Technical Specification

Transport and Main Roads Specifications
MRTS263 Standalone Solar (PV) Power Systems

November 2019

Queensland Government

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1 Introduction

This Technical Specification applies to the design, supply, fabrication, installation, testing and commissioning, performance, documentation, training and maintenance requirements for isolated Standalone Solar (PV) Power Systems.

The system shall include all PV modules and mounting hardware, charge controllers, batteries, inverters (if required), disconnectors, cabling, and all balance of system (BOS) components and connections needed for a “turnkey” installation of the complete solar power system suitably protected against vandalism and theft. All appropriate documentation, software including data acquisition software, and any special maintenance tools shall also be included with the system.

Standalone Solar Power Systems are to provide power to Transport and Main Roads Intelligent Transport Systems (ITS) and electrical equipment in locations where reticulated mains electricity is not available or financially viable.

This Specification does not apply to solar systems fixed to the roofs or facades of buildings, or to systems connected to the grid.

This Technical Specification forms part of the Transport and Main Roads Specifications Manual and shall be read in conjunction with MRS263 *Standalone Solar (PV) Power Systems*, MRTS01 *Introduction to Technical Specifications*, MRTS50 *Specific Quality System Requirements* and other Technical Specifications as appropriate.

2 Definition of terms

The terms defined in Clause 2 of MRTS01 *Introduction to Technical Specifications* and MRTS201 *General Equipment Requirements* apply to this Technical Specification. Additional terminology relevant to this Technical Specification is defined in Table 2 below.

Table 2 – Definition of terms

Term	Definition
ac	Alternating current
ADR	Australian Design Rules
ADT	Average Daily Traffic volume in both directions and all lanes, other than for a divided road where it is the total traffic in all lanes in one direction
AGM	Absorbent Glass Mat
Autonomy	Number of days of operation of the system without energy from the PV array before exceeding the design maximum depth of discharge of the battery
battery	One or more connected electrochemical units used to store electrical energy
BoS	Balance of System
CEC	Clean Energy Council
dc	Direct current
DoD	Depth of Discharge: The capacity in Ampere Hours (Ah) that is discharged from a fully charged battery, divided by the battery nominal capacity (C20). DoD is normally presented in percent (%).
Inverter	Electronic device used to convert dc power into ac power at mains voltage and frequency

Term	Definition
Irradiance	Radiant solar power incident upon unit area of surface measured in W/m²
$I_{SC\ MOD}$	Short circuit current of a PV module or PV string at standard test conditions (STC), as specified by the manufacturer in the product specification
LED	Light Emitting Diode
LFP	Lithium Iron Phosphate
MPPT	Maximum Power Point Tracking
PCE	Power Conversion Equipment - system that converts the electrical power delivered by the PV array into the appropriate frequency and/or voltage values to be delivered to the load, or stored in a battery
PSH	Peak Sun Hours - Total quantity of radiant solar energy per unit area received over a given period (1 kWh/m² = 1 PSH = 3.6 MJ/m²)
PV	Photovoltaic
PV_{Module}	Complete and environmentally protected assembly of interconnected photovoltaic cells by which the energy of solar radiation is converted to electrical energy
PV_{Array}	Assembly of electrically connected PV Modules (Note PV array is used in this document for one or more modules.)
SLA	Sealed Lead Acid
SOC	State of Charge – charge remaining in a battery at any point in time
SPD	Surge Protection Device
STC	Standard test conditions - reference values of in-plane irradiance ($G_{I,ref}$ = 1 000 W/m²), PV cell junction temperature (25°C), and air mass (AM = 1.5) to be used during the testing of any PV device
Tilt angle	Angle between the horizontal plane and the plane of the photovoltaic array
$V_{OC\ MOD}$	Open circuit voltage of a PV module at standard test conditions, as specified by the manufacturer in the product specification
Worst month	The month for which the energy available from the PV array is lowest compared with the load for that month.

3 Referenced documents

The requirements of the referenced documents listed in Table 3 of MRTS201 *General Equipment Requirements* and Table 3 below apply to this Technical Specification. The Technical Specifications referred here are the latest version at the time of release of this document. Where there are inconsistencies between this Technical Specification and others referenced (including those referenced in MRTS201 *General Equipment Requirements*), the requirements specified in this Technical Specification shall take precedence.

Table 3 – Referenced documents

Reference	Title
AS 3996	*Access covers and grates*
AS 4086.1	*Secondary batteries for use with stand-alone power systems – General requirements*

Reference	Title
AS 4086.2	*Secondary batteries for use with stand-alone power systems – Installation and maintenance (To be superseded by AS/NZS 5139: Electrical Installations – Safety of battery systems for use with power conversion equipment)*
AS 60529	*Degrees of protection provided by enclosures (IP Code)*
AS 60947.3	*Low voltage switchgear and controlgear – Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units*
AS 62208	*Empty enclosures for low-voltage switchgear and controlgear assemblies – General requirements*
AS/IEC 62619	*Secondary cells and batteries containing alkaline or non-acid electrolytes – Safety requirements for secondary lithium cells and batteries, for use in industrial applications*
AS/NZS 3000	*Electrical installations (known as the Australian/New Zealand Wiring Rules)*
AS/NZS 3008.1	*Electrical installations – Selection of Cables – Cables for alternating voltages up to and including 0.6/1kV – Typical Australian installation conditions*
AS/NZS 3012	*Electrical installations – Construction and demolition sites*
AS/NZS 4509.1	*Stand-alone power systems – Part 1: Safety and installation*
AS/NZS 4509.2	*Stand-alone power systems – Part 2: System design*
AS/NZS 5033	*Installation and safety requirements for photovoltaic (PV) arrays*
AS/NZS 5603	*Stand-alone inverters – Performance requirements*
AS/NZS 60898.2	*Circuit breakers for overcurrent protection for household and similar installations – Part 2: Circuit-breakers for ac and dc operation*
AS/NZS 61000.6.1	*Electromagnetic compatibility (EMC) – Generic standards – Immunity for residential, commercial and light-industrial environments*
AS/NZS 61000.6.3	*Electromagnetic Compatibility – General Standards – Emission*
AS/NZS IEC 60947.2	*Low-voltage switchgear and controlgear – Part 2: Circuit-breakers*
CEC	*Clean Energy Council - Battery Install Guidelines for Accredited Installers*
CEC	*Clean Energy Council - Install and Supervise Guidelines for Accredited Installers*
EN 50539-11	*Low-voltage surge protective devices – Surge protective devices for specific application including dc – Part 11: Requirements and tests for SPDs in photovoltaic applications*
EN 50618	*Electric cables for photovoltaic systems*
IEC 60269-1	*Low-voltage fuses – Part 1: General requirements*
IEC 60269-6	*Low-voltage fuses – Part 6: Supplementary requirements for fuse-links for the protection of solar photovoltaic energy systems*
IEC 61215-1	*Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 1: Test requirements*
IEC 61730	*Photovoltaic (PV) module safety qualification*
IEC 62109	*Safety of power converters for use in photovoltaic power systems*
IEC 62262	*Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)*

Reference	Title
IEC 62548	*Photovoltaic (PV) arrays – Design requirements*
IEC 62930	*Electric cables for photovoltaic systems with a voltage rating of 1,5kV DC*
MRTS01	*Introduction to Technical Specifications*
MRTS50	*Specific Quality System Requirements*
MRTS61	*Gantries and Support Structures for Road Signs, Tolling Systems and ITS Devices*
MRTS91	*Conduits and Pits*
MRTS94	*Road Lighting*
MRTS97	*Mounting Structures for Roadside Equipment*
MRTS201	*General Equipment Requirements*
MRTS206	*Provision of Variable Speed Limit and Lane Control Signs*
MRTS218	*Vehicle Activated Signs*
MRTS219	*Internally Illuminated Pavement Markers*
MRTS221	*Help Phones*
MRTS222	*Electronic School Zone Signs*
MRTS225	*Imaging*
MRTS226	*Telecommunications Field Cabinets*
MRTS228	*Electrical Switchboards*
MRTS229	*Electronic Traffic Control Signs*
MRTS231	*Road Weather Monitor (RWM) Systems*
MRTS233	*Roadway Flood Monitoring Systems*
MRTS250	*Provision of Automatic Number Plate Recognition System*
MRTS255	*Traffic Signal Controllers*
MRTS260	*Temporary Variable Speed Limit Signs*
MRTS262	*Temporary Variable Message Signs*
MRTS265	*Type-2 Portable Traffic Signals*
SD1686	*Road Lighting – Switchboard Assembly Details*
TRUM Vol 4 Part 4	*Traffic and Road Use Management Manual, Volume 4 – Part 4: Road Lighting Dome Junction Box Assembly*

4 Quality system requirements

4.1 Hold Points, Witness Points and Milestones

General requirements for Hold Points and Witness Points are specified in Clause 5.2 of MRTS01 *Introduction to Technical Specifications*.

The Hold Points and Witness Points applicable to this Technical Specification are summarised in Table 4.1. There are no Milestones defined.

Table 4.1 – Hold Points, Witness Points and Milestones

Clause	Hold Point	Witness Point	Milestone
5.11	1. Non-department standard pits		
6.1	2. Inspection of specific locality		
6.5.8	3. Acceptance of electrical design		
6.6	4. Approval of support structure		
7.3	5. Department approval of theft prevention methods		
7.6		1. Sealing of conduits	
9	6. Compliance of equipment with standard requirements		
10	7. Design documentation		

4.2 Warranty

Warranty provisions shall meet the requirements of MRTS201 *General Equipment Requirements* except that the warranty period shall be as noted for the items below:

a) Solar photovoltaic modules and inverter: 10-year manufacturer's warranty against defects in materials and workmanship.

b) Solar photovoltaic module power output: 25-year manufacturer's power output warranty, with the first 10 years at 90% minimum rated power output and the balance of the 25 years at 80% minimum rated power output.

c) Charge controllers: 5-year manufacturer's warranty against defects in materials and workmanship.

d) Lead acid batteries, minimum design life of 5 years with 5-year warranty.

e) Lithium batteries, minimum design life of 10 years with 10-year warranty.

5 Equipment requirements

The standalone solar power system shall comply with MRTS201 *General Equipment Requirements* and the relevant parts of AS 4086.2, AS/NZS 4509.2 and AS/NZS 5033.

5.1 General

All components shall:

a) be rated for dc use

b) have a voltage rating equal to or greater than the PV array maximum voltage

c) have a minimum current rating in accordance with AS/NZS 5033

d) have an IP rating of 65 or higher

e) comply with the temperature rating requirements of MRTS201 *General Equipment Requirements*

f) be suitable for use in marine environment

g) be UV resistant, and

h) be immune to roadside vibrations and accommodate the vibrations encountered during handling and road transport without detriment.

5.2 PV modules

PV modules shall:

a) meet the relevant requirements of AS/NZS 4509.2 and AS/NZS 5033, and the 2016 edition of IEC 61215 and IEC 61730

b) except for small, low wattage modules, be on the CEC approved PV modules list current at date of contract

c) be complete with a deterrent mechanism for stopping birds from resting on the module, and

d) meet the following minimum technical requirements in Table 5.2:

Table 5.2 – PV modules technical requirements

Parameter	Requirement
Cell type	Mono or polycrystalline
Front cover	Tempered glass
Frame material	Anodized aluminium alloy
Junction box	IP56 with bypass diodes of suitable reverse voltage rating
Cable	Min. 900mm x 4mm^2 double insulated, UV resistant, solar
Connector	Multi-contact MC4 from one manufacturer only
Nominal maximum power (P_{max})	To suit application
Maximum power voltage (V_{mp})	To manufacturer's specification
Maximum power current (I_{mp})	To manufacturer's specification
Open circuit voltage (V_{oc})	To manufacturer's specification
Short circuit current (I_{sc})	To manufacturer's specification
Module efficiency	>17%
Operating temperature	-40ºC - +85ºC
Rated power tolerance	≥0%
Temperature coefficient (P_{max}) (%/ºC)	< -0.4
Temperature coefficient (V_{oc}) (%/ºC)	< -0.3

5.3 Charge controllers

The charge controller shall:

a) meet the relevant requirements of AS/NZS 4509.2

b) be maximum power point tracking (MPPT) type with battery temperature compensation and be complete with temperature sensor

c) be rated IP56 in accordance with AS 60529 or installed within an IP56 rated enclosure

d) be complete with battery state of charge metering, input current and battery voltage indication with real time recording for later download

e) be suitably matched to the PV array and battery. (Note that lead-acid chargers are not acceptable for lithium batteries; only chargers that have been designed for and are matched to the lithium battery are acceptable)

f) ensure the battery is charged efficiently in accordance with the manufacturer's requirements without being overcharged or damaged due to overheating

g) prevent the batteries from being over discharged

h) ensure the maximum possible battery life

i) provide prevention against discharge back through the PV array, even when a module is defective

j) provide reverse polarity protection

k) provide lightning/surge protection

l) provide protection against short-circuit and overload

m) provide over voltage protection and under voltage cut off

n) be complete with self-diagnostics, data logging and communications protocol, and

o) have an alarm function for remote alarm indication.

5.4 Batteries

Batteries shall:

f) meet the relevant requirements of AS 4086.1, AS/NZS 4509.2 and AS/IEC 62619

g) be suitably rated for solar application

h) be suitably matched to the charger controller

i) if lead acid type, be of AGM technology

j) if lithium type, be complete with a battery management system, to ensure battery requirements are complied with throughout the battery life cycle including low voltage disconnect, over voltage protection, short circuit protection, reverse polarity protection, internal cell balancing, cell thermal protection

k) be rated for minimum 3000 cycles to 50% DoD for lead acid and 85% DoD for lithium technology at 20ºC

l) have a round trip efficiency of >80% for lead acid and >90% for lithium

m) have self-discharge rate <3% per month

n) be of standard size and capacity and easily field replaceable

o) be suitable for installation in an underground pit (which may flood during rainy season) or above-ground enclosure in the environmental conditions detailed in MRTS201 *General Equipment Requirements*

p) be of the technology as included in the Appendix A: Schedule.

q) battery technology shall be evaluated against but not limited to the following:

i. Capital investment and operating costs:

- Whole of life costs
- Warranty period
- Maintenance interval

ii. Battery efficiency:

- Battery efficiency
- Energy density
- Low self-discharging rates
- Battery cycles life
- Fault clearing capability near full dept of discharge
- De-rating factor over the life span of the battery

iii. Installation and operating safety:

- Weight
- Safety
- Hydrogen venting and build up
- Flammability of battery
- Battery operating temperatures
- Thermal runaway
- Crash resistance and acid/fluid spills.

5.5 Inverters

The inverter shall:

a) meet the relevant requirements of AS/NZS 4509.2. AS/NZS 5033 and AS/NZS 5603

b) comply with the requirements for Performance Class A of AS/NZS 5603

c) have output frequency limits 48-52Hz

d) have ac output voltage limits 216-253V

e) be standalone, pure sine wave type compatible with the electronic equipment load to be connected

f) be capable of supplying equipment maximum demand and surge demand loads allowing for the load power factor

g) have low no-load and stand-by power consumption of less than 5W

h) be matched to the system dc voltage

i) be complete with self-diagnostics, data logging and communications protocol, and

j) have an alarm function for remote alarm indication.

5.6 Fuses and switch-disconnectors

Fuse links shall:

a) comply with IEC 60269-1, IEC 60269-6 and AS/NZS 5033

b) have rated voltage from the preferred value table to suit the application, and

c) have rated overcurrent and short-circuit current to suit the application.

Fuse bases/holders shall:

a) comply with AS/NZS 5033

b) have a current rating equal to or greater than the corresponding fuse link

c) not change fuse ratings or characteristics, and

d) provide a degree of protection suitable for the location and not less than IP2X even when the fuse link or carrier is removed.

Switch-disconnectors shall:

a) comply with AS 60947.3 category DC-PV2

b) not have exposed live metal parts in connected or disconnected state

c) have rated voltage to suit the application

d) have a current rating equal to or greater than the associated overcurrent protection device, or in accordance with AS/NZS 5033

e) not be polarity sensitive

f) be rated to interrupt full load and prospective fault currents from the PV array

g) interrupt all live conductors simultaneously, and

h) be capable of being locked in the open position.

5.7 Circuit breakers

Circuit breakers used for overcurrent protection in PV arrays shall:

a) be certified for dc use to either AS/NZS 60898.2 or AS/NZS IEC 60947.2

b) not be polarity sensitive

c) be rated to interrupt full load and prospective fault currents from the PV array

d) have rated overcurrent and short circuit current to suit the application, and

e) be capable of being locked in the open position.

5.8 Surge protection devices

Surge protection for use on the dc side of the photovoltaic system shall:

a) comply with EN50539-11

b) be explicitly rated for use on the dc side of a PV system

c) have maximum continuous dc voltage rating of 1000Vdc

d) have nominal discharge current (8/20µs) of 20kA

e) have maximum discharge current (8/20µs) of 40kA

f) have voltage protection level (3kA 8/20µs) of <4200V

g) have short circuit withstand level of 40kA

h) provide line-to-line and line-to-earth protection, and

i) be DIN-rail mounted.

5.9 Diodes

Bypass and blocking diodes shall:

a) comply with AS/NZS 5033.

5.10 Cables and connectors

Cables shall:

a) comply with EN 50618 designation H1Z2Z2-K, or IEC 62930

b) be of suitable voltage rating and current carrying capacity for the application

c) be suitably sized for voltage drop and prospective fault current, and

d) be colour coded for positive and negative cables.

Cable connectors shall:

a) comply with AS/NZS 5033

b) be MC4

c) be of the same type from the same manufacturer throughout

d) ensure contact pressure over the lifetime of the system

e) have a voltage rating equal to or greater than the PV maximum voltage

f) have a current rating equal to or greater than the current carrying capacity of the circuit to which they are fitted

g) be suitably matched to the cable used for the circuit to which they are fitted

h) require a tool to separate

i) be polarised if multi-polar

j) comply with the temperature rating requirements of MRTS201 *General Equipment Requirements*, and

k) be UV resistant and of an IP rating of 65 or higher.

5.11 Conduits and pits

Conduits and pits shall:

a) be in accordance with MRTS91 *Conduits and Pits*.

However, where pits are to be used for the underground installation of solar system equipment, such as batteries, and the department approved standard size pits are not suitable, select a suitable pit from an approved pit supplier and submit for approval. Lids for these pits shall be steel, minimum rating Class B to AS 3996, and pad-lockable. **Hold Point 1**

5.12 Enclosures

Above-ground equipment enclosures shall comply with:

a) standard department switchboard enclosures to MRTS228 *Electrical Switchboards,* or

b) standard department traffic signal enclosures to MRTS255 *Traffic Signal Controllers*, or

c) standard department telecommunications field cabinet enclosures to MRTS226 *Telecommunications Field Cabinets*.

However, where the standard enclosure cannot comply with the internal temperature requirements of MRTS201 *General Equipment Requirements*, additional measures such as reflective paint, sun shields, and the like shall be considered to achieve compliance.

Plastic or fibreglass pillars or battery enclosures shall not be used, due to insufficient protection against theft and vandalism.

Trailer mounted enclosures shall:

a) comply with the relevant requirements of AS/NZS 4509.1, AS/NZS 4509.2, AS 4086.2 and AS 62208

b) be suitably sized for the equipment to be installed and be complete with suitable anchors for the equipment

c) be rated to IP56 in accordance with AS 60529

d) be rated to IK10 in accordance with IEC 62262

e) be suitably protected against theft and vandalism

f) have hinged lids with stainless steel hinges

g) have suitable means to prevent access by unauthorized persons

h) be suited for road travel

i) have materials in accordance with the materials listed on SD1686 *Road Lighting – Switchboard Assembly Details*, and

j) comply with the internal temperature requirements of MRTS201 *General Equipment Requirements.*

Where equipment is installed within, for example an electronic sign, the sign enclosure is acceptable provided it is weatherproof.

Where a separate enclosure is required, for example on an electronic sign post, the enclosure shall:

a) comply with the relevant requirements of AS/NZS 4509.1, AS/NZS 4509.2, AS 4086.2 and AS 62208

b) be suitably sized for the equipment to be installed and be complete with fixings for the equipment

c) be rated to IP56 in accordance with AS 60529

d) be rated to IK10 in accordance with IEC 62262

e) be suitably protected against vandalism

f) have suitable means to prevent access by unauthorized persons, and

g) be manufactured of materials suitable for the environment.

5.13 Labels and signs

Labels and signs shall:

a) comply with the relevant requirements of AS 4086.2, AS/IEC 62619, AS/NZS 4509 and AS/NZS 5033.

5.14 Balance of system (BoS)

All balance of system components, connections and the like shall be suitable for the application and complying with relevant standards.

6 Design requirements

6.1 General requirements

The design shall comply with the relevant parts of Austroads Guide to Road Design – *Part 6: Roadside Design, Safety and Barriers*, AS/NZS 3000, AS/NZS 4509.2, AS/NZS 5033 and IEC 62548.

The design for the standalone solar power system shall include assessing site data, the siting of the PV array to maximise solar gain, the selection of equipment to minimise system losses, and the combination of all necessary parts to optimise the supply of power to the specified load, while complying with all required standards.

For fixed locations, the specific site locality for a proposed solar installation shall be investigated prior to the design stage, to ensure the specific locality is suitable. Trees, steep embankments, buildings or other structures that could shadow the PV array shall be identified.

When a site is selected:

a) ensure the array will not be shaded from 9am to 3pm on any day.

b) ensure the array is not shaded in any month of the year during the solar window.

c) identify any obstacles that would shade the array between 9am and 3pm.

d) make recommendations to:

   i. eliminate any shading

   ii. move the array to avoid shading, or

   iii. increase the array size to offset losses due to shading.

Hold Point 2

The system shall be designed to provide full load power to the designated load for the required autonomy as detailed in Appendix A: Schedule without exceeding the allowable DoD, and on the return of solar input, to fully recharge the batteries within seven days during the worst month irradiance, while under load.

In addition, where the solar power system is to be transportable or trailer mounted, it shall:

a) comply with AS/NZS 3012 and the relevant requirements of the Australian Design Rules

b) be suitable for deployment anywhere in Queensland, and

c) be sufficiently rugged to withstand the vibrations encountered during handling and road transport without detriment to the system.

Guidance shall be provided to the user on how the system is to be setup on site to achieve maximum solar gain.

6.2 PV array and charge controller

The charge controller is used between the PV array and the battery bank to monitor battery voltage, optimise charging, keep the array from overcharging the batteries and keep the load from over discharging the batteries (where an inverter is not part of the system).

The following minimum requirements shall be included in the design of the PV array and charge controller:

a) The PV module wattage, efficiency, and technology shall be chosen to minimise the number of modules required.

b) The watt-hours for the load shall include 25% spare capacity.

c) The peak sun hours shall be determined for the worst month under the best average performance from the Australian Solar Radiation Figures for the location of the site.

d) PV arrays shall face north with a tilt angle calculated to be close to the optimum tilt angle for no seasonal load variation.

e) A solar tracking system is not required.

f) Correction shall be allowed for PV cell operating temperature above STC.

g) Soiling factor depending on the location shall be included.

h) Negative module power tolerance maximum 0%.

i) Module mismatch maximum 2%.

j) Battery efficiency shall be minimum 90% unless more accurate figures are provided by the battery manufacturer for the battery technology and operating temperature.

k) The array minimum output voltage must not be less than the battery's required charging voltage.

l) The charge controller efficiency shall be from the technical data for the equipment selected.

m) Inverter efficiency shall be from the technical data for the equipment selected.

n) Highest winter array voltage must not exceed the maximum charge controller input voltage.

o) Lowest summer array operating voltage must not fall below the charge controller minimum dc input voltage.

p) Allowance for voltage loss as modules age (20%).

q) Compatibility of the charge controller output voltage with the selected battery bank.

r) Where more than one PV module are used, all modules shall be identical.

s) Allow a 25% safety margin in the controller for higher irradiance conditions.

t) Maximum allowable voltage drop on the PV circuits is 2%.

u) Provide protection against reverse current leakage from the batteries during night time.

6.3 Mains battery charger

Portable and trailer mounted systems as specified in MRTS229 *Electronic Traffic Control Signs*, MRTS260 *Temporary Variable Speed Limit Signs*, MRTS262 *Temporary Variable Message Signs* and MRTS265 *Type-2 Portable Traffic Signals* shall be provided with a mains battery charger as defined in MRTS201 *General Equipment Requirements* so that the batteries can be fully charged prior to being deployed on site and while on site. While on mains charger, a lead acid battery shall be charged to 100% within 16 hours and a lithium battery shall be charged to 100% within 4 hours.

Provide the necessary protection so that the mains battery charger dc supply and solar supply are isolated from each other and cannot be connected to the battery bank simultaneously. Ensure isolation so that the ac mains cannot feed through into the dc supply.

6.4 Battery bank

The following shall apply to the design of the battery bank:

a) The battery bank voltage shall be 12V, 24V or 48V.

b) For all lead acid batteries, the maximum DoD shall not exceed 50%.

c) For lithium batteries, the maximum DoD shall not exceed 85%.

d) Design the battery bank with suitable capacity based on C20 rate and the temperatures expected at site.

e) Include for battery bank temperature sensors and derating if required.

f) Physical dimensions and weight of the battery shall be selected so that the battery can be easily installed/removed by one person.

Consideration shall be given to factors such as theft, vandalism, battery technology, site, environment, maintenance, aesthetics, potential impact by motor vehicles, and the like to optimise the installation and minimise any detrimental effects.

Where batteries are to be installed in an underground pit, ensure the batteries and cable terminals are protected from submergence.

6.5 Electrical design

6.5.1 General

The following shall apply:

a) The output requirements of the standalone solar power system shall be as included on the Appendix A: Schedule.

b) The dc power shall be available at the dc output terminals of the charge controller.

c) The ac power shall be available at the ac output terminals of the inverter.

d) Integrate with the load to provide a seamless power supply connection.

e) Where the standalone solar power system is feeding an ac load, the MEN configuration shall be used on the ac side.

6.5.2 Protection against electrical shock

To provide protection against electrical shock, electrical design shall comply with the requirements of AS/NZS 3000 and AS/NZS 5033.

6.5.3 Protection against overcurrent

To provide protection against overcurrent, electrical design shall comply with the requirements of AS/NZS 3000, AS/NZS 4509.2 and AS/NZS 5033.

Where batteries are installed underground, provide fuses between the battery and the charge controller as close as possible to the battery, within a Transport and Main Roads standard reopenable joint, in accordance with TRUM Vol 4 Part 4.

6.5.4 Protection against earth faults

To provide protection against earth faults, electrical design shall comply with the requirements of AS/NZS 5033.

6.5.5 Protection against effects of lightning and overvoltage

Where standalone solar powered systems are installed in locations where the lightning flash density is greater than two flashes per square kilometre per year provide lightning/overvoltage protection measures in accordance with AS/NZS 5033.

6.5.6 Cables

Sizing of cables shall be in accordance with AS/NZS 3008.1 and AS/NZS 5033, and where relevant using manufacturer’s data for the cables selected.

6.5.7 Electromagnetic compatibility

The PV installation shall comply with the electromagnetic compatibility provisions of AS/NZS 61000.6.1 and AS/NZS 61000.6.3 for immunity and emissions respectively.

6.5.8 Electrical design documentation

The complete electrical design of the standalone solar power system including solar generation, derating factors and battery selection to achieve the required power supply and autonomy, equipment selection demonstrating suitability for system voltage and current, cable selection and calculations, wiring diagrams and the like shall be carried out and certified by an RPEQ currently registered as an electrical engineer and submitted for review and acceptance by the Administrator. **Hold Point 3**

6.5.9 Monitoring

Where required under the contract to send an alarm to a specified location in a specified manner, the following shall be solar system alarm conditions:

a) PV array loss/fault

b) charge controller loss/fault

c) lead acid battery low level alarm activated at 40% DoD

d) lithium battery low level alarm activated at 70% DoD

e) loss of load, and

f) inverter loss/fault.

Where the solar system connects to another system that has monitoring facilities, integrate the two systems to provide the required data.

6.6 Support structures

Slip base solar lighting poles are now approved for use.

Design of the support structures, racking, footings/foundations and the like for the solar system shall:

a) be in accordance with the relevant requirements of AS/NZS 5033, MRTS61 *Gantries and Support Structures for Road Signs, Trolling Systems and ITS Devices* and MRTS97 *Mounting Structures for Roadside Equipment*

b) be suitably designed for the equipment to be mounted at the site location

c) provide means of adjusting the PV array tilt from 0º to 45º and rotation of 360º without stops, and then securing the array in place

d) be designed and certified by an RPEQ currently registered as a structural engineer

e) where the array support structure is to be included as part of another system support structure, for example solar power flag light, integrate the array requirements into one common structure, and

f) enable the PV array to be mounted at a minimum height of 6m above the ground unless otherwise specified.

In addition, for trailer mounted structures:

a) The PV array shall have a mechanical system which allows the array to be safely secured to the trailer for transportation.

b) The mechanical system shall allow for the PV array to be safely erected on site so that the array can be adjusted to ensure optimum solar exposure and maximum energy generation anywhere in Queensland.

c) When erected, the mechanical system shall ensure that the array cannot rotate, or the tilt change due to wind gusts up to the ultimate wind speed for which the structure is designed.

d) The solar system structure shall be designed such that it does not prevent the trailer complying with the applicable Australian Design Rules nor its suitability for registration in accordance with the statutory requirements of the State of Queensland.

Full design documentation shall be submitted for review and approval by the Program Director (Road Operations), Engineering and Technology Branch of Transport and Main Roads, prior to commencement of manufacture of the support structure. **Hold Point 4**

7 Installation requirements

7.1 General

The installation of the standalone solar power system shall be carried out by an experienced and competent installer in accordance with product manufacturer's recommendations, AS/NZS 3000, AS/NZS 4509.1, AS 4086.2, AS/NZS 5033, structural engineer's requirements, and relevant parts of the CEC documents *Install and Supervise Guidelines for Accredited Installers* and *Battery Install Guidelines for Accredited Installers* as applicable.

The installation shall minimise the potential for theft and vandalism with cables being concealed, equipment located out of reach as much as practicable and securely fixed, enclosures/pits securely locked and disconnects being protected against misuse and vandalism.

The installation shall be immune to roadside vibrations and, where portable or trailer mounted be constructed to accommodate the vibrations encountered during handling and road transport without detriment to the system.

The Contractor shall inform and alert workers that photovoltaic modules will be live and generating electricity when there is any ambient light source. Workers shall take appropriate precautions to prevent shock hazard.

7.2 Location

Where located adjacent to a roadway, the PV array and above-ground enclosures shall be installed outside the clear zone as defined by Austroads Guide to Road Design – *Part 6: Roadside Design, Safety and Barriers* – Table 4.1 Clear zone distances from edge of through travelled way for the maximum vehicle speed and Design ADT designated at the installation site unless suitable barrier protection is provided.

7.3 PV array

The PV array shall be positioned for the correct tilt and azimuth as detailed under Design Requirements and secured in place.

All PV module fittings and adjustments shall be designed, manufactured, installed and tested with appropriate and Transport and Main Roads approved theft prevention methods. **Hold Point 5**

7.4 Batteries

Batteries shall be installed in accordance with AS 4086.2 and the battery manufacturer's requirements and allowing suitable accessibility for terminal connector maintenance. Consideration shall be given to factors such as theft and vandalism.

7.5 Functional earth

A functional earth in accordance with AS/NZS 5033 shall be provided if required by the PV module manufacturer.

7.6 Cables and connections

Cable installation shall comply with the requirements of AS/NZS 5033.

Utilize on-site measurements in conjunction with engineering designs to accurately cut cables, and layout before making permanent connections. Ensure cables are free of snags and clear of sharp edges that have the potential to compromise the cable insulation. All cabling shall be mechanically fastened. Connectors shall be installed in a manner to minimise strain on the connection.

All connections shall have an IP rating of 65 or higher.

In dc systems, overheating of connections and consequent arc faults may occur when high resistance connections are present or develop due to temperature cycling in an installation. It is essential that care be taken to ensure:

a) all connections have an IP rating of 65 or higher

b) all connections are correctly tightened to avoid points of failure over time

c) all connectors are properly locked into place, and

d) all crimp connections are performed according to manufacturer's requirements.

After installation of the cables, conduits shall be sealed to prevent vermin entry. **Witness Point 1**

7.7 Conduits and pits

Install conduits and pits in accordance with MRTS91 *Conduits and Pits*.

Pits shall be located within 3 metres of other system components to minimise cable lengths, out of traffic ways, and where there is free drainage. Install pits such that water does not accumulate in the pit.

Where pits are to be used for the installation of underground equipment such as batteries, take appropriate measures so that:

a) the equipment does not become submerged during a deluge

b) the equipment is located conveniently for installation, maintenance, and removal

c) the equipment is protected from theft and vandalism, and

d) there is adequate ventilation of any evolved gasses.

7.8 Enclosures

Comply with the requirements of AS/NZS 4509 and AS 4086.2 for installation of batteries and other components within enclosures. Ensure there is sufficient ventilation in accordance with AS 4086.2 and the battery manufacturer's requirements.

Location of batteries within the enclosure shall depend on other equipment within the enclosure, battery technology, maintenance requirements, battery size and weight, and ease of battery placement/removal.

Trailer mounted enclosures for batteries shall be separate from equipment enclosures.

8 Specific applications

Some Transport and Main Roads systems specify standalone solar power but have specific requirements. The solar supply for these systems shall be as defined in this Technical Specification except where modified below. Where there is conflict with the general requirements of this specification, the specific requirements here take precedence.

8.1 MRTS94 Road Lighting

The solar supply shall be as defined in this Technical Specification.

The PV array may be located on the light pole above the luminaire at a height above the ground as detailed in MRTS97 *Mounting Structures for Roadside Equipment*.

8.2 MRTS206 Provision of Variable Speed Limit and Lane Control Signs

The solar supply shall be as defined in this Technical Specification.

8.3 MRTS218 Vehicle Activated Signs

The solar supply shall be as defined in this Technical Specification.

If permitted by the roadside safety assessment and solar exposure is suitable, the PV array may be mounted on the same pole above the top of the sign at a height of no less than 4.5m above the ground. Otherwise, the PV array shall be mounted on a separate structure outside the clear zone.

8.4 MRTS219 Internally Illuminated Pavement Markers

As these are proprietary items, this Technical Specification does not apply.

8.5 MRTS221 Help Phones

The solar supply shall be as defined in this Technical Specification.

The help phone shall incorporate a PV array mounted 3m above areas accessible to the public and a custom-built enclosure as part of the integrated system.

8.6 MRTS222 Electronic School Zone Signs

The solar supply shall be as defined in this Technical Specification.

If permitted by the roadside safety assessment and solar exposure is suitable, the PV array may be mounted on the same pole above the top of the sign at a height of no less than 4.5m above the ground. Otherwise, the PV array shall be mounted on a separate structure outside the clear zone.

8.7 MRTS225 Imaging

The solar supply shall be as defined in this Technical Specification.

The PV array shall not be mounted on the same pole as the imaging equipment.

The PV array shall be mounted at a height above the imaging equipment and in a location where it does not adversely affect the field of view.

8.8 MRTS229 Electronic Traffic Control Signs

The solar supply shall be as defined in this Technical Specification

The PV array size shall not exceed the trailer footprint.

The solar system shall utilise a voltage of 12 or 24 Volts dc.

8.9 MRTS231 Road Weather Monitor (RWM) Systems

The solar supply shall be as defined in this Technical Specification.

The PV array shall not be mounted on the same pole as the RWM equipment.

The PV array shall be mounted at a height above the RWM equipment, but no less than 4.5 metres above the ground, and in a location where it does not adversely affect the field of view.

8.10 MRTS233 Roadway Flood Monitoring Systems

The solar supply shall be as defined in this Technical Specification.

The PV array shall be mounted at a height of no less than 4.5m above the ground.

8.11 MRTS250 Provision of Automatic Number Plate Recognition System

The solar supply shall be as defined in this Technical Specification.

8.12 MRTS260 Temporary Variable Speed Limit Signs

The solar supply shall be as defined in this Technical Specification.

The PV array size shall not exceed the trailer footprint.

The solar system shall utilise a voltage of 12 or 24 Volts dc.

8.13 MRTS262 Temporary Variable Message Signs

The solar supply shall be as defined in this Technical Specification.

The PV array size shall not exceed the trailer footprint.

The solar system shall utilise a voltage of 12 or 24 Volts dc.

8.14 MRTS265 Type-2 Portable Traffic Signals

The solar supply shall be as defined in this Technical Specification.

The PV array shall be mounted above the portable traffic signals lantern at a height to suit the trailer/barrow installation.

The PV array size shall not exceed the trailer or barrow footprint intended for portable traffic signal mounting.

The solar system shall utilise a voltage of 12 Volts dc.

9 Testing and commissioning

The testing and commissioning requirements defined in MRTS201 *General Equipment Requirements* apply to work under this Technical Specification.

Equipment test sheets shall demonstrate compliance with the technical requirements of this Technical Specification prior to the delivery of the equipment to site. **Hold Point 6**

All mandatory and optional tests of AS/NZS 4509.1 and AS/NZS 5033 shall be carried out and the results recorded and included with the submission documents.

The charge controller shall be setup and programmed for the specific PV array, battery and load parameter requirements including initial charge procedures.

Mains battery chargers shall be setup and programmed for the specific battery.

The inverter shall be setup and programmed for the specific system parameters.

Where any part of the installation is found to be non-conforming, the Contractor at his own cost shall rectify the non-conformance by replacing faulty components with new materials and/or components or correcting the non-conformance to the satisfaction of the Administrator.

10 Documentation

The documentation requirements defined in MRTS201 *General Equipment Requirements* apply to work under this Technical Specification. In addition, provide the documentation required by AS/NZS 4509.1, AS/NZS 5033 and the following:

a) full design calculations showing site specific criteria, derating factors, and equipment selected demonstrating that the design achieves the specified requirements

b) battery ventilation requirements, and suitability of battery underground installation

c) fabrication drawings

d) structural design calculations, and

e) certificates of compliance where required.

For transportable and trailer mounted systems, provide a laminated instruction sheet within the equipment enclosure detailing the setup required to attain the maximum solar gain.

Prior to issue of practical completion, the Contractor shall provide a laminated A3 sized copy of the "As Constructed" electrical schematics and wiring diagrams, together with all the above required documentation to the satisfaction of the Administrator. **Hold Point 7**

11 Training

The training requirements defined in MRTS201 *General Equipment Requirements* apply to work under this Technical Specification.

12 Maintenance

The maintenance requirements defined in MRTS201 *General Equipment Requirements* apply to work under this Technical Specification.

13 Handover

The handover requirements defined in MRTS201 *General Equipment Requirements* apply to work under this Technical Specification.

Appendix A: Schedule (to be completed by Transport and Main Roads)

Mounting of PV array	On standard 7m road lighting pole		☐
	On standard 8.5m road lighting pole		☐
	On standard 5m pathway lighting pole		☐
	On special structure		☐
	On trailer		☐
Battery location	In pit		☐
	In switchboard enclosure		☐
	In traffic signal controller enclosure		☐
	In ITS enclosure		☐
	In portable enclosure		☐
	In trailer enclosure		☐
ac load estimate (W & pf)			☐
ac surge load estimate (W & pf)			☐
dc load estimate (W)			☐
Required autonomy (No of 24-hour days without solar input) d: Day n: Night	Integral flag light	4n	☐
	Road lighting	4n	☐
	Pathway lighting	3n	☐
	Variable speed limit and lane control signs	7d	☐
	Vehicle activated signs	7d	☐
	Help phones	3d	☐
	Electronic school zone signs	7d	☐
	Imaging	7d	☐
	Electronic traffic control signs	7d	☐
	Road weather monitoring (RWM) systems	7d	☐
	Roadway flood monitoring systems	7d	☐
	Automatic Number Plate Recognition	7d	☐
	Temporary variable speed limit signs	10d	☐
	Temporary variable message signs	10d	☐
	Fixed variable message signs	7d	☐
	Type 2 portable traffic signals	7d	☐
Battery technology	Lithium iron phosphate (LFP)		☐
	Lead-acid AGM		☐