1.0 GENERAL

1.1 Related UBC Guidelines

.1 Division 7
.2 Division 25
.3 Division 26

1.2 Coordination Requirements

.1 UBC Facilities Electrical (Vancouver)
.2 UBC Facilities Management (Okanagan)

1.3 Description

.1 UBC Requirements for rooftop Solar Photovoltaic (PV) systems

1.4 Definitions

.1 Unless otherwise specified or indicated, electrical terminology used in this specification shall be as defined by the latest EGBC adopted version of the Canadian Electrical Code C22.1, Part I.

2.0 MATERIALS AND DESIGN REQUIREMENTS

2.1 General Requirements

.1 The Solar PV System shall be connected to the UBC electrical grid at 120/208 volts AC.

.2 All design, material procurement, and construction shall be completed in accordance with CSA, IEEE, NEMA, and local codes, as specified in the UBC Technical Guidelines, and as shown in the drawings.

.3 The total nameplate module power (total installed DC capacity) for the Solar PV System shall be 100 kW DC or less, with consideration for host facility loads and limited export. This is determined without estimating bifacial gain.

.4 Proponent shall provide a simulation production report using PVsyst or Helioscope as a part of the bid package. Refer to section 2.9 Simulation Production Report Parameters.

.5 Proponent shall provide ETAP simulation to show impacts of project within existing UBC model. Current model shall be provided by UBC.

.6 The sum of the maximum DC and maximum AC wiring voltage drop from photovoltaic source circuits to the points of interconnection shall not exceed 3.0%.

.7 Voltage drop calculations shall be as outlined in the Canadian Electrical Code and include all vertical and horizontal lengths, resistivity values, and a 7.0% slack factor.

.8 All terminals used for all power conductors within the Solar PV System shall be rated CU9AL.

.9 All equipment exposed to direct sunlight and environmental elements shall be outdoor-rated and sunlight-resistant.

.10 All equipment shall be installed and protected to maintain its enclosure protection rating.

.11 All AC electrical distribution used for the Solar PV System shall be sized for continuous load at 100% of PV inverter nominal AC power.

.12 All female and male PV connector connections shall be mated pairs from the same manufacturer and model family.

.13 Rodent protection of PV conductors is required as per CEC Rule 64-210 5). The proposed solution (enclosed wireway, mesh, split loom, etc.) shall be reviewed and approved by UBC and TSBC during the design phase and prior to procurement. The proposed solution shall be designed and installed with materials and in a manner to last the life of the project. An estimate of bifacial loss due to the proposed solution shall be provided by the design-builder as a part of simulation and performance verification activities.

.14 The Solar PV System shall be designed such that access for maintenance, repair and testing of the system does not require personnel-lifts or fall protection. The entirety of the system shall be located at least 3 meters from a fall hazard or unprotected edge (Any side or edge (except points of access) of a walking/working surface where there is no wall or guardrail system at least 1070mm or parapet at least 1.2m high).

.15 The Solar PV System shall allow for access to other equipment and systems (mechanical, envelope, etc.) for maintenance and replacement without requiring personnel-lifts or fall protection.

.16 Exemptions to design requirements will be considered on a case-by-case basis by UBC.

2.2 DC Wire and Wire Management Specifications

.1 Characteristics of the PV wiring shall be:
- .1 Copper
- .2 RPVU90, XLPE, CSA approved.
- .3 1000V rated.
- .4 Sunlight resistant.
- .5 -40°C to 40°C ambient temperature rated.
- .6 90°C operating temperature rated.
- .7 Red for positive, black for negative

.2 Characteristics of the PV wire management shall be:
- .1 Cables shall be run to connect adjacent panels using the leapfrog method.
- .2 Cables at the source circuit shall be permitted to be routed along PV module frames and racking system with or without a raceway but must be protected from damage.
- .3 Cables beyond 300mm of the array must be in a raceway.
- .4 Cable runs shall be continuous, and splices are not permitted.
- .5 Cables shall be protected from any sharp edges by use of protective grommets.

2.3 PV Combiner Specifications

.1 Solar PV systems incorporating combiners will be evaluated on a case-by-case basis, combiners generally used for larger, utility-scale projects and applications.

.2 Characteristics of PV combiners shall be:
- .1 PV Combiner Type
  - .1 Disconnect Combiner.
  - .2 Ungrounded PV.
  - .3 Positive and Negative Fused.
  - .4 Continuous Rated.
- .2 Safety Features
  - .1 Load Break Rated and Lockable DC Disconnect.
  - .2 Dead Front Over Live Parts.
  - .3 Lockable Cover.
  - .4 Touch-Safe Fuse Holders.
  - .5 Transient Surge Protection.
  - .6 90 °C terminals (source and output).
- .3 Enclosure Protection Rating
  - .1 NEMA 3R or 4X.
- .4 Certifications and Approvals
  - .1 CSA C22.2 107.1 Power Conversion Equipment.
  - .2 UL 1741 Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources.
- .5 DC-AC Ratio
  - .1 Rated maximum DC current shall allow for DC-AC ratio of connecting PV inverter to be 1.4 or greater.
- .6 Operating Temperature Range
  - .1 Minimum temperature shall be -25°C or lower.
  - .2 Maximum temperature shall be 40°C or higher.
- .7 Storage Temperature Range
  - .1 Minimum temperature shall be -40°C or lower.
  - .2 Maximum temperature shall be 60°C or higher.
- .8 Manufacturer Warranty
  - .1 Standard shall be 5 years or longer.
  - .2 Optional extensions shall be available.

.3 Approved manufacturers of photovoltaic combiners are as follows:
- .1 SolarBOS.
- .2 Bentek Solar.
- .3 Additional manufacturers will be considered at the discretion of UBC.

.4 Depending on selection of PV inverters, PV combiners may not be required.

2.4 PV Module Specifications

.1 Characteristics of the PV modules shall be:
- .1 Module Type
  - .1 Bifacial or monofacial.
  - .2 Mono-crystalline or poly-crystalline silicon.
  - .3 60 or 72 full-cell modules.
  - .4 Anodized aluminum frame.

.5 Anti-glare glass.
.6 Potential Induced Degradation-free certified.

.2 Module Power
.1 Front-side STC power shall be 375 watts DC or greater.
.2 Power tolerance shall be positively sorted.

.3 Maximum System Voltage
.1 UL rated for 1500 volts DC or greater. IEC ratings are not acceptable.

.4 Junction Box Protection Rating
.1 IP 67 or IP 68.

.5 Certifications and Approvals
.1 ULC/ORD C1703 Standard for Flat-Plate Photovoltaic Modules and Panels.

.6 Module Efficiency
.1 Front-facing STC efficiency shall be 19% or greater.

.7 Bifaciality Ratio
.1 Module power bifaciality shall be 70% or greater.

.8 Temperature Coefficients
.1 Maximum power temperature coefficient shall be higher than -0.36% per °C.
.2 Open-circuit voltage temperature coefficient shall be higher than -0.30% per °C.
.3 Short-circuit current temperature coefficient shall be lower than 0.06% per °C.

.9 Operating Temperature Range
.1 Minimum temperature shall be -25°C or lower.
.2 Maximum temperature shall be 85°C or higher.

.10 Mechanical Loading
.1 Front side maximum static loading shall be rated for 5400 Pa or higher.
.2 Rear side maximum static loading shall be rated for 2400 Pa or higher.

.11 Manufacturer Warranty
.1 Standard product warranty shall be for 12 years or longer.
.2 Standard performance warranty shall be linear and for 25 years or longer.
.3 At the end of year 1, actual power output shall be guaranteed for greater than 97.4% of the front-side STC power. (low Light Induced Degradation)
.4 At the end of year 25, actual power output shall be guaranteed for greater than 80% of the front-side STC power.
.5 For installations lower than -25°C, manufacturer letter required stating extreme minimum that is compliant with warranty

.2 Approved manufacturers of PV modules are as follows:
.1 Canadian Solar.
.2 Hanwha Q Cells.
.3 LG.
.4 Longi Solar.
.5 Trina Solar.
.6 Jinko Solar.
.7 Additional manufacturers will be considered at the discretion of UBC.

2.5 PV Inverter Specifications

.1 Characteristics of the PV inverters shall be:

.1 Voltage

.1 PV inverters shall be 3 phase only.

.2 PV inverters shall be rated for 120/208 volts AC.

.3 AC connection topology shall be grounded-wye, with or without neutral.

.2 Safety Features

.1 DC Reverse Polarity Protection.

.2 DC AFCI Arc-Fault Protection.

.3 Remote Disable for Rapid Shutdown.

.4 DC Ground Fault Protection.

.5 DC Disconnect.

.6 Grid-Interactive Protection Features (IEEE 1547 compliant).

.3 Enclosure Protection Rating

.1 NEMA 3R or 4X.

.4 Interconnection Standards

.1 IEEE 1547-2018 Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces.

.5 Certifications and Approvals

.1 CSA C22.2 107.1 Power Conversion Equipment.

.2 UL 1699B Standard for Photovoltaic (PV) DC Arc-Fault Circuit Protection.

.3 UL 1741-SA Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources.

.6 Efficiency

.1 California Energy Commission (CEC) determined efficiency shall be 97.0% or greater.

.7 DC-AC Ratio

.1 Rated maximum DC power to AC nominal power shall be 1.4 or greater.

.8 Operating Temperature Range

.1 Minimum temperature shall be -25°C or lower.

.2 Maximum temperature shall be 60°C or higher.

.9 Storage Temperature Range

.1 Minimum temperature shall be -40°C or lower.

.2 Maximum temperature shall be 60°C or higher.

.10 Manufacturer Warranty

.1 Standard shall be 5 years or longer.

.2 Optional extensions shall be 15 years or longer.

.3 For installations lower than -25°C, manufacturer letter required stating extreme minimum that is compliant with warranty.

.4 Manufacturer shall provide letter and custom nameplate labels for de-rated inverters.

.11 Grid Support Features

.1 Low/High Voltage Ride-Through Capability.

.2 Low/High Frequency Ride-Through Capability.
.3 Non-Unity (Reactive) Power Factor Capability.

.12 Monitoring and Control
.1 PV inverters shall have read and write capabilities to communicate with the monitoring and control platform.

.13 Connectivity and Configuration
.1 PV inverters shall communicate with the monitoring and control platform and be configured via ethernet port.
.2 Where an ethernet connection is not possible, Bluetooth connectivity requirements shall be provided to UBC IT for review prior to selection.
.3 Where required, Bluetooth connectivity shall only be enabled for configuration of PV inverters, and shall be disabled once configuration is complete.

.2 Approved manufacturers of PV inverters are as follows:
.1 SMA.
.2 Sungrow.
.3 Fronius.
.4 Additional manufacturers will be considered at the discretion of UBC.

2.6 Weather Station Specifications

.1 Minimum sensor requirements of the weather station shall be, but not limited to the following:
.1 Plane-of-array (POA) Pyranometer.
.2 Ambient Temperature Sensor.
.3 Cell Temperature Sensor.
.4 Wind Direction Sensor.
.5 Wind Speed Sensor.

.2 Approved manufacturers of weather stations are as follows:
.1 Campbell Scientific.
.2 Hoskin Scientific.
.3 Hukseflux.
.4 Kipp and Zonen.
.5 Additional manufacturers will be considered at the discretion of UBC.

.3 Monitoring and Control
.1 Weather station shall have read and write capabilities to communicate with the monitoring and control platform.

.4 Certifications and Approvals
.1 All weather station components to be certified for use in Canada (CSA, ULC, ETLC, or TUVC).

2.7 Monitoring and Control Platform Specifications

.1 Characteristics of the monitoring and control platform shall be to:
.1 Measure and monitor all inverters within the system.
.2 Provide an illustrative display of the status, power flows, and environmental impact of the system.
.3 Provide multi-level fault reporting to UBC personnel based on measured data and reading device fault and alarm registers.

.4 Provide local access to monitoring and control platform via ethernet port for connection to a laptop.
.5 Provide SIM/cellular data connection for internet access where required.
.6 Bluetooth connectivity for configuration and commissioning only shall require UBC IT review.

.2 Approved manufacturers of monitoring and control platforms are as follows:
.1 Fronius Smart Meter
.2 Cachelan
.3 Meteocontrol
.4 AlsoEnergy
.5 Additional manufacturers will be considered at the discretion of UBC.

2.8 Integration with Building Management Systems

.1 Provide a bi-directional meter for each project, refer to requirements listed in Division 25 Building Management Systems (BMS) Design Guidelines.
.2 Provide contact-based connection to BMS to allow for monitoring of PV system.
.3 Provide required information to reprogram existing building protection relays to meet EWS requirements for bi-directional power flows.

2.9 Rooftop Racking Specifications

.1 Characteristics of the rooftop racking system shall be:
.1 Aluminum rails.
.2 Ballested.

.2 Approved manufacturers of racking systems are as follows:
.1 Terragen
.2 Polar Racking
.3 Kinetic

.3 Certifications and Approvals
.1 CSA SPE-900-13 Solar photovoltaic rooftop-installation best practices guideline.

2.10 Simulation Production Report Parameters

.1 The Geographical Site shall be West Point Grey, Canada
.2 Parameters for the simulation production report shall be as follows:

Table 1 Summary of Simulation Report Parameters

MODEL PARAMETER	INPUT/VALUE	NOTES
PVsyst Version	7.2 or newer	Other variants should be verified before use
Project Location	As per design	
Meteorological Data	West Point Grey, Meteonorm 8.0 ,Sat=100% - Synthetic	
Module	As per design	
Inverter	As per design	
DC Capacity	As per design	
AC Inverter Capacity	As per design	
Racking Configurations and Dimensions	As per design	

Tilt Angle	As per design	
Azimuth	As per design	
Horizon	Free Horizon	
3-D Model/Near Shading	2-D Layout	
Transposition Model	Perez	
Bifacial Setting – Albedo	Concrete 0.35	
Bifacial Setting – Height	As per design	
Bifacial Settings - Rear Shading Factor	Industry Standard Value - 8.5%	Update Rear Shading Factor based on design.
Bifacial Settings – Rear Mismatch Loss	Industry Standard Value - 6.0%	Update Rear Mismatch Loss based on design.
Bifacial Settings - Bifaciality Factor	As per design	
Bifacial Settings – Transparency	0%	
String Length	As per design	
Sub Arrays	As per design	
Soiling Loss	As per Table 2 or Townsend model	
IAM	Default or Module manufacturer provided	
Thermal Loss Factor	Constant Value - 29.0 W/m^2k Wind Value – 0 $W/m^2k/m/s$	
LID (Light Induced Degradation)	2%	
Module Quality Loss	Module datasheet	
Module Mismatch	2%	
Global DC Losses at STC	As per design	
AC Losses at STC	As per design	
Transformer Losses – Iron Loss	Transformer datasheet	
Transformer Losses – Resistive/Inductive Losses	Transformer datasheet	
Auxiliaries Losses	As per design	
Availability Loss	0%	To be accounted for by Owner
Grid Power Limitation	As per design	
Power Factor	As per UBC requirements	

Table 2 Array Soiling Losses

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
16.4%	7.7%	2.6%	2%	2%	2%	2%	2%	2%	2%	5.7%	17.9%

The above soiling losses are to be used for projects where soiling is not estimated on a site-specific basis. The above soiling losses are not applicable for ground-mount projects.

3.0 ACCEPTANCE TESTING

.1 Photovoltaic module manufacturer, photovoltaic combiner manufacturer, inverter manufacturers, and weather station manufacturer shall provide factory test reports for the procured equipment for UBC's review and approval.

.2 Acceptance testing shall include, but not limited to the following:
  .1 IV Curve Tracing

.1 Commissioning personnel shall IV curve trace each PV string to demonstrate acceptable performance of the photovoltaic modules across the possible range of voltage and current levels.

.2 System Performance Testing

.1 Commissioning personnel shall demonstrate over 3 separate days that the measured exported energy from the solar photovoltaic system is greater than 90% of the modeled exported energy determined by the as-built solar simulation model using the same meteorological dataset.

.2 During the testing period, the following variables shall be measured and recorded:

.1 Weather conditions
.2 Time
.3 Irradiance
.4 Temperature
.5 Output power

.3 The expected output power shall be calculated from the following formula:

$P_E = P_{STC} \times (I_{MEASURED} / I_{STC}) \times [1 + (C_T \times (T_C – T_{STC}))] \times PF \times D_T$

where:

P_E = the expected instantaneous output power
P_{STC} = the module power rating at STC multiplied by the number of modules
I_{STC} = the irradiance at STC (1000 W/m2)
C_T = the module temperature coefficient
T_{STC} = the module temperature at STC (25°C)
PF = power factor set (as required by UBC)
D_T = total calculated system derate factor

D_T is determined as a sum of the following derate factors:
Average Module Quality
Module Mismatch
CEC Inverter Efficiency
DC Wire Losses
AC Wire Losses
Weighted Transformer Efficiency
Annual Average Soiling
Light Induced Degradation
Yearly Degradation

For an example of how D_T is calculated, see Table 3 below:

Table 3 Example Derate Factors

Description	**Loss**
Average Module Quality	-0.98%
Module Mismatch	0.4%
Inverter Efficiency Loss	3.5%
DC Losses	1.5%
AC Losses	1.0%
Transformer Loss	2.0%
Annual Average Soiling	2.0%
Light Induced Degradation	1.5%
Yearly Degradation	0.7%
Total Calculated System Derate D_T	**88.38%**

.4 All system derate factors shall be approved by UBC prior to their use in performance testing.

.3 Local Command Testing
.1 Commissioning personnel shall demonstrate that the solar production system can accept commands to transfer between grid-interactive and standalone modes.

.4 Power Quality Testing
.1 Commissioning personnel shall demonstrate that the solar photovoltaic system complies with the frequency, voltage, power factor, and harmonic distortion requirements of UL 1741 in both grid-interactive and standalone modes.

.5 Anti-Islanding Testing
.1 Commissioning personnel shall demonstrate that the solar photovoltaic system complies with the anti-islanding requirements of UL 1741 in both grid-interactive and standalone modes.

.3 Deliver the following documents on completion of the project:
.1 As-built drawings
.2 Shop drawings
.3 Manufacturer Operating and Installation Manuals
.4 Datasheets
.5 Warranties
.6 Additional Maintenance instructions, as applicable.

*****END OF SECTION*****