HUNTER WATER CORPORATION

STANDARD TECHNICAL SPECIFICATION

STS 501

Solar Photovoltaic (PV) Systems

This Standard Technical Specification was developed by Hunter Water Corporation to be used for the design, construction/installation and/or maintenance of facilities that are, or are to become, the property of Hunter Water Corporation. It is intended that this Technical Specification be used in conjunction with various other standard and project specific drawings and design requirements as defined by Hunter Water Corporation for each particular project.

Hunter Water Corporation does not consider this Technical Specification suitable for use for any other purpose or in any other manner. Use of this Technical Specification for any other purpose or in any other manner is wholly at the user's risk.

Hunter Water Corporation does not assume a duty of care to any person using this document for any purpose other than stated.

In the case of this document having been downloaded from Hunter Water Corporation's website;

- Hunter Water Corporation has no responsibility to inform you of any matter relating to the accuracy of this Technical Specification which is known to Hunter Water Corporation at the time of downloading or subsequently comes to the attention of Hunter Water Corporation.
- This document is current at the date of downloading. Hunter Water Corporation may update this document at any time.

1 Purpose

This standard technical specification (STS) details the requirements of Hunter Water Corporation (Hunter Water) for the design, manufacture, supply, installation or modification of grid connected Photovoltaic (PV) solar power systems, including PV systems that are, or is to become, the property of Hunter Water.

STS 501 Solar Photovoltaic (PV) Systems complements the electrical requirements in specific equipment-type and facility-type standard technical specifications (E.g. *STS 500*) and facility design manuals issued by Hunter Water. These specifications are available from the Hunter Water website: www.hunterwater.com.au.

All work shall be performed in a tradesman-like manner to current industry standards. All electrical installation work shall be performed by licensed electrical contractors. On-site work shall be performed under the constant supervision of a person holding a Qualified Supervisor Certificate – Electrician, issued by the Department of Fair Trading, and a Hunter Water electrical induction.

Hunter Water shall not be bound to check any documents submitted for errors, omissions or compliance with the requirements of the specification or standards.

1.1 Scope

STS 501 Solar Photovoltaic (PV) Systems applies to PV system equipment that is supplied, installed or modified, and that is to be owned or controlled by Hunter Water.

The scope includes the following:

- selection and provision of key system equipment,
- pre-installation requirements including location/siting assessment,
- installation practices, and post installation activities,
- operation and maintenance,
- commissioning requirements to deliver a consistent quality of PV system installed.

2 Interpretation

For the purposes of interpreting *STS 501 Solar Photovoltaic (PV) Systems*, except where the context requires otherwise:

- 'drawings' means the drawings detailing the work involved in a particular project in hand
- 'include' means including, but not limited to, and is used to provide clarification or examples of the type and nature of items intended
- 'specification' means a specification detailing the work involved in a particular project
- 'standard drawings' means Hunter Water drawings
- 'standards' means applicable industry standards and includes:
    - Australian Standards (AS)
    - Australian/New Zealand Standards (AS/NZS)
    - American National Standards Institute (ANSI) Standards and
    - International Organization for Standardization (ISO).
- 'standard technical specification' (STS) references any of Hunter Water's standard technical specifications, as implied by the text.

Headings are for the convenience of the reader and shall not be used in the interpretation of this standard technical specification.

Unless otherwise stated, expressions such as 'give notice', 'submit', 'approval', or 'directed' mean 'give notice to', 'submit to', 'approval by', or 'directed by' the person nominated by Hunter Water.

Approval does not imply acceptance of responsibility by Hunter Water for compliance with this STS. Unless issued in writing, approval has not been granted.

Failure to comply with the requirements of this STS or any referred documentation may result in rejection. Where equipment or manufacture are rejected, notice will be given by Hunter Water in writing. All associated rectification work shall be completed by the contractor at their cost.

2.1 Order of precedence

All work shall meet all stated requirements in this STS in addition to project specifications or standards specified.

Any deviation from this STS shall be approved in writing on a case by case basis by Hunter Water's Document Owner.

3 Roles and responsibilities

3.1 Document Owner

The Document Owner of this Hunter Water STS for Solar Photovoltaic (PV) Systems is Hunter Water's Manager Capability Engineering.

3.2 Responsibilities

The Document Owner shall approve the issue of any updated version of this STS.

Any concession to any requirement in *STS 501 Solar Photovoltaic (PV) Systems* is valid only when authorised in writing by the Document Owner.

4 Definitions

Where the following term, abbreviation, or expression occurs in this STS, it is defined as follows, unless the context implies otherwise.

Term, abbreviation or expression	Definition
Approval	Approved by Hunter Water
Approved	Included on a list prepared by Hunter Water of approved products and services
AC	Alternating Current
AS	Australian Standard
AS/NZS	Australian/New Zealand Standard
CEC	Clean Energy Council
Consumer mains	Supply cable from supply authority point of connection or from the low voltage terminals of a Hunter Water substation to the main switchboard
Contract manager	A person appointed by Hunter Water to act on behalf of the principal, as detailed in the contract
CT	Current transformer
Directed	Directed by Hunter Water
DC	Direct Current
DNSP	Distribution Network Service Provider
DOL	Direct online
EDB	Electrical distribution board
ELV	Extra low voltage
FAT	Factory acceptance test
FCL	Fault current limiter
FLC	Full load current
FVC	Fused vacuum contactor
HD-PVC	Heavy duty PVC
HMI	Human-machine interface
IMCC	Intelligent motor control centre
Indicated	As specified or shown in the contract documents
IP rating	Degree of protection as described in *AS 3000*
ITP	Inspection test plan
ITC	Inspection test check sheets
LV	Low voltage
MCB	Miniature circuit breaker
MCC	Motor control centre
MCR	Maximum continuous rating
MEN	Multiple earthed neutral (system)

Term, abbreviation or expression	Definition
MIMS	Mineral insulated metal sheathed (cable)
MPPT	Maximum Power Point Tracking
MSB	Main switchboard
OHEW	Overhead earth wire
OPGW	Optical ground wire
Proprietary	A commercial supplier's standard design of equipment or process
PFC	Power factor correction
PLC	Programmable logic controller
PWM	Pulse width modulation
PVC	Polyvinylchloride
PV	Photovoltaic
RCP	Remote control panel
RTD	Resistive thermal device/resistance temperature detector (analog instrument)
SAT	Site acceptance test
SCA	Switchgear and Controlgear Assembly
SCADA	Supervisory control and data acquisition. A control system architecture that uses computers, networked data communications and graphical user interfaces for high-level process supervisory management.
SLD	Single-line diagram
Spur	A radial section of the power distribution network
STS	Standard Technical Specification
Submit	Submit to Hunter Water
Supply authority	The authority that supplies electricity to the locality of the project
Switchboard	A generic term used interchangeably that includes DBs, MCCs, MSBs, SCAs, LCPs, operator panels, marshalling cabinets, free- standing VSD, AHF, or similar electrical enclosure with hinged door. This definition is in addition to that contained within AS/NZS 3000.
TEFC	Totally enclosed, fan-cooled (motor)
THD	Total harmonic distortion
THDC	Total harmonic distortion current
THDV	Total harmonic distortion voltage
TPI	Thermoplastic insulated
TPS	Thermoplastic sheathed
UPS	Uninterruptible power supply
UV	Ultraviolet
VCB	Vacuum circuit breaker
VSD	Variable speed drive
VT	Voltage transformer

Term, abbreviation or expression	Definition
Wet environment	Any of the following: outdoor area room containing pipework which contains liquid under pressure area where equipment is located that requires wash down area below natural ground level
Witness point	An opportunity provided to Hunter Water to witness an event. Notice is to be provided but work is not required to stop.
WPS	Water pumping station
WTP	Water treatment plant
WWPS	Wastewater pumping station
WWTW	Wastewater treatment works
XLPE	Cross linked polyethylene

5 Design & Construction Requirements

The Contractor is required to perform decommissioning and demolition of all redundant services and infrastructure in the works area, and remove any hazardous materials in accordance with Hunter Water procedure.

6 Compliance with Australian Standards and Guidelines

The PV system shall be designed and installed in accordance with the most recent Australian Standards, guidelines and Hunter Water STS's including, but not limited to, the following:

6.1 Australian Standards

- AS/NZS 1170.2 Structural Design Actions - Wind Actions
- AS/NZS 3000 Wiring Rules
- AS/NZS 3008 Electrical Installation – Selection of Cables
- AS 4777 Part 1 Grid connection of energy systems via inverters (Installation Requirements)
- AS 4777 Part 2 Grid connection of energy systems via inverters (Inverter Requirements)
- AS/NZS 5033 Installation and safety requirements for photovoltaic (PV) arrays
- AS 1768 Lightning Protection
- AS 1664.1 Aluminium Structures
- AS 2159 Piling Design and Installation
- AS/NZS 1891.4 Industrial fall-arrest systems and devices
- Electricity Distributor Service and Installation Rules
- AS 2676 Guide to the Installation, Maintenance, Testing and Replacement of Secondary Batteries in Buildings
- AS 4086.1 Secondary Batteries for Use with Stand-Alone Power Systems – General Requirement
- AS 4086.2 Secondary Batteries for Use with Stand-Alone Power Systems – Installation and maintenance
- AS/NZS 4509.1 Stand-Alone Power Systems – Safety and installation
- AS/NZS 4509.2 Stand-Alone Power Systems – System Design
- AS 62040 (All Parts) Uninterruptible Power Systems (UPS)
- AS 60947.3 Low Voltage Switch gear and Control gear Switches, disconnectors, Switch disconnectors and fuse combination units

6.2 Guidelines

- Clean Energy Council Grid Connected Solar PV systems – Design guidelines for accredited installers
- Clean Energy Council Grid Connected Solar PV systems – install and supervise guidelines for accredited installations
- National Electricity Rules (NER)
- NS 194 Secondary Systems Requirements for Embedded Generators
- National Construction Codes - Board Building Code of Australia
- IEC-61215.
- IEC-61646.
- IEC-61730

6.3 Hunter Water STS's

- STS 104
- STS 500, STS 550
- STS 600
- STS 903, STS 904, STS 906, STS 911

7 System Planning

7.1 Contractor

Unless identified otherwise by Hunter Water, the Contractor shall carry out the design, supply, installation and commissioning of the PV system and all necessary ancillary work to deliver the completion of the PV system as specified.

In carrying out the installation of grid-connected solar power systems, the Contractor shall be required to undertake the work in accordance with the NSW Work Health and Safety Act 2011. In addition, personnel carrying out work relating to the PV system shall hold appropriate licenses, accreditations and certificates. Specifically:

- The designer of any PV system shall be fully accredited by the Clean Energy Council (CEC) of Australia;
- At least one person undertaking installation work shall have full CEC installer accreditation.

7.2 Site Assessment

A site assessment of the installation site should be carried out prior to the installation.

As a minimum, the following should be assessed and presented in a report:

- Suitability of building roof or ground mounted location for system installation by taking into consideration:
    - Solar access e.g. roof orientation and pitch, shading from objects on roof;
    - Available space for PV modules;
    - Roof condition;
    - Structural integrity of roof structure to bear extra weight and wind loading of the proposed solar installation;
    - Suitability of the roof or ground mounted location as a whole for the proposed installation work, such that no damage is likely to occur to the infrastructure during installation and maintenance of the system.
    - Any potential future use(s) of the nominated land for ground mounted systems.
    - Consideration for location of inverters and isolators.
    - Consideration for flood prone areas
- Suitability of existing AC mains supply:
    - Rating of electrical distribution board;
    - Identify if upgrades to electrical distribution board (EDB) are needed to accommodate switches and/or reduce losses;
    - Confirm that potential voltage rise will not exceed required values.
- Solar resource:
    - Ensure that there are accurate insolation data for the site: taking into account location specific factors including shading from surrounding topography and buildings and local weather patterns.
- Ballast systems are not to be installed.

7.3 Safe Roof Access

The contractor shall provide a means of safe roof access to facilitate ongoing inspection and maintenance of the system. This is to be calculated on whole of life costs including maintenance. If permanent access is required for maintenance purposes, a handrail system is to be installed.

7.4 System Design

The design of the PV system shall meet requirements as set out by the Clean Energy Council Grid Connected Solar PV systems – Design guidelines for accredited installers and comply with STS 500 when connecting to Hunter Water electrical assets.

7.5 Location of PV Array

The PV modules shall be arranged so that they are grouped together where possible and are symmetrically or geometrically ordered.

The location of the PV array should be designed to maximise Hunter Water's self-generation, based on Hunter Waters load profile.

The PV array should be arranged such that shading of PV modules by nearby buildings, trees, obstacles are taken into consideration and minimised wherever possible.

This information will be provided in a report.

7.6 System Size

The PV system size shall be provided as both the sum of the PV array nominal capacity rating under Standard Test Conditions in kilowatt peak (kWp), and the sum of the nominal power output of all inverters in the system in kilovolt-ampere (kVA).

Unless otherwise specified by Hunter Water, the PV system capacity shall be determined from the energy usage of the Hunter Water building; the Contractor shall propose a system size and provide financial calculations. This information should reference the site's existing power bills, and interval meter data as the basis for these calculations, or for new buildings, an estimate of the predicted load profile at the connection point.

The expected operating life of the system should be 30 years. For the purposes of estimating the cost of ongoing system maintenance, assume that Hunter Water will carry out a system operation and maintenance inspection every three years. Ongoing system costs should include inverter replacement every 13 years.

To aid in the calculation of the system size of the above, the Contractor should obtain the following information from Hunter Water:

- Electricity usage and load profile;
- Cost of electricity during the hours of generation

7.7 Array and Inverter Matching

The CEC Grid Connected Solar PV systems – Design guidelines for accredited installers Inverter selection and AS/NZS 5033 shall be adhered to.

7.8 Distribution Network Service Provider (DNSP) Approval

The Contractor shall apply for, and obtain, the approval for connection of the proposed system by the relevant electricity distribution network service provider (DNSP) prior to installation of the PV system.

The Contractor shall meet all requirements set out by the DNSP connection requirements. In particular:

- Voltage rise calculation shall be carried out by the PV Contractor to ensure that the percentage voltage rise at the installation is within limits set by AS 4777, and DNSP requirements;
- Systems having a generation capacity greater than 5kVA or AC current rating above 20A shall not be connected to a single phase installation unless prior approval is received from the DNSP;
- The Contractor shall comply with a DNSP request for additional grid protection equipment as per NS194

The Contractor shall provide the reprogramming or replacement of existing meters to facilitate bi-directional metering.

Contractor shall submit all paperwork and be responsible for liaison with the DNSP until the DNSP has offered a connection agreement and the agreement has been accepted by Hunter Water.

A copy of the connection agreement and all paperwork submitted to the DNSP shall be included in the system documentation.

The cost of the interconnection of the PV system to the network, including equipment, processing charges and labour, shall be included in the Contractor's quotation.

The Contractor shall register the installed solar system in the Australian Energy Market Operator's (AEMO) Distributed Energy Resource (DER) Register within 20 days of commissioning.

8 System Equipment Requirements

8.1 PV Module Requirements

The PV modules proposed shall have the below requirements or better:

8.1.1 Certification

The PV modules supplied shall be compliant with AS/NZS 5033

Crystalline photovoltaic modules (monocrystalline and multi/poly-crystalline): shall be certified to IEC-61215.

Thin film photovoltaic modules (amorphous, cadmium telluride, copper indium gallium selenide, etc.): shall be certified to IEC-61646.

All PV modules shall be certified to IEC-61730 and shall be listed on the Clean Energy Council approved PV modules list at time of installation. The Fire Test MST-23 shall be carried out as part of the IEC 61730-2 testing and IEC 61730 certification. Modules installed on buildings shall be listed as fire tested on the approved CEC PV modules list at time of installation.

8.1.2 Equipment Class

PV modules shall be Class A as defined by AS/NZS 5033

8.1.3 Protection Rating

PV module junction boxes that are exposed to the environment shall be at least IP65 compliant in accordance with AS 60529 and shall be UV resistant.

PV modules installed close to HWC facilities can be exposed to any of the following gases: H2S, CL2, SO2 , These gases alone or in combination with humidity (rain, fog, dew, etc.), can cause corrosion of structures and exposed terminals. (being acids HCl, H2SO4, HCL, etc.). H2S also attacks cable insulation.

PV modules installed in a coastal environment or areas with high agricultural activities shall be certified to the following IEC standards respectively:

IEC 61701 Ed 2.0 Salt mist corrosion testing of photovoltaic (PV) modules

IEC 62716 Ed 1.0 Ammonia corrosion testing of photovoltaic (PV) modules

Preference should be given to PV modules certified to the above IEC standard in all installations.

8.1.4 Temperature Coefficient

Maximum allowable temperature coefficient of maximum power is -0.5% / °C above Standard test condition.

8.1.5 Module Efficiency

Minimum allowable panel efficiency of 17%.

8.1.6 Operating Temperature

Operating module temperature -20°C to +80°C.

8.1.7 Mechanical Protection

- Hailstone impact testing: Required
- Minimum permissible wind load rating: 2.4KPa
- Minimum permissible snow/mechanic load: 5.4KPa

8.1.8 Connectors and Cables

Connectors shall be compliant with EN 50521 (2012). Datasheet and/or installation manual shall indicate the make and model of the connector.

8.1.9 Warranty

Minimum Warranty: 15 years

8.2 Inverter Requirements

8.2.1 Selection of Inverter

Inverters installed in an outdoor environment should have Ingress Protection of IP56 or greater.

8.2.2 Certification

The inverter(s) supplied shall be compliant to AS 4777.2, IEC 62109-1 and IEC 62109-2. The inverter(s) shall also be listed on the Clean Energy Council's list of compliant inverter and power conversion equipment.

8.2.3 Technical Requirements

The inverter shall be provided with an Ethernet connection to facilitate a wired connection of the inverter to a monitoring system, via Hunter Water's network.

The earth fault alarm should be installed such that any fault indication is detectable by the building's administrative office and/or Hunter Water Corporate Services.

Inverter shall meet any DNSP and AS 4777 demand response mode requirements.

8.2.4 Load Balancing

Integrated three phase inverters shall be used for PV systems connecting to three phase power supply unless micro-inverters are used.

PV systems connected to multiple phases shall be balanced within 20A or to the approval of the DNSP. In addition, protection shall be installed to isolate the inverter if the current imbalance is greater than 20A or where a voltage imbalance greater than 2% is detected.

8.2.5 Other Requirement

DC connectors between the inverter and PV array DC input shall be of the same manufacturer and model.

8.2.6 Warranty

The inverter shall have a minimum warranty of 10 years.

8.3 Micro-Inverter Requirements

Micro-inverters shall meet all inverter requirements as listed above and all requirements set out by AS/NZS 5033 4.3.12 Small micro-inverter installations.

Systems with micro inverters shall have AC isolators installed at the array. If the system is installed in multiple locations or spread over different roof surfaces then an AC isolator shall be provided at each group of modules.

8.4 DC Power Optimiser Requirements

Power Optimiser units shall comply with requirements set out by AS/NZS 5033 for strings constructed using DC conditioning units.

8.5 Mounting System Requirements

The mounting frame and associated parts, including but not limited to parts such as bolts, splices, etc. shall be a suitable proprietary made product.

Raked mounting system should be used on roofs with less than 10 degree pitch.

The mounting system manufacturer's installation specification, including but not limited to: maximum fixing width for wind regions and roof zones, maximum building height and roof mounting requirements, shall be followed.

8.5.1 Certification

The mounting system documentation shall include engineering certification of the product's compliance with AS/NZS 1170.2. The manufacturer shall provide installation methods that are compliant with AS/NZS 1170.2 for the terrain category and wind region applicable to the installation site.

8.5.2 Warranty

Minimum of:

- 5 years finish warranty
- 15 years product warranty

8.5.3 Monitoring System Requirements

The system monitoring shall include, but not limited to;

- Electrical meters at the distribution board
- Inverter monitoring including;
    - DC Inverter Input voltages
    - DC Inverter Input currents
    - DC Power
    - AC voltage
    - AC current
    - AC power
    - AC kVA

- AC power factor
- THD
- Earth fault detection and alarming

If weather monitoring is required, sensors and data logging for insolation (measured at array tilt) and PV cell temperature shall be provided.

If energy storage is installed, monitoring and data logging of charging, discharging and state of charge shall be provided.

All system monitoring data shall be collectively recorded so that the entire system, including PV production, weather data and energy storage data, can be easily assessed.

8.5.4 DC Isolators

DC isolators shall be installed where required by AS/NZS 5033, and the isolators shall meet the device requirements set out by AS/NZS 5033 and AS 60947.3.

DC isolators shall be selected from HWC approved products list:

Isolator enclosures shall be installed according to manufacturer's specifications to ensure IP rating is maintained.

DC isolator enclosures should be constructed of metal and equipotentially bonded to earth.

See Appendix B: DC Isolator Rating and Installation for more information.

8.5.5 AC Equipment

AC equipment between PV system inverter output and consumer mains shall comply with STS 500, be selected from HWC approved products list: and be selected such that:

- Voltage rise between inverter and main switchboard is less than 1% and,
- Voltage rise between main switchboard and consumer main is less than 1%.

AC circuit breaker ratings shall be above inverter maximum AC current output rating to avoid unnecessary tripping of circuit breaker.

8.5.6 PV String Protection

PV string overcurrent protection, if needed, shall adhere to sizing and location requirements as set out by AS/NZS 5033.

Circuit breakers should not be used for string overcurrent protection.

8.5.7 Plugs, sockets and connectors

Plugs, sockets and connectors used in the PV system shall comply with AS/NZS 5033.

Note: Plugs and sockets shall only be mated with those of the same electrical characteristics.

Mating of plugs and sockets that are compatible but do not meet the above criteria (e.g. mating of MC4 connectors with MC4 compatible connectors from another manufacturer) is not acceptable.

Ensure that PV modules and/or inverter warranty will not be voided in the event that pre-installed connectors need to be replaced. To avoid the need to replace pre-installed connectors it is recommended to only use PV modules and inverters for which matching connectors can be sourced.

9 System Installation

PV system installation includes the installation of all PV system components, e.g. PV modules, inverters and balance of system components, as well as ancillary work such as forming openings in the building envelop for cable entries etc. The PV Contractor shall ensure that the integrity of the building, especially waterproofing and fireproofing properties, is not affected by the installation of the PV system.

All PV system components shall be installed in a manner such that the manufacturers' product warranties are not affected.

9.1 PV Module Installation

Installation of the PV modules onto the mounting system and attachment of mounting system equipment to the roof shall follow the respective manufacturer's specifications for the specific application.

For more information see Appendix C: Installing PV Modules on Roof.

All equipment used shall be fit for purpose and care is to be taken while installing so as to not adversely affect the system finish or void warranties.

Ensure that bolts, washers, screws, nails or other metal objects in contact with the mounting frame are of a similar metal to reduce the likelihood and severity of galvanic reaction. The use of stainless steel with aluminium frames is recommended. Where the use of dissimilar metals cannot be avoided insulating washers or similar shall be used.

9.2 Module Performance

PV modules shall be installed such that all strings connected in parallel to the same MPPT input comprise the same number of panels and are of the same make and model.

A string of PV modules shall be connected such that all modules in the string have the same tilt and the same orientation. This does not include micro-inverters and DC power optimisers connected to individual modules.

9.2.1 PV Module Spacing

A gap should be provided between PV modules to allow for thermal expansion.

Arrays should be installed as follows so that adequate access is provided for maintenance of the array:

- 600mm clearance around the perimeter of the PV array;

9.3 Inverter Installation

The area surrounding the inverter and all associated protective devices such as PV array DC isolator, inverter AC isolators, and wiring is known as the inverter station.

Inverter/s shall be installed according to AS 4777.1 requirements, manufacturer's specifications and STS 500. In addition, where multiple inverters are installed connecting to the same switchboard, the inverters shall be installed grouped in a common location. Each inverter shall be provided with an AC isolation switch at an electrical distribution board.

A main switch (inverter supply) shall be provided to isolate all inverters installed on the distribution board.

9.3.1 Inverter Station Location Selection

The inverter station location shall have restricted access. Access will be in accordance with STS 500 and STS 105. Staff or general public shall not be able to gain unauthorised access.

Arrangements shall be approved by Hunter Water for the location of the inverter onsite.

Inverters shall be installed such that the ventilation and clearance requirements recommended by the inverter manufacturer are met.

The inverter station should be located and configured such that:

- No inverter is exposed to direct Western and Northern sun;
- DC losses are minimised by locating the inverter as close as possible to the PV array;
- AC losses are minimised by locating the inverter as close as possible to the nearest electrical distribution board;
- Access to the inverter station components and cabling is restricted as described by AS/NZS 5033 regardless of system voltage.
- No flammable liquids or gasses shall be stored at the inverter station location.

Inverter stations should be configured as outlined in Appendix D: Inverter Station Equipment Configuration.

9.4 Cable Management and Wiring

Regardless of system voltage, the entire PV installation, including the PV array, inverters, associated wiring and protection, shall have restricted access as described by AS/NZS 5033, AS3000 and STS500.

Cables entering junction boxes shall be bottom entry only and shall comply with AS/NZS 5033.

All AC and DC wiring and components shall be installed in separate enclosures and run in separate conduit.

All cables shall be mechanically and UV protected where the cable is installed above ground.

9.5 Roof Penetration by PV System

Any roof penetrations shall require written approval by Hunter Water prior to installation.

9.6 PV System Signage

9.7 All signage shall comply with the CEC guideline, STS 500, AS 5033 and AS 4777.parts 1 and 2Lightning Protection

The metal portions of the photovoltaic array should be bonded to the existing lightning protection system as per AS/NZS 1768 and AS 3000.

9.7.1 Surge Protection Devices (SPD)

SPDs installed on the DC side of the PV system shall be explicitly designed and manufactured for DC PV application.

Surge protection should be installed for each inverter. Surge protection to meet the following requirements:

- Connection type: shunt diverter
- Nominal voltage: > PV system operating DC voltage
- Maximum continuous voltage: 1000VDC
- Maximum continuous current rating: PV system short-circuit current
- Response time: < 5nS
- Maximum surge current (8/20µS): > 20kA
- Earth leakage current: <10µA

9.7.2 Minimising Wiring Loops

To reduce the magnitude of lightning-induced over voltages, the PV array wiring should be laid in such a way that the area of conductive loops is minimized. See AS/NZS 5033 for examples with minimum loop area.

9.8 Earthing

All exposed conductive parts of the PV system, including PV module frame and mounting rails, shall be bonded to earth (equipotential bonding) in accordance with CEC guideline, AS/NZS 5033 and AS 3000.

10 System Workmanship Warranty

The Contractor shall install the photovoltaic system to meet all relevant standards, building codes and local council requirements and in such a way that the manufacturers' warranties on all system equipment remains valid.

11 PV System Upgrades

The whole system shall be brought up to standards applicable at the time of the upgrade.

If any additional PV strings are added to the system and these additions are PV modules of a different make or model to the original, the additional PV string/s should be installed and connected to an inverter's separate MPPT and within the input constraints of the inverter.

12 Documentation and Records

Site-specific system documentation shall be provided as outlined by:

- AS/NZS 5033 and AS4777.1.
- Appendix A: Documentation Checklist outlines specific requirements for drawings.

12.1 Design Submission

The following design documents shall be provided:

- As per STS 500, inclusive of DC arc flash levels.
- Return Brief defining the systems proposed and any deviations from this specification;
- System sizing calculations and performance estimate.
- Budget calculations;
- Recycling requirements of PV modules and batteries where applicable
- Design drawings including as a minimum;
    - A plan view of the PV array identifying key features
    - Single line diagram/s and schematics of all electrical systems
    - Metering and monitoring diagrams
    - Structural drawings
- Applications to Supply Authorities, and their responses;
- Requests for any variations to this Standard
- Hunter Water Controls System Network architecture
- The contractor shall be responsible for ensuring that principles of Safety in Design is carried out throughout the design phase.

12.2 Commissioning Documentation

After installation, the PV system shall be commissioned according to AS/NZS 5033 and AS 3000 as a minimum. Note that if the PV system has a rated capacity greater than 10kW, AS/NZS 5033 includes additional commissioning tests that shall also be carried out.

At the completion of commissioning tests, the completed copy of the commissioning documents shall be included in the system documentation provided to Hunter Water.

The contractor shall submit the following commissioning documentation including what is listed Appendix A.

12.2.1 Commissioning

Contractor shall keep the PV system installation information for a minimum period of 7 years including installation and commissioning photographs. The contractor shall also submit photographs showing:

- The position of the PV array relative to the building on which it is installed;
- Mounting and external cabling;
- Inverter station layout;
- Key equipment, such as, isolators, junction boxes and system protection;
- Electricity board showing inverter system isolation switches and relevant signage;

- Meter switchover (where applicable).

12.2.2 Completion

- The Contractor shall submit to Hunter Water the operation and maintenance requirements of the PV system components upon completion as per STS 906.
- The Contractor shall provide training of the monitoring systems installed
- The Contractor shall submit the As Built drawings as per STS 904 and STS 911.

13 Document Control

Document Owner: Manager Capability Engineering

Document Author: Team Leader Electrical Engineering

Document Controller: Manager Planning Systems

Version	Date	Author	Details of Change	Approval Date	Approved By
1.0	August 2019	R. Watson	Initial release	7/08/2019	C. Thomson
2.0	October 2020	R. Watson	Document Review	October 2020	L. Backhausen

Appendix A: Documentation Checklist

In addition to the documentation listed in AS 5033 and AS 4777, Contractor shall, as minimum submit following documentation:

Drawings:

1. Plan view drawing complying with STS 911 of the PV array, clearly showing:

- How the PV array is wired;
- Access routes (as relevant);
- Electrical reticulation;
- Penetration points;
- Module identifier number (corresponding to serial numbers on the asset schedule);
- Tilt angle
- Location of key system equipment and switches.

2. Electrical diagram/s complying with STS 904 showing:

- Connection of all PV system equipment to electrical distribution board, including the electrical ratings of the PV array and electrical ratings of all overcurrent devices, isolators and switches
- A table nominating which strings are connected to which inverter, by both inverter number and inverter input (A/B);
- Indicate total number of panels and installed capacity on title block;
- Lightning protection system (if required);
- String configuration back to the inverters. String configuration is to be identified using hatching or colour and string number to distinguish strings;
- Location and rating of DC isolation points and the strings connected;
- DC string fuses including rating (if required);
- Surge diverters;
- Cable size;
- Identifying AC connection point (DB name/number) and breaker size;
- Inverter schedule;
- Indicating type and number of panels connected to each inverter;
- Array Voc;
- Array Isc;
- Inverter maximum AC current rating;
- Panel Voc;
- Panel Isc;
- Secondary protection devices;

3. Metering and monitoring drawings (complying with STS 904):

- Power and Control;
- Communications;

4. Structural drawings (complying with STS 911):

- Mounting system drawings and details as required;
- Details of any structures that tie into the building fabric. e.g. structural plinths.

5. Operation and Maintenance Manual (complying with STS 906), including:

- A description of the function and operation of the system's installed equipment;
- A procedure to verify the correct operation of the system;
- The supplier's contact details for installation queries and system support;
- The shutdown and isolation procedure for emergency and maintenance, including any electrical safety warnings;
- A list of equipment supplied, with serial numbers of all equipment where applicable;
- A list of actions to be taken in the event of an earth fault alarm;
- A site specific system performance estimate providing monthly generation estimates taking into account expected seasonal, operational and site specific variation. The system performance estimate should at a minimum factor in effects of the PV array orientation, shading effects and de-rating factors such as temperature and equipment efficiency. Any assumptions made shall be clearly stated.
- Array frame engineering certificate for wind and mechanical loading;
- Installer/designer's declaration of compliance to AS/NZS 5033:2014 2.2 Mechanical design;
- Warranty information for all applicable equipment and workmanship warranties;
- Network Provider's PV system approval to connect and connection offer;
- Equipment manufacturer's documentation and handbooks for all equipment supplied. As a minimum the following shall be included:
    - Panels;
    - Mounting frame;
    - Inverter;
    - Isolators;
    - Cable;
    - Monitoring devices.
    - Log-in details for any monitoring systems
    - The commissioning sheet and installation checklist;
    - Maintenance procedure and timetable

6. Power System Registration

The Contractor shall supply all relevant documents to enable the Principal to successfully register the system as

- a Small Generation Unit (SGU) and to create Small-scale Technology Certificates (STC) for the project for systems below 100kW
- a large power station with the Clean Energy Regulator to create Large-scale Generation Certificates (LGC) for the project for systems above 100kW

Appendix B: DC Isolator Rating and Installation

The follow procedure shall be used when selecting and installing load breaking DC isolators for PV systems.

DC Isolator Sizing Requirements

If sufficient information is provided by the manufacturer, temperature derating shall be accounted for when assessing isolator ratings. Where possible, temperature derating at 80°C shall be applied.

The DC isolator's voltage rating shall be above the required voltage rating. Depending on the PV installation characteristics, PV Array DC isolators at the inverter and the array are to be rated to the PV array maximum voltage, either for each positive and negative conductor individually (a per pole voltage rating) or, less commonly, for both positive and negative conductors collectively (an overall voltage rating).

The DC isolator's current rating shall be above the required current rating. In most cases the required current will be 1.25 x the short circuit current (ISC), however AS 60947.3 and AS/NZS 5033:2014 Table 4.2 shall be used to confirm the required current rating.

To calculate the PV array maximum voltage, multiply the PV array open circuit voltage (VOC) by the appropriate correction factor in the following table from AS/NZS 5033:2014 Table 4.1. Use the lowest expected ambient temperature for the installation location as the lowest expected operating temperature.

DC Isolator Installation Requirements

Installing load breaking DC isolators adjacent to the array is a requirement under AS/NZS 5033. In addition to this, load breaking DC isolators are also required at the inverter unless the inverter is within 3 metres of the array and visible from the array. This standard specifies that the IP rating shall be a minimum of IP66 and enclosures should be constructed of metal and equipotentially bonded to earth.

Furthermore, enclosures shall be installed to the manufacturer's instructions to maintain their IP rating. Installation of DC isolator enclosures shall comply with AS/NZS 5033.

Unless otherwise specified by the manufacturer the following installation methods shall be followed.

- Enclosures shall be readily available as defined by AS/NZS 5033.
- Enclosures should be mounted so that it is standing upright or lying on its side according to AS/NZS 5033 unless otherwise specified by the manufacturer.
- Penetrations should be made at the lowest point of the enclosure. This includes: cable entries, conduit entries and screw holes;
- Enclosure openings/lids should not be upwards facing;
- Any penetrations made during installation, such as for screwing the enclosure to the mounting rail, should be waterproofed using an appropriate gland or gasket;
- Enclosures should not shade the array. If some shading is unavoidable, there should be no shading between 9am and 3pm;
- All conduit entries and connections shall be glued unless not required by the manufacturer;
- Any cable glands used shall be appropriate for the number of cables installed. Single cable glands used for multiple cables is not acceptable;
- All unused cable entry bungs or caps should be tightened and if no gasket is provided then they should be glued or adequately sealed with silicone;

- Ensure enclosure openings/lids are not obstructed by module frames or other objects and can open fully;
- Mounting holes provided by the manufacturer shall be used to mount the enclosure. Where applicable caps/pips will be used to seal the screws. Any screws inside the enclosure that are not covered with a cap/pip will be covered with silicone to provide galvanic insulation.
- A shroud shall be installed over all DC isolators that are exposed to direct sun or rain.

Appendix C: Installing PV Modules on Roof

Manufacturers' installation instructions shall be followed to ensure secure installation of the PV system to last the expected lifetime of the system. It should also be noted that manufacturers' ratings and compliance to certain standards will only be achieved by installing PV systems to manufacturers' specifications.

PV Module Attachment to Rail

A PV module's ability to withstand wind and static load is affected by the attachment area.

Manufacturers will specify the clamping area of the module. Clamping of PV modules onto rails shall fall within the modules' specified clamping area to ensure that the modules can withstand loads up to the rated pressure.

Mounting System Attachment to Roof

Mounting systems will only be compliant to AS/NZS1170.2 if the manufacturer has supplied installation instructions certified to AS/NZS1170.2 and these instructions are followed. Care shall be taken to ensure the manufacturer's installation requirements for the specific wind region and terrain category are met, especially:

- Maximum allowed rail end overhang;
- Maximum rail support spacing;
- Extra rail support spacing requirement in roof edge zones;
- Method of installing fixings to roof, such as screw type, gauge and quantity per fixing point.

If an installation configuration is not covered by the mounting system manufacturer's specification, a structural engineer's certificate shall be obtained for the proposed installation configuration, stating the compliance of the proposed installation method with AS/NZS1170.2.

Manufacturer's installation instructions and corresponding engineer's certificate shall be provided as part of the system documentation.

If a ballasted racking system is to be installed, signed engineering certification shall be obtained: both for the roof's ability to support the ballast system and array components; and for the ballast requirements to adequately secure the array.

Appendix D: Inverter Station Equipment Configuration

Inverter station refers to the area where one or more inverters and related equipment are installed. An inverter station is typically located near an electrical distribution cupboard to reduce losses, but can be installed in a designated space within a 1% AC voltage rise margin, and where inverters are protected from exposure to excessive heat, dust and moisture.

Installing inverter station equipment in a clear and logical way can ensure segregation of AC and DC electrical systems and ease of operation for maintenance or safety reasons.

Inverter Station Equipment Installation Requirement

Inverter station equipment includes the following:

- PV system inverter/s;
- PV array DC isolator/s and isolator enclosure/s;
- Inverter AC isolator/s and isolator enclosure/s;
- AC and DC cables connected to the inverter and cable enclosure;
- Any electrical switchboard adjacent to inverters.

Inverter station equipment shall be installed meeting manufacturers' specified minimum clearance to maintain inverter efficiency and rated lifetime. Where objects are installed within the clearance zone, system owners shall be made aware of the effects of having reduced clearance around inverters and an inverter manufacturer declaration, stating that this installation configuration is permitted, shall be included in the system documentation.

Conduits enclosing PV array DC cables shall be installed to AS5033 requirements.

Cables leading up to the inverter shall be secured by saddles so they cannot be inadvertently unplugged from the inverter.

Cable penetration through walls into isolator enclosures shall be sealed to AS3000 requirements to prevent the spread of fire.

Where multiple inverters are installed at the inverter station, an AC isolator shall be provided for each inverter. Additionally, a single AC isolator should be provided for isolation of all inverters connected to the same electrical distribution cupboard.

Equipment Arrangement

Equipment at the inverter station should be arranged as follows:

- Provide AC isolators at the inverters if the inverters are not within 3 metres and in line of sight of switchboard to which they are directly connected;
- Install all switching devices and inverters no lower than 0.5 metres and no more than 2.0 metres above the ground, floor or platform;
- Access clearance in front of all switching devices and inverters shall comply with AS/NZS 3000