# PHOTOVOLTAIC SYSTEM TECHNICAL SPECIFICATION

## 1 GENERAL

### 1.1 AIM

Provide three photovoltaic rooftop grid-connected power generating systems as documented to the following locations:

1. Penrith Civic Centre, 601 High Street, Penrith.
   System size – 99.84kWp
2. Joan Sutherland Performing Arts Centre, 597 High Street, Penrith.
   System size – 47.32kWp
3. Penrith City Council Works Depot, Copeland St, Kingswood.
   System size – 29.64kWp

The systems are to be eligible for Small-scale Technology Certificates (STCs) under the Australian Government's Small-scale Renewable Energy Scheme (SRES).

### 1.2 SCOPE OF WORK

The works in this contract shall comprise the provision of all materials, labour, transport, tools, plant, applications, payment of fees and everything else necessary for the design, supply, installation, commissioning and maintenance of three(3) photovoltaic (PV) rooftop grid-connected power generating systems as documented and shall include:

- Photovoltaic (PV) modules.
- Grid-connect inverters.
- Mounting framing system for installation of PV modules and inverters.
- Balance of system components including DC and AC cabling and switchgear, data cabling, junction boxes, switchboards, conduit, cable tray, mounting brackets, etc.
- Modification of existing switchboards.
- Protection systems to the requirements of Endeavour Energy.
- Detailed labelling and signage to the requirements of Endeavour Energy and appropriate Australian Standards.
- Bi-directional metering to the requirements of Endeavour Energy.
- Installation of a fixed vertical line access ladder to the roof at the Depot building.
- Installation of an access bridge connecting the roofs of the Joan Sutherland Performing Arts Centre.
- Installation of certified roof anchor points and static line systems.
- Data-logger for monitoring PV system performance at each site.
- Web-service for displaying the PV system performance and monitoring.
- TV display of PV system performance at the Civic Centre and the Joan Sutherland Performing Arts Centre.
- Testing and commissioning.
- Inspections and witness testing of the PV systems by Endeavour Energy.
- Training of local staff in the basic operation, maintenance, and trouble-shooting of the PV systems.
- Operation and Maintenance manuals.

- Operating warranties.
- All permanent and temporary safety and access equipment necessary for lifting materials and working at heights.
- Design documentation required to satisfy Endeavour Energy for connection of the PV system to their network.
- All supports, brackets, drilling, penetrations, fire stops, water proofing and other building works associated with the above.
- Sundry minor works as specified herein.
- Operating maintenance for a 12 month period commencing from system handover.

The tenderer shall advise any ambiguities in the document at the time of tender for the works specified. Claims for extra costs based on lack of knowledge of the documents will not be accepted after submission of the tender.

Provide all apparatus, appliances, materials, labour and services not specifically mentioned, that are necessary to form complete fully operational photo voltaic power systems in all respects and without any additional cost. Price variation or extensions of time will not be allowed on the basis of lack of knowledge or familiarisation with other documentation for the project.

## 1.3 STANDARDS

In carrying out the installation of grid-connected solar power systems, the contractor will be required to undertake the work in accordance with the following most recent Australian Standards:

| | |
|---|---|
| AS 5033 | Installation of Photovoltaic Arrays |
| AS 3000 | Electrical Wiring Rules |
| AS 3439 | Low-voltage switchgear and controlgear assemblies |
| AS 1768 | Lightning Protection |
| AS 1170.2 | Wind Loads |
| AS 4777 | Grid Connections of Energy Systems via Inverters |
| AS 2053 | Conduits and Fittings for Electrical Installations |
| AS 4509 | Stand-Alone Power Systems |
| AS1664 | Aluminium Structures |

National Construction Code

NATSPEC Reference Specification latest Edition

Endeavour Energy Network Standards

New South Wales Service and Installation Rules

Other appropriate Australian Standards

## 1.4 CROSS REFERENCES

### General

Electrical services design and installation is to comply with the following sections from the NATSPEC ELECTRICAL SERVICES specification:

- General requirements
- Adhesives, sealants and fasteners
- Fire-stopping
- Metals and prefinishes
- Cable support and duct systems
- Electrical systems
- Electrical design and install
- Low voltage power systems
- Power Generation – Photovoltaic
- Switchboards – proprietary
- Switchboards – custom-built
- Switchboard components

- Telecommunications cabling
- Lightning protection

### 1.5 NATSPEC REFERENCE SPECIFICATION

This project specification and the associated drawings have been prepared as a two-part specification i.e.

- NATSPEC ELECTRICAL SERVICES
- this specification containing specific requirements of the contract.

The NATSPEC ELECTRICAL SERVICES specification is referred to without reference to edition. Use the edition of the NATSPEC ELECTRICAL SERVICES specification that is current at the date of tenders closing. For additional information including current edition of NATSPEC ELECTRICAL SERVICES refer to www.natspec.com.au. NATSPEC is published by and is obtainable from Construction Information Systems Pty Ltd.

The NATSPEC REFERENCE specification is being referred by implicit selection. NATSPEC REFERENCE specification provisions apply unless the project specific documents say they do not. This is being done implicitly, by context. For example, if the project clearly (e.g. from the drawings and specification) has no steel conduit then the clauses dealing with metallic conduit in the Cable support and duct systems section do not apply. Statements in the project specification do not exclude such items explicitly.

At a finer level of detail, if the NATSPEC REFERENCE specification contains a default provision for an applicable element, but the project specification describes a different provision, then the provision in the project specification will override that in the NATSPEC REFERENCE specification.

**Site Copy**

Keep a hard copy of NATSPEC ELECTRICAL SERVICES on site during installation.

## 2 CONTRACTOR REQUIREMENTS

### 2.1 ACCREDITATION

The contractor must be accredited by the Clean Energy Council of Australia (CEC) in order to carry out PV design and installation works.

For further information please see the Clean Energy Council of Australia Website at: http://cleanenergycouncil.org.au/

### 2.2 LICENCES

A licenced electrician must carry out all Low Voltage electrical work (i.e. exceeding Extra-Low Voltage of 50V a.c. or 120V ripple free d.c.) and all electrical work associated with connecting the photovoltaic system into the building's power system and electricity grid.

### 2.3 SMALL SCALE TECHNOLOGY CERTIFICATES (STC)

Where STCs are sold to the Contractor as a part of this contract, the STCs shall be signed over/transferred to the Contractor by the Principal after the formal commissioning and written acceptance of a fully operational and complete Photovoltaic Power System.

## 3 SITE CONDITIONS & INFORMATION

### 3.1 OCCUPIED SITE

The three sites are all busy and fully operational service and function centres, with many events, people and staff moving around as well as hazards such as moving trucks and heavy machinery at the Depot. All three sites will remain fully operational during construction of the photovoltaic power systems and the contractor is to ensure minimal disruption to existing work and operations. Close management with the project manager and site staff will be essential throughout the installations.

### 3.2 USE OF FACILITIES

The contractor may use existing site amenities, including kitchen and lunch rooms, during operational hours.

### 3.3 SITE COMPOUND

No area is available on each of the sites for a site compound.

### 3.4 STORAGE

Minimal site storage is available.

### 3.5 PARKING

Restricted site parking may be available.

### 3.6 DELIVERIES

Any large deliveries or use of cranes will require careful planning, sufficient notice and need to coordinate with the site contact and project manager.

### 3.7 SCAFFOLDING / FENCING / ROOF EDGE PROTECTION

The contractor is to provide all temporary scaffolding towers and/or stairs, secure fencing, barricades, roof edge protection etc, required to meet WHS requirements for construction at each site.

### 3.8 RESTRICTED ACCESS

The Joan Sutherland PAC roof cannot be accessed during performances.

### 3.9 SHUT-DOWNS

All electrical shut-downs required for connection of the photovoltaic systems shall occur outside of normal working hours or performance hours and must be with the consent of the project manager and site contacts.

## 4 SUBMISSIONS

### 4.1 SMALL-SCALE TECHNOLOGY CERTIFICATES DISCOUNT

As part of the tender pricing shedules, the tenderer is to provide an upfront lump sum discount for the Principal to assign all eligible Small-Scale Technology Certificates (STC's) for each site/system to the contractor. However, the assignment will occur only after all acceptance tests are completed and successful, as well as the written acceptance of Endeavour Energy for the systems to be energised and connected to the grid.

An STC had a spot market value of $38.50/STC excluding GST as of 6th January 2016.

For further information on STC's, please see the Clean Energy Regulator website at: http://www.cleanenergyregulator.gov.au/

### 4.2 TECHNICAL DATA

Provide a Statutory Declaration with the tender submission that all items of equipment proposed are the latest generation/models available on the market and that no equipment is a 'run-out' or superceded model.

Prior to purchasing equipment, submit for approval to the Principal the following technical data:

- Technical description and specifications of each system component
- Reaffirm with a Statutory Declaration that all equipment now detailed is the latest generation/models available on the market.
- Physical layout of each building's photovoltaic array showing location of photovoltaic modules, mounting equipment, inverter locations and cable runs.

- Single line schematic showing the configuration of photovoltaic strings and inverters and the interconnection with each building's electrical system and connection to Endeavour Energy's network.
- Shop drawings of switchboards for review.

### 4.3 ENDEAVOUR ENERGY

Submit all design, testing and commissioning documentation necessary to satisfy the requirement of Endeavour Energy for the connection of each PV system to their network prior to commencing work on site. As a minimum this includes:

- Application for connection;
- Single line diagram of the installation showing the solar panels, inverters and protection equipment, along with datasheets of proposed equipment;
- Voltage rise calculations;
- Detailed commissioning test plan at least six weeks prior to intended commissioning date;
- Earthing arrangements for the installation;
- Plant characteristics and nature of any disturbing load (nature of power electronic plant that may produce harmonic distortion, size of disturbing component kW/kVAR, duty cycle, etc);
- Effects of supply network faults or power quality (frequency and voltage tolerances) on installation;
- Proposed operating and protection schematic;
- As built drawings of all PV system components, protection systems and cabling routes as installed.

A copy of all documentation submitted to Endeavour Energy must be copied to the Principal at the same time as it is submitted to Endeavour Energy. All responses from Endeavour Energy must also be forwarded to the Principal at the time of receipt.

Should this documentation (other than the as-built drawings) not be available to the Principal, the Contractor cannot commence work on each site.

## 5 PV SYSTEM REQUIREMENTS

### 5.1 GENERAL SYSTEM REQUIREMENTS

Each photovoltaic array must comprise sufficient number of photovoltaic modules whose individual nominal rating under Standard Test Conditions (STC) results in a minimum kilowatt peak total array nominal rated capacity of 99.84 kilowatts peak (Penrith Civic Centre), 47.32 kilowatts peak (Joan Sutherland Performing Arts Centre) and 29.64 kilowatts peak (Penrith City Council Works Depot – Kingswood).

The systems are to be eligible for Small-scale Technology Certificates (STCs) under the Australian Government's Small-scale Renewable Energy Scheme (SRES). For more information on the SRES, see the Clean Energy Regulator's website at:

http://www.cleanenergyregulator.gov.au/Renewable-Energy-Target/Pages/default.aspx

### 5.2 MAINTENANCE ACCESS

The arrangement of all the components of the photovoltaic systems will be arranged so that the photovoltaic modules, inverters, data loggers, and any other component, are readily accessible for maintenance and replacement when required.

## 5.3 PV MODULE REQUIREMENTS

### Selection of Modules

The designs for this tender are based around using Trinasolar 260W TSM-260 PC/PA05A modules. The tenderer must provide a price for these modules but may offer an alternative option using another brand and model of PV module for this contract, with the alternative option meeting all the following criteria.

### Australian Standards

The proposed photovoltaic modules must comply with AS/NZS 5033.

### Certification

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

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

All PV modules: must be certified with IEC-61730 and must be listed on listed on the Clean Energy Council approved PV modules list.

### Equipment Class

PV modules must be Class A as defined in AS/NZS 5033.

### Encapsulation

PV modules must be encapsulated in toughened glass.

### Protection Rating

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

### Temperature Coefficient

Maximum allowable temperature coefficient of maximum power is -0.5% / °C.

### Operating Temperature

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

### Module Efficiency @ Standard Test Conditions

Monocrystalline: > 14%

Multi/poly-crystalline: > 14%

Thin film: > 9%

### Mechanical Protection

Hailstone impact testing: Required.

### Warranty

Minimum power output warranty: 20 years – at 80% power output.

Minimum product warranty: 10 years.

The contractor is responsible for ensuring the photovoltaic modules are installed as per manufacturer's installation, operation or maintenance instructions.

The warranty certificate must be submitted within four (4) weeks of the commencement of the contract. Where the warranty certificate is not presented to the Principal, the final contract claim cannot be processed.

## 5.4 PHOTOVOLTAIC MODULE ARRAY ARRANGEMENT

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

Locate the PV arrays within the areas and to a similar layout as indicated with each Drawing.

## 5.5 PV MOUNTING FRAMES

### General

Provide proprietary products that are appropriate for this particular installation and the installation environment.

PV panels on each Building roof shall be mounted as indicated on the drawings, being either flush on the pitched roofs or tilted on mounting frames (part of the system for the Joan Sutherland Performing Arts Centre), oriented as indicated on each drawings. Alternatives can be proposed for consideration at the time of tendering.

For flush mounted systems, use a propriety roof mount/rail system that is fixed to the existing roof purlins. The panel mounting/fixing system is to be independent of the roof fixing system.

For the Joan Sutherland PAC, the roof is curved requiring a mounting system that follows the arc of the roof.

For the tilted system for part of the Joan Sutherland PAC, use a propriety system for the tilt and rail system that provides clear space for water to pass, that is fixed with at least three purlin fixing points for each rail

Proprietary mounting structures should be used and the installation certified to AS1170.2.

All dissimilar metals must be separated to prevent galvanic corrosion.

Provide an engineering certificate for wind and mechanical loading of all mounting systems.

### Warranty

The mounting systems must have a minimum warranty of 10 years in meeting the requirements of AS1170.2 for normal operating conditions. The contractor must supply a warranty for each system to which the Principal, when necessary, can make a warranty claim.

The warranty certificate must be submitted within four (4) weeks of the commencement of the contract. Where the warranty certificate is not presented to the Principal, the final contract claim cannot be processed.

## 5.6 INVERTER REQUIREMENTS

### General

The design and specification for the documented PV systems are based around using string inverters. The tenderer may propose an alternative design using micro-inverters, as long as a complying tender is also submitted using string inverters.

### Selection of Inverter

The design in this tender is based around using SMA Tripower commercial inverters as a complying tender, with the inverter ratings suiting the power requirements detailed on the drawings as well as including LED digital display panels as part of the inverter units. The tenderer must provide a price for these inverters but may offer an alternative option using another brand and model of inverter for this contract, that meet all the following criteria.

The inverter systems must be suitable for use with the specified photovoltaic systems and string configuration taking into account voltage drop and PV module temperature effects.

The total inverter(s) AC nominal power output rating must be appropriately rated and be in accordance with Clean Energy Council Design Guidelines.

Three phase inverters must be used, with all phases balanced in accordance with NSW Service and Installation Rules and Endeavour Energy requirements.

All inverters must be the latest commercially available model. Refer Clause 4.2 for accompanying declaration.

Note: An alternative tender using single or three phase micro-inverters may also be submitted, as long as a complying tender is also submitted.

**Australian Standards**

The inverter(s) supplied must be certified with AS4777. The inverter(s) must also be listed on the Clean Energy Council approved grid-connect inverter list.

**Technical Requirements**

The inverter(s) must be also be well ventilated to prevent over-heating and must be capable of autonomously synchronizing with the existing grid voltage.

Waveform: True sine wave.

Waveform quality: to AS 4777.

Voltage regulation: ± 8%.

Max DC voltage: must exceed open-circuit voltage (Voc) of PV strings at 5ºC cell temperature.

Maximum power point tracking range: must be between maximum power voltage (Vmp) of PV strings at 25ºC and 70ºC cell temperature.

Total harmonic distortion of output current:< 4%.

Frequency regulation: ± 1%.

Efficiency: ≥ 90% at 10% load.

Protection: Overload, short circuit and transient required.

Automatic no-load shutdown: required.

Display – must include a LED digital display panel that can show:

- Grid stability.
- Normal operation and historical generation.
- Fault events.

**Earth Faults & Alarms**

Inverter/s must be capable of detecting earth faults and an earth fault alarm system must be installed as per AS/NZS 5033.

When an earth fault is detected the inverter must create an alarm, which results in an action being initiated to correct the fault.

As a minimum, an alarm email and/or SMS must be sent to an appropriate person onsite in the event of an earth fault. An audible alarm in an appropriate location where it will be heard, may also be installed.

A set of operational instructions shall be provided to the system owner that includes actions to take when the alarm operates.

**Load Balancing**

A multiple inverter system must be balanced across the 3 phases and to the approval of Endeavour Energy's requirements.

**Warranty**

The inverters must have a minimum warranty of 10 years. The contractor must supply a warranty to which the Principal, when necessary, can make a warranty claim to the inverter manufacturer.

The warranty certificate must be submitted within four (4) weeks of the commencement of the contract. Where the warranty certificate is not presented to the Principal, the final contract claim cannot be processed.

## 5.7 DATA-LOGGER REQUIREMENTS

**General**

A data-logger from the same manufacturer as the inverter must be supplied, installed and connected to the solar PV power system's inverters for each system. The data-logger must be fully compatible with the nominated inverter(s).

**Technical Requirements**

The data-logger must be capable of recording the following information:

- Energy Total (kWh)
- A calculation of $CO_2$ saved (kg)
- Power now (W, kW)
- Energy today (kWh)
- Time period / date for energy generated
- Instantaneous voltage of PV system (V)
- Instantaneous current of PV system (A)

The data-logger must be capable of monitoring multiple inverters at once and must be able to record individual inverter performance and operation parameters of the PV, such as DC voltage and current, and AC voltage, current and frequency.

The data-logger and interface must have the following capabilities:

- Storage data capacity ≥ 1 gigabyte
- Save cycles ≤ 30 minutes
- Connection interfaces: USB-interface, USB socket, 8-pin data cable (RS 485), network plug (RJ 45-sockets) and RS232.

The inverter and the data logger must have the function to directly integrate/transfer the solar data to the Penrith City Council Buidling Management System (BMS) for the Civic Centre and the Joan Sutherland Performing Art Centre using all necessary equipment, including any required development and the commissioning of the inverter/data logger to the BMS. Penrith Council's BMS is a Niagra Tridium BMS with full Bacnet open protocol language.

**Web Service**

Provide a free proprietary web service and internet platform for the Photovoltaic system monitoring and visualisation for each system.

The web service must provide the following functions:

- System information via e-mail (energy yield, maximum output, $CO_2$ reduction, system fault messages)
- Presentation of system data in diagrams and tables
- Ability to publish web data on other websites
- Ability to customise individual web pages through HTML and insert own images
- Ability to export the data in raw format, including web service API's such as JSON or XML and flat CSV or text files.
- Access must be platform agnostic for access and adhere to modern web standards include HTML 4 and HTML 5.
- System must be capable of providing access to the raw data or be capable of using custom or other off-the-shelf web service providers.

A data flow diagram must be provided at the time of contractor engagement detailing and including transmission protocols and ports.

The contractor shall order a separate land line and modem that provides connection to the internet. The contractor shall register the web service product and test the system for functionality. Data shall be broadcasted on the web service daily.

Make all necessary applications and pay any licence fees in relation to registering the photovoltaic solar power system to the web service for 25 years operation of the system.

The contractor shall provide training for a miminum of 4 nominated staff, for up to 1 hour, in the use and functionality of the web service product and shall supply all information necessary to maintain the system upon practical completion, including necessary licences, usernames and passwords.

**Weather Station**

Provide a weather station and sensors fully compatible with the nominated inverter(s) and data logger for each system, to monitor weather conditions during operation of each PV system. The following weather sensors should be provided as minimum:

- Solar radiation
- Module temperature
- Ambient temperature
- Wind speed

The location of the weather station shall be nominated on the workshop drawings with the anemometer mounted in the horizontal plane.

**Installation**

General: To manufacturers recommendations.

Interface the data-logger to the inverter(s).

For the separate land line, test for functionality.

Only where the client allows their business communications network to be uses to connect the web services, liaise with the building's network administrator to connect the data-logger to the building's communications network and upload data to the web-service. Liaise with the building's network administrator to obtain a static IP address and modify the existing fire-wall settings. Test for functionality.

**Warranty**

Minimum 5 years.

The warranty certificate must be submitted within four (4) weeks of the commencement of the contract. Where the warranty certificate is not presented to the Principal, the final contract claim cannot be processed.

## 5.8 PROTECTION RELAY (IF APPLICABLE)

**General**

Generally, Photo Voltaic Power Systems larger than 30kW with multiple inverters require the use of this additional protection relay.

Depending on Endeavour Energy's final assessment of the PV system designs, the installation may require additional backup protection in the form of a relay, to ensure the installation is disconnected from Endeavour Energy's network in the event of a fault or failure of the network.

Endeavour Energy will need details that this protection is properly designed and configured and properly installed. Endeavour Energy will witness the commissioning process.

Additional protection is often required for backup anti-islanding protection for the installation. Provide backup protection relay(s) as necessary, if advised by Endeavour Energy.

The tenderer should allow for liaising with Endeavour Energy during the design phase and allow for any protection systems that may or may not be required.

Endeavour Energy will provide settings for the backup anti-islanding protection if required.

The submitted tender submission must include the result of any discussions with Endeavour Energy as well as including how the system will comply with the anti-islanding protection requirements.

## 5.9 MOULDED CASE AND MINIATURE CIRCUIT BREAKERS

Moulded case breakers: To AS 60947.1, AS 2184 and AS 60947.2.

Miniature circuit breakers: To AS/NZS 60898.1 or AS 3111.

Operation: Independent manual operation including positive ON/OFF indicator.

Trip type:

- Moulded case breakers: Adjustable thermal, fixed magnetic.
- Miniature circuit breakers: Fixed thermal, fixed magnetic.

Current limiting:

- Moulded case breakers: Required.

Isolation facility: Required.

Mounting: Mount circuit breakers so that the ON/OFF and current rating indications are clearly visible with covers or escutcheons in position. Align operating toggles of each circuit breaker in the same plane.

Utilisation category: Moulded case breakers:

- Final subcircuits category: Category A.
- Mains and submains: Category B.

Trip units: Connect interchangeable and integrally fused trip units so that trip units are not live when circuit breaker contacts are open.

## 5.10 DC FUSES

If string fuses are used for DC protection, they must be installed to AS5033 and AS3000, be rated for DC use and have the appropriate voltage and current ratings.

## 5.11 DC ISOLATORS

Isolators used for DC protection must be installed to AS5033 and AS3000, be rated for DC use and have the appropriate voltage and current ratings.

The voltage rating of each DC isolator pole should be at least the maximum array voltage.

DC isolators must not be polarity sensitive.

DC Isolators located in roof isolation boxes must be mounted close to walkway or roof access location.

## 5.12 DC CIRCUIT BREAKERS

Circuit breakers used for DC protection and isolation must be installed to AS5033 and AS3000, be rated for DC use and have the appropriate voltage and current ratings.

The voltage rating of each DC circuit breaker pole should be at least the maximum array voltage.

DC circuit breakers must not be polarity sensitive.

## 5.13 POWER CABLES

### Standard

Cable sizing in accordance with AS/NZS 5033 and AS/NZS 3008.

PVC and XLPE cables: To AS/NZS 5000.1.

### Cable

General: Select multi-stranded copper cable generally, except for mineral insulated metal sheathed (MIMS).

DC cables must be PV1-F rated and certified.

Minimum size: 2.5 $mm^2$.

Voltage drop: Select final subcircuit cables within the voltage drop parameters dictated by the route length and load.

Fault loop impedance: Select final subcircuit cables selected to satisfy the requirements for automatic disconnection under short circuit and earth fault/touch voltage conditions.

Distribution cables: To AS/NZS 4961.

### Conductor colours

General: For fixed wiring, provide coloured conductor insulation. If this is not practicable, slide at least 150 mm of close fitting coloured sleeving on to each conductor at the termination points.

Active conductors in single phase circuits: Red.

Active conductors in polyphase circuits:

- A phase: Red.
- B phase: White.
- C phase: Blue.

**DC Cabling Sizing**

DC cables must be sized to maximise system performance. The voltage drop of the photovoltaic system between the photovoltaic array and inverter must be lower than 1% of the total PV array DC voltage.

**AC Cabling Sizing**

The AC cables must be sized such that the voltage drop:

- between the inverters and Solar Distribution Boards is less than 1% of the total PV inverter AC voltage.
- between the Solar Distribution Boards and the Distribution Boards being connected to is less than 1% of the total PV inverter A.C. voltage.

The AC cables must also be sized such that the voltage rise in accordance with NSW Service & Installation rules:

- between the inverters and the site's Main Switchboard is less than 1% of the total PV inverter AC voltage.
- across the Service Mains is less than 1% of the total PV inverter AC voltage.

### 5.14 FIXED VERTICAL LINE ACCESS LADDER

For the Depot, the Contractor is to install a certified Fixed Vertical Line Roof Access Ladder with Lockable Access Control Gate and Vertical Handrails to allow safe and easy roof access The lockable access control must prevent unauthorised access to the roof from ground level and prevent access by climbing between the wall and the ladder.

### 5.15 ACCESS BRIDGE

For the Joan Sutherland Performing Arts Centre, the Contractor is to install a certified Access Bridge with Handrails connecting the Main Building roof with the Atrium Extension roof in the area suggested on the drawings. The bridge ensures that the roof membrane below is not used as a walkway.

### 5.16 CERTIFIED ROOF ANCHOR POINTS SYSTEM

The contractor to install new or additional certified roof anchor points and static line systems for fall protection and safe access to the roof mounted PV systems. The contractor will also modifiy existing systems to suit the new PV Systems at all three sites.

Where the Contractor installs new or additional roof anchor points or relocates existing roof anchor points, the modified roof anchor systems shall be provided with a recertification certificate.

## 6 ELECTRICAL INSTALLATION REQUIREMENTS

### 6.1 AUSTRALIAN STANDARDS

In addition to the standards listed elsewhere, grid protection devices must be installed in accordance with AS4777.

The photovoltaic system must also be installed in accordance with AS/NZS 5033.

The installation must also comply with AS/NZS 3000.

### 6.2 DC CABLING INSTALLATION

The DC cables shall not be positioned in locations of water drainage or in locations that are likely to prevent the egress of rainwater.

Provide DC isolation adjacent to the PV array as per AS3000 and AS5033. If the DC isolation equipment is exposed to the environment, provide an IP65 rated enclosure.

The Contractor must allow for the shortest possible DC cable run with facilitated cable installation and cable access without obstructing any walkways, passages or windows.

No DC cabling is to be run live without being terminated at both ends with appropriately rated enclosures.

Any DC cabling within the building must be installed in HD conduit and be labelled “Solar” as per AS5033.

## 6.3 AC CABLING INSTALLATION

The Contractor must allow for the shortest possible AC cable runs with facilitated cable installation and cable access without obstructing any walkways, passages or windows.

## 6.4 WIRING

Conceal cables and conduits wherever practicable.

## 6.5 CONDUITS

### General

Unless otherwise indicated, conduit shall be of the rigid PVC type.

The entire works shall be carried out on the draw-in principle.

Conduits shall be securely fixed to wall boxes by means of conduit clamps. All conduit clamps must be non-corrosive metal. Plastic cable ties are not approved. Formed conduit sweeps and bends shall be used in lieu of elbows. Elbows and tees shall only be used where specifically approved by the Authorised Person and only where readily accessible at all times.

All conduit joints shall be free from burrs and rough edges and adequate precautions shall be taken at all times to prevent entry of moisture or foreign matter into the conduit systems.

The use of flexible conduit shall be kept to a practical minimum.

All flexible conduit shall be corrosion resistant and fully weatherproof and of Sealflex or equivalent manufacture. Positive type screwed fittings shall be used at all terminations of flexible conduits.

All conduits for future use shall be complete with polypropylene draw-cords.

### PVC Conduit

Corrugated PVC conduit shall only be installed with the prior approval of the Principal.

### Heavy Duty UPVC Conduit

HD UPVC conduit shall comply with AS 2053 and with 'Category A' enclosures as defined in AS 3000.

### Heavy Duty PVC Conduit

HD PVC conduit shall comply with AS 2053. Any DC cables within the building (including the roof space) shall be enclosed in HD PVC conduit as per AS 5033.

## 6.6 CABLE TRAYS

### General

Cable trays shall be of perforated metal and fully earthed. All trays shall have a cold rolled galvanised finish and shall be machine press formed, with both edges returned a minimum of 50mm for stiffening. Tray shall be of the following minimum gauges:

| Width of Tray | Thickness of Material |
|---|---|
| 75, 100, 150 mm | 1.0 mm |
| 225 mm | 1.2 mm |
| 300 mm | 1.6 mm |

The tray width selected with each application shall allow 20% spare space for future cables.

Tray shall be complete with galvanised perforated fishplates, bends and galvanised fixings, all to manufacturer's recommendations.

**Installation**

Tray shall be secured to the structure and shall be installed with sufficient clearance to permit installation of cable clips and other cable fixings. Supports shall be evenly spaced to ensure that tray is true and straight. Spacing of supports shall be within the manufacturer's recommendations for the loading concerned and in any case not less than two (2) supports shall be provided per length of tray.

Supports shall be of substantial fabricated hot-dip galvanised steel construction. The complete installation shall be free of any distortion or bowing.

Cable trays installed on the roof or external to the building shall have covers.

All cable trays, covers and supports where exposed shall be painted to match existing. Colour to be approved by Principal prior to painting.

All dissimilar metals must be separated to prevent galvanic corrosion.

## 6.7 COLOUR CODE

The following colour code must be used throughout the installation:

Busbars and cabling within switchboards, and all submains cores and polyphase subcircuits must be coloured red, white and blue in accordance with the Electricity Distributor's phase rotation and consistent throughout the site. Wrong phase rotation and consequences shall be rectified at the contractor's expense.

Single-phase subcircuits for lighting and power must be coloured as follows:

| | | |
|---|---|---|
| Active conductors | Three Phase | red, white, blue |
| | Single Phase | red |
| Neutral conductors | black | |
| Switchwires | white | |
| Earth conductors | green/yellow | |

## 6.8 MARKING AND LABELLING

General: Provide labels including control and circuit equipment ratings, functional units, notices for operational and maintenance personnel, incoming and outgoing circuit rating, sizes and origin of supply. All labels shall be traffolyte – texture pen labels are not approved.

ADDITIONAL MARKINGS: Provide marking as follows in addition to that required by AS 3000.

Labelling of switchboards must be in accordance with AS 4777.1 and AS 5033. Signs shall be installed in prominent positions on the Main Switchboard, Mechanical Control Centres, Solar Distribution Boards, Distribution Boards and Inverters. The warning label wording must be identical to the SIGN EXAMPLES given in APPENDIX A of AS 4777.1.

Lettering heights: Include the following requirements:

- Isolating switches: ≥ 5 mm
- Switchboards, main assembly designation: ≥ 25 mm
- Switchboards, outgoing functional units: ≥ 8 mm
- Switchboards, sub assembly designations: ≥ 15 mm
- Warning notices: ≥ 4mm

Provide all necessary signs as indicated in AS/NZS 5033: Appendix A.

A circular sign with green background and white “PV” wording shall be installed on the Main Switchboard for emergency services information, as per AS/NZS 5033 Appendix A.

## 6.9 SINGLE-LINE DIAGRAMS

Provide a single-line diagram of the photovoltaic solar power generator within the Solar Distribution Boards, Main Switchboard and other Distribution Boards that are part o fthe PV Systems. The diagrams must be either fixed to the internal area of a switchboard door or provided with a safe storage system.

Format: Non-fading print, laminated, at least A3 size, showing the situation as installed.

Colour coding must be used to identify each solar panel string on the array layout.

### 6.10 SHUT-DOWN PROCEDURE

Provide a step-by-step shut-down procedure immediately adjacent to the Inverters, Solar Distribution Boards and Main Switchboard as set out in AS4777. Specifically reference circuit breaker numbers in shut-down procedure.

The shut down procedure must be detailed using a traffolyte label.

### 6.11 ENDEAVOUR ENERGY NOTIFICATION

Notify Endeavour Energy, comply with the NSW Service & Installation Rules and Endeavour Energy Network Standards. Lodge all applications necessary to connect the installation to their network, including but not limited to:

- Lodging an Application for Connection form. Must be submitted prior to starting site work with a copy provided to the Principal;
- Provide Certificate of Compliance Electrical Work. Must be provided to the Principal prior to commissioning otherwise commissioning cannot proceed. The system must not be energised or connected to the grid until Endeavour Energy has issued the Certificate of Compliance;
- Make all necessary applications and pay any fees in relation to connecting the photovoltaic solar power system to Endeavour Energy's network.

## 7 METERING REQUIREMENTS

### 7.1 ELECTRICITY METERING

The contractor will arrange for each site's revenue metering to be upgraded to bi-directional, for billing purposes. This includes the provision and installation of appropriate meters or software upgrade of meters, which meet Endeavour Energy requirements.

The metering equipment and metering installation must comply with the following:

- NSW Service and Installation Rules;
- Endeavour Energy's Network Standards & Meter Installation rules;
- AS/NZS 3000 Wiring Rules;
- The National Electricity Rules.

The metering reconfiguration must be completed 2 weeks prior to commissioning. Provide evidence from Endeavour Energy that the metering reconfiguration has occurred.

## 8 TESTING AND COMMISSIONING

### 8.1 TESTS

**Inspection Notifications**

The contractor shall provide 48 hours written notice to the Principal when inspections of the installation or the system are required.

**Commissioning Tests**

Commissioning tests as listed below must be performed in accordance with AS/NZS 5033:2012 Appendix D and E.

In addition to the commissioning tests outlined below all photovoltaic equipment must be tested that they are operating correctly including the photovoltaic modules, modules strings, inverter(s), meter, data-logger and electrical protection devices.

Open Circuit Voltage Measurements

Short Circuit Current Measurements

Earth Fault Protection Test

**Functional In Service Test of Inverter Protection**

Remove all loads in the installation (e.g. remove all circuit fuses except for the inverter circuit). Isolate normal supply main switch. The inverter should trip by its own internal

protection in less than 2 seconds following disconnection from the distribution system supply. Then close the main switch. The inverter should reconnect after a minimum 1 minute time delay.

**Electrical Installations**

Inspection: Visually inspect the installation to AS/NZS 3000 before testing. Record on a checklist.

Test and verify the installation to AS/NZS 3000 Section 6 (Mandatory and Optional tests), using the methods outlined in AS/NZS 3017. Record the results of all tests.

Where electrical tests are required and the actual load is not available, provide a dummy load equal to at least 75% of the design load.

Before completion, provide a copy of the Certificate of Compliance Electrical Work, as submitted to Endeavour Energy and as required by Endeavour Energy and NSW Fair Trading.

### 8.2 RECORDS

The contractor must prepare a report that includes voltage and temperature measurements, the current and irradiance measurements and the Earth Fault Protection Test and also states the condition of the PV array wiring after the test, including any repairs and corrections carried out as a result of the inspections.

## 9 COMPLETION

### 9.1 ON-SITE TRAINING

On completion of each installation, the contractor will provide instructions to the Principal and a minimum of 4 nominated staff on the main components of the system (including cabling, wiring and shut-down procedure) and instruct them in basic maintenance and trouble shooting (for a minimum of one hour).

### 9.2 WARRANTEES OR GUARANTEES

The contractor shall obtain, and ensure the Principal will have the benefit of all warranties or guarantees on all new equipment and materials installed by the contractor.

Copies of any warranty documents must be forwarded to the Principal within four (4) weeks of the commencement of the contract.

The installation works must be warranted for a period of not less than 12 months from the successful completion and hand over of the project.

### 9.3 OPERATION AND MAINTENANCE MANUAL

Two hard copies and an electronic copy must be made for the PV installation, and forwarded by practical completion.

The Operation and Maintenance Manual must contain all the documentation and information set out in AS5033, including but not limited to:

- Contractor's name and logo and project name in full – i.e. Photovoltaic System, Project Title.
- Full contact details of all parties to the project – Contractor, Consultant, Client, Sub-Contractors - addresses, phone and fax numbers, email addresses.
- Detailed description of complete installation, including all separate systems, all system component locations, ID names, etc.
- Design criteria for system – photovoltaic system power output, photovoltaic array arrangement, climate data of location, insolation data for location, system performance estimates, single line diagram, voltage drop/rise calculations, etc.
- Detailed description of photovoltaic systems operation and control methods – how everything works – including all controls topography drawings, controls settings and controls logic diagrams.
- Complete schedules of all equipment – ID numbers, make and model, capacities.

- Comprehensive PV system manufacturers' literature for every item of PV system and/or equipment – each PV system literature separated by coloured divider.
- Full step by step shut-down procedure for maintenance and emergencies, including locations of all equipment, isolation points, breaker/switch numbers and explanation of all signs.
- Explanation of earth-fault alarms and actions to be taken in the event of an earth fault.
- Full step by step start up procedure of the entire PV system.
- Manufacturers' maintenance requirements for every item of PV system.
- Contractors' maintenance requirements for the system.
- Owner's maintenance requirements for the system.
- Maintenance Schedule Timetable – showing all maintenance requirements including locations, actions and frequency.
- All certification documents for each PV system component.
- Array mounting frame engineering certificates.
- Certificate of Compliance Electrical Work.
- Comprehensive PV system commissioning report including all tested components.
- Every approved as-installed drawing for the contract.
- Overview wiring diagram, single-pole complete with electrical ratings of the PV array, and the ratings of all fuses, isolators and circuit breakers.
- A simple trouble-shooting guide to help quickly resolve simple problems that may occur with the solar PV power system.

## 10 OTHER REQUIREMENTS

### 10.1 INSPECTION AND PUBLICATION OF PV SYSTEM INFORMATION

Parties chosen at the Principal's discretion will be allowed to visually inspect all parts of the photovoltaic system after practical completion, at the Principal's own risk. This does not include physical intervention with any part of the system, other than simple operation of the data logger or inverter, or for physical intervention during emergency situations.

In addition, pictures of any part of the photovoltaic installation, or documents regarding the photovoltaic system, and any other information obtained by the system's data-logger, are the property of the Principal.

The contractor must obtain the approval of the Principal before the project can be used in any marketing or advertising material. If no approval is provided, then marketing or advertising is prohibited.

### 10.2 PRECAUTIONS IN CARRYING OUT WORKS

In carrying out the works, the Contractor shall comply with all requirements of the main body of the specification. Work processes and any specific safety precautions which may be applicable during the installation of works.

The Authorised Person shall have the authority to restrict or deny the contractor's staff access to the site if the Contractor's staff do not comply with required safety precautions. The Authorised Person shall not be responsible for any additional costs associated with the Contractor's inability to comply with safety requirements or recall / return costs for the Contractor's staff or any specific safety equipment or machinery in the event of the Contractor being denied entry due to non-compliance with a WH&S matter.

### 10.3 BUILDING SERVICE DAMAGE

The Contractor shall take particular care to ensure that damage to internal or external services or the building roof is not incurred either directly or as a consequence of works or actions undertaken by the Contractor within or on the exterior of the building. The Contractor shall at his expense repair any damage to any existing services or building

materials caused either directly or as a consequence of the Contractors actions during the installation works. A reference to damage to internal services shall also be taken to mean damage to internal ceilings and walls.

## 10.4 POST COMPLETION PERIOD

During the post completion period (refer Preliminaries), the contractor will regularly review the system performance to ensure all components are functioning correctly and that the PV System is delivering optimal generation.

Where the PV generation output is below expectations, a site assessment of all components needs to be completed and a brief report provided to the Principal detailing the findings and planned remedial actions.

**END OF SECTION – PHOTOVOLTAIC SERVICES**

# Statement of Environmental Effects
## 597-599 High St, Penrith

**Description of proposal:**

Installation of a grid-connected 47.32 kW solar photovoltaic (PV) system on the roof of the Joan Sutherland Performing Arts Centre (JSPAC). The PV panels will be mounted on both newer northern block and south block of the JSPAC. The PV panels for the newer northern block at the JSPAC will be mounted on a tilted frame assembly. The roof falls 10° to the south, while the panels will be tilted so that they have an angle of 10° to the north, resulting in a total tilted angle of 20° to the roof sheeting. It is very difficult to see this roof from the ground level. Further, the PV panels will be set back a minimum 2.5m from the roof edge because of wind loading issues that will also reduce their visibility.

The PV panels on the south block of the JSPAC will be mounted flush on the northern facing roofs. Only the panels placed on the eastern section of the roof may be visible from the adjoining shopping centre upper levels. The majority of the panels will be shielded from view by the North Block building.

The PV panels will be a dark blue colour and placed in a geometric pattern.

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**Site Suitability**
*Discuss the suitability of the site. Consider factors such as Flooding, Drainage, Landslip, Mine subsidence, Soil erosion, Bushfire or any other risk.*

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This site is zoned B3 Commercial Core under LEP 2010. The installation of the solar photovoltaic (PV) system permissible with Council consent (under Clause 34 of State Environmental Planning Policy (Infrastructure) 2007.

Clause 7.2 Flood controls also applies to the site. Although the site is flood affected, the panels are located on the roof and system is connected to the network rather than on site batteries. Therefore the installation of the solar photovoltaic (PV) system will not impact on the flow of flood waters within the site.

The site is suitable for the installation of a 47.32 kW solar photovoltaic (PV) system. An engineering certificate has been provided detailing the existing building can support the installation of the solar photovoltaic (PV) system.

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**Access and Traffic**
*Discuss the effects your proposal may have on access and traffic. Consider factors such as Driveway access, Maneuverability, Pedestrian safety, Suitability of the existing road network, Number of vehicle movements entering and exiting the site, including delivery trucks, Number and location of parking spaces.*

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During installation of the photovoltaic power system the site will remain fully operational and the contractor will ensure minimal disruption to existing work and operations. Close management with the project manager and site staff will be undertaken throughout the

process.
Installation of the solar panels may require large deliveries or use of cranes. As such, the contractor has been advised to provide sufficient notice of deliveries or use of cranes and impact on access to the site or traffic. In the event that roads need to be closed, a traffic management plan will be undertaken by the contractor.

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**Streetscape and Design**
*Discuss how the design of the development has taken into consideration the existing streetscape.Include details of the proposed external finishes, material type and colour.*

The design is consistent with existing streetscape and design.

The PV panels will be mounted on both newer northern block and south block of the JSPAC. The PV panels for the newer northern block at the JSPAC will be mounted on a tilted frame assembly. The roof falls 10° to the south, while the panels will be tilted so that they have an angle of 10° to the north, resulting in a total tilted angle of 20° to the roof sheeting. It is very difficult to see this roof from the ground level. Further, the PV panels will be set back a minimum 2.5m from the roof edge because of wind loading issues that will also reduce their visibility.

The PV panels on the south block of the JSPAC will be mounted flush on the northern facing roofs. Only the panels placed on the eastern section of the roof may be visible from the adjoining shopping centre upper levels. The majority of the panels will be shielded from view by the North Block building.

The PV panels will be a dark blue colour and placed in a geometric pattern.

A photomontage has been provided detailing the impact the solar photovoltaic (PV) system will have on the façade of the building.

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**Services**
*Discuss the availability of utility services such as Power, Water, Sewer and Telephone services.Method of sewerage effluent and Stormwater disposal.*

The proposed solar photovoltaic (PV) system will reduce demand on the grid system on boost the generation of solar power within the local government area.

**Privacy, Views and Overshadowing**
*Discuss how the development may impact on neighbouring properties and any measures proposed to reduce the impact. Consider affects to Privacy, Views, Overshadowing, and solar access of the neighbouring properties.*

The proposed development will have minimal impacts on privacy, views and overshadowing.

**Social and Economic Effects**
*Discuss whether the development will have a positive or negative social impact on the locality. Proposed measures to address any negative impacts are to be provided. Discuss what economic impact the development will have on the locality.*

The installation of solar panels at the site provides positive economic & social impacts by reducing the site's carbon footprint and reliance on coal fire power stations.

Installing solar at the site will also help Council achieve adopted sustainability targets that encourage energy efficiency within the organisation and the transition to more sustainable sources of energy into the future, including:

- 15% of Council's energy supplied from low carbon sources by 2030
- 40% reduction in greenhouse gas emissions by 2030 based on 2010-11 levels.

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**Flora and Fauna**

*Discuss the impact that the development will have on any existing vegetation. In relation to the Threatened Species Conservation Act, discuss the impact that the development will have any threatened or endangered species.*

No trees to be removed from the installation of the solar panels.

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**Planning Policies and Controls**

*Address how the development satisfies the relevant planning controls applying to the site and justify any areas of non-compliance.*

**Penrith Local Environmental Plan 2010**

This site is zoned B3 Commercial Core under LEP 2010, with the installation of the solar photovoltaic (PV) system permissible with Council consent. Clause 7.2 Flood controls also applies to the site. Although the site is flood affected, the panels are located on the roof and system is connected to the network rather than on site batteries. Therefore the installation of the solar photovoltaic (PV) system will not impact on the flow of flood waters within the site.

**Penrith Development Control Plan 2014**

Penrith Development Control Plan 2014 has been considered, however none of the controls are considered to be relevant due to the nature of the proposal.

Signature of Applicant: _____ Date: 22/6/16