~~M3-01-01~~

APPENDIX M3
~~-~~ATTACHMENT ~~-~~01
EXHIBIT 01

~~(a)~~ **SOLAR PHOTOVOLTAIC PLANT SPECIFICTION STATEMENT OF WORK - PV**

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

~~2023~~20253~~3~~

REQUEST FOR PROPOSAL

NO.	DATE	REVISION	BY	CHK'D	APPROVALS	
0	14Apr23	Issued for Implementation	1898 & Co.	PGE	CPA	Craig Armstrong

1.0 GENERAL

1.1 PURPOSE

Without limiting the information summarized herein, the purpose of this document is

(a) to summarize the minimum scope of work responsibilities for Contractor, which generally include the complete development, engineering, procurement, and construction of the Project as defined herein; and (b) to summarize the minimum performance specifications, quality standards, and other criteria required for the development, engineering, procurement, and construction of the Project.

1.2 REFERENCES

In addition to anything summarized herein, all Work related to the Project shall conform to the following Owner standards. In the case of any conflict between any Owner standards below and any requirement set forth herein, the more stringent requirement shall apply.

- A. PGE Appendix M1, Attachment 01, Exhibit 02: Engineering Documents, Drawings, and Other Deliverables (“PGE Exhibit M1-01-02”), including the Documents and Deliverables Table (M1-01-02-01-Solar) (“PGE Exhibit M1-01- 02-01”) attached thereto.
- B. PGE Appendix M1, Attachment 01, Exhibit 07: Security and Compliance (“PGE Exhibit M1-01-07”)
- C. PGE Appendix M1, Attachment 01, Exhibit 09: PGE CAD and Numbering Standards (“PGE Exhibit M1-01-09”)
- D. PGE Appendix M1, Attachment 04, Exhibit 02: General Power Transformer Specification (“PGE Exhibit M1-04-02”)
- E. PGE Appendix M1, Attachment 05, Exhibit 04: Communication, SCADA, and Metering Facilities (“PGE Exhibit M1-05-04”)

1.3 DEFINITIONS

A. “AC” or “ac” shall mean alternating current.

B. “AC Rated Plant Capacity at the POI” shall equal the total net export capability at the Point of Interconnection as defined by the Interconnection Agreement.

C. “AC System Losses” shall mean the resistance losses (I^2R) through the AC cabling and magnetization and winding losses associated with the inverter step-up transformers and is exclusive of Auxiliary Loads.

D. “Agreement” shall mean the [Engineering, Procurement and Construction Agreement] to which this M3-01-01 is attached.

E. “Array” shall mean a collection of solar modules connected in series, all tying into one Inverter Skid Assembly (ISA).

F. “Auxiliary Loads” shall mean power consumption from activities not directly associated with power generation or transmission losses. These include, but are not limited to, inverter power and SCADA system power.

F.

G. "Circuit" shall have the definition set forth in M3-01-60405.

H. "Contractor" shall mean qualified developer or Engineering, Procurement, and Construction firm responding to Request for Proposal (RFP).

I. "DC" or "dc" shall mean direct current.

J. "DC Voltage Drop Maximum" shall be the maximum allowable voltage drop of any one inverter array (from module string to inverter DC input) at full load and STC.

K. "DC/AC ratio" shall mean the ratio of the ISA installed DC power to the Inverter power rating operated at maximum expected inverter-level power factor to meet power factor requirements at the POI. For example, a 2.75MVA inverter operated at a power factor of 0.92, with a total installed DC power of 3.5MW_{DC}, would have a MW_{AC} rating of 2.53MW and a DC/AC of 1.38.

L. "Equipment and Materials" as defined in section 3.01.2.

M. "HZ" shall mean hertz.

N. "ISA" shall mean the Inverter Skid Assembly consisting of the static power inverter(s), inverter step-up transformer, associated controls, monitoring, cabling, and grounding systems.

O. "kV" shall mean kilovolts.

P. "kW" shall mean a measure of instantaneous power as measured in kilowatts. If not specified, it shall be assumed to be in Alternating Current (AC).

Q. "kWh" shall mean kilowatt-hours. If not specified, it shall be assumed to be in Alternating Current (AC).

R. "MET Station" shall mean the meteorological station/(s) installed within the solar field to measure critical weather data such as wind speed and direction, ambient temperature, solar irradiance, etc.

S. "Operation and Maintenance Building" shall mean the building that houses the Project Control Room and offices. Refer to this exhibit M3-01-01 and M1-02-02 for O&M Building scope.

T. "Owner" shall mean solicitor of RFP to who will own the facility upon Final Completion, i.e., PGE.

U. "POI" shall mean the Point of Interconnection which defines the location of the physical electrical interconnection to the Transmission Provider as defined in the Interconnection Agreement.

V. "PV" shall mean photovoltaic.

W. "Solar Substation" shall mean the interconnection facility which collects the feeds from the ISA and transforms the voltage (as required) for electrical interconnection to the Transmission Provider. Refer to M3-01-02 for Solar Substation Statement of Work.

W.

X. "Project" shall mean the solar Project as defined in the Agreement. The Project shall include all equipment and systems producing solar energy, from the solar modules up to the POI, including the collector system, substation and Generation Tie-line between the project substation and the POI, as applicable.

Y. "SCADA" shall mean the Supervisory Control and Data Acquisition system, including all monitoring/control hardware and software, field instrumentation and communication devices.

Z. "STC" shall mean standards test conditions, which is 1000 watts per square meter insolation, 25ºC module temperature, 1.5 AM (air mass).

AA. AA. "Transmission Provider" shall mean the public utility (or its designated agent) that owns, controls, or operates transmission or distribution facilities used for the transmission of electricity in interstate commerce and provides transmission service under the Tariff.

Capitalized terms not otherwise defined above shall have the meaning given such terms in the Agreement.

1.4 CONTRACTOR SCOPE OF WORK OVERVIEW

A. Contractor shall furnish a ground-mounted single-axis solar-tracking utility- scale-scale Project for Owner at the specified capacity and energy production (defined in M3-01-05).

B. The Project shall be capable of operating in accordance with the terms and conditions of the Agreement, this "Statement of Work" and associated attachments.

C. Contractor shall design and construct the Project in accordance with the Agreement and this Specification. Scope of Work shall consist of:

1. Specify and furnish the Equipment and Materials which shall include, but not be limited to perimeter fences, structural support and tracking systems, module string DC wiring harnesses and CAB system (as applicable), DC combiner boxes or load break disconnects (LBDs), ISAs, SCADA system, MET Stations, AC collection, and ancillary hardware required to connect and operate listed equipment. Scope shall also include that defined in M3-01-202 for the Solar Substation and section 6.0 for O&M Building.

2. Project design engineering, software models, and drawing packages for construction permitting, installation and "as-built" documentation.

3. Project construction including all site/civil work, structural, electrical, mechanical, and monitoring/control systems.

4. Third party verifications shall include soils, concrete and shall also be performed where required to comply with Applicable Permits and codes.

4.

5. Project and construction management, including quality assurance/quality control, site safety, site material control and management of all subcontractors.

6. Design Review meetings in accordance with M1-01-02 and table M1-01- 02-01-Solar. All design review meetings will be held at agreed upon meeting place and may be broken up into several meetings as required to meet schedule.

7. Project commissioning and testing in accordance with M3-01-04 and M3- 01-05.

8. Project turnover including Owner training and Project operations and maintenance documentation.

D. Contractor shall provide all temporary electrical and internet services for use during construction and commissioning.

E. Contractor shall provide all temporary lighting, including at trailers and parking lot.

F. Contractor shall provide all design documents required to support Owner in obtaining Owner-Acquired Permits and other regulatory agreements.

G. Temporary Facilities

1. Contractor shall provide Owner with one furnished office trailer complete with electrical, internet service. Minimum space shall include two (2) offices, conference room, restroom (running water) and common areas.

2. Contractor shall be responsible for establishing and maintaining all restroom, lunchroom, and other office and meeting areas for the duration of the construction and commissioning portion of the Project.

3. Contractor shall provide temporary running water sanitary facilities for the temporary office trailer complex. For in-field work areas Contractor shall provide temporary sanitary facilities consisting of above ground Porta- John type. Contractor shall be responsible for decommissioning the temporary sanitary facilities at the termination of construction.

4. Contractor shall maintain on-site dumpsters and personnel to maintain a clean and rubbish--free work site.

5. Contractor shall be responsible for designing and implementing temporary traffic control measures as required by applicable County or local agencies throughout construction duration.

6. Contractor shall be responsible for permitting, installation, and removal of a temporary water storage facility to satisfy water requirements for dust control purposes.

7. Contractor shall be responsible for establishing and maintaining temporary parking areas for construction and office personnel. Temporary p

7. parking areas shall be returned to design grades and surfacing at the termination of construction.

G.H. Contractor shall be responsible for design, permitting and implementation of dust suppression and erosion control measures.

H.I. Contractor shall be responsible for permitting, and installation of a temporary water storage facility to satisfy water requirements for dust control purposes and other uses during construction as required by local authorities. Sizing of temporary water storage facility shall be of adequate volume for dust suppression. Temporary water storage facilities shall be removed, and the area returned to design grades and surfacing. All costs for water during construction shall be paid for by Contractor.

H.J. Contractor shall be responsible for site security throughout construction duration until turn over.

I.K. Contractor shall provide fire mitigation, and fire protection and access as required.

J.L. Contractor shall provide temporary barriers (snow fence or agreed upon barrier) to physically separate Circuits turned over to Owner prior to Substantial Completion.

K.M. Contractor shall provide traffic management as necessary to ensure safe site access from nearby public roads for all vehicles and equipment.

L.N. Contractor is responsible for meeting storm water quality requirements and retention basin requirements as dictated by Applicable Law.

M.O. Contractor shall provide all relevant electrical engineering studies for a comprehensive and complete design. This will include, but not be limited to, grounding study, arc flash study, short circuit study, ampacity study, temporary over voltage study, load flow (reactive power) study, harmonics analysis, and relay settings and coordination study.

N.P. Contractor shall conduct a Geotechnical Study suitable for the project level design work.

1.5 OWNER PROVIDED FACILITIES, INFORMATION AND SERVICES

A. A. Owner will provide all applicable Owner permits for the Project.

1.6 SITE AND ENVIRONMENTAL CRITERIA

A. A. Project design shall be based upon the design conditions listed below (Spaces marked with ‘X’s to be filled in by Contractor):

~~(b)~~ **Table 1-1**

Existing Site Design Conditions

~~Project Location~~	~~Approximately XX miles XXX of XXXX, XX.~~
~~Minimum/Maximum Dry Bulb Temperature (for inverter design)~~	~~X°F/X°F (ASHRAE extreme annual)~~
~~Extreme low temperature (for module string design)~~	~~X°F (ASHRAE extreme low annual) (OR Contractor can use SAM simulation to determine and submit to Owner for review)~~
~~Design Wet Bulb Temperature or relative humidity (for HVAC design)~~	~~X°F (ASHRAE 0.4% Design)~~
~~Maximum Elevation~~	~~X feet above mean sea level~~
~~Site Road Access~~	
~~Seismic Criteria~~	~~TBD SDS = XX, SD1 = XX, Seismic Design Category (SDC) = XXX, Site Class = D (assumed), Importance Factor = 1.0 unless otherwise approved by the local authority having jurisdiction (AHJ)~~
~~Wind Design~~	~~For Risk Category I structures (trackers), V = X MPH (X sec gust), Exposure = C (assumed), in accordance with the most recent edition of ASCE 7, unless otherwise approved by the local authority having jurisdiction~~ ~~For Risk Category II structures (ISAs and MET stations), V = X MPH (X sec gust), Exposure = C (assumed), in accordance with the most recent edition of ASCE 7, unless otherwise approved by the local authority having jurisdiction~~ ~~Wind on Ice shall be considered~~
~~Snow Load~~	~~XXXX psf~~ ~~For Risk Category I, Importance Factor = 0.8, in accordance with the most recent edition of ASCE 7, unless otherwise approved by the local authority having jurisdiction~~ ~~For Risk Category II, Importance Factor = 1.0, in accordance with the most recent edition of ASCE 7, unless otherwise approved by the local authority having jurisdiction~~

Risk Category	Unless indicated otherwise by the AHJ: For racking structures and racking foundations, Risk Category I For all other structures, Risk Category II
Project Location	**Approximately XX miles XXX of XXXX, XX.**
Minimum/Maximum Dry Bulb Temperature (for inverter design)	X°F/X°F (ASHRAE extreme annual)
Extreme low temperature (for module string design)	X°F (ASHRAE extreme low annual) (OR Contractor can use SAM simulation to determine and submit to Owner for review)
Design Wet Bulb Temperature or relative humidity (for HVAC design)	X°F (ASHRAE 0.4% Design)
Maximum Elevation	X feet above mean sea level
Site Road Access	
Seismic Criteria	SDS = XX, SD1= XX Seismic Design Category (SDC) = XXX, Site Class = D (assumed), Importance Factor = 1.0 unless otherwise approved by the local authority having jurisdiction (AHJ)
Wind Design	For Risk Category I structures (trackers), V = X MPH (X sec gust), Exposure = C (assumed), in accordance with the most recent edition of ASCE 7, unless otherwise approved by the local authority having jurisdiction For Risk Category II structures (ISAs, ballance of plant equipment, and MET stations), V = X MPH (X sec gust), Exposure = C (assumed), in accordance with the most recent edition of ASCE 7, unless otherwise approved by the local authority having jurisdiction Wind on Ice shall be considered
Snow Load	XXXX psf For Risk Category I, Importance Factor = 0.8, in accordance with the most recent edition of ASCE 7, unless otherwise approved by the local authority having jurisdiction For Risk Category II, Importance Factor = 1.0, in accordance with the most recent edition of ASCE 7, unless otherwise approved by the local authority having jurisdiction
Risk Category	Unless indicated otherwise by the AHJ: For racking structures and racking foundations, Risk Category I For all other structures, Risk Category II

Project Location	Approximately XX miles XXX of XXXX, XX.
Maximum storm water velocity and depth	To be determined as part of design
Average Annual Rainfall	X inches
100 yr /Maximum 24 hr Rainfall	X – IX inches
Design Maximum Rainfall Rate	100yr – Shall comply with applicable county requirements
Environmental Constraints	See Constraints Map
Floodplains	XXXX
Subsurface Soil Conditions	Per final Geotechnical Report

1.7 DESIGN CRITERIA

A. Project and individual components shall have a minimum design life of 25years.

B. Project shall be designed for automatic operation.

C. Project electrical design will be in compliance with applicable codes and standards listed under section 1.8 unless otherwise noted.

D. Dissimilar metals in contact anywhere in system shall be avoided where possible to eliminate the possibility of galvanic corrosion. Lugs shall be rated for dissimilar metals where applicable.

E. During engineering design, Contractor shall work with the Owner when determining all signage, labeling and nomenclature.

1.8 SYSTEMS AND EQUIPMENT

A. Provisions shall be included in the design of all systems to allow the performance of all routine maintenance without requiring a plant shutdown.

B. Contractor shall:

1. Receive, inspect, store, unload, maintain, erect, clean, align, and prepare all equipment in strict accordance with equipment manufacturer’s instructions prior to Substantial Completion.

2. Provide lifting lugs on all equipment components or system components requiring removal for maintenance and weighing over 25 lbs.

3. Select materials of construction and design equipment and systems to provide a minimum of a 25-year operating life at all operating conditions specified.

4. Design the facility for a life of 25 years consistent with good engineering practice for solar generation facilities. However, it is understood that some of the equipment will require routine maintenance and possible replacement during the life of the facility.

1.9 OPERATING CRITERIA

A. DC grid voltage: 1500 volts DC negatively grounded.

B. AC Medium voltage: 34.5 kV, 60Hz

C. DC &AC electrical systems under 1000V shall be radially configured. Medium voltage AC transformer systems shall be radially configured with open-loop feed features. No redundancy is required.

D. Convenience Power: 120VAC

E. Meteorological Instrumentation voltage: 24VDC or 125VDC

F. Communications network: Ethernet via ~~direct~~ buried fiber optic cable/innerduct within the arrays to the Communications Interface. Fiber optic to all field equipment shall be designed in a 'collapsed loop' configuration, at a minimum, to provide redundant path back to SCADA system. The network shall be 1 Gigabit and shall include adequate spare capacity to run parallel networks.

G. The DC/AC ratio of each inverter array shall be within 5% of the overall project DC/AC ratio.

1.10 CODES, REGULATIONS AND STANDARDS~~S~~

~~A. Reference Section M1-05-06. In the event that any Applicable Law or Industry Standard does not govern specific features of any item of Equipment and Materials, Temporary Work or system, Contractor or Original Equipment Manufacturer (OEM) standards shall be applied, with Owner's approval. Where local codes or ordinances will have an impact on the design, Owner and Contractor shall jointly address these with the local authorities having jurisdiction.~~

~~B. Listed herein are the principal codes and standards applicable in the design, fabrication, and installation of the Project; these are not intended to be all inclusive. Where local codes or ordinances will have an impact on the design, Contractor shall be responsible for meeting the codes or obtaining variances from local authorities having jurisdiction.~~

~~C. Contractor shall design and construct the Project in accordance with the most recent versions of the following standards, as applicable:~~

~~D. ACI - American Concrete Institute~~

~~E. AISC - American Institute of Steel Construction~~

~~F. ANSI - American National Standards Institute~~

~~G. AISI – American Iron and Steel Institute~~

H. ASCE – American Society of Civil Engineers

~~I. ASME – American Society of Mechanical Engineers~~

~~J. ASTM - American Society for Testing and Materials~~

~~K. AWS – American Welding Society~~

~~L. IBC - International Building Code~~

~~M. ICEA - Insulated Cable Engineers Association~~

~~N. IEC - International Electrotechnical Commission~~

~~O. IEEE - Institute of Electrical and Electronics Engineers~~

~~P. ISA – Instrumentation Society of America~~

~~Q. NEC - National Electrical Code~~

~~R. NEMA - National Electrical Manufacturers Association~~

~~S. NESC - National Electrical Safety Code~~

~~T. NETA - National Electrical Testing Association~~

~~U. NFPA – National Fire Protection Association~~

~~V. OSHA - Occupational Safety and Health Act~~

~~W. TUV SUD America~~

~~X. UL – Underwriters' Laboratories~~

A. In the case where standards have conflicting requirements, Owner and Contractor will develop a mutual agreement of the prevailing standards.

2.0 SPECIAL CONDITIONS

2.1 CONSTRUCTION WATER

A. Contractor shall size and provide all construction-water related infrastructure necessary to support Contractor's construction and schedule.

2.2 FLOOD PROTECTION

A. Associated flood hazard requirements shall be incorporated into the design and construction of the Project. Contractor shall elevate and/or provide flood protection for structures subject to the approval of the [To be filled in by Contractor] County Engineering, Surveying, and Permit Services Department/Floodplain Management.

3.0 EQUIPMENT AND MATERIALS

A. Contractor shall furnish all Equipment and Materials as required to construct a fully functioning Project. Minimum requirements for major equipment are described herein.~~:~~

3.1 PV MODULES

A. Contractor shall provide PV modules and will submit the module type and specifications for project reference and use.

B. PV Modules shall be compatible with racking system.

C. PV Modules shall be installed per manufacturer's written instructions.

D. Contractor shall have a documented QA/QC program to ensure module installation meets or exceeds the module manufacturer's installation requirements.

E. Contractor shall make best efforts to distribute modules across site to balance bin classes.

3.2 TRACKER AND SUPPORT STRUCTURE

A. The module support structures shall be designed and constructed to provide a stable support system for the PV modules that will remain effective throughout the design life of the Project.

B. Foundation shall be designed to be driven galvanized steel and corrosion resistant over the design life of the Project.~~Foundation shall be driven galvanized or equivalent corrosion-resistant steel members, mini-cast augured piles or equivalent.~~ Corrosion resistance shall be as required by the findings of the Geotechnical Study and Corrosion Study. Corrosion Study shall be performed by an Owner-approved Corrosion Engineer.

C. Module support sub-structure frame may be corrosion-resistant steel or extruded aluminum.

D. Mounting hardware shall include corrosion resistant clips and fasteners.

E. Corrosion protection to be evaluated by Contractor to verify soil conditions are compatible with the module support structures.

F. The maximum support structure deflections shall prevent PV module and electrical system damage and shall not exceed allowable limits provided by the manufacturer and the most recent edition of IBC and ASCE 7 codes.

G. The module support system shall be designed and constructed to withstand environmental conditions and applied loads for the design life of the Project.

H. Dynamic force conditions from wind shall be considered and included in design.

I. Horizontal single-axis with backtracking capabilities. Backtracking to be configured based on module manufacturer's recommendations to maximize energy output.~~.~~

J. Tracker drives electric motors or hydraulic. If hydraulic, oil must be bio- degradable type oil, not considered an environmental hazard.

K. Galvanized steel structural components.

L. Accurate stowing required for wind events based on design tolerance. Capable of quick stow or stowing based on accurate wind predictions or measurements.

M. Designed and manufactured per applicable AISC, AISI, AST~~sada~~M, ANSI & AWS codes and standards.

N. The tracking system shall be designed and constructed to withstand environmental conditions and applied loads for the design life of the Project.

O. Bearings and gears shall have Basic Rating Life (L_{10}) of 100,000 hours.

P. Tracker supplier must have robust proven QA/QC program installed at shops supplying torque tubes, torque arms, drive struts, and other main components of tracker.

Q. DC cable management system - open cable tray or CAB systems may be used.

Q.

R.

R.S. Racking system and module mounting shall meet the requirements of UL 3703 and 2703, respectively.

S.T. All modules shall be a minimum height of twelve (12) inches and a maximum height of eight (8) feet above finished grade at full tilt the ground. Combiner boxes, disconnect switches, inverter/transformers, and any other electrical equipment shall be a minimum 12" above the 100-year , 24-hour storm event flood level flood level. Module height at stow position shall be above the 100-year flood level unless otherwise required by AHJ.

3.3 DC FUSED COMBINER BOXES (AS APPLICABLE)

A. Enclosure shall be rated NEMA 3R (or better)or 4.

B. Combiner boxes shall be installed above groundat a minimum of 18" above grade or 12" above 100-year flood level, whichever is greater.

C. Factory assembled back panel complete with finger safe fuse holders rated for maximum VDC, reinforced, plated bus bars and power distribution blocks.

D. Combiners shall have a load-break DC disconnect switch with the capability of being pad-locked in the off position.

E. Enclosures doors shall have provisions for pad locking.

F. Completed assemblies shall be listed to UL 1741.

F.

G. Combiner shall be labeled to meet NEC code requirements and labeled with an arc flash warning.

H. All feeders and cables into combiner boxes shall have preprinted labels with unique tags/identifiers.

I. Safety covers shall be provided for live components.

J. Surge suppression devices shall be mounted internal to combiner box.

K. All terminals shall be 90°C rated.

3.4 DC LOAD BREAK DISCONNECTS (AS APPLICABLE)

A. Enclosure shall be rated NEMA 3R (or better) 4.

B. Load Break Disconnects (LBDs) shall be installed- a minimum 18" above grade or 12" above 100-year flood level, whichever is greaterabove ground.

C. Provisions for pad locking in the off position.

D. Completed assemblies shall be UL listed.

E. Combiner LBD shall be labeled to meet NEC code requirements and arc flash warnings.

F. All feeders and cables into LBDs shall have preprinted labels with unique tags/identifiers.

G. Surge suppression devices shall be mounted internal to LBD.

H. All terminals shall be 90°C rated.

3.5 INVERTER SKID ASSEMBLY (ISA)

~~3.5 Inverter Skid Assembly (ISA)~~

A. Each ISA shall consist of inverters with step up transformer, DC cabling/bus, AC cabling/bus, auxiliary equipment, and grounding system.

B. Inverters

1. Inverter shall be on Approved Supplier List and approved by Owner.
2. Inverter shall be UL 1741 Supplement A listed.
3. Inverter shall be rated for use in 1500 Vdc applications.
4. Inverter shall have California Energy Commission (CEC) weighted efficiency greater than or equal to 98% (without medium voltage inverter step-up transformer).
5. Environmental ratings:
   a. Inverter shall be capable of operation at ~~full nameplate rating from~~ ambient air temperatures between -20 ºC to 50ºC (-4 ºF to 122ºF). Derates from environmental conditions shall be taken into consideration when determining the quantity of inverters.~~Depending on Site Design Temperature a 45 ºC upper limit may be acceptable.~~
   b. Inverter electronic compartments (IGBTs, communications, etc.) shall be NEMA 4 or better (or European equivalent) and the overall enclosure rating shall be NEMA 3R or better (or European equivalent).
6. Nameplate: Inverter shall be sized to deliver rated power at ±0.95 power factor at the environmental conditions detailed in table 1-1.~~up to 50°C.~~
7. Quantity: Adequate inverters shall be provided, considering losses and reactive power, in order to deliver the required power at the POI at the design temperature.
8. Inverters shall have the capability of dynamic power factor adjustment from 0.8~~95~~ lag to 0.8~~95~~ lead, unless more stringently defined by Interconnect Agreement.
9. Inverters shall not de-rate while operating within their rated DC voltage range ~~for an ambient temperature of 50˚C and below.~~and design temperature. A gradual de-rate may be experienced in the case that the operating conditions are outside the rated DC voltage or ambient temperature range(s). De-rating characteristics shall be submitted to Owner for review.
10. Current and voltage harmonics: <3% THD and IEEE-519-2014 requirements at the POI.
11. Inverter shall be designed to the requirements of IEEE C57.159 to be compatible with its step-up transformer in terms of harmonics and resonance.
12. Inverter cooling system shall not be susceptible to particle contamination and require minimal maintenance.
~~13.~~ Inverters shall be provided with surge suppression devices on both the DC Input and AC Output.

13.

14. Inverter shall have protective measures to prevent single IGBT failures from causing cascading failures.

15. Inverter AC breaker shall be externally operated and capable of remote operation to minimize arc flash hazards.

16. Inverter shall be provided with ground isolation detection devices where used with systems having ungrounded PV arrays.

17. Inverter shall be operated in accordance with manufacturer's recommendations. Any deviation shall be authorized in writing from the manufacturer and not before notification and acceptance by Owner.

18. Inverter shall have built-in protection against undervoltage, overcurrent, overvoltage, and transients.

19. Inverter shall have capabilities for voltage and frequency ride-through and the features shall be compliant with NERC and ~~FRCC~~ FERC requirements.

    a. Inverter shall be compliant with NERC PRC-024 ~~-2~~9 ride through requirements.

20. Inverter shall integrate Inverter Step-up Transformer signals (low oil, high pressure, high-temp warning, and high-temp trip) into SCADA system and trip/warn/de-rate signals appropriately.

21. Each electrical equipment enclosure on the ISA shall be labeled with a UV resistant placard.

3.6 INVERTER STEP-UP TRANSFORMERS

~~3.6 Inverter Step-up Transformers~~

A. Transformers shall be of the compartmental pad-mount design with dead front and loop feed features.

B. Ratings: Transformer kVA rating, including any environmental derates, shall match ISA combined inverter rating. Impedance shall match inverter manufacturer requirements. Cooling class = KNAN or KNAF

C. Low-side voltage: Matched to selected inverter.

D. High-side Voltage: 34.5kV Delta/ with elbow surge arrestors located on transformers ~~-~~that do not contain a loop feed out.

E. High efficiency: 99.2% or greater at nameplate output.

F. No-Load losses shall be limited to 0.15% of full KVA rating.

G. BIL ratings: To be stated in data sheet for Owner review.

H. Winding insulation: 65ºC rise over 45ºC ambient.

I. Number of windings: Maximum of three.

J. De-energized tap changer with high voltage taps: (2) 2.5% above and below nominal position – fully rated.

K. Hook stick disconnect switch shall be located such that Arc Flash protection is not required for operation.

~~K.~~

L. Over-current protection via bayonet fuse (with holder) in series with partial range current limiting fuse, or internal expulsion fuse in series with oil immersed with current limiting fuse shall be provided.

M. Top powder coat of ANSI 70 light grey or ~~Munsell~~ color approved by Owner~~Green~~.

N. Oil level, pressure/vacuum, and oil temperature gauges. All instrumentation shall be read into SCADA. Oil temperature gauge to be furnished with two alarm contacts (warning and trip). Oil temperature and pressure transmitters shall provide binary outputs. Oil level gauge to be furnished with alarm contacts. Instrument gauges shall be located in a separate cabinet such that gauges can be read without requiring Arc Flash protection. Access to the equipment shall be provided in accordance with NEC and OSHA standards.

O. Drain valve with oil and dissolved gas analysis (DGA) sampling provisions, readily accessible in normal operation. Valve shall be located external to the high voltage and low voltage compartments in a pad-lockable cover or in gauge cabinet.

P. NEMA 2-hole ground terminal pads.

Q. Transformer mounting pad design may be required to incorporate features for secondary containment of oil. Contractor shall conform to requirements of local authorities having jurisdiction and design shall be reviewed and accepted by Owner.

R. Transformer insulating/cooling liquid shall be non-hazardous and environmentally friendly such as FR3 or Owner approved equivalent.

~~O.~~S. In addition to all routine factory testing per most recent standard of ANSI/IEEE standard C57.12.90 and C57.12.00, the following tests shall be conducted:

1. Full ANSI impulse test on one (1) unit, preselected during production by Owner.
2. Heat run test on one (1) unit, preselected during production by Owner.

~~P.~~T. Shall comply with the following latest ANSI/IEEE standards:

1. C57.12.00 - IEEE Standard for General Requirements for Liquid- Immersed Distribution, Power, and Regulating Transformers
2. C57.12.10 - IEEE Standard Requirements for Liquid-Immersed Power Transformers
3. C57.12.28 – Switchgear and Transformers, Pad-Mounted Equipment – Enclosure Integrity.
4. C57.12.34 - IEEE Standard Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers
5. C57.12.90 - IEEE Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
~~2.~~6. C57.159-2016 – IEEE Guide on Transformers for Application in Distributed Photovoltaic (DPV) Power Generation Systems
~~3.~~7. ~~C57.12.90 - IEEE Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers~~C57.91 – Oil-immersed transformer temperature monitoring

~~Q.~~U. Baseline DGA, conducted at factory or on Site, shall be provided with each transformer.

3.7 PROJECT SCADA

~~3.7 PROJECT SCADA~~

A. SCADA system shall be composed of hardware and software, field instrumentation, meteorological stations, and communications devices designed for remote monitoring, control, and historical trending of the Project.

B. Shall be NERC CIP compliant and meet cyber security requirements, following Owner's compliance and security addendum M1-01-07. For further information refer to M1-05-04.

C. Site SCADA and ~~telecom~~telecoms shall be fully protected and behind a firewall.

D. Shall allow for multiple external connections and be able to accommodate private networks (MPLS, etc.).

E. Shall be able to communicate with external parties in their protocols. For further information refer to M1-05-04.

F. All power plant controller set points, etc. must be logged (set point, user, etc.).

G. The SCADA system shall include 10% spare hardware I/O points for Owner's future use.

H. The SCADA system shall meet all data frequency and duration requirements specified in M3-01-05.

I. Contractor shall supply, install, and commission the SCADA System hardware at the Site in connection with the performance of its services pursuant to the terms of the EPC Agreement.

J. SCADA system shall display data in real time and record and log performance data at regular intervals from the Project.

K. All SCADA data shall be made available for a Pi interface and other third parties as required for remote access, monitoring and data collection.

L. Communications infrastructure shall be fiber optic based and incorporate a collapsed-loop, or path diverse ring fiber network or equivalent.

M. SCADA System

~~3.~~1. Contractor shall program the control software for the Project on an industry-standard SCADA platform for easy integration into Owner's operation. Software shall employ both remote monitoring and control and an Antivirus server.

~~4.~~2. Contractor shall provide a historian capable of capturing all data points, at one second intervals (or fastest available or permitted by each device) and log data for at least 1 year or minimum required to meet local ISO, NERC, or other requirements. All data must be made available to Owner at native resolutions.

~~5.~~3. IP addressing to be coordinated with Owner.

~~6.~~ All SCADA and network equipment must be of utility grade substation quality equipment by standard industry grade suppliers~~.~~.

~~4.~~

~~7.~~5. Field Area Network (FAN) shall maintain a dedicated redundant fiber gigabit Ethernet backbone from the central control room to each ISA. Inverter structures switch sub connections to Ethernet based inverter devices may be 10/100 megabit minimum connectivity.

~~8.~~6. Field network connectivity shall be established using Owner approved protocol and a physical ring topology. Each ring will be comprised of less than 34 switches. Loop connectivity for field network may be achieved ~~through the use of~~with 2 parallel fibers within the same cable (~~closed-loop~~closed loop).

~~9.~~7. All fiber shall be terminated on bulkheads in weatherproof enclosures or fiber patch panels~~s/enclosures~~.

~~10.~~8. All fiber networks shall support 1 Gigabit network architecture.

~~11.~~9. Contractor shall install ~~minimum~~a minimum of one operator station for access to the SCADA system and historian server and provide all SCADA/historian licensing for the Project. Such hardware/software shall be located at the Site, and title to such hardware/software shall be transferred to Owner.

~~12.~~10. SCADA shall employ Remote I/O to be deployed at major data collections points in the Project. Typical locations for ~~the Remote~~Remote I/O include the ISAs.

~~13.~~11. The Remote I/O shall function as the input/output point for the ~~command and control~~command-and-control signals.

~~14.~~12. The SCADA system shall be either connected to its own UPS or connected to the substation backup energy system. 8hr run-time required.

~~15.~~13. The SCADA shall be designed with redundancy in mind, i.e. power supplies, network paths, etc. UPS system is required ~~at Control~~in the Control Room.

N. Power Plant Controller: The Power Plant Controller shall be able to accept commands from the ~~the~~ following locations and distribute these commands to all equipment on Site as necessary:

1. Local operator station (HMI)
2. Owner's centralized remote command center
3. Utility or ISO dispatch commands (such as Automated Dispatch System in CAISO) .

4. At a minimum, the following controls ~~capabilites~~capabilities shall be available at the plant level:

~~1.~~a. Power factor control

~~2.~~b. Reactive power (VAR) control

~~3.~~c. Output power curtailment

~~4.~~d. Power and VAR ramp rate adjustment

~~5.~~ Frequency droop control (freq vs. kW~~)~~)

e.

6.f. Automatic voltage regulation (AVR) at the point of interconnection (POI) utilizing reactive power (VAR) control

O. Power Plant controller shall utilize an SEL-3530 RTAC or similar quality controller.

P. Control Room (Shall be located inbe in either O&M Building or Control House of the Solar Substation)

1. The Project shall have a Control Room that will act as the central point for the SCADA System. The Control Room will also function as the SCADA room. SCADA network and all associated hardware will be located here.

2. The Control Room shall also function as the communications center for the site. A 144 ct SM fiber cable will connect main communications room to owner POI or Owner LEC interface for transport to owner data center.

3. The Control Room shall also contain the Contractor or owner supplied SCADA communications equipment which will transport all SCADA to the Solar Substation control house via min.60ct SM fiber optic cable in a collapsed or ring topology. Telecom transport Network fiber will terminate in the Control Room, and/or O&M building Communicaitons RoomThe Contractor will be allowed access to this data via the remote system for an agreed upon time period (if applicable). The access method must be agreed upon by the Owner.

Q. Meteorological Station (the “Met Station”). The Met Station shall consist of instruments to measure the meteorological parameters listed below. The minimum number of stations corresponding to facility size is listed in the table below shall be installed. Accuracy requirements of Met Station sensors are specified in M3-01-05. Met Station must have a backup power supply to allow normal data collection for a period of 48 hours without external power. Additional MET Station equipment required by the Utility shall be provided by the Contractor. Proposed locations shall be reviewed and accepted by the Owner.

Project Size	Met Stations	POA Pyranometers	GHI Pyranometers
<=50MW	3	3	3
<=100MW	5	5	3
<=150MW	7	7	5
<=300MW	9	9	7

R. Typical SCADA points monitoredmonitored points include the following:

1. Meteorological Parameters shall conform to all Participating Intermittent Resource Program (PIRP) requirements including but not limited to the following unless otherwise specified in these Contract documents (accuracy requirements specified in M3-01-05):

1.

a. Outside Air Temperature and Relative Humidity

b. Secondary Standard Horizontal Thermopile Pyranometer (Direct & Indirect Irradiance)

c. Secondary Standard Plane-of-Array Thermopile Pyranometer (Direct & Indirect Irradiance)

d. Rear Plane-of Array Thermopile Pyranometer (Direct & Indirect Irradiance), if applicable

~~c.~~e. Rainfall Amount

~~d.~~f. Barometric Pressure

~~e.~~g. Back of module Temperature (see PV Module Points below)

h. Anemometer and Wind Vane (Wind Speed and Direction. Wind speed should be ranged for the full design spec of the site.)

i. Albedo sensor, if applicable

2. ISA Points (per ISA)

~~a.~~ Inverter Performance Points:

~~i~~a. To include real time AC and DC electrical characteristics, including but not limited to power, energy generated, inverter status and diagnostics, alarms, cooling system and component temperatures, and all data available from inverter system.

3. PV Module Points

a. PV Module Back Surface Temperature (minimum two (2) per MET Station). Temperature sensors shall be placed so as to accurately represent the average module temperature in the inverter array.

4. PV Sub-Array DC Current Points

a. PV Sub-Array DC Current Transmitters (one for each Inverter DC Sub-Array or inverter feeder input)

5. Inverter step-up Transformer at ISA Points

a. Transformer Oil Temperature Warning (Digital)

b. Transformer Oil Temperature Trip (Digital)

c. Transformer Pressure (Digital)

d. Transformer Low Oil Level (Digital)

6. Tracker

a. Tracker angles (setpoint and actual position)

b. Tracker status and operating state (including stow)

c. Tracker alarm states

d. All other applicable and industry standard data points

7. Soiling Station (as required for Capacity Test, see M3-01-05)

a. Soiling Ratio

b. Voltage of clean and dirty panels

c. Current of clean and dirty panels

8. Solar Substation Points

a. SCADA system shall be open architecture and support bidirectional data exchange between the Owner supplied equipment and the Contractor supplied equipment. See M3-01-02.

9. AC Revenue Meter Points

a. ~~Shall include real time AC electrical characteristics, including but not limited to power, energy generated, meter status and diagnostics.~~ Revenue meters shall be installed at the project substation and downstream plant to account for gross and net generation, as well as station service and auxiliary loads. Each revenue meter shall be sourced from high accuracy, revenue grade current and voltage transformers, and shall comply with the requirements shown in the Interconnection Agreement and and any power purchases agreement(s). Actual revenue meter locations and instrument transformer specifications shall be determined by PGE metering personnel.

~~a.~~b. SCADA meters shall be installed on each medium-voltage (34.5kV) collection system circuit feeder.

~~b.~~c. All points required by utility and ISO

4.0 ELECTRICAL INSTALLATION

4.1 GENERAL

A. Cable runs shall only be made parallel and perpendicular to array mounting system.

B. Grounding lugs installed outdoors within 18” of grade shall be UL-listed for direct burial. Other grounding lugs installed outdoors shall be copper or brass with brass or ~~stainless steel~~stainless-steel hardware, or tin-plated aluminum with stainless steel hardware. All grounding lugs shall be UL listed.

C. All ground grids must be installed at a depth below the frost line.

D. Backfill and compaction of trenches shall meet geotechnical recommendations and shall be performed with compaction equipment specifically designed for such duty. Lifts shall not exceed 12”.

~~E.~~ All cable -management materials shall be impact modified, heat-stabilized, UV resistant Nylon 66 or better. This means their exterior materials shall be rated to withstand sunlight and extreme heat as defined per table 1-1 and NEC requirements. ~~cables and cable ties shall u.v. resistant. This means their exterior materials shall be rated to withstand sunlight and extreme heat as defined per table 1-1 and NEC requirements. Materials shall contain u.v. inhibitors and a minimum of 2% carbon black, with a particle size no larger than 35 nm.~~

E.

F. Direct-buried wiring shall meet NEC requirements for burial depth and warning ribbon. Warning ribbon width shall be 4” minimum. Cables shall be surrounded by a minimum of 4” of clean fill free of stones larger than 1-inch in diameter.

G. Electrical equipment shall be located a minimum of 12” above the 100-year floodplain elevation unless otherwise noted.

H. Conduit openings shall be sealed to protect against intrusion of pests and other wildlife.

I. All outdoor enclosures shall be NEMA 3R or better.

4.2 DC SYSTEM WIRING

A. Contractor may combine strings in combiner boxes or with factory-supplied in- line fused connections and load break disconnects (LBD).

B. System shall be designed such that the maximum DC voltage drop between a string and an inverter DC termination is no greater than 2.5% at STC. The average wire loss for all DC circuits shall not exceed 1.5% at STC.

~~B. All 1500V connections shall be the same make and model as connectors on PV modules. DC Voltage Drop Maximum for any one inverter array (from module string to inverter DC input) at full load and STC does not exceed 1.5%.~~

C. Series string connections between modules will be via locking multi-contact connectors and jumpers factory-supplied with modules.

D. No~~All~~ wiring will be loose and shall be supported per NEC and manufacturer's requirements.

E. DC cabling may run above grade where allowed by code. Method to be reviewed and accepted by Owner.

F. Contractor shall submit cable data sheets and project cable schedule to Owner for approval for each application prior to procuring the cable.

G. Unless routed in conduit or a CAB system, DC cabling routed below grade from the modules to the DC disconnect shall be rated for direct burial, conforming to NEC Article 310 provisions, and installed a minimum of 30" below grade in a clean fill material free of stones larger than 1-inch in diameter within 12" of cables. Cables shall be laid in the trench such that no cable crosses or rests upon another cable. If there is more than one layer of cable within a trench, a minimum of 4 inches of soil shall separate the layers. A 4-inch-wide marker tape shall be placed 12" below grade continuously over the conductors per NEC Table 300.50.

~~G.~~H. DC cable for the wiring from the combiner box or trunk cable to the inverters shall be 1.5kV minimum, 90ºC (wet or dry), power cable type RHW-2 or XLPE with UL 1581, VW-1 rating, and suitable for direct burial. Conductors may be stranded copper or aluminum.

~~H.~~I. DC cable for the wiring from the modules to the combiner boxes or trunk cables shall be 1.5kV minimum, 90ºC (wet or dry), power cable type XHHW-2 or PV wire (as applicable), with UL 1581, VW-1 rating, and suitable for application. Conductors shall be stranded copper or aluminum.

J. Harnesses or cabling shall be rated to withstand sunlight and extreme heat as defined per table 1-1 and NEC requirements. ~~For ultraviolet protection materials shall contain a minimum of 2% carbon black with a particle size of 35 nm or less.~~

K. All DC string or harness wiring shall be factory cable assembled and must be pre-cut to length.

~~I.~~L. Fuses shall be accessible and replaceable. All fuses shall be mounted greater than 12" above the 100-year flood plain.

~~J. Factory cable assemblies may be pre-cut to length.~~

~~K.~~M. Locking multi-contact connectors shall mate with module terminations.

~~L.~~N. Wiring harnesses and cabling shall be UL listed.

M.O. Metal wire loom clamps or approved equivalent shall be used for cable fastening.

4.3 LOW VOLTAGE AC SYSTEM WIRING

A. All conductors, lugs and cable accessories shall be UL listed.

B. No splicing shall be allowed.

C. System wiring installed in raceways shall be type THHN/THWN-2, or XHHW-2. Conductors may be stranded copper or aluminum.

D. System wiring installed in direct burial applications shall be type USE-2 with XLP insulation. Conductors may be stranded copper or aluminum.

E. When terminating aluminum conductors, coat conductor with oxide inhibitor and install per terminator manufacturer's instructions.

F. When terminating to bus terminal pads, one-hole compression lug for sizes #2/0 and below and two-hole for sizes #3/0 and greater are to be utilized.

G. All control and instrumentation conductors shall be terminated with ring-tongue connectors.

4.4 MEDIUM VOLTAGE AC SYSTEM WIRING

A. Phase conductors shall be 35kV type MV105 or MV90 (if temperatures are low enough), (dry or wet) single compact or compressed concentric conductor, aluminum, 100% or 133% TRXLP or EPR insulation, copper tape shield or concentric neutral.

B. Equipment grounding conductor shall meet the requirements of the Short Circuit Study.

C. Conductor size to not exceed temperature rating of conductor insulation at full generation and to allow for no more than 2% voltage drop at full generation at Solar Substation connection.

D. System shall be designed such that MV conductor kW losses (from high-side of MV ISA transformer to Solar Substation) at full load do not exceed 1.25% in total across the entire facility at Project nameplate rated capacity.

E. Conductors shall be installed below grade. Direct buried conductors shall be rated for direct burial and installed with at depths required per the NEC in a clean fill material free of stones larger than 3/8"-inches in diameter within 4" of conductors. A 4-inch-wide marker tape shall be placed 12" below grade continuously over the conductors.

~~D.~~F. Medium voltage terminations shall be a minimum 600A-rated dead break elbows that meet the requirements of ANSI/IEEE 386. Allow sufficient slack to facilitate re-termination.

G. Provide directional fault current indicators on the field-side of all MV junctions, and the substation-side of all MV feed-through transformer connections.

H. Conduit sleeves in and out of all transformers shall be provided.

~~E.~~I. No splices shall be allowed unless long AC collection cabling runs required due to site geometry. In such cases, only above ground splice boxes, approved by Owner, shall be acceptable.

4.5 OVERHEAD MEDIUM VOLTAGE AC WIRING

A. Overhead conductors ~~shall~~may be used where economically efficient in routing power to Solar Substation with minimal losses.

B. Overhead wiring and poles shall be routed ~~so as to~~to minimize shading on the solar arrays.

C. All overhead lines shall be designed to maintain all applicable code and regulatory clearance requirements.

4.6 GROUNDING

A. ~~Grounding~~All ground conductors shall be stranded copper and may be bare.

A.B. All electrical Equipment shall be bonded to the grounding system as required by applicable codes and standards. The Ggrounding system shall meet the requirements of NEC, NESC, IEEE 80, and ANSI C2 at a minimum. Grounding design shall be verified in grounding study.

B.C. All grounding hardware shall be listed and approved for the application.

D. Equipment grounding conductors shall be routed with the phase conductors.

E. Module mounting structure and disconnect boxes shall be grounded per NEC requirements. Where bolts and screws are provided, thread forming screws or equivalent shall not be acceptable.

F. Contractor shall provide a detailed grounding calculation to verify grounding design and conform designs based on results of grounding study.

G. ISAs (inverter(s), transformers, and associated Equipment) shall be bonded to the ground ring.

C.H. Where applicable, ground equipment per the manufacturer's requirements.

D.I. OneA ground test well shall be furnished at each ISA. A flush cover over the test well shall expose one ground rod and cable with mechanical cable to rod connectors to allow disconnection for testing purposes.

E.J. Contractor shall install supplemental fence grounding or isolation sections where deemed necessary by the grounding study. Perimeter fence grounding shall comply with applicable NESC requirements including official interpretations.

4.7 LABELING AND IDENTIFICATION

A. For diagnostic and troubleshooting purposes, all PV string harnesses and combiner boxes, or load break disconnects (LBD), shall be uniquely tagged and identified with such tagging on the record construction drawings. These cables shall have a label affixed to the outer jacket with a cable marker tape at each termination. The marker tapes shall be vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process. Marker tapes to be approved by Owner before installation.

B. As part of the Contractor Deliverables that must be delivered prior to Final Completion, Contractor shall provide to Owner a Microsoft Access database including all module serial numbers which can be sorted by array, combiner box or LBD, and harness. Contractor shall also submit an “As-Built” drawing depicting the physical location of each array, combiner box or LBD, and harness indicating the unique tag number for each combiner box or LBD and harness. Electrical equipment shall be labeled to meet applicable safety codes and requirements.

4.8 ELECTRICAL STUDIES

A. Contractor shall prove the design meets Contract requirements and all relevant standards by performing the following studies:

1. Short Circuit Study: fault analysis of collection system. Contractor shall show that all equipment is rated for the relevant fault current with appropriate safety margin.
2. Ampacity Study: Contractor shall prove equipment will not exceed its temperature rating at full load. Ambient temperatures shall be per ASHRAE. Contractor shall use no less than a 60% load factor for cable design. Greater values for AC cables shall be used if the interconnect agreement requires VAR-at-night support or energy storage is included. If Geotechnical Study is not available at time of bid, Contractor shall assume a soil temperature of 28°C and a thermal resistivity of 200 °C- cm/W.
3. Load Flow and Reactive Power Compensation Study: Contractor shall prove Project performance will meet all GIA and IEEE 399 requirements.
4. Harmonics Study: Contractor shall prove Project meets all IEEE 399519399 and IEEE 2800 harmonics requirements.
5. Grounding Study: Contractor shall prove Project meets all IEEE 80 requirements, taking into account considerations in IEEE 2778. Show that step and touch potentials on all exposed conductors, including tracker tubes and fence, do not pose a hazard to site personnel or the public. Perform the analysis using a soil model based on the Geotechnical survey, taking freezing and thawing conditions into account. Assume a 50

6. kg body and no PPE. Fault duration shall be per Protection Coordination Study, or 0.5s if it has not yet been performed.

6.7. Arc Flash Study: Contractor shall perform an arc flash hazard analysis in accordance with NFPA 70E and (for equipment operating between 208 VAC and 15 kVAC) IEEE 1584, taking the relevant switching and generation scenarios into account. All electrical junctions and terminations shall be labelled with the calculated arc flash hazard, minimum approach distance, and minimum PPE. Permitted software shall be the same as enumerated in M1-04-01, General Electrical Study Requirements.

4.9 ELECTRICAL EQUIPMENT ENCLOSURES

A. 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:

1. Indoor: NEMA 1
2. Outdoor: NEMA 3R

B. All enclosures shall be provided with pad locking provisions.

4.10 LIGHTNING PROTECTION FOR FIELD ENCLOSURES

A. Lightning protection, (where required) shall be limited to air terminals, down conductors and a connection to the ISA grounding electrode loop as well as surge arrestors at the inverter step-up transformer and inverter. Lightning protection (where required) shall comply with the requirements of NFPA 780 Standard for the Installation of Lightning Protection Systems. Master label certification is not required.

B. All components shall be un-insulated, copper, and exposed for inspection purposes.

5.0 FIRE PROTECTION

5.1 FIRE PROTECTION SYSTEM

A. Adequate access roads and spacing to PV arrays and equipment shall be provided as required by local Fire Marshall.

B. General

1. Fire protection during plant construction shall meet the requirements and recommendations of NFPA 10 and 241.
2. All fire protection systems are subject to the review and approval of the local fire department authorities.
3. Locate fire extinguishers where convenient and effective for their intended purpose.
4. Store combustible materials in containers in fire-safe locations.

5. Maintain unobstructed access to fire extinguishers, fire hydrants, temporary fire protection facilities, stairways, and other access routes for fighting fires. Prohibit smoking in hazardous fire exposure areas.

6. Provide supervision of welding operations and similar sources of fire ignition.

7. Post warning and instructions at each extinguisher location and instruct construction personnel on proper use of extinguishers and other available facilities at Project Site. Post local fire department telephone number on or near each telephone instrument at Project Site.

~~A. As necessary, the Contractor shall provide a complete fire protection system in accordance with the recommendations and requirements of NFPA, UL, FM, and the local Fire Marshall. The systems shall receive the approval of the Owner's insurance carrier.~~

~~B. The engineer responsible for the fire protection system shall be a practicing fire protection engineer registered as a Professional Engineer in the applicable State. All drawings and specifications shall be signed and sealed by the Professional Engineer.~~

~~C. The fire protection and detection systems requirements for specific plant locations are summarized in Table 5-1.~~

~~D. Portable CO_2 fire extinguishers of sufficient size shall be provided in all areas requiring handheld fire protection.~~

E. Fire walls for oil-filled transformers shall be provided between transformers and adjacent structures in accordance with Section 5.0 of NFPA 850.

F. Adequate access roads and spacing to PV arrays and equipment shall be provided as required by local Fire Marshall.

G. General

1. Fire protection during plant construction shall meet requirements and recommendations of NFPA 241.

2. All fire protection systems are subject to the review and approval of the local fire department authorities.

TABLE 5-1
Plant Fire Protection and Detection Systems

Plant Location	Type of Fire Protection	Fire Detection
ISA	handheld CO2 fire extinguishers*	N/A
O&M Building Offices, conference room/multi-purpose room, restrooms, storage room, and kitchen area	Fixed, automatic, wet-pipe sprinkler & Handheld extinguishers*	Smoke and heat detectors
Control room	FM200 plus handheld extinguishers*	

(*) or as required by local Fire Marshal

6.0 O&M BUILDING (IF APPLICABLE)

6.1 GENERAL REQUIREMENTS

A. Contractor shall design and construct the O&M Building in accordance with this Specification and the referenced applicable standards. The O&M Building shall comply with the Project's future service provider requirements and shall

(i)A. incorporate a furnished office space reserved for Owner of at least [TBD] square feet and (ii) reserve adequate space in the SCADA room for any Owner-installed communications equipment.

B. Where feasible and economically more efficient, O&M BULDING shall be combined with the Solar Substation control house, without direct access between the two areas (only sharing the same roof and power). O&M Building

B. shall not allow for any direct access to Solar Substation or Solar Substation control house.

6.2 SCOPE OF WORK SHALL CONSIST OF:

A. Prepare design documents, size equipment, generate drawings and specifications, and other supporting activities to the degree of detail required to fully and clearly define design and construction work requirements.

B. Prepare calculations as required for design decisions, equipment and material selection and preparation of construction drawings.

C. Prepare system descriptions indicating equipment data, operating characteristics, sizing basis, functions, air flow rates and other process information for all building systems.

D. Prepare mechanical, electrical and instrument equipment lists with summary descriptions, vendors and pertinent data.

E. Prepare arrangement drawings for Owner's Review and finalize arrangement drawings for construction. At a minimum, O&M Building to include:

1. Control room with HMI screens interconnected SCADA system.
2. Office with 2 desks.
3. Break room with sink, table, and refrigerator.
4. Men and women's bathroom.
5. Storage/spare parts room.
6. Reception area.
7. Communications equipment, AC/DC power system, Fiber entrances and termination.

F. Provide all architectural, civil, electrical, mechanical and structural construction drawings for the building and supporting systems including but not limited to the following:

1. Site Arrangement
2. Architectural Plans, Elevations and Details
3. Control Room and Electrical Room Arrangements
4. Access Roads, Curbs, Walkways and Parking
5. All Grading
6. All Drainage
7. Foundations
8. Structural Steel
9. All above grade and below grade piping
10. Conduit, Cable, and Raceways
11. Fire Protection Systems

12. One-Line Electrical Diagram

13. Lighting

13.14. Fiber Design, one-line, splice diagrams, termination schedules.

G. Prepare technical specifications and other documentation to support all equipment procurement, materials, and construction requirements.

H. Obtain necessary plan approvals and building permits from appropriate state, county and local building authorities. These permits may include but are not limited to the following:

1. Storm Water Pollution Prevention Plan
2. Dust Control Permit
3. Building Permit
4. Grading Permit
5. Septic Tank Permit
6. Construction Trailer Permit

I. All Architectural, Civil, Structural, Mechanical, Electrical, and Instrument and Control design documents that are issued for construction or procurement shall be prepared by or under the direct supervision of a Registered Professional Engineer or Architect according to the requirements in the applicable state. Each engineer or architect responsible for the design shall stamp or certify that the design documents have been prepared by him/her or under his/her direction.

7.0 SITE WORK

7.1 GENERAL REQUIREMENTS

A. This section covers the minimum scope and quality for the plant civil design and construction.

B. Contractor shall develop a Worker Environmental Training Program based on AHJ requirements and own safety plan meeting industry standards. All site personnel shall undergo the Worker Environmental Training Program prior to being allowed to work on the site.

C. Contractor is responsible to inspect the Site, obtain all necessary Site data, obtain all required geotechnical and drainage investigations, and determine all Site data for the design and construction of the PV power plant. This shall include determination of local code requirements for seismic and wind design loads. It is Contractor's sole responsibility to ensure that the Site work complies with all federal, state, and local code requirements and all applicable industry codes and standards, including standards of applicable authority having jurisdiction.

D. The scope shall include, but not be limited to the following:

1. Design and prepare the construction plans, final design reports, and project specifications for the civil site work, including the storm water drainage, grading, roads, temporary construction facilities, etc. All must meet the approvals of the Owner and jurisdictional government agencies.
2. Coordinate design with other engineering firms and utilities responsible for scope outside of the Contractor's own scope.
3. Obtain all necessary permitting associated with civil site work construction such as grading permits, haul permits, dust permits, storm water pollution prevention plans, pole permitting in ROW, etc., in compliance with City or County requirements and other jurisdictional government agencies as may pertain.
4. Construction of all civil site work, including the storm water drainage infrastructure, earth grading, roads, security fencing, etc. Construction of any temporary civil site work such as temporary security fencing, temporary construction roads, etc.
5. Perform flood damage management and storm water pollution management during construction in compliance with state and local sediment and erosion control rules, regulations, ordinances, and approved Storm Water Pollution Prevention Plan (SWPPP).
6. Perform dust control measures during construction in compliance with state and local rules, plans, regulations, permits and ordinances for fugitive dust emissions.
7. Perform the geotechnical evaluations as necessary for the civil site work.
8. Prepare the drainage report(s) to meet applicable agency's permit requirements.
9. Perform all construction surveys (construction staking).
10. Prepare record drawings that depict any deviation from original design drawings.

E. The Project design shall ~~take into account~~consider existing site conditions with respect to soil characteristics, site clearing, grading, and drainage. The Contractor shall be responsible for all site preparation including any demolition, soil stabilization, grading, drainage, roadways, and temporary parking areas.

F. Contractor shall develop and provide a site layout diagram/map (showing all major features of the proposed project, including access points) and all drawings, diagrams, and documents required for attainment of any/all permits required for the site preparation, and the installation and operation of the solar PV system.

7.2 UNITS

A. All design dimensions and design calculations shall be in British (United States Customary) units.

7.3 GEOTECHNICAL

A. The Contractor's final design shall be based on the recommendations of a final Geotechnical investigation and report performed by a licensed professional Engineer in the applicable state. If a preliminary geotechnical study is provided by Owner, it is recommended that a final report be executed by the Contractor.

B. Because the Geotechnical Study forms a large portion of the design basis for Civil, Structural, and Electrical disciplines, the report shall be thorough and comprehensive, and shall cover the following topics at a minimum:

1. Include appropriate quantity and depth of test bores to result in a representative characterization of all soils on the site, including the substation area.
2. Identify soil types at each depth.
3. Chemical makeup.
4. Excavation, fill, backfill, and compaction requirements.
5. Thermal resistivity with dry out curves.
6. Electrical conductivity.
7. Earth pressure and hydrostatic pressures.
8. Groundwater levels.
9. Identify presence of aggregate, caliche, rock, etc. and map out locations
10. Soil bearing values.
11. LPILE design parameters.
12. Corrosion characteristics. If Geotechnical firm does not perform Corrosion Studies, at a minimum will identify corrosivity of soils based on pH, sulfates, and electrical conductivity.
13. Seismic considerations.
14. Pile load testing.
15. Grubbing depths.
16. Recommendations

7.4 CONSTRUCTION SURVEYS

A. Contractor will provide the boundary and topographical survey(s) for the site.

B. Contractor is responsible for the construction surveying and staking. All construction surveying and staking shall be performed under the supervision of a surveyor licensed in the applicable state. Environmentally sensitive areas shall be flagged in a different color than other flagging.

C. Contractor is responsible for all surveys required for environmental and cultural permitting and shall meet all such permit requirements during the execution of the Project. If required by environmental permits, Contractor shall retain a qualified biologist to clear the site of sensitive species in advance of ground- disturbing activities. Nesting birds or other species protected by state or federal law shall be avoided by an appropriate buffer until the species have fledged or left the site of their own accord, in connection with the Worker Environmental

D. Training Program. The qualified biologist shall guide flagging of environmentally sensitive areas, as appropriate.

D.E. If required by environmental permit, Contractor shall retain, as needed, a qualified archaeological monitor to evaluate any potentially significant archaeological material identified during construction activities. Significant archaeological material is not anticipated, but unknown significant resources may be unearthed during site preparation activities. Contractor shall avoid disturbing significant archaeological material if identified in the field, shall allow the archaeological monitor to evaluate the material, and shall follow the instructions of the archaeological monitor regarding avoidance or treatment of the resource(s), as applicable.

7.5 SITE PREPARATION AND MAINTENANCE

A. Site Clearing and Grubbing

1. Immediately prior to Substantial Completion, Contractor shall remove all weeds and trim all native vegetation from areas surrounding PV Modules, other electrical equipment and site infrastructure, in compliance with local regulations or the Vegetation Management Plan the Revegetation Plan. The Contractor shall be responsible for all applicable permitting with jurisdictional agencies for use of herbicides should the decision be made to use them during construction.

2. Owner will provide specific clearing and grubbing restrictions, if any.

B. Debris

1. All construction-related debris and unsuitable material including material from site clearing and grubbing shall become the immediate property of Contractor and shall be removed from the premises and lawfully disposed of off-Site by Contractor at Contractor's cost.

2. All vegetation and trees removed from the site shall be disposed of by the Contractor at an Owner approved land fill. Conditioned upon Owner's prior written approval, vegetation and trees may be sold by Contractor or otherwise beneficially used.

C. Stormwater Management and Erosion Control

1. Contractor shall prepare a Storm Water Pollution Prevention Plan (SWPPP) for its construction activities. Contractor shall be responsible for installing and maintaining the storm water controls and best management practices in compliance with the SWPPP. The Contractor shall provide for sediment and erosion control during and after construction in accordance with project permits and local and state laws and regulations. Best management practices such as check dams and sedimentation basins shall be used during construction to minimize erosion. Long-term operational best management practices shall be installed prior to substantial completion and be designed to minimize erosion on site and sedimentation of waterways.

2. Drainage facilities shall be designed and constructed in a manner to minimize erosion and prevent excessive erosion within the Array areas. Excessive erosion shall be considered as anticipated erosion exposing the pile such that the design embedment depth is no longer met. Drainage facilities should also be designed to limit off-site sedimentation and meet all permitting requirements.

2. of waterways per applicable regulations or permits and may include retention basins as appropriate to achieve these objectives.
3. Drainage design shall be approved by AHJ, as applicable.
4. Contractor shall design and construct site grading/drainage to minimize potential for site flooding and ponding. The working area of the site shall be well drained during and after construction. The civil drainage infrastructure design shall conform with the standard of the jurisdictional government agencies.
5. Contractor shall prepare drainage report(s) to support obtaining construction permits for the project, as applicable. The report(s) shall meet the standards and requirements of the applicable agency and shall describe the final design of the storm water drainage infrastructure and provide the hydrologic and hydraulic calculations applied.
6. The Contractor shall prepare a design meeting the acceptance of Owner, such acceptance shall not be unreasonably withheld, which incorporates permanent, long-term measures which mitigate the flood potential associated with on-site generated storm water runoff.
7. Waters of the United States shall not be impacted, filled, or used in connection with the site drainage plan unless proper permits are obtained.

D. Road Maintenance

1. All temporary access roadways used by Contractor, as well as the new site permanent roads shall be maintained in serviceable condition. Contractor shall keep the surfaces of those roadways free from spills, mounds, depressions, and obstructions, which might present a safety hazard or annoyance to traffic.
2. Contractor shall be responsible for securing authorization and permits to transport oversized/overweight loads on local, County and State roads for the supply of materials under Contractor's scope.
3. Contractor shall supply and install any temporary or permanent facilities required to facilitate delivery of Contractor and Owner equipment/materials. Contractor shall also be responsible for removing all such temporary facilities.
4. Contractor shall prepare a road use/delivery plan for the proposed deliveries of PV equipment.

E. Signs and Barricades

1. Signs and barricades shall be provided and maintained by Contractor and shall be in accordance with jurisdictional regulations for accident prevention and Contractor's safety plan. Signs shall further comply with any County-specific design standards.

F. Dust Control

1. Dust Control for Construction Activities

a. Contractor shall be responsible for obtaining dust control permits, if required, and complying with requirements of said permit. Contractor shall be responsible for compliance with State and local requirements for fugitive dust emissions and shall obtain local authority approvals and conform to the dust control regulations and reporting requirements.

b. Contractor is responsible for locating source of construction water to support dust control and construction activities.

G. Open Burning

1. Onsite open burning is not permitted without Owner's approval and without first obtaining any applicable burn permit.

H. Earth Grading

1. Contractor shall balance the earth grading and leave no stockpiles or pits remaining at the completion of the full build-out of the project. (Stock piling in accordance with applicable regulations may be permitted in support of phased construction.) The grading design shall balance the earth work such that no major volumes of soils will be imported or exported from the Site for grading purposes. Any permitting, or costs for import or disposal will be the responsibility of the Contractor.

2. The Contractor is responsible to meet the grades and slopes as necessary to support the solar installation. The Contractor is responsible for any re-grading or repair costs associated with not providing ground surfaces which adequately support the solar installation.

3. Contractor shall identify site specific grading restrictions, if any.

I. Excavation, Filling, and Backfilling

1. Excavation, filling, and backfilling shall meet the requirements of the Geotechnical Study.

2. Excavated native material may be used on the site for embankment and backfill, if suitable. All unsuitable materials such as; rock, concrete, wood, metal, and other materials from the excavation shall be considered debris and disposed of as described herein.

3. Structural fill, bedding material, topsoil, and other materials not readily available on site shall be procured, tested, and delivered to the site by the Contractor.

4. Contractor shall be solely responsible for maintaining the stability of all excavated faces and shall provide adequate sheeting, shoring, and bracing to support any lateral earth pressure.

5. Contractor shall be solely responsible to protect personnel and adjacent structures against any damage from cave-ins, heaving or other earth movements. Sheeting, shoring, and bracing shall be removed as

5. backfilling proceeds or it may, with the approval of Owner, be left fully or partially in place.
6. Fill characteristics and compaction requirements shall be determined by Contractor's geotechnical investigation and report recommendations.
7. All equipment used to meet compaction requirements shall be specifically designed for such duty. Reference Section M1-02-01.

7.6 ROADS

A. Site Access:

1. Site access road improvements shall be the responsibility of the Contractor.
2. Access to the Site will be constructed in accordance with applicable agency requirements, including, but not limited to the local fire department.
3. Contractor shall be responsible to obtain and comply with all encroachment permits required to construct driveway aprons or otherwise connect access roads to county-maintained roads, as applicable.

B. Roads on-site shall consist of the following:

1. The perimeter roads shall be routed around the exterior of the solar arrays, connecting the Solar Substation, O&M Building (if applicable), inverter access driveways, and any areas designated for flood management. Roads shall be stabilized in accordance with the recommendations of the geotechnical evaluations.
2. Array access driveways shall be constructed to provide access to the interior array inverters. Array access driveways shall consist of a compacted dirt roadway. Widths will vary depending on design, but design should consider access requirements for operations and maintenance. Design shall consider stormwater management and use low water crossings or culverts to prevent erosion and/or rutting of road.

C. Access Design Characteristics

1. The following plant design characteristics shall be adhered to:
   a. Inverter access road width shall be at minimum 12-feet wide within a 20-foot corridor to allow access by larger vehicles.
   b. Substation/O&M access road width shall be at minimum 20-feet wide to allow access by larger vehicles.
   c. Site design shall include a 20-foot width from module edge to fence line to allow for operations and maintenance access after plant is in operation.
   d. The perimeter road width shall be at minimum 16 feet with an additional 6 feet of cleared ground on either side to allow sufficient t

d. space to get a tractor trailer and or crane down a row to replace transformers or inverters in the event one fails.

e. All roads shall have sufficient turning radii for expected use of large construction ~~vehicles.~~vehicles. ~~(~~Minimum inside turning radius shall be 30 feet, with centerline turning radius of not less than 50 feet, unless otherwise approved by the Owner. Tighter radii may be acceptable for limited-access or dead-end service spurs, subject to Owner review and approval ~~30' minimum) for expected use of large construction vehicles.~~

f. All roads shall meet minimum requirements of local fire department or AHJ, if required.

g. The minimum distance between an inverter and the nearest module shall allow for maintenance and repair of any and all components of the ISA with locally available equipment.

7.7 SECURITY

A. Refer to PGE Exhibit M1-01-07 for Owner security requirements.

7.8 SITE REVEGETATION

A. Prior to substantial completion, Contractor shall prepare the site in compliance with the Revegetation Plan that meets Owner and permitting requirements. Owner requires re-seeding with an approved ground cover that will prevent erosion and be easily controlled and managed. If there are requirements beyond this from permitting, those must be adhered to as well.

7.9 AS-BUILT DRAWINGS

A. Contractor shall prepare as-built drawings as may be necessary to meet the standards of the Owner and jurisdictional government agencies. At minimum, Contractor shall prepare as-built drawings for the Owner's record which contain as-built elevations, dimensions, etc. and any variation from the design drawings, sealed by an engineer or surveyor licensed in the applicable state.

B. Contractor shall coordinate as-built drawing format with Owner.

8.0 STRUCTURAL

8.1 MATERIALS

A. Steel

1. Design of hot-rolled structural and miscellaneous steel shall be in accordance with the American Institute of Steel Construction (AISC) “Manual of Steel Construction”. Design of structural and miscellaneous steel shall also be in accordance with National Electrical Manufacturers Association (NEMA) “SG6” and “TT1”, American Society of Civil Engineers (ACSE) “Guide for the Design of Steel Transmission Towers, Manual No. 52” and the International Code Council “International Building Code”. Design of cold-formed steel shall be in accordance with the American Iron and Steel Institute (ANSI) “North American Specifications for the Design of Cold-Formed Steel Structural Members”.

~~2.~~ Materials for structural steel and miscellaneous steel shall conform to the following requirements of the American Society for Testing and Materials:~~:~~

2.

a. Wide Flange (WF) Shapes and Tees cut from WF: ASTM A992, Grade 50 or multi-certification A36/A572, Grade 50.

b. M shapes, S shapes, HP (Bearing Piles), Channels, and Angles:

c. ASTM A36

c.d. Structural Plates and Bars: ASTM A36

d.e. Square/Rectangular Hollow Structural Sections (HHS): ASTM A500 Grade B

e.f. Pipe: A53, Grade B

3. High strength bolts, nuts, and washers shall conform to ASTM A325, ASTM A563, and ASTM F436 respectively and shall be galvanized in accordance with ASTM A2329.

4. Bolts, nuts and washers under one-half inch in diameter shall conform to ASTM A307, Grade B, ASTM 563 and ASTM F844 respectively and shall be galvanized in accordance with ASTM F2329.

5. Anchor bolts, anchor bolt assemblies and concrete ~~embedments~~embedment's shall be galvanized.

6. Anchor bolts shall conform to ASTM A449, ASTM F1554, Grade 36, or A307. Anchor bolt sleeves shall conform to ASTM A501.

7. All structural welding shall conform to the requirements of AWS D1.1.

8. Galvanizing, as specified herein, shall conform to the requirements of ASTM A123, ASTM A153 or ASTM A2329, as applicable.

9. Stainless steel shall conform to ASTM A167.

B. Aluminum

1. Design of structural and miscellaneous aluminum shall be in accordance with the latest version of the Aluminum Association – "Aluminum Design Manual" and "Aluminum Standards and Data".

2. Materials for structural and miscellaneous aluminum, including structural shapes and plate, shall conform to ASTM B209 and ASTM B308 and shall be aluminum alloy 6061-T6.

3. Bolts and nuts shall conform to ASTM F468 and ASTM 467, respectively and shall be aluminum alloy 6061-T6. Washers shall be aluminum-clad steel Alclad 2024-T4 or approved equal.

C. Concrete

1. Design of structural concrete shall be in accordance with the latest version of the American Concrete Institute (ACI) - "Building Code Requirements for Structural Concrete," ACI 318. All concrete formworks shall conform to ACI 347.

1.

2. Concrete intended for use on native soil shall be specified consistent with the properties of the soil. Concrete mix proportions, including documentation of materials, admixture product information, and compressive strength of mix, shall be submitted and approved by the Owner prior to placing concrete.

3. Minimum concrete strength classes for various structures shall be as follows:

Item	Minimum Ultimate Compressive Strength (psi) (at 28 Days)
Electrical Duct banks	3,000
Major equipment/structures where required and all other construction	4,000

4. Reinforcing bars shall be deformed bars conforming to ASTM A615, Grade 60. Welded wire fabric shall conform to ASTM A185. Plain wire shall conform to ASTM A82. Placement shall be in accordance with Chapters 7 and 12 of ACI 318 and the Manual of Standard Practice of The Concrete Reinforcing Steel Institute.

5. Cement shall be Portland cement conforming to ASTM C150, Type I or Type II or as required by the ~~Engineer of Record.~~Contractor's Geotechnical report.

6. Aggregates for normal weight concrete shall conform to ASTM C33.

7. All foundations shall extend a minimum of 6 inches above the adjacent finish grade.

~~8. Slump of concrete, if pump truck is used, for foundations shall be 4 inches plus or minus 1 inch, unless otherwise noted.~~

~~9.~~8. All concrete trucks may be rinsed out at one designated location on-site. Rinse material shall be properly disposed of off-site.

8.2 CONCRETE TESTING

A. Field testing and sampling shall be performed by an independent testing laboratory at Contractor's expense. The testing technician shall be an ACI Concrete Field Testing Technician Grade 1.

B. Compressive strength determinations shall be made from 6-inch diameter by twelve inch long concrete cylinders tested in accordance with ASTM C39. Cylinders shall be prepared for compressive strength tests on concrete with a designed compressive strength of 2,500 psi or higher for the following conditions:

~~1.~~ Each one hundred (100) cubic yards or fraction thereof of concrete poured;

1.

2. At least once per day

3. For each 5,000 square feet of surface area for slabs or walls.

4. A minimum of four concrete cylinders shall be prepared from each composite sample.

C. Field slump tests shall be performed in accordance with ASTM C143 and shall be performed for the following conditions:

1. The first batch produced each day,

2. For every 50 cubic yards or fraction thereafter, and

3. With every set of test cylinders.

D. Air content, concrete temperature, and air temperature tests shall be performed for the first batch of each day and with each set of test cylinders. All testing shall be done in accordance with the requirements of the American Society of Testing Materials (ASTM). Test results shall be provided to Owner for records within 30 days of test completion. In the event of failure of any aforementioned test, the Owner shall be notified.

8.3 STRUCTURAL LOADING

A. Contractor shall determine all Site data for the design and construction of the plant. This shall include determination of local code requirements for seismic and wind design loads. It is the Contractor's sole responsibility to ensure that the plant structural and architectural facilities comply with all federal, state, and local code requirements and all industry codes and standards.

B. Structural loads shall be applied with post embedment depth accounting for maximum scour associated with 100-year storm event.

C. Dead Loads

1. Dead loads shall include all vertical loads due to weight of permanent structural and nonstructural components, including permanent hung loads.

D. Live Loads

1. Live loads shall be in accordance with the IBC and ASCE 7 as modified by the applicable agency Local Additions and Addenda.

E. Snow Loads

1. Snow loads shall be in accordance with the IBC and ASCE 7 as modified by the applicable agency Local Additions and Addenda

2. Snow drift shall be evaluated and considered in the design.

F. Wind Loads

1. Wind loads shall be in accordance with the adopted versions of the IBC and ASCE 7, as modified by the applicable agency Local Additions and Addenda. Wind tunnel testing method is permitted upon explicit Owner

1. consent. Irrespective of any wind tunnel testing results, the minimum design wind pressure shall be no less than 10 pounds per square foot (psf) applied normal to the face of each PV module. The PV module rack shall be designed in such a way that deflections due to wind will not damage the PV modules. Contractor shall ensure that the PV modules support foundations can withstand the uplift due to wind loading.

G. Seismic Loads

1. Seismic loads shall be in accordance with the adopted versions of the IBC and ASCE 7, as modified by the applicable agency Local Additions and Addenda. The soil profile type shall be determined by the Contractor based on the results of a subsurface investigation, which shall be obtained by the Contractor.

H. Thermal Loads

1.2. Buildings and structures shall be designed for forces and/or movements resulting from changes in temperature. Induced thermal loads (i.e., thermal loads induced by equipment operating temperatures) shall be considered in design of applicable structural elements.

I. Vehicle Loads

1. Design loading, for areas accessible to trucks, shall be (AASHTO) HS20.

J. Soil and Hydrostatic Pressure Loads

1. Earth pressure and hydrostatic pressure loads shall be based on the geotechnical conditions and groundwater levels at the project site.

K. Transmission Line Loads

1. In addition to the aforementioned loading criteria, overhead transmission loads shall also conform to ASCE Manuals and Reports on Engineering Practice No. 74 “Guidelines for Electrical Transmission Line Structural Loading” and to NESC requirements.

L. Load Combinations

1. Load combinations shall be in accordance with the IBC and ASCE 7. If the county that the project is located in has any Additions or Addenda to this code, it is the Contractor’s responsibility to determine this and adhere to it.

8.4 STRUCTURAL FOUNDATIONS

A. Type of foundations required and allowable bearing values for soil and rock shall be as recommended by Contractor's Geotechnical Engineer based on the subsurface conditions found in the Contractor’s Geotechnical report. All loose materials shall be removed from excavation bottoms. Unsatisfactory foundation subgrade material shall be removed and replaced with compacted structural fill material or with 2000 psi (minimum) concrete. Total foundation settlements will

A. be limited to 1 inch or as required by applicable building or industry codes, and equipment supplier's recommendations.

B. A minimum of 18 inches of the native soil to be removed and compacted to 95% of relative compaction as a subgrade for various concrete housekeeping pads.

1. All equipment used to meet compaction requirements shall be specifically designed for such duty.

C. Building and Equipment Foundations

1. Building and equipment foundations shall be of reinforced concrete and their construction shall incorporate formwork, appropriately sized and configured rebar, waterstops, expansion joints, etc.

D. Transformer Foundation and Containment

1. Transformers shall be provided with secondary oil containment equal to 110% of the volume of oil present in the transformer~~,~~.

8.5 CORROSION PROTECTION

A. In general, all exposed carbon steel surfaces shall be treated for corrosion protection. Contractor shall design and specify corrosion protection systems, which shall include surface preparation measures, for the following conditions:

1. Carbon steel exposed to ambient environmental conditions (i.e. PV module support structure, if applicable)

~~2.~~ Carbon steel exposed to soil conditions below grade (e.g., driven or augered piles) shall be hot-dip galvanized in accordance with ASTM A123 prior to installation. The galvanized coating shall be specified and detailed to withstand abrasion and damage during pile driving or augering. If additional corrosion protection is warranted due to site-specific soil conditions (e.g., high chlorides, sulfates, or low resistivity), the Contractor shall consult a corrosion engineer to recommend supplemental corrosion protection measures. These recommendations shall be submitted to the Owner for review and acceptance. In no case shall bare carbon steel be installed below grade without corrosion protection.~~Carbon steel exposed to soil conditions below grade (i.e., driven or augured piles, if applicable). This coating shall be designed such that it is not damaged during installation. The Contractor shall consult a corrosion engineer to recommend corrosion protection measures based on the soil conditions. Submit the corrosion engineer's recommendations to the Owner for information and acceptance of the recommendations. In no case, however, shall a galvanized coating be assumed to last the life of the project.~~

2.

~~B.~~3. Stainless steel and galvanized steel shall not be painted.

8.6 BUILDINGS/STRUCTURES (IF APPLICABLE)

A. The Contractor shall obtain Owner's approval of building arrangements prior to detailed design.

9.0 COMMISSIONING AND PROJECT ACCEPTANCE TESTING

A. See M3-01-04 and M3-01-05 for requirements of Commissioning, Functional Testing, and Capacity Testing.

A.

10.0 PROJECT AND CONSTRUCTION MANAGEMENT

10.1 STAFFING

A. Contractor shall provide the appropriate personnel to manage all aspects of the Work.

B. Contractor shall provide ensure an OSHA "competent" and designated safety person person be present during all work hours.

C. Contractor may work on Site at any time subject to applicable laws and permit requirements.

10.2 REPORTING/MEETINGS

A. Contractor shall provide progress and schedule reporting on a weekly basis. A two-week look ahead of activities shall be provided at weekly reoccurring meetings with the Owner, Contractor and Contractor's subcontractors.

B. Progress meetings shall be held at the Site on a monthly basis on dates mutually agreeable to Owner and Contractor.

10.3 SAFETY PLAN

A. Contractor shall maintain a safety plan and observe all safety practices required for performing construction work of this type including OSHA standards.

B. Contractor shall submit final Safety Plan, per the requirements of M3-01-03, a minimum of 30 days before the start of construction for review and approval.

10.4 WORK SCHEDULE

A. Contractor shall submit a detailed schedule in native file using Primavera P6 or similar mutually agreed upon project management software which also meets the requirements of M3-01-706.

B. The Project Schedule shall be updated monthly against the baseline schedule and submitted to the Owner.

11.0 DESIGN ENGINEERING

11.1 ENGINEERING DESIGN PACKAGE

A. Contractor shall develop a comprehensive design package consisting of drawings generated in a format in accordance with M1-01-02 and table M1-01- 02-01-Solar. Design packages and submittals shall be provided for Owner review in native or PDF format.

A.

~~M3-01-02~~

APPENDIX M3
ATTACHMENT 01
EXHIBIT 02

~~(a)~~ SOLAR PHOTOVOLTAIC PLANT SPECIFICATION STATEMENT OF WORK - HV

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

~~2023~~2025~~3~~

REQUEST FOR PROPOSAL

NO.	DATE	REVISION	BY	CHK'D	APPROVALS	
0	14Apr23	Issued for Implementation	1898 & Co.	PGE	CPA	Craig Armstrong

1.0 GENERAL

1.1 INTRODUCTION

M3-01-02 describes the main requirements of the Substation, interconnection, and gen-tie requirements. Refer to PGE Attachments and Exhibits for further information.

Wherever 'X's are shown, these are areas for the Contractor to specify or fill in.

1.2 REFERENCES

In addition to anything summarized herein, all Work related to the Project shall conform to the following Owner standards. In the case of any conflict between any Owner standards below and any requirement set forth herein, the more stringent requirement shall apply.

A. PGE Appendix M1, Attachment 01, Exhibit 02: Engineering Documents, Drawings, and Other Deliverables ("PGE Exhibit M1-01-02"), including the Documents and Deliverables Table (M1-01-02-01-Solar) ("PGE Exhibit M1-01- 02-01") attached thereto.

B. PGE Appendix M1, Attachment 01, Exhibit 07: Security and Compliance ("PGE Exhibit M1-01-07")

C. PGE Appendix M1, Attachment 01, Exhibit 09: PGE CAD and Numbering Standards ("PGE Exhibit M1-01-09")

D. PGE Appendix M1, Attachment 04, Exhibit 02: General Transformer Specification ("PGE Exhibit M1-04-02")

E. PGE Appendix M1, Attachment 05, Exhibit 04: Communication, SCADA, and Metering Facilities ("PGE Exhibit M1-05-04")

1.3 DEFINITIONS

Capitalized terms not otherwise defined in this M3-01-02 shall have the meaning set forth in Article 1 of the Agreement or as defined in M3-01-02.

A. "Agreement" shall mean the Engineering, Procurement and Construction Agreement to which M3-01-02 is attached.

B. "AC" or "ac" shall mean alternating current.

C. "Contractor" shall mean the successful bidder which designs, procures, constructs, and commissions the proposed Project.

D. "DC" or "dc" shall mean direct current.

E. "HV" shall mean high voltage.

F. "HZ" or "Hz" shall mean hertz.

G. "kV" shall mean kilovolts.

H. "kW" shall mean a measure of instantaneous power as measured in kilowatts. If not specified in particular it shall be assumed to be in Alternating Current (AC).

I. "POI" shall mean the Point of Interconnection which defines the location of the physical electrical interconnection to the Transmission Provider.

J. "Project" shall mean the solar Project as defined in the Agreement. The Project shall include all equipment and systems producing solar energy, from the solar modules up to the POI, including the collector system, substation and Generation Tie-line between the project substation and the POI.

K. "PV" shall mean photovoltaic.

L. "Solar Substation" shall mean the facility which collects the feeds from the PV Field and transforms the voltage (as required) for electrical interconnection to the Transmission Provider.

M. "SCADA" shall mean the Supervisory Control and Data Acquisition system and shall include all monitoring/control hardware and software, field instrumentation and communication devices.

N. "Transmission Provider" shall mean the public utility (or its designated agent) that owns, controls, or operates transmission or distribution facilities used for the transmission of electricity in interstate commerce and provides transmission service under the Tariff.

1.4 GENERAL SPECIFICATIONS

A. The purpose of the Technical Specifications is to define the minimum scope, substation, gen-tie line features, and quality standards for the design, procurement, construction, testing, and commissioning of the electrical interconnection systems supporting the new Solar Plant.

B. Owner has prepared a conceptual arrangement for specifying the minimum scope and features of the Project. Contractor shall provide final design and detailed specifications and drawings for the system in conformance with M3- 01-02.

1.5 CONTRACTOR SCOPE OF WORK OVERVIEW

A. Contractor shall design, fabricate, furnish, install, test, and commission a complete functional, operating, interconnection system as specified herein with a high degree of reliability, integrity, maintainability, efficiency, and environmental compatibility which conforms to normally accepted standards of HV substation and gen-tie facilities. Contractor shall provide all components necessary for a fully functional substation.

B. Contractor shall furnish a new XXXkV single circuit Gen-Tie line from the POI to the new XXX/34.5kV Solar Substation.

~~C.~~ Contractor shall furnish a new XXX/34.5kV Solar Substation. The substation will consist of one (1) XXXkV line position to the POI, one (1) or more XXX/34.kV transformer(s) (Owner Provided), [Contractor to specify number of]

C. 34.5kV collection circuit positions, and one a 34.5kV-coupled aggregated reactive power resource sufficient capacity when coupled with inverters to deliver a power factor between 0.95 lead and 0.95 lag (over entire plant operational temperature, power and voltage range) to the POI and as necessary to meet the requirements of the Generator Interconnection Agreement and NERC compliance obligations.

D. The Project shall be capable of operating in accordance with the Agreement and M3-01-01, “Statement of Work - PV”, and this M3-01-02.

E. Contractor shall design and construct the Project in accordance with this Specification and the Agreement. Scope of Work shall consist of:

1. Specify and furnish the equipment and materials which shall include, but not be limited to, disconnect switches, circuit breakers, instrument transformers, main and auxiliary voltage transformers, capacitor banks, substation structures, relay equipment, control enclosures, gen-tie line structures, all foundations, and associated ancillary hardware.
2. Project design engineering and drawing packages for construction permitting, installation and “as-built” documentation.
3. Project construction including all final grading site/civil work, structural, electrical, mechanical and monitoring/control systems.
4. Project and construction management, including quality assurance/quality control, site safety, site material control and management of all subcontractors.
5. Project commissioning and testing in accordance with M3-01-04 of the Agreement.
6. Project turnover including Owner training and Project operations and maintenance documentation.

F. Except as specified otherwise, provide all equipment, materials, transportation services, labor, labor supervision, technical field assistance, scheduling, consumables, construction equipment, construction tools, special tools, construction utilities, permanent utilities, testing services, instruments, spare parts, and other services and items required for, or incidental to the engineering, design, procurement, installation, construction, startup, testing, commissioning, and training for the Project. The supply of construction equipment shall include fuel, lubricants, spare parts, and any other elements required for operation and maintenance.

G. Contractor shall procure and obtain all permits required for the construction of the project with the exception of permits acquired by Owner.

H. Design, fabricate, install, inspect, examine, and test each system in accordance with the specified industry standards, Applicable Permits and Applicable Laws.

I. Perform specified, code required, and Contractor's standard quality assurance testing, inspection, examination, and documentation.

J. Submit design, fabrication, and quality assurance documentation, and operating and maintenance manuals in accordance with the submittal requirements M1-01-02 of the Agreement.

K. Contractor shall provide all design documents required to support Owner in obtaining permitting and other regulatory agreements.

L. Receive, inspect, store, unload, maintain, erect, clean, lubricate, align, and prepare all equipment in strict accordance with equipment manufacturer's instructions. Contractor shall arrange for and provide properly conditioned storage in strict accordance with manufacturer's requirements for all equipment and material to be incorporated into the Project.

M. Except as specified otherwise, provide all technical assistance, equipment, and supplies required, specialized and non-specialized, for erection, testing, commissioning, and start-up of equipment furnished and installed by Contractor.

N. Contractor shall procure, deliver, unload, install, commission and test main

O. step-up transformer(s). Contractor shall be responsible for securing transformer to foundation and connecting it to electrical and SCADA and testing any protection or monitoring devices it installs for operation of the transformer.

~~O.~~P. Coordinate start-up and commissioning operations with Owner's operating and maintenance personnel and involve Owner's personnel in start-up and commissioning activities to the extent desired by Owner.

~~P.~~Q. Train Owner's operators and maintenance personnel on all operating and maintenance aspects of the Project prior to system start-up in accordance with the Agreement. Contractor shall complete all formal training efforts prior to start-up of associated system, including training for Owner supplied equipment. Contractor shall provide all facilities necessary for all required training.

~~Q.~~R. Fire protection during construction shall meet the requirements of NFPA241. All fire protection systems shall be subject to the review and approval of the local fire department authorities.

~~R.~~S. Provide all special tools and lifting devices for equipment supplied by Contractor as required for maintenance and operations of Contractor furnished Equipment and Materials.

~~S.~~T. Contractor shall furnish and maintain temporary construction facilities and provide construction services including, but not limited to, the following aspects applicable to the Solar Substation Site:

~~1.~~ Temporary Storage Facilities at the Site for the proper unloading and storage of all Contractor furnished substation equipment and material delivered to the Site. If adequate facilities are not available, such material

1. shall be stored at suitable off-site facilities (e.g. warehouses, storage yards, etc.) provided by Contractor.
2. Construction Power and Distribution.
3. Contractor shall be responsible for all transmission and distribution electric power tie-ins at the Site.
4. Temporary communication system and internet access
5. Temporary lighting system
6. Site drainage, erosion and sedimentation control, and dewatering systems
7. Temporary roads
8. Fire protection
9. Temporary water supply and distribution (potable and non-potable). Potable water shall be high quality bottled water.
10. Parking Facilities
11. Site Security
12. Construction testing services (e.g., welding, megger testing, concrete strength and placement, fill and backfill compaction testing, etc.)
13. Safety and first aid services
14. Contractor shall provide temporary sanitary facilities consisting of above ground Porta-John type. Contractor shall provide separate male and female facilities. Quantity shall be per OSHA requirements.
15. Contractor shall maintain on-site dumpsters and personnel to maintain a clean and rubbish free work site.

~~T.~~U. Contractor shall be responsible for design, permitting and implementation of dust suppression and erosion control measures.

~~U.~~V. Contractor is responsible for storm water quality requirements or retention basin requirements during construction as required. Permanent storm water quality requirements shall be installed in accordance with the drainage requirements of the associated Authority Having Jurisdiction.

~~V.~~W. Contractor shall provide:

- 1. Protective Device Coordination Study including time coordination curves and a narrative document explaining relay settings philosophy and calculations.
- 2. Electronic settings files for insertion to applicable relays.
- 3. Load Flow Study.
- 4. Short Circuit Analysis.

5. Facility Rating Report in accordance with FERC and NERC regulations.

6. Grounding System Study (including step and touch potential).

7. Any other studies required by the Interconnection Agreement, Power Purchase Agreement, or by local utility/ISO.

8. These engineering studies and documents shall be prepared by a licensed Professional Engineer in the corresponding state. Contractor shall furnish completed study to Owner for review.

~~W.~~X. Contractor shall provide all necessary information and facility models (PSCAD, PSS/E, PSLF, short-circuit, or other) required by NERC, FERC, local utility, or ISO.

~~X.~~Y. Contractor will furnish and install a communication link between the Solar Substation and the operations building (if applicable).

~~Y.~~Z. Contractor shall furnish and install primary ADSS or Optical Ground Wire (OPGW) and secondary fiber optic communication link from POI to the Solar Substation. The secondary path must be physically separate and diverse from the primary communication path.

~~Z.~~AA. Contractor shall upgrade the access road(s), as required, to allow delivery of 34.5kV-XXXkV step-up transformer.

BB. AA. Contractor shall coordinate with applicable Transmission Provider for the Solar Substation regarding the control and integration of the Solar Substation including but not limited to the control and monitoring 34.5kV-coupled reactive power resources, 34.5kV breakers, XXX kV breakers, XXX kV disconnects, monitoring of the 34.5kV to XXX kV transformer and all revenue meters located in the Solar Substation. Contractor shall comply with all requirements of the Transmission Provider.

CC. BB. Contractor shall coordinate with Transmission Provider regarding the SCADA and protection relaying (including testing).

DD. CC. Contractor shall provide all water for dust suppression.

EE. DD. If local utility power is available, Contractor shall supply main power for Substation through local distribution system and back-up from the Solar Substation aux transformer. If local utility power is not available, Contractor shall supply a stand-by emergency generator (12-hour capacity) as back-up source.

FF. EE. Contractor shall be responsible for geotechnical information which is required by Contractor in performance of the Work, and Contractor shall conduct geotechnical studies required for detailed design.

1.6 OWNER PROVIDED FACILITIES AND SERVICES

A. [RESERVED]

1.7 CONSTRUCTION FACILITIES AND SERVICES

A. Coordination

1. Contractor shall attend pre-construction meetings as may be requested by Owner. At the initial meeting, Contractor shall present a construction plan including, but not limited to, the following: safety, procurement plan, major equipment receipt, inventory and storage plan, construction sequence, methods and equipment to be used in all phases, proposed access and right-of-way roads, locations of staging areas, and a construction schedule showing all activities for the entire construction phase of the project. Pre-construction coordination meetings and design review meetings shall be held in Owner's or Contractor's office.
2. Contractor shall be responsible for contacting all involved utility companies prior to starting any work to coordinate schedule of work (including outage windows) and location of all temporary and permanent utilities in the Project area.
3. Contractor shall prepare an outage plan for all scheduled interruptions of electrical power or other utilities that would affect the Solar Plant, or third parties. This plan shall be submitted by Contractor to Owner and the affected parties at least six (6) weeks prior to outage.
4. Representatives of Contractor shall attend weekly coordination meetings to discuss matters relative to the progress and execution of the construction and startup of the project. Current week progress and three- week look-ahead schedules shall be presented by Contractor and reviewed at these meetings in addition to other site coordination items. Past and current safety statistics shall also be provided.
5. Owner shall be given the opportunity to attend any and all factory acceptance tests and perform shop visits for equipment procured by Contractor. Contractor shall notify owner at least two weeks in advance of factory acceptance test dates and shall coordinate all such events with Owner.

B. Safety and Security.

1. Contractor shall develop Safety Plan and submit to Owner for review and approval. Contractor shall ensure all personnel adhere to Safety Plan provisions and wear proper personal protection equipment (PPE) at all times. Contractor shall conduct a safety briefing each day before work, and before each construction activity. Refer to section 11.3 of M3-01-02, and M3-01-01, for further information.
2. Sufficient access space shall be provided for maintenance of all equipment.
3. Substation shall meet requirements of Critical Infrastructure Protection (CIP) and NERC for security. Refer to M1-01-07 (Security and Compliance) for more Owner requirements.

C. Fire Protection

1. Only work procedures which minimize fire hazards to the extent practicable shall be used. Combustion debris and waste materials shall be collected and removed from the site each day. Fuels, solvents, and other volatile or flammable materials shall be stored away from the construction and storage areas in well-marked, safe containers. Good housekeeping is essential to fire prevention and shall be practiced by Contractor throughout the construction period. Contractor shall follow the recommendations of the Associated General Contractors “Manual of Accident Prevention in Construction” regarding fire hazards and prevention.
2. Formwork, scaffolding, planking, cabling, and similar materials which are combustible, but which are essential to execution of the work shall be protected against combustion resulting from welding sparks, cutting flames, and similar fire sources.
3. Contractor shall provide qualified personnel for fire control as appropriate. Contractor shall provide adequate fire protection equipment in each warehouse, office and other temporary structures, and in each work area that he is occupying. Suitable fire extinguishers shall be provided in enclosed areas, in areas that are not accessible to fire protection water, or in areas that may be exposed to fire that cannot be safely extinguished with water. Each fire extinguisher shall be of a type suitable for extinguishing fires that might occur in the area in which it is located. In areas where more than one type of fire might occur, the type of fire extinguisher required in each case shall be provided. Each extinguisher shall be placed in a convenient, clearly identified location that will most likely be accessible in the event of fire.
4. Contractor shall be responsible for providing adequate fire protection of the construction areas.

D. Cleanliness

1. Contractor shall keep the Site and surrounding grounds clean and free from trash and debris. Contractor shall require all disciplines to thoroughly clean their work areas each working day. Contractor’s Construction Manager shall be responsible for Site maintenance and cleanliness. This shall include sweeping the floor, collecting and disposing of trash, and all other functions required to keep the site clean. All hoses, cables, extension cords, and similar materials shall be located, arranged, and grouped so they will not block any access way and will permit easy cleaning and maintenance.
2. A roll-up of all hoses, welding leads and electrical cords will be executed once a month as a minimum or as determined by site management. Material and equipment not required for immediate use or installation will be stored in designated laydown and warehouse areas.

3. All trash, debris, and waste materials shall be collected, sorted, and deposited in waste collection receptacles near the work. These receptacles shall be emptied by Contractor regularly and the waste disposed of properly and off-site.

4. Promptly upon the completion of a construction task, Contractor shall thoroughly clean the equipment or structure affected by the task activity by removing all accumulations of dirt, scraps, waste, oil, grease, weld splatter, insulation, paint, and other foreign substances. Contractor, without additional cost or burden to Owner, shall properly and adequately restore surfaces affected by deposits of insulation, concrete, paint, weld metal, or other adhering materials.

E. Energized Facilities

1. Contractor shall be completely responsible for the safety and protection of its personnel, the Owner's personnel, any and all other personnel of 3rd parties and other contractors, and the public, and shall employ all methods necessary to achieve such safety and also assure continuity of all service systems encountered. These methods shall include, but not be limited to, providing barriers, guard structures, insulating guards and sleeves, warning signs, and prevention of unauthorized access to service system areas. Refer to section B above for further information on safety and security.

F. Reference Points

1. Contractor shall establish baselines, monuments, and reference points for construction as necessary to proceed with layout of the work. Contractor shall be responsible for laying out the work to such lines and grades indicated on the drawings and shall protect and preserve the established reference points.

G. Dangerous Materials

1. Contractor shall not use explosives, radioactive, or other dangerous material without prior notification to the Owner. Contractor shall be responsible for the proper handling, transporting, storage, and use of such materials. When the use of such materials or methods is necessary, Contractor shall exercise the utmost care and carry on such activities under supervision of its properly qualified personnel. Contractor, at its expense, shall repair any damage caused by its handling, transporting, storage, and use, and shall be responsible for obtaining permits as applicable.

H. Waste Disposal

1. Contractor shall be responsible for removal and lawful disposal of all discarded material, debris, rubbish, unusable excavated material, and waste, including hazardous substances, if any, generated by Contractor and its subcontractors and suppliers during construction of the plant.

I. Hazardous Material Management

1. Contractor shall be responsible for managing hazardous materials and hazardous wastes as described in the Agreement. Contractor shall obtain an EPA I.D. Number for its work, if necessary.

J. Adjoining Utilities

1. Contractor shall make necessary efforts to protect the existing power gen- tie facilities, any and all parallel, converging, and intersecting electric lines and poles, telephone lines and poles, highways, waterways, railroads, and any and all property from damage as a result of its performance of the Work. Contractor shall bear all liability for and shall at its expense repair, rebuild or replace in kind any property damaged or destroyed caused by the Contractor in the course of its performance of the Work.

1.8 SITE AND ENVIRONMENTAL CRITERIA

A. Project design shall be based upon the design conditions listed in M3-01-01 Table 1-1.

1.9 DESIGN CRITERIA

A. Project and individual components shall have a minimum design life of 25 years.

B. Project shall be designed for automatic, unmanned operation.

C. Project electrical design will be in compliance with applicable codes and standards listed under section 1.9 unless otherwise noted.

1.10 OPERATING CRITERIA

A. Convenience Power: 120VAC

B. Instrumentation voltage: 125VDC

C. Communications network: Ethernet via direct buried fiber optic.

~~C.~~

D. Solar Substation Voltage.

1. High Voltage (phase-to-phase, maximum): XXX kV
2. Medium Voltage (phase-to-phase, maximum): 38 kV

E. Supply voltage wave form: per IEEE 519-2014 requirements.

F. System phase rotation: [to be determined by Contractor and Transmission Provider - Contractor to verify that all sources, including auxiliary and backup sources are in phase at the MV leve]

G. Volts per hertz ratio: 1.05

H. Electrical system ambient temperature range: •-XX°C to XX°C

I. 24--hour average ambient temperature: XX°C plus adjustment factors for the Site

J. Relative humidity range: 10-95% without condensation

K. ~~MPTwindings~~MPT windings BIL ratings shall be determined per IEEE C57.12.00:

1. HV: [by Contractor]
2. MV: [by Contractor]

L. MPT Bushings BIL ratings shall be determined from insulation coordination study and IEEE Standard C57.19.01:

1. HV: [by Contractor]
2. MV: [by Contractor]

M. Steady State XXXkV substation maximum current: [to be determined by Contractor] (per phase)

N. Steady State 34.5kV substation maximum current: [to be determined by Contractor] (per phase)

O. Maximum XXXkV fault current – sym.: [to be determined by Contractor].

P. Isokeraunic activity: In accordance with standard nationally published maps for thunderstorm activity.

Q. Soil resistivity: According to results of Geotechnical Study

1.11 CODES, REGULATIONS AND STANDARDS

A. In the event that any Applicable Law or Industry Standard does not govern specific features of any item of equipment and materials, Temporary Work or system, Contractor or Original Equipment Manufacturer (OEM) standards shall be applied, with Owner's approval.

B. Listed herein are the principal codes and standards applicable in the design, fabrication, and installation of the Project; these are not intended to be all inclusive. Other recognized standards may be utilized when required in Contractor's opinion and when not in conflict with the standards listed below. Contractor shall notify and obtain Owner approval prior to us of any such other standards.

C. Contractor shall design and construct the Project in accordance with the latest accepted edition of the following standards:

1. AA – Aluminum Association
2. AASHTO – American Association of State Highway and Transportation Officials
3. ACI - American Concrete Institute
4. AISC - American Institute of Steel Construction
5. AISE – Association of Iron and Steel Engineers
6. ANSI - American National Standards Institute,
7. AREMA – American Railway Engineering and maintenance Association
8. ASCE – American Society of Civil Engineers

9. ASME – American Society of Mechanical Engineers
10. ASNT – American Society of Nondestructive Testing
11. ASTM - American Society for Testing and Materials
12. AWS – American Welding Society
13. CMAA – Crane Manufacturer Association of America
14. CRSI – Concrete Reinforce Steel Institute
15. EPA – United States Environmental Protection Agency
16. FAA – Federal Aviation Agency, Department of Transportation
17. IBC - International Building Code
18. ICEA - Insulated Cable Engineers Association
19. IEC - International Electrotechnical Commission
20. IEEE - Institute of Electrical and Electronics Engineers
21. ISA – Instrumentation Society of America
22. ISO – The International Organization for Standardization
23. NEC - National Electrical Code
24. NEMA - National Electrical Manufacturers Association
25. NERC – North American Electric Reliability Council
26. NESC - National Electrical Safety Code
27. NETA - National Electrical Testing Association
28. NFPA – National Fire Protection Association
29. OSHA - Occupational Safety and Health Act
30. UL – Underwriters' Laboratories

~~1.12~~D. Refer to M3-01-01 for Special Conditions

2.0 EQUIPMENT AND MATERIALS

2.1 EQUIPMENT

A. Contractor shall furnish all equipment and materials as required to construct a fully functioning Project. Minimum requirements for major equipment are described herein:

2.2 34.5KV CAPACITORS, REACTORS, OR COMBINATION.

A. Nominal system voltage: 34.5kV

B. Reactive power: To be determined by Load Flow Study meeting Interconnect Agreement requirements, minimum of [by Contractor] kVAR.

C. Stepped Capacitor [by Contractor] MVAR

D. Stepped Reactor [by Contractor] MVAR

E. Frequency: 60 Hz

F. Capacitors shall be equipped with an internal discharge device which will reduce the residual voltage to 50 volts or less within 5 minutes.

2.3 34.5KV CIRCUIT BREAKERS (COLLECTORS)

A. Model/Type: Vacuum

B. Rated Voltage; Nominal: 34.5kV

C. Rated Voltage; Maximum: 38kV

D. BIL: 200kV

E. Rated Current-RMS: Continuous: [by Contractor] A

F. Rated Current-RMS: 3 seconds: [by Contractor] kA (the continuous duty shall not be greater than 85% of rating)

G. Rated Current-RMS: Interrupting: [by Contractor] kA (the interrupting duty shall not be greater than 85% of rating)

H. Current Transformer:

X	Y	Z	Bushing	Z	Y	X
B	B		5	6	A	A
B	B		3	4	A	A
B	B		1	2	A	A

Ratio

A: [Ratio by Contractor]

~~(b)~~ B: [Ratio by Contractor]

Relay accuracy classification: C800

C57.13 metering accuracy current transformers: 0.3

I. Control Voltage: 120/240 VAC

J. Control Voltage: 125 VDC

K. Voltage for Space Heater: 120V Single Phase

2.4 XXXKV CIRCUIT BREAKER(S)

2.4 Model Type: SF6

A. Model/Type: SF6

B. Rated Voltage; Nominal: XXXkV

C. Rated Voltage; Maximum: XXXkV

A.

B. Rated Voltage; Nominal XXXkV

C. Rated Voltage; Maximum: XXXkV

D.B. Rated Voltage; Nominal: XXXkV

E.C. Rated Voltage; Maximum: XXXkV

~~D.~~ BIL: XXXkV~~—~~

D.

~~E.~~ Rated Current-RMS: Continuous: XXXXA

E.

F. Rated Current-RMS: 3 seconds: [by Contractor] kA (the continuous duty shall not be greater than 85% of the rating)

G. Rated Current-RMS: Interrupting: [by Contractor] kA (the interrupting duty shall not be greater than 85% of the rating)

H. Current Transformer:

X	Y	Z	Bushing	Z	Y	X
B	B		5	6	A	A
B	B		3	4	A	A
B	B		1	2	A	A

Ratio

A: [Ratio by Contractor]

~~(c)~~ B: [Ratio by Contractor]

Relay accuracy classification: C800

C57.13 metering accuracy current transformers: 0.3

I. Control Voltage: 120/240 VAC

J. Control Voltage: 125 VDC

K. Voltage for Space Heater: 120V Single Phase

2.5 XXXKV DISCONNECT SWITCHES

A. Nominal System voltage: XXXkV

B. Basic Impulse Level: XXXkV

C. Continuous current:

1. [by Contractor]

D. Momentary current: XX-kA minimum [by Contractor]

E. Three-pole, single throw

F. Switches rated XXXkV shall be vertical break or center side break horizontally mounted.

G. Switchblades and related current-carrying parts shall be of aluminum alloy construction and contact-making components shall be of silvered inlay copper or other approved metals.

H. Provide 4-hole or 6-hole NEMA terminal pads at each high-voltage connection.

I. Design to provide smooth, completely controlled simultaneous movement of switchblades throughout the entire cycle of operation with mechanism continually loaded to prevent switch from alternately leading or lagging the control.

J. Furnish group operated mechanism with necessary rods, bell cranks, interphase operating connections, bearings, supports, linkages, and vertical operating pipe. All operating pipe connections shall have set screws. All operating pipes shall be furnished precut to the specific lengths required for the phase spacing and bus height indicated.

K. Provide with permanently double-sealed maintenance free automotive steel ball bearing assemblies.

L. Provide for individual adjustment of the operating mechanism of each pole; all hardware shall be fabricated with non-corrodible metal.

M. Provide a semaphore to be located at or near each operating mechanism to give positive indication of the open or closed position of the switch.

N. Operating handles or cranks shall have provision for locking in both the open and closed position.

O. Provide bolted ground connector and flexible grounding jumper for operating handle.

P. Switch bases shall be heavy-duty galvanized steel.

Q. Switches shall be of an essentially maintenance-free design.

R. XXXkV switches shall be provided with worm gear operating mechanisms operated with a non-detachable crank having a clockwise operation of crank to close switch, with all gears and worms completely sealed, and requiring a torque of no more than 40-pound feet to operate the switch. Motor-operated switches shall have means of de-coupling the motor operator and locking out operation of the mechanism.

S. Furnish mechanically operated auxiliary switches with operating points individually adjustable over the entire travel of the operating mechanism.

2.6 34.5KV DISCONNECT SWITCHES

A. Nominal System voltage: 34.5kV

B. Basic Impulse Level: 200kV

C. Continuous current:

1. [by Contractor] A – QTY [by Contractor] (Transformer)
2. [by Contractor] A – QTY [by Contractor] (Feeders and Cap Bank)

D. Momentary current: 40-kA minimum

E. Three-pole, single throw

F. Switches rated 34.5kV shall be vertical break horizontally or vertical mounted.

G. Switchblades and related current-carrying parts shall be of aluminum alloy construction and contact-making components shall be of silvered inlay copper or other approved metals.

H. Provide 4-hole or 6-hole NEMA terminal pads at each medium-voltage connection.

I. Provide with ball studs for grounding, minimum one ball stud per phase, per 20kA of AIC.

J. Design to provide smooth, completely controlled simultaneous movement of switchblades throughout the entire cycle of operation with mechanism continually loaded to prevent switch from alternately leading or lagging the control.

K. Furnish group-operated mechanism with necessary rods, bell cranks, interphase operating connections, bearings, supports, linkages, and vertical operating pipe. All operating pipe connections shall have set screws. All operating pipes shall be furnished precut to the specific lengths required for the phase spacing and bus height indicated.

L. Provide with permanently double-sealed maintenance free automotive steel ball bearing assemblies.

M. Provide for individual adjustment of the operating mechanism of each pole; all hardware shall be fabricated with non-corrodible metal.

N. Provide a semaphore to be located at or near each operating mechanism to give positive indication of the open or closed position of the switch.

O. Operating handles or cranks shall have provision for locking in both the open and closed position.

P. Provide bolted ground connector and flexible grounding jumper for operating handle.

Q. Switch bases shall be heavy-duty galvanized steel.

R. Switches shall be of an essentially maintenance-free design.

S. 34.5kV switches shall be provided with worm gear operating mechanisms operated with a non-detachable crank having a clockwise operation of crank to close switch, with all gears and worms completely sealed, and requiring a torque of no more than 40 pound-feet to operate the switch. Motor-operated switches shall have means of de-coupling the motor operator and locking out operation of the mechanism.

T. Furnish mechanically operated auxiliary switches with operating points individually adjustable over the entire travel of the operating mechanism.

~~27~~ XXXKV SURGE ARRESTER

2.7

~~A.~~ Nominal System Voltage: XXXkV

A.

B. Arrester rating: [by Contractor] kV MCOV

C. Outdoor Station Class

D. Polymer

E. Mounting: Vertical

~~28~~ XXXKV CCVTS

2.8

~~A.~~ Nominal System Voltage: XXXkV

A.

B. Basic impulse level: XXXkV BIL

C. Frequency: 60 HZ

D. Secondary Windings: 2

E. Base mounted with potential adjusting unit mounted in the capacitor base or in separate weatherproof housing.

2.9 STATION SERVICE TRANSFORMER

A. Size to be determined by Contractor for review and approval by Owner.

2.10 TUBULAR AND STRAIN BUS

A. Provide schedule 40, 6063-T6 seamless aluminum bus. Provide corona-free and watertight welded end covers on all exposed ends. Bus diameter shall be determined in accordance with the methods given in IEEE 605. Provide corona rings as required for High Voltage fittings. Provide internal damping cable to reduce Aeolian vibration. Damping cable dimensions and weight shall be determined in accordance with the methods given in IEEE 605. Bus shall withstand the stresses from short circuit forces stated in design criteria.

2.11 BUS AND SWITCH INSULATORS

A. Provide station post bus insulators rated as indicated in design criteria. The minimum cantilever strength shall be determined in accordance with the methods given in IEEE 605, including wind and short circuit overload factors.

2.12 BUS CONNECTOR AND FITTINGS

A. Provide connectors and fittings as required. Connectors shall be welded type for aluminum tubing connections and compression or puddle welded type for aluminum cable connections. Use expansion type connectors with internal ball- type alignment guides where tubing connections are made to switches. Fittings shall develop the full strength of the conductor and shall be capable of carrying the full current capacity of the conductor.

B. Bus support clamps for rigid bus shall be fixed or slip type as required to firmly support the bus while allowing for temperature expansion and contraction. Provide bolted ground connector and flexible type grounding jumper for

C. operating handles of disconnect switches. Provide bus grounding stud weldments on main bus in at least three locations. Provide wire guides and bundled conductor spacers as required and indicated to maintain adequate clearance and support on cable jumpers, connections, and overhead lines.

D. Provide corona shields for all XXX-kV connections.

2.13 RELAYING

A. All relays shall be microprocessor-based and wired to a central communication processor with IRIG-B time stamping. The communication processor shall integrate all relaying.

B. Relay panels shall be located in the Project Substation control building and shall include all hard-wired and soft-wired protection and control interlocks.

C. Programming of devices shall be provided in electronic format straight from the device.

D. All protection device settings shall be provided for Owner's review no later than 60 days prior to the system energization date. Final design and procurement are contingent upon Owner review and approval.

E. The Contractor shall coordinate with local utility confirm line protection and signal exchange requirements.

F. The relaying schemes shall monitor and respond to over-currents, phase faults, ground faults, and other system abnormalities. Protection schemes to be utilized shall include, but not be limited to, line impedance/differential, bus differential, transformer differential, breaker failure, backup relaying, switch into fault, and sync check.

G. Annunciation and alarms shall be communicated to the Operator through an RTU that will signal loss of protection integrity including but not limited to: coil monitoring, loss of tripping power, gas pressure, relay failure, and other similar items.

H. High-side lines shall include primary and backup relaying

I. Relays shall be SEL and of the model and type as required by Owner and compatible with Transmission Provider for substation relays:

1. Line Differential,
2. Line Distance
3. Breaker Failure
4. High Side Bus
    a. Bus Differential Primary
    b. Bus Differential Secondary
5. High Side Transformer Breaker
    a. Breaker Failure

6. Transformer
   a. Transformer Differential Primary
   b. Transformer Differential Secondary
7. 34.5kV Collectors
   a. Collection System Protection
8. 34.5kV Supplemental Reactive Power Resources
   a. Overcurrent
   b. Voltage

J. Owner shall approve the model and firmware version of all relays prior to procurement by Contractor. SEL must be informed that Owner is the end user of the relays to apply Owner's Special Specification requirements, including standard firmware. Model and firmware shall follow the owner's standard in effect at time of purchase.

K. Relay settings shall, to the extent applicable and possible, follow Owner's standard template in effect at the time settings are developed.

L. Relay settings shall conform to good engineering practice; equipment manufacturer requirements; PRC-027, PRC-025, and PRC-024, as applicable; and, to the extent possible and applicable, Owner's standard protection practices in effect at the commencement of the Protection Coordination Study. Contractor shall request standards the latest standards from Owner prior to starting work.

M. To the extent possible and applicable, any Solar Plant relay systems shall follow the same design masters and standards as the substation relay systems.

~~b.~~N. All relays protecting auxiliary power circuits used for life safety, fire protection systems, or circuits which are critical for operation of and restoration of the plant shall be fully redundant and powered by the step-up substation DC supply if feasible. If not possible, then the control power to such relays and breakers shall provide reliability and be equipped with monitoring equivalent to the substation DC supply. DC power quality, including excessive ripple and transients, shall not cause protection system misoperations. AC sources to UPSs and battery chargers powering relays shall be connected upstream of any breakers or switches controlled by the relay, or on an independent circuit.

2.14 MAIN POWER TRANSFORMER

A. Contractor shall furnish one (1) or more XXX/34.5kV step-up transformer(s) for

B. the PV Plant. This main power transformer shall be high efficiency type configured with its primary (low side) winding as solidly grounded WYE to allow ground fault sensing and protection of the 34.5kV ~~distribution~~ collector system.

C. Transformer shall be sized to at least 10% above MVA rating of plant.

B.D. Submittals:

1. Contractor shall submit complete specification for review and approval by Owner per timeline defined in M1-01-02 and table M1-01-02-01-Solar.
2. Contractor shall submit transformer design drawings for review and approval by Owner per timeline defined in M1-01-02 and table M1-01-02- 01-Solar.

C.E. On Load Tap Changer (OLTC) required for voltage regulation at POI.

D.F. Performance Requirements:

1. No load losses shall not exceed 0.10% of rated power.
2. Load losses shall not exceed 0.70% of rated power at full load.

3.0 ELECTRICAL

3.1 GENERAL

A. This section covers the minimum scope and quality standards for the systems. Contractor shall provide all material and labor for the engineering, design, procurement, installation, construction, startup, inspection, and testing of all electrical systems specified herein and necessary for a complete substation in conformance with generally accepted practices.

B. Contractor shall develop a detailed design based on Owner's conceptual layout. Alternative designs may be acceptable if they meet the functional requirements of this specification. Any changes must be approved by the Owner.

B.

C. The design and specification of all work shall be in accordance with all applicable industry codes and standards and accepted standards of good engineering practice.

3.2 SUBSTATION SYSTEM STUDIES

A. Contractor shall perform a set of studies and analyses to demonstrate the adequacy of the proposed electrical system design, by performing the following studies as a minimum. The design and construction of the electrical systems shall reflect the findings and conclusions of these studies. These system studies shall be subject to review and comment by Owner.

1. AC System Studies:

   a. The capacity of the Solar Substation low voltage AC system to determine size of station service.

2. DC System Studies:

   a. A load profile shall be developed for all DC loads to determine the capacity of the batteries and chargers with the DC service required for the equipment at the Solar Substation. The studies shall determine if the minimum voltages are maintained as specified and required by equipment vendors.

3. Short Circuit and Grounding Studies:

   a. Ensure equipment is rated to handle expected fault currents.

   b. The study shall assure that the ground grid modifications maintain touch and step voltages within tolerable limits. The study shall determine the ground potential rise (GPR) with respect to remote earth.

   c. The analysis of the ground grid shall have the following basis:

      A.• Fault current per project characteristics.

      B.• 50 kg body weight

      C.• A fault split factor may be applied.

      D.• Ground resistivity determined from the Geotechnical Report.

      E.• Fault duration of 0.25 seconds.

   d. Ground grid design, including tolerable step and touch voltage and conductor fusing temperature, shall be in accordance with the procedures, data, and recommendations given in IEEE 80.

4. Relay coordination Study: To ensure designed protection devices will function properly to protect plant and its systems, as well as high side components.

   4.a. A system model of all Bulk Electric System elements shall be provided in ASPEN One-Liner format. Auxiliary, low voltage, and balance of plant systems may be modeled in Easy Power. Inverters shall be modeled per the manufacturer instructions, and use of synchronous generator models for inverters are not permitted. Contractor shall verify Owner's version of all software prior to creating any models to ensure consistent results. Contractor shall follow Owner's ASPEN modeling and naming conventions.

5. Bus Design Analysis:

a. Analyze the performance of the substation buses, disconnect switches, and separately mounted current transformers to determine the ampacity, structural integrity, vibration, and required mechanical and electrical ratings are in accordance with the methods and recommendations of IEEE 605. Bus design, including gust factor, exposure height factor, importance factor, and corona considerations, shall be in accordance with the procedures and data given in IEEE 605.

6. Bus Ampacity:

a. Continuous current rating as given on the one-line diagram.

b. Fault current as appropriate for the Project.

c. A temperature of 50˚C with a minimum wind speed of 2ft/sec

d. perpendicular to the bus.

d.e. Solar radiation with material absorptivity and emissivity to 0.5.

7. Bus Structural Design (bus, insulators, bus structures and foundations):

a. Use wind speeds and ice loads as appropriate for the Project.

3.3 MAST FOR DIRECT STROKE PROTECTION

A. Steel masts for direct stroke protection shall be round tapered seamless extruded or spun aluminum tubes.

B. The overall height of the masts above grade shall be determined from the Direct Stroke Protection Study. Mast design shall be for the site design.

C. Masts shall have a single uniform taper from top to bottom. Each mast shall be capped with a suitable finial. Each mast shall be equipped with an internal vibration dampening device. The design of masts shall have a safety factor of 2 based on the allowable yield stress for the mast material in accordance with the latest ASCE specifications governing design of structures. The horizontal deflection at the top of each free-standing mast shall be limited to L/20 of its height above foundation.

D. Each mast shall be provided with two grounding pads located 12 inches above the foundation.

3.4 LIGHTING

A. A lighting system shall be furnished for the Solar Substation. The lighting system shall provide personnel with illumination for substation operation and maintenance under normal conditions and means of egress under emergency conditions.

B. The lighting system shall be designed in accordance with the Illuminating Engineering Society (IES) to provide acceptable illumination levels.

B.

C. Lighting sources and fixture selections shall be based on the applicability of the luminaries for the area under consideration and shall comply with all local codes and standards.

D. Lighting levels shall meet the requirements of ANSI C2, the NESC.

3.5 XXX/34.5KV SOLAR SUBSTATION

A. Contractor shall design and install the substation and associated equipment and materials for the XXX/34.5kV substation. Coordinated design between the substation, gen-tie, and Solar Plant will determine the final placement of the structures and equipment; feedback of equipment status to the RTU; and associated details. Contractor shall provide all interface points. Contractor shall provide for status to the RTU of all substation equipment including open/close indication, voltage, currents, and alarms (including battery/battery charger related alarms), and revenue meter information (power, energy, accumulators).

B. Contractor is responsible for all site preparation, foundations, fencing, control building, grounding, crushed rock, structures, switches, instrument transformers, surge arresters, station service, instrument metering, relaying, conduit, cable, bus, conductor, connectors, insulators, and other associated equipment.

C. Contractor to furnish main power transformer (MPT) and deliver the transformer(s) to Site meeting all necessary transportation requirements to maintain manufacturer warranty. Contractor will unload, install, dress-up, and fill transformer, and have initial commissioning of transformer performed as required for warranty. Contractor shall provide foundations, oil containment, high voltage bus work, and low voltage power and control cables for the MPT.

D. The substation shall conform to the requirements of IEEE 605, the IEEE C37 and C57 family of standards, and, in general, conform to the preliminary arrangements provided by Owner. Minimum conductor clearance criteria shall be per ANSI C2 (NESC). Clearances shall be increased at locations where additional clearances are required for access to site equipment.

E. Design of the interconnect voltage and 34.5kV systems shall be based on short circuit study.

3.6 INSTALLATION OF MAJOR SOLAR SUBSTATION EQUIPMENT

A. Contractor shall provide all equipment required for the installation of substation equipment and materials.

B. Contractor shall receive, inventory, and store substation equipment. Equipment to be installed at substation shall be stored and protected. Installation and assembly of equipment and materials shall be according to manufacturer's recommendations complete as specified and as required for operation and continuous service at the locations in accordance with Contractor's detailed design.

B.

C. Contractor shall erect structures in strict compliance with the manufacturer's drawings, code markings and instructions, after foundations have completely cured. Contractor shall repair all cuts, welds, and damaged areas.

D. Contractor shall assemble, install, lubricate, and adjust all switches and operating mechanisms in accordance with the manufacturer's instructions. Erect and install all buses, bus supports, bus support insulators, strain insulators, conductors, shielding wires and masts, and interconnections as required by manufacturer's drawings.

E. Welded aluminum bus erection shall include fabricating all buses and interconnections to the correct length and shape. Bends shall be made with a hydraulic bender without kinks or surface damage. Field weld all pipe-to-pipe and pipe-to-fitting connections using inert gas arc welding. Submit to Owner complete details of the proposed welding procedure, experience record, and certification data on the person(s) proposed to do the welding, as well as samples of welds made at the jobsite in all four standard positions.

3.7 BATTERY SYSTEM

A. Codes and Standards

1. All equipment furnished under these specifications shall conform to applicable standards of IEEE, ANSI, and NEMA. All materials and devices shall be in accordance with the applicable requirements of the Federal "Occupational Safety and Health Standards." The latest edition of each code and standard shall apply.

B. Design and Construction

1. Batteries shall be provided with racks, connection devices, tools, instruction books, and other standard items.

2. Solar Substation battery chargers shall be 125VDC output, sized as required for 8-hour recharge while serving continuous load. Chargers shall include an AC circuit breaker in the charger input circuit to provide a disconnect point and overcurrent protection. Chargers also shall include DC ammeters, DC voltmeters, AC power failure alarm relays, high/low DC voltage alarm relays, ground detection alarm relays, and battery temperature compensation systems which reduce the charge rate if necessary. The chargers shall maintain output voltage (in a settable range between 125 and 140 volts DC) within 1/2 percent from no load to full load even with input voltage variation of 10 percent, maintain output voltage automatically without requirement for voltage readjustment, and automatically vary the charging rate in accordance with the requirements of the substation battery.

3. For the Solar Substation, provide DC systems including batteries, chargers, and panelboards. Batteries shall be lead antimony. Battery size shall be determined using the battery load profile. Nominal voltage shall be 125VDC with 60 cells. Battery shall be capable of being recharged to

3. rated capacity from a discharge down to zero volts per cell, following an equalization charge. The battery shall be capable of being recharged within 8 hours following a complete discharge. Design shall be based on an 8-hour discharge time to 1.75 volts per cell and the voltage is to be maintained for the minimum 20 year life of the battery. The battery shall be sized accordingly to accommodate ultimate design loads but shall be no less than 240 Ah capacity.

4. Each battery cell shall be wet cell, lead-acid pasted plate-type with lead- calcium alloy plate grids or sealed type with 20-year expected life. Cell containers shall be sealed, clear, shock absorbing, heat resistant plastic, with electrolyte high and low-level markers and spray-proof vents. Batteries shall be manufactured for full float service with a high discharge rate, low deterioration rate, and low maintenance. Batteries shall be supplied complete with all accessories (e.g., battery rack, inter-cell connectors). Racks shall be a 2-step configuration.

5. The DC switchboard and panel shall have a main bus current rating as required to supply the connected load. The continuous current ratings and interrupting ratings of the feeder breakers shall be based on the available fault current and the characteristics of the connected loads or the battery chargers. Each panelboard shall include the feeder breakers required to supply the connected loads. Switchboard shall include bus voltmeter, battery ammeter with shunt, ground detection and alarm, and low voltage alarm.

C. Rating

1. Contractor shall determine the capacity of each battery in accordance with the methods of IEEE 485 and these Specifications. With the battery initially fully charged at the floating voltage specified, and with the battery chargers disconnected, the battery shall be capable of supplying the duty cycle specified. The ambient temperature during the duty cycle shall be 25° C. An aging factor of 25% and design margin of 20% shall be used. Contractor shall submit battery calculations for approval.

D. Duty Cycle – The duty cycle for battery sizing shall include:

1. One minute at the level of current required to operate Solar Substation circuit breakers plus the continuous load.

2. Duration of continuous load to be reviewed and approved by Owner.

3. One minute at the level of current required to operate all Solar Substation circuit breakers plus the continuous load.

E. Battery Charger Requirements

1. Each battery charger-eliminator furnished shall be self-regulating, natural cooled, solid-state silicon controlled full wave rectifier type designed for single and parallel operation with the batteries specified under these

1. Specifications. Charger shall be able to provide the DC load requirements in the event that battery is disconnected.
2. The chargers will be served from the substation AC system.
3. The battery charger shall maintain output voltage within plus or minus
4. ½% from no load to full load, with an input power supply deviation in voltage level of plus or minus 10% and an input power supply deviation in frequency of plus or minus 5%.
5. Solid-state electronic circuits shall have AC and DC transient voltage protection and shall be designed to recharge a totally discharged battery without overloading and without causing an interrupting operation of AC or DC circuit breakers.
6. Charger shall be a full capacity charger and shall have the capacity to recharge the battery in 8 hours following complete discharge. Battery charger shall also have an equalizing charge mode. Battery charger will be self-regulating after charging levels are manually selected. Battery charger shall be manufactured in NEMA 1 enclosures suitable for placement in an indoor, environmentally controlled atmosphere. The battery charger shall require only front access and will allow either top or bottom conduit/cable entry.

3.8 RACEWAY

A. This section covers furnishing and field installation of a complete raceway system in accordance with these specifications.

B. Raceway shall conform to the recommendations included in IEEE 525.

C. The raceway system is defined to include conduit, flexible conduit, underground duct, wireway, cabinets and boxes, and all materials and devices required to install, support, secure, and provide a complete system for support and protection of electrical conductors.

D. Raceway that contains multiple cable circuits shall have all cables with identical insulation ratings.

E. Individual raceway systems shall be established for the following services:

1. 600-volt control cable, AC power and control cables.
2. Special electrical noise-sensitive circuits.

F. Routing of Above Grade Raceway and Conduit

1. Contractor shall route raceway and conduit and shall coordinate conduit locations with other equipment and structures.
2. All raceway and conduit shall be installed in a neat, rectangular form. Special attention shall be given to securing a neat appearance. All raceway and conduit shall be installed perpendicular or parallel to the major equipment, and bus structures.

2.

G. Material:

1. Underground duct system materials furnished under these Specifications shall be new and undamaged and shall conform to the following requirements:

a. Duct - Polyvinyl chloride, Schedule 40 PVC in accordance with NEMA TC-2.

b. Couplings - Plastic, for use with duct previously specified and "Duct- to-steel" adapters as required, including joint cement.

c. Spacers - Plastic high impact, interlocking, base, and intermediate type

d. Factory bends and sweeps - Schedule 40 PVC, 36 inch minimum radius.

e. End bells – Plastic

f. Plugs – Plastic, high impact, tapered to fit end bell provided.

g. Duct binder – Hemp or sisal twine coupling

h. Riser termination – Rigid hot-dip galvanized mild steel coupling.

i. Riser bends - Rigid steel conduit elbows, factory or field made, 36- inch minimum radius, 90 degree, entirely concrete encased below grade; hot-dip galvanized rigid mild steel in accordance with ANSI C80.1 and UL 6; the conduit interior and exterior surfaces having a continuous zinc coating with an overcoat of transparent enamel or transparent lacquer.

3.9 CONDUCTORS

A. Power conductor size and ampacity shall be coordinated with circuit protection devices. Conductor size shall be determined for 125% of connected load, or the short circuit duty, at the design basis maximum outdoor ambient temperature. Below grade power cable conductor size shall be determined in accordance with the methods in IEEE 835.

B. Insulated cable, conductors, and conductor accessories shall be furnished and installed in accordance with the requirements of these Specifications and the recommendations given in IEEE 525. Insulated cable, conductors, and conductor accessories shall be furnished in quantities sufficient for a complete installation as indicated in these Specifications.

C. Installation shall be defined to include placement, splicing, terminating conductors; coiling and taping of spare conductors; identification, testing, and verification of each circuit, cable, and conductor. Manufacturer’s pulling or side wall tension shall never be exceeded. Contractor shall submit recorded cable tension reports.

D. All Solar Substation control and instrument cables shall be shielded. Connectors, sizes 12 - 2 AWG, shall be vinyl or nylon pre-insulated ring-tongue

D. type and power connectors, sizes 1 AWG – 750 MCM, shall be uninsulated two-hole rectangular tongue.

E. Cable Specifications

1. The cable furnished shall be flame retardant construction in accordance with the applicable ICEA standards and suitable for wet or dry locations. All cable shall have surface printing showing manufacturer's name, insulation type, jacket type, conductor size, conductor type, voltage rating, and numbered footage markers. Control and instrument cables shall be terminated with ring tongue connectors, compression connections, or. as required to meet equipment supplier requirements.

2. The cable furnished shall conform to the cable descriptions included below:

~~(d)~~ CABLE TYPE	DESCRIPTION
Low Voltage Power	600 volts, single-conductor, Class B stranded copper; EPR or XLP insulated; CPS, PVC, or CPE jacketed.
Low Voltage Power	600 volts, three-conductor; concentric lay, stranded copper with a ground wire in the interstices; FRXLPE or FREPR insulation; CSP, PVC, or CPE jacketed overall.
Control	Control cable, 600 volt, multiple-conductor, as required, stranded copper, 10 AWG, 12 AWG, 14 AWG; multiple-conductor, XLP insulation; CSP, PVC, or CPE jacketed overall.
Instrumentation	Instrumentation cable, 600 V, flame retardant single- and multiple-twisted pairs and triads, shielded instrument cable with individually shielded pairs, overall shield, and overall jacket; FRXLPE or FREPR insulation; CSP, PVC, or CPE jacketed overall. (Single pair or triad 16AWG, multi-pair or triad 18AWG).
Lighting & Receptacles	Lighting circuit runs totally enclosed in conduit, NEC Type RHH-RHW-USE with XLPE insulation for use in outdoor or unheated areas.
Shielded Control	Control cable, shielded, 600-volt, multiple conductor,

as required, stranded copper, 10 AWG, 12 AWG, 14 AWG; multiple conductor, XLP insulation; CSP, FRPVC or CPE jacketed overall

3.10 GROUNDING

A. The section covers the furnishing and installation of grounding materials completed as specified herein.

B. The Solar Substation grounding system shall be an interconnected network of bare copper conductor and copper-clad ground rods (ground wells maybe used instead of ground rods if dictated by the soil analysis). The system shall be designed such that substation personnel are protected from the hazards that can occur as the substation grounding system provides the earth return electrode during power system phase to ground faults.

C. Contractor may perform ground resistivity testing prior to final design to determine ground analysis parameters. The ground resistivity shall be measured with the methods given in IEEE 81.

D. The station grounding grid shall be designed in accordance with the methods and recommendations of IEEE 80. The grounding system shall have adequate capacity to dissipate heat from ground current under the most severe conditions in areas of high ground fault current concentrations, with grid spacing such that safe voltage gradients are maintained. Ground conductors shall be sized for fault duration of 0.25 seconds. The ground system shall be designed to comply with IEEE 80 requirements.

E. Bare conductors to be installed below grade shall be spaced in a regular pattern that is consistent with the grounding analyses. Each junction of the grid will be bonded together by an exothermal welding process.

F. Grounding connections shall be made to fences, and equipment. Equipment grounds shall conform to the following general guidelines:

1. Grounds shall conform to the NESC.
2. All equipment grounding connections shall be connected to the ground grid.

G. All substation bus and equipment support structures shall be connected to the station ground grid. Metal support structures in direct metallic contact with other metal structures do not require a separate grounding connection to the station ground grid. Fences shall be grounded in accordance with the requirements of the NESC. The Solar Substation ground grid shall be extended 1 meter outside of the substation fence. The Solar Substation fence shall be connected to the substation ground grid.

H. Ground Grid Design.

1. The final conductor sizing, grid configuration, grid depth, grid spacing, and quantities of conductor for the grid is to be determined during detailed design.

I. Materials

1. All grounding materials required shall be furnished new and undamaged in accordance with the following requirements.

a. Rods - ¾ inch 10-foot copper-clad standard type. The copper cladding shall be electrolytically bonded to the steel rod or bonded by a molten welding process. Cold rolled copper cladding is not acceptable. Ground rods shall be as manufactured by Blackburn, Weaver, or Owner-approved equal.

b. Cable

A.• Bare – Soft drawn copper, Class B stranding, ASTM BB.

B.• Insulated – Soft drawn copper, Class B stranding with green colored polyvinyl chloride insulation, UL 83, Type TW, THW or THHN.

c. Wire Mesh – Copper-clad, 6 AWG, 6 inch by 6 inch mesh spacing, copper weld or Owner-approved equal.

d. Bus and Bars – Soft copper, cross section not less than 1/8 inch thick by 1 inch wide, ASTM 8187.

e. Exothermal Welds - Molds, cartridges, materials, and accessories as recommended by the manufacturer of the molds for the items to be welded. Cadweld heavy duty or Owner-approved equal. Molds and powder shall be furnished by the same manufacturer.

f. Flush ground plates - Cadweld B-162 Series, B-164 Series, or Owner-approved equal ground plates with NEMA hole spacing.

2. All clamps, connectors, bolts, washers, nuts, and other hardware used with the grounding system shall be made of copper.

3.11 CONTROL, PROTECTION, AND METERING

A. Contractor shall design and fully manufacture, test, and deliver the control and protection system at the Solar Substation. The system shall include instruments, devices, panels, racks, protective relays, meters, switches, accessories, and wiring. Relay panels are to be installed in a Contractor furnished Solar Substation control building.

B. For the control design Contractor shall provide drawings sets for all relaying drawings including one-line drawings, three-line drawings, control panel arrangements, fabrication details, Bill of Materials, nameplate lists, DC control schematics, AC schematics, circuit schedules, auxiliary equipment schematics, wiring diagrams, index sheets, and legends. Drawings shall be provided in electronic format.

C. Each PV circuit feeder shall have its own revenue grade meter (SEL-735 or similar) and revenue grade voltage and current sensing required to meet requirements for Capacity Test (M3-01-05)

3.12 LABELING AND IDENTIFICATION

A. Substation and Electrical equipment shall be marked with signage and labeling to meet applicable safety codes, including NESC ANSI Z535, and NFPA 70E- 2015 Art. 130.5(D),

3.13 ELECTRICAL EQUIPMENT ENCLOSURES

A. 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:

1. Indoor: NEMA 1
2. Outdoor: NEMA 3R or 4

B. All enclosures shall be provided with pad locking provisions.

4.0 MECHANICAL

4.1 GENERAL REQUIREMENTS

A. This section provides requirements for major mechanical equipment, mechanical systems, and mechanical interfaces with other plant systems and off-Site facilities.

4.2 GENERAL ARRANGEMENTS

A. The location of equipment shall be based on safety, economics, ease of maintenance, and operation. Sufficient space shall be provided for maintenance of all equipment including equipment removal without excessive rigging or removal of surrounding equipment.

4.3 MECHANICAL SYSTEMS AND EQUIPMENT

A. Provisions shall be included in the design of all mechanical systems to allow the performance of all routine maintenance without requiring a plant shut down.

B. Contractor shall:

1. Receive, inspect, store, unload, maintain, erect, clean, align, and prepare all equipment in accordance with equipment manufacturer's instructions before initial operation.
2. Provide lifting lugs on all equipment components or system components requiring removal for maintenance and weighing over 25 lbs.
3. Select materials of construction and design equipment and systems to provide a minimum of a 25-year operating life at all operating conditions specified.
4. Design the facility for a life of 25 years consistent with good engineering practice for solar generation facilities. However, it is understood that some of the equipment will require routine maintenance and possible replacement during the life of the facility.
5. Provide grounding lugs and ground all equipment.

4.4 FIRE PROTECTION SYSTEM

A. Contractor shall provide a complete fire protection system in accordance with the recommendations and requirements of NFPA, UL, FM, and the local Fire Marshall. The systems shall receive the approval of the Owner's insurance carrier.

B. The engineer responsible for the fire protection system shall be a practicing fire protection engineer registered as a Professional Engineer in the state of the Project location. All drawings and specifications shall be signed and sealed by the Professional Engineer.

C. The fire protection and detection systems requirements for specific plant locations are summarized in Table 5-1.

D. Portable fire extinguishers shall be provided in all areas requiring handheld fire protection.

E. All local alarms shall report status to the SCADA System.

F. Fire walls for oil-filled transformers shall be provided between transformers and adjacent structures as required in accordance with Section 5.0 of NFPA 850.

G. General

1. Fire protection during plant construction shall meet requirements and recommendations of NFPA 241.

2. All fire protection systems are subject to the review and approval of the local fire department authorities.

~~(e)~~ **TABLE 5-1**

Plant Fire Protection and Detection Systems

Plant Location	Type of Fire Protection	Fire Detection
Control House(s)	Handheld extinguishers*	Smoke/heat detectors
Transformer(s)	Fire walls if required by NFPA	Fire walls

(*) or as required by local Fire Marshal

5.0 SITE WORK

5.1 GENERAL REQUIREMENTS

A. This section covers the minimum scope and quality for the plant civil design and construction.

B. Contractor is responsible to inspect the Site, obtain all necessary Site data, and determine all Site data for the design and construction of the Project. This shall include determination of local code requirements for seismic and wind design loads.

C. The scope shall include, but not be limited to the following:

1. Clearing and grubbing.
2. All subgrade preparation.
3. Dust control, including furnishing construction water.
4. Drainage during construction.
5. Permanent drainage system.
6. Construction wastewater and storm water disposal.
7. Final Site grading.
8. Construction of all foundations and structures.
9. Roads (permanent and temporary construction).
10. Temporary parking and laydown areas.
11. Site Security (permanent and temporary fencing including gates, card readers, and cameras as required).
12. Revegetation of disturbed areas.
13. Off-site rRoad iImprovements and repair (if required to transport or receive equipment or if required as a result of construction work).

D. The Project design shall take into account existing site conditions with respect to soil characteristics, site clearing, grading, and drainage. Contractor shall be responsible for all site preparation including any demolition, soil stabilization, grading, drainage, roadways, and temporary parking areas.

5.2 UNITS

A. All design dimensions and design calculations shall be in United States Customary units.

5.3 GEOTECHNICAL

A. Contractor's final design shall be based on the recommendations of Contractor's geotechnical investigation and report.

B. If subsurface conditions are encountered at the site are inconsistent with the data found in the Contractor's geotechnical report, additional subsurface data shall be gathered and evaluated at Contractor's expense. Any subsurface anomalies discovered by Contractor shall be reported immediately to the Owner.

5.4 SITE PREPARATION AND MAINTENANCE

A. Contractor shall be responsible for all Site preparation, backfill, and excavation. Cut and fill for the entire site, including storm water ponds (if necessary), shall be managed by Contractor. Contractor shall clean permanent site drainage system components immediately prior to Substantial Completion.

B. Site Preparation:

1. Contractor shall design and specify site grading to include all trench excavation for underground utilities which includes electrical duct banks. The Site shall be properly leveled with no construction debris or dirt piles. Contractor may store native material on Site that is suitable for use as backfill or topsoil.
2. Installation of all Site construction utilities shall be planned and constructed by Contractor. Location shall be approved by Owner.

C. Site Clearing and Grubbing:

1. Completely clear the Site of all trees, debris, rubbish, shrubs and vegetation as required for construction of new facilities. All debris from clearing and grubbing shall be removed from the Site. All root mats and stumps shall be completely removed and holes refilled with engineered fill material and compacted adequately for the ultimate expected loading for the material used.

D. Debris:

1. All construction-related debris and unsuitable material shall become the immediate property of Contractor and shall be removed from the premises and lawfully disposed of off-Site by Contractor at Contractor's cost.

E. Erosion:

1. Contractor shall prepare a Storm Water Pollution Prevention Plan (SWPPP) for their construction activities. Contractor shall be responsible for maintaining the storm water controls and best management practices. Contractor shall provide for sediment and erosion control during and after construction in accordance with project permits and local and state laws and regulations. Best management practices such as check dams and sedimentation basins shall be used during construction to minimize erosion. Drainage facilities shall be designed and constructed in a manner to minimize erosion.

F. Road Maintenance:

1. All access roadways used by Contractor shall be maintained in serviceable condition. Contractor shall keep the surfaces of those roadways free from spills, mounds, depressions, and obstructions, which might present a hazard or annoyance to traffic.
2. Contractor shall be responsible for securing authorization and permits to transport oversized/overweight loads on local, County, and State roads for the supply of materials under Contractor's scope. Contractor shall supply and install any temporary or permanent facilities required to facilitate delivery of these equipment/materials. Contractor shall also be responsible for removing all such temporary facilities.

G. Signs and Barricades

1. Signs and barricades shall be provided and maintained by Contractor and shall be in accordance with jurisdictional regulations for accident prevention and Contractor's Safety Plan.

H. Dust Control

1. Dust Control for Construction Activities

a. Contractor shall be responsible for dust control for the Work. Contractor shall prevent the spread of dust during its operations. Contractor shall moisten all surfaces with water to reduce the risk of dust becoming a nuisance to the public and neighbors. Contractor shall furnish labor and equipment necessary for dust control including tank trucks and hoses to apply the water. Contractor shall be responsible for compliance with State and local requirements for fugitive dust emissions and shall obtain local authority approvals and conform to the dust control regulations. Contractor shall conform to all requirements of the applicable permits.

I. Open Burning

1. Onsite open burning is not permitted.

J. Excavation, Filling, and Backfilling

1. Excavated native material may be used on the construction Site for embankment and backfill, if suitable. All unsuitable materials such as rock, concrete, wood, metal, and other materials from the excavation shall be considered debris and disposed of as described herein.

2. Structural fill, bedding material, topsoil, and other materials not readily available on Site shall be procured, tested, and delivered to the Site by Contractor. All materials brought to site shall be reviewed and approved by Engineer of Record prior to delivery.

3. Contractor shall be solely responsible for maintaining the stability of all excavated faces and shall provide adequate sheeting, shoring, and bracing to support any lateral earth pressure.

4. Contactor shall be solely responsible to protect personnel and adjacent structures against any damage from cave-ins, heaving or other earth movements. Sheeting, shoring, and bracing shall be removed as backfilling proceeds or it may, with the approval of Owner, be left fully or partially in place.

5. Fill characteristics and compaction requirements shall be determined by the geotechnical investigation and report recommendations.

6. Site dewatering during construction is the responsibility of Contractor.

a. Contractor shall follow all requirements of the SWPPP when removing water from excavations.

b. Contractor shall, at a minimum, check groundwater and stormwater visually and olfactorily (by odor) for contaminants such as oil and grease prior to pumping.

K. Site Grading and Drainage

1. Design and prepare the construction plans, final design reports, and project specifications for the civil site work, including the storm water

1. drainage, grading, roads, temporary construction facilities, etc. All must meet the approvals of the Owner and jurisdictional government agencies.

5.5 SITE IMPROVEMENTS

A. Paving and fencing improvements shall be in accordance with the Site plan.

B. Storm Water Drainage System

1. Design and prepare the construction plans, final design reports, and project specifications for the civil site work, including the storm water drainage, grading, roads, temporary construction facilities, etc. All must meet the approvals of the Owner and jurisdictional government agencies.

C. Duct Banks

1. Underground banks of power and instrument conduit shall be encased in concrete. Encasements shall be reinforced to withstand AASHTO HS20 loading at roadway crossings and non-paved equipment access areas susceptible to damage by cranes, trucks, etc. Refer to Section 7.1.C.3 of this document for required compressive strength of concrete encasement. The concrete at the top of the duct bank shall be colored red.

D. Crushed Stone Surfacing

1. Crushed rock surfacing within the substation fence shall be 4 inches thick with a resistivity of 3000 ohm-meters. Crushed rock shall conform to ASTM C33, gradation 1-1/2 to No. 8 particles.

E. Roads and Parking

1. Subgrade preparation and compaction shall be in accordance with sound geotechnical engineering practice and as recommended by the geotechnical investigation and report.

2. Roadways and driveways areas shall be designed for AASHTO HS20 loading as a minimum. The laydown areas shall also be designed with consideration for concentrated loading due to handling of heavy loads.

3. Except as noted herein, no off-site road improvements are included unless required by Contractor for access or damaged by Contractor during construction.

5.6 ROADS

A. Two access points to the Solar Substation shall be provided.

5.7 FENCE

A. Refer to PGE Exhibit M1-01-07 for Owner security requirements.

B. Contractor shall repair and/or replace fencing damaged by construction activities.

5.8 GATES:

A. Refer to PGE Exhibit M1-01-07 for Owner security requirements.

5.9 BOLLARDS

A. Buildings, electrical enclosures and equipment adjacent to traffic areas shall be protected with minimum 6" diameter steel pipe guard post painted yellow. Guard post shall be minimum height of 42" above finished grade, and 36” below finished grade. Post shall be set in 18” minimum diameter hole filled with concrete. Post shall be filled with concrete.

6.0 STRUCTURAL

6.1 MATERIALS

A. Steel

1. Design of structural and miscellaneous steel shall be in accordance with the American Institute of Steel Construction (AISC) “Manual of Steel Construction”. Design of structural and miscellaneous steel shall also be in accordance with the American Society of Civil Engineers (ASCE) “Substation Structure Design Guide, Manual of Practice 113”; NEMA TT1

2. – Design of Tapered Tubular Steel Structures; “Design of Steel Transmission Pole Structures”, ASCE/SEI 48; Minimum Design Loads for Buildings and Other Structures”, ASCE/SEI 7; and the International Code Council “International Building Code”. Seismic design shall be in accordance with the Institute of Electrical and Electronics Engineers (IEEE) “IEEE Recommended Practice for Seismic Design of Substations”, IEEE 693.

~~2.~~3. Materials for structural steel and miscellaneous steel shall conform to the following requirements of the American Society for Testing and Materials:

a. Wide Flange (WF) Shapes and Tees cut from WF: ASTM A992, Grade 50 or multi-certification A36/A572, Grade 50.

b. M shapes, S shapes, HP (Bearing Piles), Channels, and Angles:

c. ASTM A36

~~c.~~d. Structural Plates and Bars: ASTM A36

~~d.~~e. Square/Rectangular Hollow Structural Sections (HHS): ASTM A500 Grade B

~~e.~~f. Tubular – a structure composed of closed sections (tubes) of circular, multi-sided, or elliptical cross section and tapered or untapered: NEAM TT1

~~f.~~g. Pipe: A53, Grade B

~~3.~~4. High strength bolts, nuts, and washers shall conform to ASTM A325, ASTM A563, and ASTM F436 respectively and shall be galvanized in accordance with ASTM A153.

~~4.~~5. Bolts, nuts and washers under one-half inch in diameter shall conform to ASTM A307, Grade B, ASTM A563 and ASTM F844 respectively and shall be galvanized in accordance with ASTM A153.

~~5.~~6. Anchor bolts, anchor bolt assemblies and concrete embedments shall be galvanized in accordance with ASTM A153.

~~6.~~7. Anchor bolts shall conform to ASTM A449, ASTM F1554, Grade 36, or A307.

~~7.~~8. All structural welding shall conform to the requirements of AWS D1.1.

~~8.~~9. Galvanizing, as specified herein, shall conform to the requirements of ASTM A123, ASTM A143 and ASTM A153 as applicable.

~~9.~~10. Stainless steel shall conform to ASTM A167.

B. Aluminum

1. Design of structural and miscellaneous aluminum shall be in accordance with the latest version of the Aluminum Association – “Aluminum Design Manual” and “Aluminum Standards and Data”.

2. Materials for structural and miscellaneous aluminum, including structural shapes and plate, shall conform to ASTM B209 and ASTM B308 and shall be aluminum alloy 6061-T6.

3. Bolts and nuts shall conform to ASTM F468 and ASTM F467, respectively and shall be aluminum alloy 6061-T6. Washers shall be aluminum-clad steel Alclad 2024-T4 or approved equal.

C. Concrete

1. Design of structural concrete shall be in accordance with the latest version of the American Concrete Institute (ACI) - "Building Code Requirements for Structural Concrete," ACI 318. All concrete formwork shall conform to ACI 347.

2. Concrete mix proportions, including documentation of materials, admixture product information, and compressive strength of mix, shall be submitted, and approved by the Owner prior to placing concrete.

3. Minimum concrete strength classes for various structures shall be as follows:

Item	Minimum Ultimate Compressive Strength (psi) (at 28 Days)
Electrical Ductbanks	3,000
Major equipment/structures where required and all other construction	4,000

4. Reinforcing bars shall be deformed bars conforming to ASTM A615, Grade 60. Welded wire fabric shall conform to ASTM A185. Plain wire shall conform to ASTM A82. Placement shall be in accordance with Chapters 7 and 12 of ACI 318 and the Manual of Standard Practice of The Concrete Reinforcing Steel Institute.
5. Cement shall be Portland cement conforming to ASTM C150, Type I or Type II or as recommended by the Engineer of Record.
6. Aggregates for normal weight concrete shall conform to ASTM C33.
7. Slump of concrete used for substation foundations shall be 4 inches plus or minus 1 inch, unless otherwise noted.
8. All foundations shall extend a minimum of 6 inches above the adjacent finish grade.
9. All concrete trucks may be rinsed out on-site. Rinse material shall be properly disposed of off-site.

6.2 STRUCTURAL LOADING

A. Contractor shall determine all Site data for the design and construction of the plant. This shall include determination of local code requirements for seismic and wind design loads. It is the Contractor's sole responsibility to ensure that the plant structural and architectural facilities comply with all federal, state, and local code requirements and all industry codes and standards. Occupancy Category III shall be used for all structural loading in the design of this plant.

B. Dead Loads

1. Dead loads shall include all vertical loads due to weight of permanent structural and nonstructural components, including permanent hung loads.

C. Live Loads

1. Live loads shall be in accordance with the International Building Code as modified by the applicable Local Additions and Addenda Agency.

D. Snow Loads

1. Snow loads shall be in accordance with the International Building Code as modified by the applicable Local Additions and Addenda Agency.

2. Snow drift shall be evaluated and considered in the design.

E. Wind Loads

1. Wind loads shall be in accordance with the International Building Code as modified by the applicable Local Additions and Addenda Agency.

F. Seismic Loads

1. Seismic loads shall be in accordance with the International Building Code as modified by the applicable Local Additions and Addenda Agency. The soil profile type shall be determined by Contractor based on the results of Contractor's subsurface investigation.

G. Thermal Loads

1. Buildings and structures shall be designed for forces and/or movements resulting from changes in temperature. Induced thermal loads (i.e., thermal loads induced by equipment operating temperatures) shall be considered in design of applicable structural elements.

H. Vehicle Loads

1. Design loading, for areas accessible to trucks, shall be (AASHTO) HS20.

I. Soil and Hydrostatic Pressure Loads

1. Earth pressure and hydrostatic pressure loads shall be based on the geotechnical conditions and groundwater levels at the project site.

J. Gen-tie Line Loads

1. In addition to the aforementioned loading criteria, overhead gen-tie line loads shall also conform to ASCE Manuals and Reports on Engineering Practice No. 74 "Guidelines for Electrical Transmission Line Structural Loading" and to NESC requirements.

K. Load Combinations

1. Load combinations shall be in accordance with the International Building Code as modified by the applicable Local Additions and Addenda Agency.

6.3 STRUCTURAL FOUNDATIONS

A. Type of foundations required and allowable bearing values for soil and rock shall be as recommended by the geotechnical engineer based on the subsurface conditions found in Contractor's geotechnical report. All loose materials shall be removed from excavation bottoms. Unsatisfactory foundation subgrade material shall be removed and replaced with compacted structural fill material or with 2000 psi concrete. Total foundation settlements will be limited

A. to 1 inch or as required by applicable building or industry codes, and equipment supplier's recommendations.

B. Building and Equipment Foundations

1. Building and equipment foundations shall be of reinforced concrete and their construction shall incorporate formwork, appropriately sized and configured rebar, waterstops, expansion joints, etc.

C. Transformer Foundation and Containment

1. Transformers shall be provided with secondary oil containment equal to 110% of the volume of oil present in the transformer.

6.4 CORROSION PROTECTION

A. Stainless steel and galvanized steel shall not be painted.

6.5 SOLAR SUBSTATION CONTROL BUILDING

A. The Solar Substation control building shall contain relay and communications panels, telecommunication panel, an RTU, station service equipment, and other items associated with the Project including any required utility/ISO equipment.

B. To reduce site congestion, building shall be delivered as a single, completely assembled unit to the greatest extent practical. Contractor will unload and place on foundation.

C. Roof and supporting structure shall be designed for minimum 30 psf uniformly distributed load plus a 200-pound concentrated load over a 1'x1' area located anywhere on the roof surface plus any interior loads imposed by suspended equipment or cable tray. For wind and uplift loads, structure and anchorage shall be designed for 100-mph winds. Floors shall be designed for a minimum of 150 psf loading. Design for loading of battery rack; batteries; charger; electrical equipment and raceways; heating, ventilating, and air conditioning equipment; relay switchboards; and transformers, lighting, and other miscellaneous items as required.

D. The enclosure base shall be all welded steel frame construction. The enclosure floor shall be a minimum of 3/16-inch steel plate welded to the base. Provide special anchoring and support members under the battery racks and relay control panels. The floor shall be finished with a non-skid coating. The floor and walls shall be insulated to a minimum R11 value. Provide a bottom plate to enclose and protect the insulation. The entire enclosure shall be framed with an equivalent of three (3) inch square tubular steel. All openings, such as doors, windows, etc., shall be similarly framed with three-inch square tubular steel or structural equivalent. The height from floor to ceiling shall be ten (10) feet minimum

E. The exterior and interior walls shall be a minimum of 16 gauge paint quality galvanized steel. The walls shall be designed and assembled to allow for future lateral expansion of the enclosure. Interior walls and supporting panels shall be

E. designed so that interior loads of 400 pounds per linear foot of wall length may be attached to the wall without compromising the design wind loads. If additional reinforcement is required to mount equipment, the manufacturer may use Unistrut or equivalent.

F. The exterior of the roof shall be 16 gauge paint quality galvanized steel panels. The roof shall be sloped away from door openings, at a 2-degree pitch, to allow for adequate drainage. The roof shall be designed to support interior loads of 100 pounds per linear foot of truss length without compromising the roof design load. Screened, louvered ventilation openings shall be provided, to prevent condensation in attic space. The ceiling shall consist of formed 16 gauge paint quality galvanized steel panels. It shall be designed to retain the insulation and to provide a smooth ceiling surface. Ceiling shall be insulated to a minimum value of R30. Interior ceiling and supporting structure shall be designed so that interior loads of 100 pounds per linear foot of truss length may be suspended from the ceiling without compromising the specified roof design load. Design for additional load, as required, to support cable tray, lighting, conduits, and other items provided by this Contract.

G. The enclosure shall have two (2) separate 16 gauge heavy-duty steel doors; one (1) 36 by 84 inch and one (1) 72 by 96 inch with removable transom. The doors shall be equipped with low profile panic-type door hardware and an automatic door closer. A drip shield shall be provided above all doors. Each set of door hinges shall include one entry alarm hinge comprised of an integral SPST electric switch rated 125VDC. Contractor shall provide and terminate a two-wire circuit from each alarm hinge to the RTU.

H. The room-type heat/cool air conditioners shall be sized and provided by the Contractor based on the heat loads and cooling loads. Consideration shall be given to the ambient site conditions, the dimensions and heat retention of the enclosure building, and the heat dissipated by the control/monitoring equipment inside the building. Equipment shall be capable of maintaining a building temperature of not more than 75 degree F for cooling and not less than 65 degree F for heating. Contractor shall provide calculations of heating and cooling capacity requirements. Furnish and install one staging thermostat with two-stage heat and two-stage cooling that cycles equipment of both heating and cooling stages. Air conditioning and heating shall have 100% redundancy.

I. Interior lighting shall consist of fluorescent lights that provide 40 foot candles of light at a level three feet above the floor. Lighting shall be controlled by heavy- duty 3-way switches located near each door. Lighting locations indicated on Contract drawings shall be modified to meet illumination requirements. External lighting shall be provided above each personnel door with automatic operation provided by a photo-electrically controlled lighting contactor. Provide 100 watt, enclosed, weatherproof, heavy-duty high-pressure sodium fixtures. Emergency lighting shall consist of self-contained, battery powered units with two illuminating heads. The units shall switch-on automatically upon loss of AC power, shall provide 1.5 hours of continuous illumination, and shall recharge when AC power is resumed. Duplex receptacles, polarized, arc resistant,

I. specification grade, shall be rated 120V AC, 20A. Lighting contactors and switches shall also be provided for all yard lighting.

J. Provide cable risers to extend from yard cable trench and duct bank to cable entrance wall openings to access the building cable tray. A generation interface junction box containing terminal blocks shall be integral to one of the cable risers. Risers shall be designed and sealed to prevent infiltration of water, snow, dust, and animals into the cabinet or building. Cabinet shall be constructed of corrosion-resistant aluminum or stainless steel and meet or exceed NEMA standards. Risers shall be provided with removable, gasketed covers to accommodate easy access for cable installation and termination.

K. Provide wall mounted exhaust fans sized and located as required to provide proper ventilation for the selected battery arrangement. Provide a gravity intake damper with an exterior weather hood associated with each exhaust fan. Provide exhaust fan on/off toggle switches to control the exhaust fans and intake dampers

L. Furnish and install AC panelboards sized as required and located generally as shown on the drawings. Furnish and install all cable tray as shown on the drawings. Furnish and install conduit and wireways as necessary to wire the control building. Provide an automatic transfer switch for the incoming station service sources to allow immediate restoration of AC service in the event of loss of the primary station service source. provide safety switches for AC and DC systems. Provide station service transformers for 208V three-phase service.

M. Provide a battery system as described in Section 4.

N. Furnish and install one combination smoke and heat detector unit with one normally open and one normally closed alarm contact rated 5A at 125V DC. Provide LED or fluorescent illuminated exit signs above each door. Provide an appropriate eye wash station, a dry chemical fire extinguisher (ABC rated), and other items required or indicated for a complete building system.

7.0 GEN-TIE LINE (AS APPLICABLE)

7.1 INTRODUCTION

A. Section 8 of M3-01-02 shall form the technical basis for the design, material procurement, and construction of the Gen-Tie line between the Solar

A. Substation to POI.

7.2 GENERAL

7.2

A. A new single circuit XXX kV Gen-Tie line, to be installed on existing self-

B. supporting tubular steel poles (or Owner approved structures), shall begin at

C. the Solar Substation and terminate at the POI or Point of Change of Ownership as defined in the Interconnection Agreement.

B.D. Contractor shall be responsible for the following:

1. Perform Gen-Tie line engineering, analysis, and design.
2. Prepare a complete construction package to include the following: final plan and profile drawings, sag charts, complete bills of material, structure foundation drawings, structure erection drawings, insulator and hardware assembly drawings, right-of-way constraints, outage constraints with complete schedule, and construction technical provisions.
3. Procure equipment and material.
4. Receive, inventory, store, and protect equipment and material.
5. Install the line.
6. Test and commission.
7. Prepare as-constructed documents, which shall include the gen-tie facilities, right-of-way widths, easement areas, fences and gates, and labeling of all major roads and points of interest in both AutoCAD and pdf formats.

~~C.~~E. It shall be Contractor's responsibility to complete all tasks necessary to provide Owner with a complete and fully functional Gen-Tie line facility that meets all Owner's standards and specifications, including the Interconnection Agreement.

~~D.~~F. Contractor shall review and comply with all permit requirements and stipulations.

7.3 GEN-TIE LINE ENGINEERING AND DESIGN

A. General Requirements.

1. The design specifications and drawing requirements provided or referenced in this document are to be considered as minimum requirements. Any criteria not specifically addressed in this specification shall as a minimum meet or exceed the requirement of the current edition of the National Electric Safety Code (NESC) C2.
2. Contractor shall use PLS-CADD software to spot and perform detailed analysis and design of the gen-tie line.
3. Gen-tie shall fit within defined right-of-way while adhering to all NERC and NESC regulations.

B. Survey.

1. The survey firm is responsible for establishing a ground control network and collecting controlled, color, digital, ortho-rectified photography and terrain data. The survey firm is also responsible for processing the raw data and delivering a digital elevation model in a format readily imported into PLS-CADD.
2. Contractor shall be responsible for identifying and obtaining any additional survey data needed for design.

C. Geotechnical.

1. Contractor shall be responsible for obtaining all geotechnical data needed for foundation design.

D. Loading Conditions and Load Cases: For evaluation of existing gen-tie poles and design of new poles:

1. Contractor shall apply the load cases and load factors appropriately for Gen-Tie poles according to NESC 250 as applicable for tangent and dead end structures.
2. Maximum Deflection at the pole tip shall be limited to the 1% of the total structure length.
3. The structure shall be designed and analyzed for any combination of intact and/or dead-ended wires that result in the highest stress in the pole.
4. The construction load case shall incorporate any and all loading conditions which may occur as a result of wire stringing and/or other construction activities.

E. Wire Tension Limits.

1. Tensions shall be limited to protect conductor against damage due to vibration.
2. Stringing tensions for the ADSS/OPGW shall not exceed 20% of the ultimate cable strength.
3. Wire tension limits for design of the conductor, shield wire, and ADSS OPGW shall be based on applicable weather cases (wind, ice, temperature).
4. Vibration Protection.
5. Contractor shall consider and design all wire systems (OPGW,ADSS, shield wire, and conductor) to prevent wire damage due to Aeolian vibration.
6. Contractor shall incorporate manufacturer (wire and damper manufacturers) recommendations.

F. Structure Loading and Electrical Clearances.

1. Contractor shall be responsible for wiring on the existing structures such that electrical clearance requirements are met and design loads are not exceeded.
2. Calculation of the design loads is the responsibility of the Contractor.

G. Phasing.

1. Phasing shall be determined in the field by the Contractor.
2. Phasing shall be placed on the Plan & Profile Drawings.

7.4 MATERIAL

A. Material shall be of new manufacture and unused and be free of defects and irregularities.

B. All assemblies, hardware, and components of assemblies shall be designed to meet the strength requirements of most recent edition of NESC C2.

C. Contractor shall verify that all material, assemblies, hardware, and components of assemblies meet the strength requirements for the application and intended use.

D. Any piece of hardware in an insulator assembly must at a minimum match the ultimate strength of the insulator.

E. Corona-free hardware shall be used.

F. Galvanized steel shield wire shall be ½ inch extra high strength (EHS) steel.

G. Optical ground wire (OPGW) shall be 48 ~~24~~-fiber OPGW or as specified in the Interconnection Agreement.

~~G.~~H. ADSS fiber will be 144cnt or as specified in the interconnection agreement

~~H.~~I. If conductors are bundled horizontally, Contractor shall install spacers per conductor and spacer manufacturer's recommendations.

~~I.~~J. Mid-span spacers are not required for vertically bundled conductors.

~~J.~~K. Contractor shall be responsible for design of the jumper assemblies such that all electrical clearances are maintained.

7.5 CONSTRUCTION

A. Contractor shall prepare, compile, issue, and update a construction specification for the work described in Section 8 of M3-01-02.

B. Contractor shall procure material and construct the gen-tie line such that, when in operation, does not cause nuisance audible noise or radio or television interference.

C. Contractor shall make all reasonable efforts to minimize all damages due to construction activities.

D. Contractor shall be responsible for preparing and acquiring all crossing permits from the owners of the foreign overhead or underground facilities crossed.

E. Contractor shall be responsible for preparing and acquiring all construction access permits from the state and local agencies with jurisdiction.

F. Contractor shall be responsible for preparing and acquiring all stormwater construction permits.

G. All temporary openings in fences created by the Contractor shall be removed and the fence repaired when access is no longer required. Contractor shall be held responsible for damage to crops, livestock, or other property resulting from failure to keep fences, gates, or fence gaps in proper condition.

H. Contractor shall be responsible for grounding all fences and structures along the gen-tie route.

I. Contractor shall repair and restore the right-of-way and clean up each structure location to the satisfaction of the Owner and the landowner/tenant. All earthwork, culverts, bridges, and drainage structures constructed by the Contractor shall be removed when no longer required.

J. All parts of the structure shall be purchased and installed by the Contractor.

K. Conductor, shield wire, and/or OPGW shall be installed in accordance with "IEEE Guide to the Installation of Overhead Transmission Line Conductors", Std. No. 524.

~~K.~~L. All aerial ADSS fiber shall be installed per NESC rule 235.

8.0 SECURITY PERFORMANCE GUIDELINES

8.1 REFER TO PGE EXHIBIT M1-01-07 FOR OWNER SECURITY REQUIREMENTS.

8.2 SECURITY LIGHTING

A. Basic security lighting shall be provided to assist in maintaining acceptable levels of facility protection. This includes, but is not limited to, lighting at entrance gates, employee entrances, building entrances, employee parking areas, and areas around the building perimeter.

B. Boundary lighting must consist of a series of fixed lights to light the boundary or area from which an intruder could approach.

C. Area lighting shall supplement existing street lighting to provide a maximum level of illumination from a minimum number of fixtures. The system shall be designed to illuminate the entire area evenly, including doorways, structures and all opening into the structures.

D. Lighting shall be provided to cover the building faces evenly. Doorways and other openings in the building must be lighted to eliminate shadows.

E. Pedestrian and vehicle entrances that are actively used are to be provided with sufficient illumination to permit recognition of individuals and examination of credentials. All vehicle entrances must be lighted so that the entire vehicle, occupants, and contents can be viewed. Doorways and other recesses must be lighted to eliminate shadows.

F. Lighting Minimum Requirements:

Location	Minimum Foot-Candles (fc) on a Horizontal Plane at Ground Level
Vehicular entrances***	1.0**
Pedestrian entrances	2.0
Security-sensitive site areas	2.0
Employee parking and maneuvering areas	1.0**

* Lighting should be directed inward from the property line.
** Lighting must be increased to 2 fc if an exterior security CCTV system is provided. This is based on the worst-case or reflective light conditions (asphalt).
*** Lighting must be increased as necessary to allow proper identification of the individuals in the vehicle.

G. Contractor must document security lighting requirements by providing a point- by-point, computerized photometric plan or other method that demonstrates that appropriate lighting has been planned.

H. Alternate circuitry must be used in the power circuits so that the failure of any one lamp does not leave a large portion of either the site perimeter or critical or vulnerable area in darkness.

8.3 BUILDING UTILITIES

A. To the extent possible, all utilities associated with the Security Performance Requirements are to be run underground. All circuits must be run in conduit.

8.4 ELECTRONIC SECURITY SYSTEM (EXTERIOR DESIGN)

A. The exterior security system encompasses the required exterior lighting and fencing with top guard as well as all exterior electronic security equipment (i.e. access control, intrusion detection, and CCTV).

B. When the electronic system is required there must be sufficient lighting throughout the site so that the cameras can operate effectively and record the required information. The electrical and the security systems architects or engineers shall coordinate their efforts. If there are areas of concern, e.g., lack of or limited coverage, alternatives or additional camera locations shall be approved by Owner.

8.5 SECURITY CCTV SYSTEM

A. The security CCTV system consists of CCTV cameras housings, video and power cable, control panel, switchers, multiplexers, monitors and recorders. The system must be designed so that it is capable of recording and being monitored 24 hours per day, 7 days per week.

B. The security cameras shall provide a color picture, have an automatic iris and pan-tilt-zoom (PTZ) control lens, and, if for exterior use, installed in environmentally controlled, domed housings. The domes must be designed to eliminate the ability to observe the camera operation and location from inside the dome.

C. The entire substation area shall be covered by the CCTV system without any areas being blocked or obscured by substation equipment and/or structures. The entire exterior of the O&M Building shall be covered without being blocked or screened by any equipment and/or structures.

D. The cameras shall be mounted on light poles when possible. The camera's lens configuration shall be able to provide identifiable personnel images as well as read license plates and numbers. A separate camera coverage drawing showing camera placement as well as the focal distance and arcs for each camera shall be submitted to the Owner at a design review meeting.

E. The CCVT System shall be provided with an operator interface in the control room.

9.0 TESTING, COMMISSIONING, AND PROJECT ACCEPTANCE

9.1 See M3-01-04 for requirements of Field Testing, Functional Testing, and Commissioning. All commissioning and testing shall be coordinated with the Utility.

10.0 PROJECT AND CONSTRUCTION MANAGEMENT

10.1 STAFFING

A. Contractor shall provide the appropriate personnel to manage all aspects of the Work.

B. Contractor shall ensure an OSHA "competent" person be present during all work hours.

C. Contractor may work on Site at any time subject to Applicable Laws.

10.2 REPORTING/MEETINGS

A. Contractor shall provide progress and schedule reporting on a weekly basis. A two-week look ahead of activities shall be provided at weekly reoccurring meetings with the Owner, Contractor and Contractor's subcontractors.

B. Progress meetings shall be held at the Site on a monthly basis on dates mutually agreeable to Owner and Contractor.

10.3 SAFETY PLAN

A. Contractor shall maintain a Safety Plan and observe all safety practices required for performing construction work of this type including OSHA standards and adherence to Owner standards.

10.4 WORK SCHEDULE

A. Contractor shall submit a detailed critical path schedule using Primavera P6 or similar mutually agreed upon project management software which also meets the requirements of the Agreement.

B. The Work Schedule shall be updated monthly against the baseline schedule and submitted to Owner in its native and .pdf file formats.

B.

~~M3-01-04~~

APPENDIX M3
-ATTACHMENT 01
EXHIBIT 04

~~(a)~~ SOLAR PHOTOVOLTAIC PLANT SPECIFICATION COMMISSIONING

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

2025~~3~~

REQUEST FOR PROPOSAL

NO.	DATE	REVISION	BY	CHK'D	APPROVALS	
0	14Apr23	Issued for Implementation	1898 & Co.	PGE	CPA	Craig Armstrong

1.1.21.0 1.0 OVERVIEW - COMMISSIONING

The Commissioning process provides a quality-oriented methodology for verifying and documenting the design, construction, functionality, and performance of the Project. The commissioning process shall ensure that all system components perform interactively to meet the defined system objectives and criteria of the Owner, as established in the EPC Agreement and its attachments.

The Commissioning representative to be used by the Contractor must be proposed to Owner as part of Commissioning Plan and agreed upon by Owner before start of work.

2.0 SCOPE

All commissioning activities shall be executed under a phased approach, as identified below. Activities of each phase shall be documented and submitted to the Owner for review, acceptance, and documentation:

2.1 DESIGN PHASE

A. Design Review: Design review is part of the Commissioning process. The Contractor shall provide regular design reviews with the Owner to ensure the Owner's project requirements are being met. There is to be a Conceptual Design Review at the launch of the project (LNTP) and at each of the design package milestones of the Construction Drawings (refer to Agreement). The Commissioning team will participate in later phases of the reviews.

B. Commissioning Plan: A project-specific Commissioning Plan shall be developed and issued by the Contractor. The Plan shall outline the proposed personnel and/or company, tasks, processes, procedures, and deliverables required to prove the function and performance of the Project and all ~~of~~ its systems. It will include a section on Deficiencies and Resolution Procedures for each phase and the Commissioning Schedule. The Plan shall also reference safety requirements for start-up and commissioning, including electrical safety and lock-out/tag-out procedures. The Plan shall be submitted to the Owner for review and approval. The plan shall include example forms for each commissioning activity that clearly state the pass/fail criteria, the individual(s) performing the test, the date and time of the test and the results of the test.

C. Commissioning Specifications: Commissioning specifications shall be provided by the Contractor to outline the requirements for the installing contractors.

D. Commissioning Review: A commissioning review of the design drawings shall be performed by the Contractor and shall address design fundamentals for reliability, maintainability, and commission ability (e.g., design, location, and quantity of primary and secondary measurement devices)

E. Commissioning Log: A detailed commissioning log will be developed and issued by the Contractor for the tracking of all commissioning issues, observations, and deficiencies. The commissioning log will enable current status and resolution tracking of any open items. The log will be ~~circulated to the project team~~provided to the Owner ~~on a regular basis~~weekly for review.

2.2 CONSTRUCTION PHASE

A. Meetings: Commissioning meetings will be held on-site on a periodic basis. A commissioning kick-off meeting will be held with the Commissioning Tproject team at the commencement of project construction, or at least 30 days before commissioning. The Commissioning Team consists of, at a minimum, the Contractor's Commissioning Agent, project manager, design team representative, construction team representative, the Owner's project manager and project engineer.

B. Submittal Reviews: Approved equipment submittals shall be reviewed by the Contractor for compliance with the project design, intent and specifications.

C. Factory Acceptance Tests:

1. The following PV equipment shall be tested for functionality, operability, and performance:
   - 1.a. Solar Modules (IEC 61215 tests and Flash Tests)
   - 2.b. Combiner Boxes (or Load Break Disconnects as applicable)DC combining system equipment and assemblies
   - 3.c. Inverter Skid Assemblies and components
   - 4.d. Solar Substation equipment (as applicable to Contractor scope)GSU
   - 5.e. SCADA system & instrumentation
   - 6. PV Trackering Systems
   - 7.f. MET Station
2. OWNER and OWNER'S ENGINEER shall be given the opportunity to witness each test and shall be given 15-day advance notice prior to any planned test. The related expenses for hosting the test(s) will be paid by the Contractor. Owner and/or OWNER Engineer's travel expense for attending factory acceptance testing will be paid by the Owner.
3. Refer to Attachment 1 of this document for the required factory tests on the inverter. Since inverter efficiency and other testing are impractical in the field, the Project requires more stringent testing in the factory. All testing results shall be fully documented and reported to Owner.

D. Pre-functional Checklists: Project and equipment-specific pre-functional checklists shall be developed and issued by Contractor to the installing contractors. The pre-functional checklists shall address proper installation methods, manufacturer's vendors' requirements, applicable codes and standards, and good engineering practice requirements. A master check list, with acceptance criteria, shall be included in the Commissioning Plan which is issued to the Owner. Pre-functional check-out of all systems shall be required as part of Mechanical Completion [refer to Agreement section for more definition].

~~E.~~ Inspections: Equipment delivery inspections shall be carried out by Contractor during ~~the course of~~ construction. Reports shall be issued for inspections of

E. inverter skids. This will include signatures of the responsible personnel and verification of proper installation of all equipment, devices, and wiring per the manufacturer's recommendations. This will also include observations and punch ~~–~~lists from Contractor's ~~g~~Quality ~~c~~Control personnel verifying installation that has occurred per their design drawings and specifications.

F. Functional Testing: There are two types of functional testing required:

1. Equipment-specific functional testing.

~~1. and 2)~~ PV Plant Functional Testing.

2.

3. The Contractor shall develop and execute ~~these~~ protocols for each of these to address~~will be developed and executed by Contractor to address~~ the functionality and safe operation of components and systems. The functional testing protocols shall be detailed ~~so as to~~to address operation, failure modes, and recovery modes.

~~2.~~4. Equipment-specific functional testing: The Project will consist of PV generation equipment and sub-systems: PV modules, DC wiring, combiner boxes or Load Break Disconnects (LBD), Inverter Skid Assemblies, trackers, and all associated structural elements and interconnecting cables that will allow the PV Plant to generate and deliver the AC power to the Project Point of Interconnection. Prior to energization, all NETA-ATS tests shall be completed including the following checks and testing, at a minimum:

a. Proper mechanical and electrical installation of the PV modules per tracker and module manufacturer requirements.~~.~~

b. Completion of the pre-functional tests of the PV Modules and DC collection system, including but not limited to:

~~b.~~• ~~s~~String level Open Circuit Voltage Testing, Operating Current Testing, IV Curve Tracing (to be performed on 1% of the strings, and to re-test strings that are outside acceptable tolerances), cable Megger Tests, Polarity Tests and Grounding Tests.

c. AC cabling Very Low Frequency (VLF) testing or Partial Discharge (PD) testing.

• Inspection and testing shall be performed after all splices and cable terminations have been installed. In all cases, the tested sections shall include all cable sizes and shall test the cable insulation, the terminations and the splices (if any) on the cable sections. The test shall be performed after cable terminations have been installed. Other test methods may be used subject to Owner approval, except that DC dielectric withstand testing shall not be used. If partial discharge testing (PD) is required, each of the MV collection system cables shall be tested in accordance with IEEE 400.3 and ICEA S-94-649.

c. • Include a documented sensitivity assessment performed in accordance with IEEE 400.3 on every cable system to assureensure the test results are comparable with IEEE and manufacturer levels. The design of the cable system shall consider the limitations of the required test methodology.

d. Proper installation and operation of the Inverter Skid Assemblies.

e. • Completion of Inverter pre-functional checks and functional tests per Contractor's commissioning protocols (Including phase rotation and synch checks, emergency and safety features). Inverters shall be checked for proper firmware, installation and connection of all components and systems such as fuses, capacitors, CTs, IGBTs, grounding, and cooling. All pre-functional checks shall be followed strictly per the manufacturer's instructions (Cold commissioning plans).

e. Inverters shall have no manual deratings and shall be set to default manufacturer nameplate ratings. Inverters shall have all settings at factory default settings unless required by Project and approved in writing by inverter manufacturer in advance.

f. Perform point to point test from the end of the furthest tracker torque tube in each tracker group to the inverter grounding electrode. Test results shall have no more than 1 ohm of resistance to earth, if the measured ground resistance exceeds this value, the Owner and Owner's Engineer shall be notified and shall assess if the results are acceptable.

g. Perform testing by the fall-of-potential method, in accordance with IEEE-81 and NETA-ATS section 7.13.B.2, at the locations below. Fall-of-Potential tests shall be completed on each ISA ground ring and similar ground rings or rods while such grounding systems are isolated from other grounds and before any underground grounding conductors are installed. Ground rings shall have no more than 5 ohms of resistance to earth and their resistance shall be compared with the values in the grounding study. If the measured ground resistance exceeds the value in the grounding study, the Owner and Owner's Engineer shall be notified and shall assess if the results are acceptable.

- Inverter ground ring.

f. • Sectionalizing Cabinet ground ring

g. ~~Grounding tests shall be completed for each system. Grounding path from inverter skid to tracker piles shall also be checked in each inverter array and not exceed [TBD] ohms.~~ Completion of the pre-

h. functional checks and functional tests of the inverter medium voltage transformers, including but not limited to Megger Tests, HI-POT Tests, Oil sampling tests (Dissolved Gas Analysis is required to be performed either in factory or field ~~in order to~~to establish a baseline), Grounding Tests, operation of alarm and indication sensors. Insulation resistance of windings and turns ratio test at all tap settings shall be performed in both the factory and the field by the inverter manufacturer.

~~h.~~i. Liquid filled transformers shall be tested per the transformer manufacturers' requirements where integrated into inverter skid. If liquid filled transformer is separate from the integrated inverter~~.~~ skid, ~~have the~~ following field testing requirements shall be completed:

- ~~i.~~• Verify nameplate data.
- ~~ii.~~• Coordinate and perform instrument transformer tests on CTs with transformer assembly.
- ~~iii.~~• Winding Tests:
  - ~~1.~~• TTR at all no-load taps.
  - ~~2.~~• Megger winding to ground.
  - ~~3.~~• Megger winding to winding.
- ~~iv.~~• Set high-side voltage taps at positions determined by Engineer of Record.
- ~~v.~~• Check and measure equipment ground; neutral to grounding grid resistance shall not be more than one ohm.
- ~~vi.~~• DGA:
  - ~~1.~~• Check insulating fluid for clear or pale amber color and report any variance to Owner. Other colors may indicate contamination from decomposition of insulation, foreign material, carbon, or other substances.
  - ~~2.~~• Test oil samples from each transformer with standards in accordance with ASTM D1816.
- ~~vii.~~• Check liquid level in tanks.
- ~~viii.~~• If equipped with cooling fan, check operation of cooling equipment and cooling controls before energizing transformer.
- ~~ix.~~• Check calibration of pressure relief device, top oil temperature gauge.
- ~~x.~~• Test all gauges including level, temperature, and pressure gauges.

~~i.~~j. Dry type transformers shall be tested per the transformer manufacturer's requirements where integrated into inverter skid. If liquid filled transformers are~~is~~ separate from the integrated inverter skid, ~~have~~ the following field~~-~~ testing requirements shall be met:

- ~~xi.~~• Verify nameplate data.
- ~~xii.~~• Winding tests:

1. TTR at all taps.
2. Megger winding to winding.
3. Megger winding to ground.
4. Winding resistance measurement on center tap
5. Partial discharge measurement

xiii. Check equipment ground to assure continuity of connections. Notify Owner if ground is more than one ohm.

xiv. Check for proper operation of the winding temperature gauge and cooling fans.

xv. Set high-side voltage taps at positions determined by Engineer.

xvi. Check connections for tightness; clean out dust and other foreign material.

j.k. Trackers: Verify trackers are fully functional per the manufacturer's requirements. Ensure they operate in unison and adjust angle accurately remaining normal to sun (in the E-W direction) even with clouds and reset to proper angles after stow or night; if required, back-tracking function works properly with no interior shading. Proper tracker stow shall be checked and wind and hail stow shall be verified.

k.l. Completion of the functional test of cable terminations in all electrical cabinets including switchgear (if applicable) per Contractor's commissioning protocols, including but not limited to PID or VLF testing, and Ddisconnect devices integrity and operability and, insulation test on each phase conductor with respect to phase to phase and phase to ground., verification of ratios of all VTs, and CTs, insulation resistance test of all VTs, CPTs, and CTs, polarity check of all CTs, verification of protective relay settings, secondary injection test.

l.m. Test plant controls to verify all control features are fully functional, including reactive power control (PF/VAR/voltage) and power curtailment.

m.n. All auxiliary systems and devices are installed and functionally tested.

n.o. Proper operation of the SCADA monitoring and control system. This includes all associated instrumentation, communications and controls between SCADA and other System Devices (e.g., Inverters), alarms, data acquisition and historian, and testing of the data links between Owner's systems and PV Plant SCADA.

o. Fiber loop feed shall be tested to verify a fully functioning fiber ring. Perform, including OTDR testing on each fiber strand (including spares).

p.

35. PV Plant Functional Testing

a. Plant Functional Testing is required on the entire electrical generation system prior to Substantial Completion [refer to Agreement section].

b. The Functional Test will ensure that a fully functioning PV Plant is commissioned and placed into automatic operation, including confirmation of the following systems: Inverters, trackers, auxiliary systems, transformers, SCADA, Power Plant Controller (PPC), MET stations, and other equipment. For substation testing refer to Attachment 2.

c. The Contractor shall develop a detailed plan to test the functionality of the PV Plant and submit to Owner for Owner's review and acceptance. Functional Testing shall be conducted by Contractor in accordance with the agreed upon Functional Test Plan.

d. The Functional Test Plan shall define and record the pre-test start condition of each Circuit, automatic start-up and shut-down of the inverters, trackers, auxiliary systems or devices, or any other automatic operation. Basic parameters that define such automatic operation shall be recorded as part of the test (e.g., Inverter Wake-up Voltage, shutdown, etc.)

e. Energization shall have been fully completed. There shall be no power curtailment or non-standard facility set points or settings, unless approved by Owner in writing in advance.

f. During the Test, as a minimum, the following operating parameters shall be captured of the Circuit of Project under test:

ii. • Irradiance

iii. • Ambient Temperature

iv. • Wind speed

v. • Inverter Voltage, Amperage (both DC and AC)

vi. • Inverter IGBT (measured at heat sink) Temperature

vii. • Power, Voltage, Amperage

viii. • Module Temperatures

ix. • Transformer temperatures and pressures and alarm status

x. • Tracker angle

xi. • All faults, alarms, errors, and warnings of all equipment

g. The Test shall be carried out for 120 hours without interruption or operator intervention under Normal Operating Conditions and emergency conditions shall be excluded. The Test shall maintain a 100% time-based availability of all equipment under test for the entire

g. duration of the Test. An allowance of one inverter's downtime for one hour will be allowed during the Test (for the avoidance of doubt, no downtime is allowed for a 2nd inverter). The Test shall provide 100% data availability for all equipment under test for the entire duration of the Test. Owner will consider allowing some secondary data reporting to be temporarily non-functioning such as angle of one tracker.

2.3 ACCEPTANCE PHASE

A. Capacity Testing: The performance of the PV Project and its components and systems shall be measured and documented pursuant to the procedures set forth in M3-01-05.

B. Aerial Thermographic Survey: An aerial survey of the plant shall be completed prior to Final Completion. The survey shall use infrared imagery with adequate resolution to identify hot spots in the individual modules, strings, and ISAs. A report summarizing the findings shall be submitted to Owner for review.

C. Training: Contractor shall provide a training program to the Owner, including classroom and field training. The training program will cover operational aspects of the Project. Refer to exhibit M3-01-11 for more information.

D. O&M Manuals: Contractor shall provide detailed and specific Operations and Maintenance (O&M) Manuals in mutually -agreed format. The O&M Manuals shall include, but not be limited to: System descriptions, method of plant operation, sequences of operation, troubleshooting procedures, maintenance procedures, as- built drawings, and all equipment vendor and subcontractors supplied manuals, warranties, and specification sheets.

E. Warranty Review: Contractor shall providereview allmanufacturer equipment warranties forthat complyiance with the contract documents. Extended warranty requirements and warranty activation dates shall be documented. Contractor shall provide all warranty information to the Owner and transfer the warranties to the Owner upon transfer of the project.

F. Commissioning Manual: Contractor shall create a Commissioning Manual, addressing the disposition of all system installation, functionality and operation tests identified in the Commissioning Plan. The Commissioning Manual shall include all relevant start-up and commissioning documentation, test data, site reports, equipment start-up data, and checklists in a logical and sequential format. Upon completion of the project, the Commissioning Manual shall be submitted to Owner electronically.

3.0 INSTRUMENTATION

A. Contractor shall be responsible for all standard testing instrumentation. Testing instrumentation should include, but is not limited to:

A.1. Power meters

B.2. Voltmeters

C. Clamp-on meters (Amp meters)

3.

~~D.~~4. Irradiance meters

~~E.~~5. Power quality test equipment

~~F.~~6. Temperature sensors

7. Met stations: Wind speed sensors, rain gauge, ambient temperature sensors, and all other sensors.

8. IV Curve Tracers

~~G.~~9. PD test equipment

~~H.~~10. Specialized electrical apparatus test equipment.

B. All instrumentation is to be NIST, or approved equivalent, calibrated; calibration certificates shall be current for all instrumentation used by Contractor during testing.

C. All irradiance meters shall be cleaned no less than once per week during testing.

4.0 SAFETY

A. During commissioning, Contractor shall be responsible for any requirements for specific safety procedures and equipment that are in addition to the standard site safety requirements. This shall include, but not be limited to, such items as:

~~A.~~1. Fall Protection

~~B.~~2. Electrical- and Arc Flash Safety

~~C.~~3. Lockout/Tagout

1.1.3 ATTACHMENT 1 – INVERTER TESTING REQUIREMENTS

1.0 OVERVIEW

The Inverter factory testing shall ensure that all inverter components perform interactively to meet the inverter requirements and criteria of the Owner, as related to the site-specific requirements of the Project. This includes all safety, control, performance, and environmental aspects.

The Owner's objective is to verify that the inverter is fully functional and performing to meet all Project requirements. Test instrumentation accuracy shall be according to table A-1.

Owner shall have the opportunity to witness factory testing. EPC Contractor shall give Owner fifteen business days advanced notice along with factory testing plan for review and response prior to testing.

2.01.0 SCOPE

The inverter manufacturer shall provide the following documentation from a certified NRTL:

1.A. UL 1741 Test Report

2.B. UL 1741 Certification

3.C. UL 1741 SA and/or SB Test Report (if applicable)

4.D. UL 1741 SA and/or SB Certification (if applicable)

5.E. IEEE 1547/519 Harmonics Test Report (including raw test data)

F. Current THD < 3%

a.G. IEEE 1547/519 Harmonics Certification

6.H. NERC PRC-024-2 3 Voltage and Frequency Ride-Through Test ReportCertification

7.I. CEC Efficiency Test Results

The inverter manufacturer shall provide the following documentation from type testing (or from a certified NRTL) to show the inverter meets the specifications outlined in the data sheet. The documentation shall include, at a minimum: active power, reactive power, frequency, DC voltage/current, AC voltage/current, and critical component temperatures (for ambient temperature testing).

1.A. Active Power

1. Inverter manufacturer shall provide test documentation showing the inverter can operate up to the nameplate power rating (including any "overdrive" or 110% functionality).

a.

2.B. Reactive Power

a.1. Inverter manufacturer shall provide test documentation showing the inverter can operate up to the maximum reactive power capabilities.

~~b.~~ Minimum Requirement: 0.8 lead/lag in 0.01 intervals, or as required by the interconnection agreement at rated apparent power.

2.

3.C. Plant Controller Response

a.1. Inverter manufacturer shall provide test documentation showing the inverter can receive active and reactive commands from a simulated plant controller interface and as required by the interconnection authority.

b.2. Inverter manufacturer shall provide test documentation showing the inverter can operate at the maximum and minimum ramp rates for both active and reactive power variation as required by the interconnection authority.

4.D. Edge-of-Cloud Effects

a.1. Inverter manufacturer shall provide test documentation showing the inverter can track the PV array maximum power point (MPP) during high DC voltage and current transients.

5.E. DC Voltage

a.1. Inverter manufacturer shall provide test documentation showing the inverter can operate over the rated DC voltage operating range.

b.2. Inverter manufacturer shall provide active power vs. DC voltage de-rating curves.

6.F. AC Voltage

a.1. Inverter manufacturer shall provide test documentation showing the inverter can operate over the rated AC voltage operating range.

b.2. Inverter manufacturer shall provide active power vs. AC voltage de-rating curves from 0.9 to 1.1 p.u. terminal voltage and 0.89 lead/lag.

7.G. Ambient Temperature

a.1. Inverter manufacturer shall provide test documentation showing the inverter can operate over the entire ambient temperature range (minimum 4 hours at each test condition).

b.2. At a minimum, the test documentation must include the following operating conditions:

i.a. 25°C

ii.b. 45°C

iii.c. Maximum Operating Temperature

iv.d. Minimum Operating Temperature

v.e. Any “corner points” on ambient temperature de-rating curves

c.3. Inverter manufacturer shall provide active power vs. ambient temperature de-rating curves.

8.H. DC/AC Ratio

a.1. Inverter manufacturer shall provide design calculations and/or test data showing the inverter performance and reliability information at multiple DC/AC ratios including, but not limited to, the maximum and minimum DC/AC ratios specified for the project.

9.I. Reliability

a.1. Inverter manufacturer shall provide test documentation summarizing the accelerated life testing (ALT) and highly accelerated life testing (HALT) testing that has been completed.

b.2. Inverter manufacturer shall provide mean time between failures (MTBF) and mean time to failure (MTTF) rates for critical components such as:

i.a. IGBTs

ii.b. DC switches/contactors

iii.c. AC contactors/breakers

iv.d. DC link and AC filter capacitors

v.e. Communications boards

vi.f. Cooling system components (fans, pumps, etc.)

At a minimum, the following tests shall be performed on each inverter during production testing:

1.A. Calibration of all DC and AC voltage, current, and power circuitry/sensors.

2.B. UL 1741 production testing such as hi-pot and PE/ground testing

3.C. GFDI

4.D. Emergency stop (fast stop)

5.E. Remote start/stop

6.F. Burn-in (minimum 4 hours per inverter)

a.1. Burn-in testing should be completed under elevated ambient temperature and high DC current conditions at maximum rated power.

7.G. Harmonic content verification (during burn-in tests)

8.H. Efficiency verification

a.1. Verify inverter efficiency at multiple DC voltages and power levels which shall be consistent with the levels tested during CEC testing.

i.a. The official CEC test procedure is not required.

9.I. Reactive power control (0.95 lead/lag, or as required by the interconnection agreement) at rated apparent power

10.J. Voltage and frequency ride-through verification per IEEE 1547 and/or PRC-024-2

(a) **Table A-1 Basic Measurement Requirements**

Parameter True RMS (V, I, P)	Allowable Maximum Uncertainty
DC Voltage	± 1% of reading
AC Voltage	± 1% of reading
DC Current	± 1% of reading
AC Current	± 1% of reading
DC Power	± 1% of reading
AC Power	± 1% of reading
Temperature	± 1°C
DC Current Ripple	± 5% of reading

Table A-2 Power Conversion Efficiency Test Points

Test	Vdc	Vac	Inverter DC Input Power Level						
			100%	75%	50%	30%	20%	10%	5%
A	Vnom	Vnom							
B	Vmax	Vnom							
C	Vmin	Vnom							
D	Vmin	102% Vmin							
E	Vmax	98% Vmax							

ATTACHMENT 2~~B~~ – SOLAR SUBSTATION TESTING REQUIREMENTS

1.0 ~~1.0~~ INTRODUCTION

The requirements of the Commissioning specification, M3-01-04, are applicable to the Solar Substation power delivery system. The purpose of this attachment is to provide further detail on the requirements. This specification, however, is not meant to be all-inclusive or completely comprehensive but outlines the main tests that shall be performed on the Substation.

2.0 TESTING AND COMMISSIONING

The Contractor shall perform the Solar Substation testing listed below, though the list is not meant to be all-inclusive. This shall include all testing and recording required by the interconnection authority, and NETA-ATS. Equipment tests shall be in accordance with the manufacturer's recommendations. It is up to the Contractor's discretion whether or not to use an independent certified testing company in order to complete some or all of the tests. However, substation commissioning and testing will be observed by Owner's qualified personnel or representative for conformance to NETA-ATS and industry standards. Submit to the Owner for approval a proposed plan for testing 30 days prior to commencement of testing. In addition to schedule and personnel qualifications, the proposed testing plan shall also include pass criteria and a list of equipment to be used for the project testing.

A. Electrical Testing

1. Types of tests covered by this Contract shall include but not be limited to:

- a. Megger tests
- b. Instrument transformer tests
- c. Insulating oil tests
- d. Ground testing
- e. Power panel tests, AC and DC
- f. Low voltage automatic transfer switches
- g. Battery chargers
- h. Batteries
- i. Molded-case circuit breaker trip test
- j. High voltage testing
- k. Radio interference tests
- l. Lighting
- m. Hot-spot tests on buses, connectors, and fittings
- n. Miscellaneous tests on other equipment furnished and installed by the Contractor
- o. Other tests as required by the Owner.

2. All relay functions, control, status, alarm, and interlock functions, and metering functions shall be tested by this Contract, and meet NETA ATS requirements.

3. Record any malfunctions noted in the operations and when repairs are completed, repeat the tests and record on the connection drawings the date that the scheme functioned satisfactorily and who conducted the tests.

4. After completion of bench testing and after connection of all external wiring, conduct functional tests by forcing each relay contact to see the proper breaker is tripped and/or alarm picks up.

5. Testing of relays shall include the tests wherein current and voltage are applied to the disconnected leads to relaying at current and potential transformers as well as phase angle and current checks after relays are actually in service and carrying load current.

6. Instrument transformer tests including ratio tests and excitation current tests.

7. High current tests shall simulate actual load current and fault current operation of the substation electrical equipment.

8. Megger each high-voltage bus, PCB, transformer, switch, and CT, or other important item of equipment just before it is energized each time during construction.

9. Maintain correct phasing on all circuits and buses. Solar Substation buses and connections shall conform to the phasing of the POI. Make phasing tests on all circuits that can be energized from two or more sources to prevent paralleling of sources out of phase.

10. Immediately after initial energization, complete load tests and checks to include current checks on all applicable relays, meters, transducers, etc. Perform voltage checks on all applicable relays, meters, transducers, etc. Perform angle checks on all applicable relays, meters, transducers, etc.

11. Supplemental reactive power resources: Test capacitor banks and reactor banks (as applicable) for operability. Test in conjunction with the PPC to ensure proper power factor control is obtained.

12. Due to the critical nature of the substation and the use of high-current equipment and connections, the Contractor shall provide equipment, supervision and labor as required to perform infrared temperature inspections. Obtain infrared scanning service including equipment and an operator from a qualified source if the Contractor does not own infrared equipment. Survey all substation bus, conductors, and connections installed by this Contract and all major equipment installed by this Contract.

13. Infrared (IR) scanning of all electrical connection points including terminal points is required. Scans will be performed by an IR Technician Level 2 standard with equipment in service or operating at X% capacity or greater. A report will be submitted on all IR scans including pictures of all equipment for baseline measurements. Any problem or questionable areas must be documented. A questionable area will be defined as an area where temperature is 10 degrees

13. Celsius greater than its surrounding area. The Contractor shall correct any deficiencies in equipment or connections that resulted from improper installation.

14. Functional Testing: Project and equipment-specific functional testing protocols will be developed by Contractor to address functionality and safe operation of components and systems. The functional testing protocols shall include all substation interfaces and shall be detailed so as to address all facets of operation, failure modes, and recovery modes.

15. Interconnection authority testing: Documentation as required by interconnection authority (check lists and data forms) shall be submitted on time to meet project schedule for required testing of the substation at the completion of the project. Contractor shall conduct all testing as required by interconnection authority but at a minimum these shall include:

    a. Primary Frequency Response (PFR)

    b. Reactive Power

    c. Automatic Voltage Regulation (AVR)

~~M3-01-05~~

APPENDIX M3
-ATTACHMENT 01
EXHIBIT 05

~~(a)~~ SOLAR PHOTOVOLTAIC PLANT SPECIFICATION PV CAPACITY TEST

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

202~~5~~3

REQUEST FOR PROPOSAL

NO.	DATE	REVISION	BY	CHK'D	APPROVALS	
0	14Apr23	Issued for Implementation	1898 & Co.	PGE	CPA	Craig Armstrong
~~1~~	~~08May25~~					

1.1.21.0 1.0 OVERVIEW

Capitalized terms not otherwise defined in this document shall have the meaning given such terms in the Agreement. The following is an overview of the procedures to be utilized in connection with the execution of performance tests of the PV Power Plant. The objective of the Capacity Test is to verify contract requirements and guarantees have been met. A PV Power Plant Capacity Test will be performed once the entire PV Power Plant is fully functional. The Contractor has the option of performing capacity tests on circuits prior to the contractual Capacity Test.

The tests are to be executed once Contractor has successfully completed all Functional Tests set forth in M3-01-04, Commissioning, however, the Capacity Test may be run concurrently with the Functional Test if approved by the Owner. Contractor shall remediate the shortcomings and re-test until the guarantees are achieved.

On or before Substantial Completion of the PV Power Plant, Contractor shall commence the Capacity Test which may be witnessed by Owner and/or Owner's representative. In such case that Contractor fails to satisfy all requirements of the PV Power Plant Capacity Test on or before the Substantial Completion of the PV Power Plant, Contractor shall remediate the shortcomings during the Cure Period before commencing re-tests.

This Capacity Test is based on ASTM E2848 but incorporates considerations for bifacial modules. PRC is the actual power measured at the Reporting Conditions (RC). PMIN is the guaranteed power at RC. Pass/fail: PRC/PMIN *100 greater than or equal to 97% (depends on the calculation of test uncertainty). PRC is determined from filtered on-site data (5 min or 1 min), running multiple regression and calculating from resulting equation with its coefficients, at RC. PMIN is determined by running Pvsyst with site weather data (1 hr, averaged from site data) or if not available from other source such as Solar Anywhere, filtering, running regression, calculating at RC. RC is determined from site data (can also use modeled but prefer site data), finding Irradiation Irro mean +/- 20%, 40%/60% distr., above 400 W/m2, and averaging T0 and W0.

1.1.32.0 2.0 DEFINITIONS

(a)2.1 AGREEMENT

The Engineering, Procurement and Construction Agreement between Owner and Contractor.[fill in actual final document name/date here]

(b)2.2 CIRCUIT

Group of ISAs that make up a portion of the full capacity of the PV Power Plant. This is the total AC power associated with one circuit breaker of the Solar Substation. If there are two feeders connected to one circuit breaker this will still be considered one Circuit.

(c)2.3 GUARANTEED CAPACITY

This is the guarantee by the Contractor for the total Power Rating of the PV Power Plant. It shall be verified by the Capacity Test (see section 5 below) in which the guaranteed

Minimum Power Rating, $\mathbf{P_{MIN}}$, as calculated and predicted with the PV Simulation Model at the Reporting Conditions, is compared to the Power Rating, $\mathbf{P_{RC}}$, as measured by the Main Facility Meter at the Point of Interconnection. Guaranteed Capacity shall ~~be calculated as 100% of the~~ have a Facility Performance of 97% ~~minus the Test Measurement Uncertainty~~. It shall be expressed as a percentage.

~~(d)~~2.4 MINIMUM FACILITY CAPACITY

Shall be a Facility Performance of 95% ~~with no correction for measurement uncertainty~~.

~~(e)~~2.5 MINIMUM POWER RATING (PMIN)

This shall mean the expected power output of the PV Power Plant at the Reporting Conditions, as computed by the procedure outlined in section 5 below.

~~(f)~~2.6 FACILITY PERFORMANCE

Shall mean the Power Rating divided by the Minimum Power Rating for the PV Power Plant at the time the Capacity Test is performed, expressed as a percentage.

~~(g)~~2.7 PV POWER PLANT

The PV Power Plant (also referred to as the “Facility”) will consist of XX MWAC of PV generation equipment, including the PV Arrays, cable harnesses, combiner boxes, DC fuse boxes, inverters, transformers and switchgear (if required), as well as all associated structural elements and interconnecting cables that will allow the PV Power Plant to generate and output AC power to the Owner-supplied interconnection point.

~~(h)~~2.8 POINT OF INTERCONNECT (POI)

~~This shall have the meaning set forth in the Agreement.~~POI shall mean the point of interconnection of the PV Power Plant.

~~(i)~~2.9 POWER RATING (PRC)

This shall mean the actual power output of the PV Power Plant at the Reporting Conditions, per ASTM E2848-13. It shall be computed by the procedure outlined in section 5 below.

Power measurements will be conducted within the range of power factor as required by the Project.

~~(j)~~2.10 PV SIMULATION MODEL (ENERGY MODEL)

The PV Simulation Model shall be based on the most recent version of PVsyst at the time of limited notice to proceed. All of the program inputs shall be put forth by Contractor and M3- 01-07 and reviewed and approved by Owner and Contractor at the time of contract execution with a corresponding Guaranteed Capacity. In the event the PV Power Plant is modified by mutual agreement between the Contractor and Owner, the program inputs may be modified to match the constructed PV Power Plant if agreed upon by Owner and Contractor.

~~(k)~~2.11 PRIMARY MEASUREMENT DEVICE

An instrument that~~which~~ provides a measurement or reading that is used in calculating the PV Power Plant Power Rating.

~~(l)~~2.12 REPORTING CONDITIONS

This shall be as defined as the reference irradiance (Irr0), the reference temperature (T0), and the reference wind speed (WS0) as determined by the procedures outlined below and referred to in ASTM E2848-13.

~~(m)~~2.13 SECONDARY MEASUREMENT DEVICE

An instrument that~~which~~ provides a measurement or reading that is not used in calculating the output power but is used as a check on primary measurements or for further analysis.

~~(n)~~2.14 SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA)

The hardware and software installed at the Project Site which is used to control, monitor and collect ~~the~~ weather and performance data from the PV Power Plant. This typically consists of programmable logic controllers, data loggers, software, and other network devices.

~~(o)~~2.15 TEST MEASUREMENT UNCERTAINTY

Shall be calculated as described by ASTM E2848-13 (referred to as expanded uncertainty in ASTM E2848-13), but shall not exceed 3%.

~~(p)~~2.16 TEST PERIOD

Shall mean the “data collection period” referred to in ASTM Standard E2848 and Test Period contained in this document below.

3.0 TEST MEASUREMENTS

All test measurement devices shall be fully defined for their make/model, accuracy, calibration and location. The following tables summarize these measurements that will be required for all of the tests:

Test Measurements (Minimum)

Measurement	Quantity	Type	Instrument Type	Range	Minimum Accuracy
Global Horizontal Irradiance	1 per Met Station	Secondary	Secondary Standard Thermopile Pyranometer mounted in the horizontal plane	0-1600 W/m2, 285 to 2800 nM	ISO 9060 Spectrally Flat Class A
Plane of Array Irradiance	1 per Met Station	Primary	Secondary Standard Thermopile Pyranometer mounted within Array	0-1600 W/m2, 285 to 2800 nM	ISO 9060 Spectrally Flat Class A

Rear Plane of Array Irradiance – for estimating bifacial gain	1 per Met Station	Primary	Secondary Standard Thermopile Pyranometer mounted within Array	0-1600 W/m2, 285 to 2800 nM	ISO 9060 Spectrally Flat Class A
Net Power Output (kW)	1	Primary	Owner's power meter(s) installed at the POI with calibrated CTs and PTs		+/- 0.2%

~~Measurement~~	~~Quantity~~	~~Type~~	~~Instrument Type~~	~~Range~~	~~Minimum Accuracy~~
			~~at the POI with calibrated CTs and PTs~~		
Net Power Output (kW)	1 per Inverter	Secondary	Inverter internal power meter		+/- 2%
Ambient Temperature	~~At each Met Station~~1 per MET Station	Primary	Part of weather station	-50 – 60°C	+/- 0.3°C
Module Temperature	2 per Met Station	Secondary	Platinum RTD (resistance temperature detector) (.00385 TCR DIN B), on back surface of module	-10 - 140°C	+/-0.3°C
AC/DC Power, Volts and Amperage	1 per Inverter	Secondary	From inverter CTs and PTs connected to plant SCADA		+/- 2%
Meteorological Stations: Ambient Temp, Wind Speed and Direction, GHI, Rainfall, and others as required	1 per 50 MW, minimum 2	Primary	On-Site weather station		Per manufacturer
Module Soiling	1 per 50 MW, minimum 2	Primary	On-Site soiling stations		Per manufacturer

3.1 INSTRUMENT CALIBRATION

All instruments used for primary measurements shall have current NIST-based or equivalent calibration certificates. All calibrations certificates shall be submitted for Owner Review prior to commencement of the applicable test.

3.2 DATA COLLECTION

Data shall be recorded by the SCADA system. The use of alternative means for data acquisition shall be used only with the prior written consent of Owner, which consent shall not be unreasonably withheld or delayed. Contractor shall provide sufficient means for Owner to access the test data during the Test Period. Should remote access to the SCADA system not be available Contractor shall provide daily test reports containing the 1-min interval data for the duration of the Test Period.

4.0 GENERAL TEST REQUIREMENTS

4.1 SCHEDULING

Contractor, in coordination with Owner Owner's Engineer, shall notify Owner in writing of proposed PV Capacity Test date not less than ten (10) Business Days prior to the proposed date for the Performance Test.

4.2 PRE-TEST CONDITIONS

The Performance Tests may be performed only when the following conditions are met:

- Weather conditions as required to complete the Performance Tests, as addressed in this document and in the approved Performance Test Procedure as provided by the Contractor.
- There is grid connectivity at each inverter such that the Performance Tests can be accomplished under load.
- Contractor has achieved Mechanical Completion.
- Contractor has completed Functional Test and hot commissioning and energization.

4.3 PRE-TEST MEETING

Prior to each test, a pre-test meeting shall be conducted and recorded. The meeting shall review the applicable approved test procedure, instrumentation locations, calibration sheets and other relevant topics including safety requirements. Minutes of this meeting shall be recorded by Contractor and approved by all parties.

4.4 TEST DURATION AND DATA FREQUENCY FOR CAPACITY TEST

Testing duration and frequency shall be as follows:

CAPACITY TEST DATA COLLECTION	
Test Period	The Test Period shall be a minimum of five (5) Days. The Test Period will continue until sufficient filtered measurement data has been obtained
Data Sampling Interval	1 minute
~~Data Averaging Interval~~	~~5 minute~~

4.5 ADJUSTMENTS

Any adjustments made during the tests to any portion of the PV Power Plant or test measurement devices shall be documented by Contractor and reviewed and approved by Owner prior to execution. Owner, and Owner's Engineer, shall be available during test ~~in order to~~to grant such approval, which will not be unreasonably withheld.

4.6 TEST REPORTING

Contractor shall submit a detailed test report, within five (5) Business Days of completion of successful test, to Owner consisting of the following:

~~1)~~1. Test procedures (as executed)
~~2)~~2. Instrument calibration sheets/certificates
~~3)~~3. Test data (manual and data acquisition) including table of averaged and filtered data
~~4)~~4. Test results uncertainty
~~5)~~5. Field notes
~~6)~~6. Calculations and results

4.7 TEST VALIDATION

Contractor shall validate the performance of the overall PV Power Plant through the following Capacity Test, which will be conducted by Contractor, in order to determine if the guarantees have been met:

5.0 CAPACITY TEST

5.1 GENERAL

The Capacity Test is used to determine the Facility Performance, by evaluating the Power Rating of the PV Power Plant compared to the expected Minimum Power Rating at the Reporting Conditions. The results of the Capacity Test are used to determine if Contractor has met the Guaranteed Capacity.

5.2 DATA COLLECTION - GENERAL

~~a)~~A. The pyranometers used to collect irradiance measurements shall be cleaned immediately prior to testing and daily during the test period. Soiling will be accounted for by Contractor utilizing the average of the measurements from the on-site soiling stations, with data collected in accordance with the manufacturer's recommendations.

~~b)~~B. Owner shall be responsible for:

~~i)~~1. Routinely reviewing collected weather and operating data for the PV Power Plant following Substantial Completion.

~~ii)~~2. Agreeing to the Test Period proposed by Contractor for which there are sufficient valid data to meet or exceed the data requirements necessary to perform the procedures as described below.

~~c)~~C. Contractor shall collect, filter, and average data until 750~~120~~ valid data points are obtained.

~~d)~~D. For PV plants comprising bifacial modules, rear pyranometers shall be used to collect irradiance measurements from the underside of the module. Rear pyranometers shall follow the same above criteria for testing and shall be mounted in the middle of any given PV string on the underside of the torque tube for optimal and representative irradiance collection. Contractor shall verify ~~Care shall be taken to assure~~ that the ground conditions in the vicinity of the rear-facing pyranometers is as typical of the ground conditions under the solar arrays to the extent practicable.

E. The following acronyms and definitions for the Capacity Test are as follows:

1. PRC is the actual power measured at the Reporting Conditions (RC).
2. PMIN is the guaranteed power at RC.
3. Pass/fail: PRC/PMIN*100 greater than or equal to 97% (to account for test uncertainty). PRC is determined from filtered on-site data (1 min), running multiple regression and calculating PRC from resulting equation with its coefficients, at RC.
4. PMIN is determined by running PVsyst with site weather data (1 hour, averaged from site data) or, if not available, from other sources such as Solar Anywhere, filtering, running the regression, and calculating PMIN at RC.

RC is determined from site data (can also use modeled but prefer site data), finding Irradiance Irro to be the mean filtered irradiance above 400 W/m2 +/- 20%, with a distribution skewed no more than 40%/60%. T0 and WS0 will be the average ambient temperatures and wind speeds in the resulting data set.

5.

5.3 DATA COLLECTION AND SELECTION OF REPORTING CONDITIONS (RC)

a)A. Data collected on site per the above shall be used to determine the Reporting Conditions, per the following procedure. If site measured data is not available for determining Reporting Conditions, the contractual historical weather data file for the period of the test may be used.

b)B. For the Plane-of-Array (POA) and Rear Plan-of-Array (RPOAfor bifacial modules) irradiance measurements, the data recorded from multiple pyranometers will be averaged for each time interval.

i)1. In the event that data from one of the pyranometers is excluded due to malfunction or sensor discrepancy, the data from the un-excluded pyranometers shall be averaged (in the case of malfunctions), or the data from all the pyranometers may be excluded (in the case of sensor discrepancy out of range of sensor accuracy).

ii)2. In the event multiple ground coverage ratios (GCRs) exist on site, a meteorological station shall be provided in each differing GCR area.

c)C. The collected data set shall be filtered according to the following operations:

i)1. The guidelines and calculations described in ASTM E2848-13 will be followed. All data identified by the applied filters shall be excluded.

ii)2. Any test data points in which the inverter is “clipping” shall also be excluded.

iii)3. POA irradiance below 400 W/m^2 will be excluded.

d)D. After filtering, the resultant data set shall be used to determine the Reference Irradiance (Irr_0) for the Reporting Conditions.

i)1. In order to determine the Irr_0, the test data (or data from PV Simulation Model using the contractual historical weather data file) shall be sorted according to POA irradiance from highest to lowest and examined to determine the highest POA irradiance value for which there is a nearly equal distribution of valid data points in the range of the selected POA irradiance +/- 20%. This irradiance shall be considered Irr_0.

ii)2. There shall be no more than a 40%/60% spread in the irradiance distribution, i.e., no more than 40% of irradiance data above Irr_0 and 60% of irradiance data below Irr_0, or vice versa.

3. All test data where the irradiance is outside of the range of Irr_0 plus or minus the irradiance band (Irr_0 ± 20%) shall be excluded. At the agreement of Contractor and Owner, the irradiance band may be increased (not to exceed Irr_0 ± 50%), in order toto obtain a necessary and reasonable number of data points.

4. The minimum value for consideration as the Irr0 will be calculated by the following equation:

$$Irrmin = (400\ W/m^2) / (1 - Irrband) = (400\ W/m^2) / (1 - 0.2) = 500\ W/m^2$$

Where:

Irrmin is the minimum value for Irr0.

Irrband is the size of half the irradiance band expressed as a number, so a band of +/- 20% would mean Irrband = 0.2. For the avoidance of doubt, the full irradiance band would be 0.4.

All irradiance values less than Irrmin shall be excluded from consideration as the Irr0.

5. The maximum irradiance value for consideration of the Irr0 shall be determined by the following equation:

$$Irrmax = (Irrhigh) \ / \ (1+Irrband)$$

Where:

Irrmax is the maximum value for Irr0.

Irrhigh is the highest irradiance value of collected and filtered data set (as determined in section iii above)

~~iii)~~ All irradiance values greater than Irrhigh shall be excluded from consideration as the Irr0.

~~iv)~~6. For bifacial modules, the same above criteria shall be used where POA irradiance shall be replaced with the variable Total Plane-of-Array (TPOA) Irradiance to represent the sum of the filtered POA and RPOA of the system outlined by the following Equation (Eq.1):

$$TPOA = POA + (RPOA * \phi) \qquad \text{(Eq. 1)}$$

Where ϕ is the bifaciality factor of the module as provided in the module specification sheet. If the ϕ is available as tested by an independent nationally recognized testing laboratory then this value shall be used.

~~e)~~E. The Filtered Measurement Data shall be defined as the resulting data set of section d (iii) above, and it shall have a minimum of one hundred twenty (120) data points.

~~i)~~1. The seven hundred fifty~~one hundred twenty~~ (750~~120~~) or more data points are under the assumption of a one~~five~~ (15) minute ~~averaged~~ data interval.

~~ii)~~2. If the filtered data set does not contain enough data, then additional days (maximum 4 weeks) shall be added to the Test Period to collect enough valid data.

3. A wider filter can be applied to irradiance band as mentioned above in section d (iii), if agreed upon by Owner and Contractor.

~~iii)~~4. All data points with irradiance less than 400 W/m^2 shall be excluded.

~~f)~~F. The average ambient temperature of the Filtered Measurement Data shall be calculated. This average ambient temperature shall be the reference (RC) temperature T_0.

~~g)~~G. The average wind speed of the Filtered Measurement Data shall be calculated. This average wind speed shall be the reference wind speed WS_0.

5.4 MINIMUM POWER RATING (PMIN)

~~a)~~A. The PV Simulation Model, as derived from PVsyst simulations, shall be used to establish the Facility's expected power output as ~~to be compared~~ measured by the inverters and confirmed by the revenue meter.~~to the power output at the revenue meter as adjusted at the relevant conditions.~~

~~i)~~1. Owner and Contractor, upon execution of the Agreement, shall review and agree on all inputs to PVsyst for the creation of the PV Simulation Model, including (but not limited to): losses, weather data file, and component model files.

~~b)~~B. Each of the PV Simulation Model outputs shall include, as a minimum, the following columns in the respective output .csv files (or 8760 files) :

~~i)~~1. Date & Time (formatted with Month; Day; Hour in separate columns)

~~ii)~~2. POA Irradiance (GlobInc, W/m^2)

~~iii)~~3. RPOA Irradiance (GlobBak, W/m^2)

~~iv)~~4. Horizontal Irradiance (GlobHor, W/m^2)

~~v)~~5. Ambient Temperature (T Amb, °C)

~~vi)~~6. Wind Speed (WindVel, m/s)

~~vii)~~7. Near Shadings Beam Loss (ShdBLss, W/m^2)

~~viii)~~8. Inverter Loss Due to Low Voltage Maximum Power Point (MPP) Window (IL Vmin, kW)

~~ix)~~9. Inverter Loss Due to Power Limitation (i.e., "clipping" loss) (IL Pmax, kW)

~~x)~~10. Available Energy at Inverter Output (EOutInv, kW)

~~xi)~~11. Energy Injected into Grid (E Grid, kW)

~~c)~~C. For the purposes of this procedure, the Target Period shall be derived from historical or site-measured weather data. Using the contractual historical weather data is an option to simplify the procedure. The Target Period shall consist of a minimum of sixty~~fourteen~~ (60~~14~~) days: the thirty~~seven~~ (30~~7~~)-Day period prior to and after the Test start. The Target Period may be extended further than sixty~~fourteen~~ (60~~14~~) Days upon agreement of Contractor and Owner.

~~d)~~D. The Minimum Power Rating (PMIN) expected from the Plant at the Reporting Conditions shall be determined from the PV Simulation Model for the site in accordance with the following:

~~i)~~1. Run PV Simulation Model with the contractual historical weather file, or the measured site weather data from the collected Target Period. (PVsyst will receive 1- minute or 5-minute data but will convert it to one-hour data)

~~ii)~~2. Apply the following filters to the resulting Target Period data file:

~~a)~~a. Exclude any data points with beam shading values ShdBLss > 0.

~~b)~~b. Exclude any data points where the inverter is not in 'Peak Power Point Tracking' mode, as such term is defined in section 9.1.8 of ASTM E2848-13.

c. Exclude any data with irradiance values outside of the range established section (3)(d)(iii) above.

~~c)~~d. Exclude data points with POA irradiance < 400 W/m2.

~~iii)~~3. After filtering, the resulting dataset shall have 50 one-hour data points, or more.

~~a)~~a. If less than 50 data points remain in the set, then the Test Period shall be shifted and a new Target Period shall be identified per to section (3)(e)(ii) above.

~~b)~~b. At Owner's discretion, the irradiance threshold may be expanded to a larger range as described in (3)(e)(iii) above.

~~iv)~~4. For the filtered Target Period dataset, a regression analysis shall be performed on the POA irradiance, ambient temperature, wind speed, and energy at the POI meter. The regression analysis shall be used to determine the modeled regression coefficients A, B, C and D in the following Equation 2 (Eq. 2):

$$E\ Grid = Irr_T * (A + B * Irr_T + C * TAmb + D * WindVel) \quad \text{(Eq. 2)}$$

For bifacial modules use Irr_T in the regression where Irr_T = GlobInc + (GlobBak * ϕ) for bifacial modules. Otherwise, Irr_T = GlobInc.

Where ϕ is the bifaciality factor of the module as provided in the module specification sheet. (above adjustment assumes bifacial modules in single portrait configuration)

~~v)~~5. The Minimum Power Rating (P_{MIN}) shall be calculated for the site by substituting in coefficients A, B, C and D and the appropriate Reporting Conditions (Irr_0, T_0 and WS_0) as shown in the following Equation 3~~. (Eq. 3):~~

$$PMIN = Irr_0 * (A + B * Irr_0 + C * T_0 + D * WS_0) \quad \text{(Eq. 3~~)~~)}$$

For projects utilizing bifacial modules, use the Reference Irradiation, Irr0, from both sides of the module, i.e., the sum of the irradiation in the plane of array on the front side and back side multiplied by the bifaciality factor as illustrated in Equation 1.

5.5 POWER RATING (PRC)

~~a)~~A. The Filtered Measurement Data for the site identified in section 5.3~~(3)(c)~~ above shall be used to calculate P_{RC} for the site.

~~b)~~B. Filtering of the test data and calculation of the P_{RC} shall be conducted according to section 9 'Calculation of Results' of ASTM E2848-13. The equation used for the final calculation (equation 2 in ASTM E2848-13, modified for the terminology used in this test report) is:

$$P_{RC} = Irr_0 * (a_1 + a_2 * Irr_0 + a_3 * T_0 + a_4 * WS_0) \quad \text{(Eq.4)}$$

Where Irr_0, T_0, and WS_0, are the Reporting Conditions and the coefficients a_1, a_2, a_3, and a_4 are calculated from the measured, filtered data as described in ASMT E2848-13. The regression shall be based on the below for determining the actual coefficients from the equation using the measured site data,

Revenue meter power (for each time stamp) = TPOA * (a1 + a2 * TPOA + a3 * TAmb + a4 * WindVel)

Where TPOA (=POA+RPOA*ϕ for bifacial modules), TAmb, and WindVel are the measured values

~~c)~~C. The results of this section (P_{RC}) shall be reported in accordance with section 10 'Report' of ASTM E2848-13.

5.6 FACILITY PERFORMANCE

~~a)~~A. The Facility Performance shall be calculated as below and expressed as a percentage:

$$\text{Facility Performance} = (P_{RC} / P_{min}) * 100$$ ~~- TMU~~

~~b)~~B. If the Facility Performance is greater than or equal to the Guaranteed Capacity (after deducting the Test Measurement Uncertainty), then Contractor has met the Guaranteed Capacity. If the PV Power Plant has metso achieved the Guaranteed Capacity, then no further analysis is required.

~~c) IF, HOWEVER, THE PV POWER PLANT DID NOT SO SATISFY THE GUARANTEED CAPACITY, THEN CONTRACTOR SHALL FOLLOW THE PROCESS OUTLINED IN THE AGREEMENT.~~

5.7 TEST REPORTING

~~a)~~A. Upon completion of the Capacity Test, Contractor shall submit a Capacity Test Report to the Owner consisting of the following and per the requirements set forth in M1-01-02 and table M1-01-02-01-Solar

~~i)~~1. Test procedures

~~ii)~~2. Instrument calibration sheets/certificates

~~iii)~~ Test data (manual and data acquisition)

3.

~~iv)~~4. Test Results uncertainty

~~v)~~ Field notes

5.

6. Calculations and Results

~~vi) Calculations and Results~~

APPENDIX M3
ATTACHMENT 01
EXHIBIT 06

SOLAR PHOTOVOLTAIC PLANT SPECIFICATION PROJECT SCHEDULE

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

2025~~3~~

REQUEST FOR PROPOSAL

NO.	DATE	REVISION	BY	CHK'D	APPROVALS	
0	14Apr23	Issued for Implementation	1898 & Co.	PGE	CPA	Craig Armstrong

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1.0 GENERAL

Refer to M1-01-05 (Project Management and Controls) for additional Schedule requirements.

2.0 PROJECT SCHEDULE

Contractor is to provide a detailed Work Schedule (hard and native electronic copies) thirty days after the issuance of Full Notice To Proceed (FNTP). This Work Schedule, as subsequently accepted by Owner, shall become Attachment 1 to M3-01-06 of the EPC Agreement.

3.0 KEY DATES SCHEDULE

Key Date Schedule shall include major project milestones, including substantial completion of each Circuit, as defined in M3-01-05. Milestones indicated in the Key Date Schedule will be used as a basis for milestone payments.

4.0 CRITICAL PATH SCHEDULE

The Critical Path Schedule shall identify Contractor's plan of execution for the installation, Commissioning and Performance Testing for the Work. The Critical Path Schedule shall be a time-scaled critical path method logic diagram schedule (resource loaded) of all design and equipment procurement for the Project and all material Work activities so that Substantial Completion occurs on the Substantial Completion Guaranteed Date. The Critical Path Schedule shall include allowance for normal delays and difficulties that may be encountered in work of this nature including weather and holidays, etc. The Critical Path Schedule, as a minimum, must show an orderly array of activities in support of all the dates established in the Key Date Schedule, and shall be sufficiently detailed so that each of the following are included and will be readily apparent:

1. The engineering and detailed design activities necessary to complete design, procurement and construction.
2. Permits required that have not been received by the start of construction.
3. Materials and equipment purchase and deliveries.
4. Subcontractor interfaces and requirements.
5. Construction, by Circuit and system.
6. Dates for the completion of Key Date Items.
7. Contractor and Subcontractor data cycles, and Owner's review cycles.
8. Functional Tests, Commissioning and Capacity Testing.
9. A schedule for completion of post-Substantial Completion Date items including as built drawings and specific Non-Critical Deficiencies listed on the Punchlist costing more than [$100,000] to complete.

5.0 SUBMITTAL

The Critical Path Schedule shall be delivered both in native electronic form and in hard copy, in both .pdf and Primavera P6 file formats. The Functional and Capacity Test schedules must be coded in such a way as to provide individual test progress and schedules in accordance with an agreed upon Commissioning Plan.

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~~M3-01-07~~

APPENDIX M3
-ATTACHMENT 01
EXHIBIT 07

~~(a)~~ SOLAR PHOTOVOLTAIC PLANT SPECIFICATION ENERGY MODEL

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

2025~~3~~

REQUEST FOR PROPOSAL

NO.	DATE	REVISION	BY	CHK'D	APPROVALS	
0	14Apr23	Issued for Implementation	1898 & Co.	PGE	CPA	Craig Armstrong

1.0 OVERVIEW

~~A.~~1.1 ENERGY MODEL OVERVIEW

Using the Project Weather File, the PVSyst Parameters, and additional loss parameters, simulations will be run to model the expected energy output from the PV system at the revenue meter. The owner will use this energy model for its own financial monitoring and asset management, and the Contractor will use it as the PVsyst model in the Capacity Test calculations.

~~B.~~ The general procedure is as follows:

1. Project Weather File shall be defined and agreed upon by both Owner and Contractor for preliminary models, see section 4.0. Upon project completion, ~~weather file and~~ system operational data shall be gathered and recorded by SCADA to update the model with site data.
2. The Project Weather File will be ~~compiled and used to generate a file that will be~~ loaded into PVSyst.
3. PVSyst will produce an output based on~~for~~ the Project Weather File, which will then be loaded into the Energy Model File.
4. Calculate any losses not modeled in PVSyst.
5. Add up the contributions from all the Circuits (if modeled separately).
6. The r~~R~~esult is the expected net output of the PV power plant which will serve as the Energy Model.

Wherever [ ] appears in this document, it is a value to be proposed by Contractor.

2.0 ACCOMPANYING RESOURCES

~~A.~~2.1 ASSOCIATED SOFTWARE, FILES, AND REFERENCES:

- ~~A.~~ Software:
  - ~~a.~~1. Most recent version of PVSyst.
  - ~~b.~~2. Microsoft Excel

~~•~~2.2 FILES:

~~a.~~A. Energy Model File
- ~~i.~~1. [ ].xls

~~b.~~B. Module Equipment Files for PVSyst
- ~~i.~~1. [ ].PAN

~~c.~~C. Inverter Equipment File for PVSyst
- ~~i.~~1. [ ].OND

~~d.~~D. Shading Profile File for PVSyst
- ~~i.~~1. [ ].SHD

~~e.~~E. Project File, Variant Files by Array Type

~~i.~~1. [ ].PRJ

~~ii.~~2. [ ].VC2

~~iii.~~3. [ ].VC3

~~f.~~F. PVSYST Output Reports by Array Type or Circuit

i. [ ].pdf

1. ~~iii.~~ [ ].xlsx

2. [].pdf

~~g.~~G. Energy prediction Report by Array or Circuit with AC losses excluded

~~i.~~1. [ ].xlsx

~~•~~2.3 REFERENCES

~~a.~~ System design specifying module types, strings per inverter, inverters per Circuit, cable and transformer losses.~~.~~

3.0 DATA PREPARATION

~~A.~~3.1 DATA COLLECTION – CALIBRATED TO ACTUAL SITE DATA

Preliminary models to use Solar Anywhere TMY files as specified in section 4.0. Upon project completion, data points to be used in the Energy Model will be measured and recorded by the SCADA ~~at one minute increments~~system at the agreed-upon data time intervals. SCADA recorded ~~weather~~ file to be submitted to Owner with updated E~~e~~nergy M~~m~~odel as specified in M1-01-02 and table M1- 01-02-01-Solar. Measurement data ~~recorded by the SCADA and~~ used in running the updated Energy Model will include:

A. Measured Meteorological Data (inputs to PVSyst):

- ~~GHI Pyranometer irradiance (W/m^2)~~
- ~~Ambient temperature, T_{amb} (°C)~~
- ~~Wind speed (m/s)~~
- ~~DHI (W/ m^2)~~

1. Albedo (W/ m^2) (If bifacial modules used)

2. Soiling Loss (%)

~~•~~B. ~~-~~Discussion:

~~•~~1. ~~GHI will be used to calculate POA in the model and ambient temperature and wind speed will be used to calculate module temperature. Though POA and T_{bom} are measured and could be input directly, the Energy Model is based on the POA/GHI transposition and T_{amb}/T_{bom} calculation and so the Energy Validation will be as well~~The Albedo and Soiling loss are to be recorded during the agreed-upon Capacity Test Period.

~~B.~~ Data Preparation

C.

- ~~The necessary meteorological measurements will be averaged into time intervals consistent with the minimum input parameters required for analysis in PVSyst. Currently this time interval is one hour, but if a smaller time interval becomes available, this will become the default time interval. All data fed into and read from PVSyst should be in hour beginning format.~~

1. The raw test data shall ~~also~~ be analyzed and reduced to eliminate data points that clearly exhibit a high degree of random error (such as errors caused by faulty instruments).

2. Missing or obviously faulty data due to equipment error shall be discarded or be replaced in accordance with the Acceptance Test Procedures.

3. All methods for data filtering and manipulation shall be agreed upon between Owner and Contractor. A report of all data filtering will be provided.

~~C.~~D. Site-Specific Measurements~~Load Weather File~~ into PVSyst

1. The resulting ~~Weather File created~~measurements will be ~~converted into a TMY3 or ASCII format compatible with the~~ input requirements for PVSyst and will replace or modify the preliminary values ~~the existing weather bid file~~ used for the base PVSyst energy model.

4.0 PVSYST SIMULATIONS

~~A.~~4.1 DETERMINE PVSYST SIMULATIONS TO RUN

~~Although module types and string configurations can vary within a Circuit, e~~Each Array or Circuit must be modeled by a single average configuration and single module degradation amount (one PVSyst .VC file per Array or Circuit) Include 8760 data as Attachment B.

Contractor shall fill out and bracketed [ ] values.

~~B.~~4.2 PVSYST PARAMETERS

~~1.~~A. Project Tab

1. Latitude = [ ] deg.
2. Longitude = [ ] deg.
3. Meteo Data File: Solar Anywhere, satellite data, SUNY model - TMY
4. Altitude = [ ] meters
5. Time zone = [ ]
6. Monthly Albedo = [These values assume a one-in-portrait tracker]

Month	PVsyst Inputs
January	~~[ ]~~[ ]
February	[ ]~~[ ]~~

March	[ ][ ]
April	[ ]
May	[ ]
June	[ ]
July	[ ]
August	[ ]
September	[ ]
October	[ ]
November	[ ]
December	[ ]

- ~~Lower temperature for V_{max} Abs limit = [ ] degrees C~~
- ~~Winter operating temperature for V_{mpp} Max design = [ ] degrees C~~
- ~~Usual operating temperature under 1000 W/m = [ ] degrees C~~
- ~~Summer operating temperature for V_{mpp} Min design = [ ] degrees C~~

~~2.~~B. Orientation Tab

- ~~Unlimited sheds~~
- 1. See attached input and assumptions for Tracker parameters

~~3.~~C. Horizon Tab

- 1. As applicable for the site, from Solar Anywhere or other source.

~~4.~~D. Near Shadings Tab

- 1. 3D model representative of the site layout, including shading objects and as-left terrain.~~As applicable~~

~~5.~~E. System Tab

- 1. 3rd-party validated PV Module .PAN file
- 2. 3rd-party validated Inverter .OND file
- 3. Nb of inverters. = I[ ]
- 4. Modules per String = I[ ]
- 5. Strings per Inverter = This varies by array type. See Attachment A Input and Assumptions System Definition section.
- 6. Detailed Losses section of System Tab
  - ~~i.~~a. Uc= [ ]~~25.0~~ W/m^2k

ii.b. Uv= [ ]1.2 W/m^{2}k / m/s

iii.c. Ohmic Losses = [ ]

1.• 1.5% DC loss at STC

2.• See AC circuit loss table below

Circuit	AC Circuit Losses: Inverter to Injection Point (@STC)
1	[ ]
2	[ ]
3	[ ]

Table 1: AC circuit losses per Circuit for *n* Circuits (Note: Contractor to fill out table with actual values)

- 3.1. Skid (MV) Transformer [ ]0.10% iron loss, 0.90 [ ]%% resistive/inductive losses at STC.
- 4. Main Power (HV) Transformer: Add [ ]% 0.10% iron loss and [ ]% 0.40% resistive/inductive losses if including GSU transformer.

iv.d. Module Quality, LID, Mismatch

1.• [ ]% 1.5% for LID, per Manufacturer's Datasheet

2.• [ ] Module Quality loss

3.• [ ]% 1.0% Mismatch loss at MPP

e. Soiling losses:

Month	PVsyst Inputs
January	[ ]
February	[ ]
March	[ ]
April	[ ]
May	[ ]
June	[ ]
July	[ ]
August	[ ]
September	[ ]
October	[ ]
November	[ ]

December	[ ]

~~v.~~

~~Month~~	~~PVsyst Inputs~~
~~January~~	~~[ ]~~
~~February~~	~~[ ]~~
~~March~~	~~[ ]~~
~~April~~	~~[ ]~~
~~May~~	~~[ ]~~
~~June~~	~~[ ]~~
~~July~~	~~[ ]~~
~~August~~	~~[ ]~~
~~September~~	~~[ ]~~

~~October~~	[	]
~~November~~	[	]
~~December~~	[	]

f. Average Soiling Losses = [ ]%

~~vi.~~g. Incidence angle effect: As per Manufacturer, provided in ~~b0= see~~ .PAN~~pan~~ file ~~for table.~~

~~vii.~~h. Bifacial System:

~~1.~~• Shed transparent fraction = [ ]%~~2%~~

~~2.~~• Structure shading factor = [ ]%

~~a. 15% for one-in-portrait~~

~~b. 5% for two-in-portrait~~

~~3.~~• Mismatch loss factor = [ ]%~~10%~~

~~6.~~7. Module Layout Tab

~~2~~a. Not used

~~7.~~8. Hidden Parameters Menu

~~2~~a. Not used

~~8.~~9. Preferences Menu

~~2~~a. Physical Model = Perez

~~C.~~4.3 ADDITIONAL LOSS PARAMETERS

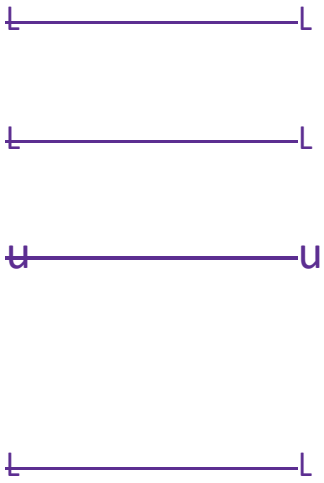
Contractor may desire to calculate some of the AC system losses outside of the PVsyst software instead of relying on PVsyst for these losses. If losses are calculated separately from PVsyst, ~~Some losses cannot be calculated in PVSyst or not calculated to the specifications necessitated by the Contractor. T~~these loss calculations~~es~~ must be ~~fully~~ completed in Microsoft Excel with all the formulas, constants, and justification available for review by Owner~~spelled out here~~.

~~D.~~4.4 MODULE DEGRADATION AMOUNT

To account for accumulated module degradation that has occurred for the PV Plant between the warranty start date of the Long Term Module Warranty to the end of the Life of the plant, annual, module degradation ~~amount listed in the table below shall~~should be applied to the Energy Model for predicting the energy output for the Capacity Testing done for each project Phase~~each year~~.

	Module Degradation	Total
Years since Circuit Substantial Completion Start Date	Guaranteed Module Degradation Amount (GDA)	Total Module Power Output Loss Entered into PVSyst (LID + GDA)
< x ≤ 1		
1 < x ≤ 2		
2 < x ≤ 3		
3 < x ≤ 4		
4 < x ≤ 5		
5 < x ≤ 6		
6 < x ≤ 7		
7 < x ≤ 8		
8 < x ≤ 9		
9 < x ≤ 10		
10 < x ≤ 11		
11 < x ≤ 12		
12 < x ≤ 13		

1.2



	Module Degradation	Total
Years since Circuit Substantial Completion Start Date	Guaranteed Module Degradation Amount (GDA)	Total Module Power Output Loss Entered into PVSyst (LID + GDA)
< x 16 < 17	[illegible]	[illegible]
< x 17 < 18	[illegible]	[illegible]
< x 18 < 19	[illegible]	[illegible]
< x 19 < 20	[illegible]	[illegible]
< x 20 < 21	[illegible]	[illegible]
< x 21 < 22	[illegible]	[illegible]
< x 22 < 23	[illegible]	[illegible]
< x 23 < 24	[illegible]	[illegible]
< x 24 < 25	[illegible]	[illegible]
< x 25 < 26	[illegible]	[illegible]
< x 26 < 27	[illegible]	[illegible]
< x 27 < 28	[illegible]	[illegible]

1.3 L

~~L L~~

~~L L~~

~~U U~~

~~L L~~

~~(a) TABLE 2: MONTHLY MODULE DEGRADATION.~~

~~(NOTE: CONTRACTOR TO FILL OUT TABLE WITH ACTUAL VALUES)~~

5.0 COMPILE AND ADJUST SIMULATION RESULTS

Once the Weather File has been compiled and input into the PVSyst model, a simulation will be run and exported in .csv format. This data can then be input into the Annual Hourly Energy Output spreadsheet to calculate the combined plant output. The procedure for running the simulation and generating the reports includes the following steps:

~~1.~~A. In ~~the Simulation Screen~~Pvsyst, input a unique output file name for each run/circuit. (not to exceed the number of Circuits).

~~2.~~B. The output parameters will include at least the following variables:

~~a.~~1. Horizontal global irradiation

~~b.~~2. Global incident in coll. Plane

~~c.~~3. Ambient Temperature

~~d.~~4. Average Module temperature

~~e.~~5. Wind velocity

~~f.~~6. Effective energy at the output of the array

~~g.~~7. Available Energy at Inverter Output

~~h.~~8. Energy injected into grid

~~i.~~9. Inverter efficiency (operating)

~~3.~~C. Run the simulation.

~~4.~~D. A .csv file will be created for this simulation and ~~will be~~ saved with the designated file name. The .csv file can be opened in MS Excel where the data can be parsed.Review the data for each case to verify the output calculated by PVSyst does not exceed the nameplate output of the inverter/circuit/plant.

E. Copy and paste the output data into the appropriate column in the Energy Model File.

~~(b)~~5.2 ENERGY MODEL FILE

There will be a single tab in the Excel file titled “Hourly Energy” that will include the energy production and subtract any additional losses (AC Losses, Aux Load, Availability, etc., if not already included in PVsyst). There will also be columns listing the metered energy production and the applicable project weather file (GHI, POA, wind speed and direction) for the corresponding time period. There will be an additional column listing the hourly energy shortfall.

~~1.3.2~~6.0 ~~6.0~~ FINAL ENERGY MODEL

If any changes occur to Contractor's design (such as equipment selection) that would affect the energy model files that were used as the basis for the bid, these must be reviewed and approved by the Owner prior to modification or inclusion in Contract. If approved, updated energy model files will be created and submitted as a revision to M3-01-07. All parameters are to be submitted in attachment A, with an explanation for any parameters differing from thosee~~e~~ given~~s~~ in this document.

Attachment A PVSyst Assumptions

~~(a)~~

Soft[illegible]ware	Version	Comment
PVsyst		
Microsoft[illegible] Excel		Provide Na[illegible]ve Post Processing File, if applicable

PVsyst File	Type	File Name
Project	.PRJ	
Variant(s)		
Meteorological	.MET	
Site	.SIT	
Module	.PAN	
	.PAN	
	.PAN	
Inverter	.OND	
Shade	.SHD	
Horizon	.HOR	
PVsyst Report	.PDF	
8760	.xlsx	

PVsyst Parameter	Value	Comment
Transposi[illegible]on Model		
MET File Source (e.g., SolarAnywhere)		
Lati[illegible]tude		
Longitude		
Alti[illegible]tude (m)		
Module/Tracker Orientation (e.g., 1-Portrait)		
Axis Tilt		
Axis Azimuth		
Minimum / Maximum Phi		
Backtracking (On/Off)		
Ground Coverage Ratio (GCR)		
Number of Sheds		
Pitch (m)		
Tracker/Collector Width (m)		
Inactive Band, Le[illegible] (m)		

PVsyst Parameter	Value	Comment
Inactive Band, Right (m)		
Axis Height Above Ground (m)		
Module Bifaciality Factor (%)		
Rear Shading Factor (%)		
Module Transparency (%)		
Rear Mismatch Loss (%)		
Monthly Albedo Profile	Jan =	
	Feb =	
	Mar =	
	Apr =	
	May =	
	June =	
	July =	
	Aug =	
	Sep =	
	Oct =	
	Nov =	
	Dec =	
Module Manufacturer		
Module Model		
Total Number of PV Modules		
Number of PV Modules (Bin Class 1)		
Bin Class 1 (W)		
Number of PV Modules (Bin Class 2)		
Bin Class 2 (W)		
Number of PV Modules (Bin Class 3)		
Bin Class 3 (W)		
Number of Modules per String		
Number of Strings in Parallel		
Inverter Manufacturer		
Inverter Model		
Number of Inverters		
Monthly Soiling Profile	Jan =	
	Feb =	
	Mar =	
	Apr =	
	May =	
	June =	
	July =	

PVsyst Parameter	Value	Comment
	Aug =	
	Sep =	
	Oct =	
	Nov =	
	Dec =	
Thermal Loss Factor - Constant		
Thermal Loss Factor - Wind		
DC Wiring Loss at STC (%)		
Module Quality Loss (%)		
Module Mismatch Loss (%)		
String Mismatch Loss (%)		
LID - Light Induced Degradation (%)		
AC Circuit Loss at STC (%)		
External Transformer Iron Loss (%)		
External Transformer Resistive/Inductive Losses(%)		
Auxiliary Loss		
Grid Power Limit (MW)		
Power Factor		
Facility Availability (%)		

PVsyst Parameter	Value	Comment
	Nov =	
	Dec =	
Module Manufacturer		
Module Model		
Total Number of PV Modules		
Number of PV Modules (Bin Class 1)		
Bin Class 1 (W)		
Number of PV Modules (Bin Class 2)		
Bin Class 2 (W)		
Number of PV Modules (Bin Class 3)		
Bin Class 3 (W)		
Number of Modules per String		
Number of Strings in Parallel		
Inverter Manufacturer		
Inverter Model		
Number of Inverters		
Monthly Soiling Profile	Jan =	
	Feb =	
	Mar =	
	Apr =	
	May =	
	June =	
	July =	
	Aug =	
	Sep =	
	Oct =	

~~M3-01-09~~

APPENDIX M3
-ATTACHMENT 01
EXHIBIT 09

~~(a)~~ SOLAR PHOTOVOLTAIC PLANT SPECIFICATION FORM OF MONTHLY PROGRESS REPORT

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

202~~3~~5

REQUEST FOR PROPOSAL

NO.	DATE	REVISION	BY	CHK'D	APPROVALS	
~~0~~0	14Apr23	Issued for Implementation	1898 & Co.	PGE	CPA	Craig Armstrong

1.0 GENERAL

1.1 DESCRIPTION

A. The Monthly Progress Report shall summarize the month's project status in engineering, permitting, procurement, construction, safety, quality, schedule and milestones reached, RFIs and open action items, commissioning, and commercial items as applicable

Cover sheet to show the project name, the time span covered and the date of the report.

2.0 COVER SHEET AND INDEX

2.1 COVER SHEET

Cover sheet to show the project name, the time span covered and the date of the report.

1.2.2 PROJECT TEAM

List personnel and functions of team comprising of:

- Contractor
- Subcontractors
- Major suppliers

2.2.3 EXECUTIVE SUMMARY

Provide high level summary delineating project status, milestones and issues. Limit to 1 page or less.

3.2.4 HEALTH SAFETY AND ENVIRONMENTAL

Details may be represented using charts, graphs or narratives.

- Total man-hours worked, total recordables and total Lost Time Accidents (LTAs) and Lost Time Injuries (LTIs)
- Total man-hours since last LTA or LTI
- Total work force on site
- Reportable Incidents since last report
- Medical/incident details
- Details of any LTA
- Near-miss details
- Actions taken to mitigate any future near-miss, recordable or LTA
- Environmental compliance update (if applicable)

~~4.~~2.5 PROJECT EXECUTION STATUS

Describe for each category/bullet items:

- Major accomplishments/activities this month
- Goals and milestones for next month
- Key milestones – tabular form showing Plan, Forecast and Actual EPC progress

~~a.~~ PROJECT SCHEDULE

2.6

- Include % complete against time (Engineering Procurement, Construction, Overall)
- Progress curves for planned versus actual (Engineering Procurement, Construction, Overall)
- Overall project status

b.2.7 PERMITTING PROGRESS

Detail any permitting progress and issues that have continued into construction phase, as applicable: site access, encroachments, building permits, etc.

c.2.8 CONSTRUCTION REPORT

List each area of major activity and its progress and any discussion points, key milestones, and goals for next month. This should include:

- Interconnection and substation work
- PV field
- On site structures

d.2.9 PROCUREMENT REPORT

- Procurement Progress
- Manufacturing Status
- Factory Inspection and Testing
- Shipping, Expediting, and Delivery
- Procurement Status Report – Include a table of major equipment to be procured by CONTRACTOR (including its subcontractors).

EQUIPMENT DESCRIPTION	MANUFACTURER	CONTRACTED DELIVERY DATE	ACTUAL DELIVERY DATE

e.2.10 START-UP AND COMMISSIONING

- List major systems commissioned and turned over to owner during the reporting period
- List major systems to be commissioned and turned over to owner during the next month

f.2.11 QUALITY ASSURANCE AND CONTROL

Report on QAQC status of project. List which areas have been inspected and the % of NCRs or some other acceptable tracking method to indicate overall quality of each installation.

5.3.0 KEY ISSUES AND REMEDIES (AREAS OF CONCERN)

- Late activities which impact the Project Schedule and mitigation plan
- Interface data problems
- Deviations of Work from Quality Assurance/Quality Control Plan

~~M3-01-10~~

APPENDIX M3
ATTACHMENT 01
EXHIBIT 10

~~(a)~~ SOLAR PHOTOVOLTAIC PLANT SPECIFICATION CONTRACTOR'S QUALITY ASSURANCE PROGRAM

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

2025~~3~~

REQUEST FOR PROPOSAL

NO.	DATE	REVISION	BY	CHK'D	APPROVALS	
0	14Apr23	Issued for Implementation	1898 & Co.	PGE	CPA	Craig Armstrong

~~1.1.2~~1.0 ~~1.0~~ GENERAL REQUIREMENTS

This exhibit ~~e following sections of~~ M3-01-10 describes the minimum requirements of Contractor's Quality Plan for this Agreement. The inspections, tests and related actions specified in this section and elsewhere in the Agreement are not intended to limit Contractor's own quality assurance/control procedures that facilitate overall compliance with the requirements of the Agreement. Contractor ~~may~~ shall use its own Quality Assurance/Quality Control (QA/QC) procedures provided such procedures have been reviewed and commented on by Owner prior to start of Work. Contractor shall submit their QA/QC procedures for review to Owner prior to the start of Work. Contractor's procedures must address, as a minimum, the information contained here in M3-01-10 and referenced documents.

2.0 QUALITY CONTROL PROGRAM

~~A.~~ Basic objectives of Contractor's Quality Plan shall be as follows:

- To ~~ensure~~verify that all work adheres strictly to all requirements of the Agreement and governing agencies where the work is being performed.
- To maintain QC procedures and to ~~ensure~~verify that tasks performed will comply with the requirements of the Agreement.
- To prevent deficiencies through pre-construction quality control coordination.
- To detect and correct deficiencies in a timely manner.
- To provide an auditable record of all tests, inspections, procedures, non-compliances and corrections, and any other pertinent data as required.
- Verify compliance with Contractor's QC procedures, including those QC procedures of subcontractors and suppliers.
- To provide a basis of measuring Contractor's performance for input to Owner~~'s Contractor resource database.~~.

Contractor may select either an outside "agency" or in-house personnel to administer Contractor's QC system. In either case, the Contractor's on-site quality control staff shall only be responsible for quality control. The QC supervisor (or person designated as the QC representative) shall report directly to Contractor's Site Manager. Contractor's QC staff shall not be involved in the management and/or control of the construction process. Contractor's QC staff members shall interface with Owner, its inspectors and consultants, as required.

~~1.1.3~~3.0 ~~3.0~~ TESTING CRITERIA

Contractor shall perform all testing and inspection of all Work (including materials) both on and off~~-~~site as required by the Agreement. This shall include pre-functional, and functional tests. Test passing criteria shall be clearly spelled out on work instructions and check sheets.

4.0 RESPONSIBILITIES OF THE CONTRACTOR'S QC SUPERVISOR

Responsibilities and duties of the Contractor's QC supervisor are:

- To communicate these minimum QC requirements to any suppliers and/or contractors.
- To have the authority to stop Work for cause, reject work, order work removed, initiate remedial work, propose solutions, and reject material not in compliance with the Agreement.
- Be~~Is~~ present on-site and ~~shall~~ designate alternate individual(s) to assume responsibilities in ~~the~~case of temporary absence ~~of the QC supervisor~~. Designated alternate individual(s) must be trained and experienced in the Work and be qualified to inspect the Work.
- Be completely familiar with the Agreement Scope of Work and Drawings.
- Establish and implement QC programs for Contractor and ~~with~~ its various subcontractors and monitor their conformance.
- Inspect existing conditions ~~prior to~~before the start of new work segments.
- Conduct a pre-construction quality control meeting with Contractor's responsible field and office representatives prior to the start of each major item of work required by the Agreement.
- Perform in-process and -follow-up- inspections on each ~~of the~~ work segment~~s~~ to ~~ensure~~verify compliance with the Agreement. Upon request, ~~accompany~~ Owner may attend ~~on~~ such inspections.
- Coordinate required test~~s~~, inspections, and demonstrations with Owner or any other authority having jurisdiction.
- Inspect Contractor purchased materials and equipment arriving at the j~~J~~obsite to ~~ensure~~verify conformance with~~to~~ the requirements of the Agreement. Prepare and submit documentation as required by the Agreement.
- Inspect material to ~~ensure~~verify conformance to the requirements of the Agreement.
- Identify, report and reject defective work not in conformance with the Agreement. Monitor the repair or reconstruction of rejected work and document corrective action. Confirm that the repaired work meets QC requirements.
- If necessary, retain specialists or sub-contractors for inspection of Work in areas where additional technical knowledge is required. Submit qualifications of sub- contractors and specialists to Owner for approval.
- Work closely with Owner to ~~ensure~~verify optimum quality control. Attend meetings as required by Owner.
- Initiate and maintain regular training of the quality team, and construction teams, to verify quality does not falter.

5.0 SUBMITTALS

- Submit Aa letter signed by a responsible officer of Contractor outlining the authority of the QC supervisor to include, among other things, the authority as described herein.
- Contractor shall submit its quality plan manual for review, comments, and approval prior to beginning any Work.
- Contractor shall submit an Inspection and Test Plan (ITP) for review, comments, and approval prior to beginning any Work.
- The ITP shall identify all items that are to be inspected and tested, the frequency of inspection and testing, vehicle form of reports that will be used to document the inspection, and personnel who will witness the inspections. The ITP shall identify witnesses, review, and hold points.
- It shall be the responsibility of Contractor to providesubmit all of the above documents for any andto all subcontractors under their direction prior to beginning work.
- Contractor shall perform random quality audits on all disciplines and subcontractors to verify compliance of the quality program.
- Contractor shall submit reports detailing the results of each test and describing each inspection. Submit separate reports for each test and inspection procedure immediately upon completion of each procedure and test.

6.0 GENERAL QC REQUIREMENTS

Inspection and test reports, as a minimum, shall include:

- Date issued
- Date of inspection or test
- Record of test conditions relevant to test
- Project title and number
- Testing agency name and address
- Name and signature of the inspector/tester
- Identification of the product (including serial number) and applicable specification section
- Type of inspection or test
- Pass/fail criteria
- The results as related to requirements

1.1.47.0 7.0 INSPECTION, MEASURING, AND TEST EQUIPMENT

Contractor shall provide and maintain all measuring and testing devices. Laboratory devices shall be calibrated as required by the Agreement specifications. The standards against which the measurement equipment is periodically calibrated shall have their accuracy verified directly by, or through a precise comparison with standards traceable to the National Institute of Standards and Technology or to a recognized national standard. Refer to traceability requirements and standards in other attachments.

8.0 EXECUTION

Contractor's quality inspections shall be adequate to cover all operations, including both on-site and off-site. and willThey shall be keyed aligned withto the proposed sequence of the Work and shall include as a minimum at least four (4) phases of inspection for all definable items or segments of the Work, as follows:

- Preparatory Inspection: To be performed prior to beginning any work on any definable segment of the Work and shall include:
  - A review of Agreement requirements
  - Verification that all materials and/or equipment have been tested, submitted, and accepted
  - Verification that provisions have been made to provide required control testing
  - Examination of the work area to ascertain that all preliminary work has been completed
  - A physical examination of materials and equipment to assure verify that they conform to accepted shop drawings or submittal data and that all necessary materials and/or equipment are available

As a part of this preparatory work, Contractor's organization willshall review and verify that all documents, including but not limited to, shop drawings, submittal data, method of quality control, product data sheets, test reports, affidavits, certification and manufacturer's instructions have been submitted and accepted by Owner as required herein. Each submittal to Owner shall bear the date and the signatureconfirmation of acceptance by of the Contractor's quality control manager (or authorized designee) indicating that he hasthey have reviewed the submittal and certified it to be in compliance withconforms to the Agreement Drawings, or showing the required changes.

- Initial Inspection: To be performed as soon as a representative segment of the particular item of work has been accomplished and to include examination of the quality of workmanship and a review of control testing for compliance with Agreement requirements, exclusion of defective or damaged materials, omissions, and dimensional requirements.
- Follow-up Inspection: To be performed daily or as frequently as necessary to ensureverify continuing compliance with the Agreement requirements, including control testing, until completion.

- Final Inspection: To be conducted immediately prior to Mechanical Completion. Contractor shall inspect the work for quality, workmanship and completeness prior to notification that the item or segment of the Work has been completed.

In addition, Contractor shall provide the following:

- Specific tests and inspection procedures (including documentation) for each material or item of work are specified in the Agreement Scope of Work and the Drawings.
- Contractor shall have any third party (special) inspections performed as required by the authority having jurisdiction.
- Contractor~~'s testing laboratory~~ shall perform tests according to method(s) of testing specified in the Agreement.
- Contractor shall ~~ensure~~verify that Owner is given sufficient time to witness tests and re- inspect work performed by Contractor.
- Contractor shall ~~ensure~~verify that all work ~~that does~~ not comply~~ing~~ with the requirements and references specified in the Agreement Scope of Work is identified and correctly dispositioned. All work installed or fabricated by the Contractor shall be inspected (i.e., punched) and resolved prior to notifying Owner the Work is ready for Mechanical Completion. Contractor shall record all punch list items (i.e., deficiencies) on a punch list record. Material or equipment that is supplied by Owner and is found by Contractor to have deficiencies is to be immediately identified to Owner with proposed ~~for~~ corrective action.
- Contractor shall package and prepare all inspection and testing documentation for turnover after ~~at the completion of~~ construction. Turnover packages are to be developed for each Project~~by~~ system as determined by Owner. Each system package~~file~~ will contain all field inspection and testing records for the components of the system. Unless otherwise specified, Contractor shall submit two (2) clean, legible copies of all turnover packages to Owner at the completion of construction. Refer to M1-01-02 and table M1-01-02-01- Solar for submittal requirements.

~~M3-01-11~~

APPENDIX M3
~~-~~ATTACHMENT 01
EXHIBIT 11

~~(a)~~ SOLAR PHOTOVOLTAIC PLANT SPECIFICATION OWNER TRAINING

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

~~2023~~
2025

REQUEST FOR PROPOSAL

NO.	DATE	REVISION	BY	CHK'D	APPROVALS	
0	14Apr23	Issued for Implementation	1898 & Co.	PGE	CPA	Craig Armstrong

1.1.21.0 1.0 GENERAL

Contractor shall conduct site-specific training for Owner-assigned administrative, operations, technical, and maintenance personnel. The courseTraining shall be conducted during a standard 8- hour day. Classroom training will be augmented by include classroom and field reinforcementportions, and feature SCADA HMI viewing of the instruction topics. All studentsStudents shall be taught in a one- or two- -day class session, as required. Each training session shall be conducted in an air-conditioned classroom with the appropriate visual aids. A conference call in and online web instructionVirtual remote participation capability shall be provided. The training program will cover all related aspects of knowledge required by the individual disciplines to allow them to competently operate, troubleshoot, and maintain all plant processes and utility systems.

Beyond thisIn addition to the classroom based training, operations personnel shall be provided with a minimum of 12 hours of on-the-job, in the field training of operation personnel will be conducted during start-up and commissioning activities, see

2.1.7 below.

Owner shall advise one month in advance the number of personnel attending the training. A training sign-up sheet shall document Owner's personnel attendance and Contractor's instructor(s). Contractor shall submit the proposed Training Schedule, Training Course Outline and Training Manual for Owner's review prior to the training, refer to M1-01-02 and table M1-01-02-01-Solar.

Owner shall ensureverify that all Operating Personnel attendees (i) are adequately pre-trained in ALL safety aspects of an industrial electrical generation facility as required by Governmental Authorities and Applicable Law and (ii) shall arrive at the classroom with all appropriate personal protective equipment required for touring the PV Power Plant. Contractor shall provide site specific safety training to these personnel.

In addition to the requirements set forth herein, the training shall meet the O&M service provider's requirements.

2.0 SITE-SPECIFIC TRAINING

This Program will encompass on-site training.

2.12.0 CONTRACTOR RESPONSIBILITY

Contractor shall be responsible for:

2.1.1A. Provide training facilities which presentwith an environment conducive to learning (heating, lighting, low noise level and air conditioned and be furnished with an LCD projector or equivalent screen, white boards and markers and podium). Each student's desk (table) shall have enough working space for training manuals and the associated C size drawings.

2.1.2B. Preparation of all classroom and training materials.

2.1.3C. Scheduling and coordination of all classroom-training courses.

2.1.4 Provision of instructions, lesson plans, review, and on-the-job training of the students.

D.

2.1.5E. Coordination of the training schedule with Owner to allow Owner to conduct its own employee training.

2.1.6F. Completion of training program scheduled close enough to the hands-on operating phase so that the material will remain fresh in the minds of the operating personnel.

2.1.7G. On-the-job training throughout the start-up and commissioning period. During this time, Contractor's personnel, as well as representatives from the equipment representatives, shall be available to advise, support, and coach the operating staff.

2.22.1 TYPES OF TRAINING

This Program will be based on the Plant Operating and Maintenance Manuals to be prepared by Contractor and equipment manuals to be furnished by equipment providers. Training sessions will be grouped into logically organized modules. A trainer experienced in the specific subject matter will present each of the training modules. Thesemodule. The modules will include lesson plans, system descriptions, and power point presentations for the systems. Each trainee will be provided withshall receive a copy of the classroom materials and other training documentation. Larger scale drawings of the solar power plant will be displayed for orientation and discussion.

All sessions shall be presented in an informal lecture style with each student having their own set of training material. Each student shall be encouraged to ask questions and to participate in group discussions. This shall be stated in the course objectives and expectations.

2.2.1 Two types of training shall be provided:

- 1. PV System, Substation, and SCADA System, performed by Contractor's Training Staff.
- 2. Vendor specific training by the appropriate equipment supplier or his duly authorized factory representative.

Training will consist of classroom instruction, discussions, site walk downs, and a demonstration of the ability to properly operate the facility. Contractor's training instructors will discuss the overall photovoltaic power plant, while representatives from the equipment manufacturers will address their scope of work.

2.32.2 TRAINING TOPICS

2.3.1 PV Systems

During this section, Contractor will describe the process and discuss the principles of operation for the photovoltaic power plant.

Contractor shall provide experienced instructors to conduct its training program, which shall consist of classroom sessions bolstered by system walk--downs and examinations. The course curriculum shall include the site's PV system

design. The following outline of topics shall typically be covered but not limited to:

A. Introduction

B. PV Systems

1. During this section, Contractor will describe the process and discuss the principles of operation for the photovoltaic power plant.

C. Substation

D. Commissioning and Startup

E. SCADA Systems

F. Meteorological (MET) Stations

G. Security Systems

2.42.3 LESSON FORMAT

Each session shall typically include the following information:

- Lesson Objectives
- Design Basis and List of Resources
- System Overview with Drawings
- Component Description with Supporting Documentation (figures, tables, graphs, etc.)
- Demonstration of ability to properly operate the facility

2.52.4 LESSON CONTENT

2.5.1A. Lesson Objectives

1. The major information the student is expected to learn and retain from the lesson shall be presented. Referenced materials utilized in the training session shall be displayed. Listed references shall include page numbers in manuals, diagram and/or drawing numbers, and appropriate procedure of section numbers.

2.5.2B. Design Basis and List of References

1. The design basis and reference documents shall be presented. The student is expected to learn and retain this information from the lesson.

2.5.3C. System Overview with Drawings

1. This section shall include a brief description of the intended use of the system.

2.5.4D. Component Description with Supporting Documentation

1. This section shall include information on the major components in the system. Tables, figures, drawings and design details shall also be provided.

2.5.5E. Principles of Operation, Including Start-up and Shutdown Procedures

1. The various operational modes of the system and documents shall be presented, including:
   - a. Operating Philosophy
   - b. Start-up
   - c. Normal Operation
   - d. Normal and Emergency Shutdown
   - e. Understanding and responding to alarms
   - f. Recognizing and Handling Abnormal Operating Conditions (Troubleshooting)
2. Trained Owner's personnel will participate in the commissioning and start-up of Owner's facility. Therefore, Contractor's training shall emphasize safety practices and precautions throughout the entire program with the associated "do's and don'ts".

2.5.62.5 WALK-DOWNS

Walk-downs shall be conducted to familiarize the students with the physical location and appearance of equipment and to clarify equipment features, controls, and displays, as well as site features such as drainage, roads, access, and security.

~~M3-01-12~~

APPENDIX M3
ATTACHMENT 01
EXHIBIT 12

~~(a)~~ SOLAR PHOTOVOLTAIC PLANT SPECIFICTION PV MODULE WARRANTY REQUIREMENTS

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

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REQUEST FOR PROPOSAL

NO.	DATE	REVISION	BY	CHK'D	APPROVALS	
0	14Apr23	Issued for Implementation	1898 & Co.	PGE	CPA	Craig Armstrong

~~1.~~1.0 OVERVIEW

Contractor shall supply, through the PV Module Supplier, a PV Module Warranty that is applicable to utility scale solar projects. This will include the following main features:

1. A linear module Power Output Warranty that is for the life of the project 25 years, providing no less than 82% power output at STC at the final year of the Design Life (year 30 preferably), and no more than 2.5% in the first year. See Power Output Schedule below.
2. A 12 year minimum product warranty.
3. Provisions for on-site testing methodology to verify defective products.
4. Provisions for sharing in-and-out costs. OWNER prefers a warranty which will provide for labor to remove and re-install product, and shipping, at no cost to OWNER.
5. Commitments (guarantees) to maximum timeframes for testing, removal, shipment, and reinstallation of defective or deficient product.
6. 60 day notice prior to shipping if module power output mix is different than agreed- upon values.

~~2.~~2.0 LIMITED WARRANTY

The following main elements shall be addressed in the PV Module Warranty:

~~1.~~A. Warranted Products.

~~a)~~1. Photovoltaic modules including factory assembled junction box and cables and connectors, and

~~b)~~2. Mounting products including factory assembled basic hardware, if any,

~~2.~~B. Warranty Descriptions and Durations

~~a)~~1. Product Warranty

~~b)~~2. Power Output Warranty

To include warranted degradation amount for each successive year:

(b) **Power Output Schedule at STC (values included as an example)**

Year	If the module(s) has a power output less than the percentage below multi□plied bythe STC power nameplate rati□ng on the back of the applicable module, then such Product shall be deemed to be in breach of the Power Output Warranty	% Degradati□on
1 (i.e. the first 365 days beginning on the Warranty Start Date, expiring the day before the first anniversary of the Warranty Start Date of the applicable Product)	97.50%	2.50%
2 (i.e. the second 365 days of such period unti□l the day before the second anniversary of the Warranty Start Date of the applicable Product, etc.)	97.00%	0.50%
3	96.50%	0.50%
4	96.00%	0.50%
5	95.50%	0.50%
6	95.00%	0.50%
7	94.50%	0.50%
8	94.00%	0.50%
9	93.50%	0.50%
10	93.00%	0.50%
11	92.50%	0.50%
12	92.00%	0.50%
13	91.50%	0.50%
14	91.00%	0.50%
15	90.50%	0.50%
16	90.00%	0.50%
17	89.50%	0.50%
18	89.00%	0.50%
19	88.00%	0.50%
20	87.50%	0.50%
21	87.00%	0.50%
22	86.50%	0.50%
23	86.00%	0.50%
24	85.50%	0.50%
25	85.00%	0.50%

Year	If the module(s) has a power output less than the percentage below multi□plied bythe STC power nameplate rati□ng on the back of the applicable module, then such Product shall be deemed to be in breach of the Power Output Warranty	% Degradati□on
26	84.50%	0.50%
27	84.00%	0.50%
28	83.50%	0.50%
29	83.00%	0.50%
30	82.50%	0.50%

Year	If the module(s) has a power output less than the percentage below multi□plied bythe STC power nameplate rati□ng on the back of the applicable module, then such Product shall be deemed to be in breach of the Power Output Warranty	% Degradati□on
18	89.00%	0.50%
19	88.00%	0.50%
20	87.50%	0.50%
21	87.00%	0.50%
22	86.50%	0.50%
23	86.00%	0.50%
24	85.50%	0.50%
25	85.00%	0.50%
26	84.50%	0.50%
27	84.00%	0.50%
28	83.50%	0.50%
29	83.00%	0.50%
30	82.50%	0.50%

3.C. Warranty Start Date

4.D. Exclusions and Limitations

5.E. Repair, Replacement or Refund Remedy

6.F. Rights and Remedies against Third Parties

7.G. Claims Procedure, Notice Periods, Dispute Resolution, Testing and Verification Procedures

Appendix M1
Attachment 01
Exhibit 02

(c) **Engineering Documents, Drawings, and Other Deliverables**

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

2023

REQUEST FOR PROPOSAL

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