads served from each associated circuit.

5.6.3 **Control Panels and Consoles**

All external connections to any control panel, unless prefabricated, shall be terminated on screw type terminal blocks. The maximum number of conductors per terminal is two. All panels shall be mounted level and plumb and shall meet all NEC requirements. In addition, unless otherwise noted all junction and terminal boxes shall be NEMA 4 unless otherwise specified. Conduit penetrations for outdoor junction boxes shall be on the bottom and sides only and shall use liquid tight fittings. Where necessary to provide rigidity, heavier steel plate or stiffening members shall be used.

5.6.4 **Fire Alarm**

If required by the local Authority Having Jurisdiction, the Seller shall design, fabricate, furnish and install all fire alarm systems including local power and control wiring, panels, devices, terminal boxes, enclosures, etc., as required by the local Authority Having Jurisdiction.

5.6.5 **Lightning Protection**

Lightning protections is not required unless the Seller determines that applicable codes require it, or if required by the PV array manufacturer.

5.6.6 **Cathodic Protection**

The Seller shall determine whether cathodic protection is required due to local soil conditions and the proposed equipment design. If required, the Seller shall design, fabricate, furnish and install all cathodic protection systems.

5.6.7 **Grounding**

The Site grounding grid shall consist of buried stranded copper conductors, ground rods, and ground wells as required. The buried grounding conductors shall be sized on actual maximum available fault current at the main circuit breaker switch and at the inverters. All major electrical equipment, metal fences, structural steel and/or aluminum racks, metal cable tray, metal module frames, and metal conduit shall be grounded directly to the earth ground. The ground resistance shall be verified by measuring final grounding resistance by Fall-of-Potential method per IEEE 81 and shall comply with the requirements of NEC Articles 690 and 250, the NESC, and recommendations contained in ANSI.IEEE Standards 80, 142, and 367.

All mounting structures associated with each combiner box shall be bonded in accordance with the NEC to the grounding electrode system at the combiner box. The communication, instruments, and control cable shields shall be grounded per IEEE 789 and the instrument supplier requirements as applicable.

Exothermic-type connectors that meet the requirements of IEEE 837 shall be used for the buried connections. Compression-type connectors may be used above ground. The ground grid shall be designed so that the step, touch, and mesh potentials are within acceptable levels per IEEE 80. The calculated ground grid resistance shall be verified by measuring final grounding resistance by Fall-of-Potential method per IEEE 81.

In addition, the following grounding rules shall apply:

- Number 4/0 AWG bare stranded copper conductor shall be the minimum grounding grid conductor size utilized.
- Conduit shall not be used as a grounding conductor except for itself and lighting fixtures.
- All grounding conductors shall be 12 AWG or larger.
- All below grade connections between grounding conductors shall be made using exothermic weld type connections.
- Equipment grounding conductors shall be installed with all feeders and branch circuits. These ground conductors shall be terminated on each end on a suitable lug, bus or bushing.
- All underground grounding conductors shall be supplied with slack to allow for earth movement.
- All grounding surfaces shall be thoroughly cleaned prior to the connection of any grounding conductor.

5.6.8 **Cable Installation**

All cables and conductors shall be installed in continuous lengths from end to end and without splices. Cables and wiring cut too short shall be replaced. Cables shall be adequately supported inside of all electrical raceways, equipment, and junction boxes to prevent distortion of the insulation jacket. Power cables in horizontal runs shall be attached to the raceway or tray at least every 6 feet along the run, within 12 inches of change in direction, and when leaving the tray or raceway. Cables shall be arranged to minimize cable stresses at all bushings and end bells. All conductors and cables shall be neatly bundled together with sunlight UV resistant nylon ties. Reusable hook latch material, Velcro, or equivalent devices may be permitted in some applications such as inside panels.

Cables shall maintain voltage and communication separations. Cable and conduit burial depths, backfill, and installation requirements shall be in accordance with the NEC and NESC Section 3. Minimum burial depth shall be 24 inches. As per section 300.5(D)(3) in NEC, underground cables in conduit shall have their location identified by a warning ribbon that is placed in the trench at least 12 inches above the underground installation. Multiple cables and conduit in trenches shall not cross or rest upon each

other. Cable and circuit separations within the trench shall be based on thermal resistivity of soil, ambient design temperatures, depth of bury, and design ampacities.

PV module cables shall be laid neatly along the back side of the mounting structures running the length of each row. Unnecessary cable crossings between rows shall be avoided. Cables shall be supported every 18 inches at minimum and minimum bending radii shall be maintained. While being pulled, cables shall be protected contacting sharp corners, obstructions, rough floors, and other potential damage risks. During storage and after installation, cables shall be protected from mechanical and/or fire damage. Cables shall not be installed until structures are bonded and grounded.

5.6.9 **Cable and Electrical Equipment Terminations**

1. All cables shall be terminated as soon as practical, and shall be sealed in accordance with the manufacturer's instructions between pulling and terminating. Indoor terminations shall be conducted in a clean environment, free of excessive dirt or dust and other potential contaminants.
2. When necessary, the Seller shall erect temporary weatherproof shelters to enable outdoor termination work in clean, dry conditions.
3. Connectors and terminal lugs for all power cable or equipment shall be of the crimp compression type unless otherwise noted. Only dies and fittings of proper matching sizes shall be used. All terminal fittings shall be of the closed barrel type. Compression tools shall give positive indication of completion of compression and shall be hydraulically operated for size #6 AWG and larger. For size #8 AWG and smaller, except for PV cable, compression tools may be manual positive ratchet type compression devices.
4. All connectors and lugs shall be ring type, except for PV cable. Ring tongue type connectors shall not be cut to facilitate installation on screw terminals. Pressure type connectors for 4/0 and larger conductors shall be of the two-hole type.
5. PV Panel interconnect connectors shall be multi-contact (MC) Tyco, Amphenol, or approved equivalent termination connectors in accordance with NEC article 690.33.
6. Cable terminals having two or four bolt pads shall be used whenever possible. Bolt hole spacing shall meet NEMA standards and match the corresponding holes in the equipment terminal pads. When terminating to bus terminal pads, one hole compression lugs for sizes #2/0 and smaller and two hole for sizes #3/0 and larger shall be utilized.
7. Adapters shall be supplied by the Seller at all low voltage terminations that do not provide sufficient space to accommodate the pad widths of the compression lugs utilized. If there is insufficient clearance between terminations, the portion of the cable terminal and adapter outside of the barriers shall be insulated with materials approved by SDGE.
8. Joints between cable terminal pads and equipment terminal pads, buses, and other cable terminals shall utilize standard Unified National Course (UNC) nonmagnetic bolting hardware.
9. Silicon-bronze hardware and Belleville washers shall be used with proper torque values for connecting all copper to copper surfaces.

10. Power cables terminations at or within switchgear and at other enclosures shall utilize clamping or sealing fittings where applicable to provide support to assure watertight assemblies at each conduit end. The Seller shall supply correct sizes and fitting types for each associated cable. All cable openings shall match the actual diameters of cables. Sealing fittings shall be of the gland seal type and shall be installed in accordance with the manufacturer's instructions.
11. After the completion of testing and QA inspection, all cable lugs shall be bolted to the equipment terminals and final insulation shall be completed. Bare copper contact surfaces shall be cleaned and wire brushed if heavily oxidized. Copper or aluminum contact surfaces which are tinned shall not be wire brushed or otherwise abraded.

5.7 ELECTRICAL IDENTIFICATION

5.7.1 General Requirements

All nameplates and electrical identifications shall be supplied by the Seller as part of the complete electrical system. In general, each nameplate shall identify the equipment or device designation. All electrical equipment, including, but not limited to, inverters, motor controls, combiner boxes, disconnect switches, instrumentation, and panelboards shall be furnished with an external nameplate for identification. Nameplates shall be made from permanent corrosion resistant material. Prior to nameplate mounting, the associated surface shall be cleaned as necessary to assure proper adhesion.

5.7.2 Cable and Wire Labels

Permanent identification tags delineating the complete cable number shall be installed at both ends of each cable. Cable identifiers shall be of either heat shrink or tie wrap type. Supplementary to the cable identification tags, the Seller shall tag each individual conductor or instrument pair at each terminal with the wire designation as shown on the Project schematics and/or the manufacturer's as-built drawings. The preferred method of wire identifiers should be specified as "destination" labeling. These identifiers shall be manufactured with white heat shrink tubing and shall be sized to slip neatly over each associated wire. The lettering shall be sized to facilitate the quick identification of each conductor and all spare wires shall be identified as such.

END OF SECTION

6 ENVIRONMENT, SAFETY, AND HEALTH

6.1 PURPOSE

The prevention of accidents and injury to personnel during construction is the highest priority of the Project. This philosophy is not only important to the safety of workmen, Facility personnel, students, and visitors, but is also critical to the timely, successful completion of the Project. The Seller shall be solely responsible for onsite environment, safety, and health until the project is turned over to SDG&E.

END OF SECTION

7 DOCUMENTATION AND SUBMITTALS

7.1 GENERAL DOCUMENTS AND SUBMITTALS

This section identifies the minimum requirements for types and forms of documents to be submitted by the Seller to SDGE, and identifies which documents require SDGE's approval, those for review and comment, or which are to be provided for information only. This section also describes the document submittal process and acceptable submittal formats. Further details shall be agreed upon at a Project Kick-off Meeting which shall be held shortly following the Effective Date of the Agreement.

From time to time additional submittals will be required. It shall be the responsibility of the Seller to make all required submittals in a timely fashion.

7.2 SUBMITTAL FORMAT AND COPIES

All Project submittals shall be transmitted by the Seller to SDGE electronically through the provided SDGE website to facilitate the tracking and organization of documents through the course of the Project, except where hard copies are specified below. SDGE will provide training to the Contractor's personnel on the use of the website as required. E-mail shall not be used for drawing or document submittals due to file size concerns. However, e-mail shall be used to notify SDGE that files have been posted to the project website and for Project correspondence. An e-mail distribution list shall be established at the Project Kickoff Meeting. The subject line for e-mails that include Project documentation or correspondence shall include SDGE's name, Date, and Document Type being transmitted (i.e., transmittal, submittal).

All Seller submittals shall have a transmittal cover sheet clearly identifying the document, data, and drawings (with revision number) contained in the submittal, and action required. All transmittal sheets and drawings shall clearly indicate the unit designation, specification title and number, component identification numbers, and SDGE's name.

Documents shall be submitted in the form identified below. Electronic submittals shall be in PDF format (and native program files when required). Electronic as-built drawings shall be submitted in both PDF and AutoCAD® (2014version compatible) format files. Data Lists shall be submitted electronically in PDF and MS Excel format. Written documents shall be submitted in MS Word. Drawings and lists shall be completely legible both to view on a standard PC monitor and to print. The transmittal cover sheet shall be a stand-alone document in PDF and detachable from the transmittal email. Hard copies, when required, shall be the full size of the original document.

The following minimum number of documents will be submitted to SDGE for distribution per the schedule of these Specifications:

DOCUMENT	NUMBER OF COPIES
Major Use /Administrative Permit	Electronic
Building Permit	Electronic
As-Built Drawings	3 sets hard copy
As-Built AutoCAD®--CD ROM	3 sets
O&M Manuals	3 sets hard copy and Electronic
System Turnover Packages	2 sets hardcopies and Electronic
PVSyst Model (Final)—CD ROM	2 sets

7.3 SUBMITTAL CRITERIA

7.3.1 Submittal Recipient

All Project correspondence shall be submitted to SDGE's Program Manager or other designee. All signed commercial documentation shall be submitted in writing. Contact information for both the Seller and SDGE Representatives shall be established at the Project Kickoff Meeting.

7.3.2 Submittals for SDGE Review and Approval

The Seller shall submit documents as listed below. This list is a minimum requirement. Other items requested in the Contract Documents may not be listed herein, but are still required to be submitted by the Seller.

Documents will be reviewed for Agreement conformance and good engineering practice. The Seller is ultimately responsible for the final design. The following is a minimum requirement of information to be submitted:

1. Major Use or Administrative Permit
    a. To Include accepted final submittal package to the Authority Having Jurisdiction (AHJ)
    b. Approved permit with final conditions
2. Approved Building Permit Package
    a. All design and construction documents
    b. Specifications and specification sheets submitted.
3. PVSyst model and estimated site production

Additional documents to be supplied upon project completion:

4. As Builts Documents including:
    - Site General Arrangement Drawings
    - Equipment Arrangement Drawings

- Foundation Drawings
- Structural Design Drawings
- Electrical One Line Diagrams
- Electrical Three Line Diagrams
- Wiring Diagrams
- Electrical load flow and short circuit calculations
- System Design and Control Criteria documents
- Underground utilities (trench) drawings.
- Shade Structure Plans, Elevations, and Typical Details
- Communications diagrams
- Data acquisition system input and output points list
- Internet based HMI control screen graphics through PMRS
- Catalog cut sheets and/or equipment technical specifications
- Arc Flash analysis
- Post Construction BMP design/plan with supporting analysis
- Post-Construction BMP Maintenance Plan
- Test and special inspection reports

5. Turnover Commissioning and Testing Documents
    - Construction turnover packages
    - Commissioning Procedures Manual
    - Commissioning test procedures
    - Commissioning test reports
    - Acceptance Test procedures
    - Acceptance Test reports

Operation and Maintenance Manual

7.4 O&M MANUAL

The Seller shall provide Operating and Maintenance (O&M) Manuals for all equipment supplied by the Seller for the Project. In addition, the Seller shall provide an integrated full-System O&M schedule. . The O&M Manuals shall meet the following criteria as a minimum:

1. O&M Manuals will include all literature, data sheets, etc. required for operation and maintenance of the equipment. Nomenclature used to reference each item will be consistent throughout O&M Manuals.
2. Data will be complete for all equipment and systems.

3. Data will include drawings, diagrams (including wiring diagrams), pictures or actual photographs when they add to the understanding and clarity of the text.
4. Precautions and warnings relative to the safety of life and equipment will be included where applicable.
5. O&M Manuals shall be divided into the following sections:
    - Title
    - Index
    - Installation Instructions
    - Operation Instructions
    - Maintenance Instructions
    - Parts Catalog
    - Associated Publications

6. Installation instructions shall include the following:
    - Handling and rigging procedures
    - Equipment installation procedures, including assembly methods, special precautions, sequence of work and adjustment requirements
    - Set points for all relays instruments meters and other devices requiring calibration
    - Complete set of the instrument installation details
    - Complete startup instructions, including a step-by-step startup checklist

7. Operation instructions shall include the following:
    - Starting instructions, detailed and specific, for all equipment furnished, with step-by-step procedures to be followed and precautions and critical points noted and emphasized as required.
    - Operating instructions, detailed and specific, for all equipment furnished including precautions and critical points to be observed. A tabulation of possible operating difficulties with the probable cause listed and remedial action recommended to be taken shall also be included.
    - A Complete set of logic diagrams furnished with technical description
    - Shutdown instructions, detailed and specific, for all equipment furnished, noting the step-by-step procedure to be followed for shutting down the equipment.

8. Maintenance instructions will include the following:
    - Lock-out and tag-out procedures
    - Disassembly instructions completely detailed and specific for major assemblies of all equipment furnished, noting the step-by-step procedure to be followed. Precautions and critical points to be observed will be noted and emphasized as required.
    - Maintenance instructions completely detailed and specific for major equipment furnished, including preventive maintenance instructions. Schedules covering test and

inspections to be performed after various periods of operation and a summary description and identification of special tools required and furnished for maintenance shall also be included.

- Settings, clearance, and adjustment data tabulated for major equipment, covering instrument settings for operation, alarm and shutdown, and operating clearances and adjustments required for proper operation. Also, a tabulation of recommended operation conditions for all equipment and systems. Whenever instrumentation is provided with the manufacturer's equipment, calibration procedures and instrument data sheets for this instrumentation shall be provided.
- Panel washing recommendations, including frequency based on site weather report, time of the year, tools and equipment, crew size, duration, expected seasonal soiling rates.

9. Parts Catalog will include the following:
    - Detailed replacement parts drawings and lists, including applicable specific replacement part drawings and lists. These drawings and documents will include all information required for ordering replacement parts, such as part name, part number, equipment serial number, technical specifications, and quality assurance requirements. Recommend spare parts for field instruments and IMC.
    - Special storage or handling procedures required by any particular parts shall be noted including shelf life limits.

10. The Associated Publications section of the O&M Manuals shall be utilized when it is feasible to include existing publications on sub-assembly or associated equipment components in the O&M Manuals. Such publications shall be located in this section unless they can be subdivided, and integrated as previously described.

7.5 QUALITY ASSURANCE MANUAL

The Seller's QA/QC program shall be documented and submitted to SDGE. The content of the quality assurance manual may be in the form of written descriptions of QA/QC policies, procedures, methods, instructions, exhibits, or other quality assurance method descriptions.

Final QA/QC documentation records shall be turned over to SDGE at the completion of the Project. The QA/QC records include all other documentation not turned over in the System Turnover Package.

END OF SECTION

8 PERFORMANCE MODELING AND ANALYSIS REQUIREMENTS

8.1 INTRODUCTION

The Seller shall provide SDGE with a performance model for each PV Site using PVSyst modeling software. The Seller shall use the newest version of PVSyst modeling software. This performance model shall detail the hourly energy output in kWh AC (8760 hours for year 1) for each PV Site. When modeling performance, the Seller shall use the inputs specified in this section and the appropriate values for the equipment and systems as designed. All Seller assumptions shall be approved by SDGE prior to final acceptance of the model (the final Owner approved model for a PV Site, the "Energy Model" for such PV Site).

8.2 REQUIREMENTS

1. The Energy Model shall include post-inverter AC losses, including those losses occurring up to the revenue meter located on the Site.
2. The Seller shall submit the following files to SDGE:

    - [PV SITE NAME].prj (with variant files or module model/block design specified)
    - If Seller proposes to use more than one module design, block design, or mounting design to complete the System due to availability or other concerns, Seller shall:
        - Provide a .prj file for each design permutation or a single .prj file with variant files for each design permutation
        - Provide a .pan file for each module design
        - Provide a .ond file for each inverter design
        - Weather data TMY3.cvs files used

3. The Seller shall provide the weather files provided to SDGE for System design and analysis. The weather files represent a Typical Meteorological Year (TMY3) for the planned Site of the System. The file shall consist of the TMY3 file for the Site and will be named TMY_solar.csv. The PV System shall be assumed to be co-located with the meteorological site.
4. The Seller shall use the following input assumptions to PVSyst as provided. Where input assumptions are not specified, the Seller shall provide their own input assumptions in a table along with explanations and justifications. Explanations should be complete and address all inputs necessary for simulation. SDGE shall approve all input assumptions.
   The provided list was compiled based on the version of PVSyst available at the time this specification was written. If there are additional inputs in the version of PVSyst available at the beginning of the design phase, the Seller shall provide their input assumptions in a table to capture these values.
   a) Hidden Parameters and Preferences

    - Hidden Parameters – PVSyst Default Values

- Preferences – Default Values, Hay model

Please note changes in the input table when changes to hidden parameters are made to avoid run errors etc. Hidden parameters and preferences can be found in the PVSyst "preference" drop down menu.

b) Albedo – 0.2 throughout the year

c) Orientation – Choose Unlimited Sheds option
   - Plane Tilt – per Site design
   - Azimuth – per Site design
   - Number of Sheds – per Site design
   - Pitch – per Site design
   - Collector Band Width – per Site design
   - Top Inactive Band – per Site design
   - Bottom Inactive Band – per Site design

d) Horizon and Near Shadings – per Site design

e) System
   - Number of Inverters – per Site design
   - Initial Degradation – per module manufacturer
   - Modules in Series – per Site design
   - Number of Strings – per Site design

f) Detailed Losses
   - Thermal Parameters
     - Constant Loss Factor Uc – 25.0 W/m^2K
     - Wind Loss Factor Uv – 1.2 W/m^2K/m/s
     - NOCT coefficient – fixed by Uc and Uv.
     - NOCT Definition – open circuit (at Voc).
   - Ohmic Losses
     - Wiring Resistance – Seller assumption, provide supporting specs to SDGE
     - Voltage Drop Across Series Diode – Seller assumption
     - AC Circuit (loss fraction at STC) – Seller assumption, provide supporting specs to SDGE
     - External Transformer (Iron/Iron) –Seller assumption, provide supporting specs to SDGE
     - External Transformer (Resistive/Inductive) – Seller assumption, provide supporting specs to SDGE

     Note: Losses are to be included up to the revenue meter, located on the Site.
   - Module Quality/Mismatch
     - Module Quality – 0.8% Minimum. 0.5% for imperfect inverter maximum power point tracking and 0.3% for one day per year of equivalent outage time. Increase for additional losses and note.

- Mismatch Losses – 0.5%
- Soiling Losses
  - January –2.2%
  - February – 1.9%
  - March – 1.7%
  - April – 1.1%
  - May – 2.6%
  - June – 4.1%
  - July – 5.8%
  - August – 7.2%
  - September – 8.0%
  - October – 5.9%
  - November – 4.2%
  - December – 2.2%
- IAM Losses – Bo = 0.05 unless surface is characterized by independent lab for modules and report is provided.

g) Additional Losses – Seller may include additional loss factors not specifically detailed above if approved by SDGE. Seller shall provide necessary back up data, specifications and descriptions. Seller to describe where losses are input into energy estimate (done post processing or included in model inputs).

5. The Seller shall provide PVSyst module files (.pan) to SDGE for each proposed module type. The Seller shall provide PVSyst inverter files (.ond) to SDGE for each proposed inverter type.
6. The Seller shall provide analysis based on the parameters as listed below in PVSyst. The Seller shall provide corresponding model files in .prj format (with variant files) for PVSyst. The Seller shall provide to SDGE a performance prediction evaluation in hourly (8760 hours for year 1) energy output in kWh of the PV System for each PVSyst run. This should include post inverter AC losses.
   a) At a minimum, the Energy Model must output a rated inverter capacity for at least one hour of the first year, based on the TMY3 data set. This will be measured at inverter output.
   b) As per the O&M Agreement terms, the System must also meet a first year energy production measured at the System meter as specified in Section 9.
   c) System Degradation rates used in calculating lifetime energy production shall not be greater that 0.5% per year. Degradation should be assumed to be consistent over periods between set warranty percentages.
   d) Energy Model shall be designed to Minimum System Requirements as defined in Section 2.3.3.
7. All final Energy Models and associated files as described in this Section 8 shall be submitted to SDGE prior to Acceptance Testing.

END OF SECTION

9 STARTUP AND COMMISSIONING

9.1 INTRODUCTION

The Seller shall have complete responsibility for calibration, testing, pre-operational checkout, commissioning, start-up and testing of all equipment, including documentation, with the exception of responsibilities specifically assigned to SDGE or others. The Seller shall submit copies of all commissioning records to SDGE to document the results of all commissioning activities.

9.2 General START-UP AND COMMISSIONING SCOPE OF SERVICES

The Seller shall provide complete calibration, checkout, testing, and commissioning of all systems, including performance of all manufacturers' specific recommendations for commissioning, checkout or testing in addition to those activities described in this Section. Additional specific testing requirements included in this scope of work are provided in the SDG&E Electric Distribution System Interconnection Handbook.

Commissioning shall occur in a sequence that will permit systematic checkout and trial operation of each component before it is incorporated in the initial System operation. An operational acceptance test followed by a functional acceptance test shall be completed for each system.

The Seller shall provide, at minimum, the following services as part of the required commissioning scope of work:

9.2.1 **General**

1. Develop and maintain Commissioning Schedule
2. Prepare System Turnover Packages
3. Prepare required test records
4. Provide complete O&M Manuals for each equipment item provided
5. Conduct System performance, reliability, and functional tests
6. Perform site-specific training of SDGE's operations staff

9.2.2 **Mechanical**

1. Check operation of all permanent Project equipment
2. Furnish start-up spares
3. Tag all equipment

9.2.3 **Electrical**

1. Check continuity of all cables
2. Megger all power cables 120 V and higher
3. Hi-pot medium voltage cable (2-15 kV)

4. Dress out, fill and test transformers
5. Functional test all inverters, panels, and other System electrical equipment
6. Backfeed System in coordination with SDGE personnel
7. Functional test all control circuits
8. Test current transformers and potential transformers
9. Perform and calibrate final relay settings

9.2.4 **Instrumentation**

1. Verify instrumentation installation per instrument data sheets
2. Provide calibration set points
3. Complete final instrument calibration
4. Tag instruments with instrument identification numbers
5. Tag electrical panels, check breakers, etc.
6. Witness System controls Factory Acceptance Testing (FAT Testing)
7. Provide an integrated System Instrument Index
8. Check communication between System, SDGE communication base and the local Fire Department (if required)

9.3 COORDINATION AND NOTIFICATION

9.3.1 **Coordination**

The overall Commissioning Schedule and structure shall be developed by the Seller's Commissioning Manager so that each System Turnover Package is completed and presented to SDGE for review and comment in proper sequence to support an orderly Commissioning.

The Seller shall maintain a system turnover checklist to track the status of System turnover packages.

Commissioning activities shall be coordinated with SDGE's staff as necessary, and SDGE shall have the right to witness any and all commissioning activities. The Seller shall be responsible for the first energization and operation of the equipment.

The Commissioning Manager shall coordinate the efforts of the Seller's personnel and applicable OEM representatives. The Seller shall provide and connect the instrumentation required to monitor initial operation and support control balancing, and shall record all data required to analyze the initial System performance.

The Seller shall perform calibration of permanent instrumentation, coordinated by the Commissioning Manager. Errors found during or after System commissioning shall be corrected. All subsystem Turnover Package punch list items shall be completed and verified by the Commissioning Manager. Notification

The Seller's Commissioning Manager shall notify SDGE a minimum of five (5) days in advance of all scheduled construction alignments and testing of any piece of equipment or subsystem and shall provide access for SDGE's representative to witness the testing. The Commissioning Manager is also responsible for notifying and scheduling all applicable technical representatives and witnesses for testing.

9.4 TURNOVER PACKAGES

9.4.1 **Preparation**

The Seller's Commissioning Manager shall prepare System and subsystem Turnover Packages. The Commissioning sequence shall commence with scheduling and issuing packages for review and shall continue with completion of construction and testing work for each package, electrical testing and calibration, initial operation, and subsequent debugging of any operational problems by the Seller. The Turnover Package shall be reviewed by SDGE, who shall notify the Seller upon acceptance of the package.

The System Turnover Package shall contain the following:

1. Introduction
    - Brief Description of System
    - List of Interfaced equipment
2. Mechanical Completion Turnover Acceptance Form Sign-Off
    - Seller
    - Manufacturer's Service Representatives
    - Seller's Commissioning Manager
    - SDGE’s Engineer/Representative
    - Operations representative
3. Lists of Included Equipment
    - Major Equipment
    - Power Sources
    - Instrumentation/Electrical Devices
    - List of Alarms
    - List of Circuits
4. Applicable Drawings
    - Schematics
    - Network Diagrams
    - Manufacturer's drawings as required for functional checkout
    - Others as required
5. Remarks
    - Exceptions

- Special Conditions
- Temporary Connections (jumpers, bypasses, etc.)

6. Supporting Documentation
    - Test Forms
    - Calibration Sheets
    - Manufacturer's Service Reports
    - Alignment Data Report
    - Others as required

The Turnover Package shall include one-line diagrams and electrical schematic diagrams marked to define the limits of the subsystem. Applicable data and test forms and manufacturer's service reports shall be prepared by the Seller's Commissioning Manager and included in the package. Manufacturer's drawings shall be included as required to support the testing and functional checkout of the subsystem.

The Commissioning Manager shall note special instructions regarding additional construction activities after Commissioning.

Sign-offs shall be provided by the Seller designating the completion of specific construction and testing elements. Incomplete, noncritical elements shall be noted and described and an expected completion date indicated.

9.4.2 **Issuance**

An introduction, a list of included equipment, engineering drawings showing subsystem boundaries and content, and a list of applicable drawings for the Turnover Package shall be issued for information and scheduling purposes as soon as they are prepared, but no less than fifteen (15) days prior to commencement of Commissioning activities for a given system. The final Turnover Package shall be submitted to SDGE only when it includes the completed and signed sign-off sheet, the completed test sheets, exceptions sheets, manufacturer's service reports, and other applicable information.

9.4.3 **Documentation**

1. The Seller shall complete calibration and test forms for each device calibrated or tested. The format of the forms shall be acceptable to SDGE. The forms shall include, but not be limited to, the following information:
    - Equipment tag number
    - Equipment name
    - Equipment description and location
    - Description of test or check including date, time, and person performing test
    - Nameplate data
    - Readings taken

- Test results - description as required
- Description of any corrective action
- Description of test equipment including serial numbers
- Observable data for future reference – notes
- Test procedure used
- Reference drawing numbers

2. The calibration and testing forms developed by the Seller shall include, but not be limited to, the following:
    - Cable Test Data
    - Metering Test Data
    - Breaker Test Report
    - Ground Resistance Test Report
    - Power Cable Test Data
    - Ground Rod Resistance Test Report
    - Control Test Data
    - Calibration and Adjustment Report
3. All reports, calibration sheets, corrected drawings, and other data shall be maintained by the Seller. The documents shall be maintained at the Seller 's field office until the specified turnover to SDGE. The documents shall be made available for inspection and review upon request by SDGE.
4. The manufacturer's service representative shall submit a service report to the Seller's Commissioning Manager stating whether or not the equipment is ready for operation. Electrical and control testing required by the manufacturer shall be performed under the service representative's direction, and the results shall be attached to the service report. This Service Report shall be placed in the turnover package prior to final submittal to SDGE.
5. As part of the System Turnover Package (STP) the Seller shall provide documentation supporting the tasks completed per the OEM Operation Manual.

9.5 POST-COMMISSIONING CHECKOUT

9.5.1 System Checkout

Main systems shall be checked, operated, and tested by the Seller in the presence of and/or in conjunction with SDGE after each individual piece of equipment and its accessories have been operated and declared ready for on-line operation. The Seller's Commissioning Manager shall be present during the main systems checkout.

All functional and operational testing of automatic controls, instrumentation, alarm systems, and all other field testing of the main system shall be completed before the systems are started.

9.5.2 **On-Line Operational Checks**

During on-line operation of the integrated systems, all equipment shall be checked by the Seller for requirements recommended or required by the manufacturer of the specific piece of equipment. Representatives of the Seller shall be present during the on-line operational checks.

The Seller shall be responsible for any recalibration and adjustments necessary to make the system acceptable for on-line operation, and conducting System thermal imaging to identify any locations where insulation is not properly installed or equipment is running hotter than normal.

9.6 ACCEPTANCE TESTING

The Seller is responsible for conducting the Acceptance Test of the complete Project, including PV modules, inverters, metering, controls, and accessories. The Seller shall provide all test equipment and special instrumentation required for the tests.

9.6.1 **Definitions**

Nameplate Rated Capacity: This shall mean the power output of the System in kilowatts (kW - DC) based on the number of PV modules installed and the module nameplate rating at Standard Test Conditions (STC). Aggregate Nameplate Capacity of installed modules shall be no less than 100% of Project Nameplate Capacity.

- **Maximum System Losses:** This shall be the electrical energy losses from and including the PV modules through the System revenue meter, calculated as the difference between the Nameplate Rated Capacity, corrected to actual ambient conditions; and the power output as indicated at the revenue meter. Maximum System Losses include but are not limited to the following losses: Ohmic, Soiling, Module Mismatch, Module Quality, Shading, Thermal, Transformer, Inverter, etc.

- **Expected Energy Production:** The annual electrical energy output in kilowatt-hours (kWH) produced by the System as predicted by the approved Energy Model described in Section 8. This shall mean the sum of 8,760 data points as generated by PVsyst using agreed upon inputs and TMY3 weather data for the System Site, in MWh/MW_{AC}/year. It shall include all auxiliary load losses and system losses (up to the revenue meter).

- **Actual Energy Production:** The electrical energy in kWH actually produced by the operational Project during the course of the Energy Production Test, as measured by the system revenue meter.

- **Energy Production Test:** A 12 month test conducted pursuant to the O&M Agreement wherein the Parties shall evaluate the Actual Energy Production in comparison with the Expected Energy Production for such 12 month period. This evaluation is performed to demonstrate compliance

with the Energy Production Guarantee for the particular Project as described in the O&M Agreement.

- **Power Output Test:** This shall mean the test performed on the System to measure the actual power output at the revenue meter. This test shall be Successfully Run as a requirement for Substantial Completion under the applicable EPC Contract to demonstrate to SDGE that the installation is complete, that the Project satisfies the Performance Guarantee under the applicable EPC Contract , and that all components are functioning correctly. Thereafter, this test shall be performed on an annual basis under the O&M Agreement to determine compliance with System degradation guarantees as detailed in the O&M Agreement.

- **Power Output Baseline:** This shall mean the power output of the System at the time of Substantial Completion of the Project under the EPC Contract (as demonstrated by the Acceptance Test used to satisfy the conditions of Substantial Completion under such BTO Contract). The results of such Power Output Test shall be corrected to DC-STC and used for comparison with future Power Output Test results in order to measure and track System degradation.

- **Performance Guarantee:** A Project's Performance Guarantee under its BTO agreement shall be equal to ninety three percent (93%) (to account for system losses, ancillary load losses, measurement uncertainty, and modeling uncertainty) of such Project's nameplate power capacity of the Project at unity power factor (as determine by the cumulative power rating of the inverters installed in such Project), as measured at the Project's revenue meter when corrected to STC conditions.

- **Minimum System Performance Requirements:** This shall mean the minimum Power Output and Expected Energy Production values to be guaranteed by the Seller.

- **Primary Measurement Device:** An instrument which provides a measurement or reading that is used in calculating output power and annual energy production.

- **Secondary Measurement Device:** An instrument which provides a measurement or reading that is not used in calculating the output power or energy but is used as a check on primary measurements.

- **Standard Test Conditions (STC):** Standard Test Conditions are defined as the following:

    - Irradiance in the plane of the array (module tilt angle and orientation) of 1,000 W/m^2.
    - 25°C module cell operating temperature as measured at the back surface or cell of the module. (Reference module temperatures shall not be used for temperature correction.)
    - Air Mass (AM) of 1.5.

- **Temperature Corrected Output (MW_{AC}):** The Temperature Corrected Output is the solution of the linear regression equation for the Power Output Test, where x is equal to 1,000 W/m^2.

- **Seller/SDGE Representatives:** SDGE and the Seller shall define lead representatives for the Power Output Testing. Lead test representative for the Seller shall be termed the Test Manager.

9.6.2 Power Output Test and Annual Test Overview

The following is an overview of the procedures to be utilized in connection with the execution of the Power Output Test and, in accordance with the O&M Agreement, the annual tests of the complete System, composed of an annual Power Output Test and the annual Energy Production Test. A detailed Power Output Test procedure and an Energy Production Test procedure shall be developed by the Seller and agreed upon by the parties as part of the Test Procedures as further defined in this document. This approved Test Procedure shall be taken in conjunction with this section and shall be reviewed for acceptance by SDGE prior to testing.

The tests are to be executed in sequence as follows:

- Once the Seller has successfully completed all start-up and commissioning activities, including trial operation of all equipment, the Seller shall commence the Power Output Test and demonstrate that the System satisfies the Performance Guarantee and all components are complete and fully functional. The Seller shall remediate the shortcomings and re-test until the Project achieves the Performance Guarantee. Seller must achieve the Performance Guarantee to meet Substantial Completion.

- Upon acceptance by SDGE of the Power Output Test, the test results will be used to establish the Power Output Baseline. This baseline will establish the power output capacity of the new System for comparison with future Power Output Tests.

- Following the successful completion of the Power Output Test, and provided that the other requirements for Substantial Completion have been satisfied, the Project will be granted Substantial Completion, and commercial energy production will commence. As part of the O&M Agreement, at the end of one year of energy production, the Seller shall perform the annual Energy Production Test and demonstrate that the System Actual Energy Production meets the requirements of the Energy Production Guarantee as described in Section 9.6 and listed in Attachment 1, Minimum System Performance Requirements.

- As part of the O&M Agreement, and at the time specified in the O&M Agreement, and annually thereafter for the term of the O&M Agreement, the Seller shall repeat the performance of the Power Output Test, using the Performance Monitoring System (at 15 minute data acquisition intervals). The results of each annual test will be corrected to STC and compared with the Power

Output Baseline. This comparison will establish the amount of annual degradation experienced by the PV Modules (Panels). The System wide t degradation shall not exceed 0.5% per year.

9.6.3 Energy Production Guarantee

Seller guarantees that the Actual Energy Production of each Project shall equal or exceed ninety percent (90%) of the Expected Energy Production, including all system losses and auxiliary load deductions, and accounting for module degradation (the "Energy Production Guarantee").

9.6.4 Pre-Test Activities

Prior to the start of a Power Output Test, the Seller shall complete the following:

- **Test Plan:** Thirty (30) days prior to commencement of a Power Output Test, the Seller shall submit to SDGE for review and approval a formal Power Output Test Procedure which shall detail all Power Output Test activities including:

    1. Uncertainty analysis.
    2. Specification "cut-sheets" for all Primary Measurement Devices. Also provide location of these measurements for field verification.
    3. Field testing procedures (to meet minimum test duration and frequency requirement as specified in Table).
    4. List of Secondary Measurement Devices and locations.
    5. Applicable Equipment factory test certificates.
    6. Inverter factory test certificates.
    7. Calculations, methodologies, equations and procedures.

- **Pre-Test Meeting:** Prior to each test, a pre-test meeting shall be conducted and recorded. The meeting shall review the applicable approved Power Output Test Procedure, instrumentation locations, calibration sheets and other relevant topics including safety requirements. Minutes of this meeting shall be recorded by the Seller and approved by both parties.

- **Pre-Test Runs:** The Seller must, at its discretion (and cost), perform preliminary test runs prior to the official test in order to validate instrument readings, data acquisition operation and stable system operation. SDGE shall be notified of preliminary test runs and shall be allowed to observe testing.

- **Power Output Test Scheduling:** The Seller shall notify SDGE in writing of proposed test date not less than fifteen (15) days prior to the proposed date for a Power Output Test.

- **Power Output Pre-test Conditions:** Tests may be performed only when the following conditions are met:

1. All functional tests for such have been successfully completed, and System is in automatic operation.
2. Weather conditions are as required to complete the Power Output Test, as addressed in this exhibit and in the approved Test Procedures.
3. Utility grid voltage is stable and within +/- 5% of design voltage.
4. There is grid connectivity at each inverter such that the Power Output Test can be accomplished under load.

9.6.5 **Power Output Test**

The objective of the Power Output Test is for the Seller to demonstrate to SDGE that (a) with respect to the Power Output Test run as part of the BTO Contract, that the System satisfies the Performance Guarantee under the BTO Contract; and (b) with respect to a Power Output Test run as part of the O&M Agreement, that degradation is within the guaranteed limits as defined in the O&M Agreement, when the results are corrected from the test conditions to STC. The following is the outline of required steps for completion of the Power Output Test:

1. **Conduct field tests:** Measure and record AC power output (P_m) at the Combining Switchgear, module temperature(s) from representative modules in the solar field, and irradiance levels using laboratory certified reference modules identical to those mounted in the field. Record this data over a duration and frequency to achieve a sufficient data population and minimize random error.

    a) The power output monitoring through the power meter installed by Seller at the Combining Switchgear shall act as the primary measurement.

    b) Module temperature shall be measured by use of Resistance Temperature Detectors (RTD) attached to the back side of representative modules in the solar field, or embedded into the module cells. A minimum of 8 modules will be instrumented for temperature readings. These shall be distributed throughout the field with at least four on the perimeter rows of the solar arrays.

    c) Laboratory certified reference modules shall be:

        - Calibrated by National Renewable Energy Laboratory or approved equal with appropriate supporting documentation.
        - Of the same type (identical optical and electrical properties) and rated power as those in the solar field. (The Contractor shall submit flash test results of reference modules. Reference module power rating shall be equal to the rated power of the solar array modules to within +/- 1%.)
        - Mounted in the same plane (same tilt angle and orientation) and elevation as field solar arrays.

- Labeled with permanent weatherproof label as certified calibrated reference module.
- Provided in quantities as specified in Section 9.6.

2. **Compile and reduce test data set:** For each Power Output Test, raw test data shall be analyzed and reduced to eliminate data points that clearly exhibit a high degree of random error, such as shading, disturbances or unstable weather that were not indicative of the test. The Contractor shall document all data that are eliminated and review with SDGE for acceptance. Details shall be included in the agreed upon Test Procedures for the Power Output Tests.

3. **Apply temperature correction factors:** Correct each power measurement to 25°C (STC temperature) using the module temperature coefficient of power to yield the corrected output power, P_{STC}. To ensure a mean representative solar module temperature is used in this correction calculation, the module temperature transmitters shall be placed as described above in section 2 under Conduct field tests and in quantities as specified in Section 9.6.6.

4. **Ancillary Load Considerations:** The test shall account for ancillary loads up to the revenue meter which deduct energy from the net AC output. These are loads which are used for the running of the System but which reduce the net delivered power of the System. An example of this would be HVAC/lighting loads for the buildings (if used) which house the inverters, back feed power to transformers, tracking motors (if used), etc. If such loads exist, they must be run during the test. This shall be done by one of two ways:

    a) If the loads are connected to the System and not to a separate circuit, then the loads shall be forced to run during the test.
    b) If the loads are connected to a separate circuit, independent from the solar field, then an agreed upon amount shall be deducted from the resultant tested AC output.

5. **Plot data set using computational software:** Plot temperature-corrected power measurement versus measured solar irradiance as a scatter graph (y axis = power, x axis = plane of array irradiance).

6. **Generate curve fit:** Using computational software, generate a linear regression curve fit through the data and obtain the curve equation.

7. **Solve for standard insolation, 1000 W/m^2:** Solve the equation using a value of 1000 watts/m^2 for the irradiance to calculate what the value would be at STC.

8. **Determine pass / fail:** Compare the temperature corrected output resulting from the Power Output Test to (a) with respect to the EPC Contract, the Performance Guarantee; and (b) with respect to the O&M Agreement, the Power Output Baseline. With respect to the BTO Contract, failure to achieve the Performance Guarantee shall mean that Seller cannot achieve Substantial

Completion until remedial actions are undertaken to cause the System to achieve the Performance Guarantee. With respect to the O&M Agreement, the difference between actual output and the Power Output Baseline shall determine the annual System degradation. The amount of degradation shall be evaluated in accordance with the guaranteed limits as established in the O&M Agreement.

9.6.6 Test Measurements

All test measurement devices used shall be fully documented in terms of their make/model, accuracy, calibration and location. The following tables summarize these measurements:

Power Output Test Measurements (Minimum)

Measurement	Quantity	Type	Instrument Type	Range	Minimum Accuracy
Solar Irradiance	2	Primary	NREL or approved test laboratory calibrated module		+/- 5.0%
	1	Secondary (at Site Met Stations)	Pyranometer	400-1100nm	+/- 3.0%
Power (kW), PF (power factor), Current (amperes), Voltage	1	Primary	Permanent ANSI C-12 power meters installed by Seller at the main circuit breaker switch with calibrated CTs and PTs.		+/- 0.2%
Net Power Output	1	Secondary (at revenue meter)	Power Metering		+/- 0.2%
Module cell temperature	8 per Block, 16 total	Primary	Platinum RTD (resistance temperature detector) transmitter (.00385 TCR DIN B) or Thermistor, on back surface or cell of module	-10 to 120 °C	+/- 0.3 °C
AC/DC power, volts and amperage	1 per Inverter	Secondary	From inverter via SCADA	N/A	+/- 1/0%

Meteorological conditions: irradiance, air temp, wind speed and direction, rainfall, barometric pressure	1	Secondary	Site Met Station		

Instrument Calibration: All instruments used for primary measurements shall have current NIST or equivalent calibration certificates. All calibrations certificates shall be submitted to SDGE for review prior to commencement of the applicable Power Output Test.

Test Duration and Data Frequency: Testing duration and frequency shall be as follows:

Power Output Test

Power Output Test	
Test Duration	The test period shall consist of at least 5 valid days. A day is considered valid if a wide distribution of data is collected over the range of insolation values from 200 W/m^2 to 1,000 W/m^2. Each day shall have an adequate quantity (minimum of 320 data point sets per day, with respect to the Power Output Test under the EPC Contract) (minimum of 22 data point sets per day, with respect to the Power Output Test under the O&M Agreement) of valid data points in the morning (sunrise to noon) and in the afternoon (noon to sunset).
Data Frequency	One minute average (for Power Output Tests run under the BTO Contract); 15 minute average (for Power Output Tests run under the O&M Agreement)

Data Collection: Data shall be recorded by the monitoring and data collection system. The use of alternative means for data acquisition shall be reviewed for acceptance by SDGE.

Adjustments: Any adjustments made during the test to any portion of the System or test measurement devices shall be reviewed for acceptance by SDGE prior to execution. Any revisions shall be fully documented.

Cancellation of a Power Output Test: Either party has the right to cancel a test with written justification if it can be shown that test conditions or other reasons are causing erroneous data. Any test cancelled by either party shall not be deemed to be Successfully Run.

Test Data and Acceptance/Rejection of Test Data: At the conclusion of each day's data collection, the Contractor shall provide SDGE the electronic file of the data set from the data collection system. If either

party reasonably demonstrates that the data are inaccurate, the data shall be rejected and the applicable Power Output Test must be re-run.

9.6.7 **Test Calculations**

Temperature Correction of Power Measurements: Each power measurement will be corrected to 25° Celsius (STC temperature) using the module temperature coefficient of power ([TO BE INSERTED BY THE CONTRACTOR BASED ON MODULE CHARACTERISTICS] % / °C). This temperature coefficient shall accurately model the module's performance in a grid connected array in the desert southwest. This value and the basis for its validity shall be submitted during the bid process and as an attachment to the Test Procedure.

The correction is determined by the following equation:

$$\boldsymbol{Pstc = \frac{Pm}{1 + Ct(Tm - 25°C)}}$$

Where:

P_{STC} = DC power corrected to STC temperature (25°C)
P_m = measured AC power output (kW) at the Point of Interconnection corrected for assumed system losses not to exceed the Maximum System Losses (Reference Section 2.3.3). (e.g: Calculated Measured AC power output at Point of Interconnection divided by 0.85).
C_t = module temperature coefficient of power = ([TO BE INSERTED BY THE SELLER BASED ON MODULE CHARACTERISTICS]/°C
T_m = averaged measured module cell operating temperature in degrees Celsius.

$T_m = \Sigma T_f / \#T_f$

where:

T_f = measured field module temperature (distributed as described above)
$\#T_f$ = number of module temperature sensors = 8 minimum.

The Seller is allowed to propose a more accurate algorithm to be reviewed and accepted by SDGE.

Generation of Performance Curve and Determination of Temperature Corrected Output: The temperature-corrected power measurement as calculated above is then plotted as a scatter graph of temperature corrected power output (y axis) versus solar irradiance (x axis). Using the graphical data in the scatter graph, a linear regression curve is generated along with its equation, in the form of:

$$y = mx + b$$

Where:

y = power (corrected)
m = slope
x = irradiance (W/m2)
b = y intercept

The resulting equation is solved for Irradiance of 1000 W/m^2 to calculate the Temperature Corrected Output (MW).

The Coefficient of Determination (R-squared) shall be 0.96 or higher (for the complete data set of the test) to validate a statistically acceptable fit.

Combine the the Temperature Corrected Output results for each day to determine final results: The data shall be plotted together to determine the final Power Output Test result. Each day's results, however, must first be reviewed and approved by SDGE. If one day, for example, is unacceptable, then an additional test day shall be required if still below the five day minimum. The minimum R^2 value for each day is 0.92. The minimum R^2 value for the overall test (5 day minimum) is 0.96.

9.6.8 Test Reporting

The Seller shall submit a detailed test report within five (5) business days of completion of successful Power Output Test to SDGE, after which SDGE will have five business days to review and either accept or reject. The test report shall consist of the following at a minimum:

- Test Procedures (as executed)
- Instrument calibration sheets/certificates
- Test data (manual and data acquisition)
- Field notes
- Calculations and results
- Conclusions

9.6.9 Power Output Degradation Monitoring

After Substantial Completion, Seller will monitor the DC system health through use of power measurements at the inverter input or at the smart combiner boxes (if used). Seller will identify questionable module strings to SDG&E. The Seller will be responsible for testing and remediating any modules that have dropped below their warranted power output or module strings that are otherwise underperforming. The Seller's contractual responsibilities regarding power output degradation will end once the O&M Agreement is terminated. At this point, to the extent it has not already occurred, the module warranty and its enforcement shall be transferred to SDGE.

9.6.10 **Energy Production Test**

The annual System performance shall be evaluated by conducting an Energy Production Test under the O&M Agreement. The objective is to ensure that the Actual Energy Production of the System meets the Energy Production Guarantee. This Test shall be performed each year of the O&M Agreement.

The annual Energy Production Test shall be performed as follows:

1. Annually during the term of the O&M Agreement, beginning one year after the Substantial Completion Date of the applicable Project under the BTO, accounting for any down time and in accordance with the approved test procedures, the Seller, along with SDGE as a witness, shall read and record the Actual Energy Production for that year from the permanent power revenue meter. This shall be done each year that an Energy Production Test is run.

2. As a secondary measurement to check this amount, the Seller and SDGE shall sum the data from the monitoring system up to the time stamp that correlates to the visual meter reading.

3. The primary and secondary amounts shall be documented in a report and submitted to SDGE for approval.

4. If the measured annual Actual Energy Production for that year meets the Expected Energy Production as determined by the applicable Energy Model, then the Seller shall have met the Energy Production Guarantee for such Project.

5. If the measured Actual Energy Production is less than the Expected Energy Production value, then the Seller shall have failed to meet the Energy Production Guarantee for such Project. The Seller shall compensate SDGE for the Performance Liquidated Damages as set forth in the O&M Agreement .

6. If interruptions in energy production, outages, or recalibration of instrumentation occur, these events shall be recorded and reported so that the data can be evaluated accordingly. However, in no case shall these events excuse the Seller for having not met the applicable annual Energy Production Guarantee, unless there was an unplanned outage caused by SDGE or a Force Majeure event. In such case, the time that was missed will be made up so that a total of 365 valid days of testing is logged.

7. If there is a significant difference (more than ± 7.5%) between the measured Actual Energy Production and the Expected Energy Production (as determined by the Model), the cause of this difference shall be investigated and reported to SDGE.

9.6.11 **Annual Energy Production Test Procedures**

Prior to the commencement of an annual Energy Production Test, the following conditions shall be met:

1. Thirty (30) days prior to the commencement of the annual Energy Production Test, Seller shall submit to SDGE:

    - Documentation of scheduled outages and their impact on the total number of valid test days

2. Seller shall submit to SDGE:

    - Historical energy production of System to date including monthly average profiles.
    - Applicable measurement equipment calibration test certificates and records.
    - A comparison of the previous year's weather data to TMY3 data.

3. During the term of the O&M Agreement, Seller shall be allowed to monitor the measurements and maintenance of the System. Access to the site will be granted to the Seller's authorized individuals only.

4. At least two (2) weeks prior to the first day of each annual test, a meeting shall be held between the Seller and SDGE. The meeting shall schedule the Test dates; introduce the lead representatives, review the above preliminary report and applicable approved procedures, instrumentation locations, calibration sheets and other relevant topics including safety requirements. Minutes of this meeting shall be recorded by the Seller and approved by both parties.

As part of the test procedure, all test measurement devices shall be fully documented in terms of their make/model, accuracy, calibration and location. Table 9.6.12 summarizes these measurements:

Table 9.6.12 Annual Energy Production Test Measurements (Minimum)

Measurement	Qty	Type	Instrument Type	Minimum Accuracy
Energy (kWh), Power (kW)	1	Primary	Permanent ANSI C-12 power meter installed at the main circuit breaker switch.	+/- 0.2%
Energy (kWh)	1	Secondary	From Monitoring System – direct accumulated measurements from revenue meter, and from inverter.	+/- 0.5%
Meteorological conditions: solar irradiation, air temp,	1	Primary	Onsite weather station	

wind speed and direction	1	Secondary	Secondary weather station or Substation weather station (If available) or data from closest airport.	

All instruments used for primary measurements shall have current NIST or equivalent calibration certificates. All calibrations certificates shall be submitted to SDGE for review prior to turn over of the System and commencement of the applicable annual Energy Production Tests.

Any adjustments made prior to the Energy Production Test to any portion of the System or test measurement devices shall be submitted by SDGE to Contractor for review prior to commencement of the Energy Production Test.

The Energy Production Test results will be observed by, analyzed and approved by SDGE. Failure of any section will require the appropriate remedy with re-testing/reporting at no additional cost to SDGE.

END OF SECTION

Attachment 1: Minimum System Performance Requirements

Actual first year Capacity and Energy Guarantees are shown below.

Property Name	Nameplate Rated Capacity ($kW_{DC\ STC}$)	Minimum System Power Output ($kW_{DC\ STC}$)[1]	Expected Energy Production in Year One (kWh_{AC}/yr)	Minimum Actual Energy Production in Year One (kWh_{AC}/yr)[2]

[1].Minimum System Power Output ($kW_{DC\text{-}STC}$) shall be no less than 93.0% of Nameplate Rated Capacity

.[2]Minimum Actual Energy Production in Year One shall be no less than 90.0 % of Expected Energy Production in Year One

Power Output and Energy Production Guarantees

The Power Output and Energy Production Guarantees are described in Section 9.6

Attachment 2: Site Conditions

The equipment specified herein will be installed outdoors at Sites located in San Diego County, California. The design data for these Sites is as follows:

Dry bulb record minimum temperature:	25°F
Dry bulb record maximum temperature:	111°F
Maximum wet bulb temperature:	69°F (concurrent with maximum dry bulb temperature)
Annual average relative humidity:	70%
Maximum Relative Humidity:	100%
Annual average precipitation:	10.65 inches
Elevation:	200 feet above MSL
Design wind speed:	85 Mph
Greatest 24-hour precipitation:	3.23 inches

In addition to the above general data, specific hourly climate data will be provided in a TMY3 file for PV System design purposes.

Attachment 3: Approved Equipment Manufacturer List

Seller has proposed the following equipment in the Bid:

PV Module:

Inverters:

Racking Systems:

Performance Monitoring System:

Substitute equipment shall comply with the following lists, but only with SDG&E approval of the specific equipment.

The following Approved Equipment Manufacturer List provides the names of manufacturers that have been pre-approved by SDGE as potential equipment providers for the PV Systems. Seller may propose using equipment from alternative manufacturers not listed in the Approved Equipment Manufacturer List provided that the equipment complies fully with the complete requirements of this Technical Specification and Agreement. Seller must clearly define their request to deviate from this Approved Equipment Manufacturer List in the Proposal and SDGE reserves the right to reject such request.

PV Module:

- Canadian Solar
- Suntech Power
- Yingli Green Energy
- Trina Solar
- SunPower
- Sharp
- Siliken
- First Solar
- Hyundai Heavy Industries
- Solon
- Kyocera Solar
- Sanyo Electric
- Samsung Electronics
- REC Solar
- SolarWorld
- Jinko Solar
- LG Electronics
- LDK Solar
- Mitsubishi Electric
- Hanwha

Inverters:

- SMA America

Monitoring and Data Collection Systems:

- To be specified by SDG&E

Pad Mount Distribution Transformers:

- Howard
- Central Moloney
- ABB
- Cooper

Attachment 4: Photovoltaic Module Requirements

1.0 SCOPE

This section outlines the minimum design and functional requirements of the PV Modules that will be integrated into a complete Photovoltaic system referenced in the SDGE Technical Specification.

1. The PV Module will be comprised of all material and components required for a fully functional PV Module and shall conform in all respects to the requirements of this Technical Specification.

2. model crystalline silicon or equivalent modules shall be used. Alternative panels are subject to approval by SDG&E. The PV Module will meet all applicable US and international specifications in effect at the time of this Specification. All Codes and Standards to which the PV Module complies will be listed on the Module Data Sheets.

3. The PV Modules may be manufactured in the United States (preferred) or other approved locations as outlined in the commercial sections of the Agreement.

4. The PV Module Data Sheets shall contain a warranty of power output, expressed in net Watts (DC). The Manufacturer shall specify and guarantee the long term output for the first ten (10) years and twenty-five (25) years. Power Output Degradation shall be specified for each year, to 25 years.

5. The PV Module shall be designed for ease of installation with the minimum number of cabling interfaces in order to maximize the overall electrical efficiency of the final array configuration into which the PV Module is incorporated.

6. The Manufacturer shall provide a recommended procedure for disposal of the Modules at the end of their useful life. The Manufacturer shall also provide recommended procedures for disposal of broken or irreparable Modules.

2.0 GENERAL REQUIREMENTS

2.1 Codes and Standards

The PV Modules shall fully comply with all applicable Standards, including, but not limited to:

- UL 1703, Flat-Plate Photovoltaic Modules and Panels
- IEC 61730, Photovoltaic Module Safety Qualification

- IEC 61215, Crystalline silicon photovoltaic modules or IEC 61646, Thin-film photovoltaic modules
- ASTM E 1171
- California Energy Commission (CEC) Senate Bill 1 (http://www.gosolarcalifornia.org/equipment/pv_modules.php)
- NFPA compliant

2.2 Design Requirements

1. The PV Modules will have a minimum nominal rating of 70 Watts at least a nominal voltage of 600 Volts.
2. The PV Modules will be designed to operate under a range of environmental conditions, including marine, desert, alpine, and industrial environments, as defined in Attachment 2 of the Technical Specifications.
3. Each Module's actual power should be within a minimum tolerance of 5% of the Manufacturer's specified module rated power. The lower bound of the panel power tolerance will be used to calculate the DC rating of the plant.
4. Each Module will have a minimum five year guarantee for design and workmanship.
5. The Modules shall be certified by a nationally or internationally recognized certifying agency such as the California Energy Commission.
6. Each string of modules should be assembled and batched by Impp to minimize the mismatch losses.

2.3 Performance Requirements

The PV Modules shall conform at a minimum to the following general characteristics at the nominal manufacturer rating at standard test conditions (STC) (DC watts) with corresponding data at estimate PTC (watts) noted below.

The following information shall be provided by the PV Module Manufacturer at STC

- Power
- Voltage at P_{MAX} - V_{MPP}(V)
- Current at P_{MAX} - I_{MPP}(A)
- Open Circuit Voltage – V_{OC}(V)
- Short Circuit current – I_{SC} (A)
- Maximum System Voltage – V_{SYS}(Vdc)
- Temp Coefficient of P_{MPP} – T_K (%/ °C)
- Temp Coefficient of $V_{OC,}$ high temp (>25°C) – T_K (%/ °C)
- Temp Coefficient of $V_{OC,}$ low temp (-40°C to +25°C) – T_K (%/ °C)

- Temp Coefficient of I_{SC} – T_K (%/ °C)
- Limiting Reverse Current – I_R(A)
- Maximum Source Circuit Fuse – I_{CF}(A)

For the proposed Module and ratings at 1000 W/m^2, air mass at 1.5g and cell temp at 20°C, the Bidder shall provide the following:

- Nominal Power (+/-5%) – P_{MPP}(W)
- Voltage at P_{MAX} – V_{MPP}(V)
- Current at PMAX – I_{MPP}(A)
- Open Circuit Voltage - V_{OC}(V)
- Short Circuit Current - I_{SC}(A)
- IV Curve for Bidder's proposed Module showing current/voltage characteristics with dependence on irradiance and Module temperature at 1000 W/m^2 , at 800 W/m^2, and at 400 W/m^2

3.0 LONG-TERM DEGRADATION WARRANTY. The Long-Term Degradation Warranty to be provided by the Panel Manufacturer shall meet (as a minimum) the following criteria (i.e. Sections 3.1 through 3.4).

3.1 MATERIALS WARRANTY (YEARS)

The Modules shall have a minimum ten year guarantee of materials, design and workmanship. The Manufacturer shall provide information on the service levels and intervals to be maintained to sustain the warranty.

3.2 POWER WARRANTY (YEARS)

Manufacturer shall provide modules with a maximum degradation of 10% over ten years and 20% over twenty-five years.

3.3 DESIGN LIFE WARRANTY (YEARS)

The PV Modules will have a design life of at least twenty-five years from the date of installation, and no less than twenty seven years from the date of manufacture.

3.4 REPLACEMENT PROCEDURE.

The Long-Term Degradation Warranty shall clearly state the process by which Owner shall make a claim against the warranties described above, including a name, contact address, fax

number, and phone number. The facility to which any panels must be shipped for replacement shall be located in the continental United States. The Long-Term Degradation Warranty will also contain clear time lines for responses to warranty claims, including negative responses. The Long-Term Degradation Warranty shall provide an objective test in determining how panel output will be determined in case of disputes.

Attachment 7: Equipment Warranties

1.0 Inverters:
The inverters are covered by a twenty (20) year manufacturer's limited warranty.

2.0 Racking System:
The Racking system is covered by a twenty (20) year manufacturer's limited warranty.

3.0 Monitoring System:
The monitoring system is covered by a twenty (20) year manufacturer's limited warranty.

The Long-Term Degradation Warranty does not apply to:

1. Components of the Grid-Tied PV system that have been subject to misuse, neglect, accident, abuse, vandalism, alteration, force majeure event or serviced/repaired by anyone other than, for the duration of the Operation and Maintenance Agreement with . After expiration of the O&M Agreement, the manufacturer's Long Term Degradation Warranty shall remain in effect.
2. Items that require replacement due to normal wear and tear, normal erosion or corrosion or casualty loss (other than as a result of any failure of the Defect Warranty or the Long-Term Degradation Warranty)