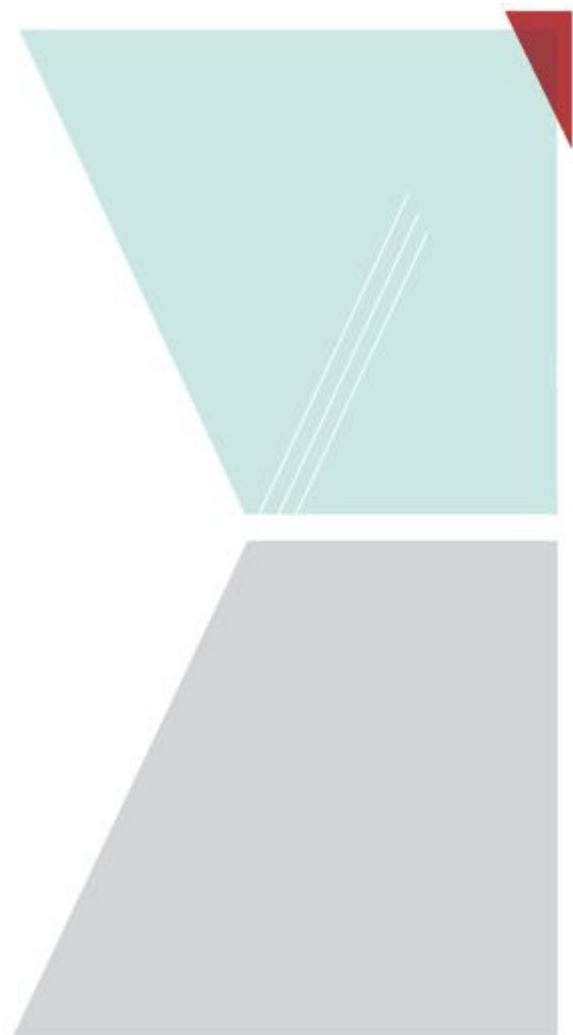


Greener Government School Buildings Program

Solar Rooftop
Installations

Performance
Specification



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1 Introduction

1.1 General

This specification as part of RFQ documentation defines the scope of works and deliverables expected from the design and construction (D&C) contractor to implement the installation of roof top solar PV systems at participating Victorian schools. The purpose of solar PV systems are to minimise the retail electricity purchased by the school by maximising the solar generation and its self-consumption, and also aid in creating revenue from the excess generated energy fed back into the grid. Wherever export to the grid cannot be achieved because of network constraints imposed by DNSP's, reduction in the installed capacity or export control by DNSP's shall be explored.

The specification elaborates on the technical works and deliverables expected from the contractor at different stages of the program including preliminary site investigation, grid connection application and legislative approvals, design, procurement, construction, commissioning, practical completion & handover, operation & maintenance (O&M) support as well as a provision for a minimum performance guarantee. This document will also touch upon technical requirements at each stage and also on obtaining approvals from and liaison with the school authorities.

The contractor shall install the solar power generation system at the allocated Victorian schools based on the building's electrical load and available roof space. The system shall be installed in such a way as to not compromise the performance, safety, operation and maintenance of the existing infrastructure. The system shall be warranted and guaranteed as detailed within this specification. The panels shall be located on the roof top of the building and the installation shall be designed to minimize cell shading and maximising energy output. The inverters shall be located in a secure and suitably safe accessible location.



1.2 Definitions and Abbreviations

Table 1-1 and Table 1-2 provide definitions and key abbreviations adopted in this document.

Table 1-1 Definitions

Term	Definition
Principal	Department of Education and Training / Victorian School Building Authority
Contractor	The business responsible for delivering the requirements of this specification. The business may be a company, an alliance, a consortium, a partnership or similar.
Operator	Personnel/Representative of the participating school nominated by the Principal
Trade/s	Specialist trades subcontracted by the Contractor (e.g. Electrical Trade)
Supply	"Supply", "furnish" and similar expressions mean "supply only"
Install	"Install" and similar expressions mean "install only, including associated terminations"
Provide	"Provide" and similar expressions mean "supply and install"
Recover	"Recover" means to recover undamaged and offer to the Principal
Remove	"Remove" means to remove (damaged or undamaged) and dispose of
Give notice	"Give notice", "submit", "advise", "inform" and similar expressions mean "give notice (submit, advise, inform) in writing to the Principal"
Obtain	"Obtain", "seek" and similar expressions mean "obtain (seek) in writing from the Principal"
Approved	"Approved", "reviewed", "directed", "rejected", "endorsed" and similar expressions mean "approved (reviewed, directed, rejected, endorsed) in writing by the Principal"
Proprietary	"Proprietary" means identifiable by naming manufacturer, supplier, installer, trade name, brand name, catalogue or reference number



Term	Definition
Pre-completion tests	Tests carried out before completion tests
Site tests	Tests carried out on site on static plant and systems before commissioning (e.g. inspection and testing of welding, electrical insulation resistance testing, and pressure testing of pipework)
Completion tests	Tests carried out before the date for practical completion on installations or systems which have been completed and commissioned, to demonstrate that the installations or systems, including components, controls and equipment, operate correctly, safely and efficiently, and meet performance and other requirements and are integrated with connecting systems
Deferred tests	Acceptance tests carried out during the defects liability period (e.g. to suit seasonal climatic conditions)



Table 1-2 Abbreviations

Abbreviation	Definition
AC	Alternating Current
BOM	Bill of materials
DC	Direct Current
D&C	Design & Construct
DNSP	Distribution Network Service Provider
EMC	Electromagnetic compatibility
ELV	Extra Low Voltage
FAT	Factory Acceptance Test
GA	General Arrangement
IFR	Issued for review
IFI	Issued for information
IFC	Issued for construction
ITP	Inspection Test Plan
ITR	Inspection Test Record
LV	Low Voltage (400V)
MSB	Main Switch Board
MV	Medium Voltage (11kV)
NATA	National Association of Testing Authorities
O&M	Operation & Maintenance
PV	Photovoltaic
REC	Renewable Energy Certificate
SiD	Safety in Design
SLD	Single Line Diagram
STC	Subject to Contract
TAP	Technical Advice Panel
uPVC	Unplasticised Polyvinyl Chloride
VSBA	Victorian School Building Authority
VSIR	Victorian Service and Installation Rules



2 Scope of work

This section provides a summary of the tasks and responsibilities of the D&C contractor with focus on the technical aspects at the following stages of the work:

- Stage 1 - Project assessment
 - Electrical assessments
 - Structural assessments
- Stage 2 – Substantive works
 - Design development
 - Grid connection application
 - Procurement and construction
 - Commissioning
 - Practical completion & handover
 - O&M support
 - Performance guarantee period

2.1 Stage 1 - Project Assessment

The contractor shall conduct a detailed site inspection and, once Principal approval is obtained, follow with the preparation of a full turnkey project with documented design and construction in accordance with this technical specification and project intent:

- Dilapidation/investigative survey and report of the existing assets and services

At the end of Stage 1 the Principal will require the outcome of the project assessment, any modifications required for the existing infrastructure and a complete project scope and fee for a turnkey solution to install the solar systems.

2.1.1 Electrical Assessments

- Conduct site inspection to identify existing site conditions with some details listed in this section
- Review the school's existing electricity load to ensure the solar system is sized optimally for self-consumption such that the return on investment (ROI) is maximised and or the payback period is minimised. Each school's electricity retail and or network rates shall be taken into account.
- Assess existing electrical infrastructure, point of connection and its interface with the solar system (e.g. connecting switchboard, cables, etc.). Advise of modifications, compliance issues with the electrical infrastructure and spatial implications.
- Identify local DNSP requirements, application forms and certificates required for the PV installation
- Liaison and coordination with the power authority/DNSP to connect and commission the system as per their requirements including required studies. Note: The DNSP may require specific protection requirements, which are to be met by the contractor.



- Assess and report the impact of shading from any neighbouring structures or trees on the solar system and the impact on energy generation.
- Assessment and report of glint and glare including review of impacts on flight routes where applicable (wherever the school is close to the airports with the proximities defined by airport regulations)
- Energy assessment reports by PVSyst, Helioscope or equivalent specialised solar software and provision of Design Solar Conversion Ration and Minimum Solar Conversion Ration as per section 9.
- Confirm expected annual energy generation for first year of the life of the system
- Confirm annual energy generation for the minimum performance guarantee of the system. Provide assumptions in modelling and Typical Meteorological Year as per Section 9.
- Liaise with and manage key stakeholders, including Principal and schools

2.1.2 Structural Assessment

- Review of the existing roof structure by a structural engineer to determine a structurally appropriate concept for the layout of panels and provide certification. If required notify the Principal if strengthening or any roofing or structural works are required to install the solar PV system.

2.2 Stage 2 - Substantive Works

2.2.1 Design Development

- Prepare a design and construction program
- Prepare and submit grid connection application including the required attachments
- Design report or reports including:
 - Array configuration and V-I assessments
 - AC and DC load analysis
 - Voltage drop calculations
 - Fault current studies
 - Surge arrester selection criteria
 - Breaker and fuse protection and coordination including coordination with the existing protection functions. Show circuit breaker required at point of connection to MSB
 - Selection criteria for combiner boxes and isolation boxes including temperature deratings, where appropriate
 - Cable sizing
 - Inverter setting
 - Earthing calculations
 - Structural loads (including wind loads)
- Arrangement and layout drawings in CAD showing:



- Locations of necessary penetrations
- Solar panels, inverters and associated equipment
- Walkways and handrails on roof wherever applicable
- Switchboard layouts
- Cable route layouts
- Label schedule and layout
- Diagram drawings:
 - Single line diagram(s) of the AC and DC system including protection, metering and monitoring. Single line diagram shall show ratings of all breakers, fuses and bus bars. It shall also show sizing of cables and settings of breakers, relays and inverters.
 - Redlined drawings showing alternation to the existing switchboards
 - Wiring diagrams of PV panels, combiners boxes and isolator boxes
 - Earthing diagram showing connections in the new installation and to the existing installation
- Provide bill of materials including brand, model, serial numbers and technical data of the equipment including:
 - Solar PV panels
 - Inverters
 - Combiner boxes, where appropriate
 - Isolator boxes
 - Framing
 - Cables
 - New switchboard and switchgear
 - Proposed alternations to the existing switchboard and switchgear
 - DNSP requirements
- Prepare a testing and commissioning plan
- Providing safety-in-design and risk management registers, and associated incorporation of findings into the design
- Monitoring system, as per section 5.6 of this Specification.
- Fill in and issue provided project checklists
- Liaise with and manage key stakeholders, including Principal and schools

2.2.2 Procurement and Construction

Procurement, supply of materials and undertake full installation and construction in accordance with the design and this specification as well as relevant Australian Standard and regulations:

- Ensure the site is safe and all precautions are taking in accordance with Victorian legislation
- Purchase equipment and materials compliant with this specification
- Provide evidences of procurements to the Principal including list and details of the ordered equipment and expected delivery times



- Provide serial numbers of the equipment as part of the O&M package
- Provision of photovoltaic modules according to this specification
- Provision of grid connecting inverters in accordance with this specification
- Framing, fixing, and walkways for photovoltaic modules and handrails for the roof. Cable pathway from roof to switchboard – including fully covered cables.
- Supply and install sub mains cabling from the inverter(s) to the MSB(s) and terminate onto circuit breakers.
- Low voltage AC reticulation, including switchgear and sub-circuit cabling to inverters and connection to the building main switchboard.
- Install DC reticulation
- Install earthing and bonding (AC and DC)
- Coordination with existing lightning protections system (where applicable).
- Temporary electrical services as required during construction, as required
- General builders work as required to deliver the works specified in this document, including but not necessarily limited to lightweight structures, fire rating, acoustic rating and water proofing
- Prepare and submit as-built drawings
- Obtain relevant certification (e.g. electrical, structural, BCA compliance, etc)
- Install and connect data monitoring that relays information to a web-based monitoring system as per section 5.6 of this specification
- Provide Safe Work Method Statements
- Maintain current sets of contract drawings and shop drawings on site
- Progressively record changes to form a record of work as installed
- Fill in and issue provided project checklists
- Liaise with and manage key stakeholders, including VSBA as Principal and school's principal or representative

2.2.3 Commissioning

- Provide as constructed drawings compliant with this specification
- Ensure all individual systems have been fully commissioned and witness tested to the satisfaction of the client.
- Provision of commissioning and test results in accordance with AS/NZS 3000, AS 5033 and AS4777 including the additional commissioning tests as outlined in Appendix E of AS 5033:2014, including, but not limiting to:
 - Megger tests
 - Earth leakage tests
 - Earth continuity and resistance test
 - Anti-islanding tests
 - PV array I-V curve
 - Inverter, breaker and relay tests as per manufacturer recommendations



- Secondary current injection test of the relays
- String polarity tests
- Open circuit voltage measurement and short circuit current of the strings
- Fixing torque measurements
- Pull out testing of structural fixings
- Thermographic imaging of the switchboard connections, sample of MC4 connection and DC switches
- Thermographic imaging of the complete solar panels' installation (using drones or other methods as required) when system is operating in midday of a sunny day.
- DNSP requirements
- Liaise with and manage key stakeholders, including Principal and schools

2.2.4 Post construction Handover

- Provide As-constructed drawings of the entire works to provide an accurate record of installation:
 - Show dimensions, types and locations of equipment, cables, piping, ductwork pits and markers in relation to permanent site features and other underground services
 - Show the "as constructed" locations of building elements, plant and equipment with particular emphasis on items requiring maintenance or cleaning
 - Show off-the-grid dimensions where applicable. Include relationship to building structure street features and other services, and changes made during commissioning
 - Include relationship to building structure, other services, and street features and changes made during commissioning
 - Include diagrammatic drawings of each system showing piping conduits and wiring and principal items of equipment
 - Control documentation to include setpoints and settings of all controls (According to the site generation capacity and grid connection agreement)
 - Drawings shall incorporate circuit breaker number on all circuits
 - Drawings of layout plans shall be produced at 1:100 scale. These shall have identical information with suitably scaled symbols to ensure readability. This is to allow larger areas of the works to be viewed on a single drawing sheet. The drawings shall have individual drawing numbers.
 - CAD drawing to be provided and included in the Principal's SAMS Plans
- The contractor is to arrange for a certified structural engineer to inspect and certify the completed system installation. This inspection shall confirm that the installation is in line with the intent of the design certification.
- Provision of Operational & Maintenance Manuals which shall include all design and manufacturer documents, SWMS, grid connection approvals, inverter and modules serial numbers etc.
- Provide warranties, and warranty certificates where applicable, associated with the system and components of the system. This should be included as part of the O&M manuals



- List and evidence of rectified defects
- Training of operating personnel of the school and Department of Education and Training, as appropriate
- Defects liability and generation guarantee period of one year from approved practical completion
- Liaise with and manage key stakeholders, including Principal and schools

2.2.5 Performance Guarantee

Contractors shall offer a Guaranteed System Performance (GSP), as measured on the AC side of the inverters at the point of connection to the existing switchboard by AC meters.

- This offer shall be the guaranteed annual kWh output.
- Contractors shall provide written evidence of their Guaranteed System Performance offer with their RFQ to be confirmed during the site visits post RFQ award. The Guaranteed System Performance is a RFQ evaluation criterion.

If the system does not meet the Guaranteed System Performance for a period of four (4) weeks, Practical Completion will not be issued. The Contractor will be responsible for improving the system performance at no cost to the Principal, until this guaranteed performance is demonstrated. This shall be achieved by rectifying defects.

2.3 Deliverables checklist

Appendix C – Document submission checklist

Lists the expected contractor deliverables at different stages of the project. All drawings shall be prepared and submitted in PDF format and AutoCAD files shall be provided as part of the O&M package. All deliverables are to be provided in an organised and structured fashion with all documents properly referenced and revision controlled.

All documentation will be released in consolidated packages, as per the stages of this specification; including the studies, reports, drawings and supporting documentation. Design documents shall be up to date and consistent where they interface with other stakeholders.

All submissions are to be in English.



3 General System Requirements

3.1 Standards

The work shall comply with the specifications, standards, codes, rules and regulations of all statutory authorities having jurisdiction over the works. This shall include, but not be limited to the latest revision of the following:

Table 3-1 Standards and Authorities

Standards and Authorities
Australian Standards, generally as listed throughout this specification
AS1170 Structural Design Actions: Part 1 Permanent, imposed and other actions.
AS1170 Structural Design Actions: Part 2 Wind Actions.
AS1170 Structural Design Actions: Part 3 Snow and Ice Actions.
AS1170 Structural Design Actions: Part 4 Earthquake Actions.
AS4100 Steel Structures.
AS3600 Concrete Structures.
AS3700 Masonry Structures.
AS1657 Fixed Platforms, Stairways, Walkways and Ladders.
AS1664 Aluminium Structures
AS5033 Installation and Safety Requirements for Photovoltaic (PV) Arrays
AS3566.2 Self-drilling for the building and construction industries
AS/NZS5000.1 Electric cables –polymeric insulated – for working voltages up to and including 0.6/1 kV
AS/NZS3000 Wiring Rules
AS/NZS5033 Installation and safety requirements for photovoltaic (PV) arrays
AS4777.1 and AS4777.2 Grid connection of energy systems via inverters
AS/NZS3835 Earth potential rise - Protection of telecommunications network users, personnel and plant Code of practice
AS2067 Substations and high voltage installations exceeding 1 kV a.c.
AS/NZS1768 Lightning protection
AS3008 Electrical installations – Selection of Cables



AS/NZS 3013 Electrical installations – Classification of the fire and mechanical performance of wiring system elements.
AS3191 Electric flexible cords
AS2373:1 Electric cables for control and protection circuits – multi-core control cables
AS2373:2 Electric cables for control and protection circuits – twisted pair control cables
AS/NZS2053 Conduits and fittings for electrical installations
AS1074 Steel tubes and tubulars for ordinary service
AS/NZS 61439 Low-voltage switchgear and control gear assemblies
IEC61215 Crystalline silicon terrestrial photovoltaic (PV) modules - Design qualification and type approval - Protection Class II
IEC61730 / EN 61730 Photovoltaic (PV) module safety qualifications
AS1657 Fixed platforms, walkways, stairways and ladders - Design, construction and installation
AS/NZS5000 Electric cables – Polymeric insulated
ISO 9001 Quality management systems - Requirements
European Community Directives 89/33/EEC, 73/23/EEC, 93/68/EEC
Certified by TÜV Rheinland as Safety Class II (IEC 60634) equipment for use in systems up to 1000 VDC
Victorian Service and Installation Rules (VSIR)
National Construction Code of Australia 2016
Local Authority requirements
Electricity Industry Act 2000 Vic
Electrical Safety Act 1998 Vic
Electrical Safety (Codes Of Practice) Notice
Telecommunications Act 1997 Vic
Local Government Act 2020 Vic
Environment Protection Act 2017 Vic
Occupational Health and Safety Act 2004 Vic
Planning Legislation Vic
Plant Protection Act 1989
Plant Protection (Red Imported Fire Ant) Quarantine Notice 2001
Clean Energy Council (CEC) Grid-Connected PV Systems Installation Guidelines
Australian Communication and Media Authority
Department of Environment and Resource Management
ISO 9060:2018 Solar Energy-Specification and classification of instruments for measuring hemispherical solar and direct solar radiation



AS1319 Safety signs for the occupational environment
AS/NZS 3017:2007 Electrical installations - Verification guidelines
AS 1627 Metal Finishing - Preparation and Pre-treatment of Surfaces
AS 3715, Metal finishing - Thermoset powder coating for architectural applications.

3.2 Design life and warranty

Unless otherwise outlined in subsequent sections of this specification, design, equipment and construction shall be suitable for a minimum life-time of 25 years.

PV modules and factory installed DC cables and connectors shall have a minimum 10-year product warranty and 25-year linear power warranty. The remedy during the product and power warranty period shall be repair, replacement, or refund as mutually agreed.

At the end of the solar PV modules power warranty, panels shall generate at least 80% of their nameplate (not minimum) rated output as measured under STC conditions with a linear generation guarantee from time of installation.

3.3 Electromagnetic compatibility

Comply with AS/NZS 61000 and the Australian Communications and Media Authority requirements for electrical and electronics products to limit electromagnetic interference (EMI).

3.3.1 Immunity

Electrical and electronic apparatus: To AS 61000.6.1

3.3.2 Harmonics and voltage surges

Level of emissions to be acceptable to the local DNSPs.

3.4 Maintenance and access

The photovoltaic services installation must allow ease of maintenance. If it is deemed that plant or equipment cannot be installed in a manner that allows ease of maintenance, seek direction from the Principal.

3.5 Labelling and Identification

3.5.1 Extent

Provide detailed warning labelling in accordance with AS/NZS 3000, AS 4777 and AS/NZS 5033, including all upstream LV AC switchboards.



Contact the Principal for access to the substation and main switch rooms as required.

Provide labelling of conduits, cables, inverters and PV modules. The labelling hierarchy is as follows:

The same level of information for "Site ID / Building number / Inverter number" will be provided by the following string:

'## / X / I## / S### /
Example -
'01 / A / I20 / S112'

String cabling will be identified by this label at the inverter and at the DC isolator, which will be physically next to the string of modules. Coded string layout diagrams will be detailed in the maintenance manuals.

More details on the application of this labelling is provided in subsequent sections of this specification.

All labelling shall be included on shop drawings, design drawings and As Constructed drawings.

3.5.2 Type and colour

Labelling shall be engraved multi-layered Traffolyte, compliant with AS 1319. Colour shall be black on white for ID labelling, red on white for warning labelling.

For external cable labels, external labels shall be engraved stainless steel, minimum thickness 1 mm.

Traffolyte or similar is acceptable for DC Switches, inverters, PV-DB equipment.

If labels exceed 1.5 mm thickness, use radiused or bevelled edges.

3.5.3 Installation

Locate labels so that they are easily seen from normal access adjacent to the item being marked. Do not install labels on components normally removed or replaced.

Exposed locations: Provide durable materials as described above.

Fixing: Use mechanical fixings on rooftops and switchboards. Adhesive fixing will be acceptable on inverters.

3.5.4 Modules and inverters

Refer to the subsequent sections of this specification for specific labelling requirements and the Contractor shall follow CEC installation guidelines and relevant Australian Standards.

3.6 Installation

3.6.1 General

Carry out the work in a proper and safe manner.

Arrangement: Install equipment and services parallel or perpendicular to building elements unless otherwise approved by the Principal. Organise reticulated services neatly. Provide for movement in



both structure and services. Keep services at least 150 mm clear above ground surface, additional to insulation.

Movement and Expansion: Provide expansion facilities in ductwork, piping, cables, cable trays and supports to accommodate thermal expansion and movement at structural expansion joints.

Protection: Protect equipment from weather and the ingress of dirt, moisture, vandalism and tampering.

Access: Provide access to all components requiring entry, inspection or maintenance.

Store materials and equipment (including cables) in a clean, dry environment, out of sunlight.

3.6.2 Materials

Specifications

Provide paints and other materials in accordance the Australian Paint Approvals Scheme

Table 3-2 List of approved products

Item No	APAS Specification	Approved Product
1	APAS-0134	Latex primer for galvanised steel and zincalume (buildings)
2	APAS-0015/1	Full gloss exterior enamel (buildings)
3	APAS 0016/1	Solvent borne undercoat - interior/exterior (buildings)
4	APAS 0181	Solvent borne wood primer (buildings)
5	APAS 0024/1	Full gloss oil and petrol resistant enamel
6	APAS 0280/1	Gloss exterior latex paint (buildings)
7	APAS 2916	Organic zinc rich coating for steel protection in the atmosphere
8	APAS 0032	Metal primer (buildings) (lead and chromate free)
9	APAS 0035/2	One pack etch primer (Chromate free)
10	APAS 0044	High temperature heat resistant paint (equipment)
11	APAS 0045	Heat resistant primer for 200°C (equipment)
12	APAS 0155/1	Interior grade powder coating
13	APAS0155/2	Exterior grade power coating
14	APAS 0162/1	Zinc phosphate metal primer

3.6.3 Warranties

Name the Principal as warrantee. Register with manufacturers as necessary. Retain copies delivered with components and equipment.

Commencement and duration: Commence warranty periods at practical completion or at acceptance of installation if acceptance is not concurrent with practical completion. Warranty periods to end at expiry of defects liability period unless specified otherwise.

Approval of installer: If installation is not by manufacturer, and product warranty is conditional on the manufacturer's approval of the installer, submit the manufacturer's written approval of the installing firm.



3.7 Safety in Design

The Contractor and any of the Contractor's design Subcontractors shall undertake a Safety in Design process in accordance with the requirements of Victorian Work, Health and Safety Legislation.

The Contractor shall run these meetings and invite the Principal to participate in all safety in design workshops or meetings. The designers, including any design subcontractors shall also be involved in the safety in design meetings and workshops.

It is a project requirement to provide Safety in Design (SiD) meeting minutes and produce a live risk register to be issued to the Principal at design and construction stages.

3.8 Commissioning

The contractor shall be responsible for commissioning and energisation of works. All the commissioning activities must be carried out to demonstrate the system operates safely and continuously complying with the requirements of technical specification and is suitable for the purpose of generating electricity at the injection point.

3.8.1 General

Notice

The contractor should adhere to the following in regard to notice and liaison with the Principal:

- Adequate notices are to be agreed with the Principal.
- Inspection witness points: Give notice for inspection in respect of relevant parts of the works and advise if and when those parts are to be concealed.

Minimum notice for inspections to be made: four hours for inspector's full time on-site, otherwise two working days for on-site inspections, and five working days for local pre-delivery inspections.

3.8.2 Commissioning Requirements

- Prepare a full commissioning plan to the Principal's satisfaction, as part of design submissions.
- Provide completed ITP and ITR as part of the commissioning records
- Where using subcontractors, ensure the Contractor provides a representative on the Project Commissioning Management Team
- Maximise use of off-site pre-commissioning activities where appropriate
- Engage equipment manufacturer and the Principal in the commissioning process, where approved
- Failure scenarios – Configure the operation of systems under failure and fault scenarios including but not limited to following
 - Failure of mains power
- Prior to Practical Completion, ensure all individual systems have been fully commissioned and witness tested to the satisfaction of the Principal.



3.9 Practical Completion Tests

The contractor shall be responsible for conducting, completing and passing all the tests included but not limited to this section. Testing shall be considered as passed when all the activities within that particular testing domain are complete, and all identified defects have been rectified and re-tested. The contractor is responsible for operation and maintenance of works until practical completion.

3.9.1 General

Notice

The contractor should acknowledge the notice period and plan the testing activities accordingly.

Witness tests: Give sufficient notice for designated tests to be witnessed.

Testing authorities

Except for Site Tests, have type tests carried out by authorities accredited by NATA for testing in the relevant field, or an organisation outside Australia recognised by NATA through a mutual recognition agreement. Cooperate as required with testing authorities.

Site tests: Use instruments calibrated by authorities accredited by NATA.

Where certain test equipment is project specific and thus their first practical use will be on this project, approval from Principal is required. In this instance it is required that the test is carried within the first-year factory calibration warranty period.

Reports

Submit reports indicating observations and results of tests and compliance or non-compliance with requirements. Include dates, testing data, test results, protection relay settings for all equipment and systems, with completed checklists. Include all software.

3.9.2 Practical Completion Test 1 – Verification of Civil Work

Where applicable, the test will be conducted following completion of all civil, remediation and revegetation work and when no further heavy vehicle use is expected on the Site.

The Contractor shall:

- Verify that Site Entrance has not degraded due to the use by the Contractor in performing the Works or that any degradation has been remediated to the satisfaction of the Principal
- Verify that there is no erosion present on the site. Verify that all slopes and soils have been stabilised to prevent any future erosion, where applicable.

3.9.3 Practical Completion Test 2 – Verification of Structures

This testing shall be applied to all PV structures and fasteners making up part of the solar system unless noted otherwise below.

The Contractor shall:



- Perform visual verification of the correct installation of the PV module structure (member spacing, , alignment according to plan, etc.). This procedure to be performed during the installation and recorded on the relevant ITPs
- At random, verify the correct torqueing of fasteners on structures (all fasteners on a minimum of 10% of the structures (including PV module connections) shall be tested). To be performed following complete installation of structures, PV modules, earthing cabling so that all fasteners can be tested. Results to be provided with O&M manual.
- Perform visual inspection of the PV module structures for corrosion or damage to galvanising.
- Confirm framing has been installed as per the structural certification and the design documents associated with the certification as well as the relevant product manufacturing guidelines

3.9.4 Practical Completion Test 4 – Verification of Communication and Control System

The school must be operational and delivering electricity to the Connection Point before commencing the test.

The Contractor shall verify that all required data is able to be received by the Principal through the agreed communication methods

3.9.5 Practical Completion Test 5 – Verification of DC Cabling

This test shall be applied to all DC cabling and PV module leads at the school associated with the solar power system.

This test shall be undertaken following the complete installation of all DC cabling and the complete installation of all cable supports and protection.

The Contractor shall:

- Verify that excessive bending radii and tension applied to cabling has been avoided. Verify that all cabling (and supports) are fastened to structural elements so that stability is ensured at all times
- Verify that no cables or sections of cables are dangling or unsupported
- Verify that all cable sections are fastened and in good condition with no damage. Verify that there are no sharp edges that may damage the cabling
- Verify that plastic cable ties have not been used as a primary means of support for DC cabling
- Verify that all transitions, if applicable (including above ground to below ground cabling, above ground transitions) are correctly fastened to the structural elements using weather resistant joint elements and are protected from mechanical damage
- Verify that all underground cabling, if applicable, has been installed according to the design and in accordance with all Applicable Standards (to be completed during the installation process and recorded on ITPs).

3.9.6 Practical Completion Test 6 – String Polarity Testing

All strings of PV modules within the school shall be subject to this test. The test may commence once the PV modules under test are installed and connected in series back to the combiner box/inverter.



The test shall verify the polarity of strings by following the procedures detailed below:

- Connect the voltmeter at the positive and negative terminal input block of the string
- Verify the polarity of all strings and document the results in a report for each
- Combiner box/inverter.

3.9.7 Practical Completion Test 7 – Open Circuit Voltages

All strings of PV modules within the school shall be subject to this test.

The procedure shall be performed when the strings are connected back to the combiner box/inverter. The test shall be conducted on a sunny day with stable global horizontal irradiance greater than 600 W/m² and the measurements shall be carried out on a single combiner box/inverter within a short period of time. The tests shall be undertaken when all the PV modules under test are in open circuit.

The tests shall only be performed after the measurement of solar irradiance as per section 9.

A digital voltmeter with a precision of 1% or better shall be used for this test. The Contractor shall verify that the terminal insulators are open before the measurements are made. Record the measured open circuit voltage (Voc) of all strings in a report for each combiner box/inverter. Take the above values in the shortest time possible to ensure that temperature and irradiance conditions are as similar as possible during the test. For each string the measurement is to be taken three (3) times. If there are deviations greater than 30% between the measurements the route cause is to be identified and corrected and the procedure repeated.

The open circuit voltage measurement of any two strings must not differ more than 5% of the average PV module open circuit voltage within the same combiner box/inverter. The difference must be found in at least two (2) of the three (3) measurements taken. If greater values are obtained, perform all appropriate corrective actions. Repeat the measurements as many times as required to obtain differences within the limit.

3.9.8 Practical Completion Test 8 – DC Cable Insulation Testing

This test shall cover all DC cable between PV strings and inverters. The procedure will be performed once all the DC circuits have been completed.

- The Contractor shall perform a visual inspection of all accessible cabling and:
 - Check the cabling for proper condition
 - Ensure there are no shredding, splices or repairs with insulating tape or any other improper elements
- Following the visual checks, the Contractor shall perform the IR test procedure according to the standard AS 3017 (IEC 60364-6) “LV electrical installation verification”.
- The test shall be passed once all of the cabling under test meets the following requirements:
 - The cabling is in good condition and the cable resistance of the test shows insulation greater or equal to 1MΩ and in accordance with AS3017
 - The cabling complies with all other criteria in Applicable Standards
 - All faulty sections found have been replaced.



3.9.9 Practical Completion Test 9 – Earthing Resistance Test for new earth systems-if applicable

Testing shall only be undertaken when the earthing system is complete and is to be carried out by competent persons.

The Contractor shall:

- Perform a visual inspection of all accessible earth cabling. Check earth cabling for condition. Ensure there are no slices or repairs with insulating tape or any other improper elements.
- Verify that all metallic elements (including all cable tray sections) are connected to the earthing system by a fastener, terminal or by the electrical continuity of the structure.
- Continuity tests of earthing connections
- Carry out current injection resting of the earth grid, where a new grid has been installed or existing grid has been modified, to verify the installation against the design including:
 - Earth grid combined impedance
 - Earth potential rise measurement
 - Current distribution
 - Transfer, step and touch potential testing.

The above tests are to be carried out in accordance with AS/NZS 3000 & AS 2067. The test results are to be recorded and provided to the designer to review. The test will be passed if the installation is within the design requirements.

3.9.10 Practical Completion Test 10 – Inverter Testing

All inverters at the school associated with the solar power system shall be subjected to this test. The Contractor must conduct testing of the inverter as required or recommended by the inverter supplier and any tests required for maintenance of the inverter warranty. All inverter testing must demonstrate compliance with the requirements of the inverter supplier and with the inverter data sheet.

3.9.11 Practical Completion Test 11 – Visual Inspection of the PV Modules

This test shall be applied to all the installed PV modules at the school.

- Following the complete mechanical and electrical installation, the Contractor shall perform a thorough visual inspection of each module for the following defects, as well as inspecting or any other non-compliances with the manufacturer's specifications:
 - Cracked (including micro cracks), bent, misaligned or torn external surfaces;
 - Broken Cells;
 - Cracked Cells;
 - Faulty interconnections or joints;
 - Cells touching one another or the frame;
 - Failure of adhesive bonds;
 - Bubbles or delamination forming a continuous path between a cell and the edge of the module;



- Tacky surfaces of plastic materials;
- Faulty terminations, exposed live electrical parts;
- Any other conditions which may affect performance.

The nature and position of any cracks, bubbles or delamination etc. which may worsen and adversely affect the module performance in subsequent tests shall be noted and/or photographed.

For defects not explicitly stated above, the Contractor shall determine the cause and potential present and future impact. If it is determined that the defect affects or will affect production or the integrity of the PV module, it will be considered a reason for rejection.

- During the inspection, for any identified defect, the following shall be recorded:
 - Position
 - PV module serial number
 - Description of the defect observed (if any)
 - Date of detection of the defect
 - Hyperlink to photographs showing the defect.
- Compliance with the following is required to pass the test:
 - All PV modules at the school have been inspected in accordance with the test procedure and any PV modules determined to be defective under the test have been replaced with new PV modules
 - Replacement PV modules have been inspected in accordance with the test procedure and have been found defect free.

3.9.12 Practical Completion Test 12 – Installed Capacity Guarantee

This test shall occur following the complete installation of all PV modules at the school.

The installed DC capacity is equal to the sum of the nameplate rated power under STC of all PV modules.

The installed AC capacity is equal to the sum of the rated AC output power of all inverters installed at the school.

- For the test to be passed the following must hold true
 - The installed DC capacity must be equal to or greater than the guaranteed DC capacity.
 - The installed AC capacity must be equal to or greater than the guaranteed AC capacity.

3.9.13 Practical Completion Test 13 – Performance Guarantee Test

Refer to Section 9.

3.10 General O&M Manual requirements

Operation and maintenance manuals provide a detailed understanding of the plant and its operation, an aid for training of operation, a reference for fault diagnosis and a framework for preventive and breakdown maintenance.



The Contractor shall submit draft copy of the operation and maintenance manuals for the electrical services installation, prior to Practical Completion, for the Principal's acceptance.

The Contractor shall use personnel experienced in the maintenance and operation of the equipment and systems installed and must have the technical ability to write an operation and maintenance manual that can be handed over to the Principle prior to Practical Completion.

3.10.1 Content Requirements

- Format: Electronic (pdf, jpg and AutoCAD)
- Table of contents: For each volume. Title to match cover. First volume to have an index of all volumes.
- Directory: Names, addresses, and telephone and facsimile numbers of principal consultant, sub-consultants, contractor, subcontractors and names of responsible parties.
- Scope of works: Statement of scope of services and interfacing with other contracts.
- Installation description: General description of installation.
- Systems descriptions: Technical description of the systems installed, written to ensure that the principal's staff fully understand the scope and facilities provided. Identify function, normal operating characteristics, and limiting conditions. Include schematic diagrams.
- Systems performance: Technical description of the modes of operation of the systems installed.
- Equipment descriptions:
 - Name, address and telephone and facsimile numbers of the manufacturer and supplier of items of equipment installed, together with catalogue list numbers.
 - Schedule (system by system) of equipment, stating locations, duties, performance figures and dates of manufacture. Provide use a unique code number cross-referenced to the record and diagrammatic drawings and schedules, including spare parts schedule for each item of equipment installed.
 - Manufacturers' technical literature for equipment installed, assembled specifically for the project, excluding irrelevant matter. Mark each product data sheet to clearly identify specific products and component parts used in the installation, and data applicable to the installation. Do not include advertising literature.
 - Supplements to product data to illustrate relations of component parts. Include typed text as necessary.
- Operation procedures:
 - Safety procedures for protection against electrical, mechanical, fire, explosive and chemical hazards including first aid and reporting.
 - Prestart checklist, safe starting up, running-in, operating and shutting down procedures for systems installed. Include logical step-by-step sequence of instructions for each procedure.
 - Control and switching sequences and flow diagrams for systems installed, including safety features. Also, procedures for operating and adjusting control systems.
 - Legend for colour-coded services.
 - Schedules of fixed and variable equipment settings established during commissioning and maintenance.



- Testing logging and reporting.
 - Procedures for seasonal changeovers.
 - Manufacturer's operational and safety literature as appropriate.
 - Trouble shooting check lists and simple diagnostic analysis.
- Maintenance procedures:
 - Emergency maintenance procedures, including telephone numbers for emergency services, and after hours contacts for suppliers and contractors and procedures for fault finding.
 - Manufacturer's technical literature as appropriate. Register with manufacturer as necessary. Retain copies delivered with equipment.
 - Detailed recommendations for preventative maintenance frequency and procedures which should be adopted by the principal to ensure the most efficient operation of the systems installed. Include inspection, testing and maintenance programme in tabular form showing frequency and level of routine checks for each item.
 - Safe trouble-shooting, disassembly, repair and reassembly, cleaning, alignment and adjustment, balancing and checking procedures. Provide logical step-by-step sequence of instructions for each procedure. Include calibration and recommissioning of controls.
 - Schedule of spares recommended to be held on site, being those items subject to wear or deterioration and which may involve the principal in extended deliveries when replacements are required. Include complete nomenclature and model numbers, and local sources of supply. Include sectionalised diagrams of machines identifying component parts.
 - Schedule of normal consumable items, local sources of supply, and expected replacement intervals up to a running time of 40,000 hours.
 - Referenced documents: If referenced documents or technical sections require that manuals be submitted, include corresponding material in the operation and maintenance manuals.
 - Certificates:
 - Statutory Certificates of Compliance for:
 - Electrical Work
 - Copies of manufacturers' warranties
 - Certificates from authorities and utilities
 - Product certification
 - Copies of test certificates for the mechanical installation and equipment used in the installation
 - Electrical Works Request
 - SWMS
 - Network approval(s)
 - Certificate of Electrical Safety
 - STC Assignment Form
 - Structural Certification
 - Drawings:



- Drawings and technical data: As necessary for the efficient operation and maintenance of the installation.
- Record drawings.
- Switchgear and control gear assembly circuit schedules including electrical service characteristics, controls and communications.
- Commissioning Records:
 - Equipment test sheets.
 - Power consumption
 - Completion test results
 - List of inverters and modules serial numbers
- Photographs of installation and installed equipment

Warnings and Cautions

Warning and Cautions shall be used throughout the O&M manual to emphasise conditions hazardous to personnel or equipment, giving instructions to avoid the hazard.

Format to be:

WARNING: An examining or testing procedure or practice which must be observed or risk loss of life or injury to personnel.

CAUTION: An examining or testing procedure which must be followed or risk damage to equipment.

Software backups

For each software-based system, provide an electronic copy of the complete software source code. The As Constructed software records shall include all modifications made during final testing and commissioning. As Constructed software records shall be provided at Practical Completion, with another copy provided at the completion of the defects liability period.

Update existing site survey drawings

Obtain an electronic copy of the existing site services drawings from the Principal, where available and update with the new electrical services' routes. If not existent, provide as-built drawings.

Timing and quantity

First draft manuals: Submit a first draft manual before the date for practical completion for review and to enable the principal's staff to familiarise themselves with the installation. Include provisional record drawings.

- Format: As for the final manuals, with temporary insertions for items which cannot be finalised until the installation is commissioned and tested.

Final copies: Submit the final electronic copy within two weeks after practical completion. Incorporate feedback from review and from training of principal's staff, including preparation and insertion of additional data. Include a section containing commissioning test reports.



Required operating instructions

Provide operating instructions and schematic diagrams mounted alongside equipment to meet statutory requirements. Diagrams to be colour coded, colour fast, laminated and mounted.

Additional requirements

Additional specific requirements for operation and maintenance manuals are outlined in the relevant sections of this specification.

Photos

Submit all photos taken during the construction process to the Principal, as this may aid future maintenance. This may be as part of the final submission.

3.11 Training

3.11.1 Operation and maintenance

Prior to practical completion, explain and demonstrate to the operators the purpose, function, operation and maintenance of the installations.

Issue the handover documents and warranties.

Provide a comprehensive training course including formal tuition, informal discussion, and demonstrations.

Use items and procedures listed in the final draft operation and maintenance manuals as the basis for detailed instruction of staff nominated by the Principal.

Submit the training procedures and programme for each system and equipment, prior to Practical Completion for acceptance by the Principal.

Documentation: Upon completion, submit certificates of training, signed by trainer and operators.

Demonstrators: Provide qualified manufacturer's training representatives who are knowledgeable about the installations.

3.11.2 Technical assistance

During the warranty period, provide technical assistance and advice to the Principal's staff regarding the operation and maintenance of the plant.

3.12 Spare parts

3.12.1 General

Provide a spare part schedule necessary for the expected maintenance of the installation over the next 10 years. The spares are expected to include balance of system components such as circuit breakers, combiner boxes, safety switches, cabling, etc. Inverters are not required in this list.

Confirm with the Principal when spares will be required to be provided for the site.



3.12.2 Spare parts schedule

At least eight weeks before the date for practical completion, submit a schedule of spare parts. State against each item the recommended quantity, and the manufacturer's current price, including for:

- Packaging and delivery to site
- Checking receipt, marking and numbering in accordance with the spare parts schedule
- Referencing equipment schedules in the operation and maintenance manuals
- Packing to prevent deterioration during storage

3.13 Maintenance

Co-extensive with the defects liability period.

3.13.1 Required maintenance

During the maintenance period, carry out routine maintenance, inspections and tests in accordance with the equipment manufacturer's recommendations and prepare a brief report summarising all maintenance activities.

At the completion of the defects liability period, clean all PV modules to the satisfaction of the Principal.

3.13.2 Routine maintenance

During the maintenance period, carry out preventive maintenance work in accordance with the operation and maintenance manuals, as recommended by manufacturers of supplied equipment, and as required by referenced documents.

3.13.3 Breakdown maintenance

Repair and maintain plant subject to breakdown during the maintenance period. Attend emergency calls promptly.

3.13.4 Maintenance program

Submit details of maintenance procedures and program, relating to installed plant and equipment, six weeks before the date for practical completion. Indicate dates of service visits. State contact telephone numbers of service operators and describe arrangements for emergency calls.

3.13.5 Supplies

During maintenance period provide all replacement parts free of charge.

3.13.6 Site control

Report to the Principal's designated representative on arriving at and before leaving the site. Adhere to school induction procedures for all on-site personnel.



3.13.7 Maintenance records

General: Submit, in binders which match the manuals, loose leaf log book pages designed for recording completion activities including operational and maintenance procedures, materials used, test results, comments for future maintenance actions and notes covering the condition of the installation. Include completed logbook pages recording the operational and maintenance activities performed up to the time of practical completion.

Number of pages: The greater of 100 pages or enough pages for the maintenance period and a further 12 months.

Service visits: Record comments on the functioning of the systems, work carried out, items requiring corrective action, adjustments made and name of service operator. Obtain the signature of the principal's designated representative. Submit duplicate copies.

Referenced documents: If referenced documents or technical sections require that log books or records be maintained include this material in the maintenance records.

3.13.8 Plant shutdowns

If applicable, coordinate any plant shutdowns with the principal and advise when plant is returned to service.

3.13.9 On-going maintenance

Prior to final completion submit a proposal for on-going maintenance of all systems and plant.



4 Structure

4.1 Introduction

The contractor is responsible for the detailed design, supply and installation of all structural elements required to support the proposed photovoltaic panel system or switchboards. This shall include but is not limited to: module support frames, raking system, fixings, connections to the existing roof and roof access system required for support and maintenance of the system. The contractor shall also be responsible for ensuring the structural capacity of the existing building is sufficient for the proposed works.

4.2 Existing Roof Structure

4.2.1 Project Assessment

Preliminary assessment

A preliminary assessment of the site shall be conducted by the contractor prior to design of the system as outlined in section 2.1 of this specification. This shall include a site visit and review of any existing information provided by the Principal to determine appropriate layout of panels. The layout design should account for how best to apply the additional structural loads imposed on the roof from the new system without requiring modification of the existing structural system, where possible. If it is found that strengthening of the existing roof is required to meet the system requirements this should be brought to the attention of the Principal for review.

Dilapidation survey

Prior to the commencement of detailed design, prepare a dilapidation/investigative report, summarising the condition of the existing building, and findings of the initial investigations as required elsewhere in this specification.

This report shall address the following key items as a minimum:

- The exact make and model of roofing material for each building roof.
- The type, location and system of roof drainage and waterproofing.
- Condition of existing roof, identifying any pre-existing defects, including locations of ponding.
- Condition and cleanliness of existing gutters and downpipes.
- Suitability and condition of the roof access or fall arrest system.
- Suitability and condition of the existing roof access infrastructure.
- Photographic documentation of the roof including a reference document with all existing defects.



4.2.2 Design

Structural review

The structural capacity of the existing roof shall be reviewed and certified by a suitably qualified structural engineer; the assessment shall include loads imposed by the new works.

The capacity of the existing structural elements of the roof to resist the additional loads shall be checked for compliance with the relevant Australian Standards. This shall include but is not limited to items including purlins, rafters, beams, slabs, roof sheeting, fixings, etc.

Additional deflections that result from the new loads shall not exceed Australian Standards and shall not adversely affect the function of the roof.

The loads imposed on the roof by the system shall be determined as per section 4.3.1 of this specification. The assessment of the existing roof should take into account all loads however particular attention shall be on the wind force applied to the system that may generate a significant load on the associated building structure. This load shall be included in an assessment of the capability of the roof to withstand the resulting forces.

Where building movement joints are present the system shall be designed so as to allow the relative movement of the building.

The contractor is to provide a written statement from a suitably qualified engineer confirming, in line with this specification and relevant Australian Standards and Codes that the existing roof has sufficient capacity to support the new loads. If it is found that strengthening of the existing roof is required to meet the system requirements this shall be brought to the attention of the Principal for review.

The written statement shall include the following key inputs:

- Scope/Purpose
- Standards
- Assumptions
- Observations
- Building Description
 - Site Wind Classification
 - Loads
 - Proposed Layout
 - Building characteristics including age, construction and defects wherever related to the solar installation
- Comments and recommendations
- Conclusion
- Signature
- Reference Material
 - Photos
 - Drawings



- Details and condition of the structural system supporting the roofing material. Details should include the following:
 - Member sizes and type
 - Spacings of members
 - Purlin type and size
 - Other structural information necessary for certification of the existing roof.

4.3 Structural Framing

The structural requirements for all elements associated with the photovoltaic system which include but are not limited to: the panel support framing and members, fixings, clamps, roof fixings, roof access and maintenance access system and all penetrations shall be designed, fabricated and installed as per the following section.

The contractor is to provide installation requirements and guidelines from the manufacturer for the fabricated system. This shall include information on the capacity of the system as required. The installation guidelines shall be accompanied by a certification from the manufacturer by a qualified engineer that the system if installed as per their recommendations and guidelines meets Australian Standards.

Depending on the site, this typically falls under one of these paths:

- 1) The building and environment meet exactly the specific circumstances (envelope) the manufacturer has had "their" structural engineer certify.
- 2) The application is outside the envelope and a full structural certification must be done by the Solar Supplier's structural engineer using the results from component and systems test reports or first principles.

The contractor is to engage a suitably qualified structural engineer to review the proposed installation and confirm the system is designed in line with the manufacturers recommendations for the specific rooftop type in accordance with this specification and the relevant Australian Standards and Codes. Where the proposed system is outside of the manufacturer's recommendations this should be allowed for in the engineer's certification.

4.3.1 Design loads

The system shall be designed and installed so as to comply with the loads described in AS1170. This shall include but is not limited to allowances for, permanent and imposed loads, wind loads including cyclonic events, earthquake loads and snow loads.

General

The system shall be designed to have a 25 year design life.

The contractor's structural engineer shall determine the importance level of the system in line with AS1170 and the Building Code of Australia, this shall not be less than Importance level 2. The engineer shall consider the supporting building's importance level in their assessment. This assessment is to be included as part of the preliminary design documentation for approval and acceptance.



Wind Loads

The system including fixings shall be designed to resist the ultimate wind actions for the site. Wind loads on the system are to be calculated in accordance with AS1170.2 and the information included below. For applications beyond the limits of AS1170.2, wind testing may be required.

The system shall comply with the following:

Annual probability of exceedance as per AS 1170.2

Wind region: As per AS 1170.2

Mz,cat: As per 1170.2

Ms: 1 (No shielding from surrounding structures shall be assumed).

Mt: As per 1170.2

Key issues to be considered by the designer when considering the wind loads include but are not limited to:

- Fixing spacing appropriate to roof type and location on roof.
- Minimum sheet thickness of steel roof sheeting
- Fastener specification
- Exclusion zones
- Torque requirements for fixings

Snow Loads

The system including fixings shall be designed to resist snow loads, where appropriate. Snow loads on the system are to be as per AS1170.3. Where the configuration of the panels may increase the snow loads on the existing structure this should be assessed and acceptance of the buildings capacity to withstand the additional loads be approved by a suitably qualified engineer.

Earthquake Loadings

Components and attachments to resist horizontal earthquake forces in any direction up to half the mass of components. Comply with AS 1170:4.

The fixity of all electrical equipment and components and assemblies shall be installed to meet the requirements of AS 1170.4 for structures of earthquake design category II.

This is to ensure that all structural and non-structural components, plant and equipment are mechanically secured in place for all applied directions of force including horizontal and vertical. The installation of large heavier items (e.g. modules, inverters etc) will not rely solely on gravity or friction for locating any such equipment. Provide all necessary anchor points, tie-bolts and securing rods as required.

4.3.2 Panel support

General

Provide a fabricated framing system compliant with the standards referenced in this specification to support the extent of the module system required, this should include an allowance for the site-



specific tilt angle and orientation of the system. The system shall generally be orientated orthogonal to the building structure. Framing shall be fixed to the roof without any screw fixings or penetrating the existing roof, otherwise approved by the Principal or wherever not applicable.

The contractor is to engage a suitably qualified structural engineer to design and certify a framing system for each rooftop application, certification of the design should be submitted to the Principal for review prior to construction.

Use metalwork capable of transmitting the loads imposed, and enough to ensure the rigidity of the assembly without causing deflection or distortion of finished surfaces. Construct to prevent rattle and resonance.

The modules and arrays shall be set-out to suit the structural limitations of the building (i.e. purlin spacings, wind loadings, etc).

Materials

All components of the framing system shall be suitable for the location and duty of the system. All components should be anodised aluminium or stainless steel.

Where the system is to be installed within close proximity to a coastal zone or corrosive environment, stainless steel (Grade 316) shall be used for the system. For the purpose of this work a coastal zone is within 1km of the shoreline of large expanses of saltwater. Where there are strong prevailing winds or vigorous surf, the distance should be increased beyond 1km.

Non-metallic

All Non-metallic materials used for various applications in the panel support system shall be heat and UV resistant for the intended design life. This shall include but is not limited to sealants, nylon, plastics etc. The contractor shall include these materials in the warranty.

Fabrication

Edges and surfaces: Keep clean, neat and free from burrs and indentations. Remove sharp edges.

4.3.3 Safety precautions

Fire and electrical: To AS 1674.1 and AS 1674.2, Safety in welding and allied processes, fire precautions and electrical.

4.3.4 Welding

Steel: To AS/NZS 1554.1, Welding of steel structures.

Aluminium: To AS 1665, Welding of aluminium structures.

Stainless steel: To AS 1554.6, Welding stainless steels for structural purposes.

Bolts, Nuts, Fasteners, Clamps

Fixings required in the support system including those required between the support members and the PV panels should be designed for the required design loads and as per this specification and relevant Australian Standards and Codes.



Generally, fixings should be stainless steel or anodised aluminium and dissimilar metals should be avoided.

Where torqueing of fixings is specified by the manufacturer this should be done as per the manufacturer's specification and recommendations to avoid damaging the panels. Appropriate tools should be used as per manufacturer's recommendations.

Galvanic Isolation

Dissimilar metals shall be avoided. Where mechanical fixing between dissimilar metals is required, provide suitable isolation (nylon or similar).

4.3.5 Roof Fixing System

The contractor is to design a fabricated fixing system for the rooftop type, certification of the system should be submitted to the Principal for review prior to construction. The fixing system shall not penetrate the roof unless previously approved by the Principal or wherever is not possible such as colourbond roofs. The designer should liaise with the roof sheeting manufacturer as required.

General

Fix (not pierce) all plant directly to structure in an approved manner. Submit details to the Principal of types of fixings, locations and loads for review.

Where the roof is steel clad a clamp system should be installed. Where a concrete, flat surface tiled or similar roof type is present a ballast type system should be installed.

Fixings shall be designed and spaced to comply with AS1170 and the requirements of this specification. This shall include all combinations of loads and not simply the pull-out capacity of the fixings, consideration should be given to horizontal loads and shear forces in combination with vertical forces.

Calculations showing the design of the roof fixing system should be submitted for review. Test results from a NATA or approved equivalent facility shall be submitted, showing the capacity of the fixings to resist the critical combination of loads this is necessary where testing has been relied upon for structural certification or installation guidelines. Consideration is to be given to the ability of the roof sheeting and roof sheeting fixings to transfer the load to the roof structure. This should be reviewed and confirmed by the structural engineer. This shall be confirmed in the structural certification and where required NATA or approved equivalent test certificates should be provided for specific roof sheets. Where an equivalent test is proposed (e.g. clamp pull-off test), this is to be previously approved by the Principal.

Fasteners

Standard: To appropriate Australian Standards.

Type: Use proprietary corrosion resistant fasteners capable of transmitting the loads imposed, and sufficient to ensure the rigidity of the assembly. Use metal expansion bolts or chemical anchors for concrete and masonry. Do not use explosive charge fixings without approval.

Corrosion Protection: Use corrosion resistant and electrolytically compatible fasteners. Provide electrically insulating spacers where necessary.

All external fasteners to AS 3566.2 Class 4.



In situ Testing of Fixing System

- Where torqueing of fixings is required, these shall be torqued as per the manufacturer's specifications and recommendations. The contractor is to ensure the minimum torque required is achieved and that the torque required is not exceeded by more than the manufacturer's recommendation, or 20% of the manufacturer's specified torque. Care should be taken to use appropriate tools to ensure the fixings are not over torqued. 20% of the systems fixings, where accessible, shall be tested and results submitted for review.

Adhesives

Adhesives shall generally not be used, instead use mechanical fixings and flashings. If adhesives are required, submit technical data and warranty information of the proposed product to the Principal for review, prior to commencing work.

4.3.6 Protective Walkways and access

General

The framing and fixing system shall also incorporate allowance for safe access and maintenance of the system. Where required this should include dedicated mesh walkways between the arrays for maintenance. The extent of the walkway should extend from the point of access to the roof as appropriate and provide access to the array as required for maintenance. The contractor should notify the Principal or its representative if access to the roof and array is not sufficient.

Protective Walkways

Use proprietary expanded mesh aluminium or stainless steel (where appropriate) walkways as supplied by a manufacturer. Fix (not pierce) all walkways directly to roof sheeting in an approved manner unless previously approved by Principal. The fixings and material properties shall comply with all the requirements of section 3 of this specification and should be allowed for in the structural engineer's assessment of the existing structure

The walkways shall have a minimum clear width of 600mm and comply with AS 1170 and AS1657 where required. Specifically loads are to be determined in accordance with AS1170.1 Clause 3.5.1.

Contractor to advise if no clamping system is available for fixing expanded mesh walkways to the roof and provide details on proposed alternative.

Where required handrails, steps, ladders and other access requirements should be designed and installed to AS1657 to allow safe access and maintenance to all panels.

Shop drawings of the proposed layout and all details should be submitted to the Principal for review prior to construction.

4.3.7 Penetrations

General

Coordinate all penetrations with the Principal or its representative. Allow two weeks for review and certification of the penetrations by the Principal.



Seal all penetrations to maintain the fire rating, acoustic rating, and water proofing requirements of the building.

Refer also subsequent sections of this specification for specific requirements of rooftop penetrations.

Do not provide chases in structure without the prior approval of the Principal.

Flashing

Provide overflashing for ducts, piping, conduits, cabling and supports passing through roofs, external walls, and floors and walls of wet areas.

Use similar material to the service, sealed and secured to ensure durability and water tightness.

Escutcheon plates

If piping or cabling emerges from building surfaces, exposed to view, provide flexible type flashings such as Dektite or approved equivalent. Flashing diameter to be 50 mm larger than the outside diameter of the pipe including insulation.

Roof penetrations

Propose and provide roof penetrations that are:

- Certifiable
- Waterproof under any duration rainfall of an intensity which has an average recurrence interval of 100 years
- Hail-proof
- Trafficable (step on by one person)
- Reinstate any fire rating
- Graded to mitigate ponding
- Accommodating of building movement
- Where possible, penetrations shall be made in a vertical façade element in lieu of rooftop.

Existing structures

Obtain approval from the Principal for penetrations through existing structures.

Warranty

Provide a 10 year warranty on all roof top penetrations unless otherwise pre-approved. The system shall provide adequate water resistance when subjected to once in 100-year storm.

Waterproofing

The design and installation of all elements to roof tops should not be detrimental to the current function of the roofing system.

Existing waterproofing elements should be maintained and should not be damaged during installation.



The ability for water to drain and flow as per the original intent of the roof shall be maintained.

Wall, ceiling, and structural penetrations.

General

Walls, ceiling and/or floor penetrations shall be sealed with an approved sealant after all cables have been installed. Audible sound leaks via penetrations and similar deficiencies shall be rectified to the satisfaction of the Principal.

Fire walls and structural members

Do not penetrate without approval from the Principal.

Damp courses

Do not penetrate.

Floor slab

Run pipes entering a building at ground level under the waterproof membrane and vertically penetrate the membrane and the floor slab. Seal membrane penetration to approval by membrane manufacturer.

Existing structures

Obtain approval from the Principal for penetrations through existing structures.

Sleeves

Fit a uPVC sleeve for each approved penetration through ground floor slabs, ground floor beams and external walls for cables not enclosed in conduit. In addition, for MIMS cables fit a sleeve for each masonry penetration.

Penetration size

Provide a penetration of diameter 10 mm greater than the pipe or sleeve diameter for pipes and sleeves penetrating existing external walls, ground slab, or ground floor beams.

Sealing

Seal penetrations around conduits and sleeves with a weak sand/cement mix, or non-setting intumescent sealing compound approved by the Principal. Seal the space between cables within sleeves with a pliable waterproof compound.

Reinstatement

General

Fireproof all penetrations through fireproof walls, ceilings, floor slabs or other barrier, irrespective of size, upon completion of installation of cables. Unless previously approved, fireproofing shall be carried out by fixing a suitable galvanised sheet metal cover (maximum thickness 1.6 mm) around



the cables on both sides of the wall and underside of slab, pack space with fireproof material to comply with AS 3000 and the Building Act. All fire-retardant materials used shall have been tested by a recognised Australian, to maintain the fire rating of the construction medium through which the penetration passes.

Metal cableways

Where metallic ducts penetrate fire-rated members, restore the fire rating of the member (wall, floor, etc) around the duct with section of lid fitted, and protruding not less than 50 mm either side of fire-rated member. Additionally, fit a removable fire barrier within the duct in the most accessible location, within the fire-rated member.

Protection

Fix plastic grommet around metal edges bearing against cables. Paint sheet metal covers to match surrounding areas.

Fire barriers

Proprietary type fire barriers may be installed. In any case, fireproofing must comply with all Building Act, Local Authority and DNSP requirements.

Airtight seals

All penetrations through building fabric subject to suction or pressurisation shall be sealed airtight.

4.3.8 Factory Applied Finishes

External Services

All services exposed to the external environment, including regions exposed but sheltered from the rain, shall have high durability coatings. This shall include, but not be limited to the following:

- Framing elements
- Fixings
- Raking systems
- Walkways, stairs, handrails

Internal Services

Apply factory-applied finishes as specified.

Preparation

General: Before applying pre-finishes to metal components, complete welding, cutting, drilling and other fabrication, and prepare the surface using a suitable method.

- Standard: To AS 1627 Metal Finishing - Preparation and Pre-treatment of Surfaces.



Priming steel surfaces: Where site painting is specified to otherwise uncoated mild steel or similar surfaces.

- Prepare substrate and prime after fabrication and before delivery to site
- After installation, repair damaged priming and complete the coating system to the primed surfaces

Thermoset Powder coating

Standard: Metal substrates except aluminium: To AS/NZS4506 *Metal Finishing - Thermoset Powder Coating*

Aluminium Substrates: To AS 3715, Metal finishing - Thermoset powder coating for architectural applications.

Powder coating material: Internal to APAS 0155/1 or 0155/2.

External (aluminium substrate only) to: 0155/2.

Finish: Full gloss

Preparation and Application:

Prepare the surface in accordance with the requirements of the powder coating supplier, the pre-treatment supplier and guidelines in AS 4506 Appendix I (Ferrous surfaces) or AS 3715 Appendix G (Aluminium surfaces).

Apply and cure coating according to manufacturer's recommendations.

Anodising

Standard to AS 1231 Aluminium and aluminium alloys. Anodised coatings for architectural applications.

Class:

- Indoor applications: At least AA10.
- Outdoor applications: At least AA25.

Repainted Metal Products

Standard: To AS/NZS 2728, Prefinished/pre-painted Sheetmetal products for interior/exterior building applications - performance requirements

Product type: Not lower than the type appropriate to the field of application.

Self-Finishes

Ensure that self-finishing materials, such as stainless steel or uPVC pipe sheathing, and foil-faced insulation are installed without surface damage. Clean and polish surfaces on completion.

Equipment Paint System

General: Brush or spray application using paint as follows:

- Prime coat to metal surfaces generally: APAS 0032 or APAS 0162
- Prime coat to zinc-coated steel: APAS 0134



- Full gloss enamel finish: APAS 0015/1 two final coats.
- Where oil resistance is required: Full gloss enamel finish APAS 0024/1, two final coats.

4.3.9 Galvanic Isolation

Dissimilar metals shall be avoided. Where mechanical fixing between dissimilar metals is required, provide suitable isolation (nylon or similar).

4.3.10 Durability

General

All elements of the new system framing and roof access including walkways shall be suitable for the location and duty of the system, the system shall be designed for a 25 year design life.

The system is to be designed to avoid corrosion. This shall include corrosion of the existing roof sheeting and structural members.

Particular care is required in selecting materials and protection in marine and other corrosive environments.

The system and roof access walkways should not prevent salt deposits from being washed off the roof by rain. If required maintenance instructions as well as roof mounting structure should allow for regular wash down with freshwater.

All bolts, nuts, fasteners shall have appropriate durability for the installed locality. Bolts and nuts should generally be stainless steel.

Protect metallic components from corrosion by factory applied pre-finishes or site finishes and by electrical separation of dissimilar metals.

Warranty

Unless otherwise pre-approved, the framing, fixing and walkway system shall be provided with a minimum 10 year warranty in meeting the requirements of Australian Standards and this specification for normal operating conditions.



5 Electrical Services

5.1 General

Provide AC and DC electrical services as required to grid connect the photovoltaic electricity generation system.

Engage a licensed electrical trade to undertake all electrical services installation and qualified designers (CEC accredited) to design the system.

Each inverter, string, cable isolator box, combiner box and module shall be labelled with a unique ID tag.

5.2 Wiring enclosures and cable supports

5.2.1 General

Use trays/ladders exclusively for all cable reticulation, with minimum 25% spare capacity at completion, unless no spare roof area for additional solar capacity.

Rooftop and exterior trays and associated equipment shall be anodised aluminium in construction, suitable for the rooftop and exterior environment and complete with lid to protect cables from sunlight and bushfire ambers.

Indoor cable trays shall be powder-coated steel in construction and colour coded.

DC and AC cabling shall be reticulated on separate cable tray systems. Maintain at least 100mm separation between AC and DC reticulation infrastructure.

5.2.2 Cable trays

General

Where the word "cable tray" is used in this specification or shown on the drawing, it shall mean 'cable ladder' or 'ladder tray' whichever is more appropriate to carry the cable load specified.

- Provide a complete cable support system consisting of trays and ladders and including brackets, fixings and accessories. Fabricate brackets, racks and hangers from powder-coated structural steel (in doors, under roof) or aluminium (on roof tops).
- All roof top cable trays shall be provided complete with a non-transparent cover to further protect the cables.
- Maintain earth continuity of the entire cable support system.
- Provide 25% spare capacity on cable support systems, unless no spare roof area for additional solar capacity.
- For internal AC cable run install a new cable tray. Where no space available, and has been previously approved, AC cable run may use existing cable tray space where available.
- The deflection shall not exceed that specified by the manufacturer and supports shall not exceed 3m spacing.



- Avoid dissimilar metals. Use nylon spacer brackets if required.
- Provide bends, connectors, trays, ladders, brackets, splice plates, clamps and other supports necessary to make a complete cable or conduit support system sized to adequately support the installed cabling and support system. All bends in cable carriers shall be curved having a minimum 600 mm internal radius.
- Provide unistrut support brackets or the like spanning between roof purlins or beams in order to achieve a fixing point for a cable support dropper rods or similar support fixing.
- Certificate of Test: All cable support systems that carry essential services cables (mains and sub-mains) shall be tested to maintain circuit integrity under fire conditions for 120 minutes in accordance with the requirements of AS/NZS 3013. The cable carriers and support systems shall achieve a WS5X classification and meet the requirements as stated in AS/NZS 3013.

Manufacture

Use proprietary trays, ladders and accessories from a single manufacturer in the same application.
Rung spacing: To suit cable size (cable manufacturer's recommendations), 300 mm maximum.

Accessories

Provide all bends, fish plates or splines for tees, crosses and joints as required.

Lids

All rooftop cable trays shall be provided with a removable lid. The lengths of lid shall not exceed 3m in length. The lid shall be securely fixed so as to not detach under cyclonic conditions. The lid shall be configured so as to not pool water.

Fixing to building structure

General: Install parallel to built elements. Fix supports to the building structure or fabric by means of direct fixing, hangers or brackets. Do not fix to roofing material.

Spacing: Space supports at maximum intervals of 3m for trays and 3 m for ladders.

Access

Provide a minimum of 150 mm free space above and 600 mm free space on one side of trays and ladders.

Cable fixing

Provide slats or rails suitable for fixing cable ties, strapping or saddles.

Bend radius

Allow cable tray minimum bend radius that will allow cables to be installed and bent to the manufacturer's minimum cable bending radius specification.



Cable protection

Provide rounded support surfaces under cables where they leave trays or ladders.

Provide lids to rooftop cable trays.

Expansion joints

Building expansion joints: Install not to resist relative movements of building sections.

Unistrut Support Systems: Provide a Unistrut support system as required

Moisture avoidance

Locate trays and lids to avoid water ingress and water pooling.

5.3 Penetrations

Coordinate all penetrations with the Principal.

Refer to section 4.3.7 for details

5.4 AC reticulation

5.4.1 General

Provide AC cabling from the LV switchboards to the inverters, protected by circuit breakers. AC Electrical reticulation system shall be suitable for 400 V, three phase, 4-wire, 50 Hz or otherwise required by the DNSP.

5.4.2 Design

Design AC reticulation to comply with the abovementioned standards. Minimise cable lengths.

Undertake calculations to determine cable sizes and circuit breaker selections. Calculations must allow for full circuit breaker loading, and the results shall demonstrate compliance with the following:

- Voltage drop requirements of AS/NZS 3000 and AS/NZS 3008. The voltage drop between the switchboard and the inverter must not exceed 1%.
- Voltage rise requirements of AS/NZS 4777.1:2016
- Fault loop impedance requirements of AS/NZS 3000
- Current rating of cable in its installed arrangement (considering de-rating factors due to cable bunching and installation techniques) to AS/NZS 3008
- Cascade and discrimination of circuit breakers
- Where underground AC cable routes are required, design shall be done according to AS/NZS 3000 and AS/NZS 3008. Contractor shall provide soil thermal resistivity tests as part of the design calculations to support cable sizing calculations.



5.4.3 AC cables

General

AC power cables shall generally be of commercial standard/quality, and meet the following specification:

- High-conductivity multi stranded copper conductors, V90 insulated, PVC sheathed
- Multicore or single core
- 0.6/1kV rated
- Minimum conductor area of 4 mm²

Terminations

General

Terminate copper conductors to equipment with compression-type lugs of the correct size for the conductor. Compress using the correct tool.

Do not solder joints and terminations.

Circuit breakers

Provide new miniature circuit breakers within the existing electrical distribution boards and ensure the nominated switchboard and new circuit breaker(s) are adequately rated to safely withstand the additional load of the nominated PV system. Circuit breakers shall be rated in accordance with inverter manufacturer's recommendations.

Provide integral residual current protection if required (subject to system earthing design).

The new circuit breakers shall be of equivalent make and model to the existing circuit breakers.

At each distribution board, provide circuit breaker lock-out tags to suit the new circuit breakers. Provide a quantity of at least 30% of the new circuit breaker quantity. Provide a small lockable enclosure adjacent the switchboard to house the tags. Label the enclosure accordingly.

5.4.4 Low voltage Switchboards

Where new LV switchboards are required or modifications to the existing switchboards is needed, design including arc flash protection shall comply with AS/NZS 3000, AS 3439, AS/NZS 61439.

Contractor to note that AS/NZS 61439 replaces AS 3439 from 2021.

5.4.5 Cabling

The requirements outlined in this Section shall apply to all applicable cabling making up part of the Works.

- All LV cables shall be manufactured and tested in accordance with AS 5000.1 or the relevant Australian Standard. Each phase and each conductor within each phase must be clearly and permanently marked in accordance with a scheme that complies with AS/NZS 3000 and AS 5033.



- For buried cable, the depth of burial, level of mechanical protection and inclusion of warning tape or other barriers for the underground LV and HV cabling shall be in accordance with Applicable Standards. If polymeric cable cover is used for mechanical protection of underground cables, it must comply with AS 4702.
 - Underground cables must be protected from loads arising from all traffic where the cables cross the access roads.
 - Underground cables must be protected from damage by termites, rats, mice, rabbits and other animals and include water-blocking.
 - All HV cabling shall be buried. Where LV cable is installed above-ground it shall be UV-resistant or be laid within UV-resistant conduit suitable for the Design Life.

Cable thermal ratings must be calculated in accordance with AS 3008.1.1 and IEC 60287, or an equivalent standard. The cable ratings shall be based on maintaining the conductor temperature below the manufacturer's normal operating temperature under all operating conditions, including extremes of low voltage and low power factor. The designs must pay special attention to cable ratings in accordance with their burial conditions and passage through ducts or in air, and in cases where cables are grouped together or enclosed.

- Cable installation must comply with the following:
 - cable sheaths must be maintained (excluding within reason any sacrificial sheaths) in an intact condition at all times until burial and subsequent compaction
 - water-blocking (including end-caps) and insect-proofing must be maintained
 - the manufacturer's specified bending radii must be maintained both when in position and when pulling in position
 - the manufacturer's maximum allowed pulling tension and side-wall bearing pressure must be respected
 - the bedding (below the cable) and the cover (above the cable) must be maintained in a condition that is absolutely free of any rocks or other hard or sharp material that could damage the cable sheath or insulation
 - the correct depth and separation as required by the thermal design and all applicable regulations, codes and standards must be followed.

All cables must be clearly and indelibly marked at each end. The identification scheme must indicate at least the origin and destination of the cable. The identifiers must be recorded and used on the Works itself and any applicable drawings, specifications, manuals, cable schedules or other documentation. Underground cable routes must be clearly marked and shown on drawings.

5.4.6 Cable Joints and Terminations

The Contractor shall not procure any cable joining kits without receiving prior approval for the installation from the Principal. The Contractor must request approval from the Principal for any joints with sufficient time to prevent delaying the Works. The Contractor must nominate the location of the joint and provide the details of the jointing kit to the Principal for review. The Principal will only approve the installation of cable joints where there is no other practical solution. Notwithstanding the above, cable joints in cables of less than 500m length are not permitted.



Any tee-off junction boxes or cable joints must be suitably designed to account for cable expansion. Approval for the number (if any) and location of cable joints and junctions is to be given by the Principal. Buried tee-joints are not permitted.

All in-line joints, if installed, must be clearly and indelibly marked with a unique identifier. Electronic markers shall be buried with each in-line cable joint to more easily locate joint positions and a corresponding locating device shall be provided.

All equipment comprising terminations and in-line joints must be selected and installed such that its thermal, fault and insulation ratings are equal to or better than the plant (i.e. cable/busbar/other) to which it connects.

Where outdoor air-insulated terminations are required the termination shall include a weather shield. All terminations and joints must be installed by competent and qualified personnel holding up-to-date training in the kits and methods to be used. Documentary evidence of appropriate experience and suitable qualifications of all personnel involved in termination and jointing shall be supplied to the Principal upon request.

All terminations, in-line joints, their kits and associated components including lugs and connectors must be manufactured according to an approved Applicable Standard and must be type-tested for the intended purpose.

5.4.7 Installation

Connect the A.C. cable from the inverter to the adjacent electrical distribution board via cable tray.

Update the circuit breaker schedule in each distribution board with the details of the new circuit (label each circuit breaker with the associated inverter ID number). The updated schedule shall be type written, provide the Principal with a soft copy of the schedules.

5.5 DC reticulation

5.5.1 General

Provide DC cabling from the module arrays to the inverters, installed in such a way as to minimise losses.

5.5.2 Design

Design DC reticulation to comply with the applicable standards.

Undertake calculations to determine cable sizes. Cables shall be selected to meet short circuit currents, and to minimise voltage drop. The voltage drop between the array and the inverter must not exceed 1% of the total string voltage.

Due to the system earthing arrangement, all DC cabling shall comply with both the DC and LV AC requirements of AS/NZS 3000.

Connect PV modules in series to maximise the string voltage and reduce voltage drop. String voltage shall be calculated on worst case scenario, at minimum historical temperatures at nearest BOM site and at STC. The string voltage shall not exceed 1000V, or the inverter limitation, whichever is less.

Inverters loading and DC/AC ratio is to be approved during design phase.



General

DC cables shall generally be of industrial standard/quality, and meet the following specification:

- Multi stranded copper conductors, XLPE insulated, XLPE or TPE sheathed
- Multicore or single core
- 1000V (minimum) rated
- Water resistant, submersible to 5 m
- Halogen free, low toxicity, flame retardant to AS/NZS 1660
- Operating temperature range from -40°C to +90°C
- UV and sunlight resistant
- Minimum conductor area of 4 mm²

Colour

- Single core cables shall have a black sheath (for negative conductors), and red sheath (for positive conductors).
- Multicore cables should preferably have a black outer sheath. Each inner core (within) shall preferably have a black sheath (for negative) and a red sheath (for positive). If this cannot be offered, provide a 50mm length of black heat shrink (for negative) and red heat shrink (for positive) around the core sheath, adjacent every termination.

5.5.3 Terminations

All terminations shall be via polarised 1000V (minimum) DC rated shrouded connectors. These shall be of the same make as the connectors used on the PV modules.

5.5.4 Installation

General

Each PV module string shall be separately cabled back to the inverters, with no paralleling of strings in the field (on the roof top) wherever applicable without combiner boxes on the roof. Strings can be paralleled at the inverter, within the power limitations of the inverter. The string cabling shall be reticulated in an orderly and logical manner on the roof. Cable route lengths shall be minimised and shall align with building elements (i.e. diagonal routes are not acceptable).

Cables shall be located so as not to cause a trip hazard.

Rooftop cables shall be mounted on aluminium cable trays and protected from direct sunlight using covers. These cables shall be securely fixed to the modules and cable trays using UV resistant cable ties, suitably sized and located to avoid ongoing wind fatigue.

Cables shall not dangle or hang. Trays shall be provided immediately up to the termination point.

Adjacent string cables shall be adequately spaced on the trays to avoid de-rating. Approval is required if stacking or bunching cables on the trays is proposed (under-sized cable trays will be rejected by the Principal).

Unless unavoidable due to length or difficult installation conditions, provide cables without intermediate straight-through joints. Seek approval from the Principal for straight-through joints.



Cables shall be located to avoid water ingress.

DC side isolation is not required to be separately provided, but rather no-load DC disconnection shall be provided by the 1000V DC polarised shrouded connectors as allowed by AS 5033.

Each string shall be given a unique ID as outlined in the *Labelling and Identification* section of this specification.

Labelling

Label each cable string at each termination. At the array end, the label shall be located on the module. At the inverter end, this shall be located on the inverter (immediately adjacent the termination). The label shall be as specified in the *Labelling and Identification* section of this specification.

5.6 Monitoring and control

As part of the works a web-based monitoring system shall be provided to enable and verify the performance of the solar array. The monitoring system connectivity is to be agreed with the Principal.

It should be installed in such a way that potential future installations could be integrated.

The monitoring of the solar systems should be integrated with the principal's monitoring system, in such a manner that enough result granularity can be monitored (e.g. generation per array).

The contractor is to liaise with the Principal for further details on the monitoring system and its integration. According to the information provided by the Principal, following criteria shall be met as a minimum:

- It is recommended to install the Inverter on the school curriculum network and not to be connected to the school administration network.
- Remote access applications such as TeamViewer must be uninstalled after the initial installation of the inverter and solar panel monitoring display system.
- The monitoring data must be logged to the cloud and be presentable and accessible by the user through the web.
- Use port 443 on the inverter to connect to the data logging server.
- Use static IP's on the inverter and the display screen and apply appropriate access control lists on the school network devices such as a Router/Switch.
- Use specific proxy PAC or URL and lock down the inverter including the display screen to specific and required web addresses only e.g: **<https://10.x.y.19/autocconf/iot.pac>**
- Technical support arrangements to be available for ongoing maintenance and patch updates of display screen TV/computer.

5.7 Independent certification

The electrical installation must be independently tested upon completion of the project and relevant certificates provided within O&M Manuals for review.

Provide appropriate accurate instruments. Submit current NATA certificate of calibration prior to commencement of testing.



- Statutory Certificates of Compliance for:
 - Electrical Work
 - Copies of manufacturers' warranties.
 - Certificates from authorities and utilities.
 - Product certification.
 - Copies of test certificates for the equipment used in the installation.



6 Modules and Arrays

6.1 General

Provide arrays of crystalline photovoltaic modules to convert sun energy into DC current electricity.

All rooftop works require stringent safe work procedures as outlined in this specification.

Preference is for Tier 1 modules as per Bloomberg ranking with low losses associated with temperature coefficient (P_{max} ; %/°C).

Within the Tier 1 modules, preference will be given to those modules that have a Positive Quality Rating.

6.2 Technical requirements

Modules shall also comply with CEC Grid-Connected PV Systems Installation Guidelines.

As this system will operate at greater than 50V and greater than 240W, PV modules shall comply with Class A of IEC 61730.1

NOTE: Class A modules in IEC 61730-1 and IEC 61730-2 and EN 61730-1 and EN 61730-2 are considered to meet the requirements for Class II equipment in AS/NZS 3100.

6.2.1 Equipment class

Class II or better.

6.2.2 Encapsulation

Modules must be encapsulated in toughened glass

6.2.3 Environmental Protection

Minimum Ingress Protection rating of IP65. Framing should be designed such that it does not hold water when mounted in any orientation or tilt angle.

- All components to be UV resistant.
- Operating temperature suitable from -20°C to +80°C.

6.2.4 Mechanical

PV modules shall be aluminium framed low-iron tempered glass modules. Provide hailstone impact testing results.

Frames shall be constructed of anodised aluminium (alloy 60636T6 or similar). Matt black colour is preferred to reduce reflected light intensity.

6.2.5 Electrical

Reverse current rating should be sufficient to allow up to three (3) PV module strings to be paralleled without fusing.



Maximum allowable temperature coefficient of maximum power is $-0.45\% / ^\circ\text{C}$.

Schottky by-pass diodes shall be included as part of each module, preferably in the module junction box. Blocking diodes shall be also installed for each string where applicable.

Factory terminated DC string cables complete with polarised weather resistant DC rated connectors. Length of cables shall be suitable for connection to adjacent modules without extension.

Cables:

- Minimum cable cross sectional area 4 mm^2
- UV stabilised sheath
- Double insulated
- Cable insulation to be 1000 V rated
- Connectors:
 - IP67 when assembled
 - Touch proof when not assembled
 - Polarised
 - Captive (locking)
 - Require tool for disassembly
 - Minimum 1000 V rated
 - Connectors are to be Multi-Contact (MC4) or identical to PV module connectors. Alternatives will not be accepted without prior approval of the Principal.

6.3 Installation

6.3.1 General

Mount PV modules to frames at a minimum of 10 degrees. The number of fixings shall be as per the module manufacturer's recommendation. Take care in fixings' material selection to avoid galvanic reaction (stainless steel fixings are required due to the sea-side location).

Notwithstanding the total photovoltaic array power capability as required under this specification, the number of individual photovoltaic modules must be such, and the array so arranged, that the physical arrangement of the array is grouped together symmetrically or geometrically ordered.

Arrays shall be arranged so that they are readily accessible for cleaning and maintenance.

Install DC cabling as outlined in the relevant section of this specification. DC cables from the modules shall be suitably fixed, and not left to hang or dangle.

Provide earthing and bonding as outlined in the relevant section of this specification. In particular, earth each frame. Do not daisy chain earth cables to panels. Panels shall be able to be removed without interrupting the operation of other panels.

Clean modules prior to practical completion.



6.3.2 Delivery

When modules are delivered to site, consideration must be given to how modules are delivered to the rooftop. Submit details of the proposed rooftop delivery to the Principal for review.

6.3.3 Labelling

Provide labelling as per AS4777.1:2016 requirements.



7 Inverters

7.1 General

Provide DC-AC inverters with integrated maximum power point tracking (MPTT) and grid protection (anti-islanding) devices to allow injection of power into the LV electricity network.

Inverters shall be compatible with the photovoltaic modules and configured for optimal performance.

Provide inverter loading or DC:AC ratio for approval during design.

Inverters shall be CEC accredited.

7.2 Technical requirements

7.2.1 Mechanical requirements

- Ingress Protection rating of IP65 for electronics, inverter suitable for outdoor installation
- Operating Temperature range -20°C to 55°C
- Ventilation: fan-less convection cooling preferred, alternatively regulated forced cooling by approval.

7.2.2 Electrical requirements

Inverters shall be of transformer-less design, single phase or three phase (three phase is preferred). If single phase inverters are being proposed, these must be connected as balanced multiples of three.

The inverters shall operate without de-rating in ambient temperatures of up to 55°C.

As the PV array string wiring must be fully isolated from ground, the inverters shall provide integral ground fault detection.

Inverters shall meet the following specification:

Table 7-1 Inverter specification

Item No	Parameter	Value
1	Output voltage, frequency	230V (phase to neutral), 50 Hz 400V (phase to phase), 50 Hz (Contractor to confirm the voltage level and number of phases as per the existing installation)
2	Output current waveform	True sine wave
3	Waveform quality	to AS 4777
4	Total Harmonic Distortion	No greater than 3.5%
5	Minimum nominal power rating	10 kW
6	Input voltage	Up to 1000V



7	Minimum specific power:	150 W/kg (nominal power rating per unit mass)
8	Minimum power density: (nominal power rating per unit volume based on overall dimensions)	75 W/l
9	Minimum peak efficiency	97%
10	Minimum Euro-efficiency	96%
11	Automatic no-load shut down	Required
12	Standby power consumption	< 15 W
13	Night-time power consumption:	< 5 W
14	DC surge voltage protection:	Integral
15	Input reverse polarity protection	Integral
16	Behaviour on DC overload	Shift the operating point
17	Earth fault monitoring	Integral
18	DC side switching	Integral
19	Maximum Power Point Tracker	Required
20	Earth fault alarm to AS/NZS5033	Required

As a minimum, inverters should have front panel annunciation of grid connection and power generation.

7.2.3 Data acquisition requirements

General

Inverters shall be capable of measuring and reporting the following information, as a minimum:

- Continuous solar irradiation at the site
- Instantaneous AC output power (W) and/or AC output voltage and current
- Cumulative AC output energy (kWh)
- Inverter temperature (optional but desirable)

Each of these quantities should be accurate to +/- 3%, with a resolution of 1% or better.

The inverter shall be capable of logging relevant system parameters for up to one month. Data storage cycles shall not exceed 30 minutes. The ability to record more frequently is highly desirable. The data logging should be synchronised to an external, accurate, known source. Suggested sources include GPS satellite service, mobile cellular network or TCP/IP time server.

The inverter shall be fitted with an integral digital screen suitable for displaying the fundamental parameters

The inverter shall be capable of connectivity to the Principal's TCP/IP ITS and we based network.



Data Acquisition and Connection to Principal's Communication System

Connect the inverter's data acquisition and reporting system to the existing Principal's communication system to monitor any alarms related to the solar system. The system must be capable of sending electronic notification (email, SMS). Other requirements as per section 5.6.

7.3 Installation

7.3.1 Mounting

When installing inverters, give due consideration to ventilation, serviceability, and exposure to dust and weather. Inverters shall be spaced so as to be readily accessible and serviceable without the need to remove adjacent services, as defined by the manufacturer, whichever spacing is greater. Inverters, additional deflectors and/or ducting should be mounted such that the hot air flow exiting an inverter, whether by natural convection or forced air cooling, does not form a significant fraction of the cooling air for any other inverter.

Ensure inverters are capable of operating in a non-conditioned plantroom or outside.

7.3.2 DC cabling termination

There shall be sufficient connectors on the inverter such that each PV string can be separately terminated at the inverter, with any required PV string paralleling occurring at the inverter. No more than three PV strings shall be paralleled per PV inverter MPPT input converter.

DC side switching shall be provided as integral to the inverter.

Provide a label adjacent each termination with the unique string number (as defined in the *Labelling and Identification* section of this specification).

7.3.3 AC cabling termination

AC cables shall be terminated using the proprietary terminals and in accordance with the manufacturer's recommendations.

Provide a label adjacent each cable termination with the DB name and circuit breaker number.



8 Earthing and Bonding

8.1 General

8.1.1 Overview

Provide the following earthing systems (as defined in AS/NZS 5033).

- System earthing (electrical earthing)
- System bonding (protection of exposed conductive parts to mitigate step and touch potential risks)
- Both earthing system shall be at the same potential.

8.2 System bonding enabling works

8.2.1 General

Undertake a detailed investigation into the suitability of the existing buildings' earthing/bonding and lightning protection system/s, and apply remedial measures to enable the proposed PV to be safely implemented for conditions such as:

- A dedicated lightning protection system does not exist with the building fitted or not fitted with fire protection.
- The building is not fitted with surge protection.

8.2.2 Investigation and remediation

Investigation

Prior to the commencement of construction and as part of the dilapidation investigation, engage a suitably qualified electrical trade to undertake a detailed investigation into the suitability of the existing buildings' earthing and lightning protection. The aim of this investigation is to establish a common equipotential reference to earth for the entire roof (including gutters and fascia). It is recommended that the suitably qualified electrical trade engaged is a specialist earthing trade as described in the *Testing and Commissioning* section of this document.

Undertake 'resistance-to-earth' testing for all exposed conductive elements on and around the immediate roof top of each building. This shall include gutters, metallic fascia, fall arrest, lightning protection elements, roofing substructure, and a grid of points no greater than 10m x 10m for the entire sheeted roof area. Submit the results of the testing to the Principal for review.

The testing shall be carried out to a common earth reference for each building. Liaise with the Principal to establish the earth reference.



All testing shall be carried out in a non-destructive way, so as to not affect the existing surface protection. Roof sheeting shall be tested on the underside of the roof. If any surface protection must be removed for the testing, seek direction from the Principal.

Should the results indicate that a common resistance to earth does not exist, outline the findings in the dilapidation report.

The resistance between the electrical services earth and the building earth shall also be reported.

Remediation (if required)

Determine and provide remedial measures to establish consistent reference to earth for the entire roof area of each building. This may include providing dedicated bonding conductors between concrete structure reinforcement and rooftop steelwork. It may also include providing bonding conductors on the rooftop substructure. Submit details of proposed remedial action to the Principal for review.

Re-test to confirm rooftop earthing continuity.

8.3 Design

8.3.1 System earthing requirements

Submit details of proposed PV system earthing, proving compliance with AS/NZS 5033 and AS/NZS 3000.

The preferred system earthing configuration is described in Figure 4.5 AS/NZS 5033:2014, although alternative configurations will be considered.

Ensure the system earth is bonded to the system building earth reference as described in the next section.

Produce an earthing schematic for a typical inverter and its associated array.

Submit fault loop impedance calculations for review. If RCD devices are being considered, submit earth leakage calculations for review.

8.3.2 System bonding requirements

General

All exposed conductive parts shall be bonded to building earth. Un-earthed (double insulated) conductive elements will not be accepted.

Establish a service earthing bar and connect the electrical system earthing to the building earthing.

Provide equipotential bonding cable and terminations as required for bonding of exposed conductive elements. This includes bonding of PV modules frames with minimum earth conductor size as required to AS/NZS 5033.

All bonding cables shall have green/yellow insulation. If exposed to the weather, use UV resistant cables, or provide exposed aluminium strap conductors (mounted on the framing).

Submit details of bonding strategy for all conductive elements of the PV system.



8.4 Installation

Install earthing system in accordance with the design and the abovementioned Australian Standards.



9 Performance Guarantee

Unless specifically agreed with the Respondent, the PV output decline rate, or degradation, will be the degradation guaranteed by the performance of the solar panels in the Solar PV Panel Guarantee. This includes Light Induction Degradation (LID).

The Performance Guarantee is an annual output guarantee at the Point of Connection that the Respondent provides to the Principal under the conditions outlined throughout this specification.

The Performance Guarantee Test and associated calculations shall be undertaken by the Contractor to achieve Practical Completion and annually during the first one year. The Respondent shall provide, as part of their response to the RFQ, the following information:

- Designed Solar Conversion Ratio (DC:AC)
- Minimum Performance Guarantee also referred as Minimum Solar Conversion Ratio
- Annual Energy Generation and Global Horizontal Irradiation used in the calculations to estimate the Solar Conversion ratios

The Solar Conversion Ratio is to be calculated as follows:

$$SCR_i = \frac{\sum_i(E_{Meas_i})}{\sum_i(G_{real_i})} * \frac{N_j}{N_i}$$

The Designed Solar Conversion Ratio (SCR_{Des}) will be calculated as the sum of the expected (P50) energy generated (E_{Des}) during the year divided by the annual Global Horizontal Irradiation for a Typical Meteorological Year (G_{TMY}):

$$SCR_{Des} = \frac{\sum_i(E_{Des_i})}{\sum_i(G_{TMY_i})} * \frac{N_j}{N_i}$$

The Minimum Solar Conversion Ratio (SCR_{Min}) will be calculated as the sum of the Minimum Energy Generated (E_{Min}) the Respondent guarantees during the year divided by the annual Global Horizontal Irradiation for that year (G_{TMY}). SCR_{Min} will be a fraction of the SCR_{Des} .

$$SCR_{Min} = \frac{\sum_i(E_{Mini})}{\sum_i(G_{TMY_i})} * \frac{N_j}{N_i}$$

Adjusted Minimum Solar Conversion Ratio (SCR_{Min_Adj}) will be calculated as the sum of the Adjusted Minimum Energy Generated (E_{Min_Adj}) at the Connection Point, divided by the measured annual Global Horizontal Irradiation for that period (G_{Real}) multiplied by [to be inserted]. The Adjusted Minimum Energy Generated (E_{Min_Adj}) will be estimated generation using the annual Global Horizontal Irradiation (G_{Real}) as an input for the estimate.

$$SCR_{Min_Adj} = \frac{\sum_i(E_{Min_Adj_i})}{\sum_i(G_{Real_i})} * \frac{N_j}{N_i}$$

The actual energy produced by the Solar System as measured by the generation meters shall be recorded and compared to the Adjusted Respondent's Minimum Energy Generated, adjusted for the actual ambient conditions (irradiance) recorded at the Site during the Test Period.

PV Output decline rates will be multiplied by the minimum energy Generated (E_{Min}) of year 1 to calculate each year's minimum energy generated.



Conducting the Generation Guarantee Test

In order to pass a Performance Guarantee Test, the following condition must hold true during a Test Period:
:

$$SCR_i \geq SCR_{Min\ adj}$$

Where:

E_{Meas_i} = Total energy delivered to the AC side of the inverter by the Solar System (in MWh)

during the eligible 'i' period as measured by the Generation Meters

E_{Min} = The Contractor's Generation Guarantee as provided (in MWh)

$E_{DES\ i}$ = Estimated Total Energy delivered to the Connection Point (in MWh)

during the eligible 'i' period using a TMY

TMY = Using data from the The Typical Meteorological Year of the Site used for design values

The Typical Meteorological Year (TMY) is the set of meteorological data with data values for every hour in a year, used to estimate the Minimum Solar Conversion Ration. The data of the TMY is to be provided to the Principal

Real = Using data (meteorological and generation data) taken at the closest BOM Site over the test period

G_{real_i}

= The average global horizontal irradiance $\left(\text{in } \frac{W}{m^2}\right)$ during each eligible 60

– minute period, occurring during the Test Period as measured at the closest BOM MET station by the pyrometers

in the horizontal plane

G_{TMY_i} = The TMY global horizontal irradiance for the corresponding time period

i = Every eligible 60 – minute period during the Test Period

j = Every eligible 60 minute period in the TMY

N_j = the number of eligible 60 minute periods over one year using TMY data

N_i = the number of eligible 60 minute periods at the Site over the Test Period (1 year)

9.1 Test Period

For the purpose of achieving Practical Completion the Test Period will be 1 month of valid data. If the power delivery to the Connection Point is reduced or prevented in any 60-minute period due to:

- Failure of the Grid or other equipment not making up part of the Solar System and not caused by the school or the Contractor or the Operation and Maintenance Contractor
- Damage caused by vandalism or robbery
- Force Majeure
- Curtailment



Then the corresponding 60 minute periods will be excluded from the Generation Guarantee Test. All other 60 minute periods during the Test Period shall be included in the Generation Guarantee Test. At least 95% of data should be included during the generation test.

9.2 Data Collection and Validation

The irradiance Greal will be taken on the horizontal plane at the closest BOM MET station.

For every 60-minute period, the solar system shall record:

- a) The energy delivered to the AC side of the Inverter or Generation Meter
- b) The max, min, and standard deviation of the above (for data verification purposes)

The data shall be verified by the Contractor acting reasonably, as correct and accurate with any invalid data identified and treated. Invalid data shall be identified and treated as follows:

- Negative values during daylight hours are to be removed
- All values during the night, whether recording positive or negative, shall be changed to zero.
- If any other data appears invalid, the Contractor shall investigate, demonstrate that the data is invalid and why and determine an appropriate treatment for the data

As part of the performance testing results the Respondent shall provide a data validation details which shall include:

- Details of all invalid data identified including:
 - when the invalid data was recorded
 - which instrument was used to record the invalid data
 - why the data is considered to be invalid
 - how the invalid data has been treated
- All raw data from each instrument forming part of the Solar System along with the final data set used for the propose of performance testing.

If the principal disagrees with the treatment of the raw data performed by the Respondent then a meeting shall be arranged between the Respondent and the Principal to discuss a mutually agreeable determination regarding how the raw data should be treated. Where agreement is not reached the Issue Resolution process outlined in the Contract shall be followed.

Tables to be completed by the Contractor are as per Appendix D – Performance Guarantee checklists.



Appendix A - Data acquisition from embedded solar PV installations in Victorian education services

This document specifies the required data feed to be provisioned for all embedded solar PV installations in the Victorian education portfolio.

Aim

The aim is to provide a periodic structured solar data production record, readable by an automated computer system (interface) that can be automatically uploaded into the environmental data management system (EDMS) to track school solar PV electricity production data.

Transmission methodology

The system is to provide information to the interface via email, containing an attached file in Excel CSV format [i.e. \r\n for newline] containing records in the below structure:

'supplier name', 'measurement device', 'start datetime', 'stop datetime', 'measured quantity', 'measurement unit', 'activity name' \r\n

Where:

1. supplier name

- The producer of the measurement. For a school owned solar installation this is to be the school name, such as xxx.

2. measurement device

- a unique identifier for the solar PV system (or part of a system) from which the data is being supplied
- For a measurement device that reports solar production from the entire solar PV system (e.g. taken from meter, a single inverter, or for reporting an aggregate of multiple inverters), then the naming convention will follow the format of: FACILITY NAME_SOLAR_kWp (system capacity)
- As an example, for a 7 kWp array at xxx School, the measurement device would be named: xxx_SOLAR_7
- Where Solar PV data is being measured from multiple measurement points within the overall solar PV installation (such as emails generated from individual inverter outputs where there is more than one inverter) then the naming convention will follow the format of: FACILITY NAME_SOLAR_kWp_Inverter (or other device) number
- As an example, for a 200 kWp array at xxx School with separate measurement devices, the measurement devices would be named: xxx_SOLAR_200_01 and xxx_SOLAR_200_02 etc.

3. start datetime

- The time of the measurement period start in SQL format datetime YYYY-MM-DD HH:MM e.g.: 2017-09-10 23:30

4. stop datetime



- The time of the measurement period end in SQL format datetime YYYY-MM-DD HH:MM e.g.:
2017-09-10 23:44
- 5. measured quantity
 - The amount of the measurement – for example the measured amount on 200kWh is 200
- 6. measurement unit
 - The unit of the measurand – for solar this is kWh
- 7. activity name
 - The EDMS approved name for the activity type. For solar it is Solar Power with capitalisation as shown.

An example of a seven day extract is shown below:

```
School Name SOLAR_7,2017-09-10 00:00,2017-09-10 23:59,0.060,kWh,Solar Power
School Name SOLAR_7,2017-09-11 00:00,2017-09-11 23:59,0.170,kWh,Solar Power
School Name SOLAR_7,2017-09-12 00:00,2017-09-12 23:59,0.200,kWh,Solar Power
School Name SOLAR_7,2017-09-13 00:00,2017-09-13 23:59,0.370,kWh,Solar Power
School Name SOLAR_7,2017-09-14 00:00,2017-09-14 23:59,0.550,kWh,Solar Power
School Name SOLAR_7,2017-09-15 00:00,2017-09-15 23:59,0.680,kWh,Solar Power
School Name SOLAR_7,2017-09-16 00:00,2017-09-16 23:59,0.800,kWh,Solar Power
```

.csv files must:

- not contain header rows
- not contain blank rows

E-mailing

E-mails are to be sent to greener.schools@education.vic.gov.au

E-mails must contain only a single attachment file – if multiple files are generated at the same time by a batch process, they must be emailed separately.

Frequency of e-mailing from each measurement device can be set appropriate to the solution provided, but should not to be less frequently than monthly.

Solutions that require manual action by schools, Department of Education or third parties to process e-mails will not be accepted.

Notification of measurement device names

When setting up a new data supply, you must notify the department at

greener.schools@education.vic.gov.au of the measurement device unique identifier, the solar PV system it is associated with and the frequency of e-mailing.

Any queries on the collection of solar data, or naming measurement devices can be sent to:

greener.schools@education.vic.gov.au



Appendix B – Solar PV guidelines

This section provides guidelines on how to develop the solar PV systems. We note this is for information only and the contractor is responsible to ensure their design complies with the body of this specification and the relevant Australian Standards.

System component	Specification criteria	<30kWac	30kWac-75kWac	<100kWdc
Eligibility to STCs	The system needs to be eligible to STC rebate	Yes		
Inverters	Minimum of 10kWac Minimum of 2 inverters Section 7	2-3 string inverters	2-4 string inverters	3-6 string inverters
String configuration	Section 7	Above Minimum Voltage and below Maximum Voltage window of the selected inverter		
Solar PV Modules	Section 6	DC:AC Ratio of 1-1.3 (Preferred 1-1.3)		
Shading	No or minimum shading at winter solstice. Shading needs to be accounted for in minimum performing guarantee	0-3%	0-5%	0-7%
Cabling	Maximum DC voltage drop between the PV array and the inverter is no greater than 2% Maximum AC voltage drop between the inverter and the main switch board not greater than 1%	Cable design to suit specific distances and voltages		



Appendix C – Document submission checklist

Item No	Deliverable (Not in order)	Stage 1 – Project Assessment	Stage 2 – Detailed Design	Stage 2 – Procurement & Construction	Stage 2 – Commissioning	Stage 2 – Practical completion & handover	Date of Submission
1	Site inspection and dilapidation survey report	IFR					
2	Grid connection application	IFI					
3	Single line diagrams	IFR		IFC		As-built	
4	Arrangement drawings	IFR		IFC		As-built	
5	Shop Drawings					As-built	
6	AC & DC load analysis report		IFR	IFC			
7	Structural assessment report	IFR		IFC			
8	Shading analysis report	IFR					
9	PVSyst report	IFR					
10	Glint and glare assessment report (Including impacts on flight paths)	IFR					
11	Earthing calculations and layouts		IFR	IFC		As-built	
12	Design calculations		IFR	IFC		As-built	
13	EMC Calculations		IFR				
14	Labelling and Identification		IFR			As-built	
15	Wiring diagrams		IFR	IFC		As-built	
16	Fault current studies		IFR	IFC			
17	Protection coordination report		IFR	IFC		As-built	
18	Safety in design report		IFI	IFI			
19	Design report including technical specifications		IFR			As-built	
20	Cable sizing report		IFR				
21	Communications and monitoring diagrams		IFR	IFR		As built	
22	Controls documentation		IFR	IFR		As built	
23	Schedule of Manufacturers		IFR	IFR			



Item No	Deliverable (Not in order)	Stage 1 – Project Assessment	Stage 2 – Detailed Design	Stage 2 – Procurement & Construction	Stage 2 – Commissioning	Stage 2 – Practical completion & handover	Date of Submission
24	Product Data		IFR	IFR			
25	Bill of materials		IFR	IFR		As-built	
26	Evidence of compliance with specified product certification schemes		IFR	IFR			
27	Schematic layout, piping, wiring and control drawings		IFR	IFC			
28	Lifting points, Operating weight and support loadings		IFR	IFC			
29	Safe work method statements			IFI	IFI		
30	Certificate of Training					As built	
31	Testing and commissioning plan				IFR		
32	Commissioning test reports, ITP, ITR				IFR		
33	Construction progress photos			IFI	IFI	IFI	
34	Installation reports including photos and thermal imaging			IFI		IFR	
35	Equipment FAT reports			IFI			
36	Spare parts list					IFI	
37	Cable list			IFI			
38	Warranties			IFI		IFI	
39	O&M package					IFI	
40	Authorities and Utilities Approval					IFI	
41	Certificate Of Electrical Safety (COES)				IFI		
42	Checklists		IFR	IFR	IFR	IFR	



Appendix D – Performance Guarantee checklists

Description	Guarantee
Expected kWh/year generation per year measured at the connection point to the existing switchboard	
DC System rated capacity (kWp) (Installed capacity)	
AC System rated capacity (kW) (Installed capacity)	
Minimum Generation Guarantee yr. 1 (MWh/yr)	
Capital cost including STC discount (AUD)	
Ratio \$/Wp	
Ratio \$/kWh	

Equipment and materials	Brand and model number guarantee	QTY guarantee
Solar panels		
DC connectors		
Isolator boxes		
Combiner boxes		
DC Cables		
Inverters		
AC Cables		
AC switchboards		
Protection relays		
Metering equipment		
Monitoring equipment		
Communications equipment		



Appendix E- Submission Forms

E1-Schedule of Rates

Complete the schedule of rates provided in spreadsheet format, which will form a part of the Contract Documents. This schedule will be used for work as variations (addition and deductions) to the D&C works, all other variations will be considered separately.

The rates offered are to be for the complete supply, installation, testing, commissioning, etc. i.e. all miscellaneous minor works, fixings, ties, brackets, etc. will be deemed to be included as required in each rate.

Fix the rates for the duration of the works.

The unit rates include for administration costs and profit for the addition or deletion of items as detailed.



E2-Price Breakdown stage 2 works

Please provide RFQ price breakdown for the following system sizes and key elements of the project. The breakdown offered is to be for the complete supply, installation, testing, commissioning, etc i.e. all miscellaneous minor works, fixings, ties, brackets, etc. in compliance with RFQ specifications. The pricing is to be filled in the spreadsheet provided.

System size (kWdc)	Energy Savings (MWh pa)	CO2 abatement (kg Co2 e)	Roof type	Building height (Single or multiple story)	Price
10					
20					
30					
40					
50					
60					
70					
80					
90					
99.9					



Appendix F- CEC Checklists

The attached Clean Energy Council documents provides general guidelines and checklists outlining on installation and commissioning requirements for grid-connected PV systems.

<https://assets.cleanenergycouncil.org.au/documents/accreditation/grid-connected-solar-pv-systems-install-and-supervise-guidelines-for-accredited-installers-v13-2019.pdf>