APPENDIX 2-4

ELECTRICAL ENGINEERING DESIGN CRITERIA

1.0 INTRODUCTION AND OVERALL SYSTEM CONFGURATIUON

Control of the design, engineering, procurement, and construction activities on the project will be completed in accordance with various predetermined standard practices and project specific programs/practices. An orderly sequence of events for the implementation of the project is planned consisting of the following major activities:

- Conceptual design;
- Licensing and permitting;
- Detailed design;
- Procurement;
- Construction and construction management;
- Start-up, testing, and checkout; and
- Project completion.

The purpose of this appendix is to summarize the codes and standards and standard design criteria and practices that will be used during the project. The general electrical design criteria defined herein form the basis of the design for the electrical components and systems of the project. More specific design information is developed during detailed design to support equipment and erection specifications. It is not the intent of this appendix to present the detailed design information for each component and system, but rather to summarize the codes, standards, and general criteria that will be used.

The Overall One Line Diagram for the Avenal Energy Project is shown on Figure 2.3-6, Drawing A3DV01-1-SL-6-00-1, Rev C.

The power plant 230 kV switchyard is configured as a radial bus scheme with the 230 kV transmission line to the PG&E Gates Substation directly connected to the power plant 230 kV switchyard bus. A 230 kV breaker will be used for each generator step up transformer.

GTG 18 kV generator breakers will be located in the GTG iso phase bus duct. Backfeed for plant start up will be obtained from the 230 kV system through the GTG main and unit auxiliary transformers.

The STG will have a 230 kV generator breaker.

A standby natural gas engine generator is indicated on the One Line Diagram to provide emergency power in the event of a grid failure.

2.0 CODES AND STANDARDS

All work will conform to the applicable provisions of the following Codes and Standards:

- American National Standards Institute (ANSI)
- Institute of Electrical and Electronics Engineers (IEEE)
- National Electrical Manufacturers Association (NEMA)
- American Society for Testing and Materials (ASTM)
- Underwriters Laboratories (UL)
- Factory Mutual (FM)
- Insulated Cable Engineers Association (ICEA)
- Association of Edison Illuminating Companies (AEIC)
- National Fire Protection Association (NFPA)
- National Electrical Safety Code (NESC) for 230 kV only
- National Electrical Code (NEC) Occupational Safety and Health Act (OSHA)
- Illuminating Engineering Society of North America (IESNA)

3.0 VOLTAGES

The in-plant distribution voltage levels will be:

- 230 kV PG&E Interconnection voltage
- 18 kV Gas and Steam Turbine Generator Voltage
- 4160 V system voltage and 4000 V motor voltage for motors 300 hp and above
- 480 V system voltage and 460 V motor voltage for motors from 3/4 hp to 250 hp and motor-operated valves
- 480 V, 3-phase, standby generator voltage
- 480 V, 3-phase, street or flood lighting
- 208/120 Vac, 3-phase, 4-wire, for indoor lighting, receptacles, space heaters, etc
- 120 Vac system voltage and 115 Vac motor voltage for motors 1/2 hp and below
- 120 Vac, single phase, UPS power

- 125 Vdc for protection systems, switchgear, breaker controls, UPS input power, and emergency lube oil pump motors
- 24 Vdc for DCS instrumentation and controls

4.0 POWER DISTRIBUTION CENTERS AND ELECTRICAL EQUIPMENT ENCLOUSURES

MV and LV switchgear, MV MCCs, batteries, chargers and UPS will be located in Power distribution centers (PDC) with HVAC or located in the Control Building with HVAC.

Enclosures for all equipment will be in accordance with NEMA Standards and will be suitable for their location as follows:

NEMA 1	Indoors (General Purpose)
NEMA 3R	Outdoors and Indoors in wet locations
NEMA 4	Outdoors and Indoors in wet or dusty locations (dust tight)
NEMA 4X	Outdoors and Indoors in wet and corrosive locations (corrosion resistant)
NEMA 7	Classified Areas, Class I, Div 1 Groups B and D
NEMA 12	Non-environmentally controlled indoor dusty areas

Power distribution centers (PDC) will house the electrical distribution equipment and DCS I/O racks and will be located near the equipment being served. The PDCs will be elevated above grade with sufficient space for cable trays and conduits to enter from below.

The plant PDCs will be factory assembled, wired, tested and operational metal enclosures containing various combinations of electrical power and control equipment. The PDCs will be sized for the equipment with vendor recommended operating and maintenance access. The PDCs will be furnished with heating and air conditioning, fire detection and alarm system, power distribution, lighting and grounding.

5.0 230 KV SWITCHYARD

The 230 kV power plant switchyard will be rated for a maximum voltage of 245 kV with insulators and clearances suitable for 900 kV BIL. The power plant switchyard is configured as a radial bus scheme with the 230 kV transmission line directly connected to the power plant 230 kV switchyard radial bus through a line disconnect switch. The three GSU 230 kV breakers will be SF6 puffer dead tank type rated 2000 A, 63 kAIC with dual trip coils, and 15-C800 relaying class and 3-0.3B1.8 class metering current transformers. All 230 kV disconnect switches will be rated 2000 A, 900 kV BIL, vertical break manually group

operated with porcelain post insulators.

Located between the line switch and the rigid bus will be three revenue metering class current transformers and three revenue metering class potential transformers.

A CASIO approved revenue meter (ION 8600A) will be connected to each of the 230 kV GSU breakers current transformers and to the bus voltage transformers. A CASIO approved revenue meter (ION 8600A) will also be connected to the 230 kV transmission line current transformers and the bus voltage transformers. These revenue meters will send required metering signals to both CAISO and to PG&E.

Three 192 kV (152 kV MCOV) lightning arrestors will be located on the 230 kV outgoing transmission line which will connect the Avenal Plant to the PG&E Gates Substation.

The 230 kV transmission line to the PG&E Gates Substation from the power plant switchyard will consist of bundled 954 kcmil ACSR conductors with an OPGW (Optical Ground Wire).

The 230 kV transmission line to the GSUs from the power plant switchyard will consist of 954 kcmil ACSR conductor with 7#8 AWG Al shield wires. Polymer line suspension insulators will be used for all line insulators.

Dual transmission line differential relays (GE L90 and SEL 311L) with distance backup functions will be connected to the breaker current transformers and bus potential transformers. The line protection scheme will use two independent communication paths: Direct fiber for L90 and direct fiber or Sonet digital communication path for SEL-311L.

Dual transformer differential relays (GE T60 and SEL 387A) with overcurrent backup functions will have inputs from the breaker and GSU or UAT current transformers.

Separate breaker failure relays (SEL-352) will be provided on each breaker.

The 230 kV switchyard will have the following SCADA devices: (1) communications processor (SEL-2032) will be used to communicate data to the DCS, (2) remote intelligent gateway (RIG) will be used to communicate data to CAISO and (3) WAN suite 5339 device will be used to communicate data to PG&E.

Dual 125 Vdc battery systems with redundant battery chargers will provide the breaker and relaying dc power.

The switchyard will have 480 V station service power supplied from the power plant 480 V MCC's. The grounding system design will be per IEEE-80 guidelines. Lightning protection for the switchyard will be provided in accordance IEEE 998.

6.0 POWER TRANSFORMERS

The GTG Generator Step Up Transformers will have the following features:

US Standards: ANSI/IEEE/NEMA/ASTM/OSHA /UL
Max Ambient temp 40 Deg C, Daily Average Ambient temp 30 Deg C
Seismic Zone 4
60 Hz, 3- Phase
18 kV Delta to 238 kV Grd wye
132/176/220 MVA, ONAN/ONAF/ONAF, 65 Deg C
Z = 9 % (132 MVA)
HV De-energized full capacity taps plus minus 2 x 2 1/2 %
HV BIL = 825 kV, LV and HO BIL = 150 kV
HV Composite Silicone rubber bushings, Trench or equal
HV Metal Oxide Polymer lightning arrestors rated 192 kV (152 kV MCOV)
LV will be IPB connected to cover mounted bushings
Conservator oil preservation system with bladder and silicon gel breather
Qualitrol gauges and oil and temp and gas accumulation alarm relays
Qualitrol sudden pressure relay
Two 12 point Seekirk annunciators
Two 480 V power supplies with auto transfer circuitry
One 125 Vdc power supply for sudden pressure relay seal in circuit
Morgan Schaffer Type Calisto Transformer fault gas and water in oil monitor
ANSI stnd factory tests including heat run and noise test on one unit
Oil to be supplied by tanker truck to jobsite

The STG Generator Step Up Transformer will have the following features:

US Standards: ANSI/IEEE/NEMA/ASTM/OSHA /UL
Max Ambient temp 40 Deg C, Daily Average Ambient temp 30 Deg C
Seismic Zone 4
60 Hz, 3- Phase
18 kV Delta to 238 kV Grd wye
234/312/390 MVA, ONAN/ONAF/ONAF, 65 Deg C
Z = 9 % (234 MVA)
HV De-energized full capacity taps plus minus 2 x 2 1/2 %
HV BIL = 825 kV, LV and HO BIL = 150 kV
HV Composite Silicone rubber bushings, Trench or equal
HV Metal Oxide Polymer lightning arrestors rated 192 kV (152 kV MCOV)
LV will be IPB connected to cover mounted bushings
Conservator oil preservation system with bladder and silicon gel breather

Qualitrol gauges and oil and temp and gas accumulation alarm relays
Qualitrol sudden pressure relay
Two 12 point Seekirk annunciators
Two 480 V power supplies with auto transfer circuitry
One 125 Vdc power supply for sudden pressure relay seal in circuit
Morgan Schaffer Type Calisto Transformer fault gas and water in oil monitor
ANSI stnd factory tests including heat run and noise test
Oil to be supplied by tanker truck to jobsite

Unit Auxiliary Transformers:

The unit auxiliary transformers will be 3-winding oil filled, sealed tank type, with ± 2 x 2 ½ % HV winding de-energized full capacity taps (DETC) with the ratings indicated on the Overall One Line Diagram.

The HV winding will be connected delta and the LV winding will be connected low-resistance grounded Wye.

Station Service Transformers:

The station service transformers will be 2-winding oil filled , sealed tank type, with ± 2 x 2 ½ % HV winding de-energized full capacity taps (DETC) with the ratings indicated on the Overall One Line Diagram.

The HV winding will be connected delta and the LV winding will be connected high-resistance, grounded Wye with a pulsed ground detection scheme.

7.0 GENERATOR BREAKERS AND GENERATOR LEADS

GTG generator breakers will be rated at least 105% of the maximum GTG generator output at 100% voltage and be supplied with dual trip coils, isolation switches, potential and current transformers.

The iso-phase bus will be aluminum conductor and braced for the maximum available fault current for each section of bus. The iso-phase bus will be rated at least 105 % of the rated generator output at 100% voltage with total temperature limits of 80 Deg C on the enclosure and 105 Deg C on the conductor.

Filtered drains will be provided at bus duct run low points and at transformer flanges.

The bus PT's, surge capacitors and lightning arresters located between the generator breaker and the main transformer will be integrated in the generator breaker.

8.0 GENERATOR PROTECTION AND METERING

Each GTG and STG will have two (2) generator multifunction protective relays as follows: one relay type Beckwith M-3425 and one relay type GE G60. The M-3425 relay will trip 86G1A and 86G2A lock out relays. The G60 relay will trip 86G1B and 86G2B lock out relays.

Each GTG will also have one GE C60 generator breaker multifunction relay with generator and bus VT inputs for generator breaker failure (50/62BF), reverse energization (50/27), generator bus ground over voltage (59BN) functions, and breaker sync check close permissive. The GE C60 relay 50/62BF output will trip an 86BF lock out relay and the 50/27 output will trip an 86RE lock out relay. The C60 relay 59BN relay will trip an 86B lockout relay.

Each GTG and STG will have a Nexas 1250 multifunction meter with outputs sent to the turbine control system and DCS.

GTG metering and relaying panels will be located in the GTG control module.

STG metering and relaying will be on a control panel located in the control building.

9.0 MEDIUM VOLTAGE SWITCHGEAR AND MCC's

Medium voltage switchgear will use vacuum draw out circuit breakers. Power bus will be copper and will be insulated with flame retardant, non-hygroscopic insulation. Two high construction may be used.

Main incoming breakers and transformer feeder breakers will be locally controlled using a 30-foot umbilical cord control station.

Each motor feeder fused controller will be NEMA E2 with vacuum contactors. Power bus will be copper and will be insulated with flame retardant, non-hygroscopic insulation. The MCC will use microprocessor based motor relays (SEL -710) with motor RTD alarms and a relay common alarm sent to the DCS. The motor feeders will be controlled remotely only from the DCS.

Each unit auxiliary transformer will be protected by a microprocessor based differential protection, overcurrent and main breaker failure transformer management relay (SEL-387A) which will trip the switchgear incoming breaker, the generator breaker and the associated switchyard breaker via lockout relays.

Each transformer feeder will be protected by a microprocessor based feeder protection relay (SEL-551) which will trip the associated breaker via a lockout relay.

Multifunction digital metering (Nexas 1250) will be used on switchgear incoming breakers. Ammeters will be provided for motors through the motor relays.

A manual bus transfer scheme, with make before break circuitry with momentary paralleling of the two unit auxiliary transformers (UAT), will be provided on the medium voltage switchgear.

The Chiller 4160 V switchgear will be radially fed from two separate transformers as indicated on the Overall One Line.

10.0 LOW VOLTAGE SWITCHGEAR

The low voltage switchgear will be indoor, metal-enclosed type. Power bus will be copper and will be insulated with flame retardant, non-hygroscopic insulation.

All main and tie breakers will be electrically operated and locally controlled at the switchgear. Main breakers will have multifunction digital meters (V, A, W and Var).

Feeder breakers will be manually operated.

Each breaker will have local digital ammeters incorporated into the solid state trip unit.

A manual bus transfer scheme with make before break circuitry with momentary paralleling of the two auxiliary transformers will be provided on the low voltage switchgear.

The ACC 480 V switchgear will be radially fed from two separate transformers as indicated on the Overall One Line.

11.0 LOW VOLTAGE MOTOR CONTROL

Motor controllers for indoor installations will be metal enclosed, freestanding, dead front, NEMA 1 type motor control centers with NEMA Type B wiring.

The motor contactors will be controlled remotely from the DCS where dictated by the process control requirements.

Controllers for 115 volt single phase motors will be manual motor starters, except in special cases where magnetic contactor type starters are used.

Controllers for low voltage three phase motors will be the combination type consisting of a motor circuit protector (MCP) and a magnetic contactor with electronic overload relays and control transformers. The minimum contactor size will be NEMA Size 1.

12.0 AREA CLASSIFICATION

Area classification will be as defined by the National Electrical Code supplemented by the recommendations in the National Fire Protection Association Standard NFPA and API.

Areas will be classified where required as Class I, Division 2, Group D (and Group B when the fuel contains more than 30% hydrogen by volume).

Generator hydrogen control cabinets, valves and storage bottles will be classified as Class I, Division 2.

13.0 WIRE AND CABLE

Medium voltage cable will be rated 25 kV or 5 kV, 90 Deg C, stranded copper conductor, EPR insulation (133% level), copper tape shield and PVC cable jacket.

Multiconductor control and power cable will be rated 600 volts, 90 Deg C, stranded copper conductors, XLP or EPR insulation, and a PVC cable jacket.

Single conductor wire and cable will be rated 600 V, 90 Deg C, and will have XLP or EPR insulation and a PVC cable jacket. Single conductor wire (#8 AWG and smaller) used for lighting, receptacles, field jumpers and internal wiring will be non-jacketed, and will have FREP insulation with appropriate UL flame test.

Single pair instrument cable will be rated 600 V, and will have XLP insulation, PVC cable jacket.

Multipair instrument cable will be rated 600 V, and will have XLP insulation, twisted shielded pairs with drain wires, overall shield with drain wire, and a PVC cable jacket.

Thermocouple extension cable will be rated 300 V, and will be solid alloy conductor with XLP or PVC insulation, individual pair shield, overall shield and a PVC cable jacket.

Control panel wiring will be insulated with 600 V NEC type SIS insulation. Panel wiring will have wire numbers for identification.

The allowable ampacity of power cables will be in accordance with ICEA and NEC requirements.

Lighting and fixture cable will be furnished with 600 volt insulation.

Cables installed in cable trays will have insulation and jacket materials which have non-propagating and self-extinguishing characteristics to minimize possible damage caused by cable fires. As a minimum, these cables will meet IEEE 1202 flame test requirements. All cables installed in cable tray will be rated for such installation.

14.0 LIGHTING

The lighting system will be designed in accordance with Illuminating Engineering Society of North America (IESNA) illumination level recommendations. All outdoor lighting will be controlled by photocells. Self-contained battery backed emergency lighting and exit signs will be furnished to provide safe personnel egress from buildings during a total loss of plant power. Emergency lighting will be designed to maintain the necessary illumination for a minimum of 90 minutes.

The lighting system will be designed in accordance with Illuminating Engineering Society of North America (IESNA) with a 0.8 maintenance factor.

Outdoor lighting will be sodium vapor fixtures controlled by photocells.

Self-contained battery backed emergency lighting and exit signs will be furnished to provide personnel egress from buildings during a total loss of plant power.

Emergency lighting will be designed to maintain the necessary illumination for a minimum of 90 minutes.

Illumination levels shall be measured horizontally at floor or grade level. IES recommended methods of calculation and maintenance factor shall be used. Maintained in-service lighting levels shall be as follows:

LOCATION	FOOTCANDLES (fc)
Control Room	50 (Adjustable)
Outdoor Operating Area	15
Switch rooms	50
Stairways and Ladders (active)	5
General Outdoor Area	2

15.0 SIGNAL SEPARATION

The conduit and tray segregation and minimum spacing requirements for parallel runs will generally follow Table 2 of the Process Industry Practice PIP PCCEL001.

16.0 CONDUIT AND CABLE TRAY

Underground conduits will be PVC Schedule 40. Underground conduits will be encased in concrete encased duct bank.

Aboveground conduit will generally be RGS. PVC coated RGS conduit may also be used in corrosive areas. Aboveground conduit will be ¾ inch minimum except ½ inch flexible conduit may be used to connect to instruments or devices with ½ inch conduit connections as required.

Electrical Metallic Tubing (EMT) will be used for indoor applications, for example in the control and administration buildings, where the conduit is not subject to physical damage.

Cable trays will be galvanized steel or aluminum ladder type. Ventilated tray covers will be used where mechanical protection is necessary, such as vertical tray outside risers above

finished floors or top of trench up to 8 feet, and for top layers of horizontal trays beneath grated platforms or walkways.

Cable tray supports will be per NEMA VE-1.

Connections to equipment requiring removal from service or subjected to vibration or movement will be made with flexible conduit. Liquid tight flexible metal conduit and approved fittings will be used for outdoor and indoor equipment.

Open tray channel may be used for branching cables from the main tray runs to the equipment.

17.0 GROUNDING

System grounding will be as follows:

GSU	GSU Transformer High Voltage Neutral Solidly grounded
Generator	Generator neutral high resistance grounded
Medium Voltage	Low resistance grounded (400 A, 10 sec)
Low Voltage	High resistance grounded with pulse ground detection
Lighting	Solidly grounded
125 Vdc	Ungrounded with ground detection and alarms

A copper grounding grid consisting of driven ground rods interconnected by bare #4/0 AWG copper conductors to form a complete grounding system for the plant will be installed. Grid interconnections will be approved compression type connectors.

Fences will be grounded at every other post by #2 AWG bare copper conductors connected to plant ground grid.

The plant grounding system design will be per IEEE-80 guidelines.

The plant Distributed Control System (DCS) will be supplied with an isolated ground system that will be tied to the plant ground grid at one location.

Lightning protection for the facility will be provided in accordance with UL 96 & UL 96A.

18.0 UPS SYSTEM

UPS systems will have a single-phase inverter sized for the maximum operating load. The inverter will be fed from the 125 Vdc batteries.

A static switch and manual by-pass switch will be located in the inverter cabinet.

Two alternate source transformers will be provided: one for the inverter bypass source and one for the back up power supply source. The DCS loads will be normally fed from the UPS backed essential panelboard. The DCS back up power supply is from a panelboard fed from a normal ac source.

UPS distribution panels will supply the DCS and instrumentation power supply loads.

19.0 125 VDC SYSTEMS

125 Vdc battery systems using flooded (watering type) batteries will be sized to provide 125 Vdc power per the required load profile.

The UPS load on the batteries will have load profile duration of 30 minutes for safe plant shutdown. In the event of a utility grid failure, the emergency diesel generator will be able to supply power to the UPS isolation transformers in less than 30 minutes.

Dual battery chargers, sized to recharge a fully discharged battery in 24 hours, will feed each battery.

The 125 Vdc station batteries will be located in a separate battery room located in the control building. The battery room will be provided with sufficient ventilation to prevent the accumulation of an explosive mixture of gases.

Each GTG will have its own dedicated 125 Vdc battery system located in the GTG control module.

20.0 RECEPTACLES

All 120 V outdoor receptacles will be fed from GFCI type circuit breakers. All 120 V receptacles will be located so that equipment at grade can be reached with a 75 foot cord.

480 V Welding receptacles will be located within maintenance areas, at the power island pipe rack and in the gas turbine areas so that equipment can be reached with a 100 foot cord.

21.0 PLANT COMMUNICATION SYSTEM

In plant communications will be via the Owner’s portable equipment. The plant telephone system will consist of a main telephone board, termination blocks, telephone outlets and Owner supplied handsets. A motorized operator will control the main gate. The main gate operator will include inputs from control room and receptionist switches, and a local keypad

or card reader station. An intercom system will be provided to allow voice communications between the main gate and the control room.

22.0 PLANT TELEPHONE SYSTEM

The plant telephone system will consist of a main telephone board located in the Control/Administration Building, telephone outlets, and handsets.

A telephone outlet will be provided in each PDC.

23.0 ELECTRICAL EQUIPMENT ALARMS

Where applicable, common electrical equipment digital alarms and breaker status signals will be monitored by the DCS.

24.0 CATHODIC PROTECTION

A sacrificial anode type cathodic protection system will be provided as necessary to protect metallic piping, tanks and structures from galvanic corrosion. Cathodic protection equipment will be applied in accordance with resistance and chemical characteristics of the soil as given in the geotechnical study. Electric Power Research Institute (EPRI) and the National Association of Corrosion Engineers (NACE) guidelines will be used in establishing the necessity, type and extent of cathodic protection equipment.

25.0 FIRE DETECTION AND ALARM SYSTEM

A Fire Detection and Alarm System will be provided in accordance with the requirements of NFPA.

26.0 STANDBY NATURAL GAS ENGINE GENERATOR

A 480 V, 500 kW, 0.8 PF standby natural gas generator in an outdoor enclosure will be connected to a 480 V Essential Service MCC through an ATS to supply essential service power to the battery chargers, UPS, heat tracing, and control room lighting loads.

A Local Control Panel (LCP) will be located on base with standard microprocessor based engine and generator controls, interlocks, metering, alarms, and synchronizing system. Remote control of the diesel generator will be from DCS operators via a fiber optic cable to the Vendors control system.