Portland General Electric

All Source RFP Technical Specifications – Solar Projects

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APPENDIX M – SOLAR PROJECTS

TECHNICAL SPECIFICATIONS

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

2023

REQUEST FOR PROPOSAL

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SOLAR PHOTOVOLTAIC PLANT SPECIFICTION

STATEMENT OF WORK - PV

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

2023

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 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 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.

G. “Circuit” shall have the definition set forth in M3-01-6.

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 1.2.

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 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.

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. “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 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 M3-01-2 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.

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

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

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

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

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

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

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

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

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

1.5 OWNER Provided Facilities, Information and Services

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

1.6 Site and Environmental Criteria

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

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	TBD
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 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 – X 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 shut down.

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. Instrumentation voltage: 24VDC or 125VDC

F. Communications network: Ethernet via direct buried fiber optic 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

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. 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

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

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.

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 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.

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, ASTM, 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.

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

S. All modules shall be a minimum height of twelve (12) inches and a maximum height of eight (8) feet above the ground. Combiner boxes, disconnect switches, inverter/transformers, and any other electrical equipment shall be a minimum 12” above the 100-year 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 4.

B. Combiner boxes shall be installed above ground.

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.

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 4.

B. Load Break Disconnects (LBDs) shall be installed above ground.

C. Provisions for pad locking in the off position.

D. Completed assemblies shall be UL listed.

E. Combiner 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)

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). 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 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 0.95 lag to 0.95 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. 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).
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.

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 requirements.
    a. Inverter shall be compliant with NERC PRC-024-2 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.

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 shall match ISA combined inverter rating. Impedance shall match inverter manufacturer requirements. Cooling class = KNAN

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.

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 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.

P. 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.

Q. 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:

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

6. Heat run test on one (1) unit, preselected during production by Owner.

R. 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. C57.12.34 - IEEE Standard Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers

4. C57.159 – IEEE Guide on Transformers for Application in Distributed Photovoltaic (DPV) Power Generation Systems

5. C57.12.90 - IEEE Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers

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

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 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 ring fiber network or equivalent.

M. SCADA System

7. 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.

8. 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.

9. IP addressing to be coordinated with Owner.

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

11. 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.
12. 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 2 parallel fibers within the same cable (closed-loop).
13. All fiber shall be terminated on bulkheads/enclosures.
14. All fiber networks shall support 1 Gigabit network architecture.
15. Contractor shall install minimum 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.
16. SCADA shall employ Remote I/O to be deployed at major data collections points in the Project. Typical locations for the Remote I/O include the ISAs.
17. The Remote I/O shall function as the input/output point for the command and control signals.
18. The SCADA system shall be either connected to its own UPS or connected to the substation backup energy system. 8hr run-time required.
19. The SCADA shall be designed with redundancy in mind, i.e. power supplies, network paths, etc. UPS system is required at 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
2. Owner’s centralized remote command center
3. Utility or ISO dispatch commands (such as Automated Dispatch System in CAISO) .

At a minimum, the following controls capabilites shall be available at the plant level:

1. Power factor control
2. Reactive power (VAR) control
3. Output power curtailment
4. Power and VAR ramp rate adjustment
5. Frequency droop control (freq vs. kW)

6. 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 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.

3. The Control Room shall also contain the Contractor supplied SCADA communications equipment which will transport all SCADA to the Solar Substation control house via fiber optic cable. The 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 monitored 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):

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. Rainfall Amount

e. Barometric Pressure

f. Back of module Temperature (see PV Module Points below)

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

2. ISA Points (per ISA)

   a. Inverter Performance Points

      i. 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.

b. 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 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 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.

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.

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 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. All wiring 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. 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. 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.

I. 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.

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

K. Factory cable assemblies may be pre-cut to length.

L. Locking multi-contact connectors shall mate with module terminations.

M. Wiring harnesses and cabling shall be UL listed.

N. 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.

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

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

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

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

D. A 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. Contractor shall install supplemental fence grounding or isolation sections where deemed necessary by the grounding study.

4.7 Labeling and Identification

A. For diagnostic and troubleshooting purposes, all 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.
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 399 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

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

6. Arc Flash Study: Contractor shall perform an arc flash hazard analysis in accordance with NFPA 70E and 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.

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. 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) 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

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.

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

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, 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 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.

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

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

D. 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 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.

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.

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

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.

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

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.

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.

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

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 (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

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.

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:

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: ASTM A36

c. Structural Plates and Bars: ASTM A36

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

e. 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 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.

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.

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. 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;

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

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. 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

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 (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.

B. 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.

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 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 M3-01-7.

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.

APPENDIX M3

ATTACHMENT 01

EXHIBIT 02

SOLAR PHOTOVOLTAIC PLANT SPECIFICATION

STATEMENT OF WORK - HV

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

2023

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]

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 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. 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. 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. Fire protection during construction shall meet the requirements of NFPA 241. All fire protection systems shall be subject to the review and approval of the local fire department authorities.

R. 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. 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

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

U. 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. Contractor shall provide:

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

- Facility Rating Report in accordance with FERC and NERC regulations.
- Grounding System Study (including step and touch potential).
- Any other studies required by the Interconnection Agreement, Power Purchase Agreement, or by local utility/ISO.

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

Y. Contractor shall furnish and install primary 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. Contractor shall upgrade the access road(s), as required, to allow delivery of 34.5kV-XXXkV step-up transformer.

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.

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

CC. Contractor shall provide all water for dust suppression.

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.

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.

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.

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.

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]

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 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 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

G. Rated Current-RMS: Interrupting: [by Contractor] kA

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: [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)

A. Model/Type: SF6

B. Rated Voltage; Nominal: XXXkV

C. Rated Voltage; Maximum: XXXkV

D. BIL: XXXkV

E. Rated Current-RMS: Continuous: XXXXA

F. Rated Current-RMS: 3 seconds: [by Contractor] kA

G. Rated Current-RMS: Interrupting: [by Contractor] kA

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: [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.

2.7 XXXkV Surge Arrester

A. Nominal System Voltage: XXXkV

B. Arrester rating: [by Contractor] kV MCOV

C. Outdoor Station Class

D. Polymer

E. Mounting: Vertical

2.8 XXXkV CCVTs

A. Nominal System Voltage: XXXkV

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

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. 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

2.14 Main Power Transformer

A. Contractor shall furnish one (1) or more XXX/34.5kV step-up transformer(s) for 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 system. Transformer shall be sized to at least 10% above MVA rating of plant.

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

D. 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.

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.
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 perpendicular to the bus.

   d. 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.

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.

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

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

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 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%.

4. 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.

5. 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.

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

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:

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

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.

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 Road Improvements 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.

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

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 – 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. 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: ASTM A36
    c. Structural Plates and Bars: ASTM A36
    d. Square/Rectangular Hollow Structural Sections (HHS): ASTM A500 Grade B
    e. Tubular – a structure composed of closed sections (tubes) of circular, multi-sided, or elliptical cross section and tapered or untapered: NEAM TT1
    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 A153.

4. 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. Anchor bolts, anchor bolt assemblies and concrete embedments shall be galvanized in accordance with ASTM A153.
6. Anchor bolts shall conform to ASTM A449, ASTM F1554, Grade 36, or A307.
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 A143 and ASTM A153 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 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

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

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,

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 Substation to POI.

7.2 General

A. A new single circuit XXX kV Gen-Tie line, to be installed on existing self-supporting tubular steel poles (or Owner approved structures), shall begin at the Solar Substation and terminate at the POI or Point of Change of Ownership as defined in the Interconnection Agreement.

B. 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. 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. 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 OPGW shall not exceed 20% of the ultimate cable strength.
3. Wire tension limits for design of the conductor, shield wire, and OPGW shall be based on applicable weather cases (wind, ice, temperature).
4. Vibration Protection.
5. Contractor shall consider and design all wire systems (OPGW, 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 24-fiber OPGW or as specified in the Interconnection Agreement.

H. If conductors are bundled horizontally, Contractor shall install spacers per conductor and spacer manufacturer's recommendations.

I. Mid-span spacers are not required for vertically bundled conductors.

J. 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.

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.

APPENDIX M3

ATTACHMENT 01

EXHIBIT 03

SOLAR PHOTOVOLTAIC PLANT SPECIFICATION
SAFETY AND SITE SECURITY REQUIREMENTS

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

2023

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 Requirements

A. Contractor shall take all necessary precautions for the safety and security of its employees, Subcontractors, agents, owner representatives and visitors on the jobsite and prevent accidents or injury to individuals on, about, or adjacent to the Site. Contractor shall develop and provide, for the site specific work being performed, their Site Environmental, Health & Safety, and Security Plan no later than 6 weeks after Limited Notice to Proceed. Contractor shall ensure that the Plan complies with all federal, state and local regulations and any project specific requirements. This Plan, as subsequently accepted by Owner, will become Attachment 1 to M3-01-03 to the EPC Agreement[1]. Owner shall have 15 business days to review and comment on such Plan submitted by the Contractor; provided, however, that Contractor shall remain solely responsible for performing such Work in accordance with this Agreement. If Owner provides any comments with respect to the Plan to Contractor, then Contractor shall consider Owner's comments and incorporate changes into the Plan, or otherwise address, and resubmit the revised Plan to Owner. Such resubmission of the Plan shall not be considered a Change In Work. Contractor shall perform the Work in accordance with the accepted Plan. Contractor shall not perform any Work on the Site prior to final acceptance of the Plan. In addition, Contractor shall erect and properly maintain at all times, as required by the conditions and progress of the Work, all safeguards and warnings for the protection of its employees and the general public that are reasonably prudent or required by Applicable La**w.**

B. Contractor shall conduct regular inspections required to ensure that safe working conditions and equipment exist. Contractor accepts sole responsibility for: (a) providing a safe place to work for its employees and for employees of its Subcontractors working at the Site and agents, and (b) ensuring the adequacy of and required use of all safety practices, procedures and equipment.

C. Contractor shall orally notify the Owner of any serious accident or near miss occurring on the Site or in connection with the Work within 24 hours of occurrence. A fatality occurring on the Site or in connection with the Work must be communicated to the Owner within 8 hours of its occurrence. Contractor shall document any serious accident or near miss occurring on the Site or in connection with the Work and shall furnish Owner Representative with a copy of the written investigation report within 72 hours of any accident or injury to any of the employees or agents of Contractor or any and all Subcontractors utilized in the performance of the Work.

D. Contractor shall immediately notify Owner of any governmental agency (OSHA, Fire Dept., Health Dept., etc.) complaint and/or inspection of the Site.

[1] Note: Contractor Safety plan also covers security

E. Contractor shall provide to Owner at least monthly, project-related safety performance data to include at a minimum recordable injuries and illnesses, days away from work injuries and illnesses (lost time), recordable and days away from work rates, and performance to project health and safety goals.

F. Contractor shall be responsible for any and all security services (which shall consist of 24 hour services) required for the performance and completion of the Work prior to the occurrence of Project Substantial Completion. Prior to the occurrence of Project Substantial Completion, Owner shall have no responsibility for the security of Contractor's equipment, or any of its Subcontractor's equipment stored at the Site during the performance of the Work including construction of appropriate fencing. When designing, procuring and implementing any securities services, and during the performance of all security services pursuant to this paragraph, Contractor shall cooperate and cause its Subcontractors performing work at the Site to cooperate with Owner.

APPENDIX M3

ATTACHMENT 01

EXHIBIT 04

SOLAR PHOTOVOLTAIC PLANT SPECIFICATION

COMMISSIONING

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

2023

REQUEST FOR PROPOSAL

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

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 result 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 commissionability (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 on a regular basis 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 project 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:

The following PV equipment shall be tested for functionality, operability, and performance:

1. Solar Modules (IEC 61215 tests and Flash Tests)
2. Combiner Boxes (or Load Break Disconnects as applicable)
3. Inverter Skid Assemblies
4. Solar Substation GSU
5. SCADA
6. Trackers
7. MET Station

OWNER and ENGINEER shall be given opportunity to witness each test and shall be given 15-day advance notice prior to any planned test. The related expense will be paid by the Contractor. Owner and/or Engineer's travel expense for attending factory acceptance testing will be paid by the Owner.

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. Prefunctional Checklists: Project and equipment-specific prefunctional checklists shall be developed and issued by Contractor to the installing contractors. The prefunctional checklists shall address proper installation methods, 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. Prefunctional 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

inverter skids. This will include signatures of the responsible personnel and verification of proper installation of all equipment, devices, and wiring per manufacturer's recommendations. This will also include observations and punch-lists from Quality Control personnel verifying installation has occurred per their design drawings and specifications.

F. Functional Testing: There are two types of functional testing required:

1. Equipment-specific functional testing and 2) PV Plant Functional Testing – these protocols will be developed and executed by Contractor to address functionality and safe operation of components and systems. The functional testing protocols shall be detailed so as to address operation, failure modes, and recovery modes.

2. 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.

b. Completion of the pre-functional tests of the PV Modules and DC collection system, including but not limited to 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, and Grounding Tests.

c. AC cabling Very Low Frequency (VLF) testing or Partial Discharge (PD) testing.

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 manufacturer's instructions (Cold commissioning plans).

f. 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.

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-

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 required to be performed either in factory or field in order 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.

h. Liquid filled transformers shall have the following field testing requirements:

   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. Dry type transformers shall have the following field testing requirements:

   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. Trackers: Verify trackers are fully functional. Ensure they operate in unison and adjust angle accurately remaining normal to sun even with clouds and reset to proper angles after stow or night; back-tracking function works properly with no interior shading. Proper tracker stow shall be checked and wind and hail stow shall be verified.

k. 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 Disconnect devices integrity and operability, 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. Test plant controls to verify all control features are fully functional, including reactive power control (PF/VAR/voltage) and power curtailment.

m. All auxiliary systems and devices are installed and functionally tested.

n. 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 fully functioning fiber ring, including OTDR testing.

3 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

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.

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 subcontractor supplied manuals, warranties, and specification sheets.

E. Warranty Review: Contractor shall review all equipment warranties for compliance with contract documents. Extended warranty requirements and warranty activation dates shall be documented.

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

Contractor shall be responsible for all standard testing instrumentation. Testing instrumentation should include, but is not limited to:

A. Power meters

B. Voltmeters

C. Clamp-on meters (Amp meters)

D. Irradiance meters

E. Power quality test equipment

F. Temperature sensors

G. Met stations: Wind speed sensors, rain gauge, ambient temperature sensors, and all other sensors.

H. Specialized electrical apparatus test equipment.

All instrumentation is to be NIST, or approved equivalent, calibrated; calibration certificates shall be current for all instrumentation used by Contractor during testing.

All irradiance meters shall be cleaned no less than once per week during testing.

4.0 SAFETY

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. Fall Protection

B. Electrical Safety

C. Lockout/Tagout

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.

2.0 SCOPE

The inverter manufacturer shall provide the following documentation from a certified NRTL:

1. UL 1741 Test Report
2. UL 1741 Certification
3. UL 1741 SA Test Report (if applicable)
4. UL 1741 SA Certification (if applicable)
5. IEEE 1547/519 Harmonics Test Report (including raw test data)
    a. Current THD < 3%
6. NERC PRC-024-2 Voltage and Frequency Ride-Through Test Report
7. 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. Active Power
    a. Inverter manufacturer shall provide test documentation showing the inverter can operate up to the nameplate power rating (including any "overdrive" or 110% functionality).
2. Reactive Power
    a. 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

3. Plant Controller Response
    a. Inverter manufacturer shall provide test documentation showing the inverter can receive active and reactive commands from a simulated plant controller interface.
    b. 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.
4. Edge-of-Cloud Effects
    a. 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. DC Voltage
    a. Inverter manufacturer shall provide test documentation showing the inverter can operate over the rated DC voltage operating range.
    b. Inverter manufacturer shall provide active power vs. DC voltage de-rating curves.
6. AC Voltage
    a. Inverter manufacturer shall provide test documentation showing the inverter can operate over the rated AC voltage operating range.
    b. Inverter manufacturer shall provide active power vs. AC voltage de-rating curves from 0.9 to 1.1 p.u. terminal voltage and 0.9 lead/lag.
7. Ambient Temperature
    a. 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. At a minimum, the test documentation must include the following operating conditions:
        i. 25°C
        ii. 45°C
        iii. Maximum Operating Temperature
        iv. Minimum Operating Temperature
        v. Any “corner points” on ambient temperature de-rating curves
    c. Inverter manufacturer shall provide active power vs. ambient temperature de-rating curves.
8. DC/AC Ratio
    a. 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. Reliability
    a. Inverter manufacturer shall provide test documentation summarizing the accelerated life testing (ALT) and highly accelerated life testing (HALT) testing that has been completed.
    b. Inverter manufacturer shall provide mean time between failures (MTBF) and mean time to failure (MTTF) rates for critical components such as:
        i. IGBTs
        ii. DC switches/contactors
        iii. AC contactors/breakers
        iv. DC link and AC filter capacitors
        v. Communications boards
        vi. Cooling system components (fans, pumps, etc.)

At a minimum, the following tests shall be performed on each inverter during production testing:

1. Calibration of all DC and AC voltage, current, and power circuitry/sensors.
2. UL 1741 production testing such as hi-pot and PE/ground testing
3. GFDI
4. Emergency stop (fast stop)
5. Remote start/stop
6. Burn-in (minimum 4 hours per inverter)
    a. Burn-in testing should be completed under elevated ambient temperature and high DC current conditions at maximum rated power.
7. Harmonic content verification (during burn-in tests)
8. Efficiency verification
    a. Verify inverter efficiency at multiple DC voltages and power levels which shall be consistent with the levels tested during CEC testing.
        i. The official CEC test procedure is not required.
9. Reactive power control (0.95 lead/lag) at rated apparent power
10. Voltage and frequency ride-through verification per IEEE 1547 and/or PRC-024-2

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 B – SOLAR SUBSTATION TESTING REQUIREMENTS

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:

- Megger tests
- Instrument transformer tests
- Insulating oil tests
- Ground testing
- Power panel tests, AC and DC
- Low voltage automatic transfer switches
- Battery chargers
- Batteries
- Molded-case circuit breaker trip test
- High voltage testing
- Radio interference tests
- Lighting
- Hot-spot tests on buses, connectors, and fittings
- Miscellaneous tests on other equipment furnished and installed by the Contractor
- 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

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:
    - Primary Frequency Response (PFR)
    - Reactive Power
    - Automatic Voltage Regulation (AVR)

APPENDIX M3

ATTACHMENT 01

EXHIBIT 05

SOLAR PHOTOVOLTAIC PLANT SPECIFICATION

PV CAPACITY TEST

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

2023

REQUEST FOR PROPOSAL

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

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 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 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 T_0 and W_0.

2.0 DEFINITIONS

Agreement

The Engineering, Procurement and Construction Agreement between Owner and Contractor.[fill in actual final document name/date here]

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.

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 Facility Performance minus the Test Measurement Uncertainty. It shall be expressed as a percentage.

Minimum Facility Capacity

Shall be 95% with no correction for measurement uncertainty.

Minimum Power Rating (P_{MIN})

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.

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.

PV Power Plant

The PV Power Plant (also referred to as the “Facility”) will consist of XX MW_{AC} 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.

Point Of Interconnect (POI)

This shall have the meaning set forth in the Agreement.

Power Rating (P_{RC})

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.

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.

Primary Measurement Device

An instrument which provides a measurement or reading that is used in calculating the PV Power Plant Power Rating.

Reporting Conditions

This shall be as defined as the reference irradiance (Irr_0), the reference temperature (T_0), and the reference wind speed (WS_0) as determined by the procedures outlined below and referred to in ASTM E2848-13.

Secondary Measurement Device

An instrument which provides a measurement or reading that is not used in calculating the output power but is used as check on primary measurements or for further analysis.

Supervisory Control and Data Acquisition (SCADA)

The hardware and software installed at the Project Site which is used to 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.

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%.

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		+/- 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	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.
- 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 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) Test procedures (as executed)
2) Instrument calibration sheets/certificates
3) Test data (manual and data acquisition) including table of averaged and filtered data
4) Test results uncertainty
5) Field notes
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) The pyranometers used to collect irradiance measurements shall be cleaned immediately prior to testing. 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) Owner shall be responsible for:

i) Routinely reviewing collected weather and operating data for the PV Power Plant following Substantial Completion.

ii) 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) Contractor shall collect, filter, and average data until 120 valid data points are obtained.

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. 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.

5.3 Data Collection and Selection of Reporting Conditions (RC)

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) For the Plane-of-Array (POA) and Rear Plan-of-Array (RPOA for bifacial modules) irradiance measurements, the data recorded from multiple pyranometers will be averaged for each time interval.

i) 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) In the event multiple ground coverage ratios (GCRs) exist on site, a meteorological station shall be provided in each differing GCR area.

c) The collected data set shall be filtered according to the following operations:

i) The guidelines and calculations described in ASTM E2848-13 will be followed.

ii) Any test data points in which the inverter is “clipping” shall also be excluded.

iii) POA irradiance below 400 W/m^2 will be excluded.

d) After filtering, the resultant data set shall be used to determine the Reference Irradiance (Irr_0) for the Reporting Conditions.

i) 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) 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.

iii) 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 to obtain a necessary and reasonable number of data points.

iv) 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) The Filtered Measurement Data shall be defined as the resulting data set of section d above, and it shall have a minimum of one hundred twenty (120) data points.

i) The one hundred twenty (120) or more data points are under the assumption of a five (5) minute averaged data interval.

ii) 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.

iii) A wider filter can be applied to irradiance band as mentioned above in section d (iii), if agreed upon by Owner and Contractor.

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) 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) The PV Simulation Model, as derived from PVsyst simulations, shall be used to establish the Facility's expected output to be compared to the power output at the revenue meter as adjusted at the relevant conditions.

i) 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) 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) Date & Time (formatted with Month; Day; Hour in separate columns)

ii) POA Irradiance (GlobInc, W/m^2)

iii) RPOA Irradiance (GlobBak, W/m^2)

iv) Horizontal Irradiance (GlobHor, W/m^2)

v) Ambient Temperature (T Amb, °C)

vi) Wind Speed (WindVel, m/s)

vii) Near Shadings Beam Loss (ShdBLss, W/m^2)

viii) Inverter Loss Due to Low Voltage Maximum Power Point (MPP) Window (IL Vmin, kW)

ix) Inverter Loss Due to Power Limitation (i.e., "clipping" loss) (IL Pmax, kW)

x) Available Energy at Inverter Output (EOutInv, kW)

xi) Energy Injected into Grid (E Grid, kW)

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 fourteen (14) days: the seven (7)-Day period prior to and after the Test start. The Target Period may be extended further than fourteen (14) Days upon agreement of Contractor and Owner.

d) The Minimum Power Rating (P_{MIN}) 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) 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) Apply the following filters to the resulting Target Period data file:

a) Exclude any data points with beam shading values ShdBLss > 0.

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.

iii) After filtering, the resulting dataset shall have 50 one-hour data points, or more.

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) At Owner's discretion, the irradiance threshold may be expanded to a larger range as described in (3)(e)(iii) above.

iv) 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) 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 as illustrated in Equation 1.

5.5 Power Rating (P_{RC})

a) The Filtered Measurement Data for the site identified in section (3)(e) above shall be used to calculate P_{RC} for the site.

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:

$$P_{RC} = Irr_0 * (a_1 + a_2 * Irr_0 + a_3 * T_0 + a_4 * WS_0)$$

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) 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) The Facility Performance shall be calculated as below and expressed as a percentage:

$$\text{Facility Performance} = (P_{RC} / P_{min}) * 100 - TMU$$

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 so 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) 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) Test procedures

ii) Instrument calibration sheets/certificates

iii) Test data (manual and data acquisition)

iv) Test Results uncertainty

v) Field notes

vi) Calculations and Results

APPENDIX M3

ATTACHMENT 01

EXHIBIT 06

SOLAR PHOTOVOLTAIC PLANT SPECIFICATION

PROJECT SCHEDULE

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

2023

REQUEST FOR PROPOSAL

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

1.0 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.

2.0 KEY DATES SCHEDULE

Key Date Schedule shall include major project milestones, including substantial completion of each Circuit. Milestones indicated in the Key Date Schedule will be used as a basis for milestone payments.

3.0 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 (refer to Instructions to Bidders), and shall be sufficiently detailed so that each of the following are included and will be readily apparent:

(a) The engineering and detailed design activities necessary to complete design, procurement and construction;

(b) Materials and equipment purchases and deliveries;

(c) Subcontractor interfaces and requirements;

(d) Construction, by Circuit and system;

(e) Dates for the completion of Key Date Items;

(f) Contractor and Subcontractor data cycles, and Owner's review cycles;

(g) Functional Tests, Commissioning and Capacity Testing;

(h) 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.

4.0 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.

APPENDIX M3

ATTACHMENT 01

EXHIBIT 07

SOLAR PHOTOVOLTAIC PLANT SPECIFICATION

ENERGY MODEL

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

2023

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1.0 OVERVIEW

A. 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.

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 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.
6. Result 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. Associated Software, Files, and References:

- **Software:**
    a. Most recent version of PVSyst.
    b. Microsoft Excel
- **Files:**
    a. Energy Model File
        i. [ ].xls
    b. Module Equipment Files for PVSyst
        i. [ ].PAN
    c. Inverter Equipment File for PVSyst
        i. [ ].OND
    d. Shading Profile File for PVSyst
        i. [ ].SHD

e. Project File, Variant Files by Array Type
   i. [ ].PRJ
   ii. [ ].VC2
   iii. [ ].VC3
f. PVSYST Output Reports by Array Type or Circuit
   i. [ ].pdf
   ii. [ ].pdf
   iii. [ ].xlsx
g. Energy prediction Report by Circuit with AC losses excluded
   i. [ ].xlsx

- **References**
  a. System design specifying module types, strings per inverter, inverters per Circuit.

3.0 DATA PREPARATION

A. 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. SCADA recorded weather file to be submitted to Owner with updated energy model as specified in M1-01-02 and table M1-01-02-01-Solar. Measurement data recorded by the SCADA and used in running the Energy Model will include:

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)
- Albedo (W/ m^2) (If bifacial modules used)

Discussion:

- 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.

B. Data Preparation

- 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.
- 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).
- Missing or obviously faulty data due to equipment error shall be discarded or be replaced in accordance with the Acceptance Test Procedures.
- 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. Load Weather File into PVSyst

The resulting Weather File created will be converted into a TMY3 or ASCII format compatible with the input requirements for PVSyst and will replace the existing weather bid file used for the base PVSyst energy model.

4.0 PVSYST SIMULATIONS

A. Determine PVSyst Simulations to Run

Although module types and string configurations can vary within a Circuit, each Circuit must be modeled by a single average configuration and single module degradation amount (one PVSyst .VC file per Circuit) Include 8760 data as Attachment B.

Contractor shall fill out and bracketed [ ] values.

B. PVSyst Parameters

1. Project Tab
   - Latitude = [ ] deg.
   - Longitude = [ ] deg.
   - Meteo Data File: Solar Anywhere, satellite data, SUNY model - TMY
   - Altitude = [ ] meters
   - Time zone = [ ]
   - Monthly Albedo = [These values assume a one-in-portrait tracker]

Month	PVsyst Inputs
January	[ ]
February	[ ]
March	[ ]

Month	PVsyst Inputs
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. Orientation Tab
    - Unlimited sheds
    - See attached input and assumptions for Tracker parameters
3. Horizon Tab
    - As applicable
4. Near Shadings Tab
    - As applicable
5. System Tab
    - Module .PAN file
    - Inverter .OND file
    - Nb of inverters. = [ ]
    - Modules per String = [ ]
    - Strings per Inverter = This varies by array type. See Attachment A Input and Assumptions System Definition section.
    - Detailed Losses section of System Tab
        i. Uc= 25.0 W/m^2k

ii. Uv= 1.2 W/m^{2}k / m/s

iii. 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)

1. 0.10% iron loss, 0.90% resistive/inductive losses at STC. Add 0.10% iron loss and 0.40% resistive/inductive losses if including GSU transformer.

iv. Module Quality, LID, Mismatch

1. 1.5% for LID
2. [ ] Module Quality loss
3. 1.0% Mismatch loss at MPP

v. Soiling losses:

Month	PVsyst Inputs
January	[ ]
February	[ ]
March	[ ]
April	[ ]
May	[ ]
June	[ ]
July	[ ]
August	[ ]
September	[ ]

October	[ ]
November	[ ]
December	[ ]

vi. Incidence angle effect: b0= see .pan file for table.

vii. 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. Module Layout Tab
   - Not used
7. Hidden Parameters Menu
   - Not used
8. Preferences Menu
   - Physical Model = Perez

C. Additional Loss Parameters

Some losses cannot be calculated in PVSyst or not calculated to the specifications necessitated by the Contractor. These losses must be fully completed in Microsoft Excel with all the formulas, constants, and justification spelled out here.

D. 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 be applied to the Energy Model for predicting the energy output for 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)
0 < 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	[ ]	[ ]
13 < x < 14	[ ]	[ ]
14 < x < 15	[ ]	[ ]
15 < x < 16	[ ]	[ ]

	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)
16 < x < 17	[ ]	[ ]
17 < x < 18	[ ]	[ ]
18 < x < 19	[ ]	[ ]
19 < x < 20	[ ]	[ ]
20 < x < 21	[ ]	[ ]
21 < x < 22	[ ]	[ ]
22 < x < 23	[ ]	[ ]
23 < x < 24	[ ]	[ ]
24 < x < 25	[ ]	[ ]
25 < x < 26	[ ]	[ ]
26 < x < 27	[ ]	[ ]
27 < x < 28	[ ]	[ ]
28 < x < 29	[ ]	[ ]
29 < x < 30	[ ]	[ ]
30 < x < 31	[ ]	[ ]

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. In the Simulation Screen input a unique output file name for each run/circuit. (not to exceed the number of Circuits).
2. The output parameters will include at least the following variables:
    a. Horizontal global irradiation
    b. Global incident in coll. Plane
    c. Ambient Temperature
    d. Average Module temperature
    e. Wind velocity
    f. Effective energy at the output of the array
    g. Available Energy at Inverter Output
    h. Energy injected into grid
    i. Inverter efficiency (operating)
3. Run the simulation.
4. 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.

Copy and paste the output data into the appropriate column in the Energy Model File.

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.

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 to be submitted in attachment A, with explanation for any parameters differing from the givens in this document.

Attachment A

PVSyst Assumptions

Software	Version	Comment
PVsyst		
Microsoft Excel		Provide Native 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
Transposition Model		
MET File Source (e.g., SolarAnywhere)		
Latitude		
Longitude		
Altitude (m)		

PVsyst Parameter	Value	Comment
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, Left (m)		
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 =	

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 =	

PVsyst Parameter	Value	Comment
	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 (%)		

APPENDIX M3

ATTACHMENT 01

EXHIBIT 08

SOLAR PHOTOVOLTAIC PLAN SPECIFICATION

APPROVED SUPPLIERS

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

2023

REQUEST FOR PROPOSAL

NO.	DATE	REVISION	BY	CHK'D	APPROVALS	
0	14Apr23	Issued for Implementation	1898 & Co.	PGE	CPA	Craig Armstrong
1	15Dec23	Update approved suppliers in line with other technologies	PGE	PGE	CPA	Craig Armstrong

1.0 GENERAL

M3-01-08 contains a list of approved materials, equipment suppliers, and subcontractors. Contractor shall request approval from Owner prior to executing any contract for the procurement of such material or with such equipment supplier or subcontractor (a) if Contractor is considering the selection of a material, equipment supplier, or subcontractor that is not listed below; (b) for any Major Subcontractor not listed below; or (c) for the Project's engineer(s) of record and geotechnical engineer(s). Equipment catalog cut sheets shall be submitted for Owner review and approval prior to procurement. In some categories, a supplier has been identified as "Preferred" with an (*) in order to maintain the same suppliers of equipment as Owner has utilized the supplier for its generating fleet.

2.0 ACCEPTABLE SUPPLIERS

Contractor shall provide equipment from the following vendors:

2.1 PV Module

1. Canadian Solar
2. First Solar
3. GCL
4. Hanwha Q-CELLS
5. JA Solar
6. Jinko Solar
7. LONGi Solar
8. Trina Solar
9. Yingli

2.2 Tracker

1. Array Technologies (ATI)
2. NEXTracker

2.3 DC Combiner Box and/or Load Break Disconnect

1. Bentek
2. Shoals
3. Solar BOS
4. WTEC

2.4 Inverter

1. Power Electronics
2. SMA

3. Sungrow
4. TMEIC

2.5 Collection System Cable

1. Southwire
2. Prysmian Power Cables and Systems
3. Okonite

2.6 Generator Circuit Breaker

1. *ABB
2. GE Grid Solutions
3. Mitsubishi
4. Siemens
5. HVB

2.7 Generator Step-up Transformer (substation main power transformer)

1. ABB, Varennes, Canada shop
2. ABB, St. Louis, Missouri shop
3. ABB, Bad Honnef, Germany shop
4. ABB, South Boston, Virginia shop
5. HICO, ChangWon, South Korea shop
6. Hyundai, Montgomery, Alabama shop
7. Hyundai, Ulsan, South Korea shop
8. Smit, Nijimegen, The Netherlands shop
9. SPX Waukesha, Waukesha, Wisconsin shop
10. EFACEC, Arroteia, Portugal shop
11. Siemens, Guanajuato, Mexico shop
12. GE Prolec, Monterrey, Mexico shop
13. Shihlin, Taipei, Taiwan shop

2.8 Ground Reference Transformers

1. ABB
2. Cooper Power Systems
3. GE
4. Virginia Transformer

2.9 Medium Voltage Transformer

1. ABB
2. General Electric

3. Cooper Power Systems
4. Siemens
5. WEG

2.10 Instrument Transformers

1. ABB
2. Trench Ltd
3. GE/Alstom

2.11 Load Center Unit Substations

1. ABB
2. Eaton
3. General Electric
4. Powell Manufacturing
5. Schneider Electric / Square D
6. Siemens Power T&D

2.12 LV Motor Control Centers

1. *Eaton
2. ABB
3. Allen Bradley
4. General Electric
5. Powell Manufacturing
6. Schneider Electric / Square D
7. Siemens Power T&D

2.13 Medium Voltage Switchgear, Starters and Controllers

1. Powercon
2. Siemens Power T&D
3. ABB
4. Eaton
5. General Electric
6. Powell Manufacturing
7. Schneider Electric / Square D

2.14 Protective Relays and Revenue Meters*

1. Schweitzer Engineering Laboratories (SEL)
2. Schneider Ion 8650

* Final devices must be compatible with PGE standards and approved by PGE in

advance of final design and start of construction

2.15 SF6 Circuit Breakers (High Voltage and Medium Voltage)

1. Siemens
2. ABB
3. Mitsubishi
4. GE/Alstom
5. Hitachi/HVB (Georgia)

2.16 Single Mode Fiber Cable & Attachment Hardware

1. AFL
2. OFS
3. Preformed Line Products
4. Anixter

2.17 Substation Capacitors

1. Cooper Power Systems
2. General Electric

2.18 Substation Control Enclosure

1. Trachte
2. AZZ
3. Systems control

2.19 Substation Disconnect Switches (115-230KV)

1. Pascor
2. Cleaveland Price

2.20 Substation Distribution Metering

1. Novatech Bitronics M871 (SCADA distribution feeder metering)
2. Novatech Bitronics M650 (SCADA distribution transformer metering)

2.21 Substation Human/Machine Interface

1. Schneider Electric

2.22 Substation Remote Terminal Unit

1. Eaton Cooper Power System

2.23 Substation SCADA Ethernet Switches and Port Servers

1. Siemens RuggedCom RSG2300 – Managed Layer 2 switch, Rack mount, 32 ports
2. Siemens RuggedCom RS900 – Managed Layer 2 switch, Rail mount, 9 ports
3. Siemens RuggedCom RX1500 – Managed Layer 2 & Layer 3 switch, Rack

mount, maximum 24 ports

4. Siemens RuggedCom RS416 – Serial port server, Rack mount, 16 ports

2.24 Substation SCADA Gateway

1. Eaton Cooper SMP SG4250

2.25 Substation SCADA Input/Output Devices

1. Eaton Cooper Power Systems

2.26 Transformer Bushings

1. PCORE
2. ABB

2.27 Uninterruptible Power Supply System (UPS)

1. *Vertiv Chloride (formerly Emerson Network Power)
2. Ametek Solidstate Controls
3. CEG
4. Gutor/Schneider

2.28 48 VDC Battery & Charger

1. East Penn Manufacturing
2. C&D Technologies
3. Eltek/Valere

2.29 125 VDC Chargers

1. *SENS
2. *Vertiv Chloride (formerly Emerson Network Power)
3. Ametek Solid State Controls
4. Cyberex
5. Hindle Power

2.30 125 VDC Batteries

1. *GNB
2. BAE
3. Hoppecke
4. C&D Technologies

APPENDIX M3

ATTACHMENT 01

EXHIBIT 09

SOLAR PHOTOVOLTAIC PLANT SPECIFICATION

FORM OF MONTHLY PROGRESS REPORT

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

2023

REQUEST FOR PROPOSAL

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

1.0 GENERAL

A. DESCRIPTION

Cover sheet to show the project name, the time span covered and the date of the report.

2.0 INDEX

1. PROJECT TEAM

List personnel and functions of team comprising of:

- Contractor
- Subcontractors
- Major suppliers

2. EXECUTIVE SUMMARY

Provide high level summary delineating project status, milestones and issues. Limit to 1 page or less.

3. 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. 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

- Include % complete against time (Engineering Procurement, Construction, Overall)
- Progress curves for planned versus actual (Engineering Procurement, Construction, Overall)
- Overall project status

b. Permitting Progress

Detail any permitting progress and issues that have continued into construction phase, as applicable: site access, encroachments, building permits, etc.

c. 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. 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. 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. 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. 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

APPENDIX M3

ATTACHMENT 01

EXHIBIT 10

SOLAR PHOTOVOLTAIC PLANT SPECIFICATION
CONTRACTOR'S QUALITY ASSURANCE PROGRAM

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

2023

REQUEST FOR PROPOSAL

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

1.0 GENERAL REQUIREMENTS

The following sections of M3-01-10 describe 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 requirements of the Agreement. Contractor may 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'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 that all work adheres strictly to all requirements of the Agreement and governing agencies where the work is being performed.
- To maintain QC procedures to ensure that tasks performed will comply with 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.

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.
- Is present on-site and shall designate alternate individual(s) to assume responsibilities in the 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 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 segments to ensure compliance with the Agreement. Upon request, accompany Owner on such inspections.
- Coordinate required test, inspections, and demonstrations with Owner or any other authority having jurisdiction.
- Inspect Contractor purchased materials and equipment arriving at the Jobsite to ensure conformance to the requirements of the Agreement. Prepare and submit documentation as required by the Agreement.
- Inspect material to ensure 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 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 optimum quality control. Attend meetings as required by Owner.

5.0 SUBMITTALS

- A 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 that will be used to document the inspection, and who will witness the inspections. The ITP shall identify witness, review, and hold points.
- It shall be the responsibility of Contractor to submit all of the above documents for any and 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

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 inspection shall be adequate to cover all operations, including both on-site and off-site and will be keyed to 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 that they conform to accepted shop drawings or submittal data and that all necessary material and/or equipment are available

As a part of this preparatory work, Contractor's organization will 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 signature of the Contractor's quality control manager (or authorized designee) indicating that he has reviewed the submittal and certified it to be in compliance with 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 ensure 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.
- 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's testing laboratory shall perform tests according to method(s) of testing specified in the Agreement.
- Contractor shall ensure that Owner is given sufficient time to witness tests and re-inspect work performed by Contractor.
- Contractor shall ensure that all work that does not comply 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 for corrective action.
- Contractor shall package and prepare all inspection and testing documentation for turnover at the completion of construction. Turnover packages are to be developed by system as determined by Owner. Each system 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.

APPENDIX M3

ATTACHMENT 01

EXHIBIT 11

SOLAR PHOTOVOLTAIC PLANT SPECIFICATION

OWNER TRAINING

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

2023

REQUEST FOR PROPOSAL

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

1.0 GENERAL

Contractor shall conduct site-specific training for Owner-assigned administrative, operations, technical, and maintenance personnel. The course shall be conducted during a standard 8-hour day. Classroom training will be augmented by field reinforcement and SCADA HMI viewing of the instruction topics. All students 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 instruction 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 this classroom based training, a minimum of 12 hours of on-the-job 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 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 ensure 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.

2.1 Contractor Responsibility

Contractor shall be responsible for:

2.1.1 Provide training facilities which present 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.

2.1.2 Preparation of all classroom and training materials.

2.1.3 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.

2.1.5 Coordination of the training schedule with Owner to allow Owner to conduct its own employee training.

2.1.6 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.

2.1.7 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.

2.2 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. These modules will include lesson plans, system descriptions, and power point presentations for the systems. Each trainee will be provided with a copy of the classroom materials and other training documentation. Larger 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:

- PV System, Substation, and SCADA System, performed by Contractor's Training Staff.
- 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 demonstration of 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.

2.3 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 PV system

design. The following outline of topics shall typically be covered but not limited to:

A. Introduction

B. PV Systems

C. Substation

D. Commissioning and Startup

E. SCADA Systems

F. Meteorological (MET) Stations

G. Security Systems

2.4 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

2.5 Lesson Content

2.5.1 Lesson Objectives

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.

2.5.2 Design Basis and List of References

The design basis and reference documents shall be presented. The student is expected to learn and retain this information from the lesson.

2.5.3 System Overview with Drawings

This section shall include a brief description of the intended use of the system.

2.5.4 Component Description with Supporting Documentation

This section shall include information on the major components in the system. Tables, figures, drawings and design details shall also be provided.

2.5.5 Principles of Operation, Including Start-up and Shutdown Procedures

The various operational modes of the system and documents shall be presented, including:

- Operating Philosophy
- Start-up
- Normal Operation
- Normal and Emergency Shutdown
- Understanding and responding to alarms
- Recognizing and Handling Abnormal Operating Conditions (Troubleshooting)

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".

2.5.6 **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.

APPENDIX M3

ATTACHMENT 01

EXHIBIT 12

SOLAR PHOTOVOLTAIC PLANT SPECIFICTION

PV MODULE WARRANTY REQUIREMENTS

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

2023

REQUEST FOR PROPOSAL

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

1. 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. LIMITED WARRANTY

The following main elements shall be addressed in the PV Module Warranty:

1. Warranted Products.
    a) Photovoltaic modules including factory assembled junction box and cables and connectors, and
    b) Mounting products including factory assembled basic hardware, if any,
2. Warranty Descriptions and Durations
    a) Product Warranty
    b) Power Output Warranty

To include warranted degradation amount for each successive year:

Power Output Schedule at STC (values included as an example)

Year	If the module(s) has a power output less than the percentage below multiplied by the STC power nameplate rating on the back of the applicable module, then such Product shall be deemed to be in breach of the Power Output Warranty	% Degradation
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 until 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%

Year	If the module(s) has a power output less than the percentage below multiplied by the STC power nameplate rating on the back of the applicable module, then such Product shall be deemed to be in breach of the Power Output Warranty	% Degradation
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. Warranty Start Date
4. Exclusions and Limitations
5. Repair, Replacement or Refund Remedy
6. Rights and Remedies against Third Parties
7. Claims Procedure, Notice Periods, Dispute Resolution, Testing and Verification Procedures

Appendix M1

Attachment 01

Exhibit 02

Engineering Documents, Drawings, and Other Deliverables

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

2023

REQUEST FOR PROPOSAL

NO.	DATE	REVISION	BY	CHK'D	APPROVALS	
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Table of Contents

1 M1-01-02-Engineering Documents, Drawings, and Other Deliverables

1.1 Submittals

Contractor shall supply all drawings, calculations and study reports, plans, specifications, and information to the Owner as part of the scope of Work. Documents and information shall include, but are not limited to, the deliverable list in M1-01-02-01 (Engineering Documents, Drawings, and Other Deliverables Table), in each case for the relevant technology (wind, solar, storage) as applicable. Items marked in the submittals table per the applicable technology (wind, solar, storage) shall be submitted for the Owner's review and approval prior to equipment purchase or construction.

Within 60 days of the Effective Date, Parties shall identify and mutually agree upon all OEM equipment submittals and specifications which will be submitted to the Owner and those that the Owner will review. Conformed to construction record drawings (as-builts) shall be provided for selected drawings marked as Level C.

Contractor shall organize a face to face or real time meeting with the Owner prior to Construction to review design documents.

As the project progresses through engineering and construction, the Contractor shall provide to the Owner the current revision of the drawings and documents according to the normal project communication distribution to be decided upon during project kickoff. These distributions shall be provided in electronic copy in native file format.

Upon completion of any drawing or document revision(s), Contractor shall submit the drawing(s) or document(s) within 2 days to the Owner.

1.2 Document Submittal Requirements

1.2.1 Drawings

Drawings requested by the technical specifications are to be sent as directed therein. Drawings associated with this Contract shall be in the English language and English system of units.

Each submitted drawing shall be unique and shall be clearly marked with the name of the Project, facility name, facility designation, specification title, specification number, project equipment or structure nomenclature, component identification numbers, Owner’s name, revision number, and revision history.

Final as-built drawings, including Contractor drawings and vendor drawings, shall be submitted in electronic format on electronic storage device. Each form of media shall be clearly labeled for content and date.

Contractor shall submit all drawings in AutoCAD (.dwg) version 2014 format including bound files, XREF files, 3D models (saved out to

Autodesk Plant 3D 2014 or approved equal), sheet drawing files, and Acrobat Adobe (.pdf) format. All color settings files (*.ctb), font files, block libraries, title blocks, and CAD Standards used on the Project shall follow M1-01-09 (PGE CAD and Numbering Standards). Exceptions shall be submitted to Owner in electronic format that is clearly labeled for content and date.

Two electronic files of all professional engineer (PE) stamped drawings approved for construction shall be submitted to PGE. One file shall be a scan of the PE-stamped and signed (approved) drawing original in (.pdf) format. The second file shall be an AutoCAD (.dwg) drawing file and shall include as-built updates.

Contractor shall create and maintain a master drawing list including, as a minimum, drawing number, revision letter/number, revision date, drawing title, Discipline, Document Status, Document type, Plant System, and cross-reference listing for associated vendor drawing numbers, and date submitted to PGE for review. See below for a list of preferred terms. Contractor shall provide to the Owner an initial copy of the master drawings list prior to issuance of any project drawings at the start of the project. The Master Drawing list will be updated and included with every drawing transmittal. Master drawing list must be compatible with Microsoft Excel. Final electronic master drawing list and program shall be submitted to Owner in electronic format and clearly labeled for content and date.

1.2.2 Design Masters

Contractor shall produce applicable drawings per Owner's standard Design Masters. In addition to standard design requirements, Design Masters dictate scope, size, symbology, nomenclature, and level of information required in a drawing. Contractor to request latest version of Design Masters from Owner prior to initiating any design. Microstation CAD files can be provided. The following apply:

High Voltage Lines

RAS

GSU Transformers

Unit Aux Transformers

Standby Transformer Metering and Protective Relaying One Lines

Three Lines

DC Metering and Protective Relaying Schematics

Panel Layout Drawings

Wiring Diagrams

Bill of Materials

Medium Voltage Switchgear and Generator Breaker Three Lines

DC Control Schematics

SCADA Block Diagram

SCADA DC Power Schematic

SCADA Panel Layout Drawings

SCADA Wiring Diagrams

SCADA Bill of Materials.

1.2.3 Other Requirements:

Submittals shall be accompanied by copies of native, electronic design files (e.g., AutoCAD .dwg file, PLS-CADD .bak file, electrical model files (PSS/E, EasyPower, ETAP, CYME), etc.), including for interim design transmittals (e.g., 30%, 90%, etc. as applicable) and As-Built Drawings.

All design submittals shall be provided in a common and consistent coordinate system. Such coordinate system shall be subject to Owner approval.

All design submittals (including product sheets, mix designs, verification procedures, installation procedures, testing procedures, etc.) shall be approved by the applicable engineer of record prior to submitting to Owner. An approval stamp from such engineer(s) of record shall be included on the submittal to indicate such approval.

Owner's review and approval of submittals will not relieve Contractor of responsibility for any deviation from the Requirements unless Contractor has in writing called Owner's attention to such deviation at the time of submission, and Owner has given written concurrence in and approval of the specific deviation. Approval by Owner shall not relieve Contractor from responsibility for errors or omissions in submittals.

As-Built Drawings: As-Built Drawings shall be issued as the next sequential revision from previous releases. The revision block shall state "As Built". All clouds, revision diamonds, and other interim control markings shall be removed, and all information listed as "later" or "hold" shall be completed. The As-Built Drawings shall include a final bill of materials, and native copies of all drawings and layouts. As-Built Drawings shall be created in the latest version of AutoCAD, or in the version of AutoCAD utilized by Owner, as applicable. As-Built Drawings shall comply with PGE Exhibit M1-01-09.

All engineering shall be performed under the supervision of and stamped by the engineer(s) of record, who shall be a registered professional

engineer with a current license in the state where the Project is located. Such professional engineer(s) shall be registered in the applicable discipline for the drawings being signed and sealed.

1.3 Document Identification

Documents submitted by the Contractor for review shall be clear and legible and shall bear the Project Name in addition to the following:

1. Purchase order number
2. Project Facility – Unit Number – System number
3. Contractor's reference drawing number
4. Document revision status
5. Owner's documentation number (less submittal number)

This information shall be placed on the documents in or near the title block

Documents submitted shall be assigned an Owner documentation number assigned by the originator using the convention below. This number shall appear on the copy returned to the Contractor and shall be transferred by the Contractor to the Contractor's original, so that the document number will appear on subsequent submittals.

Correspondence including emails shall contain the Project Facility – Unit Number – System number, specification number, and equipment identification number.

All correspondence between Owner and Contractor shall be sequentially numbered as follows and provided in the subject line of emails:

AAA-BBB-SSSS-YYYY.X

Where:

AAA denotes the company originating the correspondence.

BBB denotes the company receiving the correspondence.

SSSS denotes the specification number

YYYY denotes the correspondence sequential number

X denotes the revision number of the correspondence beginning with zero.

Resubmittals shall bear the original submittal number and append a number sequentially as follows.

AAA-BBB-SSSS-YYYY.1

AAA-BBB-SSSS-YYYY.2

etc.

The Project Documentation Coordinator ([GPDC@PGN.com] for Owner; [ ] for Contractor) is responsible for assigning the correspondence number and maintaining their respective company transmittal log.

All correspondence shall be distributed electronically.

1.4 Document Review and Approval

The Contractor and Owner shall participate in 30%, 60%, 90%, and Issued for Construction (IFC) design and model reviews for each engineering package / discipline.

Design level	Description
30% Design	Most, if not all, of the design submittals may be conceptual in nature, without having all exact details defined. 30% design documents shall be provided as a single comprehensive submittal. To the extent possible, all PDFs shall be combined into a single file. For example, 30% design documents level of detail shall include (at minimum): • General arrangement drawings • Single line drawings • Cable and road layouts • Equipment specifications and data sheets Refer to M1-01-02-01 (Engineering Documents, Drawings, and Other Deliverables Table) for specific details.

60% Design	Design documents intended to represent a reasonably complete design package. Many of the design submittals may be conceptual in nature, without having all exact details defined. 60% design documents shall be provided as a single comprehensive submittal. To the extent possible, all PDFs shall be combined into a single file. For example, 60% design documents level of detail shall include (at minimum): • Design Basis: • Design criteria for each engineering discipline • Contractor's equipment and system designation methods • List of systems and system designations Electrical Package: Schematics and single line drawings detailing: collection system circuits, ac collection system, auxiliary and backup power, MET stations, SCADA/DAS and communications systems, grounding design Wiring details including: specifications for all conductor types, conduit, protective devices and relays; ampacity calculations for all conductors; voltage drop calculations for all conductor runs; wiring details, minimum bend radii, conductor termination details, conduit fittings, etc. Equipment arrangement including conduit entry Supporting documentation for all components including: specification of all requirements for all components, manufacturer's datasheets, installation manuals, operations and maintenance manuals Civil/Structural Package: Calculations in accordance with Specifications • Geotechnical and Hydrology Reports • Structural inspection results/reports • Detailed Site layouts with elevation and topographic detail depicting mounting configurations for all equipment, grading plans, etc. • Foundation designs • Corrosion analysis Refer M1-01-02-01 (Engineering Documents, Drawings, and Other Deliverables Table) for specific details.

90% Design	Design documents intended to represent a nearly complete design package for final approvals prior to being issued for permit approval. The 90% design documents shall be provided as a single comprehensive submittal. For example, 90% design documents level of detail shall include (at minimum): • An updated version of the 60% design documents with revisions and additional detail where applicable. • Shall include equipment ratings for all power systems equipment, bus Work, enclosures, protective devices, etc. • Include all detailed information required to obtain all necessary construction permits from the AHJ • Commissioning Plan • Acceptance Test Plan • Final Energy Estimate Refer to M1-01-02-01 (Engineering Documents, Drawings, and Other Deliverables Table) for specific details.
IFC Design	Design documents intended to provide all required information for Subcontractors to construct the Project. IFC design documents shall be provided as a single comprehensive submittal. IFC design documents shall include, at minimum, complete and fully detailed submittals (all applicable drawings and calculations) for the following: • An updated version of the 90% design documents with revisions and additional detail where applicable. • Shall include all completed test results such as pile uplift and lateral resistance testing • Shall address any responses/comments from the AHJ Refer to M1-01-02-01 (Engineering Documents, Drawings, and Other Deliverables Table) for specific details.
As-Built (AB) Design Documents	Design documents intended to reflect design changes after the release of the IFC design documents and to document the design of the as-constructed facility. All changes from the IFC documents shall be approved by Owner. Refer to M1-01-02-01 (Engineering Documents, Drawings, and Other Deliverables Table) for specific details.

Where drawings or other documents are required, these documents shall be submitted for review in accordance with the Contractor's drawing submittal schedule. Drawings, specifications, and performance data submitted will be reviewed for adherence to the specification, suitability of design, equipment selection, conformance to design criteria, interfacing data, and for general information

regarding plant operating characteristics. They shall include erection diagrams and other details, such as interface connections. Identification numbers shall be used to identify items on the documents. The sequence of submission of documents shall be such that information is available for an effective review of each document when it is received. Information on drawings shall be checked by the Contractor for accuracy before submission for review.

Owner will update the Master Document List indicating the documents have been reviewed and will email the transmittal to Contractor.

All documents and drawings submitted by Contractor for the first cycle will be reviewed by Owner and returned with comments within 20 Business Days after receipt of the documents or as agreed to between Owner and Contractor. For subsequent review cycles, a 15 Business Day cycle will be followed or as agreed to between Owner and Contractor.

Contractor documents will be considered received after documents have been posted and Owner has received email notification of the posting.

Contractor may request, in writing, expedited review for specific documents and drawings. All requests will be considered.

1.4.1 Documents / Drawings

Documents, including drawings and electronic models, submitted for review shall be provided in the document's original (native) format with another copy in Adobe Acrobat (.pdf) format. A separate file shall be provided for each unique document number. Multiple sheets with one unique document number can be submitted as one file.

All revisions shall be noted in redline format, where applicable. All drawing revisions shall be clouded.

1.4.2 Status Level Convention

Upon completion of a review, the reviewer will rename the document by appending one of four Status Levels at the end of the document file name. The status level assignments shall be as follows:

S1 = No Exception Taken. Contractor May Proceed with Fabrication or Construction

S2 = Revise as Noted and Resubmit. Contractor May Proceed Based on Making Revisions Noted.

S3 = Does Not Meet Specification Requirements. Revise and Resubmit. Hold Fabrication.

S4 = For Information Only.

Status Level S1: Documents and drawings that receive status level S1 are approved.

Status Level S2 and S3: Documents and drawings that receive status level S2 or S3 shall be resubmitted, with comments incorporated in the next revision. Documents and drawings resubmitted for review shall clearly show changes made to them from previous revisions. All changes on drawings shall be clearly designated with revision clouds or shall include a revision list on the drawings. Revision clouds from previous revisions shall be removed. Changes on other documents shall be circled or a separate list of changes to the documents shall be provided. If a separate list of changes to the documents is provided it shall be named as the original document with "_COMMENTS" appended to the end of the file name. Any comments not incorporated must be noted and explanation given, in writing, for the exclusion.

1.4.3 File Naming Convention

Reviewed documents returned to Contractor will utilize the Contractor assigned file name, but be modified to indicate comments were appended as follows:

For Documents:

Return Document File Name:

Supplier File Name_Rev_PGE_S#.pdf

For Drawings:

Supplier Drawing #_Sheet_Rev_PGE_S#.pdf

1.4.4 Resubmittal Naming Convention

Resubmittals shall bear the original submittal number and append a number sequentially. Following initial submittal of a document or drawing by Contractor, that document or drawing shall not be resubmitted until Owner comments have been received and incorporated by Contractor.

1.5 Document Transmittals

All correspondence that transmits data, documents, drawings and other information that is considered a contract deliverable (or affects the design, construction, commissioning or operation of the project), is to be transmitted with a transmittal letter. An email with transmittal number in subject line and transmittal letter attached shall be issued to alert Owner that documents/drawings were submitted. Informal correspondence can be transmitted via email or other means and will not require a transmittal number.

Document transmittals shall be in accordance with a specified project schedule.

Submittals shall be in accordance with the following:

- Prints shall be sharp, clear, and suitable for direct reading. The prints shall be black line reproducible on bond paper. Scanned submittals are not permitted.
- Hardcopy documents shall be folded, collated sets mailed flat in a regular mailing envelope. Electronic formats of documents shall be submitted on CD, DVD or electronic storage device (as appropriate) and shall be adequately protected to prevent damage during shipment.
- Drawing or engineering databases shall be included in the document transmittals with programs to access and maintain the information and must be compatible with Microsoft Excel.

1.5.1 Spare Parts List

The vendor shall provide a recommended Spare Parts list for regular equipment maintenance. The Spare Parts list shall be submitted in Microsoft Excel spreadsheet format.

1. Entries into the electronic parts list shall conform to the following:

   Description using the Noun, Modifier, Characteristic 1, Characteristic N, Standards Requirements:

2. Example description of an existing item in PGE's for – 36 IN 5/8 double arming bolt

   BOLT, DOUBLE ARMING, 5/8 IN X 36 IN, SQUARE HEAD, WITH 4 SQUARE NUTS, HOT DIP GALVANIZED PER ASTM A153, MADE IN ACCORDANCE WITH ANSI C135.1, PER ASTM A36, 12,400LB MINIMUM TENSILE STRENGTH

Description Element	Identify by answering the question:	Descriptor	Abbreviation Spelled out
Noun	What is it?	BOLT,	
Modifier	What kind?	DOUBLE ARMING,	
Dimensions	What size?	5/8 IN X 36 IN	
Characteristic	What is specific about this item?	SQUARE HEAD	
Characteristic	What is specific about this item?	WITH 4 SQUARE NUTS,	This is more of a requirement
Standard Requirements	Standard to adhere to?	HOT DIP GALVANIZED PER ASTM A153,	Specific Standard
Standard Requirements	Standard to adhere to?	MADE IN ACCORDANCE WITH ANSI C135.1,	Specific Standard
Standard Requirements	Standard to adhere to?	PER ASTM A36,	Specific Standard
Characteristic	What is specific about this item?	MIN TENSILE STRENGTH OF 12.400 LBS	This is more of a requirement

A. Dimensions Descriptors

Dimensions shall be spelled out to avoid confusion for the ordering party, the vendor, or Owner. Standard dimension descriptors should be adopted as follows:

Abbreviation	Description
DIA	Diameter
L	Long
W	Width, wide
D	Deep, depth
IN	Inches
FT	Feet
TPI	Thread per inch
TPM	Thread per millimeter

Universally accepted numeric descriptors of dimensions are to be used also. For example: Bolt, 1-1/2 IN-18x36 IN L

- 1-1/2 IN = Diameter
- 18 = Threads per inch
- 36 = Length

1.5.2 Standards Requirements Reference

Requirements based on particular standards shall be included in the following format:

Standard Abbreviated	Specific Standard Number
ASTM	A153
ANSI	C135.1
ASTM	A36

1.5.3 Special Characters

Information NOT to be Included in the Item Description:

Manufacturer's Name

There are places in PGE Owner PeopleSoft and Maximo software systems that are designated to keep this information.

Manufacturer's Model Number

There are places in PGE Owner PeopleSoft and Maximo software systems that are designated to keep this information.

Vendor's Name

Vendor's Catalog Number

Slang terms to describe items

Terms used in the trades shall not be used as item descriptors unless those terms are universally used by all manufacturers and throughout the industry.

Example: bell insulator is a lineman's term for a suspension insulator or dead end insulator. Manufacturers recognize this item as suspension insulator, not as bell insulator.

1.5.4 Use of Special Characters in Descriptions

Item Descriptions may contain any of the following characters:

Description	Character
Comma	,
Period	.
Hyphen	-

Item Descriptions must not contain any of the following special characters as they interfere with the Maximo to PeopleSoft interface.

Description	Character	Description	Character
Quotation Mark	"	Dollar Sign	$
Ampersand	&	Percentage	%
Apostrophe	'	Asterisk	*
Less Than	<	Pound Sign	#
Greater Than	>	Exclamation Point	!
Question Mark	?	At Sign	@
Equal	=	Caret	^
Plus	+	Backslash	\
Underscore	_	Square Brackets	[ ]
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1.5.5 Instruction Manual

The Contractor shall furnish draft and final instruction manuals for the unloading, storage, installation, operation, and maintenance of the equipment. The manuals shall be delivered as specified in the Contract. The electronic versions of the manuals shall be word searchable PDF format, fully indexed and shall not be protected. The index shall link to the pages referenced in the index and the bookmarks shall coincide with the required tabs in the paper form.

1.5.6 Content

Manuals shall include the table of contents and index tabs (if multiple volumes are required, a table of contents listing materials included in each volume shall be supplied for each volume) specific to the furnished equipment. All pages shall be sequentially numbered.

1.5.7 Design

Description of the equipment and systems including accessory components, including nameplate ratings, illustrations showing elevations, cross section, and all details of the equipment with all parts named, and numbered.

When multiple model numbers are shown on the drawings, the equipment supplied for the project shall be clearly identified.

Specifications, test data, and all performance curves specified in the technical specifications.

- Outline drawing - final. Assembly drawings - final.
- All fluid systems schematics and piping diagrams. Electrical wiring diagrams.
- Motor Information Sheets.
- Electric Actuator Information Sheets.
- Control Panel Arrangements, including interior equipment arrangements identifying the individual components.
- Program, software, and firmware configuration, modeling, editing, and troubleshooting guides.

1.5.8 Installation

- Instructions for receiving, inspection, storage, and handling of equipment prior to installation.
- Installation instructions including step-by-step alignment and calibration procedures.
- Online and offline inspection procedures.
- Lists of trips and alarms, complete with set points.
- Calibration Data Sheet for each adjustable instrument included in the scope of supply.
- List of acceptable lubricants, insulating fluids, flushing fluids, hydraulic fluids, and fluid additives.

1.5.9 Operation

Complete and detailed operating instructions, including safety precautions, startup procedures, shutdown procedures, normal operation procedures, non-standard event procedures, and freeze protection requirements and philosophy of operation. Operating procedures and instructions shall provide the operator with information when and how to operate the equipment, including precautions, limitations and set points. Procedures listed in step-by-step sequence shall include preoperational

checkout, startup, normal, remote, or emergency modes of operation, and stopping or shutting down part or all of the subject equipment. Troubleshooting charts and tables shall be used to list likely evidence of malfunction and what could be responsible. The effect of loss of normal power and effect of electricity supply frequency drop shall be addressed.

1.5.10 Maintenance

Detailed minor and major maintenance instructions, including description, maintenance checklist, step-by-step instructions for replacing the major components, use of special tools furnished, including but not limited to the following:

- Preventive Maintenance Schedule for all equipment with servicing procedures including instructions for dismantling and/or replacing components and routine electrical and mechanical procedures, tests, and checks for cleaning, lubricating and otherwise caring for equipment. These procedures shall include calibration and maintenance of interlocks and other safety features. The Preventive Maintenance Schedule shall be provided in an MS Excel® spreadsheet (or another consolidated database, if approved).

Step-by-step procedures for all anticipated equipment repairs.

Troubleshooting guide.

Illustrated parts breakdown including parts list including American Society for Testing and Materials (ASTM) designation (if applicable), and a list of recommended spare parts. Complete replacement parts list shall include manufacturers' part number for ordering, description, the quantity used, and the applicable item number, and drawing references.

- Recommended six (6) month layup procedure.
- List of maintenance tools furnished with the equipment.
- Safety provisions.
- Torque values for critical bolts.
- Field disassembly and assembly.
- Field overhaul of specific components.
- Tube plugging instructions including plug dimensions and recommended material.
- Overhaul instructions.
- Control system troubleshooting instructions.

- Lubrication instructions including system flushing.

The above listed requirements are the minimum requirements; however, requirements that are clearly not applicable to the equipment may be deleted with Owner's approval. Additional information that is necessary for proper operation and care of the equipment shall also be included.

The electronic versions of the O&M manuals shall be word searchable PDF format, fully indexed and shall not be protected. The index shall link to the pages referenced in the index and the bookmarks shall coincide with the required tabs in the paper form. Manuals exceeding 100 MG file size will be broken into smaller parts and labeled accordingly (e.g. XXXXXX_Manual_Part_1_of_X.PDF)

The descriptions shall not be general, applicable to any type and size of Contractor's equipment, but shall be specific with (whenever possible) references to drawings submitted by Contractor.

Manuals which contain information on multiple manufacturer models shall have the model used at Project highlighted.

1.5.11 Equipment Storage

The Contractor shall furnish complete and accurate storage records for any equipment, materials, or other Work that was previously produced, manufactured, constructed, or otherwise produced and that will be incorporated into the Project. For the avoidance of doubt, this shall include any transformers, wind turbines, or other equipment that was previously manufactured for tax qualification purposes (e.g., PTC). Storage documentation to be provided shall include visual inspection and testing records.

1.6 Project Workbook

At the conclusion of the project and prior to final completion (as defined for the applicable Project type – e.g., Wind Plant Final Completion or Solar Plant Final Completion), the Contractor shall provide the Project Workbook listing the Project documentation as specified below.

Potential terms to be used in Project Workbook drop-down menus:

Document Types:

- Bid Document
- Budget
- Calculation
- Certificate

- Collection System
- Construction Work Package
- Contract
- Correspondence
- Design Basis
- Drawing
- Easement
- Estimate
- GIS
- Historical Document
- Incident Reports
- Inspection
- Invoice
- Job Books
- License
- Manual
- Meeting
- Model
- Permit
- Photograph
- Plant Systems
- Presentation
- Plan/Procedure
- Proposal
- Purchase Order
- Regulatory
- Report
- RFI

- RFP
- Schedule
- Schematic
- Site Certificate
- Specification
- Submittal
- Transmittal
- Vendor Information
- Video
- Welding

Disciplines:

- Architectural
- Geotechnical
- Civil
- Communication
- Electrical
- Instrumentation & Control
- Mechanical
- Project Management
- Structural
- General
- Environmental
- HVAC
- Plumbing
- Fire Protection

Document Status

- 30%, 60%, and 90% design package
- As-Built

- Final Project Document
- Issued For Approval
- Issued For Construction
- Issued For Contract
- Issued For Information
- Issued for Record
- Issued For Review
- Mark-Up
- Redline
- S1 - No Exception taken. Proceed in accordance with Specification.
- S2 - Minor Comments, Revise and Return, Proceed with Construction, or fabrication.
- S3 - Major Comments, Revise and Return, DO NOT proceed with construction or fabrication.
- S4 - For Information Only
- Superseded

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Category	Deliverable:	Description:	Level			Owner Approval	Owner Proposed Schedule	Contractor Proposed Schedule
			A	B	C			
Certification	Acceptance certificates	All completed Acceptance Certificates for Works prior to Substantial Completion milestone			X	X		
Certification	Calibration certificates	Copies of calibration certificates for all instrumentation mounted on all met stations/masts, provided by recognized independent agencies and done in accordance with the appropriate calibration standards.		X			4 weeks after met station installation	
Certification	Capacity and Availability test report	Upon satisfactory completion or upon failure of the Capacity and Availability Test, as the case may be, the Contractor will issue an Acceptance Test Certificate to that effect.			X	X		
Certification	Civil Works concrete and grout design supporting information	Contractor shall provide evidence from field, production or trial tests to justify the design of the concrete or grout mix proposed.		X		X	3 months after Agreement execution	
Certification	Electrical safety certficates	Electrical Safety Certificates for all electrical works to Applicable Laws, Regulations and Standards		X		X	Prior to energization	
Certification	Electrical system certificates of compliance	All electrical certificates of compliance			X			
Certification	Factory acceptance test reports	Copies of test certificates for all routine factory tests applied to all major items included in the Work, PV Module, and electrical system components including, but not limited to, switchgear, power transformers, instrument transformers, protection relays and revenue metering systems.		X			8 weeks prior to start of relevant site work	
Certification	Factory acceptance test reports for electrical components	FAT certificates to be provided by Contractor shall include, but not necessarily be limited to, the following components: • Transformers, including: o Substation main power MV/HV transformer/s o Auxiliary MV/LV transformer/s o PCS/Inverter skid MV/LV transformers o Reactive plant transformers (if applicable) • Instrument transformers (i.e. CTs, VTs) • Reactive plant equipment (if applicable) • HV and MV switchgear and switchboards • LV distribution boards (AC and DC) • Cabling (HV, MV, LV and fiber optic) • HV and MV surge arrestors • Protection relays • Metering systems (revenue, check and power quality) • UPS systems • Stand-by diesel generator, and • Switchroom batteries and chargers		X			Prior to delivery to Site	
Certification	Performance test report	Report summarizing test as specified. Upon satisfactory completion or upon failure of the Performance Test, the Employer will issue an Acceptance Test Certificate to that effect.			X	X		
Certification	Permanent on-site buildings	Permanent building designs shall be independently checked and approved by a certified structural engineer		X			6 weeks prior to building work	
Certification	Protection settings signoff	Written endorsement by the interconnection provider in respect of all protection settings of the Project		X			Prior to Plant energization	
Certification	PV Mounting structure 3rd party certificate	3rd Party Civil/Structural Engineer's Certificate confirming the suitability of the PV Array Mounting Structure and all Civil Works, that they are in accordance with the As-built drawings and documentations and as required under the Applicable Laws, Regulations and Standards in respect of the entire Solar Farm and site building electrical works.			X			

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			A	B	C			
Certification	Reinforcement specifications and testing certificates	Certificates confirming manufacturers and processors of steel reinforcement hold a valid certificate of approval.		X			6 weeks prior to start of relevant work	
Certification	SCADA system warranty and results	Documentary evidence that the SCADA system is sufficient for recording and analysis of the data for the warranty tests; and confirmation and detailed report of how the SCADA system stores data and provides values to enable availability calculations.		X			6 weeks prior to start of relevant work	
Design	Civil works	30% Design including the following: • Buildings and structures • Roads • Crane pads • Site drainage • Earthwork and compaction • Met mast foundation/footings • HV/MV substation foundation/footings • Site landscaping • Site restoration/reclamation		X		X	3 months after Agreement execution	
Design	Civil works	60% Design: An updated version of 30% Design with revisions and additional detail where applicable: • Detailed foundation design drawings required. • ALTA survey map		X		X		
Design	Civil works	90% Design: An updated version of 60% Design with revisions and additional detail where applicable		X		X	6 weeks prior to start of relevant work	
Design	Civil works	IFC Design: An updated version of 90% Design with revisions and additional detail where applicable		X		X		
Design	Civil works	As-built Design: Design changes after the release of the IFC Design Documents and to document the design of the as-consctucted facility.			X			
Design	Electrical collector system	30% Design including the following:		X		X	3 months after Agreement execution	
Design	Electrical collector system	60% Design: An updated version of 30% Design with revisions and additional detail where applicable. Detailed foundation design drawings required.		X		X		
Design	Electrical collector system	90% Design: An updated version of 60% Design with revisions and additional detail where applicable		X		X	6 weeks prior to start of relevant work	
Design	Electrical collector system	IFC Design: An updated version of 90% Design with revisions and additional detail where applicable		X		X		
Design	Electrical collector system	As-built Design: Design changes after the release of the IFC Design Documents and to document the design of the as-consctucted facility including the following: • A GIS database which shall include all as-built cable routes recorded in a minimum of 10 meter steps and in-line joints (if installed). • MV Protection Schematics • MV CB Control Schematics • LV Air CB Schematics • UPS Schematic • Battery Charger Schematic • Distribution Board schedules			X			

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			A	B	C			
		• Cable schedules (HV, MV and LV) • LV systems and auxiliary generator schematics • As-built MV Switchroom GA drawings, including MV and LV switchboards, protection panels, SCADA, battery / UPS, chargers, etc.						
Design	Fire Protection System documentations and drawings	Including as a minimum: • Fire Risk Evaluation/Fire Protection Design Basis Document • Complete and detailed design drawings for each system. Drawings shall clearly indicate all wiring and equipment that is supplied or installed by Contractor. Drawing shall call out any design and material requirements (manufacture and code/standard). Contractor is responsible for reviewing materials and designs as part of the overall fire protection system, to ensure compliance with codes, standards and manufacturers' requirements. • Site fire protection plan drawings • Hydraulic calculations • Room integrity test results for clean agent suppression systems • Detailed control panel drawings • Detailed communication drawings		X		X	3 months after Agreement execution	
Design	Fire Protection System documentations and drawings, as builts	Including as a minimum: • Operation and Maintenance manuals shall be provided. • Complete all required documentation and obtain necessary inspection required for the fire protection systems to be operated. Signed and filled out test forms shall be provided for each system provided. • As built drawings			X	X		
Design	Meteorological station	30% Design drawing and specification of the following: • Information on the Met Masts installations including number of Permanent Met Masts	X			X	Agreement close	
Design	Meteorological station	60% Design including the following (if applicable): • An updated version of 30% Design with revisions and additional detail where applicable • Mast general layout • Instrumentation specifications and calibrations; • Proposed locations and non-wake-affected sectors • Earthing and lightning protection • Mast instrumentation & mounting arrangements • Aviation warning markings (e.g. marker balls) • Enclosures and cabling • Fencing/protection • UPS • Power supply and SCADA connection		X		X		
Design	Meteorological station	90% Design: An updated version of 60% Design with revisions and additional detail where applicable		X		X	6 weeks prior to start of relevant work	

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			A	B	C			
Design	Meteorological station	IFC Design: An updated version of 90% Design with revisions and additional detail where applicable		X		X		
Design	Meteorological station	As-built Design: Design changes after the release of the IFC Design Documents and to document the design of the as-consctucted facility.			X			
Design	Permanent on-site buildings	30% Design including but not limited to the following: • Layout • Elevation drawings • Structural • Architectural • Fire rating • Hold down	X			X	Agreement close	
Design	Permanent on-site buildings	60% Design: An updated version of 30% Design with revisions and additional detail where applicable. Detailed foundation design drawings required.		X		X		
Design	Permanent on-site buildings	90% Design: An updated version of 60% Design with revisions and additional detail where applicable		X		X	6 weeks prior to start of relevant work	
Design	Permanent on-site buildings	IFC Design: An updated version of 90% Design with revisions and additional detail where applicable		X		X		
Design	Permanent on-site buildings	As-built Design: Design changes after the release of the IFC Design Documents and to document the design of the as-consctucted facility.			X			
Design	Pre-engineered metal buildings (if applicable)	Including, but not limited to: • Detailed shop and erection drawings and product data • Foundation loads, anchor bolt setting diagrams, and details of required anchorage to concrete foundations • All calculations used in the development of building and anchor bolt design and of fabrication drawings		X		X	1 week after Agreement execution	
Design	PV Array design drawings	30% Design: Includes the general arrangement drawings of the following: • PV Array, including Sub-Array(s), Strings and Modules • Inverter Blocks • PV String Combiner Boxes and PV Sub-Array Combiner Boxes • PCS • MV/HV Substations • Permanent and temporary buildings		X			3 months after Agreement execution	
Design	PV Array design drawings	60% Design: An updated version of 30% Design with revisions and additional detail where applicable.		X		X		
Design	PV Array design drawings	90% Design: An updated version of 60% Design with revisions and additional detail where applicable		X		X	6 weeks prior to start of relevant work	
Design	PV Array design drawings	IFC Design: An updated version of 90% Design with revisions and additional detail where applicable		X		X		

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			A	B	C			
Design	PV Array design drawings	As-built Design: Design changes after the release of the IFC Design Documents and to document the design of the as-consctucted facility.			X			
Design	Substation	30% Design including the following (as applicable): • Substation general arrangement drawing • Main power transformer(s) • Manufacturer specifications for all reactive power compensation equipment (if applicable) and associated transformers • Protection equipment and switchgear specifications (including MV/HV substation, MV switchgear, NER/NET if applicable), including insulating medium, description of interlocking and protection, thermal, fault and insulation ratings, IP level, manufacturer and standards compliance, relevant type test certificates • LV systems, diesel generator and associated equipment specifications, including battery and UPS capacities/back-up time • Revenue and power quality meter specifications • Drawings and schematics for MV switchgear (if applicable), including configuration, placement, connections, civil works and/or mounting arrangements, cable terminations, and • Single line diagram (SLD) of substation, including main power transformer, reactive power compensation resources; protection SLD to be incorporated or provided separately		X		X	3 months after Agreement execution	
Design	Substation	60% Design including the following: • An updated version of 30% Design with revisions and additional detail where applicable • Main power MV/HV transformer specifications and drawings, including MVA rating, nominal voltage rating, on-load tap changer (OLTC) configuration, AVR, insulating medium, vector group, thermal ratings, temperature rise, fault ratings, insulation ratings, IP level, fire protection, corrosion protection, load and no-load loss guarantees, oil/water separator and bund details, manufacturer and standards compliance. Also required is the Type test certificate (considering environmental conditions, corrosion, cyclic loading, peak voltages and fire risk) and a fitness for purpose statement. • Submittals as required in Appendix M1 Attachment 05 Exhibit 03 – Substation Design and Construction Specification.		X		X		
Design	Substation	90% Design: An updated version of 60% Design with revisions and additional detail where applicable		X		X	6 weeks prior to start of relevant work	
Design	Substation	IFC Design: An updated version of 90% Design with revisions and additional detail where applicable		X		X		

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			A	B	C			
Design	Substation	As-built Design: Design changes after the release of the IFC Design Documents and to document the design of the as-consctucted facility.			X			
Design	SCADA and communications network	30% Design including the following: • Information on the communications system, including specifications and drawings • Information on the SCADA system, including specifications and drawings • Fiber optic network drawings • Fiber optic splicing drawings, fiber optic distribution panel drawings • Complete list of all the data points and operational parameters applicable to the Contractor's proposed SCADA system. • Documentation describing how the availability and performance is calculated, stored and analysed in the SCADA system.		X		X	3 months after Agreement execution	
Design	SCADA and communications network	60% Design including the following (if applicable): • An updated version of 30% Design with revisions and additional detail where applicable • I/O connections drawings • Network used to communicate (transmission medium, network topology, communication protocols and fault tolerance) • Interfaces • Network layout • Point addressing scheme • Grounding requirements • Redundancy and UPS • Sensor locations and sensor orientations • Remote access • Viewing and display • Data collection and storage • Control • Reporting • Software and licenses • Comprehensive user manual explaining the operation and use of all the functions • Hardware manuals for all hardware and computers systems • Documentation including manuals, quality control, installation, commissioning and testing procedures		X		X		
Design	SCADA and communications network	90% Design: An updated version of 60% Design with revisions and additional detail where applicable		X		X	6 weeks prior to start of relevant work	
Design	SCADA and communications network	IFC Design: An updated version of 90% Design with revisions and additional detail where applicable		X		X		
Design	SCADA and communications network	As-built Design: Design changes after the release of the IFC Design Documents and to document the design of the as-consctucted facility including the following: • Detailed architecture, interfacing and component product identification • Network Data Communication, detailed wiring diagram			X			

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Category	Deliverable:	Description:	Level			Owner Approval	Owner Proposed Schedule	Contractor Proposed Schedule
			A	B	C			
		• Fiber optic network • Interfacing • Power supply – SCADA distribution board SLD						
Design	Site layout/plans	Proposed Preliminary Layout including (as applicable): • PV array sections • Landowner boundaries • Public roads • Access roads • Inverter stations • Cable routes • Laydown areas • Meteorological stations • Substation • Transmission line • Borrow pits • Batch plant(s) • Permanent and temporary buildings	X			X	Agreement close	
Design	Site layout/plans	30% Design including the following (as applicable): • An updated version of Preliminary Layout with revisions and additional detail where applicable • Junction boxes • Ground-reference transformers • Foundations/footings • Crane pads/hardstands • Crane paths • Drainage and erosion control features • Spares, parts, tools and permanent storage • Temporary utilities, and • Fencing, gate, signage and label details		X		X	3 months after Agreement execution	
Design	Site layout/plans	60% Design: An updated version of 30% Design with revisions and additional detail where applicable		X		X		
Design	Site layout/plans	90% Design: An updated version of 60% Design with revisions and additional detail where applicable		X		X	6 weeks prior to start of relevant work	
Design	Site layout/plans	IFC Design: An updated version of 90% Design with revisions and additional detail where applicable		X		X		
Design	Site layout/plans	As-built Design: Design changes after the release of the IFC Design Documents and to document the design of the as-constructed facility.			X			
Design	Solar control drawings and documentation	30% Design: AC and DC Single line diagram, in sufficient detail to show all protective devices, overvoltage protection, isolation and earthing facilities; • Wiring diagrams (three-wire) for all main power and auxiliary circuits in the Solar Project • Control system block diagram of the Solar Project • Solar Project earthing drawings		X		X	3 months after Agreement execution	

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Category	Deliverable:	Description:	Level			Owner Approval	Owner Proposed Schedule	Contractor Proposed Schedule
			A	B	C			
		• Solar Project MV/HV system interface drawings, showing MV switchgear and HV/MV Transformer • GA drawings and schematics for Solar Project located MV/HV switchgear (if applicable), including configuration, placement, connections, civil works and/or mounting arrangements, cable terminations, and • Vendor data sheets for main electrical components in the Solar Project, including generator, main circuit breaker and converter/inverter (if present)						
Design	Solar control drawings and documentation	60% Design: An updated version of 30% Design with revisions and additional detail where applicable.		X		X		
Design	Solar control drawings and documentation	90% Design: An updated version of 60% Design with revisions and additional detail where applicable		X		X	6 weeks prior to start of relevant work	
Design	Solar control drawings and documentation	IFC Design: An updated version of 90% Design with revisions and additional detail where applicable		X		X		
Design	Solar control drawings and documentation	As-built Design: Design changes after the release of the IFC Design Documents and to document the design of the as-consctucted facility.			X			
Design	Solar electrical BOS specfications and design drawings	30% Design: Includes specifications and design drawings of all elements of the electrical system including, but not limited to the following: • Inverter Stations, including overall GA drawings and connection diagram, in addition to individual equipment specifications and compliance certification • (if applicable) Switchgear Stations, including overall GA drawings and connection diagram, in addition to individual equipment specifications and compliance certification. • Transformer specifications, including kVA rating, nominal voltage rating, tap changer configuration, insulating medium, vector group, thermal ratings, temperature rise, fault ratings, insulation ratings, IP level, fire protection, corrosion protection, load and no-load loss guarantees, manufacturer and standards compliance. Design drawings, including enclosure, fittings, locations and bund details (and oil/water separator specification if applicable). Transformer type test certificate and a fitness for purpose statement (considering Environmental Conditions, corrosion, cyclic loading, peak voltages and fire risk). • Cable specifications and schedules for all MV, LV, earthing and fibre-optic cabling in the Works. Cable sizing. • Full technical specifications for all termination kits, jointing kits, lugs and connectors to be used in the primary power circuits and in the earth network • Protection equipment and switchgear specifications, including insulating medium, description of interlocking and protection, thermal, fault and insulation ratings, IP level, manufacturer and standards compliance, relevant type test certificates • Auxiliary power systems and associated equipment specifications, including battery and UPS capacities/back-up time • Revenue and power quality meter specifications • In-line cable jointing kits		X		X	3 months after Agreement execution	

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Category	Deliverable:	Description:	Level			Owner Approval	Owner Proposed Schedule	Contractor Proposed Schedule
			A	B	C			
Design	Solar electrical BOS specfications and design drawings	60% Design: An updated version of 30% Design with revisions and additional detail where applicable.		X		X		
Design	Solar electrical BOS specfications and design drawings	90% Design: An updated version of 60% Design with revisions and additional detail where applicable		X		X	6 weeks prior to start of relevant work	
Design	Solar electrical BOS specfications and design drawings	IFC Design: An updated version of 90% Design with revisions and additional detail where applicable		X		X		
Design	Solar electrical BOS specfications and design drawings	As-built Design: Design changes after the release of the IFC Design Documents and to document the design of the as-consctucted facility.			X			
Design	Spare parts, tools, and permanent storage	30% Design including the following: • List of components and consumables that do not satisfy the Design Life for Work including additional information				X		
Design	Spare parts, tools, and permanent storage	60% Design: An updated version of 30% Design with revisions and additional detail where applicable. Detailed foundation design drawings required.		X		X		
Design	Spare parts, tools, and permanent storage	90% Design: An updated version of 60% Design with revisions and additional detail where applicable		X		X	6 weeks prior to start of relevant work	
Design	Spare parts, tools, and permanent storage	IFC Design: An updated version of 90% Design with revisions and additional detail where applicable		X		X		
Design	System Descriptions	IFC Design: Prepare system descriptions indicating equipment data, operating characteristics, design basis, functions, and other process information for: • PV Modules and DC wiring systems • Trackers • Inverter Skid Assemblies • AC Collection System •SCADA System • Substation		X		X	3 months after Agreement execution	
Design	Interconnection lines	30% Design including the following (if applicable): • Transmission line route including proposed pole/tower locations • Transmission line typical span and pole/tower drawings • Proposed transmission line structures and foundations • Approved Rebar Shop Drawings • Approved Concrete Mix Design • Power Cable Data Sheets • OPGW/Fiber Optic Cable Data Sheets		X		X	3 months after Agreement execution	
Design	Interconnection lines	60% Design including the following (if applicable): • An updated version of 30% Design with revisions and additional detail where applicable • Power line systems PLS-CADD model • All geotechnical data, including LPILE and SHAFT program inputs • Detailed foundation design drawings • Transmission line profile design		X		X		

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			A	B	C			
		• Structure assembly drawings, including required tolerances for installation • Drawings showing details of conductor clearances and member clearances • Drawings showing clearances of conductor sagging and existing vegetation and other objects • Line route survey drawings and data • Design of access routes, including drawings • Pole assembly • Pole erection • Conductor, and • OPGW stringing, earthing, jointing and terminations						
Design	Interconnection lines	90% Design: An updated version of 60% Design with revisions and additional detail where applicable: • Rebar/Anchor Bolt Mill Certs. • Anchor Bolt Tension Test Data. • Operational test of all equipment when complete, prior to Electrical Substantial Completion. • Mill certs for embedment ring.		X		X	6 weeks prior to start of relevant work	
Design	Interconnection lines	IFC Design: An updated version of 90% Design with revisions and additional detail where applicable: • Concrete Cylinder Test Results • Foundation-concrete air test results. • Foundation-concrete slump test results. • Ground loop test. • Foundation-compaction test dry density and moisture content of fill. • Grout cube strength test results.		X		X		
Design	Interconnection lines	As-built Design: Design changes after the release of the IFC Design Documents and to document the design of the as-consctucted facility.			X			
File	PVsyst model	The Contractor will provide their PVsyst model file (including all supporting component, horizon and other necessary files) to support their energy production figure.	X				Agreement close	
Licenses	Software licenses	All licenses, software keys, hardware keys (dongles) and the like for all software included in the Works.			X			
List	Sub-contractors list	List of all sub-contractors to be included as approved sub-contractors.	X			X	Agreement close	
Manuals	O&M Manuals	Draft, comprising Overview and Manuals from key equipment suppliers; equipment maintenance requirements		X		X	120 business days prior to commissioing activities	
Manuals	O&M Manuals	Complete and final O&M Manuals, including but not limited to (as applicable): • Overview of the Plant Works • All relevant specifications • All details for the safe and effective use, operation and maintenance of the complete Plant Works • Procedure to mitigate grease contamination from oil leaks or other contaminants that can enter blade bearing. • System description • Safety Plan with Supporting Lock-out-tag-out procedures			X		30 business days prior to commissioning activities	

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		• Equipment startup procedures • Equipment shutdown procedures • Equipment warning and trip setpoints • Normal system operations controls • Abnormal system operations controls • Equipment fault codes • Troubleshooting guides • Maintenance intervals and tasks; including: • Procedures • Tools • Inspection criteria, as required • Systems Descriptions describing normal and abnormal control for system components • Condition monitoring intervals and tasks; including: • Inspection procedures • Inspection criteria						
Manuals	SCADA system documentation	The SCADA system shall be supplied with three sets of comprehensive, complete and up-to-date documentation packages relevant to all the hardware and software supplied. This shall include but not limited to (as applicable): • A comprehensive user manual explaining the operation and use of all the functions • Detailed descriptions of the underlying theory and calculations employed especially with regard to availability and power curve measurements. These shall include complete details of any data processing carried out by the controllers • A complete electrical wiring diagram showing connections to the controller and the communications links • Hardware manuals for all hardware and computers systems • An administrator manual for system administration and configuration • Quality control, installation and commissioning documentation			X			
Permits	Permits	Permits including but not limited to: • Building • 1200c (NPDES and Sediment and Erosion control) • Removal/fill • Septic • WPCF (Wastewater)		X		X	5 business days upon obtaining	
Plan	Capacity test plan	Method Statement describing the Contractor's proposal to perform Capacity Test and Availability Test in accordance with the requirements set in the Specifications. • Details of the equipment to be used • Any deviations • The methodology for dealing with those deviations • Details of the site calibration procedure		X		X	6 months after Agreement execution	
Plan	Civil works, concrete procedure	A procedure for on-Site concrete batching, including as a minimum: • Source of materials		X		X	2 months after Agreement execution	

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		• Transport plan • Quality control If Contractor proposes to utilize a pre-existing off-Site batch plant, details shall be provided on the concrete supplier including: • Quarry materials suppliers and any additives required • How the delivery of concrete to site is to be managed Contractor shall additionally provide a method statement for forming cold joints should concrete supply be disrupted.						
Plan	Critical Lift Plans	Plan shall clearly identify precautions for all critical lifts; coordination plans, including pre-lift meetings, with all participating personnel; and sample documentation/checklists for all critical lifts.		X		X	Prior to mobilizing to Project Site or 1 week prior to lift	
Plan	Document control plan	The document control plan shall address how documents are transmitted, named, reviewed, tracked, and edited.		X		X	2 weeks after Agreement execution	
Plan	Emergency response plan	Emergency response procedures and information		X			1 month prior to accessing Site	
Plan	Environment Management Plan	Including, but not limited to: • NPDES permit • SPCC Plan • Noxious weeds management plan • Cultural resources plan • Stormwater plan • Drinking water plan		X		X	1 month after Agreement execution	
Plan	Environment Management Plan	Operations Phase SPCC Plan		X		X	Prior to Substantial Completion	
Plan	Geotechnical Execution Plan	The name, office location, and qualification statement for proposed geotechnical engineer. The proposed scope of subsurface investigation, including number, location, and depths of borings; anticipated plan for laboratory testing; and detailed descriptions of additional site investigation techniques, including thermal and electrical resistivity or other necessary testing.		X		X	Prior to initiating subsurface investigations	
Plan	Grounding and bonding plan	Plan and details, including fence as applicable		X		X	6 weeks prior to start of relevant work	
Plan	Hazardous Material Management plan	Plan includes spill and recovery procedures.		X		X	1 month prior to accessing Site	
Plan	HSE management plan	Updated and final. This shall include a comprehensive list of all HSE laws and Applicable Standards applicable to the Work		X			1 month prior to accessing Site	
Plan	Typical commissioning plan	Proposed installation and commissioning plan	X			X	Agreement close	
Plan	Installation and commissioning plan, Commissioning Test Manual	Procedure describing pre-commissioning and commissioning tests on all items in preparation for completion of individual Section of Works and to reach Substantial Completion.		X		X	30 days before start of comissioning	
Plan	Loss of grid power procedure	Provide procedures to achieve the aim of ensuring the Work is able to withstand periods without grid electrical power.	X			X	Agreement close	
Plan	Project management plan	Proposed Project Plan including: • List of key personnel with CVs • Project organization diagram • Project schedule including all milestone dates for completion of Work	X			X	Agreement close	

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Plan	Project management plan	Including: • Construction project manager and key team members (including curricula vitae) • Project organization diagram • Communication plan • Permits, licenses, certifications and agreements required • Procurement and sub-contracting plan • Project schedule and payment milestones (as defined in Appendix 01 Exhibit 01 Annex 04 Milestone Payment Schedule) • Resource loading plan • Environment, health and safety plan including description of HSE system and associated certificates • Quality control / quality assurance plan (including equipment inspections and factory acceptance tests) • Management of Owner and other external interfaces • Change control plan – including change order process • Escalation matrix – how and when to escalate issue for resolution		X		X	30 days after Agreement execution	
Plan	Project quality plan	Proposed Quality Management Plans applicable to: • Design of the Work • Manufacture of the Work • Transportation and storage of the Work • Installation and erection of the Work • Testing, commissioning, and Substantial Completion of the Work • Shall include, where appropriate, references for FATs of major components • Description of quality management system and associated certificates		X		X	45 days following NTP	
Plan	Project quality plan	Update and final Project specific quality management plan		X			1 month following Owner comments	
Plan	Project schedule	The Schedule shall include, but not be limited to, the following: • Schedule Basis Memorandum • Engineering activities (i.e. engineering studies, calculations, and designs) • Procurement activities identifying long lead time equipment • Material and equipment deliveries • Construction activities • Tie-ins to existing plant systems • Equipment factory tests • Interfaces with Owner and other external interfaces • Major milestones • Milestone payments, if applicable • Startup and commissioning activities • Testing activities		X		X	8 weeks after NTP and updated monthly	
Plan	Site Specific Safety and Health Plan	Including elements as specified in Appendix M1 Attachment 01 Exhibit 06 – Safety, Health, and Environment. • Resumes of Safety Professional	X			X	Agreement close	

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Plan	Solar energy performance test plan	Plan shall include, but not limited to: • Test procedure • Project Model (PVsyst files and loss assumptions) • Project summary • Interested parties (stakeholder) details • Start and end test dates • All sensors and transducers used • SCADA channels and calibration factors • Quality concerns • Time stamp convention and data logger averaging			X	X	45 business days prior to first day of measurement period	
Plan	Solid Waste Recycling/Recovery plan	Plan for solid waste recycling and recovery.		X		X	1 month prior to accessing Site	
Plan	Storm Water Pollution Prevent Plan (SWPPP) or Sediment and Erosion Control Plan	As required		X		X	1 month prior to accessing Site	
Plan	Testing, inspection and test plans	Proposed testing plan including but not limited to: • Proposed commissioning procedures including but not limited to: o the Commissioning Tests o the Acceptance Tests o the Performance Tests o SCADA • Details of any Tests on Completion that may threaten the safety of the Plant		X		X	2 months prior to start of relevant work	
Plan	Training program	Details of training program required to support the off-site and in-field training of Owner's personnel.	X			X	Agreement close	
Plan	Training program	Hard and electronic copies of all training material.			X			
Plan	Transportation plan	Procedure for delivery to Site for main transformer, inverter stations and other critical equipment and oversize loads		X		X	1 month prior to Site mobilization	
Plan	Transportation plan	Proposed shipping and access routes and major onsite access plan	X			X	Agreement close	
Plan	Work plans	Procedures for execution of all Work including details of number of personnel and vehicles that will be on site at all the different phases of the Project		X		X	2 months prior to start of relevant work	
Report	As left settings	Alarm set points, complete I/O database including description of each I/O			X			
Report	Bankability report	Including as applicable and available: • PV Modules • Solar trackers • Inverters	X				Agreement close	
Report	Civil work geotechnical investigation report	Geotechnical investigation of HV/MV substation, access roads, hardstands, underground cabling, Met Mast foundation/footing sites.		X		X	2 months after Agreement execution	
Report	Civil works 3rd party structural design report	Third-party Registered Professional Engineer's Report confirming the suitability of: • The permanent buildings • Any other structures as required to be certified under the local building and/or structural codes		X			6 weeks prior to start of relevant work	

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Report	Civil Works Civil/Structural design report	The design report shall contain, as a minimum, all method statements, design inputs, design calculations, specifications, design drawings, cross sections, layouts and studies regarding: • Borehole logs and relevant geotechnical test results for the HV/MV substation • HV/MV substation foundations/footings; • Met Mast foundations/footings • Crane hardstands • Access roads • Permanent buildings (including structural, architectural, fire rating and hold down details) • Site drainage • Site landscaping • Site restoration		X		X	3 months after Agreement execution	
Report	Document register	Proposal defining the contract drawings and documents in the form of a document register	X			X	Agreement close	
Report	Document register	Update of document register.		X				
Report	Electrical balance of plant power system studies and design calculations reports	Updated Electrical Design Report following any design changes during construction.			X			
Report	Electrical studies	Include Easypower/Aspen software model and complete system one line diagram, where applicable. Electrical studies including, but not limited to the following: • Ampacity and Loss Study • Auxiliary power study • Coordination study • Arc flash hazard study • Insulation coordination • GSU transformer sizing • DC/UPS sizing • Grounding Study • Harmonics study • Load Flow and Voltage Compensation Study • Relay Coordination Study • Short Circuit Study • Subsynchronous resonance study (if applicable) • Transient Over Voltage Study • Field effect study		X		X	As available during design	
Report	Electrical studies	Update and final report			X		One month prior to Substantial Completion	
Report	Electrical system optimization report	Final optimization of power cable and overhead conductor size		X			6 months after Agreement execution	
Report	Energy generation summary	Report summarising loss parameters and energy estimates for the Solar Project	X				Agreement close	
Report	Equipment list	IFC Design: Prepare electrical, instrument, and mechanical equipment lists with summary descriptions, vendors, and pertinent data.		X				
Report	Equipment maintenance records	Maintenance records for equipment			X			
Report	Failure Modes and Effects Analysis	Provide for critical supplied systems and assets: • Known / common failure modes		X		X	3 months after Agreement execution	

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		• Potential failure modes and historical/expected mean time between failures • Severity on operation relative to the system provided • Methods of detection based on vendor supplied Preventive Maintenance (PM) or Predictive Maintenance (PdM) Procedures • Improvements due to design modifications, additional PM or PdM measures or optional equipment.						
Report	Final substantial completion test reports	Completed installation and commissioning checklists, including commissioning test results, for the entire Plant electrical Works, including, but not limited to, MV/HV Transformer/s, auxiliary transformers, Reactive Plant (if applicable), protection systems and switchgear, transformers and switchgear, MV cables, fiber optic cables, metering, LV equipment, auxiliary generator, in-line cable joints (if applicable), earthing connections, terminations and joints.			X			
Report	Foundations Civil/Structural design report	Including but not limited to the following: • Design loads for all structural components • Design calculations including all assumptions • Demonstration of suitability of all structural components in extreme wind conditions and over the design life • Wind tunnel test results • Modal analysis results • Detailed foundation specifications • Concrete and Grout Design and the mix proposed as described in this document • All partial safety factors • Decision trees • Reinforcement specifications and testing, and • Conclusions		X		X	3 months after Agreement execution	
Report	Geotechnical investigation report	Comprehensive geotechnical investigation, including and as applicable: • PV Array • Inverter Station • MV/HV Substation • Access Roads • Hardstands • Underground Cabling • Met Station footing sites • Other permanent structures or buildings including the O&M facility • Soil Resistivity (Electrical and Thermal) Surveys		X		X	2 months after Agreement execution	
Report	Grid connection documentation	Update to all required grid connection documentation.			X			
Report	HSE report	Final HSE report and risk register			X			
Report	HV/MV electrical system design report	Design of proposed electrical systems including, but not limited to: • Single Line Diagrams (SLD) for MV/HV Substation, reactive plant and collector system, incorporating protection (or provided separately)		X		X	6 months after Agreement execution	

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		• Earthing general arrangement (GA) drawings and schematic diagrams • Substation GA drawings, including overall GA drawing, MV switchroom GA drawings (including MV and LV switchboards, protection panels, SCADA, battery / UPS, chargers, etc.), lightning mast locations • Schematic diagrams and distribution board schedules for MV switchroom equipment, LV supplies and metering • Details of equipment redundancy • Electronic copies of all studies, models, rating evaluations, etc. performed for the above requirements. Specific software and version information to be provided by Owner.						
Report	Hydrology and flood study	To confirm the design for flood requirements for a 1 in 100-year flooding event.		X		X	Prior to relevant design work	
Report	Installation and commissioning reports	The results of all inspections, checks and tests carried out, together with any subsequent analysis. Including but not limited to protective relay calibration tests, trial of equipment operation summary, and manufaturer field service reports.			X		Within 30 business days of commissioning	
Report	Lightning protection study	Detailed assessment of lightning risk to personnel and Works in accordance with Applicable Standards.		X		X	2 months prior to start of relevant work	
Report	Master drawing list	Table of all drawings including drawing number, revision letter/number, revision date, drawing title, discipline, document status, document type, plant system, and cross-reference listing for associated vendor drawing numbers, and date submitted to PGE for review.		X		X	As drawings are submitted	
Report	Meeting minutes	Meeting summary and reports		X	X		3 days following meeting	
Report	Met station/mast installation report(s)	An installation report for each mast including, but not limited to: • Details of installer • Installation date • Grid coordinates of mast (including details of coordinate system and datum) • Elevation of mast above sea level • Mast and equipment details including, but not limited to: o Mast dimensions o Instrumentation types, serials numbers and installation heights and positions o Dimensions and orientations of all booms and arms installed on the mast o Data logger configuration and details o Commissioning details o Reference photos		X			1 month after installation	
Report	Met station/mast maintenance log(s)	Each installed mast shall have a maintenance log detailing all work carried out on the individual mast. The maintenance log shall be such that can be used by Owner for the continuing operation of the mast over its Design Life.			X			
Report	Mounting structure preliminary study	Preliminary design information including footing design, construct & test philosophy; general arrangement drawings	X			X	Agreement close	

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Report	Project Punchlist	As generated from Construction to Commissioning Turn-over and Commissioning/Client Walkdown		X		X	As Issued after Mechanical Completion of each Circuit, and at least 10 days prior to scheduled Substantial Completion	
Report	Project schedule	Update as monthly progress reporting showing status, variance, constraints, actual versus planned progress.		X	X	X	monthly	
Report	Project status report	Weekly template provided by Owner. Monthly report to include, as a minimum, for that month: • Safety statistics, issues, and events • Summary of events including equipment delivery dates and status • Major activities accomplished during past month and those planned for the coming month • Project schedule update • Milestone payment schedule status • Earned Value Quantities Report (EVQR) • Contract progress S-curves • Contract overall man-hours S-curves • Contract overall staffing histograms • Contract overall craft histograms • Key quantity S-curves • Risks, delays, and quality concerns		X	X	X	monthly and weekly	
Report	Project workbook	List of Project documentation			X		Prior to Final Completion	
Report	Punch list	Documentation listing and detailing any and all minor non-conformances and proposed rectification not required to be completed prior to Substantial Completion.			X			
Report	PV Array Design Report	The Contractor shall submit PV Design Report describing the Contractor's approach in addressing Project design risks, such as PID, shading and others.		X		X	2 months after Agreement execution	
Report	PV module quality documentation	Reports demonstrating PV module quality and specifications: • Fash test reports for all modules • 3rd party workmanship audit report or testing score • EL reports for all modules • Batch flash and EL reports after accelerate lifetime tests			X			
Report	PV Mounting structure 3rd party report	3rd Party Structural Engineer report confirming the suitability of the PV Mounting Structure for the site conditions.		X		X	6 weeks prior to start of relevant work	
Report	PV Mounting structure design report	Including but not limited to the following: • Design loads • Design calculations including all assumptions • Demonstration of suitability of all structural components in extreme wind conditions and over the design life • Detailed foundation specifications • Detailed foundation design drawings • Concrete and Grout Design and the mix proposed as described in this document (if applicable) • Borehole logs and relevant geotechnical test results • All partial safety factors • Decision trees		X		X	3 months after Agreement execution	

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		• Reinforcement specifications and testing, and • Conclusions						
Report	Quality assurance package	Complete sets of quality assurance documentation for each of the defined construction milestones referenced in the Specifications (commonly recorded via construction job books). To include but not limited to:			X			
		• Quality Plan		X			Prior to start of construction	
		• Supplier Inspections		X			10 days after inspection	
		• Quality Audit		X			As Issued	
		• Quality Dossier			X			
		• Personnel Qualifications and Certfifications Requirements		X			30 days after Agreement Execution	
		• Personnel Qualifications and Certifications		X				
		• Non Conformity Reports and Resolutions		X			As Issued	
		• Instrument calibration sheets and certificates		X			As Issued	
		• Electrical Assurance Certificates		X			As Issued	
		• Equipment Assurance Certificates incl. Vendor Equipment		X			As Issued	
		• Material Identification and Traceability Records		X			As Issued	
Report	Reactive Plant Voltage Regulation & Reactive Power Control Design Report	Voltage regulation and reactive power flow control and coordination study to demonstrate the proposed methods of integration and coordination of voltage and reactive power control devices.		X			3 months after Agreement execution	
Report	Risk assessment report	Risk Assessment Analysis		X		X	30 days after Agreement execution	
Report	Risk assessment report	Periodic submission of risk report showing updates and control measures		X			As updated	
Report	Solar cable route layout and associated design drawings	Cable Route Layout and associated design drawings including, but not limited to: • AC and DC cable route diagrams, including details of creek and road crossings and approximate in-line cable joint locations (if applicable) • Trench layout diagrams, showing cross-section of all buried cable configurations. • LV cable route diagrams between the PCS and Substations (if applicable)		X		X	3 months after Agreement execution	
Report	Solar earthing verification report	Earthing verification report, which verifies through measurement of the as-built earthing systems, that the Plant will be safe for the lifetime of the Project.		X		X	2 months prior to energization	
Report	Solar electrical power system studies and design calculations reports	Electrical design report(s) with detailed calculations indicating method, assumptions and outcomes of design and dimensioning of all elements in the Electrical System, having regard to the potential output of the PV Module, Inverter, the Employer's reliability and availability requirements and good electricity industry practice. The Electrical design report shall include without limitation: • Load flow study, including voltage levels at all buses, cable rating calculations and loss calculation at zero, partial and full loads, and annualised losses for the AC network in percentage of annual energy. • Fault study showing minimum and maximum fault levels at all buses • Soil Electrical Resistivity Survey results, in sufficient number of locations to allow design of the entire Earthing System		X		X	3 months after Agreement execution	

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		• Earthing study, based on justifiable assumptions and proving conclusively that the Site will be safe for the lifetime of the Solar Farm, addressing transferred potentials and step and touch voltages • Protection study and protection settings report, showing compliance with the Employer's requirements • Arc flash calculations and labels • Overcurrent device coordination • Power quality study • Inverter saturation and output model calculations • Reactive power capabilities and contributions • Insulation co-ordination study • Conduit sizing calculations • EMF calculations • Detailed availability calculations showing that the availability requirement can be achieved						
Report	Solar electrical system design report	Design of proposed electrical systems including, but not limited to: • AC design single line diagram(s) and electrical drawings, including connections to the Inverters, Transformers and Protection equipment. Protection SLD to be incorporated or provided separately; • DC design single line diagram(s) and electrical drawing(s), including connections to PV Modules, Combiner Boxes, Inverters and any other equipment connected to the DC network; • Earthing GA drawings and schematic diagrams • Details of equipment redundancy		X		X	6 months after Agreement execution	
Report	Solar SCADA design report	Details of inverter station interfacing, Solar Project and Substation and equipment with design inputs, design criteria, design outputs comprising: • Systems architecture diagram showing all components in block form, specifically identifying redundant elements and interfaces; • System platform details including details of software OS & hardware for SCADA platform including details of redundant elements and expected availability; • Data map and interfacing details; • Performance ratio and other applicable calculations; • Identification of all data points, interfacing points, including how the interconnection and interfacings are to be provided as described in this Employer's Requirements; and • Optic fibre architecture.		X		X	8 months after Agreement execution	
Report	Special tools and vehicles	List of all the tools, vehicles or voice communications equipment required for the safe and effective operation and maintenance of the Plant stating whether the Employer is required to purchase this equipment or not.	X			X	Agreement close	
Report	Special tools and vehicles	Update to special tools and vehicles list		X			6 months after Agreement execution	
Report	Storage records	Storage records for any equipment, materials, or other work that was previously produced, manufactured, or constructed, per Section 1.5.11 of Attachment M1-01-02.		X		X	Prior to shipment from original storage location	

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Report	Test reports	The results of all inspections, checks and tests carried out, together with any subsequent analysis including documentation of all Acceptance, and Performance Tests (if complete) and applicable certifications. The final commissioning test summary shall be prepared and document the results of all commissioning tests. • Any mutually agreed upon deviations from the Commissioning Test Manual procedures • Instrument calibration sheets and certificates • Test data, including corrected test data • Field notes (weather conditions, observations, etc.) • Test calculations • Any deficiencies or issues identified during, or as a result, of testing • Conclusions • Signatures of Contractor and Commissioning Manager			X	X	Within 5 days after test completion	
Report	Topographic survey, pre-construction	See Appendix M1 Attachment 02 Exhibit 01 – General Civil Requirements		X			2 months after Agreement execution	
Report	Topographic survey, post construction	See Appendix M1 Attachment 02 Exhibit 01 – General Civil Requirements			X			
Report	Transformer field inspections and tests	Upon delivery to the Site, transformer supplier shall perform and record the following: • Check impact recorder • Check blocking • Check transformer trank and fittings • Inspect bushings • Internal inspections - moister, coil supports, etc. • Check all parts have been delivered • Perform field tests and compare to FAT • Check all accessories • Provide all additional field inspections, adjustments, and tests recommended by the transformer manufacturer.			X		Within 5 days of delivery	
Report	Interconnection line civil/structural design report	Foundation and structure design for every pole location, including but not limited to the following: • Design loads • Design calculations including all assumptions • Demonstration of suitability of all structural components in extreme wind conditions and over the design life • Detailed foundation specifications • Concrete and grout mix design proposed • Borehole logs and relevant geotechnical test results • All partial safety factors • Decision trees • Reinforcement specifications and testing		X		X	3 months after Agreement execution	
Report	Interconnection line earthing verification report	Earthing Verification Report, which verifies through measurement of the as-built earthing systems, that the HV Transmission Line will be safe for the lifetime of the Facility. This shall include measurements of step and touch potentials.		X			2 months prior to energization	
Report	Interconnection line other documentation	Including, but not limited to the following:		X		X	3 months after Agreement execution	

KEY

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Level C: As-built Documentation - As-built drawings and other record documentation to be submitted after the issuing of any completion certificate
Owner Approval: Must be submitted for the Owner's review and approval prior to equipment purchase or construction

Category	Deliverable:	Description:	Level			Owner Approval	Owner Proposed Schedule	Contractor Proposed Schedule
			A	B	C			
		• Electrical design report, including conductor selection (size, current rating, resistance, number of circuits, type, strength, etc.), insulation, loading, clearances, conductor sagging, etc. • Earthing study and earthing design drawings • Specifications for all components, including conductors, insulators, optical ground wire (OPGW) and hardware. • Equipment data sheets for all engineered equipment items to be provided as part of the Facility. Data sheets shall include a concise description of performance rating, materials, and design data. • Calculations to confirm audible noise, radio frequency interference, electric field and magnetic fields satisfy the regulatory requirements and Applicable Standards. • Work method statements, ITPs (inspection and test plans) and commissioning plans for all HV transmission line works, including concrete testing, foundations, pole assembly, pole erection, conductor and OPGW stringing, jointing and terminations • Test Procedures (functional and Acceptance and Reliability test procedures for acceptance. • Pole schedule • Line schedule • Minimum clearances for maintenance capability • Lists of special tools furnished with the equipment for erection and maintenance to be provided by Owner • Requirements for storage and protection of equipment upon receipt and following installation, but prior to start up;er • Spare parts list (after design) • Earthwork specifications • Concrete specifications • Structural steel specifications • OPGW/Fiber optic cable specifications • Engineered Equipment Specifications • Grounding Calculations and Details • Signage						
Report	Interconnection line stringing test report	Compress sample mid span joints, as well as phase conductor dead/end assemblies for each wire type used on the project			X	X	Prior to stringing commences	
Report	Interconnection line, post construction	Documentation including, but not limited to the following: • Operation and maintenance manuals for all Contractor-supplied equipment; • Sectional drawings showing materials and construction; • QA/QC books • System Turn Over Packages (TOP) • Test Reports			X	X		
Report	Transportation study	A report that details the proposed access roads to be used together with any off-Site road improvement required and conditions of transportation. Off-Site road improvements shall include road cross sections and construction details. Pre-delivery condition survey of the transport route to the Site access point.		X		X	1 month prior to site mobilization	

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Category	Deliverable:	Description:	Level			Owner Approval	Owner Proposed Schedule	Contractor Proposed Schedule
			A	B	C			
Report	Transportation study	Condition survey of the transport route to the Site access point post-delivery of all major loads & equipment.			X			
Report	PV electrical balance of plant power system studies and design calculations reports	Electrical Design Report(s) with detailed calculations indicating method, assumptions and outcomes of design and dimensioning of all elements in the EBoP, having regard to the potential output of the Plant, the characteristics of the Work, Owner's reliability and availability requirements and prudent industry practices. The Electrical Design Report shall include without limitation: • Load flow study, including voltage levels at all buses, cable rating calculations and loss calculation at zero, partial and full loads, and annualized losses in percentage of annual energy • Fault study showing minimum and maximum fault levels at all buses • Soil Electrical Resistivity Survey results, in sufficient number of locations to allow design of the entire Power Plant earthing system • Earthing study, based on justifiable assumptions and proving conclusively that the Site shall be safe for the lifetime of the Facility, addressing transferred potentials and step and touch voltages • Protection study and protection settings report, showing compliance with Owner's requirements and other relevant requirements • Harmonics and flicker study • Insulation co-ordination study • Reactive Power and Voltage Control Report		X			8 months after Agreement execution	
Specifications	Civil works specifications	Where not covered by the Site Layout, an outline of proposed BoP/BOS Civil Works, including but not limited to: • Overview, specifications • Details of reinforcement • Site testing	X			X	Agreement close	
Specifications	Contractor specifications	Including the following: • Standards as identified by Contractor as being relevant to the Work • Equipment suppliers detailing locations, and where major components of the Work shall be manufactured	X				Agreement close	
Specifications	Design life	Design Life for PV Modules, Inverters, PV Mounting Structures and other major components.	X			X	Agreement close	
Specifications	Electrical control documentation	Vendor data sheets for main electrical components, including generator, main circuit breaker and converter/inverter (if present)		X		X	Duration of Agreement	
Specifications	Grid connection documentation	All required information to assist Owner in its application for Grid Connection.	X	X		X	Duration of Agreement	
Specifications	Grid connection documentation	Including: • Generating System Design Data Sheets • Contractor shall supply a completed performance standard template stating the proposed level of compliance to each access standard in accordance with the TSP's GPS		X			Duration of Agreement	
Specifications	HV/MV transformer specifications	Proposed substation transformer specification which shall include at a minimum the following details: • Transformer layout	X			X	Agreement close	

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Owner Approval: Must be submitted for the Owner's review and approval prior to equipment purchase or construction

Category	Deliverable:	Description:	Level			Owner Approval	Owner Proposed Schedule	Contractor Proposed Schedule
			A	B	C			
		• Ratings and Design Life • Auxiliary Supply • Radio Interference • Short Circuit Withstand Capacity • Earth Tremors • Insulation Levels • Noise Levels and Vibration • Temperature Rise Limits • Magnetising Current and Flux Density • Transformer Core and Windings • Transformer Losses • Transformer Construction • Transformer Tank • Transformer Oil and Valves • Oil Conservator Tank • Cooling Equipment • Temperature Measuring Equipment • Gas and Oil Actuated Relay • Pressure Relief Devices • Gaskets and Flanges • Marshalling Box • Auxiliary and Control Wiring • Terminations • Bushings • Surge Diverters • Degree of Polymerisation (DP) • Inspection and Testing • Shipping						
Specifications	Inverter specifications	The following documents shall be submitted by the Contractor. • Datasheet • Track records • Type test certificates to Applicable Standards and test reports • Accelerated test certificates • Warranty terms	X			X	Agreement close	
Specifications	Manufacturer storage specifications	Manufacturers' storage and protection requirements/recommendations for all equipment and materials should be provided to Owner prior to delivery		X		X	1 month prior to delivery	
Specifications	Material safety data sheets	As required		X			As received	
Specifications	Other plant equipment as applicable (e.g. transformer, switchgear, cables, DC combiner box, met station)	The following documents shall be submitted by the Contractor. • Datasheet • Track records • Type test certificates to Applicable Standards and test reports • Accelerated test certificates (if available) • Warranty terms	X			X	Agreement close	
Specifications	Permanent on-site buildings	Functional description and preliminary design specifications including: • Layout	X			X	Agreement close	

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Owner Approval:	Must be submitted for the Owner's review and approval prior to equipment purchase or construction

Category	Deliverable:	Description:	Level			Owner Approval	Owner Proposed Schedule	Contractor Proposed Schedule
			A	B	C			
		• Elevation drawings • Structural • Architectural • Fire rating • Hold down						
Specifications	PV Module specifications	Functional description and preliminary design specifications including: • Datasheets • Latest installation figures the operational track record • Type test certificates to Applicable Standards and test reports • Accelerated test certificates • Proposed module bill of material (if available) • Warranty terms	X			X	Agreement close	
Specifications	PV Module specifications	The following documents shall be submitted by the Contractor. • Module bill of material • Estimated annual degradation justified with historical production data • Validate LID, annual degradation, IAM, or other assumptions used in the energy assessment • Demonstrate workmanship quality through a 3rd party factory audit • PID test report and information		X			3 months after Agreement execution	
Specifications	PV mounting structure specifications	Functional description and preliminary design specifications including: • Datasheets • The latest installation figures for the proposed [PV Module Mounting Structures / Trackers] along with an indication of the operational track record • Type test certificates to Applicable Standards and test reports • Accelerated test certificates • Wind tunnel test results • Warranty terms	X			X	Agreement close	
Specifications	Reinforcement specifications and testing specifications	Reinforcement specifications, testing, FATs		X			6 weeks prior to start of relevant work	
Specifications	SCADA and communications network	Functional description and preliminary design specifications including: • Information on the communications system, including specifications and drawings • Information on the SCADA system, including specifications and drawings	X			X	Agreement close	
Specifications	SCADA instrumentation specifications	Copies of calibration sheets for all sensors/transducers as appropriate in accordance with the appropriate calibration standards. Sensors/transducers shall include those mounted on: • Solar met station • Switchgear • Monitored equipment • Statcom equipment, and • Power Quality Metering			X			
Specifications	Solar electrical specifications	Functional description and preliminary design specifications of proposed electrical systems up to and including the Point of Connection, including:	X			X	Agreement close	

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Owner Approval: Must be submitted for the Owner's review and approval prior to equipment purchase or construction

Category	Deliverable:	Description:	Level			Owner Approval	Owner Proposed Schedule	Contractor Proposed Schedule
			A	B	C			
		• Preliminary AC design single line diagram/s, including connections to the Inverters, Transformers and Protection equipment. Protection SLD to be incorporated or provided separately • Preliminary DC design electrical drawing/s, including connections to PV Modules, Combiner Boxes, Inverters and any other equipment connected to the DC network • Cable route layout for the AC electrical system, including approximate in-line joint locations (if applicable) • Cable route layout for the DC electrical system • Cable schedules (AC and DC) and cable specifications • Protection philosophy • Primary and Secondary system key equipment specifications, including HV/MV Transformer, MV/LV Transformer, HV and MV switchgear, Reactive Plant (if applicable), Neutral Earthing Resistors or Neutral Earthing Transformers (if applicable) • Optimisation of AC power cable size and preliminary calculations showing electrical efficiency requirement can be achieved Preliminary calculations showing that electrical system availability can be achieved in excess of the value specified.						
Specifications	Updated solar specifications	Full specification of the PV Module, Inverters, Transformers, MV and HV Switchgear, SCADA and Met Stations including specifications of all main components		X		X	2 months prior to delivery to Site	
Specifications	Substation specifications	Functional description and preliminary design specifications including: • Substation general arrangement drawing • Reactive power compensation resources (if applicable) • Reactive power compensation support and voltage control philosophy • Protection philosophy • Primary and secondary system key equipment specifications • HV and MV switchgear, neutral earthing resistors or neutral earthing transformers (if applicable)	X			X	Agreement close	
Specifications	Welding procedure specfications	Document demonstrating welding procedure shall meet all requirements of the AWS D1.1 code		X		X	6 weeks prior to start of relevant work	

Appendix M1

Attachment 01

Exhibit 07

Security and Compliance

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

2023

REQUEST FOR PROPOSAL

NO.	DATE	REVISION	BY	CHK'D	APPROVALS	
0	26Oct21	Issued for Implementation	1898 & Co.		JAL	Jared Lathrop
1	14Apr23	Update from 2021 version	1898 & Co.	PGE	CPA	Craig Armstrong

Table of Contents

1 General

1.1 Specifications

In addition to specifications outlined herein, Contractor shall comply with the requirements provided in M1-05-04 (Communication, SCADA, and Metering Facilities). Additional requirements based on project type (wind, solar, or energy storage) shall comply with the respective requirements in M2-01-01 (Wind Plant Specifications), M3-01-01 (Solar Photovoltaic Plant Specifications), and M4-01-01 (Energy Storage Technical Specifications).

2 SCADA Cyber Security

In this section, the term “SCADA” specifically refers to the plant control system. This is not intended to influence or dictate requirements for the substation or Transmission System Operator.

Contractor shall incorporate all security appliances in the collector substation control house and Owner’s security center into the SCADA system. SCADA system to be compliant with NERC Critical Infrastructure Protection (CIP) and Owner’s internal standards.

In the event Owner is responsible for maintaining the SCADA system and/or performing day-to-day operations at the site, Owner shall have input on which security applications are used to conform with internal requirements. If Owner is not performing any day-to-day maintenance the operator shall have say of specific applications, but the requirements still apply.

2.1 Patch Management

Contractor will include a patch management system capable of deploying patches for all software, hardware, and integrated third-party applications within the SCADA system.

Contractor will evaluate, test, and provide appropriate patches to all devices and software within the SCADA system or any other provided system.

Contractor will install patches on all systems according to industry best practices to reduce operational risk due to cyber incidents. At minimum, patches should be installed on an annual basis.

2.1.1 Anti-Virus & Whitelisting

Contractor will supply an anti-virus and whitelisting system capable of managing all assets within the SCADA system.

Contractor will install whitelisting software on all Windows and Unix-based endpoints within the SCADA system and have a procedure to keep the system in restricted (blocking) mode while the system is operating.

Contractor will install anti-virus software on all Windows-based endpoints and provide ongoing definition updates according to industry best

practices to reduce operational risk due to cyber incidents. At minimum, definitions should be updated on a monthly basis.

Contractor will provide a list of all applications that need to be whitelisted on all provided equipment.

2.1.2 Backup and Restoration

Contractor will provide a backup and management system capable of taking operating system backups of all SCADA equipment for the purposes of rapid restoration in the event of a system failure or cyber incident.

Contractor will install backup and restoration software on all Windows and Unix-based devices within the SCADA system. The system must be configured to take automated backups and Contractor must have a procedure for validating backup validity.

Other devices within the SCADA system and support systems (such as networking devices) must be configured to have their configurations, firmware, and any other applicable configuration files pulled automatically on a scheduled basis.

Backups may be stored locally to the site; however, an offline backup must be maintained for incident recovery. The offline backup must be regularly updated, at minimum once per year.

2.1.3 Security Logging

Contractor will provide a log management system capable of collecting, analyzing, and alerting on logs generated by the SCADA system.

All Windows, Unix, and Syslog-capable devices within the SCADA system must be configured to send logs to the log management system.

Log management system must be continuously monitored by a Security Operations Center (SOC) using industry best practices for log correlation and incident reporting.

Contractor must inform PGE of any event or incident that could detrimentally affect the operations of the SCADA system within 24 hours of when it was detected.

Contractor will provide a log management system capable of collecting, analyzing, and alerting on logs generated by the SCADA system.

2.1.4 Vulnerability Management

SCADA Contractor will provide a mechanism for alerting Owner in the event of a vulnerability or exploit that affects the SCADA system within 10 working days after discovery.

SCADA Contractor will disclose the existence and reasons for any identified backdoor codes.

2.2 System Management

In the event Owner is responsible for maintaining the SCADA system and/or performing day-to-day operations at the site, the following requirements apply. If Owner is not performing any day-to-day maintenance, this section does not apply.

2.2.1 Device Management

Contractor will turn over management of all servers, applications, application and networking devices within the SCADA system or any other provided system to the Owner at the conclusion of the SAT. This will include Domain Administrator privileges.

Contractor must provide validated patches for the system for all provided equipment for operational life of this equipment.

Contractor will provide information on all required communications through the firewalls prior to the factory acceptance test.

Contractor will properly harden all devices including uninstalling unused software components and disabling unnecessary services and ports prior to the site acceptance test.

Contractor will provide documentation detailing all applications, utilities, system services, scripts, configuration files, databases, and all other system requirements during the site acceptance test.

2.2.2 Account Management

Contractor will supply or integrate with an Owner-provided domain controller to manage all authentication within the SCADA system and all support systems.

All default and guest accounts must be removed prior to the factory acceptance test.

Contractor will supply a list of accounts which need to be active on the SCADA system. These accounts must be approved by the Owner.

All accounts within the SCADA systems and support systems will adhere to least privilege permission schemes.

All passwords will adhere to Owner’s password policy.

Contractor will notify Owner within 24 hours of an employee, who has access to the SCADA system or any support system, quits or is terminated with cause.

Contractor will notify Owner within 3 days when an employee, who has access to the SCADA system or any support system, retires or changes position, or otherwise no longer needs access to the system.

No local accounts will be enabled within the generation SCADA system.

Contractor will provide all password change procedures/requirements during the site acceptance test.

2.3 SCADA Network Design

2.3.1 Network Segmentation

The individual SCADA system components must be logically segmented from each other. The following networks shall remain separate where technically feasible:

a. Domain Controllers

b. SCADA Servers

c. User workstations

d. Controllers/PLCs

e. Auxiliary Systems

f. Monitoring systems

g. Terminal/VPN Servers

h. Independent strings/loops of remote devices

Contractor will provide and enforce ACLs and port security address lists for all communications between subnets.

Contractor will provide and document secure network architecture where higher security zones originate communications to less secure zones.

All unencrypted protocols (FTP, telnet, HTTP, etc.) shall be disabled in lieu of their encrypted counterparts (SFTP, SSH, HTTPS, etc.).

2.3.2 Wireless Communications

Wireless technologies such as microwave, cell, Bluetooth, Wi-Fi (802.11x), ZigBee, WirelessHART, or other wireless technologies shall not be used within the SCADA system.

2.3.3 High Availability and Redundancy

All critical systems, to be jointly determined by Owner and Contractor, shall have redundant hardware and software operating in a high-availability mode.

2.3.4 Network Space

In the event Owner is responsible for maintaining the SCADA system and/or performing day-to-day operations at the site, the following requirements apply. If Owner is not performing any day-to-day maintenance, this section does not apply.

Owner will provide Contractor with banks of IPs that can be used for devices within the SCADA system or other support systems.

Contractor will provide Owner with a list of devices with associated IP address prior to the factory acceptance test.

2.3.5 Security Design Workshops

In the event Owner is responsible for maintaining the SCADA system and/or performing day-to-day operations at the site, the following requirements apply. If Owner is not performing any day-to-day maintenance, this section does not apply.

Owner, Contractor, and any pertinent subcontractor (including SCADA Contractor) will have at minimum 5 security design workshops lasting no less than one hour each.

These interactive meetings will allow the Contractor to present the methods used for conforming to the requirements of PGE Cyber Security Policies and Procedures and relevant compliance requirements.

The minimum topics that will be covered in these workshops are:

a. Review of requirements
b. Presentation of hardware and software products to be used.
c. Implementation plan
d. Long term system maintenance, operation, and support requirements
e. Network design and requirements

2.4 Remote Access

All remote access traffic must be fully encrypted.

All remote access where a user interfaces with any part of the SCADA system or support system will require multi-factor authentication.

Under no circumstances will the SCADA system or any support system have direct access to the internet.

All remote access to the control system network must be performed through a VPN.

VPN connections must have logging, alarming, and monitoring to protect SCADA system from unauthorized modification or use.

2.5 Incident Response/Disaster RecoverY

Contractor shall provide existing Incident Response and Disaster Recovery plans for the SCADA network.

Contractor shall work with the Owner to address deficiencies in Contractor's Incident Response and Disaster Recovery plans.

2.6 Site Acceptance Test

Prior to the site acceptance test the Contractor shall:

- Ensure all devices are patched to their most current level.
- Provide current configuration files for all devices.

Firewall rules, as well as all other access control mechanisms, will be enabled throughout the duration of the SAT.
All Firewall rules and router ACLs will be verified at the SAT.
Remote access and remote access restrictions must be tested as part of the SAT.

2.7 Physical Security

Contractor shall provide a lockable or locking enclosure for all control system components.

All physical security networks must be separate from SCADA networks.

3 Generation Physical Security System

3.1 General Design

Contractor shall provide the necessary below grade, and above grade infrastructure for PGE's security system that includes, but is not limited to the following requirements:

A centralized point for the security system and cabling to be housed and secured, either on a concrete foundation and an outdoor rated 4 post communications rack with a heating and cooling system, or adequate wall space of 8' X 8' in an indoor location or an indoor rated 4 post communications rack mounted in a temperature controlled secured room to be provided by Contractor.

All underground conduits provided by the Contractor and will be a minimum of 2" PVC routed from the centralized location to the appropriate point and stubbed up and capped with an 8" X 8" Non-metallic weatherproof enclosure unless otherwise specified.

There will be (1) conduit provided by the Contractor from the centralized area to the closest point on the fence line stubbed up 24" – 30 "for the Fence Detection System. If the Fence line is more than 2,600' in length, another conduit will also be needed and will be identified during design for placement.

There will be (1) conduit provided by the Contractor from the centralized location to wherever the PGE communication equipment is housed to provide a

communications pathway for the security system. If both systems are housed internally inside the same rack or building, it is acceptable to use cable tray if it is available in leu of conduit.

For each gate either personnel or vehicle there will be (1) conduit provided by the Contractor under each gate stubbed up 24”-30” and 12”-20” for both edges of the gate.

For each gate either personnel or vehicle there will be (1) conduit provided by the Contractor for the access control and Intrusion detection systems back to the centralized security location.

There will be enough camera locations within the project’s exterior within the footprint of the fence line to view the entire area without obstruction. This may require the Contractor to install footings and poles. PGE’s preference for these poles is a 16’-20’ non-metallic pole.

All internal locations may have camera coverage depending on type of work location:

a. Substation Control House – 100% coverage
b. Switchgear building – 100% coverage
c. Communications Room – 100% coverage
d. Control system Room – 100% coverage
e. All others to be determined during design process

All building external doors shall have a Contractor provided pathway for a camera that is mounted to the building to cover the entrance of the external door that goes to the centralized security system.

For all buildings there will be a location for at least (1) intrusion detection keypad and (1) access control card reader typically mounted near the main entry point and will require the Contractor to provide the pathway though the building and to the centralized security system location and mounting boxes for the equipment.

For all external doors to any building, the Contractor will provide pathway and mounting boxes for the needed security requirements, which will include at a minimum, but is not limited to door contact, REX, electronic locking mechanism, and card reader.

For all internal building doors, there will be a discussion during design on whether to secure any doors with a security system, the one exception to this is an internal communications room will require access control and this pathway through the building and to the centralized security system, and mounting boxes will be provided by Contractor at a minimum to meet the same requirements as an external door.

All keyways on all doors must be capable of housing an E-Lock core made by Assa-Abloy

All doors with access control must have electrified door lever sets with integrated request to exit devices and power door hinges.

3.2 Site Lighting

Site lighting shall be provided at the following locations:

a. All plant vehicle and pedestrian entrances

b. Entry doorways to all buildings

c. Parking areas

d. Substation or switchyard

Site lighting shall include light fixture, mounting poles, lighting controls, etc., as applicable.

Light fixtures shall be suitable for outdoor locations in wet locations.

Light fixtures shall be light emitting diode (LED) type.

All site lighting equipment shall be UL listed.

Lighting control shall consist of a HAND-OFF-AUTO switch.

Photocells shall be used for automatic control.

Photocells shall be weatherproof, swivel adjustable, with built-in time delay to prevent accidental turnoff by momentary brightness.

Photocells shall be rated at 1800 VA, 120 volts ac.

Photocells shall be field adjustable from 1 ft/c turn-on to 15 ft/c turn-off.

Site lighting fixtures shall be installed in accordance with the equipment manufacturer's installation instructions.

Lighting fixtures shall be installed plumb and level and aimed as specified on the drawings, as applicable.

For storage projects, other applicable requirements in M1-05-03 (Substation Design and Construction Specification)

3.3 Security Fencing Perimeter with Gates

8-foot high mini-mesh or expanded metal fencing with 3 barbed wire strands, as specified below or as approved by Owner

a. Fence fabric shall be 1" mesh, #9 gauge wire, Class 2 Zinc-coated steel.

b. End, corner, and pull posts shall be type 1, 2.375 inch nominal outside diameter and be hot dipped galvanized with a minimum average zinc coating of 1.8 oz./ft.2 (0.55 kg/m2) meeting ASTM F-1083 for standard weight (Schedule 40) galvanized pipe.

c. Tension wire shall conform to ASTM A-824 Type I, Aluminum-coated, 0.40 oz/ft2 (122g/m2) or Type II Zinc-coated Class 2, 1.20 oz/ft.2 (366g/m2)

d. Post tops shall consist of ornamental tops or combination tops with barbed wire supporting arms, as required. When so required, or when a top rail is to be provided, the top shall be provided with a hole suitable for the through-passage of the top rail. The post tops shall fit over the out-side of posts and shall exclude moisture from posts.

e. Tension bars shall not be less than 3/16 inch (4.76mm) by 3/4 inch (19.05mm) and not less than 2 inches (50mm) shorter than the normal height of the fabric with which they are to be used. One tension bar shall be provided for each end and gate post, and two for each comer and pull post.

f. Ties or clips of adequate strength shall be provided in sufficient number for attaching the fabric to all line posts at intervals not exceeding 15 inches (380mm); and not exceeding 24 inches (610mm) when attaching fabric to top rail or tension wire.

Powered, keycard-controlled sliding or swinging gate

a. One for access to O&M building entrance/parking area

b. One for access to storage/laydown area

c. Both of widths large enough to provide easy ingress to the facility for a full-size tractor trailer combo

4 Substation physical Security

The Project Substation shall meet the same physical security requirements as the rest of the site and as noted in this specification.

The Project Substation shall have access detection, control, and monitoring provisions to ensure that Owner is able to capture, record and monitor all personnel, authorized or unauthorized that enter the site area and must be compatible with Owner's existing security system. Contractor shall coordinate the preferred access control methodology with Owner along with additional provisions such as video monitoring and motion detection.

5 NERC and WECC Compliance

Contractor shall proactively consider NERC and WECC Compliance in the Project. New facilities connecting to the Bulk Electrical System (BES) require significant coordination with affected entities and specific planning and timely milestones will be required. The contractor will establish a schedule to ensure adherence to any standard issued by the North American Electric Reliability Corporation (NERC) or the Western Electric Coordinating Council (WECC) allowing for or applicable to the commissioning and operation of the Project.

Below are the current standards the contractor is expected to comply with:

1. **BAL-005-0.2b R1.1:** Generation facilities must be included within the metered boundaries of a Balancing Authority.

2. **BAL-005-0.2b R12:** Tie Line metering requirements
3. **CIP-002 R1:** Generator Owner will determine BES impact for generation resources.
4. **CIP-003 R2:** Generator Owner will implement controls to ensure low impact rating is met for all applicable CIP requirements.
5. **EOP-005-2 R4:** System Restoration Plan must be submitted to Peak for approval before any planned BES modification that would change the implementation.
6. **FAC-008-3 Facility Ratings:** Contractor to provide facility rating documentation of installed components.
7. **IRO-010/TOP-003:** There are a number of data specifications requiring modeling information to be submitted to Peak and others 30 days before the change to the network.
8. **MOD-001-2 R2:** ATCID methodology must take into account generation and transmission additions.
9. **MOD-025-2 R1 and R2:** real and reactive power capability verification
10. **MOD-026-1 R2 and R4:** generator excitation control system or plant volt/var control function model verification
11. **MOD-027-1 R2 and R4:** turbine/governor and load control or active power/frequency control model verification
12. **PRC-001-1.1 R5:** GOP must notify TOP in advance of changes in generation that could require changes to Protection Systems, and TOP must notify other TOPs of the same.
13. **PRC-005 R1, R2, R3, R4, and R5:** Generator Owner must perform, and document battery maintenance is a timely manner.
14. **PRC-019-2 R2:** verify coordination of voltage regulating system controls, (including in-service limiters and protection functions) with the applicable equipment capabilities and settings of the applicable Protection System
15. **PRC-024-2 R1 and ER2:** verify generator frequency and voltage protective relaying does not trip the applicable generating unit(s) within the “no trip zone” of PRC-024 Attachment 1 and Attachment 2
16. **PRC-025-2 R1:** verify generator relay settings are in accordance with PRC-025-1 – Attachment 1
17. **VAR-001-4.1 E.A. 15 and E.A. 17:** verify that generating equipment uses voltage set point, and complies with external voltage control loop specification established by these requirements
18. **VAR-002-4 (all):** comply with operation and notification requirements during testing and upon initial commercial operation

19. **VAR-002-WECC-2 R1:** have AVR in service and in automatic voltage control upon initial commercial operation
20. **VAR-501-WECC-3**: (all): comply with settings. Testing and operational requirements established by this Standard

The standards listed are subject to change and the contractor will need to communicate specific planning and timely milestones to Owner to ensure all regulatory compliance obligations are met.

Appendix M1

Attachment 01

Exhibit 09

PGE CAD AND NUMBERING STANDARDS

[Content to be provided at time of contracting]

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

2023

REQUEST FOR PROPOSAL

NO.	DATE	REVISION	BY	CHK'D	APPROVALS	
0	15Oct21	Issued for Implementation	DNV-GL	DS	CPA	Craig Armstrong
1	14Apr23	Update from 2021 Version	PGE		CPA	Craig Armstrong

Appendix M1

Attachment 04

Exhibit 02

General Transformer Specification

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

2023

REQUEST FOR PROPOSAL

NO.	DATE	REVISION	BY	CHK'D	APPROVALS	
0	26Oct21	Issued for Implementation	1898 & Co		JAL	Jared Lathrop
1	14Apr23	Update from 2021 Version	1898 & Co	PGE	CPA	Craig Armstrong

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1 Scope of Work

1.1 Description

This specification covers the general design, construction, and operating requirements for oil-immersed outdoor station type power transformers including solar/wind substation Generator Step Up (GSU) transformers.

Manufacturer shall provide Owner with a manufacturing schedule that includes an anticipated beginning date, end date, and duration in terms of calendar days for the following deliverables:

- Purchase of materials
- Drawings including submittal and approval processes
- Production including core, coil, tank, and connection assembly
- Final assembly including the vapor phase process, a pretanking inspection
- Factory acceptance testing
- Shipment and delivery to the substation site/storage

1.2 Design Requirements

Transformer cooling shall be ONAN/ONAF/ONAF at 55 degrees C rise on a 50 C ambient.

The transformer specified herein shall be designed, manufactured, and tested in accordance with all applicable regulations, codes, IEEE including IEEE C57.12.00 and IEEE C57.12.90, and NEMA standards, except as otherwise required by this specification.

The transformer shall be designed to comply with all elevation requirements, including corrective calculations which consider elevation in IEEE C57.12.90.

The transformer shall be designed to have impedance ratings as defined in the transformer supply agreement and corresponding data sheets. Transformer impedance ratings will comply with the ANSI standard tolerance of +/- 7.5% of guaranteed impedance ratings.

Transformer high-voltage to low-voltage winding angular displacement shall be zero degrees.

Noise level shall comply with NEMA standards and shall not exceed requirements as set forth in ANSI C57.12.00 when energized at rated voltage, rated frequency, and when carrying no load.

The manufacturer’s proposal shall list any additional standards, and codes the manufacturer intends to invoke in the performance of the requirements of this specification.

Control wiring and alarms shall be in accordance with PGE Design Masters (see drawings that will be provided as an Addendum or upon request). Current versions of Design Masters shall be requested by the manufacturer prior to starting design of transformer.

1.3 Inspection

Manufacturer shall give Contractor/Owner two months advance notice of the following hold points so that a Contractor/Owner representative may be present.

Design Review

Core and coil nesting

Pre-tanking

Factory acceptance testing

Design review drawings shall be submitted for approval, 3 weeks prior to the design review meeting or as otherwise noted. The design review submittal shall include, but is not limited to the following:

1. General Outline Drawings
2. Component Outline Drawings (including bushing and surge arresters)
3. Transformer Nameplate Drawings
4. Current Transformer Magnetization and Correction Ratio Curves
5. Current Transformer Connection Drawings
6. Control Schematic and Wiring Diagrams
    a. Wiring diagrams shall show all external connections to be made by Contractor
    b. Wiring diagrams shall show all internal wiring connections made by the manufacturer
    c. Wiring diagrams shall be “point to point” wiring
    d. Drawing shall show operating voltage and current ratings of fuses and circuit breakers
7. Control Cabinet Arrangement and Connection Drawings
8. Detailed Test Plan listing all tests in sequence
9. List of all transformer parts to be shipped including spare parts
10. Short-circuit test data as described in the section 4.4(A) of this specification

1.4 Shipping

All bushings, surge arresters, and radiators shall be removed from the transformer prior to shipment. The openings left in the transformer tank from their removal shall be covered with metal plates for shipment. Transformer shipping should follow IEEE C57.150 (Transformer Transportation).

If the transformer tank is to be shipped filled with oil, it shall be covered with a nitrogen gas blanket.

Positive pressure of nitrogen gas shall be maintained between 1 psi to 5 psi at all times during shipment.

If the transformer tank is to be shipped without oil, the tank shall be filled with dry air.

Positive pressure of dry air shall be maintained between 1 psi to 5 psi at all times during shipment.

Manufacturer shall provide dew point at time of shipment.

Bushings shall be marked with the corresponding winding that they were used for during testing.

Rail, ship, or truck shipping methods are acceptable. Transformer Center of Gravity (COG) should be clearly indicated using appropriate symbols. At least two functional impact recorders and GPS locator shall be installed on transformer. Rail car shall be equipped with end-of-car hydraulic cushioning devices, GPS locator and impact detector. If shipped by rail, “Do Not Hump” signage shall be attached to rail car.

1.5 Storage

Storage during/after shipping, and before installation shall be in accordance with IEEE C57.150, manufacturer’s written requirements/recommendations, and with manufacturers approval of conditions and maintenance, including confirmation of no impact to warranty. Storage measures will include oil fill and dry nitrogen blanket (for long storage durations – nitrogen pressure to be between 1 psi to 5 psi), power to control panel heater, and periodic inspection and gauge readings, all in accordance with manufacturer requirements and approval. Unassembled components shall be stored in accordance with manufacturer requirements/recommendations, in original shipping containers, and protected from weather.

1.6 Reference Standards

This equipment shall be built and tested in accordance with the applicable standards and its supplements listed in M2-01-01 (Wind Plant Specifications) (the “Wind Spec”), M3-01-01 (Solar Photovoltaic Plant Specifications) (the “Solar Spec”), and M4-01-01 (Energy Storage Technical Specifications) (the “BESS Spec”), as applicable.

2 Materials

2.1 General

Materials and components shall be new, undamaged and shall conform to pertinent NEMA and IEEE standard specifications and the following requirements.

All components and parts shall be readily available in the United States. All components shall be readily identifiable by manufacturer's name and part number.

Metric sizes are not acceptable.

2.2 Core and Windings

Contractor shall specify the winding ratings for each terminal designation, including the voltage rating, continuous current rating, BIL rating, and catalog number. BIL ratings shall be determined as per IEEE C57.12.00.

Except for pad-mount transformers, all windings shall be copper. Aluminum windings may be used pad-mount transformers only.

All windings shall be insulated with thermally upgraded paper and verified with long-duration test per IEEE C57.100.

Where applicable Netting Continuously Transposed Cable (CTC), Epoxy Bonded, is preferred.

All windings, except tertiary winding, shall have a through-circuit capacity MVA rating at a 60°C rise, of the max MVA rating of the transformer.

The average winding temperature rise shall not exceed 60°C above ambient (a maximum 30°C average 24-hour ambient, and a 45°C maximum ambient).

The maximum hottest-spot winding temperature rise shall not exceed 80°C rise over ambient (110°C continuous with 30°C ambient, 120°C short-term emergency rating with 40°C ambient).

The hottest-spot of the interior of the core should never exceed 85°C rise over ambient (125°C at 45°C ambient) to avoid gassing, and the core surface temperature must not exceed the thermal capability of the insulation or parts touching the core.

Tertiary windings (if required) shall be a delta connected stabilizing winding, and be self-protecting for short circuits at all bushing terminals. Refer to the detailed specification to determine if tertiary should be buried or brought out. Tertiary windings shall have a kVA capacity of no less than 35% of the transformer’s ONAN rating.

1. Tertiary windings that are brought out may be used for station service.
2. Assume no system impedance for short circuit calculations.

3. Tertiary windings that are buried shall be designed with provisions to have the tertiary be brought out only for factory testing.
4. Tertiary winds that are buried shall have one corner of the delta brought out with two leads, from adjacent legs. These leads shall be bonded and grounded externally.

The transformer shall be designed with impedances sufficient to make the transformer self-protecting. Manufacturer shall assume that the transformer will be operated from an infinite bus.

Nuts, bolts, and clamps of the core assembly shall be provided with positive locking devices to prevent loosening caused by vibration or change of shape or position during transportation or operation. The complete core and winding assembly shall be removable from the tank for repairs.

Nomex insulation shall be used between the core and clamping structure.

For GSU's only: fiber optic temperature probes shall be installed, and provisions shall be made for monitoring system as noted below.

1. Monitoring system and sensors shall be LumaSense Technologies QualiTROL 408-12 or Owner approved equivalent.
2. Location of sensors - Fiber optic probes shall be located at the hottest winding spots as determined by manufacturer's calculations.
3. Number of sensors - Install two in each winding (for example in case of three-phase three-winding (primary, secondary, and tertiary) GSU, each winding shall have six sensors)
4. All fiber optic temperature probes shall be connected through a tank penetration box with tank wall feed-through with proper identification. (Phase, winding, Probe 1 or 2, etc.…).
5. The fiber optic tank penetration box shall be mounted on upper tank wall.

2.3 Bushings

Contractor shall specify the bushing ratings for each terminal designation, including the voltage rating, continuous current rating, BIL rating, and catalog number. BIL ratings shall be determined from the insulation coordination study as specified in the Wind Spec, the Solar Spec, the BESS Spec, or M1-04-01 (General Electrical Study Requirements) as applicable and shall meet applicable requirements in the following standards: IEEE C57.12.00, ANSI C57.19.01, ANSI 21, ANSI 24, and ANSI C57.12.10.

Acceptable manufacturers for the bushings are provided in the Wind Spec, the Solar Spec, and the BESS Spec, as applicable.

All bushings shall be bolted on.

The bushing color shall be ANSI 70 (light gray).

Bushings shall be resin impregnated synthetic (RIS) condenser capacitive graded type and shall contain no oil.

RIS bushings shall be supplied with an air-side insulator with HTV silicone rubber adhered directly to the RIS condenser body having low stress teardrop tip and no visible parting lines.

If bushings are mounted at an angle other than vertical, the angle shall not exceed 30 degrees. The bushings shall be mounted so as to provide maximum clearance to the isolated phase bus enclosure, if applicable.

All standard routine tests as prescribed by ANSI/IEEE C57.19.00 shall be performed on every bushing at levels and requirements equal to or better than specified in ANSI/IEEE C57.19.01 for oil impregnated paper bushings.

HV bushing top terminal shall conform to the requirements of IEEE Standard C57.19.01.

Bushings 35 kV and lower shall have the 200 kV BIL rating as defined in IEEE Standard C57.19.01.

Bushings shall have 20% current margin over transformer winding rating at full load with maximum cooling.

Bushings to be attached to bus duct shall be rated to 125°C hot spot temperature with no additional loss of life.

The manufacturer shall not provide bushing terminal connectors.

Bushings with bolted bottom connections shall have spade connectors with NEMA hole spacing, through bolts, and nuts. Bolted connections shall have a minimum of 4 bolts per connection.

The neutral bushing shall be identical to low voltage line bushings if voltage ratings are the same.

The neutral bushing shall be connected to a ground pad near the base of the transformer using a continuous conductor of not less than 250-kcmil flexible copper cable or equivalent flat copper bar.

Bushing monitors may be included as a line-item option.

2.4 Surge Arresters

Manufacturer shall supply metal-oxide type surge arresters for all high-voltage bushings, low-voltage bushings, and for the high-voltage and low-voltage neutrals.

Contractor shall specify the surge arrester ratings, including the duty cycle rating (station class), MCOV rating, manufacturer, type, and catalog number for each terminal designation.

A ground loop shall be furnished, of not less than 250-kcmil flexible copper cable, which is connected from one ground pad on one side of the transformer through the three low voltage arrester ground terminals to another ground pad on the opposite side of the transformer. Also, similar separate ground loops shall be provided for the high voltage and tertiary surge arresters.

Arresters shall be mounted so that the spacing between the energized end of the arrestor and the top of the in-phase bushing is no less than half the minimum recommended phase to ground clearance for the selected arrestor. Furthermore, the spacing between the grounded end of the arrester and bottom of the in-phase bushing shall be no less the minimum recommended phase to ground clearance for the selected arrester.

2.5 Instrument Transformers

A list of approved instrument transformer vendors is provided in the Wind Spec, the Solar Spec, and the BESS Spec, as applicable.

All instrument transformers shall be C800 relay accuracy per IEEE Std. C57.13.

All instrument transformers shall have a thermal rating factor (T.R.F.) of 2.0.

All current transformer leads internal to the tank shall use ETFE insulated wire with a minimum temperature rating of 150ºC. All current transformer leads shall run the full length from the current transformer to the CT tank wall penetration box without any splices.

All taps from all current transformer secondary windings shall be connected to short-circuiting type terminal blocks located in the control cabinet.

Bushing current transformer wiring shall be a minimum of stranded No. 12 AWG, copper, terminating on ring-type terminals.

2.6 Control Cabinet

The main control cabinet shall house cooling equipment controls, electronic transformer monitor, relays, meters, test switches, indicating lights, manual control equipment, and terminal blocks.

Main control cabinet and any auxiliary control cabinets shall be a non-condensing, weatherproof, metal enclosure mounted on transformer.

The middle of the cabinet(s) shall be approximately 5 feet vertically from transformer base for easy access.

Cabinet shall be no smaller than 6 feet wide and 5 feet tall.

Cabinet shall have a minimum of two doors which shall each have:

1. A handle connected to a three-point latch to provide ease of opening and closing.

2. Door stops to hold door in "open" position. Door stops shall not interfere with opening the relay and control panel.
3. Provisions for padlocking in the “closed” position.
4. A small, clear, tempered glass window with a UV-proof coating and an aluminum hinged cover that can be lifted for viewing the transformer monitor display. Alternatively, the transformer monitor may be mounted on a swing-panel inside the control cabinet.

Cabinets shall be ventilated to avoid temperature extremes that may damage any of the contents.

Conduit entrance plate shall be removable from inside the cabinet.

Cabinets & Panels shall be configured to provide easy access to all components and their wiring during installation, testing, and maintenance.

Mounting devices on the cabinet ceiling and bottom is not acceptable.

If panel mounted equipment is used, the panels shall be hinged to swing-out for convenient access to all wiring.

Provide pockets to hold drawings and instruction books inside the control cabinet doors.

2.7 Electrical Items

Control cabinet design shall follow requirements of IEEE C57.148 and the following:

1. Interior illumination with on-off switch activated by cabinet door shall be installed on the ceiling of the control cabinet. The interior lighting shall illuminate the front of the swing panel in addition to the rest of the cabinet. A minimum of two cabinet lights with 800 lumens or more shall be installed.
2. As a minimum, a 200 watt positive temperature coefficient heater, with fan, for 120-volt AC operation shall be installed. The manufacturer shall determine if more than one 200 watt heater is required.
3. One exterior-rated 120-volt AC duplex, 20-amp, three-wire grounding-type GFI receptacle shall be installed on the exterior of the control cabinet.
4. Two interior 120-volt AC duplex, 20-amp, three-wire grounding-type GFI receptacle shall be installed inside the control cabinet.

Control cabinet instrument transformers shall follow requirements of IEEE C57.13.

Multi-breaker overload protection shall be provided for items 1, 2, 3 & 4 above.

Separate breaker overload protection shall be provided for each monitoring device: the transformer monitor, dissolved gas & moisture monitor, and bushing monitor.

Manufacturer shall supply a spare one-pole 120-volt, 20-amp breaker for use by Contractor and PGE.

All Contractor external connections for power sources, relays, alarm, and trip circuits shall be wired to terminal blocks and clearly labeled.

Manufacturer shall provide 20% spare open/unused terminal blocks for Contractor's and PGE's future use.

Any spare or unused contacts of any device used shall be connected to terminal blocks for Contractor's and PGE's future use.

Indicating lights shall have LED type displays with appropriately sized resistors in series for 125-volt DC operation. Lights shall be compatible with ET-16 lamps.

All DC circuits shall operate from an ungrounded 125V DC source. All DC equipment, including relays and alarm controls, shall be suitable for continuous operation over a range of 102-140 volt for 125V DC source.

Any device capable of producing a surge voltage in control or alarm circuits shall be furnished with surge suppressors to limit the surge voltage. Properly rated MOVs are to be applied on the AC coils. Properly rated diodes are to be applied on the DC coils.

All equipment rated 600 volts and less shall have a dielectric withstand capability of a minimum of 2500 volts, as described in IEEE Standard C37.90. Should such voltage level exceed the capability of the equipment, means shall be provided as a part of the device to protect the device against damage by voltage in excess of its withstand capability.

All lugs used for any internal compartment wiring will be of the non-insulated ring type. The indent mark from the indent tool must be clearly visible.

All control terminations made to be modular compression terminal blocks or device terminals shall be made using bare tin-plated copper ferrules. The indent mark from the compression tool shall be clearly visible.

All wiring shall be stranded, No. 14 AWG, or larger, unless otherwise specified.

All PLC and transformer monitor input (analog and discrete) wiring shall be stranded, No. 18 AWG.

Device grounds and neutrals shall be directly connected to neutral and ground buses and shall not be daisy-chained through other devices between taps.

All operating controls and indicators accessed by operating personnel in the normal operation and testing of equipment shall be located such that personnel are not unnecessarily exposed to live parts.

All circuits to the control cabinet shall be routed through flexible seal tight conduit. Conduit penetrations into control cabinet shall be conduit hubs for sealing. (Lock nuts

with RTV are not acceptable.) Conduit penetrations shall only be made in the side wall of the cabinet.

2.8 De-energized Tap-changing Equipment (DETC)

The DETC shall not limit the loading of the transformer and shall be capable of a loading that is 150% of the maximum current rating.
DETC shall be furnished to provide plus and minus 5 percent adjustment of the high-voltage winding voltage in 2 ½ percent steps with 2 steps above and 2 steps below rated high voltage.
DETC shall have an external operating mechanism with provisions for pad-locking in each position. The mechanism shall be easily accessible to personnel standing on the transformer foundation.
The tap position indicator shall use the letters A, B, C, D, and E, where “A” is the setting with the highest voltage magnitude, “C” is the center tap, and “E” is the setting with the lowest voltage magnitude.

2.9 Energized Tap Changer (OLTC)

When specified by the transformer supply agreement or by data sheet, a load tap changer shall be provided per the requirements of this section.

1. Design in accordance with ANSI C57.12.10 and project-specific transformer data sheets.
2. Load tap changing equipment shall be housed in a separate compartment mounted on the main transformer tank designed to prevent any interchange of oil between the compartment and the tank.
3. Equipment for the manual control of the tap changing equipment shall be furnished in a weatherproof compartment mounted adjacent to the tap changing equipment compartment in a location to allow access and operation from the ground.
4. The tap changer shall have full rated kVA on taps up to 110% of the rated voltage and a current rating corresponding to the full load current at rated voltage on taps below rated voltage.
5. When specified to be designed for parallel operation, all equipment required for control of the load tap changer using the circulating current method of control shall be provided. This equipment shall include a selector switch for selecting parallel or individual operation, all required paralleling reactors and current transformers, and an overcurrent relay with two circuit closing contacts for remote alarms.
6. The OLTC shall be designed for 500,000 electrical and mechanical operations before vacuum bottle or contact replacement is necessary to maintain normal operation.

7. The tap changer shall be completely wired and shall include the following features:
    a. Voltage testing terminals
    b. All required current transformers.
    c. "Remote-Local" control switch.
    d. "Raise-Lower" control switch for local control.
    e. Provisions to operate tap changer by hand. Interlock shall be provided to prevent operation by electrical controls when hand operation is being performed
    f. Limit switches and stops for full raise and full lower positions and for preventing over travel.
    g. Adjustable time delay to provide sufficient delay in the first step of a raise or lower tap change.
    h. Operations counter.
    i. Space heater, lamp, and GFI-protected convenience receptacle in control cabinet.
    j. Tap position indicator mounted on the tap changer compartment.
    k. Tap position transducer with 4-20 mA output proportional to tap position.
    l. Tap position transmitter shall be compatible with remote tap position indicator provided by transformer vendor.
    m. Any additional equipment required for manual operation from either the transformer or a remote location.

2.10 Auxiliary Power Source

Contractor will provide the following power sources:

1. Two (2) 480 volt AC, three phase, 60 hertz, three-wire grounded sources
2. 125 volt DC, ungrounded two-wire source.
3. The manufacturer shall provide main Multi breaker disconnecting devices for the power sources described above.

Manufacturer shall supply automatic transfer equipment to transfer to an alternate source upon loss of the normal source. An alarm contact shall be provided to indicate a transfer to the alternate source.

2.11 Oil and Oil Preservation System

The transformer oil shall be provided by the transformer manufacturer.

If the transformer is to be supplied with oil, the oil shall be new Type II inhibited transformer mineral oil that meets ASTM D3487.

Oil used in testing or supplied with transformer or furnished in components, such as bushings, shall contain less than 1-ppm of PCB.

All oil used or furnished with the transformer and used during factory acceptance testing shall meet ASTM Standard D1275 Modified (b), Standard Test Method for Corrosive Sulfur in Electrical Insulating Oils.

A conservator tank oil preservation system shall be used. The transformer shall include the following:

1. Oil expansion tank (OET) of the conservator system shall be capable of withstanding full vacuum.
2. There shall be no air contact with oil in the OET. This shall be accomplished by a nitrile air cell (diaphragm not allowed) vented to the outside air through a dehydrating breather. The breather shall be installed at eye level to allow for access without a ladder. Acceptable dehydrating breather manufacturers shall be Messko MTraB. The use of other manufacturers is subject to Owner approval.
3. Air cell shall be designed for flange installation; clamps not allowed.
4. A sealed entry into the air cell shall be provided to permit calibration of the oil level gauge.
5. Each end of the OET shall have sealed entry ports to adjust the bladder.
6. OET shall be of sufficient volume to operate through an ambient temperature range of minus 29°C to plus 43°C without causing a low-oil-level alarm or exceeding recommended full-oil level upper limit.
7. Two SHUT-OFF VALVES shall be provided in the oil line between OET and main tank. One at the entry point to the OET capable of holding full head of oil in OET, one at entry to main tank that will hold under full vacuum on the main tank.
8. Piping shall be provided between the oil and air space of the OET to equalize the pressure on both sides of the air cell during vacuum oil filling. A vacuum-proof valve shall be installed at the highest practical point on the oil expansion tank (OET) to isolate the two areas after the operation is completed.

2.12 Gasketed Joints

Nitrile (BUNA-N) elastomer gaskets shall be used to make pressure tight joints on the oil filled transformer. Gaskets made of cork-only or neoprene-only are not acceptable.

Gaskets that are not continuous shall be “vulcanized joint nitrile gaskets” and not have a butt or scarf joint.

O-ring gaskets are preferred for bushing flanges and manhole covers.

Flanges shall be provided with mechanical stops or grooves to prevent over compression of gasket when tightened.

Joints shall be designed so that gasket material will not be exposed to the weather.

2.13 Tank

The manufacturer shall provide the following on the transformer tank:

1. The transformer shall be single-tank.
2. At least two manhole covers for transformer inspection; they shall be 24 inches or larger in diameter and shall be bolted. Additional access manholes may be requested for larger transformers.
3. Radiator valves at inlets and outlets of tank to permit removal of radiators without draining oil from tank.
    a. Radiators shall have at least one lifting eye, a vent plug in the top header, and a drain plug in the bottom header.
    b. No gasketed joints are allowed between the valves and the tank.
    c. Valves shall provide minimum restriction of oil flow.
    d. Valves shall be lockable butterfly type valves. Flapper type valves are not allowed.
    e. Paint shall not interfere with the operation of valves.
4. Two-inch lower oil-drain globe-type valve with oil sampling device provided on discharge side of valve. Valve shall allow essentially full drainage.
5. Two-inch upper oil-fill globe-type valve connection.
6. An external 1-in, pipe shall be provided between the tap changer compartment and the main tank located not more than 3 in. below the top of each compartment. A 1-in, ball valve shall be installed for manifolding between the two tanks.
7. Core ground leads shall be brought out of the main transformer tank wall through an insulated, porcelain bushing, and connected to a separate grounding pad at an external location.

a. Grounding pad shall be identified and located within 6 feet of the transformer base.

b. A protective cover shall be provided for the core ground bushing.

8. Five grounding pads with tapped holes (NEMA 2-hole Standard); one on each corner of the transformer base, and one for the core-ground leads detachable connector.

9. If tank ribs are used for expansion space, permanent labels, noted in 3.3 (B.3) shall be attached to each rib that it is pressurized. Tank weld seams inside pressurized ribs shall be avoided. Drain plugs shall be provided for pressurized ribs.

10. Tank weld seams that are behind tank ribs shall have an inspection plug installed to verify weld integrity.

11. The entire interior of the transformer tank shall be primed white with a primer that will not affect the electrical characteristics of the oil.

12. Provide one-inch valve approximately one foot above oil drain valve for connection of an air supplier during maintenance. Valve shall be plugged with a removable plug.

13. Gas sampling valve to vent gasses from transformer tank or gas accumulation relay.

14. Seven dry thermometer wells shall be installed in the main tank for specified or future thermal devices, to be used as follows:

a. Dial-type Top Oil Thermometer.

b. Top Oil Temperature (for transformer monitor)

c. Top Oil Spare.

d. Top Oil by Radiator Header Pipe (spare)

e. Bottom Oil by Radiator Header Pipe (for transformer monitor).

f. Dial-type Winding Temperature Thermometer

15. Spare thermometer wells shall contain a removable metal plug incapable of corrosion (brass, stainless steel, etc.).

16. The high voltage bushing H2 shall be on the same centerline as the low voltage bushing X2 (not necessarily on the tank centerline).

17. Low voltage and tertiary bushings that are external to the tank shall be spaced no less than 30 inches center-to-center.

2.14 Cooling Equipment

2.14.1 Fan Motors

1. A list of approved fan manufacturers is provided in the Wind Spec, the Solar Spec, and the BESS Spec, as applicable.
2. Cooling fans shall be rated 60 Hz and 115/230Vac (for single-phase) or 208-230/460Vac (for three-phase).
3. Motors shall be suitable for operation in wind-driven rain. Motor bearings shall be ball-bearing, self-lubricating, sealed-type, designed for continuous as well as intermittent duty.
4. Motors shall be fitted with flexible cable terminating on self-locking, weatherproof connectors.
5. Manufacturer shall provide disconnecting devices, control switches, control relays, starting equipment with undervoltage protection, and separate overload protection for each fan motor.
6. Manufacturer shall provide Elapsed Time Meters capable of counting 99,999 hours, non-reset, to record each fan group's running time to the nearest hour.

2.14.2 Radiators

1. Heat exchangers are not to be substituted for radiators, unless otherwise specified.
2. Radiator materials shall have melting points in excess of 1000°C. Materials used for welding or brazing the radiators shall also have melting points in excess of 1000°C.

2.14.3 Fan Blades

1. Fan blades shall be made of corrosion-resistant metal.
2. Fans shall have OSHA-approved safety guards.

2.14.4 Cooling Equipment Control

1. The temperature monitoring equipment described in 2.15 (D) shall be utilized to control cooling.
2. A three-position "ON-OFF-AUTO" SWITCH shall be provided for automatic and manual control of cooling equipment.
3. A toggle switch shall be provided in the control cabinet to provide manual switching between Stage 1 and Stage 2, regardless of APT programming.

2.15 Accessories

Accessory devices are to be insulated from ground for use with 125 DC source. Exception: Online dissolved gas & moisture monitor shall be powered by 120 volts AC.

All devices in the control cabinet shall be provided with a stainless steel nameplate indicating their function. This nameplate shall include all impedance ratings at rated voltage, no-load and load losses, current transformer ratings and locations, maximum operating pressures, tank vacuum filling pressure, oil level as measured below the manhole flange, and current ratings at all load tap changer or de-energized tap changer taps.

Alarm and trip circuits shall operate at 125 volts DC.

2.15.1 Transformer Monitoring

A transformer monitor shall be provided. Acceptable transformer monitoring systems manufacturer is APT Eclipse Monitor.

The transformer monitor shall be mounted on the swing panel in the main control cabinet and shall be visible through a viewing window on the door.

2.16 Monitored Signals

1. Discrete Signals - Refer to the attached transformer control schematic for alarms/annunciation required.
2. Analog Signals – The following analog signals shall be wired to the monitor.
   a. LV Winding Currents (X1, X2, and X3)
   b. Cooling Motor Current (Stage 1 and Stage 2)
3. RTD Temperature Signals and Sensors – The following RTD sensors shall be wired to the monitor.
   a. Top Oil
   b. Bottom Oil by Radiator Header

2.17 Cooling Control

1. Manual Control - The monitor will have the provisions to force individual banks of cooling to turn on under manual control. The transformer monitor will continue to monitor the cooling motor current against the expected current levels.
2. Automatic Control – The monitor shall have provisions to automatically control cooling.
   a. Separate set points for all stages of cooling will be provided for calculated winding temperature and measured top oil temperature.

b. Fan stage alternating will be programmable to allow for Stages 1 and 2 to be alternated on a daily basis, equalizing fan cycling.

c. A period of daily fan cycling will be programmable to exercise fan motors during periods of inactivity.

2.18 Sensors

1. Resistive Temperature Detectors (RTD's)
   a. RTD's shall be installed in dry wells
   b. RTD's shall have insulation rated to at least 200°C.
   c. RTD's of length greater than 10cm shall be 3-4 wires compensating for lead resistance.
   d. Maximum allowed error shall be +/- 1°C.
   e. Each RTD cable shall be at least 3 feet (91.4 cm) longer than necessary. Excess cable shall be coiled and shall be located within one foot (30.5 cm) of the RTD to facilitate RTD testing.
   f. The signal cable shield shall be grounded at the transformer monitor case.

2.19 AC Current Transducers/Signal Conditioners

1. Current transducers or signal conditioners shall be non-intrusive and shall not require disconnecting sensed current signal for removal or installation.
2. The signal cable shield shall be grounded at the transformer monitor case.

2.20 Construction

1. The manufacturer shall ensure the monitor is programmed prior to and functional during factory testing.
2. The manufacturer shall program the monitor with a current PGE settings file obtained from the monitor manufacturer. Settings shall be reviewed by PGE before programming.
   a. On-line Dissolved Gas and Moisture Monitor
   b. An on-line dissolved gas & moisture monitor shall be provided. Acceptable on-line dissolved gas & moisture monitor manufacturer and model shall be Qualitrol Serveron TM8-F or Owner approved equivalent.
   c. Monitors that require oil circulation shall be plumbed to main tank valves (described below) with flexible stainless steel tubing. Installation of tubing and monitor shall be performed in field by Qualitrol Serveron.
   d. Two stainless steel ball-type valves, full-port, shall be installed for the monitor on the transformer main tank. The first shall be located near the top of the tank, 12 inches below the lowest expected oil level, in an area with oil

circulation, and shall be plumbed as the monitor's oil input from the main tank. The second shall be located at least 18 inches above the level of the drain valve and at least 48 inches away from the first valve, and it shall be plumbed as the oil return line from the monitor to the transformer. Valve size shall be 1/2" with female NPT outlet.

e. The monitor shall be provided with a dust cover over the monitor's manual oil sampling port.

f. Commissioning of monitor shall be performed in field by Qualitrol Serveron.

g. Magnetic Liquid-level Indicators

h. Acceptable liquid level gauge manufacturer shall be Messko.

3. One Main Tank Liquid-Level Indicator shall be located on the main tank wall and consist of the following:

   a. An alarm contact for low oil level.

   b. A trip contact that engages at an oil level at least 1.50 inches below the alarm level but at a level that will not cause damage to the transformer.

   c. No contacts are required for transformers with conservators. This gauge will be used for local oil level indication only.

   d. One Conservator Tank Liquid-Level Indicator shall be located on the conservator tank wall and consist of the following:

   e. An alarm contact for low oil level.

   f. A trip contact that engages at an oil level at least 1.50 inches below the alarm level but at a level that will not cause damage to the transformer.

4. The alarm and trip circuits shall include adjustable time delay relay set to delay annunciation or tripping after the contacts close.

5. Time delay relays shall be Signaline Model No. 360, 48 or 125 VAC/DC, 1-1023 seconds.

6. The trip circuit shall use a Qualitrol seal-in-relay 909-300-01 to provide a seal-in, trip and alarm for the trip circuit. For transformers with a conservator tank, the trip contacts from the main tank and conservator tank liquid level gauges shall be connected in series.

7. Alarms and/or trips shall not occur due to cold oil (minus 5°C for alarm and minus 15°C for trip). The trip shall not occur above the low-level mark on gauge.

2.20.1 Pressure Relief Devices

Acceptable pressure relief manufacturer shall be Messko. A minimum of two devices shall be located on the cover of the main tank, on opposite corners.

1. For inert gas pressure systems, a pressure relief of 8 PSI is required.
2. For conservator tank pressure systems, a pressure relief of 8 PSI is required.
3. One device shall be located on the Load-Tap-Changing compartment.
4. A pressure relief of 8 PSI is required.

2.20.2 Rate-of-Rise Fault Pressure Relay

Rate-of-Rise fault pressure relay and seal-in reset switch with alarm and tripping contacts.

2.20.3 Rapid Pressure Rise Relay

1. Qualitrol relay model 900-1, with Qualitrol seal-in-relay 909-300-01.
2. Qualitrol relay shall be installed in oil space.

2.20.4 Buchholz Relay

1. Cedaspe model EE3-ML + RG3.3, with Qualitrol seal-in-relay 909-300-01, and the following alarm and trip contacts.
   a. One Form-C trip contact for oil surge
   b. One Form-A trip contact for low oil level
   c. One Form-C alarm contact for gas accumulation

Trip and alarm contacts shall be connected to terminal blocks.

Sudden Pressure Relay shall operate on rate-of-rise pressure change to protect transformer against damage due to internal faults.

Relay shall be insensitive to pressure pulses caused by electrical disturbances such as magnetizing inrush currents, through faults, or mechanical shocks that may be caused by the normal operation of the transformer.

2.20.5 Bladder Integrity Relay

For a conservator tank system, a relay shall be installed to verify the integrity of the bladder system. Acceptable bladder integrity relay manufacturer shall be TREE Tech MBR.

2.20.6 Dial-Type Top-Oil Thermometer

Acceptable temperature gauge manufacturer shall be Messko.

Thermometer shall have three adjustable alarm contacts which close on temperature rise.

Mount remote readout less than 7 feet from transformer base.

2.20.7 Dial-Type Winding Thermometer

Dial-type winding thermometer and seal-in reset switch with alarm and tripping contacts.

Acceptable temperature gauge manufacturer shall be Messko.

For single phase, three winding transformers: Each winding shall have one thermometer.

For three phase, single tank transformers: Thermometer shall be furnished for B phase LV winding

Each thermometer shall have four adjustable contacts (alarm, trip, and two spare) which close on temperature rise.

The winding temperature indicator shall incorporate a current transformer responsive to its associated winding current, calibrating resistor, temperature detector element, and heater all mounted and connected to simulate the hot spot temperature of the winding.

The trip circuit shall use a Qualitrol seal-in-relay 909-300-01 to provide a seal-in, trip and alarm for the trip circuit.

Mount remote readout less than 7 feet from transformer base.

2.20.8 Transformer Nameplate

In addition to the requirements of IEEE C57.12.00, the transformer nameplate shall include the following:

1. Contractor transformer equipment number in upper left hand corner with extra-large lettering.
2. The current rating of the OLTC
3. The turns ratio of internal series or auto-transformers.
4. The minimum number of gallons of oil required to cover the core and coils.
5. The main tank & OLTC pressure & vacuum information (pressures shall be shown in PSI).
6. An adjacent nameplate shall show the various slings and lift positions required for proper lifting for the completely assembled transformer. It shall indicate whether the transformer may be lifted when filled with oil.
7. If tap voltages are not equally spaced, actual calculated tap voltages shall be indicated.
8. Transformer capacity ratings shall be stated in MVA, not kVA.
9. A simple plan view outline of the transformer showing bushings, control cabinet, OLTC tank and DETC handle locations.

10. Current transformers tap ratio tables.

2.20.9 Fiber Optic Connector Panel

Provide one Corning model CCH-CP12-25T fiber optic connector panel, installed in housing Corning model SPH-01P.

2.20.10 Ethernet Switch

Ethernet switch to convert Ethernet connections from transformer monitor and dissolved gas monitor to Ethernet fiber shall be provided. Acceptable manufacturer shall be Ruggedcom.

Switch shall be mounted inside control cabinet.

Minimum six RJ-45 ports shall be provided.

Minimum three ST multimode fiber connections shall be provided.

2.21 Alarms/Annunciator

All alarm/annunciation points shall be wired to the transformer monitoring device.

3 EXECUTION

3.1 Tank

3.1.1 Design

Tanks shall be of oil and gas-tight steel plate construction.

1. All seams shall be welded.
2. All butt welds shall be full penetration.
3. Weld slag and spatters shall be removed.
4. Field installation shall not require welding.
5. Corner welds on the tank are not allowed.

Tank and compartment walls shall be reinforced to permit drawing full vacuum on each compartment, with oil in adjacent tanks or compartments.

Tank and all other oil-filled compartments shall be designed to withstand, without permanent deformation, an internal pressure of 10 PSI.

Transformer designs using an oil expansion conservator tank shall be designed to channel all generated gases to a Gas Accumulation Relay. Gas-channeling piping shall not cause a tripping hazard for personnel walking on the transformer cover.

The CENTER OF GRAVITY shall be visibly and permanently marked on two adjacent sides of the tank and shall be appropriately identified as follows:

1. “CENTER OF GRAVITY - COMPLETE” for the completely assembled transformer filled with oil.
2. “CENTER OF GRAVITY - SHIP” for the transformer filled with oil, but without the radiators, bushings, and lightning arresters.

Lifting lugs shall be provided for lifting the completely assembled transformer.

Jacking bosses shall be provided at all four corners of base for jacking the completely assembled transformer with oil.

1. Boss pads shall be located a minimum of 13 inches above the transformer foundation
2. The area above the pads shall be clear of obstructions.

Transformer tank shall withstand skidding or rolling the transformer with oil, bushings, and radiators in a direction parallel to either center line of the tank.

Provision for anchors or tie downs to the foundation shall be provided.

Provide weatherproof penetration box for current transformer leads on upper tank wall.

3.1.2 Cover

Cover shall be welded to tank.

Opening(s) shall be provided to facilitate installation and removal of bushing current-transformers without removal of the tank cover.

The transformer cover shall have external lifting eyes, which shall be welded on.

All manholes, hand holes, and inspection openings shall have a gasketed, bolted cover with external lifting provisions.

All openings in the tank cover employing gaskets shall be raised above the cover surface to prevent the accumulation of water around the gasket joints.

Covers shall not trap any gas generated in transformer.

Lifting eyes shall be welded inside the tank cover at all 4 corners and approximately 1 foot from each wall to be used for emergency man lifting.

Install Pelsue FB-SW1 (same as former UNI-Hoist NUH-4000-2) weld on adapter plates for confined space entry/retrieval system.

1. One retrieval system adapter plate shall be located near each man-hole.
2. One retrieval system adapter plate shall be located on the edge of the transformer, near the clean side of the transformer as recommended by retrieval system manufacturer.
3. Quantity and spacing between plates to be determined based on transformer capacity and manufacturer requirements.

Manufacturer shall apply non-skid paint on the entire transformer tank cover.

3.2 Sound

The transformer shall be designed to comply with a decibel rating of -10 dB relative to NEMA TR1

3.3 Safety Features

3.3.1 Clearance

There shall be sufficient clearance from ground to live parts, in accordance with the NESC, to permit access to parts, which require adjustments or examination by operators while the transformer is energized.

3.3.2 Caution Labels

For nitrogen gas pressure systems a caution label shall be provided on the top of each manhole cover. The nameplate shall read as follows:

“DANGER, Pressurized with Nitrogen Gas –

1. Reduce gas pressure to zero before opening.
2. Ventilate with dry air and follow confined entry procedure to enter the transformer.”

For conservator-type transformers a caution label shall be provided on the top of each manhole cover. The nameplate shall read as follows:

“WARNING, Oil must be removed from the conservator tank before opening.”

For tank ribs that are pressurized a caution label shall be provided on each pressurized rib. The label shall read as follows

“DANGER, Rib is pressurized, do not drill, puncture or weld.”

For manholes mounted on the tank wall a caution label shall be provided on each manhole cover. The label shall read as follows

“WARNING, Oil must be removed from the main tank before opening.”

For transformers with a de-energized tap changer a caution label shall be provided next to the de-energized tap changer handle. The label shall read as follows:

“DANGER: Do not operate the de-energized tap changer with the transformer energized.”

3.4 Seismic

The transformer and all of its components shall be qualified in accordance with IEEE Standard 693 and IBC code. Transformer shall meet the requirements of the High Seismic Qualification Level.

At a minimum the follow upgrades shall be included to ensure qualification:

1. Additional radiator supports
2. Additional conservator supports
3. Additional control cabinet supports
4. Increased bracing of the active part

A note shall be added to the nameplate that indicates that the transformer was designed to meet the IEEE 693 High Seismic Qualification Level.

A finite element analysis shall be done and report, verified by a registered professional engineer, shall be submitted to verify the High Seismic Qualification Level.

4 Factory Tests

4.1 General

The manufacturer shall notify Contractor at least 30 days prior to commencement of testing so that a Contractor/Owner representative may witness the tests. The manufacturer shall notify Contractor immediately of any delays.

The tests specified in IEEE Standard C57.12.00 and manufacturer's quality control tests, shall be performed, except as stated in this specification.

Tests, which have been run on other transformers of essentially duplicate designs, are not acceptable in lieu of the tests specified, except as stated in this specification.

All tests shall be performed in accordance with IEEE Standard C57.12.90, unless otherwise specified by the Contractor/Owner. The manufacturer shall notify Contractor immediately of any test results not in compliance prior to any modifications and retesting.

Contractor/Owner will accept the transformer only if it has passed all tests to Contractor/Owner's satisfaction.

All dielectric tests shall be performed after the heat run.

All tests shall be performed on all units (including duplicates).

4.2 Specific Tests

4.2.1 Bushing Tests

Immediately after receiving the bushings into the factory, the bushings shall be thoroughly inspected, cleaned, and shall receive power factor and capacitance tests.

4.2.2 Winding Resistance Tests

Resistance measurements and impedance voltage tests of all windings on rated voltage connection and at tap extremes.

1. The same method shall be used to determine both cold-resistance and hot-resistance values (same winding resistance meter, same test leads, same connections, same current, etc.).
2. The same method shall be used to determine both the temperature associated with the cold-resistance test and the temperature associated with the hot thermal tests (same measuring device, same RTDs/probes, same calculation to determine mean oil temperature, etc.).
3. Cold resistance measurements shall be made in the following tap positions:
4. Windings with a DETC: neutral and extreme tap positions
5. Resistances for windings in a delta configuration shall be measured phase-to-phase.
6. Resistances for windings in a wye configuration shall be measured phase-to-neutral.

4.2.3 Ratio Tests

Ratio tests on rated voltage connection and on all tap connections.

4.2.4 Polarity Tests

Polarity and phase-relation tests on rated voltage connection.

4.2.5 No-Load Losses

The no-load losses test shall be repeated after dielectric tests (repeated with 100% voltage, with tap changers in the nominal positions). The test shall be sustained for at least 10 minutes to help ensure the core is well demagnetized for subsequent tests.

Values from the repeat test shall be used to evaluate actual losses compared to the guarantee losses stated in the Proposal.

No-load losses and excitation current shall be reported at 60 Hz, and 90%, 100%, 105%, 110% rated voltages (before and after dielectric tests).

4.2.6 Excitation Tests

Excitation current test at 100 percent, 105 percent, and 110 percent of rated voltage on the rated voltage tap.

1. Excitation tests shall be performed before the impulse tests.
2. The 100 percent test shall be repeated after the impulse test.

4.2.7 Load Loss and Impedance Tests

Impedance and load loss at rated current and rated frequency on the rated self-cooled ONAN connection and on the tap extremes.

4.2.8 Zero Sequence Test

Measured zero sequence impedances (primary-to-secondary, secondary-to-tertiary, and primary-to-tertiary as applicable) shall be reported in the certified test report, at the ONAN rating and the following voltage taps:

1. Units with only a DETC: neutral and extreme tap positions
2. Units with only a load tap changer: neutral and extreme tap positions

4.2.9 Temperature Rise Tests

Temperature rise tests shall be per IEEE Standard C57.12.90.

1. ONAN temperature rise test.
    a. Winding resistance measurement taken on one phase.
2. ONAF temperature rise test.
    a. Winding resistance measurements taken on all three phases.
    b. The tank wall surfaces shall be checked for hot spots with thermal imaging camera when the top oil temperature has stabilized.
    c. Thermal images shall be provided to Contractor/Owner electronically with the test report.
    d. Overload Test shall immediately follow the ONAF temperature rise test.
    e. With all cooling equipment in operation, and after the top oil rise is re-established and with the total losses of the ONAF rating being applied, the loading shall be increased to 125% of maximum ONAF rating and held until stabilized.
    f. Winding resistance measurement shall be taken on the hottest phase recorded from the ONAF temperature rise test.
    g. The top oil rise shall be limited to 60°C rise over 50°C ambient (110°C absolute).
    h. The hot spot rise shall be limited to 80°C rise over 50°C ambient (130°C absolute).
3. Any test shall be terminated if the winding, lead, bushing, and metal hot-spot temperature exceeds 80°C rise over 50°C ambient.
4. Top & bottom oil temperature, simulated hottest-spot winding temperature, and fiber optic temperatures shall be operational and recorded at intervals of

30 minutes or less. Any test shall be terminated if any fiber optic hot spot winding temperature exceeds 140°C.

5. Transformer monitor and fiber monitor (defined in Section 2.15.1) shall be configured to record all temperatures from RTD and fiber optic temperature probes at 1 minute intervals prior to heat run tests. Transformer monitors shall be energized and shall log all temperature inputs for the duration of all heat run tests.
6. The online DGA monitor specified in 2.15 (E) shall be fully plumbed, commissioned, and operating during the heat run tests.

4.2.10 Dissolved Gas Analysis (DGA)

DGA samples shall be taken from the main tank as follows and shall be analyzed using test method ASTM D3612:

1. Prior to any testing.
2. After ONAN temperature rise test.
3. After ONAF temperature rise test shutdowns.
4. After overload test or before dielectric tests if not performed on the same day.
5. After dielectric tests.
6. Prior to shipping if the transformer is being shipped filled with oil.

Cumulative dissolved gases in oil resulting from any test shall not exceed:

Gas	After ONAN or ONAF Test	After Dielectric Tests
Acetylene	0 ppm	0 ppm
Hydrogen	10 ppm	15 ppm
Carbon Monoxide	20 ppm	40 ppm
Carbon Dioxide	200 ppm	200 ppm
Methane	2 ppm	4 ppm
Ethylene	1 ppm	2 ppm
Ethane	2 ppm	4 ppm

4.2.11 Impulse Test

Switching and lightning impulse tests shall be performed in accordance with the requirements of IEEE C57.12.90 and IEEE C57.12.00. Measurement of test voltages shall be performed based on IEEE Std. 4.

The dielectrics tests shall be performed in the following sequence:

1. Lightning impulse tests (on all terminals)

2. Switching impulse tests
3. Applied potential test
4. Induced potential test

4.2.12 Applied Potential Test

Applied potential tests shall be performed in accordance with the requirements of IEEE C57.12.90 and IEEE C57.12.00 at low frequency (below 500 Hz) and duration of 1 minute. Measurement of test voltages shall be performed based on IEEE Std. 4.

4.2.13 Induced Potential Test

RIV measurements (in microvolts) and partial discharge measurements (in picocoulombs) shall be performed at the end of all dielectric tests Values shall be recorded for each phase in both microvolts and picocoulombs.

1. The test shall be recorded on at least 6 channels (3 RIV and 3 PD).
2. Limiting criteria for the test is as follows:
    a. Maximum RIV < 100 microvolts
    b. Maximum PD < 300 picocoulombs
    c. Increase of RIV during 60 minutes does not exceed 30 microvolts
    d. Increase of PD during 60 minutes does not exceed 50 picocoulombs
    e. No steadily rising trend in RIV or PD during the last 20 minutes
    f. The RIV and PD of any one phase shall not be higher than 200% of another phase (desire somewhat symmetrical values across phases)
3. If the limiting criteria is near the failure limit and/or is steadily increasing near the conclusion of the test, the test length shall be extended indefinitely until a confident judgment can be made as to whether the transformer has passed or failed.

4.2.14 Audible Sound Level Tests

Sound level tests shall be performed per IEEE C57.12.00 and IEEE C57.12.90.

1. Performed at the tap position that produces the highest audible sound level.
2. The test shall be performed a second time with both the first and second stages of auxiliary cooling energized.
3. The test report shall include all test data taken with corresponding locations of microphones at all tap settings in accordance with the referenced standards.

4.2.15 Insulation Power Factor and Excitation Tests

Power factor and excitation tests of the transformer, with bushings and oil installed, shall be performed at 10 KV before and after dielectric and load tests are complete.

1. The individual tested power factors of the winding-to ground insulation and of the inter-winding insulation (CH, CL, and CHL by Doble Method II) shall not exceed 0.50 percent at 20°C top oil temperature.
2. Power factors for bushings C1 and C2 shall be tested.

4.2.16 Current Transformer Tests

The insulation resistance and polarity of all current transformers shall be tested.

4.2.17 Sweep Frequency Response Analysis (SFRA)

Provide Sweep Frequency Response Analysis test (at nominal test positions) on all windings using Doble SFRA test equipment. To ensure the core is free of any residual magnetization due to impulse tests, the SFRA test shall follow the repeated no-load test (after impulse test). The test shall be performed with the DETC in the maximum voltage position (all winding in the circuit).

4.2.18 Furanic Compound Analysis

Analysis shall be performed after all tests, prior to removing test oil from transformer, on the main tank, DGA-syringe sample using test method ASTM D5837.

4.2.19 Oil Quality Tests

If the transformer is to be shipped with oil, oil quality tests shall be performed on the oil shipped in the transformer prior to shipping. The sample for the oil quality tests shall be taken from the main tank. The oil quality tests shall include the following:

1. Interfacial Tension @ 25°C, min, dynes/cm – ASTM D971
2. Dielectric Breakdown, min, KV – ASTM D1816
3. Power factor, max 25°C, % – ASTM D924
4. Power factor, max 100°C % – ASTM D924
5. Water, max, ppm – ASTM D1533
6. PCB content, ppm – EPA 8082
7. Acid Number, mg KOH/g – ASTM D974
8. Any oil that will be provided with the transformer shall be tested for corrosive sulfur in accordance with ASTM D1275 Modified (b) and shall be classified as

non-corrosive. A copy of this report shall be provided upon delivery of the transformer.

9. Oxidation Inhibitor content, % by weight – ASTM D2668
10. Relative density – ASTM D1298

4.3 Test Report

All test data shall be recorded in the Test Report. The Test Report shall be accompanied by copies of the raw hand-written data sheets used to record test results, including, but not limited to:

1. Tests completed for setup and calibration.
2. Tests repeated due to incomplete test records.
3. Test failures.
4. Test records incorporated into the final report.

The manufacturer shall e-mail a copy of the certified test report to Contractor/Owner for approval prior to shipment. Final copies of the test report shall be included in each instruction book and provided in electric form to Contractor/Owner. The report shall include a short summary noting any abnormal results and stating if the unit has passed or failed. The following test data shall be provided for review.

1. Winding Resistance (All tests)
2. No-load losses, Load losses & Impedance tests (All tests)
3. Excitation Current (All tests, 100%, 105%, 110% and 100% after dielectric tests)
4. TTR Results (All taps with deviation from equally spaced taps)
5. Impulse tests (including waveform comparisons, i.e. reduced wave vs. full wave, chopped wave 1 vs. chopped wave 2, etc.)
6. Induced voltage test results (all micro-volt and pico-coulomb readings)
7. Sound Level (All data points)
8. 10kV Power Factor and Excitation data (in test report and separately in Doble .XML file)
9. Doble SFRA test results (in test report and separately in Doble .SFRA files)
10. Oil sample results (All tests, including DGA, oil quality, furanic compounds, and corrosive sulfur)
11. Bushing Power Factor and Capacitance Tests (in test report and to be included in Doble .XML file specified in item 8 above)

12. Provide continuous log, in the test report and EXCEL file, of all temperatures (fiber, bottom and top oil, top and bottom header, ambient, and customer temperature gauges) and transformer loading, with date and time stamps for the temperature rise and overload tests. Provide shutdown plots of resistance.

The Test Report shall show the stray loss ratio, i.e.:

1. SFL = Stray losses / Full Load Losses
2. Full Load Losses = Total load losses - I^2R Losses X 100 % / Total load losses The Test Report shall show no-load losses at 90 percent, 100 percent, 105 percent, and 110 percent of rated voltage.

The Test Report shall show the manufacturer's quality control sound level test, including noise data by location.

The Test Report shall include ratio test results with deviation from equally spaced taps.

The Test Report shall show induced voltage test results in time vs. measurement table format. (Both RIV and picoCoulombs.)

The Test Report shall indicate PCB level of oil used for tests.

The Test Report shall include winding temperature indicator calibration value and the winding hot spot temperature rise above top oil for every heat run test shutdown.

Test Report shall include all oil test reports, including the manufacturer's ASTM D3487. The D3487 test should be from one of the tankers that deliver oil to the transformer manufacturer during the time our transformer is being filled or tested.

4.4 Short Circuit Requirements

The manufacturer shall furnish information and type test data to document that a transformer of similar design that is being furnished is capable of withstanding, without damage, the mechanical stresses caused by short circuits imposed at the bushing terminals of the secondary windings under the conditions specified in the American National Standard for Distribution and Power Transformer Short-Circuit Test Code (C57.12.90, Part II).

The transformer shall be capable of withstanding maximum expected short circuit currents which flow to any winding due to a fault at any terminal at 1.05 per-unit voltage for the maximum duration as defined by the interconnection agreement or PGE specifications, whichever is longer.

5 Assembly and Oil Filling:

The Contractor shall furnish all labor, supervision, material, and equipment required to attach all auxiliary equipment that is shipped separate from the transformer tank(s) and completely fill the transformer(s) with oil.

Prior to oil filling, the following tests shall be performed on the oil:

1. Moisture content
2. Dielectric strength
3. Power factor
4. Interfacial tension
5. Neutralization number
6. After filling with oil, check transformer(s) for oil and pressure leaks.

Facilities for lifting the coil and core assembly shall be provided by the manufacturer and shall comply with ANSI C57.12.10.

6 Field Inspections and Tests

The transformer supplier shall perform and record the following field inspections and tests upon delivery of the transformer(s) to the site:

1. Check impact recorder
2. Check blocking
3. Check transformer tank and fittings for the following:
    a. External damage
    b. Paint finish
    c. Attached fittings
    d. Oil leakage, if shipped oil-filled
    e. Positive pressure or vacuum in tank
4. Inspect bushings
5. Perform the following internal inspections:
    a. Check for moisture
    b. Check coil supports
    c. Disconnect core ground and measure insulation to ground to verify no unintentional grounds
    d. Check for any visible insulation damage
    e. Check for any loose parts
6. Check that all parts have been delivered and report and expedite shipment of any missing or damaged parts
7. Provide and record the following field tests:

a. Insulation resistance
b. Each winding-to-ground and to other windings
c. Core-to-ground
d. Winding ratio tests on all tap positions
e. CT ratio and polarity tests
f. Dissolved gas analysis sampled at least one day after energized

8. Compare results with factory test report and inform Contractor/Owner of any discrepancies.
9. Check and report on all accessories for proper operation, including the following:
    a. Cooling fans
    b. Oil pumps, if applicable
    c. Cooling controls
    d. Pressure relief device
    e. Sudden pressure relay
    f. Magnetic liquid level indicator
    g. Winding temperature indicators
    h. Liquid temperature indicator
    i. Pressure-vacuum indicator
    j. Tap changer
    k. Winding temperature detectors
10. Provide all additional field inspections, adjustments, and tests recommended by the transformer manufacturer.

Appendix M1

Attachment 05

Exhibit 04

Communication, SCADA, and Metering Facilities

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

2023

REQUEST FOR PROPOSAL

NO.	DATE	REVISION	BY	CHK'D	APPROVALS	
0	26Oct21	Issued for Implementation	1898 & Co.		JAL	Jared Lathrop
1	14Apr23	Update from 2021 Version	1898 & Co.	PGE	CPA	Craig Armstrong
2	25Aug23	Rev 2, see redline changes throughout	Jeremy Morris	Craig Armstrong	CPA	Craig Armstrong

Table of Contents

1 M1-05-04-Communication, SCADA, and Metering Facilities

1.1 Communication Facilities

1.1.1 GENERAL

1.1.2 SUMMARY

A. This Section summarizes the communications systems the Contractor shall provide as part of their proposal. The following specifications include detailed SCADA specification sections:

1. M2-01-01 (Wind Plant Specifications)
2. M3-01-01 (Solar Photovoltaic Plant Specifications)
3. M4-01-01 (Energy Storage Technical Documents)

B. The SCADA section in those specifications includes the following:

1. General
2. Main SCADA Components
3. SCADA Device Requirements
4. Interfaces
5. Fiber Optic Network Design
6. Fiber Optic Installation
7. Fiber Terminations and Testing
8. Availability and Reliability
9. Cyber Security
10. Viewing and Display
11. Reporting
12. Support for Warranty Calculations
13. Remote Alerts
14. Time Base and Date Formats

C. This Section summarizes the communications systems not covered within those specifications.

D. The proposal shall address four aspects of the telecommunications design.

1. Intra-site Communications - the Network shall primarily be an Ethernet Fiber network to support intra-site data and voice communications needs.
2. Substation Interconnect - Contractor shall incorporate plans for the communications needs required to interconnect the facility to the bulk electric power system. This may include transfer trip and any of special or remedial protection schemes needed for the interconnection of the facility to the bulk electric power system. This design shall meet any requirements from the interconnecting utility, the Public Utility Commission, and/or the Independent System Operator for SCADA or Metering.
3. PGE Connectivity - to support remote monitoring and operation of the facility. This will include one or more data links back to PGE operations center. This shall include connectivity for both the Primary SCADA link as well as the plant operational data link serving plant operations such as sending operational and maintenance data to a historian, allowing remote access and control, and voice communications to the facility.
4. PGE Local Data Collection – a data collection system will be installed to interface directly with the local plant control system (OEM SCADA) for the purposes of data collection, aggregation, and reporting.

1.1.3 TELECOMMUNICATIONS APPROACH

A. The Contractor shall provide a bid that both meets these specifications and allocates a budget for the design, procurement, and construction of these telecommunications facilities. The site network and the interconnection requirements should be known and the design and costs of these facilities should be accounted for and well understood. The communications link to PGE will depend greatly on the location, size, and type of facility proposed, and therefore the Contractor shall propose a solution that meets these functional specifications. Contractor shall coordinate the communications systems for Substation and O&M Building to ensure compatibility and cost effectiveness and obtain owner's approval. During negotiations, this aspect of the design may be revised based on site specific conditions. An allowance for each of these four sections (Intra-site Communications, Substation Interconnect, PGE Connectivity, and Local Data Collection) shall be provided. The proposal price will not be revised if the ultimate solutions remains within these allowances.

1.1.4 TELECOMUNCATIONS FACILITES

A. The facilities shall consist of the following:

1. Communications during construction: The Contractor shall provide a communications network to be used during construction, and specifically communications services to the on-site trailers used during construction. A minimum of 5 Mbps Ethernet link shall be provided to each PGE trailer, along with (2) phone lines per trailer, which may be either VOIP or POTS. The Ethernet link shall only be dedicated to PGE and no other users.
2. Intra-Site Network: The Contractor shall provide a data network that extends from a central substation or O&M building to all equipment enclosures throughout the facility that house microcontroller equipment.
    a. This network shall be constructed such that it supports the following applications:
        i. Shall support the Real-time control for the operation of the plant.
        ii. Shall support remote monitoring for the Owner to gather operational data from microprocessor-controlled equipment.
        iii. Shall support monitoring of weather information.
        iv. Shall allow the Owner to remotely access remotely configurable equipment to make settings changes and firmware upgrades.
        v. Shall support the use of Voice at each enclosure, desk, conference room, or security control point.
        vi. Shall support the use of Video where required for security and operations of the plant.
        vii. Shall include Wireless Access Points in Office locations.
        viii. Offices and conference room areas will have multiple data/analog wall jack locations. Each location will have two CAT6 station cables home run back to the Communications room where it will

terminate in the main distribution field (MDF) enclosure on a specified 110 patch panel.

b. The network shall be capable of meeting the following specifications:

i. Use IP/Ethernet communications over a fiber and copper network.

ii. At least 60 Strands of single mode (SM) fiber shall be installed between all buildings as part of the project. Fiber shall be configured in a logical ring and where possible into a diverse optical ring.

iii. Category 6 copper shall be used for all connections between switches and equipment within a building.

iv. Use gigabit Ethernet connections

v. Use VLANS for segmentation of traffic

vi. Use Quality of Service to Prioritize traffic flows

vii. Use Rapid Spanning Tree or other advanced ring convergence protocols.

viii. Support POE where phones or wireless access points are installed.

ix. Use managed equipment that support the following:

x. Centralized authentication via RADIUS or TACACS

xi. Centralized logging via Syslog

xii. Use hardened network equipment rated for the environment in which it will be installed.

3. Interconnection to Bulk Electric Power System:

a. Determine specific equipment required by the Utility/Transmission Owner and the System Operator, specifically relating to SCADA, metering, and telemetering due to the interconnection agreement as well as equipment required to complete the indicated control and protection requirements.

b. Build any fiber, microwave, or leased facilities needed in order to tie facility into bulk electric power system.

c. Follow Western Electricity Coordinating Council (WECC) teleprotection standards.

4. PGE Communications Circuits:

a. Contractor shall provide the following communication circuits, each with the respective parameters given. These communications circuits can be delivered over the one or more aggregate leased circuits if possible. These circuits may make use of a private data network or a leased facility from a common carrier. The Contractor's proposal shall include the capital cost for construction, as well as the estimated monthly recurring cost if applicable. The Contractor shall make use of the PGE equipment listed below where such equipment is required:

Circuit Name	LOC A	LOC Z	Type	Capacity	Latency	Avail.	Circuit Description
O&M CORPORATE NETWORK	O&M	PGE WHQ	ETH	25 Mbps	100 msec	99.00%	CORPORATE NETWORK SERVICE
INTRA-SITE NETWORKING	SUBSTATION	O&M	ETH	1 Gbps	0.05 msec	99.00%	CORP NETWORK & SECURITY LAN
SUB REMOTE ACCESS LAN	SUBSTATION	PGE WHQ	ETH	1.5 Mbps	0.5 sec	99.00%	REMOTE ACCESS LAN FOR PROTECTION & AUTOMATION GROUP
SUB COMM TECH LAN	SUBSTATION	PGE WHQ	ETH	1.5 Mbps	0.5 sec	99.00%	REMOTE ACCESS LAN FOR COMM TECHS
PRIMARY AGC+SCADA	SUBSTATION	PGE WHQ	ETH	64 kbps	0.5 sec	99.95%	SERIAL DNP 3.0 AUTOMATIC GENERATION CONTROL AND SCADA
SECONDARY AGC+SCADA	SUBSTATION	PGE WHQ	ETH	64 kbps	0.5 sec	99.95%	SERIAL DNP 3.0 AUTOMATIC GENERATION CONTROL AND SCADA
METERING	SUBSTATION	PGE WHQ	ETH	64 kbps	0.5 sec	99.90%	METERING DATA

1.1.5 OTHER COMMUNICATIONS CIRCUITS/SERVICE

PGE will not be responsible for any Vendor's long-term ISP or phone system at the site.

1.1.6 TELECOMMUNICATIONS EQUIPMENT

A. In each major facility provide space for (4) adjacent Communications racks. For the Plant and Switchyard/Substation facilities, locate the Communications racks in the same room or adjacent to the relay equipment racks. For the O&M Building or Administration Building, in addition to the Communications racks, provide (4) racks for IT Operations and (2) racks for Corporate Security Operations. Locate the Communications racks in the same room or adjacent to racks dedicated for IT Operations and Corporate Security. Each room to include 4'x8' fire-rate plywood backboard (white). Cabinets shall be installed with 36" clearance in rear of cabinets and 42" in the front. 36" clearance must also be allocated on the sides of the cabinets unless adjacent to another cabinet or communications rack.

B. Provide a -48VDC power system capable of supplying the load with an 8-hour reserve time at each major facility.

C. Communications equipment shall be grounded per Motorola R56 standards in O&M and Administration Buildings. Grounding in the Switchyard/Substation shall follow IEEE 80 standard industry practices.

D. Provide a SATRAD-G2 satellite phone system with exterior antenna, rack mount equipment, and a dedicated desk phone.

E. Equipment specified for this project shall be of the same manufacturer and model as PGE uses in their existing communications systems:

1. Dual-post Rack – Chatsworth "Clear", 19" x 84"
2. Ethernet Switch – Cisco
3. VoIP Phone - Cisco
4. Wireless Access Point – Cisco
5. Service Aggregation Node – Nokia 7705-SAR-8 with support cards
6. Fiber Patch Panel – Clearfield FxDS, with SC/UPC Connectors
7. ADSS Fiber Cable – OFS AT-3BE17NT-060-CMEA (60-CNT)
8. OPGW Fiber Cable – AFL DNO-8234 (48-CNT)

9. Splice Cases – Tyco FOSC-450D
10. -48 VDC Fuse Panel – Telect GMT Dual Feed 20/20-position
11. -48 VDC Charger Panel – Valere; CK4D-ANL-VC shelf, min 24 hours battery recharging capability while under load
12. -48 VDC Battery (Plant or Switchyard/Substation) – C&D (flooded) or East Penn Deka Unigy II (VRLA) w/ one-piece base and interlocking cells, min 8 hours carry time
13. -48 VDC Battery (O&M or Admin Building) – C&D (flooded) or East Penn Deka Unigy II (VRLA) w/ one-piece base and interlocking cells, min 8 hours carry time

1.2 SCADA System-Local Data Collection

1.2.1 General

A. Contractor will provide suitable space, power, and environment control to house the PGE equipment necessary to facilitate the collection of plant control system data.

1. In addition to the Telecommunications, IT Operations, and Physical Security communication racks, Vendor will also provide space for Owner to install (1) 30” x 42” x 84” fully-enclosed, lockable, 4-post network cabinet with venting doors in either the O&M communication room or the Substation.
2. Cabinet shall be installed with 36” clearance in rear of cabinet and 42” in the front. 36” clearance must also be allocated on the sides of the cabinet unless adjacent to another cabinet or communications rack.
3. Vendor shall supply and install fully redundant HVAC systems and humidity control in whatever location the houses the Data Collection Cabinet, with sufficient cooling for all equipment in that location.
4. Vendor shall provide (1) 30A, 240V circuit to each cabinet.

1.2.2 SCADA Hardware and Software Requirements

A. Contractor will provide the following equipment for Owner’s data collection system. Contractor will install all equipment in the provided cabinet in coordination with Owner at least 90 days prior to Substantial Completion. Once installed, Contractor will turn over all equipment and licenses to Owner for configuration.

B. Owner will have final approval on what hardware and software is provided to ensure system operations. If the specific devices below are not available or if the OEM has announced any end of support for the hardware or software, Owner will provide equivalent models for the Contractor to procure (at Contractor's cost).

a. 1x AR3150 (APC NetShelter SX 42U Deep Rack Enclosure) with 2x AR3150 (0U PDU mounts) and 1x AR7714 (rack roof brush strip)

b. 1x 4-node Dell VxRail Custer (E660F or newer). Each server should be single-socket with an Intel Xeon 6346 or better with 256GB RAM and 4-port SFP28 network card. Storage should be all-flash with a total usable space of 20TB, with the ability to expand to at least 45TB in the future.

c. 2x Cisco C9300X-48TX (or newer) with C9300X-NM-8Y and stack cables with 5-year DNA license

d. 16x Cisco SFP-10/25G-CSR-S= Transceivers

e. 8x Dell-compatible 10BASE-T SFP+ Copper RJ45 Transceivers

f. 2x Cisco FPR-1120 (or newer), with 5-Year Malware and Threat licenses

g. 1x Eaton 9PX8KSP

h. 2x Schneider AP8870

i. 1x Black Box LES1516A

j. 1x Recessed 19" rack-mounted DIN Rail with terminal blocks and 30A 2-pole breaker

k. 1x 1U Mixed-use (copper & fiber) feed-through patch panel

l. Software and Licenses:

i. All server cluster fully licensed with vSphere Enterprise Plus and vSAN (version 8 or newer)

ii. Windows Server 2022 (or newer) Datacenter licenses for all CPU Cores

iii. 2x Microsoft SQL Server 2019 (or newer) Standard licenses

iv. Emerson Ovation Green (MiScout) data collector software, configured in High Availability mode, with sufficient licenses for provided system.

C. Contractor, in coordination with OEM SCADA Vendor, shall:

1. Make available all datapoints within the OEM SCADA System to the Owner, including individual tower/panel/battery values, directly from the OEM SCADA System to PGE's Data Collection system.

   a. If PGE is responsible for day-to-day maintenance or control of the plant, this system shall have read/write access to the OEM SCADA System and act as an overlay-SCADA from which operators can use to manage and control the facility.

   b. If PGE will not be responsible for any day-to-day maintenance, the system shall have read-only access.

2. Ensure data values are available in the native resolution in which they were collected, up to 1Hz.

3. Configure the OEM SCADA system to allow Owner data collection system to pull all live, historical, and alarm data using one or more of the following methods:

   a. OPC UA

   b. UPC DA

   c. ODBC

   d. Direct queries to tower controllers using native protocol

1.3 METERING and TELEMETRY FACILITES

1.3.1 GENERAL

A. PGE requires one owner per Point of Interconnection.

1.3.2 DIRECT TELEMETRY REQUIREMENTS

A. PGE requires two communication paths for controlling and operating generation that is settled within its Balancing Authority Area:

1. Direct, real-time telemetry (SCADA) from RTU (site) to RTU (PGE control center)

2. ICCP over WECC Operations Network (WON)

1.3.3 METERING REQUIREMENTS

A. PGE requires primary and backup metering for each metered point. Meters shall be sourced from wound-type instrument transformers for

voltages 230kV and below. Meters shall be accessible via PGE's MV90 system for accounting purposes.

1.4 PROCESS DATA FOR PATTERN RECOGNITION

As a minimum, Contractor shall install instrumentation and make the process data available to access by Owner in the Plant's Control System for following systems and equipment (as applicable):

1.4.1 Hydro Turbine

A. Turbine Guide RTD
B. Lower Guide RTD
C. Upper Guide RTD
D. Thrust Bearing RTD
E. Lube Oil Pressure
F. Lube Oil Temperature
G. Gen Turbine Local Ambient Temp
H. Turbine Guide Bearing X VIBR
I. Turbine Guide Bearing Y VIBR
J. Upper Guide Bearing X VIBR
K. Upper Guide Bearing Y VIBR
L. Lower Guide Bearing X VIBR
M. Lower Guide Bearing Y VIBR
N. Wicket Gate Position
O. Wicket Gate Pressure
P. Cooling Water Pressure
Q. Cooling Water Temperature
R. Forebay Level
S. Tailrace Level

1.4.2 Wind Turbines

A. Pitch - Blade A/B/C Pitch Motor Current
B. Pitch - Blade A/B/C Pitch Motor Voltage
C. Pitch - Blade A/B/C Pitch Position
D. Pitch - Blade A/B/C Hydraulic Oil Accumulator Pressure
E. Pitch - Pitch Pressure Output From Hydraulic Power Unit
F. Pitch - Pitch Oil Temperature - Outlet Hydraulic Power Unit
G. Pitch - Pitch Oil Accumulator Temperature
H. Pitch - Pitch Controller Panel Temperature
I. Pitch - Pitch Bearing A/B/C Vibration
J. Hub - Hub Temperature
K. Hub - Ice Detection System
L. Main Bearing(S) - Main Bearing Temperature
M. Main Bearing(S) - Main Bearing Vibration

N. Main Bearing(S) Oil Lubrication System - In Line Metal Particle Counter
O. Main Bearing(S) Oil Lubrication System - Oil Filter Differential Pressure
P. Main Bearing(S) Oil Lubrication System - Oil Pump Amps
Q. Main Bearing(S) Oil Lubrication System - Oil Temperatures - Inlet/Outlet Heat Exchanger
R. Main Shaft - Main Shaft Brake Pressure
S. Main Shaft - Main Shaft Brake Accumulator Pressure
T. Main Shaft – Shaft RPM
U. Gearbox – All Bearing Temperatures
V. Gearbox - Gearbox Lube Oil Pressure, Before Filter
W. Gearbox - Gearbox Lube Oil Pressure, After Filter
X. Gearbox - Planetary Vibration
Y. Gearbox - High Speed Shaft Vibration
Z. Gearbox - Intermediate Speed Shaft Vibration
AA. Gearbox - Oil Temperature - Gearbox Sump
BB. Gearbox Oil Lubrication System - In Line Metal Particle Counter
CC. Gearbox Oil Lubrication System - Oil Filter Differential Pressure
DD. Gearbox Oil Lubrication System - Oil Pump Amps
EE. Gearbox Oil Lubrication System - Oil Temperatures - Inlet/Outlet Heat Exchanger
FF. Generator - Winding Temperature 1/2/3
GG. Generator - Generator Drive End Bearing Temperature
HH. Generator - Generator Non-Drive End Bearing Temperature
II. Generator - Generator Drive End Bearing Vibration
JJ. Generator - Generator Non-Drive End Bearing Vibration
KK. Generator - Phase A/B/C Voltage
LL. Generator - Phase A/B/C Current
MM. Generator - Power Factor
NN. Generator - Heat Exchanger Water Inlet/Outlet Temperatures
OO. Generator – Shaft Torque
PP. Generator – Frequency (generator side)
QQ. Generator – Shaft RPM
RR. Generator – Active Power
SS. Generator – Reactive Power
TT. Yaw - Yaw Position
UU. Yaw - Yaw Brake Accumulator Pressure
VV. Yaw - Yaw Brake Pressure
WW. Yaw – Yaw Motor/Gear Temperature
XX. Tower - Wind Speed Primary
YY. Tower - Wind Speed Secondary
ZZ. Tower - Wind Direction
AAA. Tower - Nacelle Temperature
BBB. Tower - Tower Base Temperature

CCC. Tower - Control Panel(S) Temperature
DDD. Tower – Converter Inside Compartment Temperature
EEE. Tower – Converter Coolant Pressure
FFF. Tower – Converter Coolant Temperature
GGG. Tower – Frequency (grid side)
HHH. Tower – Phase A/B/C Voltage (grid side)
III. Tower – Phase A/B/C Current (grid side)
JJJ. Tower - Misc. Panel Cooling System - Inlet/Outlet Temperatures Of Cooling Media
KKK. Tower - Misc. Panel Cooling System - Inlet/Outlet Temperatures Of Panel Air At Cooler
LLL. Tower - Transformer Temperature
MMM. Tower - Ambient Temperature
NNN. Tower – Air Density
OOO. Tower - Sway
PPP. Tower – Error Code
QQQ. Tower – Operational State
RRR. Main Breaker - Status
SSS. Main Breaker - Faults
TTT. Main Breaker - Temperature
UUU. Main Breaker - Fan Ampere
VVV. Meteorological Station - Air Temperature
WWW. Meteorological Station - Cell Temperature
XXX. Meteorological Station - Relative Humidity
YYY. Meteorological Station - Wind Speeds At 10 meter, 1/2 Hub Height, and Hub Height
ZZZ. Meteorological Station - Barometric Pressure
AAAA. Meteorological Station – Air Density
BBBB. Switchgear - Breaker Phase Currents
CCCC. Switchgear - Breaker Phase Voltages
DDDD. Switchgear - Breaker Status
EEEE. Switchgear - Relay Fault Codes
FFFF. Switchgear - Bolted Bus Connections Temperatures via Fiber Optics

1.4.3 PV Field

A. Combiner Box - DC Output Voltage
B. Combiner Box - DC Output Current
C. Combiner Box - DC Current per String
D. Combiner Box - Combiner Box Interior Temperature
E. Inverter - DC Input Voltage
F. Inverter - DC Input Current
G. Inverter - AC Output Voltage
H. Inverter - AC Output Current

I. Inverter - AC Power
J. Inverter - AC Frequency
K. Inverter - AC Reactive Power
L. Inverter - Energy Totalizer
M. Inverter - Inverter Temperatures
N. Inverter - Inverter Status
O. Inverter - Faults/Alarms
P. Inverter - Ground Current
Q. Meteorological Station - Air Temperature
R. Meteorological Station - Cell Temperature
S. Meteorological Station - Relative Humidity
T. Meteorological Station - Wind Speed
U. Meteorological Station - Global Irradiance
V. Meteorological Station - Plane of Array Irradiance
W. Meteorological Station - Solar Module Back Panel Temperature(s) - 10% of Modules
X. Switchgear - Breaker Phase Currents
Y. Switchgear - Breaker Phase Voltages
Z. Switchgear - Breaker Status
AA. Switchgear - Relay Fault Codes
BB. Switchgear - Bolted Bus Connections Temperatures via Fiber Optics

1.4.4 Oil-Cooled Transformers

A. Active Power
B. Reactive Power
C. High Side Amps (by phase)
D. High Side Voltage (by phase)
E. Ground Current
F. Low Side Voltage (by phase)
G. Control Voltage
H. Control Panel Temperature
I. LTC Tap Position
J. Oil Pump Amps
K. Oil Pump Discharge Pressure
L. Fan Bank Amps
M. LTC Tank Oil Temperature
N. Main Tank Oil Temperature
O. Top Oil Temperature
P. High Voltage Winding Temperature
Q. Low Voltage Winding Temperature
R. Nitrogen Pressure
S. Local Ambient Temperature
T. Moisture Percentage

U. Gas Analyzer H2
V. Gas Analyzer O2
W. Gas Analyzer N2
X. Gas Analyzer CO
Y. Gas Analyzer CO2
Z. Gas Analyzer CH4
AA. Gas Analyzer C2H6
BB. Gas Analyzer C2H4
CC. Gas Analyzer C2H2
DD. Gas Analyzer H2O
EE. Infrared Camera Temperatures

1.4.5 Dry Transformers

A. Active Power
B. Reactive Power
C. High Side Amps (by phase)
D. High Side Voltage (by phase)
E. Ground Current
F. Low Side Voltage
G. Low Side Amps
H. Control Voltage
I. Control Panel Temperature
J. Cooling Fan Amps
K. High Voltage Winding Temperature
L. Low Voltage Winding Temperature
M. Local Ambient Temperature

1.4.6 Switchgear / Motor Control Centers

A. Control Panel

1. Control Panel Voltage
2. Control Panel Temperature

B. 4160 VAC and Higher Bus

1. Connected Joints Temperature Via Fiber Optic Infrared Measurement

C. MCC Bucket

1. Load Amps
2. Load Voltage
3. Power Factor
4. Bucket Temperature
5. Cooling Fan Amps

1.4.7 Heat Exchangers

A. Inlet/Outlet Temperatures
B. Process Flows

1.4.8 Pump / Fan Motors Greater than 100 HP

A. Motor Stator Temperature
B. Local Ambient Temperature
C. Motor Amps
D. Motor Power Factor
E. Motor Voltage