



PROJECT MANUAL FOR THE CONSTRUCTION
OF
**HAYWARD FIRE STATION #6 &
FIRE TRAINING CENTER**

PROJECT NOS. 07481 & 07482

**VOLUME 4 OF 8
PROJECT SPECIFICATIONS (PHOTOVOLTAIC)
DSA INCREMENT #2**

APRIL 2020

RossDrulisCusenbery
ARCHITECTURE

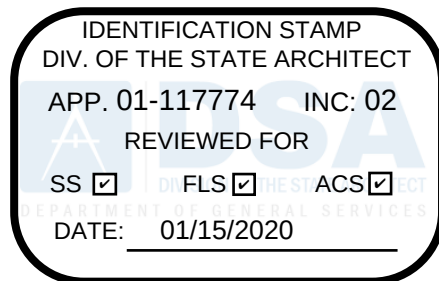


TO DOWNLOAD PLANS AND SPECIFICATIONS
AND TO CHECK BID RESULTS
Contact Engineering & Transportation at (510) 583-4730
FOR INFORMATION REGARDING THIS PROJECT
Contact Dave Hung at (510) 583-4752
FOR CONTRACT COMPLIANCE
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Hayward Fire Station #6 Fire Training Center

1401 West Winton Avenue,
Hayward, California

PROJECT MANUAL



Permit Submittal
Increment #2

July 19, 2019



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DOCUMENT 00 0109 – VOLUME DIRECTORY

VOLUME 1	PROCUREMENT, CONTRACTING AND GENERAL REQUIREMENTS (DIVISIONS 00-01)
VOLUME 2	PROJECT SPECIFICATIONS (DIVISIONS 02-21) DSA INCREMENT #1
VOLUME 3	PROJECT SPECIFICATIONS (DIVISIONS 22-48) DSA INCREMENT #1
VOLUME 4	PROJECT SPECIFICATIONS (PHOTOVOLTAIC) DSA INCREMENT #2
VOLUME 5	CONSTRUCTION DOCUMENT DRAWINGS (GENERAL, SITE AND COLLEGE- OWNED BUILDINGS) DSA INCREMENT #1
VOLUME 6	CONSTRUCTION DOCUMENT DRAWINGS (PHOTOVOTAIC) DSA INCREMENT #2
VOLUME 7	CONSTRUCTION DOCUMENT DRAWINGS (CITY-OWNED BUILDING)
VOLUME 8	CONSTRUCTION DOCUMENT DRAWINGS (SIGNAGE) DSA INCREMENT #1

END OF DOCUMENT 00 0109

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DOCUMENT 00 0110 - TABLE OF CONTENTS

VOLUME 1

**PROCUREMENT, CONTRACTING AND GENERAL REQUIREMENTS
GROUP:**

DIVISION 00 PROCUREMENT AND CONTRACTING REQUIREMENTS

INTRODUCTORY INFORMATION

00 01 09	VOLUME DIRECTORY
00 01 10	TABLE OF CONTENTS

BIDDING REQUIREMENTS

00 11 16	NOTICE TO CONTRACTORS
00 21 13	INSTRUCTIONS TO BIDDERS
00 31 00	GEOTECHNICAL DATA, EXISTING CONDITIONS AND HAZARDOUS MATERIAL SURVEYS
00 31 13	PRELIMINARY CONSTRUCTION SCHEDULE
00 31 43	PERMITS & DEFERRED SUBMITTALS
00 41 13	PROPOSAL
00 43 16	WORK TO BE PERFORMED BY BIDDER
00 43 93	BID SUBMITTAL CHECKLIST
00 45 11	BIDDER REGISTRATION AND SAFETY EXPERIENCE FORM
00 45 19	NON-COLLUSION AFFIDAVIT
00 45 30	BIDDER CERTIFICATIONS
00 49 00	EXECUTION OF CONTRACT

CONTRACTING REQUIREMENTS

00 51 00	NOTICE OF AWARD
00 52 13	CONTRACT <i>CONSTRUCTION LABOR AND MATERIAL PAYMENT BOND</i> <i>CONSTRUCTION PERFORMANCE BOND</i>
00 55 00	NOTICE TO PROCEED
00 65 19	AGREEMENT AND RELEASE OF ANY AND ALL CLAIMS
00 65 36	GUARANTY

CONDITIONS OF THE CONTRACT

00 72 13	GENERAL CONDITIONS
00 73 00	SPECIAL CONDITIONS
00 91 13	ADDENDA
EXHIBIT A	CONSTRUCTION & DEMOLITION DEBRIS RECYCLING STATEMENT
EXHIBIT B	ADMINISTRATIVE CHANGE ORDER
EXHIBIT C	STOP HUMAN TRAFFICKING POSTER
EXHIBIT D	COMMUNITY WORKFORCE AGREEMENT

GENERAL REQUIREMENTS SUBGROUP:

DIVISION 01 – GENERAL REQUIREMENTS

01 1100	SUMMARY OF WORK
01 2513	PRODUCT SUBSTITUTION PROCEDURES
01 2513A	SUBSTITUTION REQUEST FORM 13.1A
01 2600	CONTRACT MODIFICATION PROCEDURES
01 2900	PAYMENT PROCEDURES
01 3100	PROJECT MANAGEMENT AND COORDINATION
01 3119	PROJECT MEETINGS
01 3131	REQUEST FOR INFORMATION
01 3200	CONSTRUCTION PROGRESS DOCUMENTATION
01 3219	SUBMITTAL SCHEDULES, DAILY AND FIELD REPORTS
01 3233	PHOTOGRAPHIC DOCUMENTATION
01 3234	VIDEO PTZ CONSTRUCTION CAMERA
01 3300	SUBMITTAL PROCEDURES
01 3544	STORM WATER POLLUTION PREVENTION
01 4000	QUALITY REQUIREMENTS
01 4100	REGULATORY REQUIREMENTS
01 4200	REFERENCES
01 4216	DEFINITIONS
01 4339	MOCK-UPS
01 4349	DELEGATED DESIGN
01 4523	TESTING AND INSPECTING SERVICES
01 5000	TEMPORARY FACILITIES AND CONTROLS
01 5526	TRAFFIC CONTROL
01 5639	TEMPORARY TREE AND PLANT PROTECTION
01 6000	PRODUCT REQUIREMENTS
01 7123	FIELD ENGINEERING
01 7300	EXECUTION REQUIREMENTS
01 7329	CUTTING AND PATCHING
01 7419	CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL
01 7700	CLOSEOUT PROCEDURES
01 7834	WARRANTIES AND BONDS
01 7839	PROJECT RECORD DOCUMENTS
01 7843	SPARE PARTS AND MAINTENANCE MATERIALS
01 7900	DEMONSTRATION AND TRAINING
01 8113	SUSTAINABLE DESIGN REQUIREMENTS
01 8113A	RECYCLED CONTENT FORM
01 8113B	REGIONAL CONTENT FORM
01 8119	INDOOR AIR QUALITY MANAGEMENT
01 8121	ENVIRONMENTAL IMPACT OF MATERIALS
01 8419	INTERIOR FINISH PERFORMANCE REQUIREMENTS
01 9113	GENERAL COMMISSIONING REQUIREMENTS

END OF DOCUMENT 00 0110 - VOLUME 1

VOLUME 2

FACILITY CONSTRUCTION SUBGROUP:

DIVISION 2 – EXISTING CONDITIONS

02 4000	DEMOLITION
02 4200	REMOVAL AND SALVAGE OF CONSTRUCTION MATERIALS
02 4320	MEMORIAL STRUCTURE MOVING
02 4400	MANAGEMENT OF SOIL

DIVISION 3 – CONCRETE

03 1000	CONCRETE FORMING AND ACCESSORIES
03 2000	CONCRETE REINFORCING
03 3000	CAST-IN-PLACE CONCRETE
03 3500	CONCRETE FINISHING
03 3543	POLISHED CONCRETE FINISHING

DIVISION 4 – MASONRY

04 2000	CONCRETE UNIT MASONRY
04 5413	FIRE BRICK

DIVISION 5 – METALS

05 1200	STRUCTURAL STEEL FRAMING
05 1250	ARCHITECTURALLY EXPOSED STRUCTURAL STEEL
05 3000	METAL DECKING
05 4000	COLD-FORMED METAL FRAMING
05 4160	SURE-BOARD PANEL FOR SHEAR AND SHEATHING
05 5000	METAL FABRICATIONS
05 5113	METAL PAN STAIRS
05 5213	PIPE AND TUBE RAILINGS

DIVISION 6 – WOOD, PLASTICS, AND COMPOSITES

06 1053	MISCELLANEOUS ROUGH CARPENTRY
06 1500	WOOD DECKING
06 4100	ARCHITECTURAL WOODWORK
06 4216	WOOD BOARD PANELING
06 6413	FIBERGLASS-REINFORCED PLASTIC PANELS

DIVISION 7 – THERMAL AND MOISTURE PROTECTION

07 1300	BITUMINOUS SHEET WATERPROOFING
07 1329	PRE-APPLIED SHEET MEMBRANE WATERPROOFING
07 1413	HOT FLUID-APPLIED WATERPROOFING
07 1813	PEDESTRIAN TRAFFIC COATINGS
07 2100	BUILDING INSULATION
07 2129	SPRAYED INSULATION
07 2616	BELOW-GRADE VAPOR RETARDERS
07 2727	SELF-ADHERING AIR AND WATER BARRIER
07 3113	ASPHALT SHINGLES
07 3216	CONCRETE ROOF TILES

07 4113	METAL ROOF PANELS
07 4213	METAL WALL PANELS
07 4646	FIBER CEMENT SIDING
07 5200	COLD-APPLIED ASPHALT ROOFING
07 6000	FLASHING AND SHEET METAL
07 7200	ROOF ACCESSORIES
07 8116	CEMENTITIOUS FIREPROOFING
07 8400	FIRESTOPPING
07 9200	JOINT SEALANTS

DIVISION 8 – OPENINGS

08 1113	HOLLOW METAL DOORS AND FRAMES
08 1416	FLUSH WOOD DOORS
08 3113	ACCESS DOORS
08 3323	OVERHEAD COILING DOORS
08 3421	HORIZONTAL BI-FOLD DOORS
08 3613	SECTIONAL DOORS
08 4113	ALUMINUM-FRAMED ENTRANCES AND STOREFRONTS
08 4413	GLAZED ALUMINUM CURTAIN WALLS
08 5113	ALUMINUM WINDOWS
08 5123	STEEL WINDOWS
08 7100	DOOR HARDWARE – BUILDING 1
08 7100	DOOR HARDWARE – BUILDING 5
08 8100	GLASS GLAZING
08 9100	WALL LOUVERS

DIVISION 9 – FINISHES

09 2216	NON-STRUCTURAL METAL FRAMING
09 2219	CAVITY SHAFT-WALL ASSEMBLIES
09 2400	PORTLAND CEMENT PLASTERING
09 2900	GYPSUM BOARD
09 3000	TILING
09 5123	ACOUSTICAL TILE CEILINGS
09 5423	LINEAR METAL CEILINGS
09 6123	CONCRETE VAPOR EMISSION TREATMENT
09 6500	RESILIENT FLOORING
09 6723	POLYASPARTIC FLOORING SYSTEM
09 6813	TILE CARPETING
09 7217	LARGE-SCALE WALL GRAPHICS
09 8413	FIXED SOUND-ABSORPTIVE PANELS
09 8436	SOUND-ABSORBING CEILING UNITS
09 9100	PAINTING
09 9600	HIGH-PERFORMANCE COATINGS
09 9729	CONCRETE FLOOR SEALING

DIVISION 10 – SPECIALTIES

10 1100	VISUAL DISPLAY UNITS
10 2113	SOLID COLOR REINFORCED COMPOSITE TOILET COMPARTMENTS
10 2123	CUBICLE CURTAINS
10 2813	TOILET AND BATH ACCESSORIES
10 4400	FIRE PROTECTION SPECIALTIES
10 5113	METAL LOCKERS
10 7313	AWNINGS

10 7343	TRANSPORTATION STOP SHELTERS
10 7500	FLAGPOLES
10 8113	BIRD CONTROL

DIVISION 11 – EQUIPMENT

11 3100	APPLIANCES
11 5213	PROJECTION SCREENS
11 8126	PORTABLE DAVITS
11 9600	APPARATUS BAY EQUIPMENT

DIVISION 12 – FURNISHINGS

12 2413	ROLLER WINDOW SHADES
12 3613	CONCRETE COUNTERTOPS
12 3640	COUNTERTOPS
12 4816	ENTRANCE FLOOR MATS AND FRAMES
12 6613	PORTABLE BLEACHER SEATING
12 9316	BICYCLE LOCKERS

DIVISION 13 – SPECIAL CONSTRUCTION

13 1600	MOTOR FUEL STORAGE AND DISPENSING SYSTEM
13 1601	MOTOR FUEL ELECTRICAL SYSTEM
13 1602	ENVIRONMENTAL MONITORING SYSTEM
13 1603	FUEL MANAGEMENT SYSTEM

DIVISION 14 – CONVEYING EQUIPMENT

14 2100	ELECTRIC TRACTION ELEVATORS
14 5300	SLIDE POLE SYSTEMS

FACILITY SERVICES SUBGROUP:

DIVISION 21 – FIRE SUPPRESSION

21 0501	FIRE PROTECTION GENERAL PROVISIONS
21 0529	HANGERS AND SUPPORTS FOR FIRE SUPPRESSION PIPING AND EQUIPMENT
21 0548	VIBRATION ISOLATION AND SEISMIC RESTRAINTS FOR FIRE SUPPRESSION
21 0550	ACCESS DOORS IN GENERAL CONSTRUCTION FOR FIRE PROTECTION
21 0553	SYSTEMS IDENTIFICATION FOR FIRE PROTECTION
21 1001	UNDERGROUND FIRE SERVICE
21 1319	FIRE PROTECTION SYSTEMS

END OF DOCUMENT 00 0110 - VOLUME 2

VOLUME 3

DIVISION 22 – PLUMBING

22 0501	PLUMBING GENERAL PROVISIONS
22 0513	ELECTRIC MOTORS FOR PLUMBING EQUIPMENT
22 0514	VARIABLE FREQUENCY DRIVERS FOR PLUMBING
22 0516	EXPANSION COMPENSATION FOR PLUMBING
22 0519	METERS, GAUGES AND THERMOMETERS FOR PLUMBING
22 0529	HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT
22 0548	VIBRATION ISOLATION AND SEISMIC RESTRAINTS FOR PLUMBING
22 0550	ACCESS DOORS IN GENERAL CONSTRUCTION FOR PLUMBING
22 0553	SYSTEMS IDENTIFICATION FOR PLUMBING
22 0700	INSULATION FOR PLUMBING
22 0800	COMMISSIONING OF PLUMBING
22 1100	DOMESTIC WATER SYSTEMS
22 1110	PLUMBING PIPING AND ACCESSORIES
22 1123	PLUMBING PUMPS
22 1300	DRAINAGE SYSTEMS
22 2101	HYDRONIC SYSTEMS SPECIALTIES FOR PLUMBING
22 3300	DOMESTIC WATER HEATING SYSTEMS
22 4000	PLUMBING FIXTURES
22 6100	COMPRESSED AIR SYSTEMS
22 6313	NATURAL GAS SYSTEM
22 6413	PROPANE GAS SYSTEMS

DIVISION 23 – HEATING VENTILATING AND AIR CONDITIONING

23 0501	HVAC GENERAL PROVISIONS
23 0513	ELECTRIC MOTORS FOR HVAC EQUIPMENT
23 0514	VARIABLE FREQUENCY DRIVES FOR HVAC
23 0516	EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING
23 0519	METERS, GAUGES AND THERMOMETERS FOR HVAC
23 0523	GENERAL-DUTY VALVES FOR HVAC PIPING
23 0529	HANGERS AND SUPPORTS FOR HVAC
23 0548	VIBRATION AND SEISMIC CONTROLS FOR HVAC
23 0550	ACCESS DOORS IN GENERAL CONSTRUCTION FOR HVAC
23 0553	SYSTEMS IDENTIFICATION FOR HVAC
23 0593	TESTING, ADJUSTING AND BALANCING FOR HVAC
23 0700	INSULATION FOR HVAC
23 0800	COMMISSIONING OF HVAC
23 0831	CALIFORNIA TITLE 24 ENERGY STANDARDS HVAC ACCEPTANCE TESTING
23 0923	BUILDING MANAGEMENT SYSTEM (BMS)
23 0993	SEQUENCE OF OPERATIONS FOR HVAC CONTROLS
23 1125	LPG STORAGE AND VAPORIZATION SYSTEM
23 2113	HYDRONIC PIPING
23 2116	HYDRONIC PIPING SPECIALTIES
23 2123	HYDRONIC PUMPS
23 2300	REFRIGERANT PIPING AND ACCESSORIES
23 2500	HVAC WATER TREATMENT
23 3100	HVAC DUCTS AND CASINGS
23 3313	DAMPERS
23 3319	ACOUSTICS
23 3400	HVAC FANS
23 3516	MECHANICAL ENGINE EXHAUST SYSTEMS

23 3600	AIR TERMINAL UNITS
23 3700	AIR OUTLETS AND INLETS
23 4000	HVAC AIR-CLEANING DEVICES
23 6418	AIR-COOLED CHILLER/HEATER REFRIGERATION MACHINES
23 7213	AIR-TO-AIR ENERGY RECOVERY VENTILATORS
23 7318	INDOOR FAN ARRAY AIR-HANDLING UNITS
23 7418	OUTDOOR FAN ARRAY AIR-HANDLING UNITS
23 8126	SPLIT-SYSTEM AIR-CONDITIONERS
23 8129	MULTIPLE EVAPORATOR DX VARIABLE CAPACITY SPLIT SYSTEM
23 8216	AIR COILS
23 8219	FAN COIL UNITS

DIVISION 26 – ELECTRICAL

26 0501	ELECTRICAL GENERAL PROVISIONS
26 0502	EQUIPMENT CONNECTIONS AND COORDINATION
26 0519	600V WIRE AND CABLE
26 0526	GROUNDING SYSTEM
26 0533	RACEWAYS AND BOXES
26 0548	VIBRATION ISOLATION AND SEISMIC RESTRAINTS
26 0573	POWER SYSTEMS STUDIES
26 0800	COMMISSIONING OF ELECTRICAL
26 0831	CALIFORNIA TITLE 24 ENERGY STANDARDS ELECTRICAL ACCEPTANCE TESTING
26 0926	NETWORKED LIGHTING CONTROLS
26 2213	DRY-TYPE TRANSFORMERS
26 2413	SWITCHBOARDS
26 2416	PANELBOARDS
26 2726	WIRING DEVICES
26 2813	600V FUSES
26 2816	DISCONNECT SWITCHES AND INDIVIDUAL MOTOR CONTROLLERS
26 3213	ENGINE GENERATOR SYSTEM
26 3353	UNINTERRUPTABLE POWER SYSTEM
26 5100	ARCHITECTURAL LIGHTING
26 5100A	ARCHITECTURAL LIGHTING CUT SHEETS

DIVISION 27 – COMMUNICATIONS

27 0501	COMMUNICATIONS GENERAL PROVISIONS
27 0526	GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS
27 0529	HANGERS AND SUPPORTS FOR COMMUNICATIONS SYSTEMS
27 0533	CONDUITS, PULLBOXES AND BACKBOXES FOR COMMUNICATIONS SYSTEM
27 0536	CABLE TRAYS FOR COMMUNICATIONS SYSTEMS
27 0543	UNDERGROUND DUCTS AND RACEWAYS FOR COMMUNICATIONS SYSTEMS
27 0553	IDENTIFICATION FOR COMMUNICATIONS SYSTEMS
27 0800	TESTING OF COMMUNICATIONS SYSTEMS
27 1113	COMMUNICATIONS ENTRANCE PROTECTION
27 1116	COMMUNICATIONS CABINETS, RACKS, FRAMES AND ENCLOSURES
27 1119	COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS
27 1123	COMMUNICATIONS CABLE MANAGEMENT AND RUNWAY
27 1126	COMMUNICATIONS RACK MOUNTED POWER DISTRIBUTION
27 1313	COMMUNICATIONS COPPER BACKBONE CABLING
27 1323	COMMUNICATIONS OPTICAL FIBER BACKBONE CABLING
27 1513	COMMUNICATIONS COPPER HORIZONTAL CABLING
27 1543	COMMUNICATIONS FACEPLATES AND CONNECTORS
27 1619	COMMUNICATIONS PATCH CORDS AND STATION CORDS
27 3226	EMERGENCY COMMUNICATIONS SYSTEM

27 4100 AUDIOVISUAL SYSTEMS

DIVISION 28 – ELECTRONIC SAFETY AND SECURITY

28 0500 COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY
28 0513 CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY
28 1300 ACCESS CONTROL
28 1643 PERIMETER SECURITY SYSTEMS
28 2300 VIDEO SURVEILLANCE
28 3100 FIRE DETECTION AND ALARM

SITE AND INFRASTRUCTURE SUBGROUP:

DIVISION 31 – EARTHWORK

31 2300 EXCAVATION AND FILL
31 2333 TRENCHING AND BACKFILLING

DIVISION 32 – EXTERIOR IMPROVEMENTS

32 0523 CEMENT AND CONCRETE FOR EXTERIOR IMPROVEMENTS
32 1100 BASE COURSES
32 1200 FLEXIBLE PAVING
32 1343 PERMEABLE UNIT PAVERS
32 1723 PAVEMENT MARKINGS
32 3113 COLOR CHAIN LINK FRAMEWORK
32 3121 DECORATIVE CONCRETE FENCING
32 3131 SECURITY FENCES AND GATES
32 8000 IRRIGATION
32 9300 PLANTS

DIVISION 33 – UTILITIES

33 1100 WATER UTILITY DISTRIBUTION PIPING
33 3000 SANITARY SEWERAGE UTILITIES
33 4000 STORM DRAINAGE UTILITIES

PROCESS EQUIPMENT SUBGROUP:

DIVISION 40 – PROCESS INTERCONNECTIONS – NOT USED

DIVISION 41 – MATERIAL PROCESSING AND HANDLING EQUIPMENT – NOT USED

DIVISION 42 – PROCESSING HEATING, COOLING, AND DRYING EQUIPMENT

42 1416 ATMOSPHERE GENERATORS

**DIVISION 43 – PROCESS GAS AND LIQUID HANDLING, PURIFICATION, AND STORAGE
EQUIPMENT – NOT USED**

DIVISION 44 – POLLUTION AND WASTE CONTROL EQUIPMENT – NOT USED

DIVISIONS 45-48 – NOT USED

END OF DOCUMENT 00 0110 – VOLUME 3

VOLUME 4

PROJECT SPECIFICATIONS (PHOTOVOLTAIC) DSA INCREMENT #2

FACILITY CONSTRUCTION SUBGROUP:

DIVISION 13 – SPECIAL CONSTRUCTION

13 3800 SOLAR PHOTOVOLTAIC MOUNTING SYSTEM

FACILITY SERVICES SUBGROUP:

DIVISION 26 – ELECTRICAL

26 3100 SOLAR PHOTOVOLTAIC SYSTEM
26 3236 HYBRID BATTERY POWER SYSTEM

END OF DOCUMENT 00 0110 – VOLUME 4

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SECTION 13 3800

SOLAR PHOTOVOLTAIC MOUNTING SYSTEM

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Rooftop solar photovoltaic system supporting steel framework.
- B. Accessories.

1.2 RELATED SECTIONS

- A. Section 263100 – Solar Photovoltaic System.

1.3 REFERENCES

- A. ASTM A500 – Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
- B. ASTM A653/A 653M – Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
- C. ASTM A666 – Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
- D. ASTM A1008 – Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable.
- E. ASTM B749 – Standard Specification for Lead and Lead Alloy Strip, Sheet, and Plate Products.
- F. ASTM D4811 – Standard Specification for Nonvulcanized (Uncured) Rubber Sheet Used as Roof Flashing.
- G. ASTM D6878 – Standard Specification for Thermoplastic Polyolefin Based Sheet Roofing.
- H. ASCE 7 – Minimum Design Loads for Buildings and Other Structures.

- I. AWS A2.4 – Standard Symbols for Welding, Brazing, and Nondestructive Examination.
 - J. AWS D1.1 – Structural Welding Code – Steel.
 - K. AWS D1.6 – Structural Welding Code – Stainless Steel.
- 1.4 COORDINATION
- A. Coordinate Work with other operations and installation of roofing materials to avoid damage to installed insulation and membrane materials.
 - B. Coordinate Work with solar photovoltaic system installing contractor.
- 1.5 ACTION SUBMITTALS
- A. Submit under provisions of Section 013300.
 - B. Product Data: Manufacturer's data sheets on each product to be used, including:
 - 1. Preparation instructions and recommendations.
 - 2. Storage and handling requirements and recommendations.
 - 3. Installation methods.
 - C. Shop Drawings: Layout and erection drawings showing typical cross sections and dimensioned locations of all frames and base supports. Include erection drawings, elevations, and details where applicable. Indicate welded connections using standard AWS A2.4 welding symbols. Indicate net weld lengths.
- 1.6 INFORMATIONAL SUBMITTALS
- ~~A. Design Calculations: 3 copies of structural design calculations for structural components and components resisting wind loads with seal and signature of professional engineer licensed in the State of CA. Calculations shall include all required information per California Division of the State Architect IR 16-8 – Solar Photovoltaic and thermal systems review and approval requirements.~~
 - B. Manufacturer's Certificates: Certify products meet or exceed specified requirements.
 - C. Welders Certificates: Certify welders employed on the Work, verifying AWS qualification within previous 12 months.
 - D. Warranties: 3 signed copies.
- 1.7 QUALITY ASSURANCE
- A. Manufacturer Qualifications: Manufacturer with a minimum five years documented experience in producing pre-manufactured solar collector supporting steel framework.
 - B. Design Qualifications: Provide structural design calculations stamped by a professional engineer licensed in the state in which this project is located.
 - C. Installer Qualifications: Installer with a minimum five years documented experience in installing similar systems.
 - D. Welders: AWS certified within previous 12 months.

- E. Pre-Installation Meeting:
 - 1. Convene at job site, at least seven calendar days prior to scheduled beginning of construction activities of this section, to review requirements of this section.
 - 2. Require attendance by representatives of the installing subcontractor (who will represent the system manufacturer), the mechanical subcontractors and other entities affected by construction activities of this section.
 - 3. Notify Architect four calendar days in advance of scheduled meeting date.
- F. Mock-Up: Provide a mock-up for evaluation of surface preparation techniques and application workmanship.
 - 1. Locate in area designated by Architect.
 - 2. Construct mock-up, one full collector section wide, including two mounting frames with horizontal module support rails and roof supports.
 - 3. Do not proceed with remaining work until workmanship, configuration, and location is approved by Architect.
 - 4. Remove mock-up if required by Architect.
 - 5. Accepted mock-up may remain in place.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Receive, handle and store materials in conformance with the manufacturers printed instructions.
- B. Store products under cover, in manufacturer's unopened packaging until ready for installation.
- C. Protect materials from exposure to moisture.
- D. Store materials in a dry, warm, ventilated weathertight location.
- E. Protect metal fabrications from damage by exposure to weather.
- F. Handling: Use a forklift or crane to move material. Do not lift the bundles by the metal bands.
 - 1. Fork Lift: Spread the forks as far as possible to balance the load. Drive slowly when moving long bundles over uneven surfaces to avoid tipping the load
 - 2. Crane: Position the canvas sling straps so that the space between the straps is at least 1/3 the length of the bundle. Use sling straps with looped ends running one end of the strap through the loop at the other end to cinch the bundle when lifted. When setting the load on the roof, put wood blocks under it to protect the roof and allow space to remove the sling straps.
 - 3. Roof Placement: Spread the bundles and crates out as much as possible to avoid overloading the roof structure. Place the material directly over major supports such as beams or trusses.
 - 4. Position bundles of tubing parallel to the slope of the roof and block prior to opening to prevent the tubing from rolling down the roof slope when unbundled.

1.9 PROJECT CONDITIONS

- A. Field Measurements: Verify solar array dimensions and conditions of the installation by field measurements before fabrication and indicate measurements on Shop Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work.
 - 1. Established Dimensions: Where field measurements cannot be made without delaying the Work, establish reasonable rough-in dimensions and proceed with fabricating equipment enclosure without field measurements. Coordinate construction to ensure that reasonable rough-in dimensions correspond to established dimensions.

- B. Ensure that locating templates and other information required for installation of products of this section are furnished to affected trades in time to prevent interruption of construction progress.
- C. Ensure that products of this section are supplied to affected trades in time to prevent interruption of construction progress.

1.10 WARRANTY

- A. Framing System: Provide manufacturer's standard written limited warranty stating that the complete framing system shall be warranted against structural failure due to cracking, buckling, bending, tearing or corrosion arising under normal use and environmental conditions for the coverage period applicable.
- B. Products installed on projects located 2 miles or greater from salt or brackish bodies of water shall be warranted for twenty (20) years
- C. Products installed on projects located greater than 1 mile but less than 2 miles from salt or brackish bodies of water will be warranted for five (5) years, except for aluminum, stainless steel or copper Products which will be warranted for twenty (20) years.
- D. Products installed on projects located 1 mile or less from salt or brackish bodies of water will be warranted for three (3) years, except for aluminum, stainless steel or copper Products which will be warranted for twenty (20) years
- E. The above warranty is in addition to, and not a limitation of, other rights the Owner may have under the Contract Documents.

PART 2 - PRODUCTS

~~2.1 PERFORMANCE REQUIREMENTS~~

- ~~A. Design Loads: Comply with Building Code for site location and building height.
 - 1. Design to resist ASCE 7 - Minimum Design Loads for Buildings and Other Structures.
 - 2. Design all materials, assembly and attachments to resist snow, wind, suction and uplift loading at any point without damage or permanent set.~~
- ~~B. Structural Design: Prepare structural design calculations for support framing and attachment to structure including reactions at base supports for verification of roof structure by Architect.~~
- ~~C. All welds to be performed by an AWS certified welder. Valid certification to be provided.~~
- D. Provide a method for fully enclosing the perimeter of the PV array to eliminate the ability for birds to enter the space below the array. Integrate bird proofing system into the solar photovoltaic mounting system in a fashion such that it is secure from birds but provides access to building maintenance staff as required to the array.

2.2 MANUFACTURERS

- ~~A. Basis of Design Manufacturer: UFO and Ironridge brand racking. by Sun Light and Power, which is located at: 1035 Folger Ave., Berkeley, CA 94710; Toll Free Tel: 800 233 4786; Web: www.sunlightandpower.com.~~

2.3 MATERIALS

- A. Round Post Supports: 12 inch (305 mm) tall weldments fabricated from galvanized steel tube conforming to ASTM A500 and cold rolled steel plate conforming to ASTM A36, fabricated with pre-punched holes in base plate for fastening to roof structure. After fabrication, apply minimum 2 to 4 mil shop primer to base plate and weld. Provide height adjustment with galvanized tube sleeve conforming to ASTM A500, sized to telescope over outside of round post tube and fastened at desired height with self-drilling, self-tapping screws. Provide epoxy coating for all galvanized steel components to ensure resistance to saltwater environment.
- B. Round Post Cap: Weldments fabricated from AISI Type 304 stainless steel with mill finish fabricated to slip over 2-1/2" sleeve tube allowing adjustable height when used with Round Post Support. Provide epoxy coating for all galvanized steel components to ensure resistance to saltwater environment.
- C. Roof Flashing: Refer to Division 07 section that specifies the roof membrane.
- D. Framing: Carbon steel structural tubing in manufacturer's standard sizes, conforming to ASTM A500 with manufacturer's standard galvanized coating conforming to ASTM B117 salt spray testing. Provide with wall thickness as determined by structural calculations. Provide epoxy coating for all galvanized steel components to ensure resistance to saltwater environment.
- E. Connector Fittings: Fabricated AISI Type 304 stainless steel with mill finish.
- F. Steel Hat Channel Rails: Steel sheet conforming to ASTM A653, Class SS, with a G90 hot-dip galvanized coating. Provide epoxy coating for all galvanized steel components to ensure resistance to saltwater environment.
- G. Module Hold-Down Clips: Extruded aluminum conforming to ASTM B221, 6063-T6 alloy and temper. Design shall allow fastening to various common PV module thicknesses with use of self-drilling screws or through bolts. Clips shall be approved for use with WEEB grounding washers.
- H. Hardware: Bolts, nuts, washers and screws 18-8 stainless steel.
- I. Welding Materials: AWS D1.1; type required for materials being welded.

2.4 FABRICATION

- A. Fabricate ends of tubing with flat crimp for connections.
- B. Fit and shop assemble items in largest practical sections, for delivery to site.
- C. Fabricate items with joints tightly fitted and secured.
- D. Grind exposed joints flush and smooth with adjacent finish surface. Make exposed joints butt tight, flush, and hairline. Ease exposed edges to small uniform radius.
- E. Supply components required for anchorage of fabrications. Fabricate anchors and related components of same material and finish as fabrication, except where specifically noted otherwise.
- F. Fabricate system components so that portions of collector supports can be dismantled for future roof replacement.

PART 3 - EXECUTION**3.1 EXAMINATION**

- A. Examine area where work will be installed to verify the installation can be performed in accordance with the Drawings and structural calculation requirements without interference from other equipment or trades.
- B. If preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.
- C. Do not begin installation until conditions have been properly prepared.

3.2 PREPARATION

- A. Clean surfaces thoroughly prior to installation.
- B. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.

3.3 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install components plumb and level, accurately fitted, free from distortion or defects.
- C. Provide for erection loads, and for sufficient temporary bracing to maintain indicated alignment until completion of erection and installation of permanent attachments.
- D. Anchor fabrications to structure as indicated.
- E. Separate dissimilar metals and use gasketed fasteners, isolation shim, or isolation tape to eliminate possibility of corrosive or electrolytic action between metals.
- F. Exercise care when installing components so as not to damage finish surfaces. Touch up as required to repair damaged finishes.
- G. Install flashing boots at base supports as required to provide a watertight connection. Install as recommended by the roof membrane manufacturer.

3.4 CLEANING AND PROTECTION

- A. Protect installed products until completion of project.
 - 1. Ensure that finishes and structure of installed systems are not damaged by subsequent construction activities.
 - 2. If minor damage to finishes occurs, repair damage in accordance with manufacturer's recommendations; provide replacement components if repaired finishes are unacceptable to Architect.
- B. Prior to Substantial Completion: Remove dust or other foreign matter from component surfaces; clean finishes in accordance with manufacturer's instructions.
- C. Replace framing members and accessories that have been damaged or have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

END OF SECTION

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SECTION 26 3100**SOLAR PHOTOVOLTAIC SYSTEM****PART 1 - GENERAL****1.1 DESCRIPTION**

- A. Procure and construct a complete, functioning grid interconnected photovoltaic (PV) system according to Contract Documents.
- B. The system shall consist of the following:
 - 1. An array of photovoltaic modules with aluminum frames designed for grouping on racks
 - 2. Terminal and combiner box(es)
 - 3. Quick-connect electrical connectors
 - 4. DC wiring
 - 5. Disconnecting DC combiner
 - 6. Grid-connected inverter(s)
 - 7. Utility required AC disconnect
 - 8. Data acquisition and monitoring system (DAS) with revenue grade kwh meter
 - 9. Off-grid/grid-connected AC/DC inverter
 - 10. Other features as described in this specification
- C. The inverter shall be wired to and function with the building's electrical system, the building hybrid battery power system for function off-grid, and interconnected with the utility grid.
- D. Conduct fully operational system commissioning to demonstrate that the system functions as designed, and make any changes necessary to achieve design intent.
- E. Construct PV array on building roof(s) according to Contract Documents.
- F. Provide annual PV energy production model demonstrating system performance meeting at least 39.4 MWh/year using the proposed system components in the bid submission.
- G. Provide labor, materials, and accessories required to furnish, install, start up, and commission a complete operating solar photovoltaic system. Labor, materials, or accessories not specifically called for in the Contract Documents, but required to provide a complete operating system, shall be provided without additional cost to the Owner.
- H. Determine, coordinate, and incorporate the design and construction requirements of the Architect, Structural Engineer, Mechanical Engineer, Electrical Engineer, Hybrid Power System Engineer, General Contractor, other Subcontractors, the Commissioning Agent, and local power service provider.
- I. Verify utility interconnection with local power service provider in coordination with Electrical Engineer and Hybrid Power System Engineer.
- J. Perform full PV system commissioning including start-up and operational testing per contract documents.

1.2 REFERENCE STANDARDS

- A. The photovoltaic installation shall be designed and manufactured in compliance with the applicable version of the following standards and codes:
 - 1. NEPA 72
 - 2. UL 1741
 - 3. UL 1703
 - 4. IEEE 929
 - 5. IEEE 1547
 - 6. Local Codes

1.3 RELATED DOCUMENTS

- A. Division 13 – Special Sections – Solar Photovoltaic Mounting System
- B. Division 23 – Mechanical Specifications
- C. Division 26 – Electrical Specifications – Hybrid Battery Power System

1.4 SUBMITTALS

- A. Proposal Submittal:
 - 1. Pricing breakdown in accordance with the Invitation to Bid.
 - 2. Written technical description of the proposed systems broken down into the following categories:
 - a. PV modules
 - b. Mounting system
 - c. DC combiner box with disconnect
 - d. Grounding system
 - e. DC/AC inverter
 - f. Utility Interconnection
 - g. Visible blade AC disconnecting means
 - h. Data acquisition system with revenue grade kwh meter
 - ~~3. Pre-engineered shop drawings for PV mounting system including installation, roof penetration, component sizing, and component material details.~~
 - 4. Diagram showing proposed method for PV system grounding, including DC and AC connection to site grounding electrode.
 - 5. Voluntary alternates to the base proposal may be presented, at the Subcontractor's option. All such alternates shall include a description of the item, benefits obtained by the City, and associated add or deduct cost. Creativity and ingenuity are encouraged in this regard; however, the impact imposed on the building's architecture and structure systems should be considered.
 - 6. For any voluntary alternates, demonstrate that power generating system components (i.e. PV modules and inverter) provide current and voltage outputs that meet or exceed code minimum requirements.
 - 7. Demonstrate that any voluntary alternates for PV system equipment fit within the dimensions given on the Contract Documents.
 - 8. Construction Specifications:
 - a. CSI 2004 format
 - b. General Electrical Provisions
 - c. Electrical Materials and Methods
- B. Manufacturer's product data sheets for all equipment. All irrelevant information shall be marked out leaving only pertinent data.

- C. Operating and maintenance manuals for all system components.
- D. Utility company and/or state PV incentive (rebate or PBI) calculations and application forms for eligible items for City's application for incentive.
- E. Utility interconnection application complete for submission with all supporting documentation. PV System utility interconnection process is to be pursued in conjunction the building electrical and hybrid power system utility interconnection process, and therefore must be coordinated with Electrical Engineer and Hybrid Power System Engineer.

1.5 QUALITY ASSURANCE

- A. Comply with the current applicable codes, ordinances, and regulations of the Authority or Authorities Having Jurisdiction; the rules, regulations and requirements of the utility companies serving the project; and the City's insurance underwriter.
- B. PV system installer shall have local representation and shall have been actively engaged in installation and service of solar photovoltaic systems and inverters for a period of not less than five years.
- C. All equipment and installations shall meet or exceed minimum requirements of ADA, ANSI, ASTM, IEEE, IES, NEC, NEMA, NETA, NFPA, OSHA, SMACNA, UL and the CA Fire Marshal.
- D. Equipment shall be certified for use in California.
- E. Maintain uniformity of manufacturer for equipment used in similar applications and sizes.

1.6 ENVIRONMENTAL REQUIREMENTS

- A. Operating Temperature: minus 20 degrees C to plus 45 degrees C.
- B. All outdoor equipment shall be NEMA 3R enclosed or better.

1.7 IDENTIFICATION

- A. Provide an identification nameplate for each photovoltaic inverter and each feeder overcurrent protection device.
- B. Provide additional markings and identification of equipment as required by NEC 2014 Sections 690 and 705.

1.8 COORDINATION

- A. Coordinate layout and installation of PV array and balance of systems with other rooftop equipment and features and roof structure.
- B. Coordinate roof penetrations with roofing and structural contractors.
- C. Coordinate construction of array and other site work with general contractor (GC) and any other trades working on site.
- D. Coordinate size and location of housekeeping bases, support points, and conduit routing with GC and other trades working on site.

1.9 WARRANTY

- A. The PV system installation workmanship shall be warranted as specified in the purchase agreement, but shall be no less than one year from the time of acceptance. The solar photovoltaic system installer shall replace or repair any defective parts via pass through manufacturer's warranty within the first year of operation at no extra cost to the City.
- B. System acceptance shall be granted after 30 days of AC power output within 10% of predicted power at operating test conditions.
- C. The photovoltaic module power output shall be covered by the photovoltaic module manufacturer's warranty for a minimum of 20 years, and the module workmanship shall be covered for a minimum of 10 years. These warranties shall be passed through the supplier to the customer.
- D. The inverter shall be covered by the manufacturer's warranty for a period of not less than ten years, and shall be passed through the supplier to the customer.

PART 2 - PRODUCTS**2.1 ACCEPTABLE PRODUCTS**

- A. Photovoltaic Panels: REC.
- B. Inverter: SOLA REDGE.
- C. DC Combiner Box: Bentek Solar, SolarBOS,
- D. Data Acquisition System: Locus Energy.
- E. PV Mounting System: See contract drawings and Section 133800.

2.2 RATINGS

- A. DC System
 - 1. Photovoltaic Panels
 - a. Minimum power rating per PV Panel is 355W.
 - 2. DC Combiner Box
 - a. Output voltage shall be 600V minimum.
 - b. Output current rating shall be 130A minimum.
 - c. Minimum of 12 source circuit input positions.
 - d. Finger safe fuse holders required for source circuit input positions.
 - e. Weatherproof and corrosion resistant.
- B. AC System
 - 1. Inverter
 - a. Inverter AC nameplate rating: 100kWAC.
 - b. AC output voltage shall be directly compatible with building or site distribution voltage without the use of an external voltage transformer.
 - c. Total Harmonic Distortion less than two percent at rated power.
 - d. Inverter Peak Energy Efficiency greater than 95 percent.
 - e. Power Factor greater than 0.99 percent

2.3 CONSTRUCTION

- A. The inverters shall be complete with the following features:
1. Convection forced air cooling
 2. Islanding protection to meet IEEE 929 and UL 1741.
 3. Protective functions and annunciation:
 - a. AC over/under voltage
 - b. AC over/under frequency
 - c. Ground over current
 - d. Over temperature
 - e. AC and DC over current
 - f. DC over voltage
 4. User display
 5. AC and DC disconnects
 6. Remote display monitor
 7. PV ground fault protection system
 8. DC subcombiner
 9. Maximum Power Point Tracking
 10. Lightning arrester AC/DC protection
 11. Isolation transformer
 12. Communications software capable of remotely reporting kwh production
- B. Roof-mounted systems shall employ crystalline silicon photovoltaic modules enclosed in a corrosion-resistant heavy-duty frame with tempered low-iron anti-reflective coated glass and clear encapsulated insulation.
- C. Products must meet Contract Document requirements for architectural interface and energy production. The Contractor shall refer to architectural drawings for plan and elevation details.
- D. Data acquisition system (DAS) shall be furnished with all equipment necessary to measure PV system energy production and building net energy use, including PV production meter, net energy meter, and data logger, with appropriate voltage and current sensing and power supply. The DAS should employ data recording intervals that correspond to utility demand billing scheme and must be compatible with the building Programmable Logic Controller (PLC) building management system.
- The DAS must also record site weather conditions (ambient temperature, module temperature, wind speed and direction, and solar irradiance). DAS system may utilize existing weather station on site if available.
- E. The photovoltaics system must be fully integrated with the hybrid power system via the microgrid controller. The solar PV system is required to have the capability of charging the battery system and providing power to building loads in both grid-tied and off-grid modes.

2.4 SAFETY FEATURES

- A. The utility interactive inverter shall incorporate a maintained position on/off switch located on the enclosure. Under normal conditions, the on/off switch is in the ON position. Turning the switch to the OFF position will initiate a controlled shut-down and open the A/C contactor within the unit. The A/C contactor shall not close unless the switch is in the ON position. The inverter shall be prevented from being restarted until the on/off switch is turned back to the ON position.
- B. The system shall be equipped with ground fault detection circuitry. Upon detection of a ground fault, the system shall execute an orderly shut-down, and annunciate a ground fault

at the operator interface. The system shall remain faulted until the ground fault is remedied and cleared at the operator interface. This must be the only point of PV conductor ground.

- C. Anti-Island Protection: A digital phase-shift-loop (PSL) circuit shall be implemented in the inverter controller to prevent "Islanding" of the system. In the event of a utility outage, these adjustments destabilize the feedback between the inverter and the remaining load, resulting in an over/under frequency or voltage condition. The system shall perform an orderly shut-down. The fault condition will remain until the utility voltage and frequency have returned to normal for five minutes.

PART 3 - EXECUTION

3.1 FEES, PERMITS AND INSPECTIONS

- A. Pay all required fees and obtain required permits and associated inspections related to the complete photovoltaic installation.
- B. Pay royalties or fees in connection with the use of patented devices and systems.
- C. Provide controlled or witnessed inspection where required by Authorities Having Jurisdiction, Supply Authority or by these specifications.

3.2 INSTALLATION AND INTERCONNECTION

- A. Inspect all equipment for damage upon arrival. Report any damage equipment and obtain replacement(s) from manufacturer.
- B. Measure and record open circuit voltage (Voc) and short circuit current (Isc) of each module and compare the results to the manufacturer's specifications to ensure modules are within manufacturer's specified tolerances. If any modules are found to perform outside tolerance, deem module defective and do not install it. Record ambient air temperature and solar irradiance during field testing. Complete testing under constant solar irradiance and temperature conditions.
- C. Connect, mount, and ground the complete photovoltaic installation per manufacturer's instructions and Contract Drawings.
- D. Coordinate with the Electrical Contractor and Hybrid Power System Contractor for building PV wiring and point of interconnection to the building distribution system, hybrid power system, and utility grid.
- E. Ship, store, and install products and materials in a manner that will protect them from physical damage, water damage, weather and entry of debris. If items are damaged in the opinion of the Architect, take immediate steps to obtain replacement or repair.
- F. Prepare and submit utility interconnection application and all supporting documents in conjunction with Electrical Engineer and Hybrid Power Systems Engineer, as necessary. Provide all required utility interconnection protection devices as required by the utility company.

3.3 TESTING

- A. Submit PV module factory flash test data to the City for approval.

- B. Inverter shall be factory-tested for performance, and results shall be included in the O & M manual.
- C. System start-up procedure shall be performed as outlined by the inverter manufacturer's installation manual.
- D. Fully operational PV system commissioning shall be performed prior to system acceptance. System commissioning shall include the following, at a minimum:
 - 1. Verify that the installation is complete.
 - 2. Verify that the installation is safe.
 - 3. Verify that the installation is aesthetically acceptable.
 - 4. Verify that all components of the installation are robust and permanent.
 - 5. Document as-built conditions.
 - 6. Verify system operational performance and record results. Include a comparison of expected performance results at identical ambient and operational conditions.
 - 7. Verify proper system operation, including integration and compatibility with the hybrid power system.
 - 8. Establish performance benchmarks.
 - 9. Complete any required acceptance documentation.
 - 10. Train the system facilitator on basic system operation.
- E. Correct all installation defects identified during system commissioning.
- F. PV System commissioning (including start-up and operational testing) shall be overseen by the Electrical Engineer, Hybrid Power System Engineer, and Commissioning Agent as needed to satisfy the requirements of the LEED NC v4 rating system.

3.4 MEASUREMENT AND VERIFICATION

- A. GENERAL
 - 1. Provide metering of instantaneous and continuous kW and kwh output with continuous integration for outputting to the Programmable Logic Controller (PLC) Building Management system (BMS).
 - 2. Communications protocol to the BMS shall be compatible with the building PLC BMS system.
 - 3. Provide full integration with hybrid power battery system to ensure PV can provide power to building loads and batteries in grid-tied and off-grid mode.

END OF SECTION 26 3100

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SECTION 26 3236

HYBRID BATTERY POWER SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Provide a battery-based standby power system and accessories, integrated with the building solar photovoltaic (PV) system, to provide off-grid power to building loads in accordance with the Contract Documents.
- B. This specification describes a three-phase battery-based hybrid power system (hereto referred to as HPS) that shall operate in conjunction with the building electrical system, and the rooftop solar PV system, and the utility grid to provide back-up and distribution of conditioned power for electrical loads. The battery system shall also provide for peak demand management during normal grid operation.
- C. The standby power system shall consist of the following:
 - 1. Battery plant
 - 2. DC controller with DC disconnect for battery maintenance
 - 3. Structural racking for battery
 - 4. Off-grid/grid-connected AC/DC battery inverter
 - 5. 480/208V wye-wye step-down transformer
 - 6. 208/480V wye-wye step-up transformer
 - 7. Microgrid controller
 - 8. 24V UPS to provide microgrid controller grid outage ride-through
 - 9. Other features as described in this specification
- D. The individual HPS described in this specification shall be available with an output capacity kWAC as indicated in the Drawings at a power factor of 1.

1.2 REFERENCE STANDARDS

- A. UL or ETL Listed per UL 1741 – (Underwriters Laboratories) Standard for Inverters, Converters, Controllers, and Interconnection System Equipment for Use with Distributed Energy Resources.
- B. NEMA – applicable standards for standby power systems.
- C. IEC/EN 61000-4-2 – (International Electrotechnical Commission) Electrostatic Discharge Immunity Test.
- D. IEEE 587/ANSI C62.41-1980, Categories A & B – (American National Standard) Standards for surge withstand ability.
- E. FCC Rules and Regulations 47, Part 15, Subpart J, Class A – (Federal Communications Commission) Certified compliance.
- F. NFPA 111: Standard on Stored Electrical Energy Emergency and Standby Power Systems

- G. ANSI/RMI MH 16.1: Specification for the Design, Testing and Utilization of Industrial Steel Storage Racks
- H. OSHA

1.3 RELATED DOCUMENTS

- A. Information specific to the proposed equipment configuration and physical size for the specified equipment as documented on the Drawings shall apply to this contract in addition to the requirements specified herein.

1.4 SUBMITTALS

- A. The following drawings and information are to be submitted with the proposal:
 - 1. Line-by-line specification compliance review with detailed explanations of any deviations from requirements listed herein. Submit line-by-line markup, written report of deviations and alternates and a cover letter certified by Manufacturer or Installer that prepared the Specification Compliance Certification. Use the following key for preparing the line-by-line markup.
 - a. "C" for Compliance: By noting the term "compliance" or "C" in the margin, it shall be understood that the manufacturer is in full compliance with the item specified and will provide exactly the same with no deviations.
 - b. "D" for Deviation: By noting the term "deviation" or "D" in the margin, it shall be understood that the manufacturer prefers to provide a different component in lieu of that specified.
 - c. "A" for Alternate: By noting the term "alternate" or "A" in the margin, it shall be understood that the manufacturer proposes to provide the same operating function but prefers to do it in a different manner.
 - d. "N/A" for Not Applicable: By noting the term "not applicable" or "N/A" in the margin, it shall be understood that the specified item is not applicable to the project.]
 - 2. System configuration with single-line diagrams.
 - 3. Detailed descriptions of equipment to be furnished, including all deviations from these specifications and the contract drawings.
 - 4. Size and weight of individual shipping units to be handled by Contractor in the field.
- B. The following drawings and information are to be submitted within thirty days of order.
 - 1. Detailed installation manual including receiving and installation instructions, system one-line drawings, interconnection drawings and wiring diagrams.
 - 2. Functional relationship of various equipment including weights, dimensions and heat dissipation of each unit.
 - 3. Interconnect wiring diagrams showing all conduit runs and wiring for battery plant and connection to battery inverter and building electrical system.
 - 4. Data connection wiring diagram showing interconnection of data feed from battery plant, battery inverter, DC controller, and microgrid controller. Data connection must include interface with solar PV system and building PLC.
 - 5. Communications interface protocol and networking provisions for interface with building programmable logic controller (PLC).
 - 6. Factory test procedures for battery plant, battery inverter, and microgrid controller, including microgrid operational testing.
 - 7. Manufacturer's ongoing service maintenance recommendations and information regarding standard maintenance contract services.
 - 8. Detailed design drawings showing structural racking for battery plant located on first floor.

9. Anchoring details for all equipment with certified structural calculations by a professional engineer registered in California, for Seismic Zone 4 Seismic Design Category F, Importance Factor 1.5,, complying with ANSI/RMI MH 16.1.
 10. Site test procedures customized for the specific equipment to be provided.
- C. Microgrid control scheme documenting thresholds for charge and discharge, including depth of discharge, time schedule, and any other applicable variables to deliver off-grid standby power.
- D. The following drawings and information are to be submitted with the delivery of the HPS:
1. A complete set of submittal drawings.
 2. Factory test report, complete with results for specific equipment delivered.
 3. Site test procedures as approved during the submittal phase.
 4. Two (2) complete binders of instruction manuals shall be provided for the HPS. The manuals shall include a functional description of the equipment with detailed block diagrams, safety precautions, instructions and step-by-step operating and maintenance procedures, including drawings and illustrations. Include a section in the manual for the project maintenance service agreement as applicable including contact names and emergency telephone numbers for site-specific contacts.
- 1.5 QUALITY ASSURANCE
- A. The hybrid power system equipment manufacturers shall have a minimum of ten years' experience in the design, manufacture and testing of microgrids including connection to the utility grid and on-site renewable energy systems. A list of installed systems of the same type as the manufacturer proposes to furnish for this application shall be made available upon request.
- B. The HPS manufacturer shall have ISO 9001 certification for engineering/R&D, manufacturing facilities and the field service organization.
- 1.6 ENVIRONMENTAL REQUIREMENTS
- A. The hybrid power system shall withstand any combination of the following external environmental conditions without operational degradation:
1. Target Battery Operating Temperature: 0 to 40 degrees C without derating.
 2. Battery operating temperature range: -5 to 40 degrees C.
 3. Relative Humidity (operating and storage): 95 percent maximum non-condensing.
- B. Acoustical Noise: Shall not exceed 65 dbA at one meter from any operator surface, at 25 degrees C and full load.
- 1.7 RELIABILITY AND MAINTAINABILITY
- A. Reliability: The HPS shall feature redundant control power supplies. A UPS shall be provided to maintain operation of the microgrid controller during a grid outage. In the event of a grid outage, the HPS shall continue to operate in normal mode after requisite UL 1741 shut-down and restart. Failure to restart the HPS and loss of normal power after a grid outage shall be annunciated on the monitor panel and available remotely through the building PLC. A failure alarm shall automatically clear when the failed control power supply is replaced.
- B. Maintainability: Provide DC disconnect for battery maintenance and at least one point of visibility into status of system function.

1.8 WARRANTY

- A. Battery plant: The manufacturer shall warrant their batteries for 5 years at full performance and 3 years on a pro-rated basis to deliver no less than 80 percent of its rated capacity, provided the prevailing ambient temperature of the battery area does not exceed 25 degrees C.
- B. Battery Inverter, DC controller, microgrid controller, transformers, UPS: The manufacturer shall warrant their inverter for 10 years from the date of sale and covers and covers defects in workmanship and materials.
- C. Structural racking for battery: The manufacturer shall warrant their inverter for 10 years from the date of sale and covers and covers defects in workmanship and materials.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- 1. UL Listed and labeled products of any manufacturer meeting the specified performance requirements are acceptable, unless otherwise noted herein.

2.2 HYBRID POWER SYSTEM SUPPLY RATINGS AND OPERATING CHARACTERISTICS

- A. HPS System Configuration:
 - 1. As indicated on the Drawings.
- B. Battery Plant:
 - 1. Maximum output voltage: 800VDC
 - 2. Maximum charge/discharge current: 380ADC
 - 3. Battery systems shall be housed in a noncombustible, locked cabinet or other enclosure to prevent access by unauthorized personnel unless located in a separate equipment room accessible only to authorized personnel.
- C. Battery Inverter:
 - 1. Maximum output voltage: Three phase, 208VAC sinewave output
 - 2. Maximum output current: 133AAC
 - 3. Minimum efficiency: 96%
- D. Transformers:
 - 1. 480/208V Step-down transformer, wye-wye, 112.5kVA
 - 2. 208/480V Step-up transformer, wye-wye, 112.5kVA
- E. Microgrid Controller:
 - 1. Capacity: The rectifier/charger shall support a fully loaded Inverter and recharge the battery to 95 percent of its full capacity within 10 times the discharge time when input current limit is set at maximum.
 - 2. Battery plant operation logic:
 - a. At time of initial startup commissioning: Provide for off-grid backup power. The microgrid controller shall maintain capacity to supply a 10-hour discharge at all times to provide off-grid power to the building. During normal grid-tie operation, the microgrid controller shall charge the batteries from the rooftop solar and the grid, as necessary. During off-grid operation, the microgrid controller shall maintain the ability to serve loads and charge the batteries with solar power, as necessary. Coordinate controller logic with manufacturer, electrical engineer, hybrid power system engineer, and building owner.

- b. At time of recommissioning: maintain off-grid back up power capability, and add peak demand management capability in accordance with PG&E program requirements. Use minimum of one year PV energy production, battery operation, and building energy usage data to calibrate control strategy for peak demand management.
3. Battery Equalize: Automatic and manual means must be provided for battery equalization.

2.3 HYBRID POWER SYSTEM STANDARD FEATURES

- A. Battery Plant: The battery plant shall include battery modules wired in series and shall include a DC disconnect capable of opening positive and negative poles of battery system located within sight of the battery plant to serve as a manual maintenance shut down.
- B. Utility Grid Syncing:
 1. Upon grid outage, HPS shall supply power to designated loads after the UL 1741/utility-required shutdown of the system.
 2. Upon return of utility power, HPS shall sense and sync with the utility grid to ensure safety and proper operation of system.
- C. Battery Management System:
 1. CANBUS communication compatible with Microgrid Controller, network connection to push diagnostic data to manufacturer.
 2. DC Sensing: Provide redundant DC sensing methods for remote sensing battery over/under voltage, over/under current, and temperature. Automatic alarms shall be provided to building operations staff in event of abnormal battery operating characteristics.
- D. Battery Inverter: The inverter shall operate in off-grid and grid-connected modes.
 1. The inverter shall provide the specified quality output power while operating from any DC source voltage (PV or battery) within the specified DC operating range.
 2. The inverter shall include protection circuitry, which prevents the units from providing current in excess of their published ratings.
- E. Monitoring and Control Components: Provide the following components for monitoring and control capability:
 1. Digital microprocessor control
 2. Monitor panel with status indicators
 3. Alarm and metering display
 4. Input circuit breaker or contactor
 5. Inverter output contactor
 6. RS-232 (EIA/TIA-232) and RS-485 communication ports for building PLC or user alarm monitoring
- F. Microgrid Controller: The HPS module shall contain an integral battery management system which has the following features:
 1. Uninterruptible power supply (UPS) to supply ride-through power to microgrid controller during UL1741 shutdown of inverter systems in the event of grid outage.
 2. The microgrid controller shall indicate battery time available, or percent remaining, while operating in normal mode and battery mode. Battery time available information shall be displayed real-time. Once commissioned, the battery time available information shall be accurate within plus or minus 3 percent.

3. After set-up, the microgrid controller shall automatically analyze the HPS battery during a user-defined periodic test cycle (quarterly, monthly, etc). During the test, the rectifier/charger shall not de-energize, but shall share load with the battery. For determining battery time remaining information, the battery shall be tested under the same load for each user-defined periodic test. Should the battery be weak or defective, the microgrid controller shall detect and enunciate the battery failure condition without transferring the critical load to bypass.
 4. The periodic test performed by the microgrid controller shall not remove more than 10 percent of the available battery run time from the battery. The periodic test, if performed on a monthly basis, shall not reduce overall battery life.
 5. If a utility outage occurs while a test is in progress, the test shall be discontinued and subsequently conducted at the next programmed interval. The occurrence of the periodic test shall be programmable for day, date and time.
 6. The microgrid controller shall provide battery health information in the form of a health indication value. When the health indication value approaches 0.80, it shall correspond with battery string end of life.
 7. The microgrid controller shall record and display the pass/fail status, battery voltage and health indicator value of the previous thirty (30) periodic tests.
 8. The microgrid controller shall annunciate a programmable battery time remaining warning when the HPS module is on battery power and shall provide an imminent shut-down alarm to signal a low battery condition.
- G. The microgrid controller shall be fully compatible with the supplied batteries and battery management system.

2.4 HYBRID POWER SYSTEM MECHANICAL DESIGN

- A. Provide pre-engineered seismically braced racking to support each battery module above the floor slab as required by the California Building Code. Battery racking shall comply with ANSI/RMI MH 16.1.
- B. Ventilation: Direct exhaust of battery enclosure shall be coordinated with mechanical contractor.
- C. No back or side clearance or access shall be required for any enclosure. The back and side enclosure covers shall be capable of being located directly adjacent to a wall.
- D. Cable Entry: A dedicated wireway shall be provided within the HPS for routing power and communication input and output wiring.

2.5 CONTROLS AND INDICATORS

- A. Micro-Controller Operated Circuitry: The HPS controls shall have the following design and operating characteristics:
1. Fully automatic operation of the HPS shall be provided through the use of micro-controllers. (Digital signal processing shall eliminate variances from component tolerance or drift, and provide consistent operational responses.)
 2. All operating and protection parameters shall be firmware controlled. All adjustments and calibrations shall be performed without the use of potentiometers. Printed circuit board replacement shall be possible without requiring calibration.
 3. Start-up and transfers shall be automatic functions.
 4. Multiple micro-controllers shall be used, so no single controller is in a mission-critical application.
 5. All configuration, set-up, and calibration information shall be stored in non-volatile memory that does not require a control battery for data storage.

6. Emergency transfers to bypass due to HPS failure shall be independent of the control logic controlling the rectifier/charger, inverter, and monitor panel. Emergency transfer circuitry shall contain all the necessary circuitry to perform an emergency transfer without any other functioning logic.
 7. Monitoring and communications logic shall be independent of the rectifier/charger and inverter control logic. Circuitry and firmware required for monitoring and communications logic shall be functionally isolated from the bypass, rectifier/charger and inverter controls. Monitoring firmware shall be field upgradeable.
 8. The HPS shall be programmable to optionally provide automatic restart capability following loss of utility and a complete battery discharge. When utility power returns, the HPS shall automatically energize the output terminals and subsequently transfer to normal mode.
 9. Full integration with building PLC, allowing for supply to PLC all data available from the HPS as required by building owner.
- B. Monitor Panel Indicators: The HPS shall be equipped with a monitor panel providing the following monitoring functions and indicators. Each alarm and notice condition shall be accompanied with an audible alarm.
1. NORMAL: This symbol shall be lit when the HPS is operating in normal mode.
 2. BATTERY: This symbol shall be lit when the HPS is operating in battery mode. The normal indicator also remains lit.
 3. BYPASS: This symbol shall be lit when the HPS is operating in bypass mode. The normal indicator shall not be lit when the HPS is in bypass mode.
 4. NOTICE: This symbol shall be lit when the HPS needs attention. Notices shall be accompanied by an audible horn. Notices include:
 - a. Bypass not available
 - b. Battery undervoltage
 5. ALARM: This symbol shall be lit when a situation requires immediate attention. All alarms shall be accompanied by an audible alarm. Alarms include:
 - a. Over temperature
 - b. Output overload
 - c. Inverter failure
 - d. Rectifier/charger failure
 - e. Shut-down imminent (low battery in emergency mode)
 6. STANDBY: This symbol shall be lit when electricity is present in the rectifier and inverter while the normal indicator is not lit. During normal start-up this indicator shall remain lit until the HPS transfers to normal mode, at which time the normal indicator shall light. During normal shut-down, the standby indicator shall remain lit until all energy in the HPS is dissipated and shut-down is complete.
- C. Monitor Panel Controls: The HPS monitor panel shall include the following control functions:
1. Menu and Cursor Controls: Selects, displays, and scrolls data on the LCD.
 2. Load Off: Shuts down the HPS, de-energizes the critical load, and opens the HPS breakers and contactors.
 3. Horn Silence: Silences the current audible alarm(s). The horn shall sound again if new alarms occur.
 4. Screen Adjust: Controls the liquid crystal display contrast.
- D. Monitor Panel Liquid Crystal Display (LCD): The HPS shall include a liquid crystal display measuring approximately 6 inches by 7.5 inches with multiple lines of information. Graphical user screens shall be provided on the monitor panel LCD to display the HPS operating parameters with selector features used to access information in these screens. Information in the meter screen and alarm history screen shall be available to a remote alarm panel, terminal or printer through the selected interface communication port configuration. The screen shall include:

1. Common Information: The following information shall be presented on the LCD panel at all times:
 - a. HPS identification: A user-programmable HPS identification of up to 45 characters.
 - b. HPS status
 - c. Highest priority active alarm
 - d. Highest priority active notice
 - e. Real-time clock, featuring time and date indications, which is programmable from the monitor panel
 - f. Real-time battery time available (in the event a utility outage occurs) for the critical load
 2. HPS Meter Screen – real-time metering of:
 - a. Rectifier/charger inputs: Voltage (per phase, RMS), current (per phase), frequency, kW, kVA, power factor.
 - b. HPS outputs: Voltage (per phase, RMS), current (per phase plus neutral), frequency, kW, kVA, power factor. Output voltage and current sensing shall be independent of the inverter controls.
 - c. Bypass inputs: Voltage (per phase, RMS).
 - d. DC link voltage
 - e. Battery charge and discharge current
 3. Output Current Screen: Bar graph display of the present output current of each phase.
 4. Event History Screen: Shall display up to 400 of the most recent events by date and time. Time shall be displayed in tenths of seconds (0.1 sec) and recorded in thousandths of seconds (0.001 sec). The screen shall define and display events as alarms, notices, commands or status. A brief description shall be provided for each event recorded on this screen. When a system event occurs, a message shall be added to the event history log. The message shall appear on the monitor panel of the HPS.
 5. Active Events Screen: Shall automatically display a list of active alarms and notices.
 6. Statistics Screen: This screen shall display the following:
 - a. Time on Battery: A record shall display the duration and frequency of utility outages in the life of the batteries and in the current month.
 - b. Building Alarms: A record shall display the frequency of each building alarm enunciation in the life of the HPS and in the current month.
 - c. Operational History: A record shall display the total amount of time the HPS module has been in the each of the following modes of operation: normal, bypass and battery. A record shall display the total amount of time the HPS has been on generator.
 - d. Availability: The observed availability of the normal mode shall be displayed. In addition, the availability of the bypass supply as a back-up source shall be displayed.
 - e. Start-up Date: The date the HPS module was initially energized shall be displayed.
- E. Control Panel: The HPS shall be equipped with a control panel providing the HPS control functions. (A key shall be required to turn on the HPS.) The following controls shall be provided on the control panel:
- F. Microgrid Controller: The HPS shall provide the following signals and communication features:
1. Alarm and Notice Contacts: Dry contacts for summary alarms and notices shall be provided for external use.
 - a. Alarm: Indicates the HPS is experiencing an alarm condition.
 - b. Notices: Indicates the HPS is experiencing a notice condition.
 2. RS-232 (EIA/TIA-232) and RS-485 Communications Interface: Circuitry shall be provided for one RS-232 (EIA/TIA-232) and one RS-485 communication port. These

ports may be used with simple terminals to gain remote access to all unit operation information.

3. Building Alarms: Six inputs shall be provided for monitoring the status of external dry contacts. Inputs shall be dedicated to monitoring external battery disconnect(s), monitoring an auxiliary generator to initiate the reduced input current limit feature, and monitoring the position of external maintenance bypass panel breakers. The remaining inputs shall be available for user-selected monitoring (smoke, temperature, water, etc.) if noted herein, or left as spare for future interface. Building alarms shall be set up through the HPS configuration mode function on the RS-232 (EIA/TIA-232) port. The building alarm feature shall also provide the following capabilities:
 - a. Building alarms shall allow the user to customize the building alarm message (up to 30 characters maximum), which appears locally on the monitor panel or remotely through the communication ports.
 - b. Building alarm feature shall be programmable to initiate a transfer of the HPS from normal mode to bypass mode upon contact closure.
 - c. Building alarm feature shall be programmable to initiate a transfer of the HPS from bypass mode to normal mode upon contact closure.

PART 3 - EXECUTION

3.1 FACTORY TESTING

- A. Before shipment, the manufacturer shall fully and completely test the system to ensure compliance with the specification. These tests shall include operational transfer and re-transfer tests to ensure guaranteed rated performance.
- B. A typewritten test report shall be submitted indicating the results of the individual tests satisfactory completion of the tests, and demonstration of HPS capability to support the load, as required by the specifications. During factory test all system's parameters shall be recorded.
- C. The manufacturer shall provide all necessary testing equipment including load banks rated for the full system (kW and kVA). All test instruments shall be calibrated and calibration labels shall be visible on all test equipment.
- D. The factory testing shall include standard testing and tests to demonstrate all operation procedures:
 1. General operation and functional test of the HPS: Verify that all operating controls, alarms, meters, circuit breakers, and mimic lights are functioning properly.
 2. Voltage Regulation: Record system output voltage at no load, half load, and full rated load.
 3. Efficiency: HPS efficiency shall be measured at the rated kVA and kW. The efficiency test shall be performed with the battery circuit breaker open. The efficiency shall be measured at 100 percent load.
 4. Input Current Distortion: Record the input current distortion of all three input phases of HPS.
 5. Output Voltage Distortion: Record the output voltage distortion of all three output phases of HPS system level at no load and full load.
 6. Transient Tests: Record output voltage, output current, bypass voltage, and bypass current during the transient tests of applying and removing 0 percent – 100 percent – 0 percent load.
 7. Transfer Load: Record output voltage, output current, bypass voltage, and bypass current during transfer from inverter to bypass and bypass to inverter with no load and 100 percent load.

8. Overload Test: Operate each module at 125 percent and 150 percent overload for the time specified.
9. Record all parameters indicated on the LCD panel under 0 percent, 50 percent and 100 percent load.

E. Owner's Factory Witness Testing

1. The manufacturer shall include provisions, airfare and lodging for the Engineer and Owner's Representatives to witness the factory test.
2. Provide a minimum of two weeks for notification of factory test date.

3.2 INSTALLATION AND FIELD TESTING

A. Installation shall be performed in accordance with manufacturer's instructions.

B. The HPS shall be tested in accordance with manufacturers site test procedures and as required by these Specifications. Provide metering devices to measure and document system voltage, current, and frequency parameters and response. A typewritten test report shall be submitted indicating the results of the individual tests, satisfactory completion of the tests, and demonstration of HPS capability to support the load as required by the specifications. During the site test all system's parameters shall be recorded. Site test procedures shall include the following:

1. The HPS manufacturer shall provide all necessary testing equipment including load banks rated for the full system kW. All test instruments shall be calibrated and calibration labels shall be visible on all test equipment.
2. Verify the integrity of the installation.
3. Ensure that no shipping damage has occurred.
4. Record and repair all defective and missing parts.
5. Visually inspect and confirm that proper grounding and bonding is installed in accordance with Code and per the manufacturer's recommendations.
6. Calibrate HPS metering.
7. Operation and Functional Test of HPS: Verify that all operating controls, alarms, meters, circuit breakers, mimic lights and remote alarms are functioning and reporting properly.
8. Transient Tests: Record output voltage, output current, bypass voltage and bypass current during the transient tests of applying and removing 0 percent – 100 percent – 0 percent load.
9. Transfer Load: Record output voltage, output current, bypass voltage and bypass current during transfer from inverter to bypass and bypass to inverter with no load and 100 percent kW load.
10. Record all parameters under 0 percent, 50 percent and 100 percent load.
11. Additional procedures as recommended by the manufacturer to test the options and accessories provided.

C. Hybrid Power System commissioning (including start-up and operational testing) shall be overseen by the Electrical Engineer, Hybrid Power System Engineer, and Commissioning Agent as needed to satisfy the requirements of the LEED NCv4 rating system.

D. Initial start-up commissioning to include:

1. Check shipment of hybrid power system equipment, ensure no damage was sustained in transit, and confirm all components are functioning as intended by manufacturer.
2. Verify internal wiring of battery system, including verification of appropriate polarity and equipment grounding.
3. Program of microgrid controller to provide for off-grid back-up power capability with battery system charging from solar and grid during normal operation.
4. Ensure proper wiring of AC hybrid power system equipment, including proper phase rotation of inverter interconnection with building electrical system and transformers.

5. Perform fully operational testing of hybrid power system through all phases of operation, including simulation of grid outage and off-grid start up, charging from grid, charging from solar in grid mode and standby mode, and providing power to loads in standby mode.
- E. Provide one year retrocommissioning to include:
1. Run diagnostics of battery system to determine battery health.
 2. Calibrate hybrid power system controls to add peak demand management function while maintaining full off-grid standby power capability.
 3. Use PG&E peak demand management program requirements and one year of building energy data (including performance of solar, batteries, and building energy) to optimize peak demand management performance.
 4. Document control statement and provide to building Owner.

END OF SECTION 26 3236

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